The Impact of Technical Performance and Debt Structuring on Independent Power Project Viability

by

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Abstract

This article builds a financial model for estimating the net present value of an Independent Power Project (IPP) based on specific Power Purchase Agreement (PPA) contractual conditions. Partial derivatives with respect to the Plant Load Factor (PLF), the benchmark heat rate, and the debt maturity are established. These partial derivatives provide an understanding of the sensitivity of the project viability to technical performance and debt maturity. Partial derivatives are also provided for the sensitivity of consumer gains to the above factors. Both these sets of partial derivatives provide an enhanced understanding of contractual conditions. A numerical illustration demonstrates that lengthening debt maturity can add considerable value to equity holders.

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1. Introduction

In the recent past, Independent Power Projects (IPP) in India have signed (or attempted to sign) Power Purchase Agreements (PPA) with buyers of power, usually the State Electricity Boards. PPAs, both finalized and under discussion, have come in a range of flavors. This paper examines the implications for IPP viability of the most popular flavor. It concludes that potential gains from ex-post superior technical performance are easily matched by gains from ex-ante financial structuring. However, the latter gains do not preclude the former; and the paper's contribution is to provide analysis and numbers that enhance a potential buyer's understanding of IPP viability.

The paper is organized as follows. A financial model is built in section 2 that relates project viability to assumptions about the IPP and the PPA. In section 3, the sensitivities of project viability to technical parameters and debt maturity are established. Section 4 computes sensitivities of customer gains to technical parameters and debt maturity. Section 5 provides a numerical illustration. Section 6 concludes the paper.

This paper is a follow-up and a generalization of an earlier paper [Srinivasan 1999] that used spreadsheet modelling.

2. IPP Financial Model

The PPA considered here has the following features.

2.1 The IPP contracts with the Buyer to establish a power project with a specified capacity. A central feature is a two-part tariff based on incentive regulation.

2.2 The first part of the tariff reimburses fixed 'costs'. These are agreed operating and maintenance (O&M), depreciation on agreed investment in fixed assets, interest on agreed debt, and an accounting return on initial equity for a benchmark plant load factor (PLF). Higher(lower) returns are provided for operating at a superior(inferior) PLF. In this paper it is assumed that the O&M agreed and actual are the same.

2.3 The second part reimburses fuel costs. This is based on fuel unit cost, fuel calorific value, and a benchmark heat rate. Any deviation from the benchmark heat rate is on the

IPP account. Thus, any savings are retained by the IPP. It is assumed that the unit fuel cost increases with inflation and that the reimbursement mechanism covers this increase. In this paper it is assumed that the fuel calorific value is constant.

The inputs required to compute the net present value (NPV) of the project are listed in table 1. The project is assumed to be completed in Year S-1 and generate power for T years from Year S onwards. Equity (E) and debt (D) are in Year 0 terms. The fuel unit cost (F_{CO}) is in Year 1 terms. There is no salvage value. Debt is assumed to be repaid in N years, from Year S onwards with no moratorium. The IPP is contractually permitted to work to up to 90% PLF without the Buyer's consent.

Taxes are assumed zero. This assumption is motivated by the existence of a 5-year tax holiday for all IPPs. Further, IPPs located in designated 'backward' areas receive partial tax protection for an additional five years. Typical PPAs also make income tax a 'pass-through' cost that is considered for tariff fixation.

The last column of table 1 contains numbers for a 50 MW naptha based combined cycle power project involving an investment of Rs. 1900 million. These are numbers that were valid around 1999. The one number that has changed significantly since then is the price of naptha which at Rs.15 per kg in December 2000 is roughly double the 1999 cost. These numbers will be used in section 5.

