IWVC Request For Proposal
10/25/00

Table of Contents:

Project Scope
Project Background
  ❖ Environmental
  ❖ Political
  ❖ Economic
About the IWVC
Joint Venture
Technical Specifications
Specification Requirements

Project Scope:

To design and construction a non-pollutant, safe, low maintenance, cost efficient, 10MW output capacity windmill energy generation system. The site selected will be in the state of Gujarat, India. This project will be executed as a joint venture with the India Wind Ventures Company.
Project Background

1. Environmental Issues

Wind Power Programme

- There is an estimated potential of 20,000 MW of Wind Power generation in India.
- Considerable progress has been made in harnessing the large wind power potential available in the country.
- Supporting this effort is the world’s largest wind resource assessment program.
- New initiatives have been taken in re-assessment and expansion of the wind resource base.
- Centre for Wind Energy Technology has been established.
- Large private sector corporations, public sector units and power utilities are being motivated to set up wind power projects.

Installation:

- India now has the 5th largest wind power installed capacity in the world which has reached 1175MW.
- 1118 MW of the total installed capacity has come through commercial projects.
- About 5.35 billion units of electricity have been fed to various State grids from Wind power projects.

<table>
<thead>
<tr>
<th>SL.NO.</th>
<th>STATE</th>
<th>NO. OF POTENTIAL SITES</th>
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<tbody>
<tr>
<td>1.</td>
<td>Andhra Pradesh</td>
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<td>9.</td>
<td>Orissa</td>
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<td>13.</td>
<td>Uttar Pradesh</td>
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<tr>
<td></td>
<td>Total</td>
<td>192</td>
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Winds in India influenced by:

- Strong South-West summer monsoon
- Weaker north-east winter monsoon
- Strong winds over peninsula during April-September
- Sites with Annual Average Wind Power Density > 150 watts/m² generally viable

**WIND RESOURCE ASSESSMENT**

**Implemented through:** (i) State Nodal Agencies (ii) Centre for Wind Energy Technology (C-WET)

**Financial Assistance:** (i) Full establishment costs of Wind Resource Assessment Project (WRAP) of C-WET by the Central Govt. (ii) 80% of the cost of monitoring stations as per norms by the Central Govt. Remaining 20% to be met by concerned States.

**2. Political Issues**

**GUIDELINES FOR WIND POWER PROJECTS**

- Healthy and orderly development
- Optimal siting of projects
- Selection and installation of quality state-of-the-art machines.
Optimum generation of power

Proper utilization of incentives

Capacities to be announced for each windy location in line with power evaluation facilities.

Project clearance before commencement of work and commissioning certification in accordance with guidelines.

Submission of Detailed Project Report

Siting

Selection of equipment

Capital cost/means of financing

Annual energy output

Cost of generation

Captive generation or sale

O & M

Site Selection and Micro-siting

Quality Aspects

Wind turbine : Type approval/power curve certificate/Self certification by manufacturers

Manufacturing & installation capacity and infrastructure : Quality systems

Grid Parameters

Conformity with laid down parameters

Minimum monthly average power factor

Operation and Maintenance Aspects

Operations & Maintenance (OM)

Spare parts stock
Submission of Monthly Energy Output Statements

Growth of Wind Energy Sector in India: Policy and Installation

Recognizing the importance of tapping renewable energy sources, India has been working in this direction for more than two decades. With the wind power generation capacity reaching 1025 MW, India now ranks fourth in the world, after Germany, US and Denmark respectively. The importance of private sector participation in wind energy was felt as back as 1983-84 during the formulation of Seventh Five-year Plan. A national program was initiated to tap the then estimated potential of 20,000 MW by adopting a market-oriented strategy which has resulted in successful commercial development of wind power technology and substantial additions to power generation capacity in the country.

Significant progress made in this sphere was the result of a range of policy support measures and incentives announced by the government for inducting state-of-the art wind energy technology on one hand, while encouraging private entrepreneurs to take up commercial projects on the other.

Ninth Five-Year Plan: Targets

The recently announced Ninth Five Year Plan of the Government of India for the period 1997-2002 has set an ambitious target of 1000 MW of additional wind capacity installations. Also, at present there are 1800 MW wind power plants, which are at various stages of planning in the states of Tamil Nadu, Gujarat, Andhra Pradesh, Madhya Pradesh, Karnataka, Maharashtra and Kerala. Though the incentives and market-oriented policies existed during the late 1980s, the spurt in private sector participation started only in 1992, after the announcement of the "private power policy" of 1991. This, along with a booming economy and the existing fiscal incentives, provided the impetus for accelerated growth of this sector. But after a period of explosive growth that made India the world's third largest producer of wind power, investment fell sharply from mid-1996 onwards. The possible reasons being as follows: Lowering of tax-credit benefits due to levying of MAT (Minimum alternate tax) and corporate income tax by the Union Government in 1995/96 and 1996/97 respectively. Withdrawal of third-party sale in some states, and Low CUFs (capacity utilization factor).

