Wind and Conventional Electricity - Comparative Economics for Captive Power Plants and Thermal Power Stations

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Abstract

The paper compares total cost of wind electricity generation with costs of conventional electricity generation in India, using fossil fuels like coal (including co-generation), fuel oils and natural gas, both in terms of year-to-year unit costs of electricity and also total cost of ownership. Cost comparisons of wind electricity have been made for Captive Power Plants for industrial and commercial users, as well as for large scale Thermal Power Stations of Electricity Supply Companies. Though information and numbers used largely relate to Indian context, the findings are equally applicable in global perspective.

The comparison is based on relevant real life information, such as:

- Real life data on capital costs, operating costs, project life, efficiencies and other relevant data for various electricity generation options, and wheeling options for wind energy in India.
- Appropriate scales of operation as applicable to medium size industrial/ commercial consumers, such as 15 MW capacity wind farm

As per the conclusions reached, wind energy works out as the cheapest option in terms of total cost of ownership, and for most options even on year to year basis. However, costs of electricity generation of large scale thermal power stations using coal and natural gas as fuels are comparatively much lower than that of a wind farm. Government policy thrust for renewable energy, together with Renewable Power Purchase Obligations (RPOs) on utility companies and possible continuation of CDM beyond 2012 could expand tremendous scope for wind energy, leading to its sizable share in real terms in the total power scenario in India and globally.

The author hopes that the paper would be of value for promoting wind energy in general, and would be of particular interest to global wind turbine manufacturers, electricity consumers, electricity companies and policy makers in India and other countries.

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1. Why Wind Energy Project

Globally it has now been well recognized that wind energy is probably the most potential source of electricity among all renewable energy sources. Main strengths of wind energy projects are: (a) enormous wind energy potential across the globe, (b) protection against inflation or escalation in electricity generation cost over the project life, (c) ease of putting up a wind farm, (d) low operations and maintenance requirements, (e) scalability, (f) short gestation period and others. Now, wind electricity can be a viable source not only to supplement conventional electricity from fossil fuels but also to compete with it in many situations. Most wind electricity projects have one or more of following objectives:

i) For industrial and other electricity users, setting up a wind farm can be predominantly for captive use, with pragmatic renewable/ wind energy policies of central and state governments and wheeling facilities available under them.

ii) Financial investor can put up a wind energy project primarily as an investment proposition to supply electricity to the local power utilities at a predetermined rate fixed under wind energy policy of the state duly approved by State Electricity Regulatory Commission.

iii) Financial investor can also put up a wind energy project primarily for third party sale and trade in electricity markets now being opened up across the country, now permitted by various state governments, with implementation of Electricity Act 2003 and active role being played by Power Trading Corporation and other similar agencies.

iv) With Renewable Power Purchase Obligation up to 10% imposed on public sector and private sector electricity utility companies, many of them have been actively pursuing wind energy projects as an investment option.

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2. Competing Choices for Wind Energy Project

Now wind energy projects have come of age. There are competing choices available for putting up a wind energy project. Selection of appropriate choice for wind farm project has direct bearing on financial performance and relative economics of electricity generated from the wind farm. Various competing choices arise, as illustrated below:

i) Competing wind farm sites, with diverse range of wind energy potential in different states and at different locations within a given state;

ii) Competing wind energy policies of different states, differing in terms of electricity purchase prices, wheeling charges, banking facilities, evacuation infrastructure, land purchase/ leasing options, renewable power purchase obligations and others;

iii) Competing electricity markets and opportunities for third party sale and power trading coming up in different states, with varying electricity tariffs and demand-supply gap (overall and peak demand);

iv) Competing Wind Turbine Generator (WTG) technologies/ designs and capacities/ sizes available from different manufacturers;

v) Competing overall project proposals available to investors from wind farm developers including WTG manufacturers/ suppliers from India and abroad.

3. Recent Trends Affecting Wind Energy Projects

Recent trends affecting wind energy projects include:

a) Increasing costs of fossil fuels, increasing variable cost of electricity generation day by day;

b) Technological advancements in wind turbine technology in terms of increasing rotor diameters, hub heights, blade design, gearless technology, micro-processor based local and centralized controls and others, resulting into multi-megawatt capacity wind turbine units;

c) Relatively stable capital costs as well as operations and maintenance costs for wind farms over the years;

d) Diminishing role of state subsidies/ incentives;

e) Introduction of power sector reforms and development of electricity markets; Electricity Act 2003 and Regulations framed under it.

f) Availability of clean development mechanism (CDM) credits by way of Certified Emission Reductions (CERs) and Renewable Energy Certificates (RECs) for 'clean' electricity generation from wind energy; and as a result,

g) Narrowing gap between the costs of generation of conventional electricity and wind electricity.