Table 1: IPP Viability Assumptions

	Item		Symbol	Value
1	Plant capacity	MW	C	50
2	Plant life	Years	T	7
3	Initial equity	Rs. million	E	570
4	Initial debt	Rs. million	D	1330
5	Cost of equity	%	k_e	16%
6	Debt maturity	Years	N	7
7	Annual straight line depreciation used for tariff setting	%	d	123.5
8	Plant-load factor: Benchmark	%	PLF_B	68.50%
9	Plant-load factor: Actual	%	PLF_A	
10	Heat rate: Benchmark	kcal/kWh	F_{HRB}	2000
11	Heat rate: Actual	kcal/kWh	F_{HRA}	
12	Fuel unit cost	Rs. per kg	F_{CO}	15
13	Fuel calorific value	kcal/kg	F_{CV}	10800
14	Accounting return on equity at benchmark PLF	%	R_e	16%
15	Equity incentive per 1% increase in PLF	%	R_{in}	0.65%
16	Inflation rate	%	i	6%
17	Cost of debt		kd	16%
18	Annual O&M cost: Year 1		O	38

Given assumptions 1 to 16 above, the NPV of the equity holders (which is also the NPV of the project) is given by:

$$[1]\ NPV_e = \frac{1}{(1+k_e)^{S-1}}[\{R_eE + d\} * PVA(k_e,T)$$
$$+ \{R_{in}E(PLF_A - PLF_B)\} * PVA(k_e,T) * 100$$
$$+ (F_{HRB} - F_{HRA}) * \frac{F_{CO}}{F_{CV}} * C * PLF_A * 365 * 24 * PVA(k_e,i,T)/10^3$$
$$- \frac{D}{N} * PVA(k_e,N)]$$
$$- PV(K_e,E,S-1)$$

where

$PVA(k_e,T) = \left\{\frac{1}{k_e} - \frac{1}{k_e(1+k_e)^T}\right\}$ is the present value of a level annuity for T years
$PVA(k_e,N) = \left\{\frac{1}{k_e} - \frac{1}{k_e(1+k_e)^N}\right\}$ is the present value of a level annuity for N years
$PVA(k_e,i,T) = \{\frac{1}{(k_e-\iota)}\} * \{1 - \frac{(1-\iota)^T}{(1-k_e)^T}\}$is the present value of a growing annuity for T years
$PV(k_e,E,S-1)$ is the present value of initial equity investment outflows up to Year S-1

Line 1 represents the present value of the gross cash flow stream (assured accounting return plus depreciation) to equity holders at the benchmark PLF level. Line 2 is the additional present value from increased PLF at the benchmark heat rate. Line 3 is the additional present value arising from fuel efficiency at the actual PLF level (the 10^3expression arises because C is in MW and amounts are in rupees million.) Line 4 is the present value of debt installments, that have to be serviced from the gross cash flows to the equity holders. Line 5 is the present value of the initial equity investment.

What is interesting are the items that do not figure in the equation. These are the pass-through interest cost that is assumed to be contracted ex-ante, and the O&M expenses that are assumed at contracted levels. These would affect the consumer tariff but not the equity holders' net present value.

The essence of the PPA is to make all stakeholders, other than the equity holders and consumers, 'fixed-payoff' claimants. This follows from the pass-through nature of costs associated with the goods and services provided by these stakeholders to the IPP. These costs are passed through to the consumer by the tariff mechanism. Therefore, an understanding of the consequences of a PPA can be obtained by focussing on the IPP (equity holders') viability and the tariff paid by the consumer. The 'flow to equity' [Taggart, 1991] method is relevant in understanding IPP viability. Sections 3 and 4 below focus on the equity holders and consumers, respectively.

3. IPP Viability-Sensitivity

At this stage, I will assume that the project is completed immediately and commences operations from Year 1 [i.e. S=1]. This does not detract from the results. Equation [1] becomes:

$$
\begin{aligned}
[2]\ NPV_e = {} & (R_eE + d) * PVA(k_e, T) \\
& + \{R_{in}E(PLF_A - PLF_B)\} * PVA(k_e, T) * 100 \\
& + (F_{HRB} - F_{HRA}) * \tfrac{F_{CO}}{F_{CV}} * C * PLF_A * 365 * 24 * PVA(k_e, i, T)/10^3 \\
& - \tfrac{D}{N} * PVA(k_e, N) - E
\end{aligned}
$$

The sensitivity of the net present value to equity holders is provided by the following partial derivatives.

$$[3]\quad \frac{\partial NPV_e}{\partial PLF_A} = R_{in}E * PVA(k_e, T) + (F_{HRB} - F_{HRA}) * \frac{F_{CO}}{F_{CV}} * C * 365 * 24 * PVA(k_e, i, T)/10^5$$

$$[4]\quad \frac{\partial NPV_e}{\partial F_{HRA}} = -\frac{F_{CO}}{F_{CV}} * C * PLF_A * 365 * 24 * PVA(k_e, i, T)/10^3$$

$$[5]\quad \frac{\partial NPV_e}{\partial N} = \frac{D}{k_e * N} * \left\{\frac{1}{N} - \frac{1}{N*(1+k_e)^N} - \frac{\ln(1+k_e)}{(1+k_e)^N}\right\}$$

Section 5 uses numbers to help comprehend the relative importance of these sensitivities.

