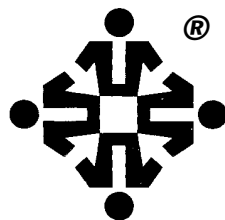


SYNERGY *with* ENERGY
Indian Energy Show 2009
5th *National Conference on*
Indian Energy Sector

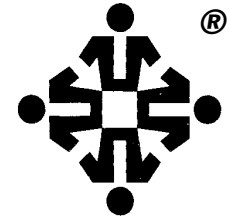
**Wind and Conventional Electricity-
Comparative Economics for Captive Power Plants
and Thermal Power Stations**

Bharat J. Mehta
Vijayant Consultants
Ahmedabad, India



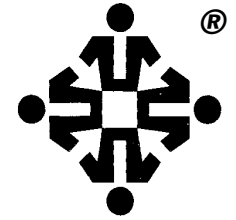
June 17, 2009

Wind and Conventional Electricity–Comparative Economics

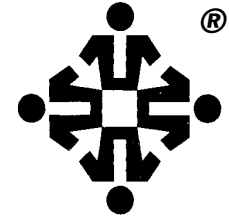


Flow of Presentation

- **Present Scenario – Opportunities, Recent Trends and Technological Advances**
- **Basic Economic Viability Model for Wind Farm**
- **Comparative Economics of Wind Electricity vs. Conventional Power – Three Scenarios**
- **Scenario I: Wind Farm vs. Captive Power Plants**
- **Scenario II: Wind Farm vs. Thermal Power Stations**
- **Scenario III: Wind Farm specifically for Sale of Electricity**
- **Conclusions**

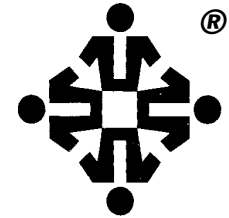


PRESENT SCENARIO



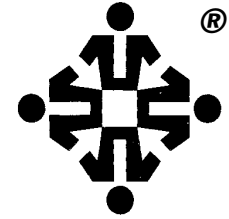
Present Scenario – Opportunities

- **Abundant Wind Energy Potential in India**
- **Installed Capacity of 10,000 MW of Wind Electricity in India**
- **Target for 10-12% Power Generation from Renewables**
- **Obligation on State Utilities for Min. Intake of upto 10% of Electricity from renewable energy sources, including wind energy**
- **Wind Energy is the Most Promising and Viable Source of Electricity Among Renewables**
- **Central and State Govt. Policies Are Generally Positive to Renewable in General and Wind in Particular**
- **Availability of Finance from Indian and Overseas Institutions and Investors**
- **Favourable Global Scenario in terms of Technology as well as Market Developments**
- **Implementation of Electricity Act 2003, National Electricity Policy, Open Access Regulations, Etc. at Central and State Levels**



Recent Trends in the Wind Energy Sector

- Increasing costs of fossil fuels, increasing variable cost of electrical energy day by day;
- Advancements in wind turbine technology
- Relatively stable capital costs and O & M Costs over the years;
- Diminishing role of state subsidies/ incentives;
- Introduction of power sector reforms and development of electricity markets;
- CER credits under CDM and REC Mechanism for meeting RPO requirements
- Narrowing gap between the costs of generation of conventional electricity and wind electricity.



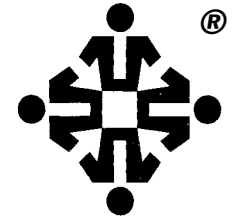
Technological Advancements

ON HARDWARE (WIND TURBINE GENERATOR) SIDE

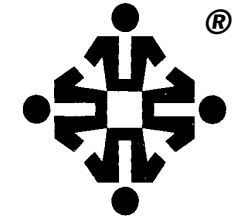
- Increasing rotor diameters
- Increasing hub heights
- Advances in blade design
- Gearless technology
- Micro-processor based local and centralized controls, and,
- Overall Result - Multi-megawatt capacity wind turbines.
- Development of wind turbines for off-shore installations

ON SOFTWARE SIDE

- Wind Profile Modeling using statistical techniques and software programs based on limited wind data and weather conditions
- Programs for wind energy potential at micro-level (Wind Farm and WTG)
- MIS for wind farms