Ninth Five-Year Plan: Concerns
Currently, total capacity of grid connected wind power plants has reached 1025 MW, of which only 125 MW were installed in the last two years. If the present policy for private sector participation, a not so healthy economy, and the taxation rule(s) remains the same, then the projected Ninth Five-year Plan target of 1000 MW would fall short by around 600 MW. Instead of the current average installation of 60-70 MW, it needs to be increased to almost 200-250 MW to achieve the projected target. Owing to present circumstances, the target of reaching a figure of 1000 MW seems difficult. Hence, there is a need for a policy shift to revive the industry on one end, while meeting the targets on the other. The broad issues and concerns of the wind sector that have to be tackled in order to achieve this target are:

- Favorable fiscal policies
- Lowering of capital cost
- High CUF

1999-2002: Issues and concerns

- The present incentives link investment in wind power to the state of the economy and provide no benefits for lowering capital costs or increasing power generation
- Bad grid management and power evacuation facility leads to low CUF.
- Lack of detailed wind resource assessment and siting, leads to low CUF.
- Negligible foreign investment in commercial wind farm projects.
- The Ministry of Non-conventional Energy Sources guidelines for wind farm development needs a fresh look.
- Need for strengthening of institutions at the center and the state level.

Issues For Discussion

- Shift from investment-linked incentives to performance-linked incentives.
- Administration and monitoring of performance-linked incentives.
- R&D to develop indigenous wind turbine technology leading to cost reduction without compromising on quality and safety standards.
- Long term policy by the State governments to enhance private sector participation.
- Better grid management and effective power evacuation facilities.
To treat Wind as a national resource.
- Regulatory bodies for implementing proper project planning methodologies.
- Wind to be considered under integrated resource planning for energy generation.

3. Economic Issues

Electricity is the key to economic development, and though the per capita electricity consumption in India has risen from 15 to 350 units over the past five decades, it is still way behind the levels prevalent in developed countries. The current power shortage(s) faced by the country has often been cited as one of the main factors hampering industrial growth. As per the current projections, India will require 240,000 MW of installed power generation capacity by 2012, which would entail an annual addition of about 10,000-15,000 MW. The required fossil fuel reserves for power generation is depleting fast. Further, there is a growing concern over the environmental degradation and the warming of the earth, caused by conventional power plants. Against this backdrop, power generation from non-conventional energy resources has assumed significance.

Wind Energy in the International Marketplace

Market opportunities for wind energy systems exist in both industrialized nations and developing countries. These opportunities include sales of wind power plants, village power systems, wind-electric water pumping systems, wind power support for telecommunications, and stand-alone wind systems for homes, cottage industries, health clinics, and community centers. Taken together, prospective wind energy markets could translate into several billion dollars in sales for the U.S. wind industry by 2000.

The U.S. wind industry is already marketing utility wind turbines and complete power plants outside the United States. Since 1990, U.S. firms have installed turbines in Canada, The Netherlands, Mexico, South America, Spain, Ukraine, and the United Kingdom. NREL supports cooperative international wind projects and provides technical assistance to international organizations that support renewable energy deployment.

IREDA Loans for Wind Power Projects
**Project Financing**

(i.) Development of wind farms on lease basis **13.75%**

(ii) Development of wind farms on ownership basis **13.5%**

(iii) Development of wind farms by machines suppliers / manufacturers up to 5 MW /party/year on built, operate, own, lease, transfer basis **13%**

(iv) Development of wind farm / estates with minimum capacity of 10 MW by Cooperative Sector / Public Joint Sector / Private Sector Companies on built operate, own, lease, transfer basis **12.75%**

(v) New technology above 750 KW machines (loan to be provided only under International lines of credit) **12.5%**

(vii) Promoter's Contribution **25%**

(viii) Repayment Period * **10 years**

**Equipment Financing**

(Up to 1MW per party per financial year, Grid connected)

(i) Interest **14.5%**

(ii) Promoter's Contribution Loan up to **80%** of the cost of eligible equipment

(eligible equipment comprise of WEG, Tower, Control Panel, Transformer and Reactive Power Compensator)

