Considerations for the Use of Wind Power for Borehole Pumping Report No. 1

by: Everett Ressler

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Appropriate Technology Unit
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A. T. UNIT REPORT

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Wind Power for Borehole
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CRDA Appropriate Technology Unit Report

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Appropriate Technology Unit
Christian Relief and Development Association
P. O. Box 5674 Addis Ababa
Tele: 15 94 70
Ethiopia

INTRODUCTION

In response to the many questions concerning the age old skill of harnessing the wind for work, this paper attempts to outline broad conditions useful for those interested in using wind power for borehole pumping.

The material presented includes; a brief introduction to windmill design; wind requirements and wind data collection; site selection, and a brief description of some structural components.

This must be viewed as a working paper. Additional information and suggestions for clarifications are welcomed.

The author expresses his appreciation for the kind assistance of Mr. Carl Jensen, head of the Mechanical Engineering Department, Faculty of Technology, at the Addis Ababa University; Mr. Peter Frankel, of Intermediate Technology Development Group; and Mr. Peter Stern, also of Intermediate Technology Development Group and presently working with the National Water Resources Commission.

1. GENERAL DESCRIPTION

There are three basically different windmill designs:

A. The HIGH SPEED RUNNER which is characterized by propller type blades - usually 2 or 3 blades;

B. The TRADITIONAL WINDMILL which is characterized by having only four to six blades (also known as sails);

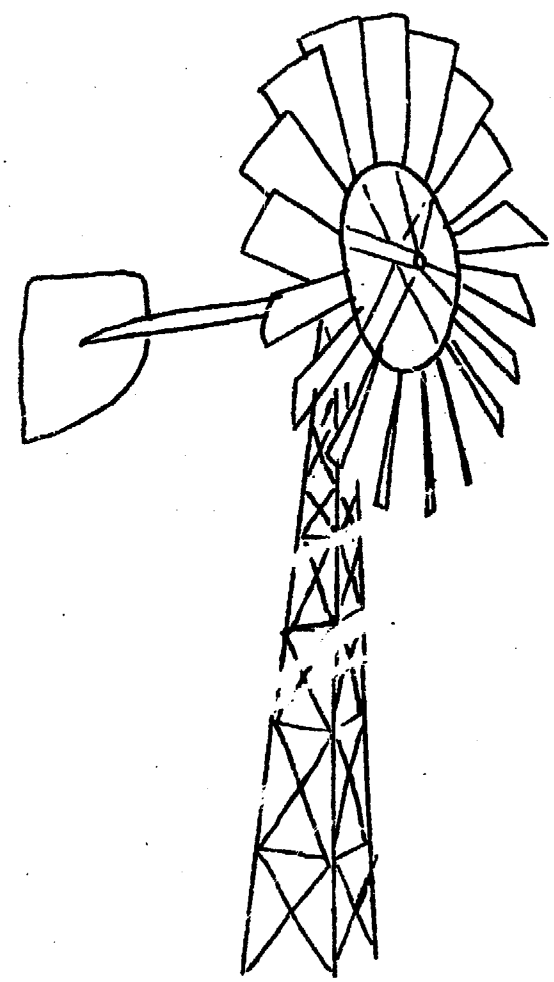
C. And the MULTIPLE BLADED ROTOR (also known as a fanmill) which is characterized by blades covering most of the swept area.

High Speed Runners and Traditional Windmills operate on the principle of an air foil while Multiple Bladed Rotors operate by channeling the air on the principle of a turbine. This basic difference means that the High Speed Runners and Traditional Windmills have a higher speed and a lower starting torgue, more generally adaptable for such work as generating electricity on a small scale, or pumping from very shallow depths.

The Multiple Bladed windmill has a slower speed and a higher starting torgue. It is these features which enable heavy work, such as water pumping, to be done. This windmill design has proven itself over many years as durable while remaining rather simple.

Most commercially produced windmills designed for borehole pumping are of the multiple bladed rotor design. Competing companies offer windmills which usually only differ by slight modification of the components, such as variations of how the windrotor is made, whether a gearbox or crank is used, different governing devices, the type of tail used and how the tower is constructed.

New designs in windmills are generally given wide publicity, and although some have become highly developed for particular purposes, i.e. electrical generation, there is to date no new design which strikingly out-performs the multiple bladed rotor, with comparable inital costs and maintenance needs.



