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Wind energy development in Tamil Nadu and Andhra Pradesh, India Institutional dynamics and barriers — A case study

A. Jagadeesh*

Wind Energy Specialist, 2/210, Nawabpet, Nellore 524 002, Andhra Pradesh, India

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Abstract

Tamil Nadu state has the distinction of 719 MW capacity windfarms at the end of September 1998 out of the country's total figure of 992 MW. Andhra Pradesh has 58 MW installed windfarms in the state. 1995–96 saw a boom when 282 MW windfarms were set up in Tamil Nadu and capacity in Andhra Pradesh increased by 39 MW. Subsequently there was a steady decline in the windfarm development in both the states. This case study attempted in detail to trace the reasons for the boom and the factors that contributed to the slump in windfarm activity in the states. The role of institutions in determining the effectiveness of National and Regional public-sector initiatives to promote and disseminate wind energy in the two states is discussed in the paper. The study has also looked into the financial, technical, transaction and institutional barriers which inhibit the diffusion of wind energy in the states. Creation of Wind Fund, establishment of co-operative windfarms, setting up of wind estates, linking generation to incentives for optimum production, promotion of reliable water pumping windmills and wind battery chargers for small-scale applications suggested in the paper for rapid growth of wind energy in Tamil Nadu and Andhra Pradesh. The results of the case study may be used to improve public policy intervention in disseminating wind energy in the country. It may also be relevant to multilateral and bilateral aid agencies in their projects and/or programmes to promote cost-effective wind energy technology dissemination in developing countries.

Keywords: Wind energy; Institutional barriers; Windfarm cooperatives

1. Introduction

Renewable sources of energy have a vital significance in the context of growing concern about sustainable energy supplies and protection of the environment from adverse effects of fossil fuel utilisation. The current pattern of energy consumption and the growing energy requirements on account of development, economic growth, population increase, etc., are considered to be essentially unsustainable. The staggering increase in oil import burden, the crippling effects of power shortage and the deterioration in environmental quality are some of the critical issues facing India today.

Worldwide, vast amounts of carbondioxide and other greenhouse gases that are being dumped into the atmosphere by fossil fuel burning and other economic activities are causing grave concern about the possible global warming and attendant consequences. It is becoming increasingly clear that any effective strategy to contain global warming must involve rational and efficient use of energy and a gradual transition from reliance on fossil fuels to alternative, environment friendly energy technologies. A major component of this strategy will admittedly be the promotion of renewable energy systems in a big way, and in this scenario, wind energy is expected to figure prominently.

The advantages of harnessing wind energy include:

- wind energy is available free,
- the production and use of wind energy does not pollute the atmosphere,
- it does not cause acid rain and contribute to the greenhouse effect which leads to global warming,
- a windfarm irrespective of its size has a low gestation period,
- the primary energy used to produce a wind turbine is recovered in about a year.

* Tel.: + + 91-861-321580; fax: + + 91-861-330692
E-mail address: a_jagadeesh@yahoo.com (A. Jagadeesh)

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PII: S0301-4215(00)00007-0

Wind energy systems have major potential applications in rural areas especially for:

- domestic water supply,
- crop irrigation,
- performing agricultural tasks such as grinding corn, crushing sugarcane, threshing and wood cutting,
- pumping water in salt works,
- aeration and water supply for acquaculture,
- generating electricity to operate water pumps for large-scale irrigation and for water pumping for small communities, in combination with diesel back-up and/or energy storage systems,
- generation of electricity to assist rural electrification.

2. Early efforts in India to tap wind energy

In India wind energy was first tapped in the 1950s for its potential to pump water for domestic use and irrigation as an alternative to diesel/electric pumpsets. Wind pumps were imported on a modest scale and installed on an experimental basis at a number of sites. A National Water-Pumping Windmill Demonstration Programme was subsequently introduced by the Government of India during the 6th (1980–85) and 7th (1986–91) plan periods and about 2800 units of the 12-PU-500 wind pumps for shallow well water pumping were installed around the country. In addition, over 200 indigenously developed gear type pumping units have also been installed in nine states under an Operational Research Programme (ORP). Unfortunately due to various technical and non-technical reasons, the 12-PU-500 could not succeed except in some regions.

A Wind Resource Assessment Programme was taken up in 1985 comprising wind monitoring, wind mapping and complex terrain projects. The programme covered 25 states with over 600 stations. Eighty three masts of 20–25 m height with sophisticated continuous wind data recording instruments, and 172 masts of 5 m height with cup counter anemometers were set up in the country. Five volumes of Wind Energy Resource Survey for India have been published so far which cover wind data from 198 wind monitoring stations (Wind Energy Resource Survey in India, 1990, 1992, 1994, 1996, 1998). The programme for demonstration of windfarms was initiated in 1985. Since 1992 private investors/developers have taken the lead in setting up commercial wind power projects in the country. Since Tamil Nadu state has become the leader in windfarm installations in the country an attempt is made to study in depth the factors that contributed to the early growth and the pitfalls that led to the slump including institutional barriers besides a comparative study with wind power developments in Andhra Pradesh, a neighbouring state.

A package of incentives have been offered by the Central Government such as accelerated depreciation, tax holiday, soft loans, custom and excise duty reliefs, liberalised foreign investment procedures, etc. Private investors/developers took advantage of these incentives and set up windfarms.

