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GAS COMPRESSOR SERVICE WITH TURBO COMPRESSORS

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ABSTRACT

Gas pipeline projects are capital intensive and normally are developed under scenarios of uncertainty. Such uncertainties vary from closing take-or-pay, ship-or-pay or delivery-or-pay agreements to those uncertainties related to the acquisition of equipments, material and construction and assembling contracts.

Natural gas compression service contracts with compressor station using gas motors and reciprocating compressors have been widely adopted at PETROBRAS as economically feasible against holding the stations as part of the pipeline asset as well as providing an effective approach to mitigate risks inherent to the gas business and associated to the compressor stations.

Although compression service contracts with turbo compressors (gas turbine drivers and centrifugal compressors) have not yet been accomplished at PETROBRAS for gas pipeline projects, studies and preliminaries discussions shows that, taken into consideration certain relevant aspects, they will also present great opportunity to be adopted and will generate the same advantages already perceived for the compression service contracts with stations that uses gas motor drivers and reciprocation compressors.

This paper has the objective of presenting an economic approach and a business model addressing the main points that must be considered while doing feasibility analysis between the alternatives of holding property of the compression station asset against the opportunity of having a compression service contract as operating cost for the project. Questions such as how to address depreciation, overhaul costs and tailor made equipment, such as centrifugal compressors, are raised and answered.

INTRODUCTION

There is a well developed market worldwide for service contract including equipment supply, operation and maintenance. For gas pipeline compression service this is not so common since some transportation companies have concern on subcontracting a service that is considered to be their core business and therefore should be part of their scope of service. We at PETROBRAS did a feasibility analysis for installing 12 reciprocating compression stations with a contractual total net present value of US$ 73,513,000.00 with a mean contractual term of 3 years. For centrifugal compressors with gas turbine drivers we had to establish a different approach to accommodate some specifics for this configuration since centrifugal compressors are considered to be tailor made and therefore would neither be easily used on other potential projects for the transportation company nor for the Service Provider.

For the purpose of this paper we considered Penapolis Compression Station – Station #12, one of the 14 compressor stations of the Bolivia Brasil Gas Pipeline to be the basis for the analysis

This approach is described on this paper that applies Monte Carlo simulation analysis to provide more reliable information that is fundamental in helping company managers to make the best investment decision for implementing transportation capacity for their gas pipeline network.

COMPRESSOR STATION DESCRIPTION

Penapolis Compressor Station consists of 4 turbo compressors Solar Taurus 60 (7000 hp ISO) with Mitsubishi centrifugal compressors, inside enclosures, compressor housing and facilities, with tho following characteristics:

Suction pressure:	70 kgf/cm^{2}g
Discharge Pressure:	100 kgf/cm^{2}g
Total flow:	30 MMm3/d @20C, 1 atm
Stand by units:	No

BUSINESS MODEL

The business model used (**figure 1**) for the compressor station with gas turbine drivers compares the option of contracting the compression service from Service Co. or holding the property of the asset by Trans Co. has taken into account the following:

1. Centrifugal compressor was considered tailor made equipment and therefore it was fully depreciated or required a payment at the contractual conclusion term.
2. Gas turbine can be reused and has salvage cost at the contractual conclusion term.
3. All the compressor station facilities either have a salvage cost or are fully depreciated at the contractual conclusion term.
4. We considered the same cost of capital for the Trans Co. and the Service Co., although the last normally have a higher cost of capital that incorporates risks on a more comprehensive way.
5. We also considered a buying option for the Service Contract alternative.