Not only must sophisticated new features be evaluated on a cost benefit basis but also in terms of maintenance, number of replaceable parts, durability, and availability of spare parts.

Thus this paper will concentrate on the multiple bladed rotor.

WIND REQUIREMENTS

The most important consideration in any evaluation of whether a windmill can be used at a particular site depends on whether there is enough wind.

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Wind strength and pattern

A "rule of thumb" for wind speeds required to operate a windmill for borehole pumping is;

- Average wind speed of 0 - 6 mph - Impossible
- Average wind speed of 6 - 10 mph - Marginal
- Average wind speed of 10 -12 mph - Good

Generally, the wind blows during the day and slacks off at night, is more forceful on the coast, near a large lake, or on the edge of a desert. (At some places in the middle of a desert there can also be strong desert winds) The wind is typically weaker in valleys.

However, specific wind data is essential !!

Average Wind Speed - The average wind speed can be very misleading. If the wind should blow hard for several hours then sharply drop off, the average over a day may appear inadequate. Yet the more forceful wind, if consistent, may be enough to fill a reservoir or provide water for irrigation.

Pattern of the Wind - Not only must the pattern of the daily wind be considered but also the wind pattern of the seasons. In some areas there may be high winds part of the year and no wind during other seasons.

If the windmill is providing a basic water supply, there must never be inadequate winds for more than 3 to 4 consecutive days or there must be storage facilities adequate to provide water during the time when the wind is inadequate.

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Before choosing a windmill, the recommended length of time for studying the wind data of an area is three to five years. If that is not feasible, even more emphasis must be placed on the collection of all available wind data.

Wind Data Available in Ethiopia

The most comprehensive wind data presently available is an "Analysis of Wind Data in the Drought Affected Areas in Ethiopia " by C.A. Munoz. The data was compiled from the wind records of the :
National Water Resources Commission, Ministry of Community Development, Bilerle Agricultural Estate, Alemaye College of Agriculture, Chilalo Agricultural Development Unit and Wollamo Agricultural Development Unit.

This paper is available from the National Water Resources Commission, or from the A.T. Unit.

Collection of Wind Data

If no data is available on the specific area being considered then it is necessary to do the best analysis possible.

Aids for assessing the wind include the following;

a. Survey the opinions of local residents as to the daily and seasonal patterns of the wind and whether they think it is a windly or calm area.

b. The Beaufort Wind Scale can be used to estimate a specific wind speed from observations such as how the wind blows the trees etc.

c. An Animometer for measuring wind speed is very important to any serious data collection. Animometers are available on loan from the National Water Resources Commission.

d. Another instrument which may be useful for wind readings is the Hand-Airspeed Indicator. It is an easy to use inexpensive instrument.