4. Comparative Fuel Costs in India

For consumer level Captive Power Plants as well as utility scale Thermal Power Stations, important fuels in use are: (a) Solid fuels – coal indigenous/ imported and lignite; (b) Natural Gas including LNG; and (c) Liquid petroleum fuels such as furnace oil, diesel, naphtha, etc.

Crude prices witnessed wild fluctuations during 2008, with world crude prices touching high of US $145 per barrel for WTI crude in June 2008, coming down under US $30 per barrel by December 2008, and average for the year 2008 was US $99 per barrel. With administered price mechanism for petroleum fuels in India, fluctuations in Indian prices of petroleum products were not so much wild. Crude oil price forecast for 2009 varies from analyst to analyst, averaging between US $50 to US $60 per barrel for the year 2009. Presently, average crude prices of Indian basket are comparable to international crude prices. Current international prices of crude are in the vicinity of US $60 per barrel. This appears to be a reasonable current level to prevail during coming months.

Table A: Typical Prevailing Prices of Fossil Fuels in India (May 2009)

Sr.	*Fuel*	*Source*	*Net HV kCal.*	*Unit*	*Landed Cost Rs.*	*Rs./ MMkCal*	*US $/ MMBTU*
1	Furnace oil	PSU	10,400	kg	22.00	2107.28	11.09
2	Natural Gas	Open Market	9,000	SCM	9.41	1045.44	5.50
3	LPG	PSU	10,900	kg	26.00	2385.32	12.55
4	Coal	Indian	5,200	kg	3.30	634.62	3.34
5	Coal	Imported	6,200	kg	3.90	629.03	3.31
6	Lignite	Indian	3,500	kg	2.15	614.29	3.23

Based on current price scenario of crude prices, average prevailing prices of petroleum and other fuels are indicated in the above table. (Exchange Rate: 1 US $ = INR 48.00)

It may be observed from the above table that prices of various solid fuels, when compared to their heating value are quite comparable. In further analysis, we shall therefore consider three major fuels, namely, coal, natural gas and furnace oil only.

5. Typical Wind Farm as an Alternative to Power Plants

For comparison with captive power plants as well as utility scale power plants, modular wind farm capacities of 15 MW and its multiples are considered. Typical equipment and project parameters as well as operational and efficiency parameters of the wind farm are given below:

If wind farm option is considered for the same captive power requirement of 30 million kWh per annum (WTG availability 97%, Grid availability 96%, i.e. uptime of 8,157 hours p.a., transformer and transmission losses up to metering 3.5%within the wind farm net after wind farm transmission losses and wheeling charges), wind farm project would need installed capacity of 15 MW.

Nominal Wind Farm Capacity:	15.0 MW and multiples thereof (Wind farm)
WTG Model Considered:	1500 kW rating of a leading Indian make (10 sets)
WTG Configuration:	Rotor Diameter 82 m, Hub Height 80 m, Tower Type Tubular.
Investment:	INR 975 million (US $ 20.31 million) (Exchange Rate: 1 US $ = INR 48.00)
Average PLF:	27.3% at 100% availability at WTG Controller
Electrical Losses:	3% (Transformer and transmission losses within wind farm)
Site Related Losses:	7% (Roughness of the site and Array Losses)
Gross Electricity Generation:	35.872 million kWh p.a.
Net Electricity Generation:	30.06 million kWh p.a. (after losses, subject to wheeling charge)
	Approx. 2 million kWh per MW p.a.

Break-up of Investment in the Typical Wind Farm in Indian context is given below, as an illustration:

Table B: Capital Investment in Typical Wind Farm (15 MW)

Sr	*Item*	*INR Millions*	*US $ Millions*
1	Land and Related Expenses	15.0	0.31
2	Wind Turbine Generators	765.0	15.94
3	Associated Electricals	40.0	0.83
4	CMCS	5.0	0.10
5	Foundations and Civil Works	40.0	0.83
6	Erection, Testing & Commissioning	20.0	0.42
7	Power Evacuation Facilities	45.0	0.94
	Sub-total	*930.0*	*19.37*
8	Project Engg. and Consultancy	5.0	0.10
9	Prelim.& Pre-Op. @ 1% approx.	10.0	0.21
10	Contingency @ 3.0% approx.	30.0	0.63
	Total Project Cost	*975.0*	*20.31*

6. Alternative Scenarios for Wind Energy Projects

Grid connected wind farms are no longer confined to industrial or institutional consumers, but they are viewed strategically as a major source of electricity even by utility companies in the emerging competitive scenario.