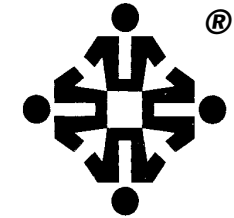


BASIC ECONOMIC VIABILITY MODEL FOR WIND FARM



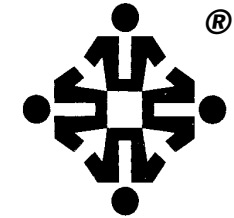
Capital Cost of 15 MW Wind Farm

Sr	Item	Rs. Milln.	US\$ Milln.
1	Land and Dev.	15.00	0.31
2	Wind Turbine Generators	765.00	15.94
3	Associated Electricals	40.00	0.83
4	CMCS	5.00	0.10
5	Foundations/ Civil Works	40.00	0.83
6	Erectn. Testing, Commissng.	20.00	0.42
7	Power Evacun. Facilities	45.00	0.94
	Sub-total	930.00	19.37
8	Project Engg.	5.00	0.10
9	Prelim. & Pre-Op.	10.00	0.21
10	Contingency	30.00	0.63
	Total Project Cost	975.00	20.31



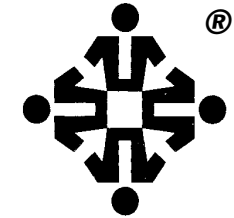
Basis of Economic Viability of Wind Farm

1	Installed Capacity (MW)	15
2	Project Cost (Rs. Milln.) (US\$ 20.31 Milln.)	975.00
3	Power Gen. (Milln.kWh p.a.)	30
4	Elect.Tariff-Var. Part (Rs./kWh) (US\$ 0.11/kWh)	5.41
5	O & M Exp. - 1st Yr. (Rs. Milln.) (US\$0.22Milln.)	10.45
6	Insurance Exp. (Rs. Milln.) (US\$ 0.13 Milln.)	6.00
7	Escaln. in Costs inclg. Ins. (% p.a.)	5%
8	Escaln. in Elect. Tariff (% p.a.)	3%
9	Deprecn. for wind farm eqpt.	80%
10	Amortsn. for P & P, etc.	10%
11	Rate of Income-tax	33.66%
12	Cost of Capital (Post-tax)% p.a.	10.64%
13	Disctg. Rate for PV Analysis % p.a.	10.64%
14	Project Life (Years)	20



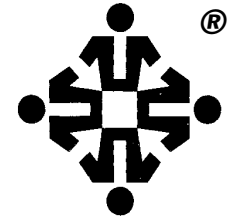
Summary Findings – Wind Vs. Electr. Grid

<i>Sr.</i>	<i>Particulars</i>	<i>Unit</i>	<i>Elect. Grid</i>	<i>Wind</i>
1	Capacity	MW	6.0	15.0
2	Investment	Rs. Millions	0.00	975.00
3	Annualsd. Cost of Invest.	Rs. Milln.p.a.	0.00	126.75
4	Var. Cost (Fuel & ED)			
	a) Elect./ Fuel Cost	Rs./ kWh	4.40	0.00
	b) Elect. Duty	Rs./ kWh	0.53	0.00
5	Operating Cost	Rs. Milln.p.a.	5.36	16.45
6	Escalation	% p. a.	3%	5%
7	Total Cost			
	Year 2008	Rs./ kWh	6.00	4.77
	Year 2013	Rs./ kWh	6.96	4.92
	Year 2018	Rs./ kWh	8.06	5.12
	Year 2023	Rs./ kWh	9.35	5.36
	Year 2028	Rs./ kWh	10.84	5.68

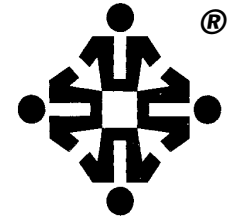


Investment Analysis Findings (15 MW Wind Farm)

Capital Investment (Rs. Milln.) (US\$ 21.3 milln.)			975.0
Debt : Equity Ratio			70:30
Cost of Debt			10% p.a.
Cost of Capital (Post-Tax)			10.64%
Simple Payback Period			6.2 Years
Discounted Payback			9.3 Years
Period	IRR (Post-Tax)	NPV (Rs. Milln.)	NPV as % Investment
10 Years	11.9%	46.5	4.8%
15 Years	15.1%	219.2	22.5%
20 Years	16.4%	338.0	34.7%

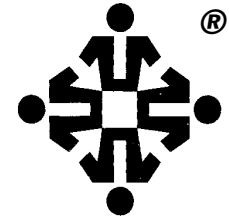


COMPARATIVE ECONOMICS – WIND ELECTRICITY VS. CONVENTIONAL ELECTRICITY



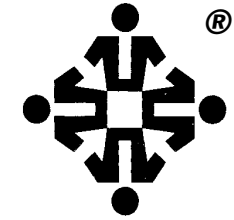
Comparison of Alternate Sources of Electricity – Methodology and Criteria