The list of wind sites with their latitudes and longitudes, annual mean wind speeds and annual wind power density measured at 20/25 m height and extrapolated to 30 m height in Tamil Nadu and Andhra Pradesh are given in Table 1.

The wind energy potential and the resources exploited till the end of September 1998 are shown in Table 2.

Statewise and yearwise wind power capacity addition (MW) in India is shown in Table 3.

The power production statewise and yearwise in the country through windfarms upto September 1998 is shown in Table 4.

Table 1 clearly indicates that most of the windy sites occur in the Tamil Nadu state like Muppandal, Edayarapalayam, Poolavadi, Kethanur, etc. From Table 2 it is evident that the bulk of Windfarm installations are in Tamil Nadu. An analysis of Table 3 reveals that there was a steady increase in windfarm activity from 1992–93 to 1995–96 and is followed by a sharp decline.

3. Initiatives and Policies that led to Windfarm boom in Tamil Nadu

- good windy sites like Muppandal were available at that time,
- the sites were nearer to towns for accessibility to bring labour and to provide accommodation to personnel involved in the projects,
- the sites were well interlinked with highways,
- grid Network by Tamil Nadu Electricity Board (TNEB) was well connected and mostly passing through the sites,
- active promotional steps by TNEB, TEDA (Tamil Nadu Energy Development Agency) and local authorities,
- boom in Textile market and Cement Industry where huge profits were earned and hence Tax concessions such as 100% depreciation, 5 yrs Tax holiday were availed by setting up Windfarms. Moreover these industries need heavy power and as such windfarms came handy for captive power consumption,
- power cuts during summer months was a handicap for industries. Incidentally during summer months wind energy generation was at its peak. It supplemented the TNEB power supply position,
- most of the Wind Turbine Manufacturers/Suppliers were situated in Tamil Nadu and as such the investors/developers were confident of supply of the machines and after sales service of the machines,
- TNEB took the first step to set up windfarms at sites like Muppandal, Kayathar and Kethanur proving the viability of windfarms thus inducing confidence among private wind farm developers,

Table 1
List of potential sites for wind power projects in Tamil Nadu and Andhra Pradesh

S. No	Station	Latitude		Longitude		Annual Mean Wind Speed (KMPH)		Annual Mean Wind Power Density (W/SQ.M)	
		°N	′	°E	′	Measured at 20/25 m	Extrapolated at 30 m	Measured at 20/25 m	Extrapolated at 30 m
Tamil Nadu									
1	Achankuttam	08	57	77	28	18.60	20.00	270	335
2	Algiyapandiyapuram	08	56	77	39	20.90	22.30	301	371
3	Andhiyur	10	36	77	11	19.10	20.60	177	213
4	Andipatti	09	59	77	35	19.00	19.60	266	298
5	Arasampalayam	10	51	77	03	20.50	21.80	195	232
6	Ayikudy	09	00	77	21	21.40	23.50	305	390
7	Edayarpalayam	10	55	77	07	22.40	23.80	273	323
8	Ennore	13	16	80	19	19.30	20.80	139	177
9	Gangaikondan[a]	08	51	77	35	18.40	19.00	246	267
10	Kannankulam[a]	08	10	77	46	21.30	22.20	238	268
11	Kattadimalai	08	14	77	33	23.70	25.30	312	380
12	Kayattar I	08	58	77	44	20.30	21.50	294	342
13	Kayattar II[a]	08	57	77	43	20.50	20.90	285	302
14	Kethanur	10	54	77	13	21.10	22.30	259	305
15	Kumarapuram[a]	08	16	77	35	22.00	22.70	288	315
16	Mangalapuram	09	03	77	22	22.30	23.40	312	257
17	Meenakshipuram	09	52	77	18	16.40	17.50	224	267
18	Meetukadai	10	52	77	23	18.00	19.20	184	221
19	Muppandal	08	16	77	33	25.50	27.60	406	519
20	Myvadi	10	36	77	19	19.60	21.00	251	305
21	Naduvakkurichi	09	07	77	30	16.80	18.00	157	190
22	Nettur[a]	08	54	77	33	19.90	20.20	338	358
23	Onamkulam[a]	08	58	77	51	19.90	20.30	247	258
24	Ottapidaram	08	54	78	01	18.50	20.00	221	280
25	Ovari	08	18	77	53	18.20	19.20	160	184
26	Panakudi	08	19	77	33	22.90	23.90	366	408
27	Pongalur	10	58	77	21	19.10	20.40	213	251
28	Poolavadi	10	45	77	16	21.20	23.00	283	343
29	Poosaripatti[a]	10	41	77	08	19.30	20.00	168	188
30	Puliyamkulam	08	19	77	44	18.90	20.80	188	245
31	Rameswaram	09	17	79	20	23.90	26.40	290	398
32	Sankaneri[a]	08	12	77	40	22.60	23.40	258	287
33	Sembagaramanpudur	08	16	77	31	21.70	23.00	300	367
34	Servallar Hills	08	42	77	21	17.80	18.90	207	247
35	Sultanpet	10	52	77	11	19.00	19.10	203	204
36	Talayathu	08	48	77	39	20.50	21.50	324	364
37	Tuticorin	08	50	78	08	17.60	19.00	148	185
38	Vakaikulam	08	45	78	00	16.60	17.00	167	201
39	Thannirpandal	10	57	77	19	18.20	21.00	216	330
Andhra Pradesh									
1	Badhrampalli Kottala[a]	14	55	77	24	21.30	21.50	248	255
2	Bhimunipatnam	17	54	83	27	19.10	20.10	195	229
3	Bandarlapalli[a]	15	01	78	04	20.79	21.60	240	265
4	Jammalamadugu 1[a]	14	49	78	23	17.50	18.30	161	184
5	Jammalamadugu 2[a]	14	46	78	22	18.60	19.40	165	183
6	Jangamguntla	15	39	79	08	16.03	16.60	149	164
7	Kadavakallu[a]	14	48	77	56	22.10	22.30	303	308
8	Kakula Konda	13	43	79	21	23.10	25.00	332	404
9	Kondamithepalli[a]	15	03	78	03	21.22	22.00	252	282
10	M.P.R. Dam	14	54	77	25	19.90	20.70	228	245
11	Mustikovala	14	15	77	32	20.20	20.80	201	216
12	Nallakonda[a]	14	07	77	34	22.80	23.10	276	288
13	Narasimha Konda	14	30	79	52	20.10	22.50	186	261
14	Nazeerabad[a]	17	11	77	55	21.00	21.60	176	189
15	Pampanoor Thanda[a]	14	38	77	24	19.60	20.10	182	194