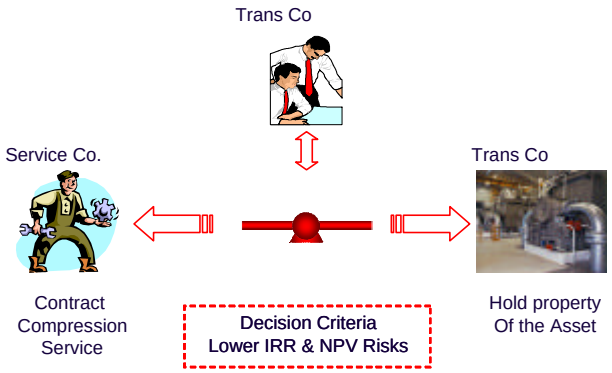

Figure 1 – Business Model

BUYING OPTION

The buying option for the Service Contract provides a mean to mitigate risks when compared to the alternative of holding the asset by the Trans Co. This is because the companies that normally provide this kind of service have more control on material and services costs and also have agreements with equipment suppliers that allows speeding up the acquisition process and reduces costs and uncertainties. The option value may be evaluated as the present value of the remaining net cash flow for the Service Contract and this provision should be included as an contractual clause.

MONTE CARLO RISK ANALYSIS SIMULATION

Uncertainty variables for the compressor station project were selected and its probabilistic distribution defined so as to incorporate them in the spread sheet using a risk analysis tool (@risk 4.0). 500 runs were performed to provide sampling results from a sampling process based on Monte Carlo Simulation. By following this procedure the project IRR and NPV reflect the effect of those uncertainties as they are sampled using Monte Carlo approach. [7]

Uncertainty Variables

We selected some main uncertainty items to perform this analysis but we can incorporate any kind of uncertainty that would affect the economics of the project as far as we can associate them with the cash flow of the project. The figures adopted are illustrative although not far away from reality.

	Trans Co.	ServiceCo.	Distribution
Equipment costs:	±10%	±2%(*)	Normal
C&A costs:	±10%	±5%(*)	Normal
Miscellaneous costs:	±15%	±5%(*)	Normal
Operating Cost	±10%	±5%	Normal
Transported Volumes:	±5%	±5%	Normal
C&A Schedule:	±15%	±10%(*)	Triangle
Salvage Cost:	-15%+0%	±10%	Triangle

(*) Values are lower since Service Co. has some equipment already in its yard and have more experience and agreements already made with main equipment suppliers as well as a level of standardization and Trans Co. should go for a bidding process.

COMPRESSOR STATION COSTS & SCHEDULE

For the purpose of this analysis it will be considered the same costs (US$) that were realized for the acquisition of Penapolis Compressor Station for Trans Co. and Service Co. as described below:

Equipment costs:	17,226,856.
C&A costs:	11,097,867.
Miscellaneous costs:	3,363,184.

Total:	31,687,907.
O&M per year:	1,584,395.
C&A schedule:	24 months

ECONOMIC ASSUMPTIONS

For the purpose of the feasibility analysis we adopted the following figures:

Return rate:	15%
Transportation rates:	@NPV=0
Contractual Schedule:	5, 10 and 15 years
Debt-equity ratio:	0% (without leverage)
Depreciation:	10% a year

TRANSPORTATION RATE CALCULATION

For the transportation rate calculation we used a spreadsheet and considered the costs and economic assumptions defined previously based on the transportation volume of 30 MMm^3/d. The transportation rate evaluation is done statically for 10 and 15 years without taking uncertainties into account. The results are shown on **figure 2** below.

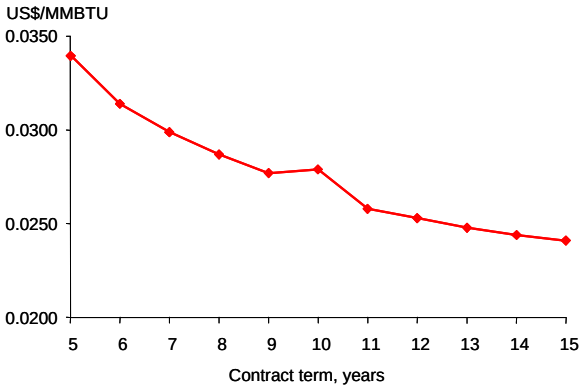

Figure 2 – Transportation Rate

RISK SIMULATION

For simulation we used the same spreadsheet adopted for the transportation rate calculation associated with @risk 4.0 which performs Monte Carlo simulation, sampling all the uncertainties modeled with each respective statistic distribution.