In this context, this paper attempts to review present status of comparative economics of electricity generation using wind and conventional sources of energy. This paper analyses three scenarios:

Scenario I – 'Wind Electricity for Captive Use': Industrial and commercial organizations, willing to consider grid-connected wind farm for captive power requirement, with a view to benefit from low cost of wind electricity and hedge against inflation;

Scenario II – 'Utility Company Putting up Wind Farm': The utility company itself puts up an investment for supplementing electricity generation and also trying to meet Renewable Power Purchase Obligation by self generating wind power, rather than buying from others.

Scenario III – 'Wind Electricity for Sale': Investor desirous of putting wind farm for sale of electricity to a utility company at price available as per wind power policy of the state, where the wind farm is located or to a third party;

In this analysis, for comparison with wind energy, conventional sources of electrical energy (fossil fuels) considered are (a) Coal, (b) Natural Gas, and (c) Fuel Oil, as conventional sources of electrical energy.

7. Methodology and Criteria for Comparison of Alternate Sources of Electricity

Comparative Economics in terms of cost of electricity generation for Captive Power Plants as well as Thermal Power Plants are worked out for different options of conventional sources as well as wind energy. Cost of purchased electricity from the state grid is also compared with electricity costs for different options based on conventional fuels and wind energy. (Gujarat state taken in this illustration).

Two sets of criteria are followed separately:

(i) Unit cost of electricity generation for each option, with annual projections for entire life of the project; and

(ii) Total cost of ownership and use of electricity over life of the project.

Total cost of electricity comprises of following components:

a) Investment component: This is expressed in the form of net annualized cost over 20-years life of the project in all cases. This is based on present value method. Present values of cash-inflows of tax-shield amounts on depreciation charged over the project life are collectively taken as a credit against the present value of investment outflow. Annualized equated cost of such net investment value is also arrived at by using appropriate capital recovery factor based on present value method. In the working presented Debt : Equity Ratio is assumed as 70:30, pre-tax cost of debt as 10% p.a., post-tax cost of equity as 20% p.a., effective income-tax rate as 33.66% and resultant cost of capital (and present value factor) as 10.64% (post-tax).

b) Fuel cost component: Unit landed costs of various alternative fuels and their heating values are mentioned in paragraph 4 under Table A. These form the basis of fuel costs per kWh of electricity. Price escalation rate of 5% p.a. is assumed for various fuels.

c) Operating cost component: This includes costs of operations and maintenance, spares, insurance of plant, machinery and fuel stocks, working capital interest and other related administrative costs. Escalation @5% p.a. is considered for all the costs. In case of electricity from the state grid, for industrial or commercial consumer, fixed contract demand charges for appropriate contracted load can be taken in place of operating costs of power generation plants. These charges are fixed commitment charges and payable irrespective of quantum of electricity consumed.

d) Electricity Duty: Captive power generation attracts electricity duty for conventional sources of electricity, as indicated. This is included as a variable cost component.

Total Unit Cost of Electricity Generation

Total unit cost of electricity for all the five alternatives (3 conventional captive power options, 1 for electricity from the state grid and 1 from wind power) are worked out over 20 years life of the project. They are summarized in the following pages in Table C for Captive Power Plants and Table E for Thermal Power Plants. Total costs over 20 years project life are also graphically presented in Chart A and Chart B respectively. Charts A and B also have annual cost projections for various alternatives over 20 years life of each of the plants.

Total Cost of Ownership over the Project Life

Based on total unit cost of electricity for all the alternatives as stated before, total cost of ownership over the life of the project is also worked out for each alternative. To make varying annual cash outflows (annual costs of ownership) comparable, present values are computed over the life of the project. Thus present value of total cost of ownership of the project, including fuel and operating costs, has been arrived at for each option for realistic economic comparison and true ranking. They are summarized in the Table D and F for Captive Power Plants and Thermal Power Plants respectively.

In subsequent paragraphs workings, analysis and conclusions for various alternatives are discussed.