Table 1 (Continued)

S. No	Station	Latitude		Longitude		Annual Mean Wind Speed (KMPH)		Annual Mean Wind Power Density (W/SQ.M)	
		°N	′	°E	′	Measured at 20/25 m	Extrapolated at 30 m	Measured at 20/25 m	Extrapolated at 30 m
16	Payalakuntla	14	53	79	02	20.10	20.40	230	241
17	Puttaparthy[a]	14	09	77	48	17.70	18.00	149	156
18	Ramagiri I	14	17	77	31	19.50	20.90	205	246
19	Ramagiri III	14	22	77	32	19.40	20.20	190	213
20	Singanamala	14	46	77	44	23.80	24.20	366	377
21	Tallimadugula[a]	14	22	77	32	22.20	22.50	260	267
22	Tirumala	13	40	79	22	20.40	21.90	26	282
23	Talaricheruvu[a]	14	57	78	03	18.11	19.30	144	179
24	Tirumalayapalli	14	54	78	11	19.00	20.80	154	195
25	Vajrakarur	14	58	77	19	19.46	20.90	173	205

[a]25 m mast.

Table 2
Wind Energy Potential and Resource Exploited[a]

Sl. No.	State	Gross potential (MW) (a)	Technical potential (MW) (b)	Installed capacity(MW) (c)
1	Andhra Pradesh	2200	1231	58
2	Gujarat	3100	1271	167
3	Karnataka	4120	687	18
4	Kerala	380	353	2
5	Madhya Pradesh	3000	775	19
6	Maharashtra	1920	2108	8
7	Orissa	840	338	1
8	Rajasthan	1210	397	–
9	Tamil Nadu	900	1011	719
10	West Bengal	180	775	–
11	Other States	2150	–	–
	Total	20,000	8946	992

[a]*Note*: (a) Assuming 0.5% of land availability for Wind Power generation in potential areas. (b) As on 31.03.98, assuming 20% grid penetration. (c) As on 30.09.98
Source: MNES.

Table 3
Statewise and yearwise wind power capacity addition (MW)[a]

State	Upto March 92	1992–93	1993–94	1994–95	1995–96	1996–97	1997–98	1998–99 (Upto Sep.)	Total
Andhra Pradesh	0.550	0.000	0.000	5.425	38.925	9.390	1.500	2.000	57.790
Gujarat	14.515	1.630	10.625	37.745	51.158	31.137	20.100	0.000	166.910
Karnataka	0.550	0.000	0.000	0.000	2.025	3.270	11.165	1.250	18.260
Kerala	0.000	0.000	0.000	0.000	2.025	0.000	0.000	0.000	2.025
Madhya Pradesh	0.590	0.000	0.000	0.000	6.300	2.700	2.700	6.155	18.445
Maharashtra	1.100	0.000	0.000	1.500	0.000	2.700	0.225	2.520	8.115
Orissa	1.100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.100
Tamil Nadu	22.310	11.070	50.465	190.865	281.680	119.765	31.140	11.580	718.875
Others	0.465	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.465
Total	41.180	12.700	61.090	235.535	382.113	169.032	66.830	23.505	991.985

[a]*Source*: MNES.

Table 4
State wise and year wise wind power projects (Kwh)[a]

State	Upto March 92	1992–93	1993–94	1994–95	1995–96	1996–97	1997–98	1998–99 (Upto Sep.)	Total
Andhra Pradesh	1,120,745	63,349	161,525	619,748	7,676,741	39,979,632	51,925,399	28,757,138	130,304,277
Gujarat	42,188,099	18,793,320	21,673,823	37,833,399	58,230,856	117,856,316	132,409,292	44,642,564	473,627,669
Karnataka	—	—	—	—	315,603	7,250,605	11,715,975	12,117,771	31,399,954
Kerala	—	—	—	59,146	2,041,468	2,565,150	1,867,326	1,085,455	7,618,545
Madhya Pradesh	1,080146	406,900	336,059	250,906	813,273	5,977,195	7,426,841	6,436,489	22,727,809
Maharashtra	3,429,901	518,610	208,620	1,138,350	1,162,914	2,577,778	3,308,370	2,201,637	14,546,180
Orissa	1,174,856	0	0	0	0	0	0	0	1,174,856
Tamil Nadu	63,911,415	68,674,598	72,389,409	151,374,106	426,198,886	702,169,655	779,801,751	521,646,244	2,786,166,064
Total	112,905,162	88,456,777	94,769,436	191,275,655	496,439,741	878,376,331	988,454,954	616,887,298	3,467,565,354

[a] *Source*: MNES.