- **Comparative Economics in terms of cost of electricity generation worked out for different options of conventional sources (including purchase from state grid) and wind energy**
- **Criteria followed:**
 - **Unit cost of electricity generation for each option annually for entire life of the project; and**
 - **Total cost of ownership and use of electricity over life of the project.**



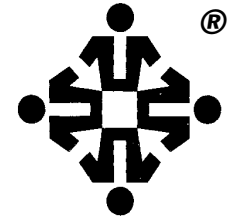
Electricity Cost Components

- **Investment Component (Expressed in terms of Annualised Cost for Various Options)**
- **Operating Cost Component**
 - **Insurance of plant, machinery and materials**
 - **O & M costs**
 - **Working Capital Interest**
- **Fuel Cost Component (Fuel as applicable)**
- **Electricity Duty, if applicable.**



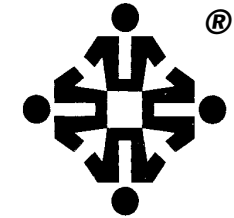
Conventional Fuels Price Scenario

<i>Sr.</i>	<i>Fuel</i>	<i>Source</i>	<i>HV kCal</i>	<i>Unit</i>	<i>Landed Cost</i>	<i>Rs./ MMkCal</i>	<i>US\$/ MMBTU</i>
S1	Coal	Indian	5200	Kg	3.30	635	3.34
S2	Coal	Imported	6200	Kg	3.90	629	3.31
S3	Lignite	Gujarat	3500	Kg	2.15	614	3.23
L1	Fuel Oil	PSU	10400	Kg	22.00	2107	11.09
G1	Nat. Gas	Open Mkt.	9000	SCM	9.41	1045	5.50
G2	LPG	PSU	10900	Kg	26.00	2385	12.55



SCENARIO – I

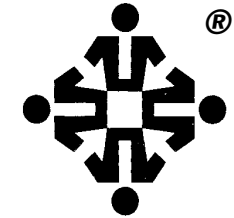
WIND ELECTRICITY FOR CAPTIVE USE



Conventional Energy Options Considered

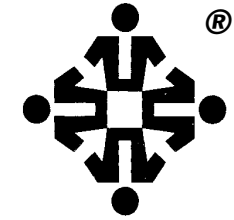
Basis: 30 milln. kWh Annual Electricity Generation

<i>Sr.</i>	<i>Fuel</i>	<i>Plant Type/ (PLF)</i>	<i>Model and Nos.</i>	<i>Capacity</i>
1	Coal	Co-gen with Steam (67%)	Generic	5.6 MW
2	Natural Gas	Gas Engine with WHR (75%)	Deutz 1000 kW (5 sets)	5.0 MW
3	Fuel Oil	Engine set with WHR (62%)	Man B&W 1500 kW (4 sets)	6.0 MW