8. Scenario I – 'Wind Electricity for Captive Use'

Basis for captive power plant capacity is generation of required quantum of electricity of 30 million kWh per annum (8242 hours p.a.). Apart from buying electricity from a utility company, following technology options of captive power plant are considered, using conventional sources of energy:

a) Coal/ solid fuel based steam turbine co-gen. (with steam as an acceptable co-product)

Nominal Capacity: 5.6 MW turbine
Model Considered: Generic

Investment INR: 315 million (US $ 6.56 million)
Average PLF: 67%

b) Natural gas based gas engine sets with waste heat recovery

Nominal Capacity: 5.0 MW
Model Considered: 1000 kW Deutz (5 sets)
Investment INR: 180 million (US $ 3.75 million)
Average PLF: 75%

c) Fuel oil based engine sets with waste heat recovery

Nominal Capacity: 6.0 MW
Model Considered: 1500 kW Man-B&W (4 sets)
Investment INR: 225 million (US $ 4.69 million)
Average PLF: 62%

Total Unit Cost of Electricity Generation

From Table C and Chart A, it is evident that though in the initial 2 to 3 years, cost of electricity generation using co-gen steam turbine with coal as a fuel and natural gas based gas engine sets work out marginally lower than total cost of wind energy, from the fourth year onwards, total cost of wind energy per kWh works out the lowest of all alternatives.

Even in the initial 2 to 3 years cost differential is so small that, if one takes into account likely CERs available under Clean Development Mechanism (CDM) and RECs likely to come into place shortly under RPO policy, wind electricity would work out cheapest alternative from the first year itself.

Total Cost of Ownership over the Project Life

Present value of Total Cost of Ownership over project life of 20 years has been worked out for various alternatives at discount rate of 10.64% (post-tax), which is equal to cost of capital for the assumed capital structure and financing costs. Total cost of ownership is expressed in Rupees Millions for every one million kWh of electricity generation annually over 20 years of project life.

Present Value of Total Cost of Ownership per MMkWh p.a. – Captive Power Plants

Energy Source	Rs. Millns.	US$ Millns.	Index	Rank
Grid-GUVNL@	61.532	1.282	150	**4**
Wind	41.065	0.856	100	**1**
Coal (Cogen)	49.018	1.021	119	**2**
Natural Gas	49.971	1.041	122	**3**
Fuel Oil	69.375	1.445	169	**5**

@ Selling Price (total cost including taxes and duties) to a typical HT Consumer

As every one would expect, with rising prices of fossil fuels and fixed one-time investment costs of wind farms (even though at significantly higher level than conventional methods of power generation), wind energy tops the list with the lowest total cost of ownership.

9. Scenario II – 'Utility Company Putting up a Wind Farm'

Here we are attempting to analyse comparative economics of wind farms vis-à-vis Thermal Power Plants of capacity of the order of 500 MW, using different fuel options, namely Coal, Natural Gas and Fuel Oil. Necessary investment and cost data for this analysis have been obtained from secondary sources, such as Special Reports and publications of Central Electricity Authority, Ministry of Power, project disclosures by investors before SEBI, SERC and such statutory authorities as displayed on their sites for public information and other published sources.

a) Coal-based Thermal Power Station

Nominal Capacity: 500 MW turbine
Model Considered: Generic
Investment INR: Rs. 45 Million per MW or Total Rs. 22,500 million. (US $ 468.75 million)
Average PLF: 80%

b) Natural gas based Thermal Power Station

Nominal Capacity: 500 MW turbine
Model Considered: Generic

Investment: Rs. 30 Million per MW or Total Rs. 15,000 million. (US $ 312.5 million)
Average PLF: 80%

c) Fuel oil based Thermal Power Station

Nominal Capacity: 500 MW
Model Considered: Generic
Investment: Rs. 37 Million per MW or Total Rs. 18,500 million. (US $ 385.42 million)
Average PLF: 80%

Total Unit Cost of Electricity Generation

From Table D and Chart B, it is evident that Thermal Power Stations based on coal and natural gas continue to be very cost effective by a good margin, as compared to wind electricity. It is only after 15 years that cost of electricity from wind becomes cheaper that that from thermal power stations, due to 5% p.a. escalation in fuel costs. At US $5.50 per MMBTU price of natural gas, (Rs. 9.41 per SCM with 9000 kCal/ SCM heating value) gas-based thermal power stations generate cheapest electricity. Next in the raw are coal-based thermal power stations. Needless to say that Fuel Oil based thermal power stations are very expensive and not economical.

With Renewable Power Purchase Obligation stipulated on all electricity suppliers, utility companies would be required to buy renewable power from investors at market prices (by captive consumers) or at purchase prices stipulated in Wind Policies or other renewable energy related policies of Central/ State Governments.

Annual escalation in fuel prices and other costs is assumed at 5% in all above workings, however, if escalation rate is significantly higher, wind energy would become competitive earlier.