- since the land at the identified windy locations was privately owned, the purchase and acquisition of the land was quick without any hitch,
- Chennai port having excellent facilities for import of heavy machinery of Wind Turbine Generator (WTG) components facilitating intra-state transportation,
- TNEB extended all facilities for private entrepreneurs like consultancy services, processing of the application for issuance of No Objection Certificate (NOC), CEIG (Chief Electrical Inspectorate to the Government) clearances, extending grid connection to windfarms and executing new dedicated sub-stations. Above all TNEB has established an effective system for registering the energy generation by each wind turbine and enabling the wind turbine owners to either adjust their energy bill thereof, or effecting payment to those who sold power generated to TNEB,
- TNEB officials assigned to wind energy field were professionally qualified, well knowledgeable and as such executed the job well.

4. Factors which led to steady decline in Windfarm activity in Tamil Nadu

- the rising cost of land for installing wind turbines is also contributed to the decline. To minimise the cost of land, some wind farm developers put up wind turbines by purchasing limited land (points) around the wind turbine to be installed.
- due to unplanned addition of windfarms at sites like Muppandal, Kayathar, Poolavadi, etc., inadequate capacity at dedicated substations resulted in shutting down of wind turbines even during peak wind speed periods with loss of generation and hence revenue loss to the Windfarm owners,
- connecting WTGs to weak and rural feeder lines in the absence of dedicated substations at some windfarm sites, poor grid — poor generation — loss of revenue,
- TNEB imposing penalties for excess Reactive Power (RKVAH) consumption,
- improper maintenance of WTGs by some suppliers during warranty period and by owners beyond warranty,
- inadequate facilities by some manufacturers of WTGs at sites for repairs as well as at their works. This led to long delays and breakdown periods — loss of generation,
- rotor blade failures in some cases due to manufacturing defects as well as lightning strike,
- disregard for earthing regulations and lightning protection leading to unduly large breakdown of control systems resulting in very expensive repairs and long breakdown periods,
- reduction in tax concessions enacted by the Union Government led to corresponding reduction in tax benefits to investors to put in windfarms,
- introduction of Minimum Alternate Tax (MAT) further eroded the gains of setting up Windfarms,
- withdrawal of third party sale,
- withdrawal of capital subsidy of 10% project cost subjected to a maximum of Rs. 15 lacs,
- slump in Textiles and Cement business activity,
- liquidity crunch,
- difficulties in availing loans from banking institutions especially for newly floated companies,
- disproportionate hike in interest rates subsequently imposed by IREDA for loans to set up windfarms,
- the earlier irrational policies of importation led to substantial numbers of unworthy and uncertified machines which resulted in failures of some models which again cast aspersions in the minds of investors about the technology itself. As a result the market for wind turbines dramatically shrunk leaving even the genuinely good technology machines in trouble,
- applying windspeed data from limited number of anemometers (two for 300 MW in Muppandal) resulted in wide variation from predicted wind turbine generation and actual generation creating doubts about the viability of wind projects.

5. Barriers to wind energy development

Although subsidies and financial incentives were given liberally to wind energy, this technology remained marginalised in the overall energy scenario. Wind energy contributes about 1% of the total power available in the country. While working out cost–benefit analysis and calculating internal rate of return for any power project, hidden or indirect subsidies on pricing a resource and infrastructure were never taken into account in the case of conventional energy sources. On the other hand, economic analysis of wind energy projects rarely supported their economic justification. Most projects were supported for their renewable nature, social and environmental benefits. Wind energy systems are now regarded as costlier than conventional power systems but if one were to take into account the life-cycle costs — and not merely the upfront costs — the former will be found competitive. If weightage is given to environmental benefits the economics of wind energy will further improve. The general impression that wind energy will not be commercially viable without subsidies will vanish if one takes into account the indirect subsidisation of the State Electricity Boards through lower tariff for certain segments of consumers. If the tariff for conventional power is corrected and a level playing field is provided wind energy systems will be commercially viable and become competitive.

The main barriers for wind power in isolated power systems in developing countries are lack of positive track records due to failures in too complex system designs applied in early pilot projects, lack of institutional sustainability at the recipient in small remote communities with limited human resources, lack of detailed knowledge of user demands and priorities and their development in time, lack of project implementation models other than turnkey, lack of financial sustainability and commercial market, lack of funding for technology development, lack of engineering tools for customizing systems, lack of generalized reported experience and guidelines(Hansen *et al.*, 1999).

5.1. Financial barriers

Lack of adequate financial resources has been a chronic problem for setting up wind energy projects. In India, Indian Renewable Energy Development Agency Ltd. (IREDA) played a crucial role in supporting wind projects in the country. IREDA's lending terms are presented in Table 5.

Bilateral development institutions from Netherlands, Denmark, and loan from Global Institutions like the World Bank through IREDA also contributed to the boom in wind energy projects in Tamil Nadu.

There is the need to create more financial institutions to support wind projects. A wind fund of Rs. 1000 crores (1 crore = 10 million, 1 US $ = Rs. 42) on the lines of the one in UK can be created in India to support wind projects exclusively. Such a fund will provide equity finance for small-scale wind energy projects and will offer investment opportunities to individuals and institutions alike.