By keeping transportation rate as defined previously we can see the effect of Monte Carlo simulation on project IRR and NPV and therefore compare their distribution and risk exposure for the two alternatives.

IRR and NPV statistic distribution can be seen on figures 3 and 4 below that allows us to compare the two alternatives considered for the project – to implement the project by Trasn Co. or contract the compression service from the Service Co.

Risk Comparative Analysis

As we can see from the results comparison presented in **figure 3** the alternative of Service Contract is the one who presents the lowest risk or the lowest volatility for IRR and NPV, for years 5, 10 and 15.

		IRR %			NPV US$ x 10⁶		
		(2 x σ)	(σ)	Mean	(2 x σ)	(σ)	Mean
Probability (*)		0.025	0.16	0.5	0.025	0.16	0.5
Service Contract	5 y	11.38	13.07	14.76	-3.230	-1.720	-0.209
	10 y	11.16	12.93	14.70	-4.641	-2.480	-0.319
	15 y	10.18	12.34	14.50	-6.588	-3.582	-0.577
Asset Property	5 y	9.08	11.75	14.42	-5.335	-2.258	-0.582
	10 y	7.28	10.75	14.22	-9.736	-5.393	-1.050
	15 y	8.15	11.36	14.57	-20.370	-11.507	-2.644

(*) Probabilities of achieving values below the ones indicated in the tables for IRR and NPV.

Figure 3 – Risk Comparison Table

Holding asset property by Trans Co. presented the lowest return rate for year 10 and the lowest NPV for year 15.

If Service Co. is risk avert the action would be to increase project return rate of to mitigate uncertainties.

Sensitivity Analysis

By running the sensitivity analysis we can see how the variation of one standard deviation of one uncertain variable will affect the objective function (IRR or NPV) and therefore we will visualize which of them worth concentrating additional effort to mitigate its influence on the total risk of the project. The tornado graphic type presents a regression for each uncertain variable and quantifies its influence as shown on **figure 4** for Compression Service with 15 year contract term.

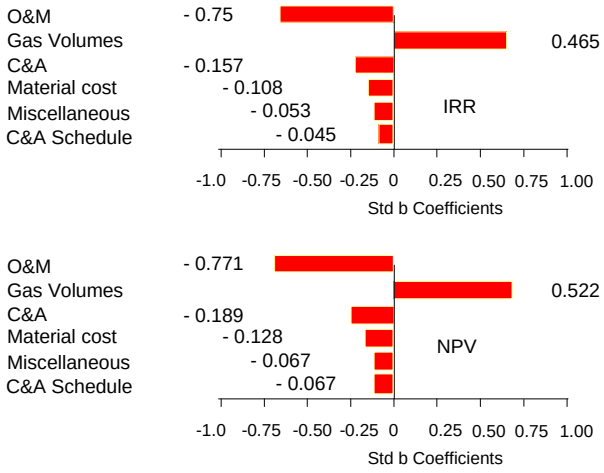

Figure 4 – Compression Service, 15 years contract term

CONCLUSIONS

The feasibility analysis presented in this paper considered two alternatives of having a compressor station installed – one from a Service Contract and the other as Having Property of the Compressor Station Asset. It has been shown that even if all the basic values for equipment cost, C&A schedule and costs, O&M costs and other costs are kept constant for both approach and by only applying uncertainties and their statistical distributions since they vary for Service Co and Trans Co because of their skills, experience and specialization, we can quantify risk and make good quality decision.

In this case study the alternative of Service Contract is the one that presented the lowest risk.

By using Monte Carlo risk simulation analysis as a decision support while selecting projects opportunities the decision maker will have a comprehensive understanding of the uncertainties that play a vital hole on risk exposure. Based on the simulation results he will be able to define the necessary actions to mitigate the risk exposure level due to some uncertainties that must be better defined and will also be able to quantify risk on a more realistic way and therefore select the opportunity that performs better and that will more probably safeguard the economic results for the company shareholders.

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