Total Cost of Ownership over the Project Life

Like previous scenario, here also, present value of Total Cost of Ownership over project life of 20 years has been worked out. Total cost of ownership also works out much lower for natural gas-based and coal-based thermal power stations as compared to wind energy.

Present Value of Total Cost of Ownership per MMkWh p.a. – Thermal Power Stations

Energy Source	Rs. Millns.	US$ Millns.	Index	Rank
Grid-GUVNL	61.532	1.282	150	**5**
Wind	41.065	0.856	100	**3**
Coal-based TPS	34.426	0.717	84	**2**
Gas-based TPS	32.449	0.676	79	**1**
FO-based TPS	60.243	1.255	147	**4**

@ Selling Price (total cost including taxes and duties) to a typical HT Consumer

10. Scenario III – 'Wind Electricity for Sale'

Cost of wind electricity has been worked out and presented in Tables C and D, as well as in Charts A and B respectively for 15 MW and 150 MW wind farms. Wind Farm being a modular design, the investment figure for 150 MW capacity wind farm in Table D is a simple multiple of that for a modular wind farm of capacity of 15 MW. Unit costs are same for both the capacities. For considering wind electricity for sale, following points may be noted:

i) Initial total cost of wind electricity at Rs. 4.77 per kWh is considerably higher than price of Rs. 3.50 per kWh offered by GUVNL and prices offered by most states in India. Even for a state like Tamil Nadu, where wind speeds and capacity factors for wind farms are considerably higher, and wind electricity cost is lower, sale of wind electricity to a state electricity board may not be viable, because unit rate offered for purchase of wind electricity is lower, commensurate with lower cost.

ii) Third party sale of wind electricity many a place attracts payment of cross subsidy, higher wheeling and transmission charges and applicability of electricity duty. Difference between high local tariff of electricity and wind energy cost in a state like Gujarat could become attractive, but for such tags attached on third party sale of wind electricity. Pragmatic approaches by state Governments and SERCs can only make tird party sale feasible for wind farms.

iii) Continuity of CDM beyond 2012 is uncertain. Prices of CERs sold in the international markets vary widely. Each country has their own mechanism for encouraging and enforcing renewable power. For Renewable Power Purchase Obligation (RPO) on electricity companies, suitable mechanism with rules and regulations for Renewable Energy Certificates (RECs) are yet to be devised in most states in India.

True picture of viability of investment for sale of wind electricity or any other renewable energy can emerge after such grey areas are reasonably cleared.

11. Conclusions

a. For captive consumption of electricity, wind electricity is probably the cheapest option. For immediate short term period of the next 2 to 3 years, apparently wind electricity may appear slightly more expensive than coal-based and naturag gas-based captive power plants, however, if one considers medium term horizon, together with benefits of CERs/ RECs, wind energy would turn out to be the cheapest source of captive electricity from the beginning. Total cost of ownership for wind farm is far lower than that of captive plants based on conventional fuels.

b. Large scale thermal power stations with coal or natural gas as fuel definitely have much lower costs of electricity than wind electricity. Future price trends of fossil fuels in coming years would determine better attractiveness of wind farms as compared to thermal power plants. It is only compulsory RPOs and compulsions of global warming, together with incentives for renewable energy options that could make renewable energy like wind energy acceptable even for large scale electrical utility companies. Probably such considerations together with whatever incentives and tax benefits presently available for wind energy are encouraging power generating companies like NHPC, NTPC and several others to venture into wind farms of large capacities.

c. No wonder, market may witness attractive rates for RECs for meeting RPOs in near future, yielding another stream of revenue from renewable energy and making it viable in more and more situations.