5.2. Transaction barriers

Transaction barriers to wind energy are similar in many ways to those in developed and developing countries (Martinot, 1998; Stern and Aronson, 1984; Reddy, 1991; Levine *et al.*, 1994; World Bank, 1993; Jackson, 1993). In India many of the sources of risk, institutional structures and conditions, experience and skills deficiencies are unique. The result is greater uncertainty in transactions about opportunities, costs and benefits.

5.3. Technical barriers

In the conventional power sector, the fossil fuel resources are limited but the technology to harness them is well stabilised. In contrast, wind energy source is unlimited but the technology to harness it is in the development stage. Thus, non-availability of cost-effective, commercially viable technology for utilisation of wind energy constitutes one of the barriers. Lack of standardisation in system components resulting from the wide range in design features and technical standards, and absence of long-term policy instruments have resulted in manufacturing, servicing and maintenance difficulties of wind turbines.

The mismatch between locally manufactured components and imported parts resulted in weakening the reliability of the overall system, in some cases. The absence of effective servicing and maintenance networks, combined with inadequate user-training, resulted in a loss of confidence among entrepreneurs and customers. Another barrier is lack of co-ordination among research groups, academic institutions and private wind industry.

5.4. Institutional barriers

These constitute the real constraint, not only to the development of Renewable Energy Sources like wind but also to their wider dissemination. Technologies that are of immediate relevance in a developing country like India are now available and, while improvements may be required in individual cases, especially to reduce production costs, the hardware for harnessing wind energy is relatively well known and reliable. What is required is therefore an appropriate institutional infrastructure capable of planning and implementing a co-ordinated programme at all levels and of mobilising community support for it at the micro-economic levels where it would be implemented. This strategy calls for a different

Table 5
IREDA's financing guidelines for wind energy sector (With effect from 6th May, 1998)[a]

S. No	Financing scheme	Interest rate (Exclusive of interest tax)	Loan repayment including moratorium period (yr)	Moratorium period (Max. ears)	Minimum promoter's contri-bution	Term loan/lending norms
Category — Financing guidelines for wind farm developers						
A. Project financing scheme						
1	International funds	13%	10	1	25%	100% of eligible equipments cost limited to a maximum of 75% of total project cost.
2	IREDA funds	14%	10	1	25%	Upto 75% of total project cost
B. Equipment financing scheme						
1	Equipment financing (upto 2 MW per party per financial year)	15%	10	1	10%	Upto 90% of the cost of eligible equipments (eligible equipment comprise of WEG, tower, control panel and transformer)
Category — Financing guidelines for manufacturers/suppliers of wind electric generators						
1	Commercial demonstration scheme for above 600 KW machines — 5 MW per financial year	12%	10	1	25%	Upto 75% of project cost
2	Manufacturers cum developers scheme upto 5MW/party/year. (With the option for transferring wind farm to eligible developer with the transfer of proportionate loan within one year)	13.50%	10	1	25%	100% of eligible equipment cost limited to a maximum of 75% of total project cost
3	Market development assistance (including export promotion)	12%	5	1	25%	1. Upto 75% of the last 3 yr average expenditure on promotional efforts 2. Minimum loan amount of Rs. 2.5 lacs and a maximum of Rs. 10 lacs per client
Category — Eligible state electricity board/utility						
1	Grid interconnection facility scheme for evacuation of electricity	15%	10	1	25%	100% of eligible equipment cost limited to a maximum of 75% total project cost
Category — financing guidelines for renewable energy users						
1	Transmission/distribution facility scheme (where borrower uses not less than 50% of his electricity requirement from renewable energy)	15%	10	1	25%	100% of eligible equipment cost limited to a maximum of 75% total project cost

[a]*Source*: IREDA

approach that would need to be compartmentalised according to the sources of energy supplies and yet to be integrated and co-ordinated to bring the results to the masses. This new strategy will require an integrated institutional approach involving political will to support it consistently, institutional arrangements to implement it and involvement of the people to sustain it (Monga, 1997).

Wind energy is being pushed in India because of its usefulness as a decentralized energy system. Its introduction initially generated a good deal of interest from the scientific perspective rather than due to its potential to meet energy demands on a decentralised basis. A growing gap in demand and supply, environmental considerations and the decentralized nature of wind projects made everyone in India realise its significance in meeting the growing energy demand to some extent. Initially, wind projects were promoted in India as panacea for all unsolved energy problems. The main emphasis on wind projects was on the target achievement rather than on consumer satisfaction of capacity building. Little efforts were made to strengthen the institutions involved in the diffusion of wind energy, or provide an enabling environment to the entrepreneur to promote the commercialisation process. This resulted in raising undue demands and expectations that wind energy was unable to fulfill.

A multiplicity of agencies has resulted in duplication, overlapping and coordination problems in the implementation of the wind projects. Multiplicity of agencies has also resulted in unnecessary delays. A bureaucratic structure with a target-oriented approach has led to rigidity in instructions and a centralised planning process that is the opposite of the decentralised nature of wind energy. Most of the decisions are still taken at the central level with little flexibility given to the field agencies and grass roots level institutions.

6. Training programmes in wind energy

Development and successful implementation of a complex technology like wind energy requires sufficient information and inputs of manpower. It is imperative that energy education including wind should be included at various levels in schools, colleges and universities and other academic institutions. Regular four year bachelor degree course in wind energy specialisation will be useful in the design, development and evaluation of this emerging technology.