4. Consumer Cost and Gains-Sensitivity

One way of measuring the impact of base case assumptions about the IPP and the PPA on consumers, is to compute the levellised tariff. A levellised tariff is an application of the equivalent annual cost concept. The actual tariff stream is replaced by a level tariff over the life of the project that has the same present value as the actual tariff stream. Changes from the base case can be assessed either by changes in the levellised tariff or by changes in consumer gains. I propose to compute the latter since it yields a number that can be compared with NPV_e. I also intend to cheat a bit and assume that the appropriate rate of discount for consumers is the cost of equity k_e. No I have not run out of symbols, my intentions are honorable and are to make zero-sum games look like zero-sum games.

Apart from the appropriate discount rate, assumptions 17 and 18 in table 1 above are required to compute the levellised tariff. Additionally, it is assumed that auxiliary

Apart from the appropriate discount rate, assumptions 17 and 18 in table 1 above are required to compute the levellised tariff. Additionally, it is assumed that auxiliary consumption is zero, i.e. gross and net generation are equal. I also ignore all transmission and distribution costs, and indirect taxes.

[6] $PV_{revenues} = [\{R_e * E\} + \{R_m * E * (PLF_A - PLF_b) * 100\} + d] * PVA(k_e, T)$
$+O * PVA(k_e, i, T)$
$+ [F_{HRB} * \frac{F_{CO}}{F_{cv}} * C * PLF_A * 365 * 24/1000] * PVA(k_e, i, T)$
$+ [k_{db} * D * PVA(k_e, N) - \frac{1}{(1+k_e)^N} * \frac{D}{(N*k_e)} * \{\frac{(1+k_e)^N - 1}{k_e} - N\}]$

Gross generation is given by:

[7] $G = C * PLF_A * 365 * 24/1000$

Therefore the present value of a unit stream (i.e. 1 kWh of power purchased annually over the life of the project) is:

[8] $PV_{tariff} = \frac{PV_{revenues}}{G}$

The sensitivity of this present value to the plant load factor is:

[9] $\frac{\partial PV_{tariff}}{\partial PLF_A} = -\frac{1}{C*PLF_A^2 365*24/1000} * [\{R_e * E - R_m * E * PLF_B * 100 + d\} * PVA(k_e, T)$
$+\{O * PVA(k_e, i, T)\}]$

$-\frac{1}{C*PLF_A^2 365*24/1000} * [k_{db} * D * PVA(k_e, N) - \frac{1}{(1+k_e)^N} * \frac{D}{(N*k_e)} * \{\frac{(1+k_e)^N - 1}{k_e} - N\}]$

The gains to consumers for a change in plant load factor ΔPLF_A is given by equation 10.

[10] Gain to consumers $= \Delta PV_{tariff} * G + \frac{1}{2} \Delta PV_{tariff} * \Delta G$

The sensitivity of the present value of the unit stream to the heat rate is zero. This follows since the contract is based on the base or "notional" heat rate, and the equity holders retain all gains.

The gains to consumers for a change in debt maturity N is derived from the following:

[12] $\frac{\partial PV_{tariff}}{\partial N} = -\frac{\partial NPV_e}{\partial N}$

This follows because of the assumptions that consumers and equity-holders having the same discount rate, k_e.; and that interest rate on debt, k_d is unchanged with maturity. This is a strict zero-sum game with wealth transferred from consumers to equity-holders as debt maturity is increased. Consumers will be burdened additionally if the interest rate on debt increases with maturity.