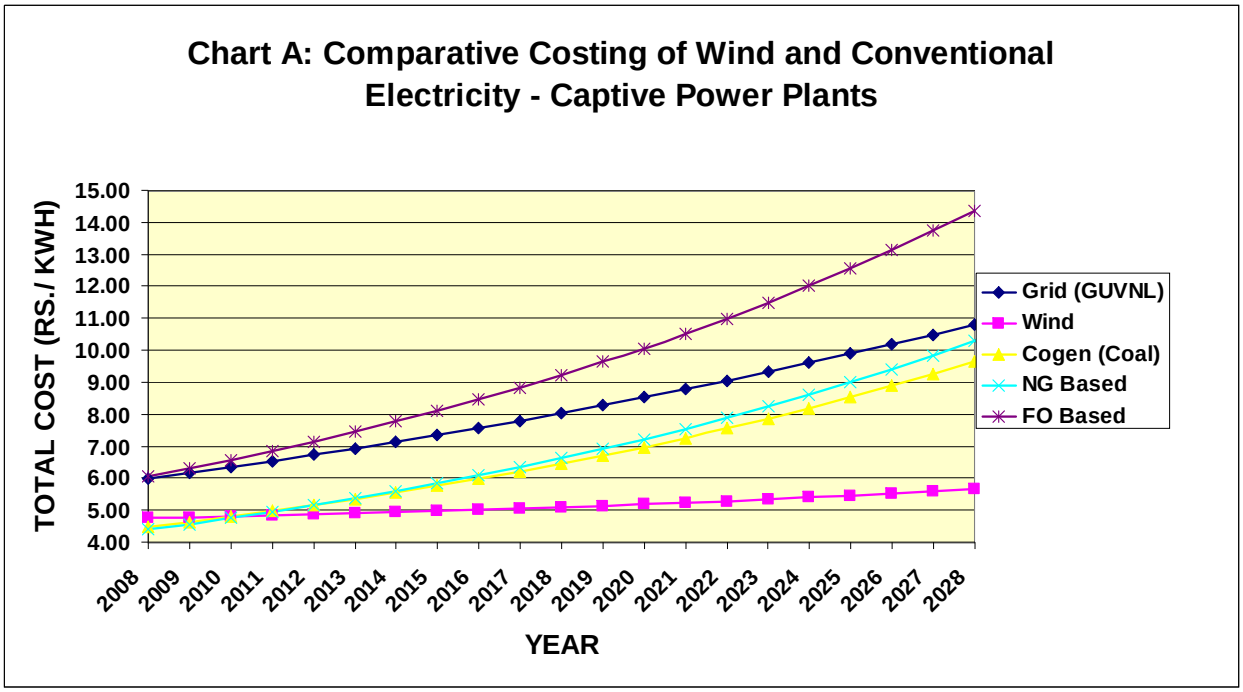
d. All said and done, there is absolutely no doubt that wind energy has a great growth potential in India and around the world.

Table C: Comparative Economics of Electricity from State DISCOM, Wind and Captive Power Plants

Sr.	*Particulars*	*Unit*	*Elect. Grid*	*Wind*	*Cogen (Coal)*	*NG Based*	*FO Based*
1	Nominal Capacity	MW	6 MVA	15 MW	5.6 MW	5.0 MW	6.0 MW
2	Model Considered		GUVNL	Indian	Generic	1000 kW Deutz	1500 kW Mann
3	P. L. F./ C. F. (100% Avail.)	%		27.3%	67.0%	75.0%	62.0%
4	Gross Power Gen. (100% Avail.)	Milln.kWh p.a.		35.872	32.850	32.850	32.850
5	Working Hours	Hrs. p.a.		8157	8000	8000	8000
6	Power Gen./ Elect. Credit (Net)	Milln.kWh p.a.	30.00	30.00	30.00	30.00	30.00
7	Investment	Rs. Millions		975	315	180	225
8	Annualised Cost of Investment	Rs. Milln.p.a.		126.75	40.94	25.43	31.79
9	Fuel Cost (Landed) per Unit	Rs.			3.30	10.50	22.00
	Fuel Unit				kg.	SCM	kg
10	Variable Cost (Fuel & ED)						
	a) Fuel Cost/ Energy Cost	Rs./ kWh	4.70	0.00	2.75	3.21	4.49
	b) Elect. Duty	Rs./ kWh	0.71	0.00	0.20	0.20	0.20
11	Operating Cost (Fixed)	Rs. Milln.p.a.	17.69	16.45	5.63	4.59	10.16
12	Escalation in costs	% p. a.	3%	5%	5%	5%	5%
13	Total Cost						
	Year 2008	Rs./ kWh	6.00	4.77	4.50	4.41	6.09
	Year 2013	Rs./ kWh	6.96	4.92	5.37	5.40	7.48
	Year 2018	Rs./ kWh	8.06	5.12	6.48	6.66	9.25
	Year 2023	Rs./ kWh	9.35	5.36	7.89	8.26	11.52
	Year 2028	Rs./ kWh	10.84	5.68	9.69	10.31	14.41