7. Windfarm co-operatives in India — need of the hour

In India most of the windfarms are set up by big industries mainly as a tax shelter plan. Unless the wind projects are mass based, it is hardly possible to get the political support besides resources to set up wind projects. On the other hand the wind developments in Denmark where the installed capacity at the end of July 1998 stood at 1259 MW are worth emulating in Tamil Nadu (India). About 75% of the wind turbines in Denmark are owned by local associations and private individuals (Meyer, 1995). More than 100,000 families are involved as share holders. Over the past decade, the popularity of wind turbines has grown to such an extent that today they cater for 7% of the country's total electricity consumption. This, in turn, provided an excellent basis for renewed community spirit and the growth of interest in energy and environment matters.

Another success story that needs close examination is the phenomenal success of wind energy in Germany which has been relegated to the top position in the world with installed capacity of 3817 MW at the end of September 1999. The wind energy boom in Germany is mainly due to the renewable energy feed in tariffs (REFITs) granted there, apart from investment grants given initially, and some research activities. All private producers of electricity from renewable energy are statutorily granted a fixed price, which the utilities are obliged to pay. The price is calculated on the basis of the average electricity rates in Germany (Wagner, 1998).

8. Some suggested policy changes to boost windfarms in Tamil Nadu

In India currently accelerated depreciation is allowed on wind projects. The main aim of extending this incentive to windfarm owners and developers is that they supplement power to conventional one. Unfortunately in majority of the cases this liberal incentive has ended merely as a tax shelter plan. This has far reaching consequences on the generation of power by wind turbines. It is hightime that the Government seriously considers to link depreciation benefits to generation of power so that the wind turbines produce optimum power. There is wide variation in the incentives offered by different state governments, Table 6. It is hoped that Tamil Nadu Government introduces third party sale as well as sales tax benefit like Madhya Pradesh, which will go a long way in setting up of Windfarms on a large scale in the state.

9. Wind energy to meet rural needs

When properly used, small, and perhaps intermittent, amounts of energy can be of critical value to the rural economy. The inability of developing countries to produce relatively small increments of energy is a major bottleneck to development programmes, particularly in the rural sector where needs are much simpler. Although the provision of such amounts of energy is not, by itself, sufficient for the improvement in economic and social wellbeing, it is a necessary condition. Its efficacy is bound up intimately with other economic, social and political factors. Energy supply is so important point of entry for rural development programmes.

The cumulative impact of the effective use of even small amounts of energy in a rural area can be considerable. Agricultural productivity, rural industries, health,

Table 6
Policies Introduced/Incentives Declared by the State Governments for Private Sector Wind Power Projects

Items	Andhra Pradesh	Tamil Nadu	Karnataka	Kerala	UP	WB	Gujarat[a]	MP	Maharashtra
Wheeling	2% of energy	2% of energy	2% of energy	2% of energy	2% of energy	2% of energy	2% of energy	2% of energy	2% of energy
Banking	12 months	12 months	12 months	6 months	12 months	6 months	6 months	—	12 months
Buy-back	Rs.2.25/KWh (5% esc., 1997–98)	Rs.2.25/KWh (5% esc., 1995–96)	Rs.2.25/KWh (5% esc., 1994–95)	To be agreed mutually	Rs.2.25/KWh (5% esc., 1995–96)	To be decided on case to case basis	Rs.1.75/KWh (no esc.,)	Rs.2.25/KWh (no esc.,)	Rs.2.25/KWh (5% esc., 1994–95)
Third party Sale	Allowed	Not allowed	Allowed	—	Allowed	Not allowed	Not allowed	Allowed	Allowed
Capital Subsidy	20% (max Rs.25 lacs)	—	Same as for other industries	15% (max. Rs.5 lakhs)	Same as for other industries	—	—	Same as for other industries	30% (max. Rs. 20 lakhs)
Other Incentives	Industry status	No generation tax	No generation tax for 5 yr	—	—	—	Sales tax (exemption/ deferment upto 50% of investment)	Sales tax (exemption/ deferrment upto 100% of investment)	Sales tax (exemption upto 100% of investment)

[a]Policy expired on 31.03.98.

communications and educational opportunities could all benefit from the availability of even low - power devices, thus leading, perhaps, to a slowing of the rural exodus.

The problem of rural energy supply therefore calls for a new approach and a new planning strategy, deliberately oriented to the specialised needs of integrated rural development. In other words, integrated rural development must be sustained by an integrated rural energy system that would encompass all facets of rural energy supply problems and result in optimum matching of supply with demand. Towards this end windmills for water pumping and other energy needs besides wind battery chargers can play a significant role.

In Tamil Nadu about 850 water pumping windmills were installed out of which 120 were geared type deep well wind pumping systems. The rest were 12-PU-500 type with 12 bladed pumping unit with 500 cm. diameter rotor fitted to the windmill. The performance of 12-PU-500 windmills has not been satisfactory due to variety of reasons like improper siting and installation, lack of user awareness, design problems, substandard material usage in the fabrication of windmill to bring down the cost and an improper implementation strategy (Murugappa Polytechnic, 1992).