(ii) Promoter's Contribution **20%**

(iv) Repayment Period * **10 years**

**Manufacturing of Equipment**

(i) Interest **14%**

(ii) Promoter's Contribution **25%**

(iii) Term loan up to **75%** of total project cost

(iv) Repayment Period* **8 years**
* includes moratorium period

## TOTAL GENERATION FROM WIND POWER PROJECTS (Kwh)

<table>
<thead>
<tr>
<th>State</th>
<th>Generation</th>
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<tbody>
<tr>
<td>Andhra Pradesh</td>
<td>199,535,532</td>
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<tr>
<td>Gujarat</td>
<td>653,707,779</td>
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<td>Karnataka</td>
<td>85,360,352</td>
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<td>Kerala</td>
<td>10,510,585</td>
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<td>Madhya Pradesh</td>
<td>47,706,114</td>
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<td>Maharashtra</td>
<td>54,668,203</td>
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<td>Orissa</td>
<td>1,174,856</td>
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<td>Tamil Nadu</td>
<td>4,439,269,434</td>
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<td>Rajasthan</td>
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<td><strong>Total</strong></td>
<td><strong>5,492,956,005</strong></td>
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## THE ECONOMICS OF WIND POWER PROJECTS

- Capital cost - Rs 4.0 - 4.5 crores per MW
- Cost of generation - Rs 2.00 - 2.50 per kWh, depending upon the site, with incentives
- Costs compare favorably with new conventional power projects
- Added advantage of short gestation, modularity and environment neutrality
- Costs will decline with technology improvements, size of wind turbines and projects, optimal siting and planning
- Cost of fossil fuels increasing.
- Subsidies, externalities and environmental costs not considered for conventional power

### About the IWVC

About the India Wind Ventures Company

India Wind Ventures Company (IWVC) is an internationally established and recognized corporation licensed to conduct business in India. IWVC was established in 1988 and has been in the windmill energy generation business for that past 12 years. India Wind Ventures Company is a private corporation, which is expected to go public in two (2) years.
With our knowledge of modern windmill generation systems, our advanced research and development department, and construction experience, we feel that it is time to use our knowledge to help improve the environment of India; and the living inhabitants of its people.

We have a 6-member management team that continues to study various factors in such an ambitious project as this. These factors include, but not limited to; the environment, politics, economics, marketing, technology, construction, and joint venture structure.

**Lloyd E. Dunn, Jr.,** Business Development Marketing Specialist/Coordinator, generating project interest, Request for Proposal bid letting, to prospective client base.

**Bryan K. Charles** Economic and Politics Professional, specializing in both political and economical issues relevant to this windmill energy generation project.

**Michael J. Lane and James D. Woodland** Technology Engineering Technicians, gathering information about the Technology Infrastructure and Specifications related to windmill energy systems.

**James L. Howard** Public Relations Officer, addressing correspondences from prospective bidders.

**Ronnie Rollins** Joint Venture Structure Specialist, coordinating the joint venture structure.

**Joint Venture**
Contractor Qualifications

The joint venture partner will sign a contract for the assembly of a 10 MW wind powered farm in a given area of India provided by IWVC. The contractor must be a well-established manufacturing company and have experience working with wind powered farms in remote desert areas. IWVC will require that the contractor be ISO 9000 certified; a similar certification may be approved at the discretion of IWVC.
Joint Venture Management and Financial Terms

In entering into a joint venture partnership, IWVC seeks to develop the next generation of wind powered farms. The joint venture objectives and goals include the following:

- To produce a wind powered farm-using 10MW
- To successfully market local consumers in India
- To maintain facilities/resources to service the farm
- To locate the fabrication/service facility in an “economic opportunity” zone in India at the discretion of IWVC
- To create jobs, training opportunities and incentives for the economically underprivileged people in the area
- To seek out international opportunities that will allow further production of wind powered farms that are efficient power sources

The J-V Board of Directors should consist of highly educated and experienced professionals who will successfully merge the mission of IWVC with the goals of the project:

- 3 IWVC executives (CEO, COO, a lawyer or policy liaison)
- 1 IWVC environmental engineer
- 2 JV Partner engineers for development of plans
- 1 JV Partner for technical consulting
- 1 JV Partner production manager
- 1 former/retired government official with experience with global politics of alternative energy issues
- 1 academic from a private alternative energy research firm
- 1 academic from a local university, specializing in wind powered farms as related to India

Strategic contributions to the JV management by both parties will result in a powerful and effective Board of Directors.