Table D: Comparative Economics of Electricity from Wind and Thermal Power Plants

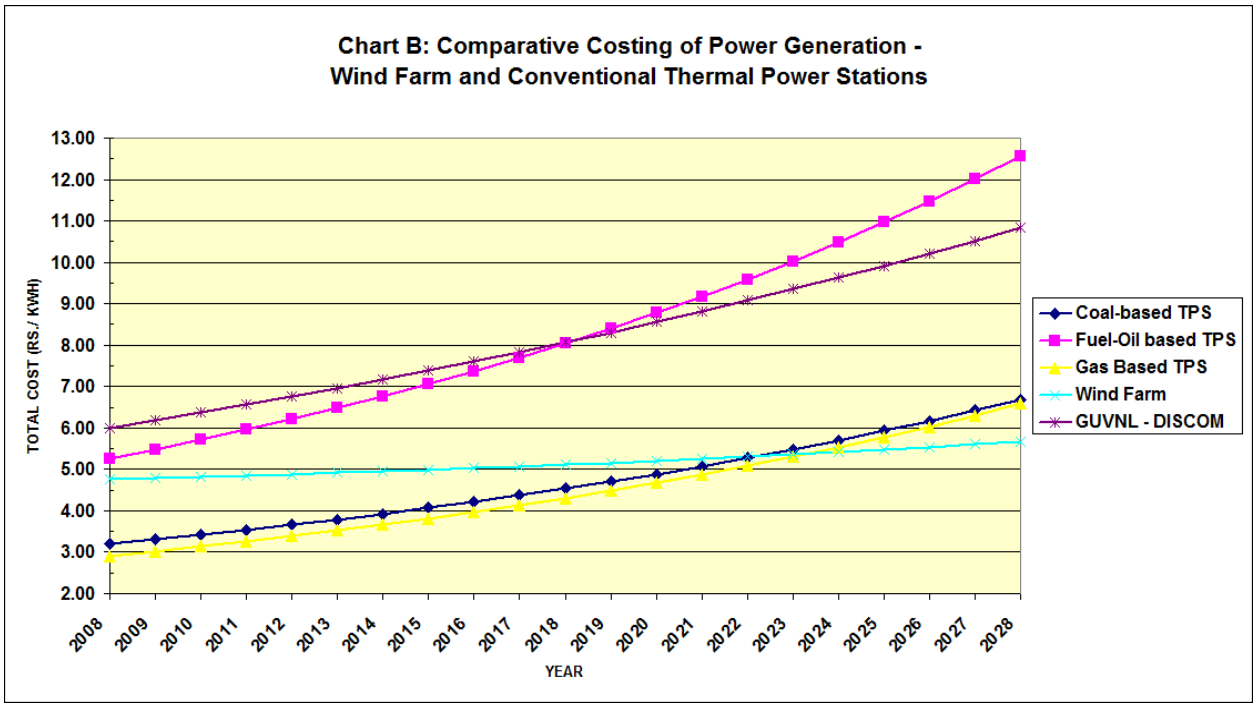
Sr.	Particulars	Unit	Coal Based TPS	F.O.Based TPS	Gas Based TPS	Wind Farm
A. Capacity and Investment Related Parameters						
i)	Typical Capacity	MW	500	500	500	150
ii)	Fixed Capital Cost	Rs. Miln./ MW	45	37	30	65
iii)	Fixed Capital Investment	Rs. Miln.	22500	18500	15000	9750
iv)	Net Working Capital	Rs. Miln.	2020	1620	1630	27
v)	Fixed Cap. Investt.	Rs./ MWh p.a.	7399	5706	4602	32431
B. Power Generation and Operating Efficiency Related			* Unit of SCM relates to Natural Gas.			
i)	PLF (Capacity Factor)	%	80%	80%	80%	27.3%
ii)	Uptime	Hrs./ Year	8400	8400	8400	8157
iii)	Total Electricity Generation	Million kWh	3040.8	3242.4	3259.2	300.6
iv)	Heat Rate	kCal/ kWh	2500	1900	1850	NA
v)	Aux. Power Consn. #	%	9.5%	3.5%	3.0%	10.00%
vi)	Fuel Calorific Value	kCal/ kg (SCM)*	5200	10440	9000	NA
vii)	Fuel Cost	Rs./ MT (Th. SCM)*	3300	22000	9409	NA
viii)	Fuel Cost	US $/ MMBTU	3.34	11.09	5.50	NA
ix)	Fuel Cost	Rs./ MMkCal	634.62	2107.28	1045.44	NA
x)	Fuel Cost per Elect. Unit	Rs./ kWh	1.75	4.15	1.99	NA
# For wind farm, figure of 10% relates to losses due to array/ roughness factors, transformer losses and internal transmission losses.						
C. Power Generation Costs						
i)	Fuel Cost	Rs. Millions p.a.	5330.77	13452.87	6498.46	0.00
ii)	O&M Cost	Rs. Millions p.a.	750.00	600.00	500.00	112.50
iii)	Insurance	Rs. Millions p.a.	67.50	55.50	45.00	48.75
iv)	Working Capital Interest	Rs. Millions p.a.	242.40	194.40	195.60	3.24
v)	Total Operating Costs	Rs. Millions p.a.	6390.67	14302.77	7239.06	164.49
		Rs./ kWh	2.10	4.41	2.22	0.55
vi)	Annualised Cost of Invstt.	Rs. Millions p.a.	3375.00	2775.00	2250.00	1267.50
		Rs./ kWh	1.11	0.86	0.69	4.22
vii)	Total Cost (Rs. Millions)	Rs. Millions p.a.	9765.67	17077.77	9489.06	1431.99
		Rs./ kWh	3.21	5.27	2.91	4.76
D. Unit Total Cost Projection Over Project Life (Rs./ kWh)						
i)	Year 2008	6.00	3.21	5.27	2.91	4.76
ii)	Year 2013	6.96	3.79	6.49	3.53	4.91
iii)	Year 2018	8.06	4.53	8.04	4.31	5.11
iv)	Year 2023	9.35	5.48	10.03	5.31	5.35
v)	Year 2028	10.84	6.69	12.56	6.58	5.67
Unit Cost Analy-sis	Fuel Cost	Rs./ kWh	1.75	4.15	1.99	0.00
	O&M Cost	Rs./ kWh	0.247	0.185	0.153	0.374
	Insurance	Rs./ kWh	0.022	0.017	0.014	0.162
	Working Capital Interest	Rs./ kWh	0.080	0.060	0.060	0.011
	Total Operating Costs	Rs./ kWh	2.102	4.411	2.221	0.547