Many potentially useful projects involving technology transfer, local manufacture, or even just testing and demonstration of renewable energy technologies result in poor performance due to inadequate follow up and little or nothing can be learnt from these exercises. Where there has been some project evaluation or follow up, the resulting reports often remain inaccessible(or unknown) to others who might benefit from reading them and adopt remedial measures. This is precisely what happened in the case of water pumping windmill programme in India. The windmills under National Demonstration Programme were heavily subsidised (the beneficiary has to meet only the foundation cost while the entire machine is given free). The projects such as water pumping windmills will not be sustainable(mainly in the case of community set-up) unless the beneficiaries somehow share a sense of ownership in the projects, and responsibility for carrying out the modest maintenance tasks that the systems require.

The water pumping windmill designs promoted in India were heavy, more expensive than necessary, and were demanding and difficult in terms of the skills and effort needed for successful installation and maintenance.

The new and innovative windpump (mechanical water pumping windmill) offers promise in meeting the needs of farmers and small communities in developing countries, many of which have a suitable wind regime for utilising wind pumps, but do not have a suitable locally manufactured product. The windpump uses modern design methods and materials to combine excellent performance with ease of manufacture, low maintenance and high reliability (Cowley *et al.*, 1999). MNES, Tamil Nadu Energy Development Agency (TEDA) and NEDCAP and other nodal agencies connected with Non-Conventional Energy Sources will do well to import the latest water pumping windmills and wind chargers from UK, Kenya, Argentina, USA and Columbia and adopt them to local conditions as a prelude to promotion on a massive scale to meet rural energy needs.

One criticism for wider deployment of wind powered water pumps has been that they may lead to excessive ground water mining. This is far from reality. Mainly the water pumping wind mills are used to pump water from open wells. Even in areas where they are deployed for underground water pumping, they have minimal effect compared to over 1 million electric motors/diesel pumpsets in operation.

As wind pumping is a well established technology that offers an alternative to diesel and electric pumpsets, and since there are many areas with good wind regime in Tamil Nadu, water pumping windmills will be a boon to conserve electricity (which is heavily subsidised for agricultural purposes) which can find application in other areas. It is hoped that MNES will promote reliable and sturdy windmills for irrigation in the country in general and Tamil Nadu in particular. Proven water pumping wind mills available globally can be adopted to local conditions.

High-speed wind electric generators currently available in a wide variety of models and sizes (Van der Stelt and Wanders, 1979) show a number of potential advantages (Sherman, 1976):

- greater flexibility in siting the wind machines in relation to the well,
- use of high capacity submersible or shaft-type turbine pumps instead of piston pumps,
- availability of pumping powers upto 100 KW or more which can be used in large irrigation projects,
- flexibility of use in conjunction with a rural electricity grid so as to permit continuous pumping, but with reduced electricity consumption.

10. Wind battery chargers for small applications

Wind energy generators can also charge batteries, which can store energy for lighting, radio communication, hospital equipment and to power various emergency-related equipment.

The development of cheap micro and mini wind turbines has made wind energy affordable and relatively easy for those living off the grid without mains power. The development of new inverters, compact fluorescent lamps and other low - power electric devices, as well as the widespread availability of photovoltaic panels has revolutionised living off the grid with a hybrid power system using both wind and solar (Gipe, 1999).

In order to introduce a new technology into a highly political arena, such as electricity generation, a political commitment is required (Garrad, 1995).

In India about 50 wind chargers were installed on a pilot scale. Their performance has not been satisfactory. Today over 100,000 wind chargers are working in Inner Mangolia and studies indicate that levelised costs of off-grid, household scale renewable energy systems are cost competitive with conventional gasoline gen-sets and pv/wind hybrid systems. Thus, wind chargers appear to be an economic means of providing year-round electricity service and meeting the rising energy demands of remote households in Inner Mangolia (Berdner et al., 1994; Byrne et al., 1997; China Electric Power, 1996; He and Shi, 1995; Li, 1991; Zhu, 1988). Tamil Nadu offers good sites to supply power in a decentralised way to charge batteries through wind.

11. Wind energy developments in Andhra Pradesh

In Andhra Pradesh the installed capacity of Windfarms stood at 57.79 MW at the end of September 1998. About 54 MW of this capacity is at Ramagiri. From Table 3 it can be seen that 1995–96 was a boom with installations totaling 38.9 MW with sharp decline subsequently as happened in Tamil Nadu.

11.1. Reasons for slow progress of windfarms in Andhra Pradesh

- In Andhra Pradesh the land for setting up windfarms used to be allotted by Non-Conventional Energy Development Corporation of Andhra Pradesh (NEDCAP). There was undue delay in the process of acquiring the land as well as allotting it. Windfarm developers who want to avail tax benefits were unable to meet the deadline because of delay in the allotment of land. Though Andhra Pradesh was estimated to have 1200 MW wind capacity, the land alienation has become a stumbling block for the progress of windfarms. However, recently the policy of land allotment has been changed and now the Government is allotting land at the market price. The District Administration has been empowered to give advance clearance for land to set up windfarms in the state.
- Ramagiri has a complex terrain. The Consultants and Manufacturers of wind turbines overestimated the generation at Ramagiri based on the wind data from 3 anemometers. The actual generation fell by about 25% from estimated generation. This led to doubts in the minds of the investors on the viability of wind projects in Andhra Pradesh.

A study on Power Generation of 5 Wind Turbines at Ramagiri (Subrahmanyam, 1997) revealed wide variation in percentage of generation with reference to 576 m level from 24.22% to 7.79%.