IWVC shall have 60% equity ownership of the J-V, while the partner shall own 40%

EQUITY

40%

IWVC
Capital investments will be estimated on the basis of production of wind generate farms and maintaining that production for up to ten years after the J-V start. The ten-year life span of the J-V has been chosen in order to allow sufficient time for evaluation of technical, environmental, social, and political effects. After several years of addressing initial local goals, the progress of the J-V shall determine its entrance into the global market.

Technical Specifications

Wind Turbines as Power Sources

Increasingly popular as alternative sources of energy, wind turbine generators are a type of windmill that produces electricity by harnessing the wind. Wind turbine generators are much less harmful to the environment
than burning fossil fuels, but they do require average wind speeds of at least 21 km/h (13 mph). The compartments at the top containing the generator, hub and gearbox weigh 30,000 to 45,000 pounds. A wind turbine's cost can range upwards to $300,000 and can produce 300 kilowatts an hour - the amount of electricity used by a typical household in a month. The largest machine, such as the one built in Hawaii, has propellers that span more than the length of a football field and stands 20 building stories high, and produces enough electricity to power 1400 homes.

**Turbine Design**

The basic wind energy conversion device is the wind turbine. Although various designs and configurations exist, these turbines are generally grouped into two types: vertical-axis wind turbines, in which the axis of rotation is vertical with respect to the ground (and roughly perpendicular to the wind stream) and horizontal-axis turbines, in which the axis of rotation is horizontal with respect to the ground (and roughly parallel to the wind stream).

Figure 1 illustrates the two types of turbines and typical subsystems for an electricity generation application. The subsystems include a blade or rotor, which converts the energy in the wind to rotational shaft energy; a drive train, usually including a gearbox and a generator; a tower that supports the rotor and drive train; and other equipment, including controls, electrical cables, ground support equipment, and interconnection equipment.

Figure 2 illustrates the basic aerodynamic operating principles of a horizontal axis wind turbine.
The wind passes over both surfaces of the airfoil shaped blade. It passes more rapidly over the longer (upper) side of the airfoil, creating a lower-pressure area above the airfoil. The pressure differential between top and bottom surfaces results in a force, called aerodynamic lift. In an aircraft wing, this force causes the airfoil to "rise," lifting the aircraft off the ground. Since the blades of a wind turbine are constrained to move in a plane with the hub as its center, the lift force causes rotation about the hub. In addition to lift force, a "drag" force perpendicular to the lift force impedes rotor rotation. A prime objective in wind turbine design is for the blade to have a relatively high lift-to-drag ratio. This ratio can be varied along the length of the blade to optimize the turbine’s energy output at various wind speeds.

**Turbine Power Output**

The output of a wind turbine varies with the wind's speed through the rotor. This relationship is usually shown graphically in a power curve (Figure 3).

The "rated wind speed" is the wind speed at which the "rated power" is achieved and generally corresponds to the point at which the conversion efficiency is near its maximum. In many systems, the power output above the rated wind speed is mechanically or electrically maintained at a constant level, allowing more stable system control.
Note that at lower wind speeds, the power output drops off sharply. This can be explained by the cubic power law, which states that the power available in the wind increases eight times for every doubling of wind speed (and decreases eight times for every halving of the wind speed). Using the power curve, it is possible to determine roughly how much power will be produced at the average or mean wind speed prevalent at a site. In the example above, the turbine would produce about 20% of its rated power at an average wind speed of 15 miles per hour (or 20 kilowatts if the turbine was rated at 100 kilowatts). This is somewhat lower than most modern wind turbines.

Inside a Wind Turbine

Wind Turbine Glossary

**Anemometer:** Measures the wind speed and transmits wind speed data to the controller.
**Blades:** Most turbines have either two or three blades. Wind blowing over the blades causes the blades to "lift" and rotate.

**Brake:** A disc brake that can be applied mechanically, electrically, or hydraulically to stop the rotor in emergencies.

**Controller:** The controller starts up the machine at wind speeds of about 8 to 16 miles per hour (mph) and shuts off the machine at about 65 mph. Turbines cannot operate at wind speeds above about 65 mph because their generators could overheat.

**Gear box:** Gears connect the low-speed shaft to the high-speed shaft and increase the rotational speeds from about 30 to 60 rotations per minute (rpm) to about 1200 to 1500 rpm, the rotational speed required by most generators to produce electricity. The gear box is a costly (and heavy) part of the wind turbine and engineers are exploring "direct-drive" generators that operate at lower rotational speeds and don't need gear boxes.