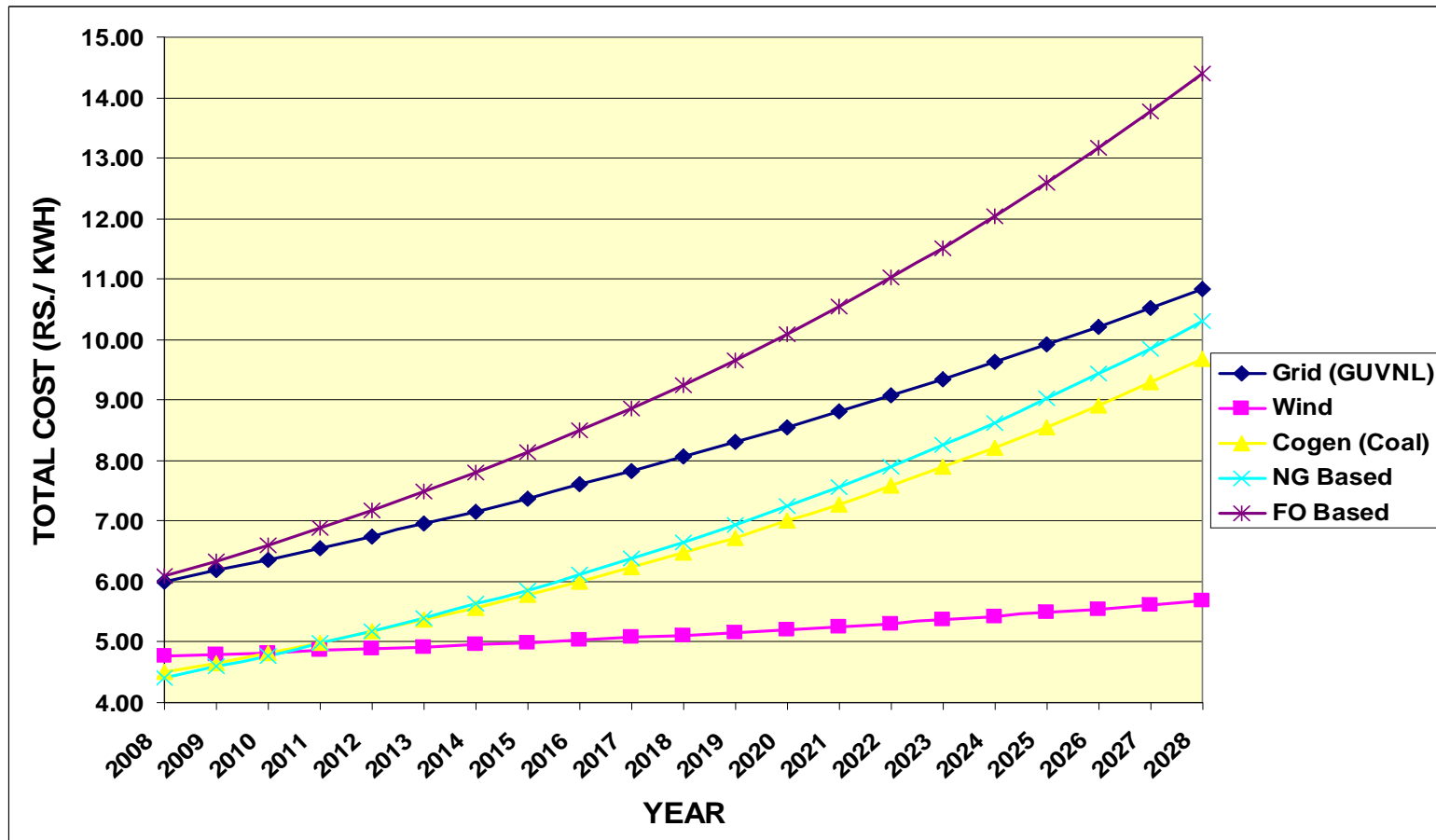


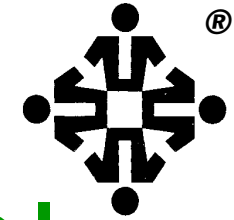
Summary Findings – Other Energy Options

<i>Sr.</i>	<i>Particulars</i>	<i>Unit</i>	<i>Coal Cogen</i>	<i>NG Based</i>	<i>FO Based</i>
1	Capacity	MW	5.6	5.0	6.0
2	Investment	Rs. Millions	315.00	180.00	225.00
3	Annualsd. Cost of Invest.	Rs. Milln.p.a.	40.94	25.43	31.79
4	Var. Cost (Fuel & ED)				
	a) Fuel Cost	Rs./kWh	2.75	3.21	4.49
	b) Elect. Duty	Rs./kWh	0.20	0.20	0.20
5	Operating Cost	Rs. Milln.p.a.	5.63	4.59	10.16
6	Escalation	% p. a.	5%	5%	5%
7	Total Cost				
	Year 2008	Rs./kWh	4.50	4.41	6.09
	Year 2013	Rs./kWh	5.37	5.40	7.48
	Year 2018	Rs./kWh	6.48	6.66	9.25
	Year 2023	Rs./kWh	7.89	8.26	11.52
	Year 2028	Rs./kWh	9.69	10.31	14.41



Comparative Cost of Electricity Wind Vs. Fossil Fuels – Captive Power Plants

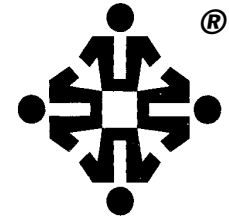




Total Cost of Ownership (CPO)- Scenario I

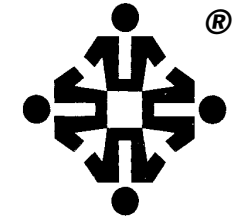
PV Disc'tg. Rate: 10.64% (Post-Tax); Values per MMkWh p.a.