In complex terrain wind data has to be obtained from an anemometer close to the site where windfarms are to be set up. In California during ‘80s there was one anemometer per 150 to 350 turbines or 10–20 MW while in the ‘90s one anemometer for every two or three 200 KW machines or 0.5 MW capacity (Gipe, 1995; Lynette, 1988). Such an approach is needed in the Andhra Pradesh context.

- Introduction of MAT as well as increase in the interest rates charged by institutions like IREDA contributed to the slowing down of wind activity in Andhra Pradesh.
- Local law and order problems led to the closure of windfarms for some period at Ramagiri. However, the intervention of the Government helped to restart the windfarms there.

11.2. Some progressive measures initiated by NEDCAP to boost windfarms

NEDCAP, a Nodal Agency responsible for the promotion of renewable energy sources in Andhra Pradesh, has taken effective steps to have a 33/220 KV substation with a ring structure exclusively for evacuating power from the windfarms at Ramagiri.

Since most of the identified sites in Ananthapur District in the state are having hilly region, NEDCAP has undertaken contour survey of all the potential areas at 3 m intervals (Reddy, 1997).

Another innovative concept initiated by NEDCAP is Wind Estate. This is mainly to assist the small developers in acquiring land and in the procurement of machinery at reasonable prices, erection, operation and maintenance by NEDCAP on behalf of small developers. Work is on to set up a 20 MW wind estate at Kadavakallu by NEDCAP.

Introduction of sales tax benefits will help to attract investors to set up large windfarms in Andhra Pradesh.

In Andhra Pradesh 320 water pumping windmills were installed but their performance was far from satisfactory. It is hoped both MNES and NEDCAP will promote efficient windmills for irrigation besides wind battery chargers for small applications in Andhra Pradesh.

12. Conclusions and prognosis

The case study of wind energy developments in Tamil Nadu and Andhra Pradesh reveals that incentives like depreciation, tax holiday, customs and excise duty reliefs should continue for some more years until the wind projects sustain on their own. There is a dire necessity to continue wind data studies by setting up more anemometers/windmasts at varying heights of 20,30,40 and 50 m to get accurate wind data rather than relying on extrapolated figures. Latest methods like Geographical Information Systems (GIS) have to be utilised for large-area screening of prospective sites for wind power development. Wind speeds at the height of a wind turbine depend strongly on terrain elevation, exposure, slope, and orientation to prevailing winds, all factors which can be calculated from a GIS-based Digital Elevation Model (DEM). In addition, with the appropriate database, a GIS can account for other factors that affect wind site suitability, such as the distance to nearby transmission lines, proximity to protected areas, and type of vegetation cover. The cost of the wind turbines has to be brought down considerably by indigenising the components. Thorough micrositing is a must by competent experts which will enable the investors to choose the best site and matching it with the suitable machines for optimum generation. The Central Government in co-operation with different State Governments can fix uniform incentives for a healthy growth of windfarms in the country. Creation of a wind fund and peoples participation through windfarm co-operatives will give a fillip to the declining wind activity in the country in general and Tamil Nadu and Andhra Pradesh in particular. Giving permissions to build and operate wind energy installations should be the responsibility of one co-ordinating authority, preferably a decentralised authority, instead of being split up between numerous local and regional agencies. Wind energy plants should be given privileged status in planning and construction law due to their multiple benefits for society. Authorisation procedures should be as simple and unbeaucratic as possible. They must favour wind energy implementation rather than hindering it. The procedures at least should set time limits for the overall authorisation process as well as for each responses from the authorities. Before permitting wind projects, the respective State Electricity Boards should ensure that suitable evacuation facilities through a dedicated substation and stable grid are in place. For optimum generation of energy by windfarms, depreciation and other incentives should be coupled to generation of energy rather than mere tax shelter plan. A remunerative price based on the ever increasing tariff by conventional sources should be fixed for wind energy generated electricity, which will enable faster growth of windfarms. Since Tamil Nadu and Andhra Pradesh have strong agricultural base, reliable water pumping windmills will be a boon to conserve energy as a supplementary to electric and diesel pumpsets in windy areas. The Central and State Governments of Tamil Nadu and Andhra Pradesh should promote water pumping windmills on a large scale. Wind battery chargers have also a role to play in the states of Tamil Nadu and Andhra Pradesh for small-scale power applications. The Centre for Wind Energy Technology (C-WET) coming up in Chennai and the Wind Turbine Test Station at Kayathar in Tamil Nadu through DANIDA assistance are expected to fill the gap of setting and ensuring standards to maintain quality in wind turbines. The all India installed capacity of electric power generating stations under utilities was 93,249 MW as on 31.3.1999 consisting of 22,438.48 MW hydro, 67,617.46 MW thermal, 2225.00 MW nuclear and 1004 MW wind. Thus wind contributes about 1% of the total installed capacity of electric power in the country. The growth in the demand for electricity has traditionally been higher than the growth in generating capacity. The demand – supply gap has been further worsened by the deficits in meeting the planned targets for generating capacity. The country has to add at an average around 9000 MW annually starting mid-1998 against the average of 4500 MW achieved in the past. As such wind energy has a significant role in supplementing the energy demand in the country. With improved design wind turbines, financial package, political will to support large wind projects through public sector undertakings and a remunerative price for wind generated electricity, it is hoped that wind energy will play a supplementary role to meet the growing power demand in the country in general and Tamil Nadu and Andhra Pradesh in particular.

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