Abstract. This paper intends to introduce the potential of utilization of “Integrated Resource Planning” for best results on the feasibility analysis of thermoelectric power plants taking into account the changing Brazilian market rules. In order to support the project finance for the new thermal generation in Brazil, current feasibility analysis methods and integrated planning concepts are discussed, considering all the involved entities roles in such process. The current market status is then presented, as well as some highlights concerning the risks mitigation related to the natural gas and spot price along the financing period, directly determining dispatch conditions. Finally, the risks of the projects and the demand behavior, hydrological scenarios and spot price volatility are carried out, emphasizing its influence in bilateral contracts establishment. The conclusion about this discussion is that some politic arrangements are needed to give stronger directions to this kind of generation investors and the integrated planning has a great contribution to give on supporting these adjustments.


1. Introduction

The electrical sector deregulation in many countries worldwide has been emphasizing the unbundling of activities and the break-up of the vertical arrangements that characterizes the traditional power sector model, giving rise to several efforts towards the competition on wholesale and retail markets. In Brazil, as referred into the RESEB (1997), this restructuring begun in 1995, motivated mainly by the lack of financial capacity of the State for the necessary investments in infrastructure, in order to meet an increasing demand with economic efficiency. Moreover, an important point of the market restructuring was the permission for private investors to participate in generation and distribution sectors. At that time, with the increasing availability of natural gas from Bolivia, the generation through Thermoelectric Power Plants became one of the most attractive technologies. Another important restructuring point was that the determinant electric generation expansion planning, that was the main Government investment decision tool at that time, gave place to an indicative expansion planning, transferring the responsibility of generation increases to private investors.

After that, it has become very important for a private investor to make the most complete power plant feasibility analysis as possible (thermoelectric plants in a singular way) considering all the factors that affect its construction and
operation along the time. These factors are, in general terms:

- Investment costs;
- Financial Costs;
- Construction time;
- Redemption time;
- O&M costs;
- Transmission costs;
- Local variables impact
- Environmental impact and costs;
- Social and politic factors;
- “Bilateral” energy sale contracts;
- Centralized ISO power generation dispatch.

Once all the factors are listed, it is important to notice that some of them are difficult to be translated into capital costs. The analysis of each factor and its influence on the results becomes more and more challenging when considering that the evaluation of each factor requires complete historical and environmental indicators access, as well as a good risk analysis considering the associated uncertainty levels. The complete research and data manipulation thought as only an investor responsibility is not supposed to be the best way to get the planning started. Otherwise, the first investor analysis will tend to underestimate the social and environmental factors. In order to avoid distortions, this task has to be considered as a many entities participation process, including the investor itself, the Government and all the involved communities. The point is defining everyone’s roles on this process.

2. The Feasibility analysis as Integration Tool

With the improvement of laws concerning about gas emissions, environmental impact (water and air), water use and a more constant participation of the society and non governmental organizations, the application of complete costs concept in a power plant feasibility analysis is strongly indicated to be used by its owner.

Reis et all (2003) shows that the equation for the unitary generation costs calculation on a thermoelectric plant is:

\[ Ct = Ci + C_{comb} + Cr & m + Ctr \]  

(1)

where the Total Annual Cost (Ct) in US$/MWh is a composition of the following parts:

- Investment Cost (Ci) – US$/MWh

\[ Ci = \frac{I}{PI \times FCM \times 8760} \times FRC \]  

(2)

where:

- I = Investment cost (US$)
- PI = Installed Power of the plant (MW)
- FCM = Maximum capacity factor
- FRC = Capital recovery factor
- 8760 = hours per year

Ex. For a Combined Cycle Power Plant with the following entries (according to GTW Handbook 2002): PI = 400MW, I = US$ 200,000,000, FCM = 0,9, FRC = 12% per year, the Calculated Investment Cost is: 

\[ Ci = US$ 7,61/MWh \]

- Natural Gas Cost (Ccomb) – US$/MWh

\[ C_{comb} = \frac{FC}{FCM} \times CUT \]  

(3)

where:
CUT = Unitary Natural Gas Cost (US$/MWh)
FC = Average Capacity Factor for the plant
FCM = Maximum Capacity Factor for the plant

Ex. Considering:
NG Price = US$ 2,581/MBTU (ANP, 2002), 3,4118 MBTU = 1MWh, Eff = 60%, CUT = US$ 13,40/MWh,
FC = 0,6  FCM = 0,9, then:
Ccomb = US$ 8,92/MWh