Data Table for Chart-A

Figures are in Rs./ kWh

Year	Grid-GUVNL	Wind	Cogen (Coal)	NG Based	FO Based
2008	6.00	4.77	4.50	4.41	6.09
2009	6.18	4.80	4.66	4.59	6.34
2010	6.37	4.83	4.82	4.78	6.60
2011	6.56	4.86	5.00	4.98	6.88
2012	6.75	4.89	5.18	5.18	7.17
2013	6.96	4.92	5.37	5.40	7.48
2014	7.16	4.96	5.57	5.63	7.80
2015	7.38	5.00	5.78	5.87	8.14
2016	7.60	5.04	6.00	6.12	8.49
2017	7.83	5.08	6.23	6.38	8.86
2018	8.06	5.12	6.48	6.66	9.25
2019	8.30	5.16	6.73	6.95	9.66
2020	8.55	5.21	7.00	7.25	10.09
2021	8.81	5.26	7.28	7.57	10.54
2022	9.08	5.31	7.58	7.91	11.02
2023	9.35	5.36	7.89	8.26	11.52
2024	9.63	5.42	8.21	8.63	12.04
2025	9.92	5.48	8.56	9.02	12.59
2026	10.21	5.54	8.92	9.43	13.16
2027	10.52	5.61	9.29	9.86	13.77
2028	10.84	5.68	9.69	10.31	14.41



Data Table for Chart-B

Figures are in Rs./ kWh

Year	Grid-GUVNL	Wind Farm	Coal Based TPS	F.O. Based TPS	Gas Based TPS
2008	6.00	4.76	3.21	5.27	2.91
2009	6.18	4.79	3.32	5.49	3.02
2010	6.37	4.82	3.43	5.72	3.14
2011	6.56	4.85	3.54	5.96	3.26
2012	6.75	4.88	3.66	6.22	3.39
2013	6.96	4.91	3.79	6.49	3.53
2014	7.16	4.95	3.93	6.77	3.67
2015	7.38	4.99	4.07	7.06	3.82
2016	7.60	5.02	4.21	7.37	3.97
2017	7.83	5.06	4.37	7.70	4.14
2018	8.06	5.11	4.53	8.04	4.31
2019	8.31	5.15	4.70	8.40	4.49
2020	8.55	5.20	4.88	8.78	4.68
2021	8.81	5.25	5.07	9.17	4.88
2022	9.08	5.30	5.27	9.59	5.09
2023	9.35	5.35	5.48	10.03	5.31
2024	9.63	5.41	5.70	10.48	5.54
2025	9.92	5.47	5.93	10.97	5.78
2026	10.21	5.53	6.17	11.47	6.04
2027	10.52	5.60	6.42	12.00	6.30
2028	10.84	5.67	6.69	12.56	6.58