<i>Energy Source</i>	<i>INR Milln.</i>	<i>US \$ Milln.</i>	<i>Rank</i>
Grid (HT) - GUVNL	61.5	1.28	4
<u>Wind</u>	<u>41.1</u>	<u>0.86</u>	<u>1</u>
Cogen – Coal	49.0	1.02	2
Natural Gas Engine with WHR	50.0	1.04	3
Fuel Oil Fired Engine Set with WHR	69.4	1.45	5



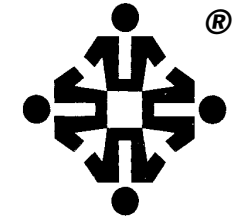
SCENARIO – II

WIND FARM FROM UTILITY COMPANY'S PERSPECTIVE



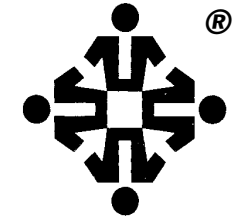
Basis for Comparison- Thermal Power Stations

Sr.	Particulars/ Fuel →	Coal	Fuel Oil	Natural Gas	Wind
1	Typical Capacity (MW)	500	500	500	150
2	Fixed Capital Cost (Rs. Miln. Per MW)	45	37	30	65
3	Fixed Capital Investment (Rs. Millns.)	22500	18500	15000	9750
4	Net Working Capital (Rs. Millns.)	2020	1620	1630	27
5	Fixed Cap. Investment (Rs. MWh p.a.)	7399	5706	4602	32431
6	PLF (Capacity Factor)	80%	80%	80%	27.3%
7	Uptime (Hrs. p.a.)	8400	8400	8400	8157
8	Total Electricity Gen. (Milln. kWh)	3041	3242	3259	301



Cost Comparison- Thermal Power Stations and Wind Farm

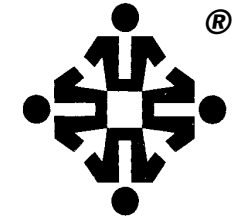
Sr.	Particulars/ Fuel →	Coal	Fuel Oil	Natural Gas	Wind
1	Heat Rate (kCal/ kWh)	2500	1900	1850	NA
2	Auxiliary Power Consn. (Wind Farm Losses#)	9.5%	3.5%	3%	10%#
3	Fuel Cost (US\$ per MMBTU)	3.34	11.09	5.5	NA
4	Fuel Cost (Rs./MT) @ (Rs./ 1000 SCM)	3300	22000	9409@	NA
5	Fuel Cost (Rs. Millns. p.a.)	5331	13453	6498	NA
5	O&M Cost (Rs. Millns. p. a.)	750	600	500	112
6	Insurance (Rs. Millns. p. a.)	67.50	55.50	45.00	48.75
7	W. C. Interest (Rs. Millns. p.a.)	242.40	194.40	195.60	3.24
8	Annualized Investment Cost (Rs. Milln. p.a.)	3375	2775	2250	1267