• Operation and Maintenance Cost (Co&m) – US$/MWh

\[
Co & m = \frac{Co & mf + FC \times Co & mv}{FCM \times 8,76}
\]

where:

Co&mf = Operation and Maintenance fixed cost (US$/kW.year)
Co&mv = Operation and Maintenance variable cost (US$/kW.year)

Ex. Considering the following O&M parameters for the current example:
Co&m = US$ 4,34/kW*year, Co&m = US$ 9,20/kW*year, FC = 0,6  FCM = 0,9, the O&M cost is:
Co&m = US$ 1,25/MWh

• Transmission Cost (Ctr) – US$/MWh

This cost can be represented by the equation:

\[
Ctr = \frac{Cx \times 10^6 \times FRC}{FCM \times 8760} + CUST + CUSD
\]

Where

Cx = Grid Connection Cost (MUS$)
FCM = Maximum capacity factor
FRC = Capital recovery factor
CUST - Transmission System Fee (US$/MWh)
CUSD – Distribution System Fee (US$/MWh)

Ex. Considering a plant close to the grid, not subject to distribution connections, and an average
Transmission Tax based on ANEEL (Res. N° 307, 2003) as:
Tax = R$ 2,50/kW*month (CUST), US$1,00 = R$3,00 FC = 0,6 , then:
Ctr = US$ 1,92/MWh

The application of the above mentioned reference costs to the equation (1) results in a Total Cost of
US$19,70/MWh. It traduces a cost higher than the current practiced spot price at the market, around US$6,00/MWh.

And notice at this point that the total cost (Ct) is strongly composed by economic and technologic items including
the ISO generation dispatch dependence, represented by the capacity factor (FC and FCM). This way, the right
consideration of each component in the equation above will result on a good simulation of real condition operation for
a thermoelectric plant.

But when trying to add environmental, social and politic factors into that equation, higher uncertainty levels
associated to not reliable cost relations take place. And the integration of social and environmental factors to the
equation above (1) as adding terms is not enough to reach a more complete relation. Moreover, if this mission is on
the private investor hand, he will try to minimize that relation for best costs. Otherwise, if it’s on the involved
communities hands, that new term could tend to grow up, and the final result would drive interested companies to
consider this market out of attractiveness. The first conclusion is that the integration of such factors requires other
entities participation on the process.
3. The Integrated Resource Planning (IRP)

In a complex electrical energy market like Brazilian case, added to a growing up consciousness about natural resources utilization, that is always related to the sustainable development, the “Integrated Resource Planning” play an important role as a suitable resources integration tool, to be applied to all sectors of this market. For that, it brings the continued involvement of all the entities affected by a development situation, with the intent to warrant the benefits to those people. As Udaeta et al (1997) defines, the IRP is different from the traditional planning in the class and range of considered resources, in the inclusion of owner, users and other involved organisms, and in the resources selection criteria.

Considering the IRP as a complex process that requires all the involved members participation, and the Government as the sustainable development promoter, it is natural to see the State as the entity responsible to conduct the integration process. As the Brazilian laws comprehension, the energy supply is considered as a public service due to its importance to the society. As the sponsor of a public service, the State is historically the first to respond for this market development in the presence of the society.

The fact that Government entities like the “Mines and Energy Ministry”, “Eletrobrás” and “BNDES” detain the best social and environmental historic indicators reinforces the idea that the Government has to be in charge of the electrical generation expansion planning and stimulation of private participation. Otherwise, a generation expansion planning totally dependent on the market may cause conflicts whenever new generation investments run against private agents interests.

Running to this issue, the recently (MME, 2003) published “Electric Sector Model Proposal” brings back the figure of the so called “Determinant Expansion Planning” to the electric sector. The document presents as targets to be reached: new incentive policies to private investors, service expansion to the unattended areas and taxes socialization. Once the energy expansion planning integrates society, market and government efforts resulting on long term rules and programs like PROINFA (Alternative Energy Sources Incentive Program) and the recent efforts to use the natural gas from Bolivia and also the Brazilian one on the electrical generation Brazilian plant, the next consequence will be the mitigation of the system operation risks and the drop of the associated high short term prices as well.

This integration of efforts intending to reach the balance point between the involved entities is the application of IRP. Notice that the previous IRP application results in a clear market environment, free from unexpected risks and making possible to consider just the factors that affect building and operation of a thermoelectric plant.

4. The ISO (ONS) dispatch and Market influence

Face to an unstable market context as Brazilian current case, the investment decision process for a new thermal unit connected to the Brazilian interconnected system requires full knowledge of the system conjuncture and structural variables behavior, as well as dispatch units profiles resulting from Independent System Operator (ONS) optimal dispatch.