**Generator:** Usually an off-the-shelf induction generator that produces 60-cycle AC electricity.

**High-speed shaft:** Drives the generator.

**Low-speed shaft:** The rotor turns the low-speed shaft at about 30 to 60 rotations per minute.

**Nacelle:** The rotor attaches to the nacelle, which sits atop the tower and includes the gearbox, low- and high-speed shafts, generator, controller, and brake. A cover protects the components inside the nacelle. Some nacelles are large enough for a technician to stand inside while working.

**Pitch:** Blades are turned, or pitched, out of the wind to keep the rotor from turning in winds that are too high or too low to produce electricity.

**Rotor:** The blades and the hub together are called the rotor.

**Tower:** Towers are made from tubular steel (shown here) or steel lattice. Because wind speed increases with height, taller towers enable turbines to capture more energy and generate more electricity.
**Wind direction:** This is an "upwind" turbine, so-called because it operates facing into the wind. Other turbines are designed to run "downwind", facing away from the wind.

**Wind vane:** Measures wind direction and communicates with the yaw drive to orient the turbine properly with respect to the wind.

**Yaw drive:** Upwind turbines face into the wind; the yaw drive is used to keep the rotor facing into the wind as the wind direction changes. Downwind turbines don't require a yaw drive, the wind blows the rotor downwind.

**Yaw motor:** Powers the yaw drive.

**Cost of Wind Energy**

Wind energy is already one of the most cost-competitive renewable energy technologies at about 3 to 5 cents per kilowatt-hour. Even so, wind-generated electricity still costs more than electricity from natural gas or coal plants. However, the wind turbine of the future is expected to close the gap, providing low-cost electricity for homes, businesses, schools, manufacturing plants, and the like. Low-cost turbines will open up a huge market for wind energy in the United States.

Cost, however, is not the only benefit wind turbines offer. Wind energy is an environmental technology that doesn't emit acid rain precursors, greenhouse gases, or other air pollutants. The growing concern about the environment is expected to drive markets for wind energy around the world.
**Specification Requirements**

The following specifications are to be used as guidelines in the design and selection of equipment for this project. Changes to required specifications must meet approval of IWVC before joint venture is granted.

**Rated Output:** Minimum 750 kW per tower

**Annual Output:** Minimum 20,000 megawatt hours per year

**Turbine Design:** Horizontal axis.

**Tower Structure:** Lattice configuration or tubular steel

**Foundation:** For lattice configuration – four (4) individually drilled caissons - diameter and depth to be determined by size of structure. For tubular steel design – concrete cylinder with depth and width to be determined by size of structure.

**Footprint:** For lattice configuration – square base - spaced 1 - 2,000 feet apart. For tubular steel design – circular base – spaced 1 - 2,000 feet apart. Footprint dimensions determined by size of structure.

**Concrete:** Amount to be determined by tower structure chosen and number of towers.

**Steel Reinforcement:** Contingent on type of tower chosen for project.

**Height:** Height from ground level to hub axis should exceed nearest vertical obstacle by 100 feet or more.

**Weight:** To be determined by the tower structure chosen.

**Blade Length:** 24 – 34 meters (79 – 112 feet).

**Rotor Diameter:** 50 – 80 meters (165 – 263 feet).

**Rotor Speed (Variable):** 11 – 34 rpm
**Swept Area:** 20,000 – 50,000 square feet per turbine (65,840 – 164,600 square meters).

**Gearbox Type:** Integrated 2 stage with parallel shafts, or three-step planetary spur gear system.

**Generator Type:** Rotary current asynchronous.

**Inverter Type:** IGBT-frequency inverter.

**Braking Systems:** Individual pitch regulation brake control system: fail-safe.

**Yaw System:** Motor driven with wind direction sensor and automatic cable unwind.

**Control System:** 32 bit microprocessor-based, embedded micro-controller, remote control operating system; microprocessor-based programmable logic controller (PLC); or equivalent.

**Lightning Protection System:** Lightning protection installed on blade tips, discharge inside the rotor blades along nacelle and tower.

**Sound Proofing:** Structure borne noise insulation of the tower, sound reduced gearbox, noise reduced nacelle.

The wind turbines should be certified to IEC Class II for a 30-year fatigue life. IEC Class II requires a wind turbine to withstand hurricane loads of up to 131.1 mph (211 km/hr) as a once in a 50-year occurrence, and 99.8 mph (161 km/hr) as a yearly occurrence.

Prepared by the Graduate Studies Program at North Carolina Agricultural & Technical State University