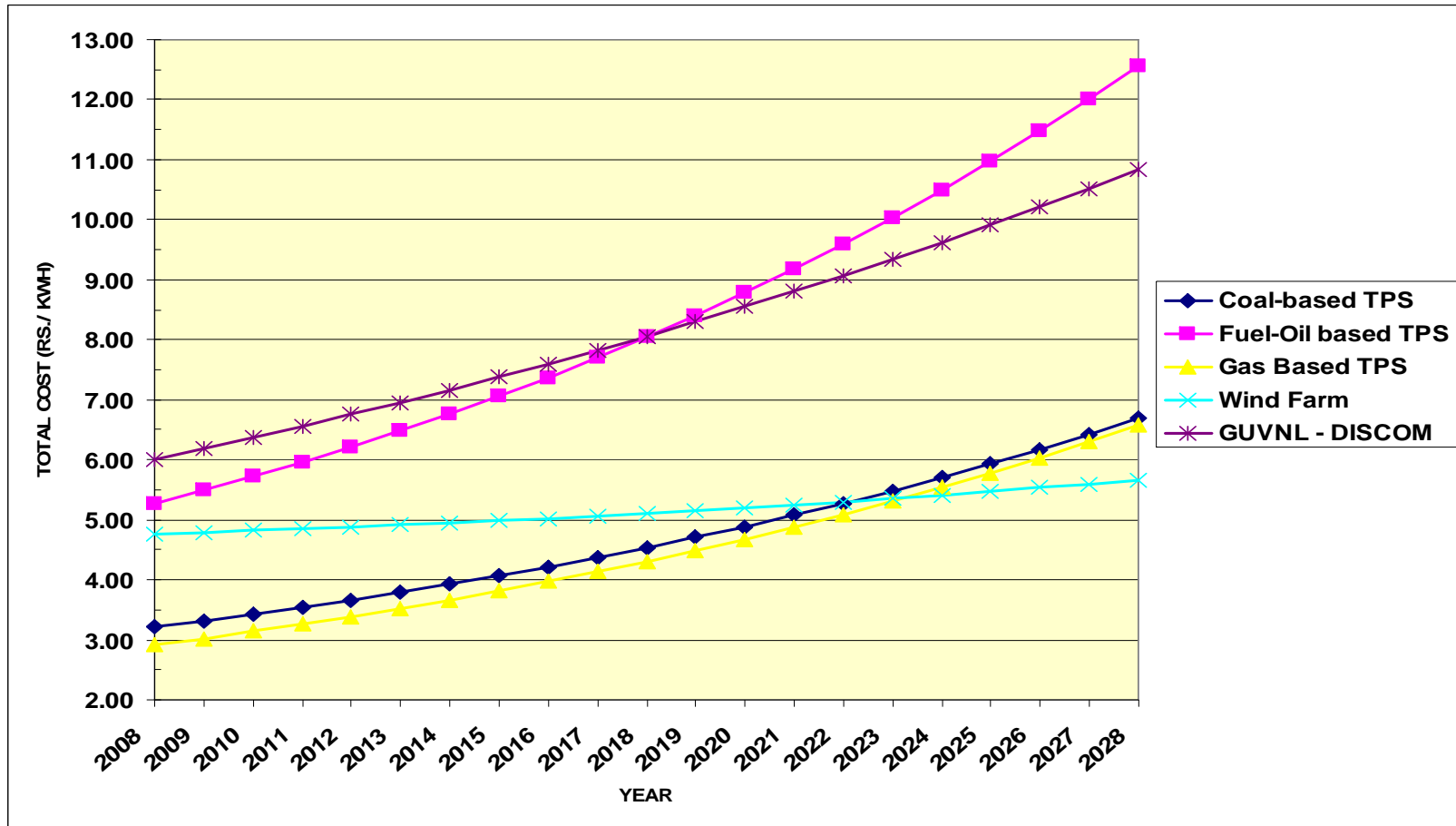
Unit Cost of Power Generation- Thermal Power Stations and Wind Farm

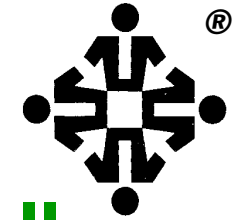
Rs./ kWh

Sr.	Particulars/ Fuel →	Coal	Fuel Oil	Natural Gas	Wind
1	Fuel Cost	1.75	4.15	1.99	NA
2	O&M Cost	0.25	0.18	0.15	0.38
3	Insurance	0.02	0.02	0.02	0.16
4	W. C. Interest	0.08	0.06	0.06	0.01
A.	Total Operating Cost	2.10	4.41	2.22	0.55
B.	Annlsd. Fxd. Inv. Cost	1.11	0.86	0.69	4.22
C.	Total Cost - 2008	3.21	5.27	2.91	4.76
	2013	3.79	6.49	3.53	4.91
	2018	4.53	8.04	4.31	5.11
	2023	5.48	10.03	5.31	5.35
	2028	6.69	12.56	6.58	5.67



Comparative Cost of Electricity Wind Vs. Fossil Fuels – Thermal Power Stations

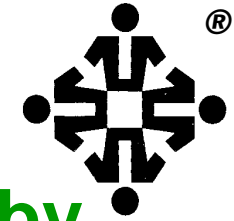




Total Cost of Ownership (TPS)- Scenario II

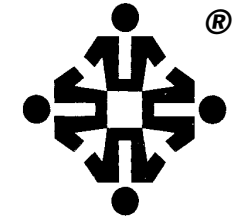
PV Disctg. Rate: 10.64% (Post-Tax); Values per MMkWh p.a.

<u>Energy Source</u>	<u>Rs. Millns.</u>	<u>US\$ Millns.</u>	<u>Index</u>	<u>Rank</u>
Grid-GUVNL	61.5	1.28	150	5
Wind	41.1	0.86	100	3
Coal-based TPS	34.4	0.72	84	2
Gas-based TPS	32.4	0.68	79	1
FO-based TPS	60.2	1.26	147	4



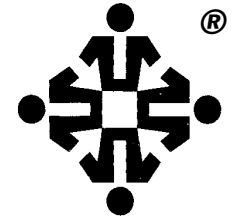
Wind Power Projects Planned/ Proposed by Energy Sector Companies – Partial List