5. Illustration

Table 1 provides numbers for a hypothetical 50 MW naphtha-based combined cycle power project. The plant involves an investment of Rs. 1900 million. Base case assumptions are actual and benchmark PLF of 68.50%, actual and benchmark heat rates of 2000 kcal/kWh, debt repayment over seven years.
With these numbers, the sensitivities of the present value to changes of PLF, heat rate, and debt maturity are as follows. (The file ippsupptable.xls contains all calculations).

$$\frac{\partial NPV_e}{\partial PLF_A} = 20.66$$

$$\frac{\partial NPV_e}{\partial F_{HRA}} = 3.09$$

$$\frac{\partial NPV_e}{\partial N} = 43.22$$

In terms of discrete consequences a 1% increase in PLF (from the benchmark of 68.50% to 69.50%) adds Rs. 20.66 million to the base case NPV. This is 3.62% of the invested equity.

With the PLF at the base case level of 68.50%, an improvement in the heat rate of 10 kcals/kWh (from the benchmark heat rate of 2000 kcals/kWh to 1990 kcals/kWh) adds Rs. 30.90 million. This is 5.42% of the invested equity.)

With both PLF and the heat rate at their benchmark levels, an increase in debt maturity to eight years from the base case of seven years adds Rs. 45.21 million to the NPV (7.93% of the invested equity.)

A second way of looking at these numbers is that the gains from stretching repayment by an extra year can be obtained either by increasing actual PLF by 2.19% or by increasing efficiency (reducing the heat rate) by about 15 kcal/kWh.

Thus equity holders can gain by either technical efficiency or by ex-ante negotiation of longer maturity debt, with the Buyer's concurrence.

Does the increase in debt maturity increase risk to equity holders? Given the tariff structure that treats interest as a pass-through cost, the possible availability of a counter-guarantee (that might even be a sovereign guarantee),and the possibility of credit-rating enhancement mechanisms such as an escrow facility; I am not very sure that risk is increased. Formally, if the interest rate on debt is increased by a lender because of a perception of increased risk, and any such increase is agreed to ex-ante and built into the tariff structure; the formulation and numbers above remain unchanged - remember the interest on debt does not figure in the NPV computation. Obviously, consumers will pay a higher tariff, this is computed below.

In the base case the consumers pay a levellised tariff of Rs. 4.91 per kWh (US $ 105 per Mega-Watt hour at an exchange rate of 1 US$ =Rs. 47.00). This may seem a happy number from a Californian point of view, but not from the average tariff paying Indian who would pay about half this price. This actual price covers, not only generation costs, but also transmission & distribution costs and indirect taxes.

If the PLF is increased by 1% to 69.50%, consumers gain Rs. 9.08 million. With R_{in} at 0.65 consumers, therefore, get 30.5% and equity-holders 69.5% of gains from increasing the plant load factor. The gain translates into a levellised tariff reduction of Rs. 0.0065 per kWh. The consumer gain increases to 50% if R_{in} is reduced to 0.47. (Recent PPAs R_{in}= 0.50 clause).

If debt maturity is increased from seven to eight years, the consumers as a group effectively pay the Rs. 45.21 million gained by the equity holders. This assumes that lenders do not increase the interest rate. The levellised tariff increases by Rs. 0.027 per kWh over the base case.

If lenders increase the interest rate by 1% per annum then the consumers pay Rs. 83.20 million. Then equity holders receive Rs. 45.21 million and the lenders receive the balance. The levellised tariff increases by Rs. 0.05 per kWh over the base case.

6. Conclusion

As stated at the outset, technical parameters and debt maturity can make significant differences to IPP viability and consumer costs. An IPP that works at 75% PLF and a heat rate of 1950 kcal/kWh would make an NPV of Rs. 163 million. These are reasonable levels of operation. The consumer would pay a levellised tariff of Rs. 4.88 per kWh. If debt is negotiated ex-ante with a 14 year repayment schedule at 20%, the IPP makes an NPV of Rs. 411 million and the consumers pay a levellised tariff of Rs. 5.13 per kWh.

The implications for policy makers are two fold. The first is to get benchmark values of PLF and heat rate right or reasonably right. This can make significant difference to consumers and the IPP. Srinivasan [1999] offers a menu for benchmark setting. The second is to be careful about accepting longer maturity debt. Debt maturities should be consistent with debt service coverage requirements and institutional practices.

An issue left unaddressed is the impact of leverage. Given that higher debt levels will also alter the revenue levels (since higher interest amounts will be built into the tariff), the application of text book formula for costs of equity seems inappropriate. The empirical evidence from Brigham et al. [1997] does not address the specific nature of PPAs that this article has focussed on.

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