Although the increment of the thermal generation has been stimulated by the Government, with the intent to minimize possible energy rationing or deficit risks and to stimulate the use of available natural gas from internal production increase and neighboring countries importation, the actual status of Brazilian power system, as available data (Fadigas, 1998 and ONS, 2003), composed of large-scale hydroelectric plants with reservoirs of multi-year regulation capacity and complex transmission networks connecting several units and load centers is a limitation factor for this issue.

System’s operation is defined in a centralized mode under the control of ONS. In order to optimize the use of reservoirs water, minimize the system deficit risk operating thermal units in Thermal Complementation Mode, and make use of the interconnected grid under the lower cost, the agent runs a stochastic modeled dispatch simulation software named “NEWAVE”. The result of each simulation is the dispatch table for all generation units connected to the system. But the stochastic nature of this software leads it to find sometimes not expected dispatch scenarios during feasibility analysis of a plant, which has itself a deterministic nature. And as a consequence of it, undesired cash flows can occur, affecting generators profits. The related operational flexibility, that recommends dispatch of a thermal plant only when the short term marginal cost is superior its variable cost of operation, is strongly conditioned by mandatory restrictions of minimum fuel consumption, as a function of “take-or-pay” clauses in fuel supply contracts.

Whenever a thermal plant is not dispatched, the fuel will be saved and the plants owner will earn the difference between his variable cost and the SRMC – Short Range Marginal Cost. In other words, a company having thermoellectric power available will “sell” the corresponding guaranteed power of the thermal station, regardless of physical production of each plant (MWh actually generated within a period); and such physical production is linked to the above mentioned optimal dispatch defined by the ONS simulator. From this standpoint, incurred fuel costs will be a function of the effective use of a thermal plant, while the plant revenue is a function of a physical and constant
parameter, i.e. “Guaranteed or Assured Energy”, which can be used as a physical support to bilateral long term contracts.

It should be noted that for an Independent Power Producer (IPP), a constant revenue flow is guaranteed (fixed cost charge) given that a long term contract is established, since the Assured Energy is a stable plant parameter (almost a nameplate value) that, in such case, allows the adequate return on the investment, with an acceptable return period. It should be noted that at the same time, if the complementation mode of operation is possible at least at a certain level, there is no loose of a relevant advantage of thermal generation within a hydrothermal system, which is the utilization of hydroelectric secondary power. Anytime ONS doesn’t require the plant dispatch, the owner will save the fuel (cost) and will pay the spot price for the energy to be delivered to the customer, earning the same revenue as before, if the plant have been dispatched, giving the long term contract premise. As the SRMC is of course lower than the variable cost for plant operation, otherwise the plant would be dispatched, the plant’s owner will experience an increase of its net revenue.

The problem that arises nowadays results from the low hydroelectric generation costs when compared to thermal generation costs. It means that is difficult to a thermoelectric plant to get bilateral contracts that warrant its profits during operation along the time. The Brazilian spot prices profile shows extreme volatility which strongly remarks that the exposure to the spot market is not advisable, unless in energy scarcity periods (rare situations). The market is adding mechanisms to correct this low cash flow stability of thermoelectric plants. The so called “pool” for example, presented in the new market government proposal as the single energy buyer, can stimulate thermoelectric energy sales contracts with the intent to keep or drop the energy deficit risk and maintain singular market conditions at a time.

5. Final Comments - Politics for Sustainable Competition

After all the above exposed arguments, the great challenge is to compose competitiveness with social and environmental compromise.

In this context, the social, environmental and politic factors and their influence to the electrical energy market are not supposed to be considered in the investor feasibility analysis, but during the system planning. These factors are to be innate to the market regulation laws and federal laws concerning about environmental and social public interests. And this must be the result of the dialogue between the Legislative Power and the society representatives along the time. In other words, the result of an integration effort is easier to be intrinsic to the natural gas price than to the investor risk analysis, for example.

The balance point between market attractiveness and sustainable development depends on the stability obtained by the Government for the energy planning. But it is very important to keep a continued planning policy, mainly during and after Government changes, respecting the before started efforts, established Government reports and laws.

It is clear that there must exist a stabilization time for the positioning of the multiple agents, when the flexibility and further ability to negotiate good contracts will be decisive.

Many situations have reached the discussion table and many others are expected. Relations protected by the legislation are then needed for a healthy market maintenance.

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7. References


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