<i>Sr.</i>	<i>Company</i>	<i>Location</i>	<i>MW</i>
1	Tata Power	Mah., Guj., Kartk.	285
2	REL	Mah., Guj., Kartk., M.P.	650
3	HPCL	Mah., Raj., Other	100
4	ONGC	Guj., Kartk., Mah.	151
5	CPC-IOC	TN, Guj.	43
6	BPCL	Kartk., Raj., Guj., Mah., TN	25-45
7	NTPC	India	650
8	NHPC	India	NA



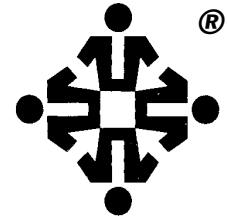
Considerations for Putting up Wind/ Renewable Energy Projects

- Abiding by national policy to reach 10% electricity generation from renewable sources.
- Renewable Power Purchase Obligation (RPO) of about 10%, with penalty attached for non-adherence to RPO.
- Forward looking policy with threatened viability or availability of fossil fuels.
- Viability of Renewable Energy Projects, by bridging viability gap through MNRE Incentive (Re. 0.50/ kWh), CERs and RECs



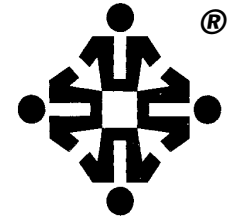
SCENARIO – III

WIND ELECTRICITY FOR SALE



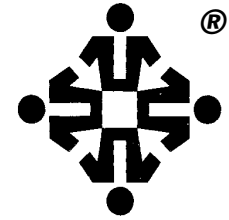
Wind Electricity for Sale – Salient Points

- **Purchase rates offered by state DISCOMs are much lower than total cost of wind electricity. Hence wind farm built exclusively for sale of electricity to state DISCOM may not be viable. For example:**
 - **Gujarat: Wind Electr. Cost Rs. 4.77/ kWh vs. GUVNL purchase rate at Rs. 3.50/ kWh.**
 - **Tamil Nadu: Wind Electr. Cost ~ Rs. 3.90/ kWh vs. State Grid purchase rate at Rs. 2.90/ kWh.**



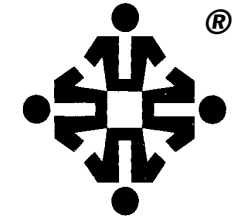
Wind Electricity for Sale (Contd.)

- Making a new wind farm exclusively for Third Party Sale, could be uneconomic due to applicability of additional levies such as:
 - Cross subsidy
 - Higher wheeling charges
 - Applicability of common rates of T&D losses
 - Applicability of electricity duty and/ or VAT



Wind Electricity for Sale (Contd.)

- **Favourable factors for Wind Electricity for Sale:**
 - **Continuity of CDM beyond 2012**
 - **Applicability of RPOs on utility companies**
 - **Institutionalisation of REC mechanism can favourably affect.**
 - **Power Trading Business**



Conclusions

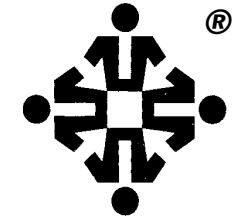
A. WIND ENERGY VS. POWER FROM GRID/ DISCOM:

If there is no investment constraint, wind energy option is certainly more economical in terms of unit cost per kWh than purchase of electricity from state DISCOM in short-term as well as long-term. Even the conclusion is unchanged in terms of 'Total Cost of Ownership' over project life.

B. SCENARIO- I: WIND ENERGY VS. CAPTIVE POWER PLANTS

Total Unit Cost of Electricity Generation:

- In the medium to long run, wind energy offers cheapest option for generation of electricity.
- In the short run, in the present context, unit costs of electricity generation for co-gen using coal (or other solid fuels) and natural gas-based engines work out marginally lower for the initial 2 to 3 years.
- Wind energy overtakes Co-gen and Natural Gas-based Engines from 3rd/ 4th year.
- Electricity based on liquid petroleum fuels is far expensive from the beginning and would work out several times higher in the years to come.



Conclusions (Contd.)

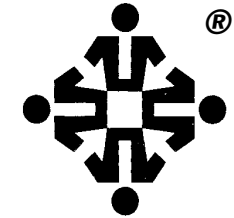
Total cost of ownership

- Total cost of ownership of wind farms over the life is substantially lower than that of all options of conventional electricity from fossil fuels.
- To put it quantitatively, (Basis: total cost of ownership for wind farms = 100), total cost of ownership of conventional electricity plants is as follows:
 - Co-gen plants – 119;
 - Natural gas-based plants – 122;
 - State grid electricity – 150;
 - Fuel oil based plants – 169.

C. SCENARIO- II: WIND ENERGY VS. THERMAL POWER STATIONS

Total Unit Cost of Electricity Generation:

- Coal and natural gas based thermal plants work out cheaper than wind energy for the initial 12 years. This is without consideration of any MNRE incentive or CDM credits (CERs) or RECs under proposed new mechanism.



Conclusions (Contd.)

- In later years of project life (after 12 years) wind energy yields lowest cost of electricity per kWh.

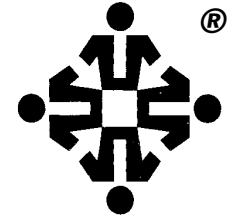
Total cost of ownership

- Total cost of ownership over the life of coal and gas based thermal power stations is lower than wind farms.
- To put it quantitatively, (Basis: total cost of ownership for wind farms = 100), total cost of ownership of conventional electricity plants is as follows:

➤ Co-gen plants –	84
➤ Natural gas-based plants –	79
➤ State grid electricity –	150
➤ Fuel oil based plants –	147

Wind Power Projects by Utility Companies

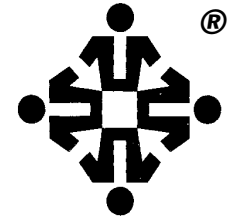
- Despite cost economics not being in favour of wind-based power as compared to coal and natural gas based thermal power plants, many utility companies have decided to put up wind farms for several hundreds of MW, for meeting requirements of Government policy including RPOs.



Conclusions (Contd.)

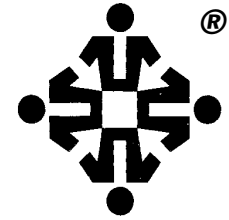
D. SCENARIO- III: WIND ENERGY FOR SALE

- Cost of wind electricity is higher than sale price available from DISCOMs. It is also higher than net price realised from third party sale (net after payment of cross subsidy, elect. duty etc.)
- In the long run, however, wind farms for sale of electricity could be profitable, depending upon supplementary realisations from CDM CERs, RECs, etc.



Vijayant Consultants - Introduction

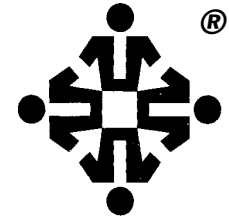
- Established in 1992. Engaged in Management and Project Consultancy practice.
- Have successful track record of pioneering wind energy projects in Gujarat, from Concept to Commissioning and Post-Project Performance Monitoring.
- Promotor Director: Bharat J. Mehta
 - B. Chem. Eng. From UICT Mumbai (1968) and M. B. A. from IIM-A (1970). Awarded Gold Medal for Scholastic Performance.
 - 22 years industry experience (1970-1992) and 17 years consultancy experience (1992-continue)
 - Certified Management consultant, globally recognized (IMCI, ICMCI)
 - Lead Auditor QMS, ISO 9001: 2000
 - Chairman IMCI, Ahmedabad, Past Treasurer, Past Regional Representative (West) and Member, Executive Council IMCI.
 - Past Chairman UICT Alumni Association
 - Past Vice Chairman, IChE, ARC.
 - Visiting Professor IIM-A (1985-1994)



Vijayant Consultants - Introduction (Contd.)

Management Consultancy

- **Business Strategy, diversifications and growth**
- **Competitive Strategy for Industrial Markets.**
- **Corporate Restructuring for Revival and Growth.**
- **Consultancy for ISO 9001: 2000 QMS and TQM**
- **Consultancy for ERP, BPR and SCM.**
- **Organisation Structure, OD, HRM**
- **Executive Placement.**
- **Management Information and Control Systems.**
- **Management Retainerships and Management Support Services.**



Vijayant Consultants - Introduction (Contd.)

Project Consultancy

- Identification of Investment Proposals.
- Strategic appraisal of diversification project proposals
- Techno-Economic Feasibility Studies.
- All Project Related Services from Concept to Commissioning, specially for Wind Energy, Captive Power, Water Systems, Environment Control, Chemicals, Pharmaceuticals, Oil and Gas, Agri-Food and others.
- Post-Project Services such as Performance Audit in relation to Technical Guarantees, Operations and Maintenance, etc.
- Technology Tie-ups, Joint Ventures and Financial Arrangements.

Contact: Bharat Mehta, Director
Vijayant Consultants, 603, Sears Tower, Near Panchvati,
Gulbai Tekra, Ahmedabad 380006, India
Phones: 91-70-26401460/ 61; Mobile: 91-9825060801
E-mail: consult@vijayant.com; www.vijayant.com