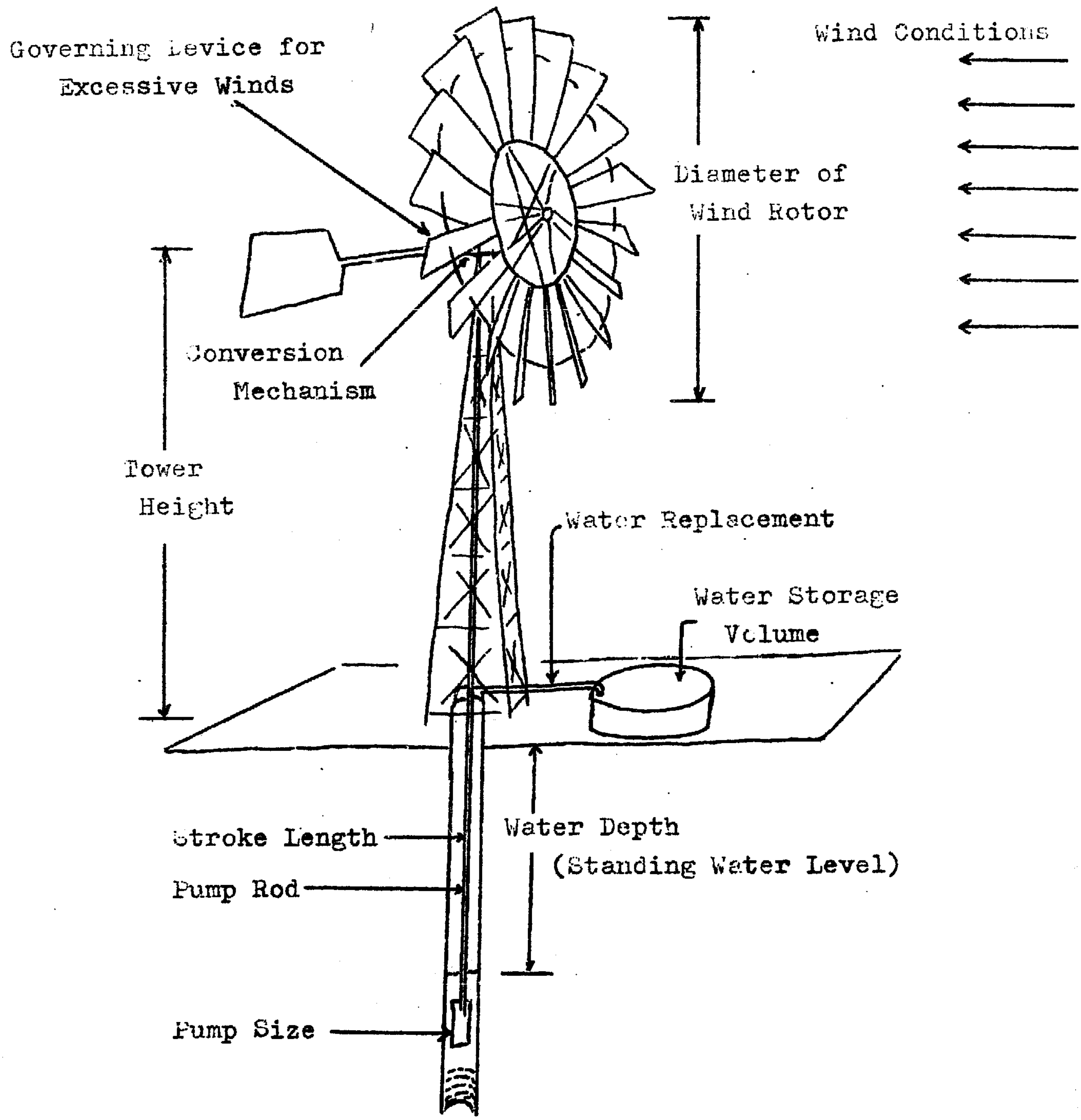
Other Considerations of the Wind

The size of the windrotor will be determined by the wind strength and the amount of work to be done. For a specific amount of work, the lower the wind the larger the windrotor must be.

It should also be noted that to start the rotor moving requires a stronger wind than is needed to keep it turning.

Also, one of the primary factors in wind requirements, both for starting and maintaining rotation is pump size and static water head. Very simply, as the volume of water needed increases or as the depth of the water increases, so must the power (wind strength) increase.

In evaluating any windmill, the components to be considered are:



The Consideration of Windmill Componets

1. Diameter of the Rotor - Generally, the stronger the wind the smaller the windrotor need be. However, the diameter of the rotor must be of adequate size to utilize the weak or marginal winds.

   When maximum use of the windmill is essential in areas of marginal wind, particularly for borehole pumping, probably not less than a 20 ft. diameter rotor should be considered.

2. Governing Device for Exeessive Winds - Windmills can be severely damaged or destroyed by excessively strong winds. Thus a type of governing device for excessive winds is an essential component to be considered in selecting any windmill. Considerations include whether the windmill will be basically left unattended or whether in a sudden severe wind, manual operations can be depended on.

   All multiple bladed rotor type windmills must have a governing device to cope with excessive winds. Some windmills are designed to be manually turned out of the wind and have a hand brake to stop the rotation of the rotor.

   Many commerical windmills have automatic governing devices which generally consist of a hinged tail, either connected to a spring or which works by gravity. Some windmills are built with the rotor slightly off center of the mast so that excessive winds force the rotor out of the wind.

3. Motion Conversion Mechanism - To change the horizontal rotation of the rotor shaft to a reciprocating vertical motion for pumping. The mechanisms used are either a gearbox or simple crank.

The pros and cons of these options have been debated for years. The gear box provides the advantage that through gearing down, greater torgue can be obtained. However, gearboxes are a complication in that the gears are parts that demand service.

It should be stated that both the gearbox and simple crank systems are quite dependable.

4. Tower - The general considerations for tower height focus on site location in reference to wind obstructions and diameter of rotor required.

In open areas with no wind obstructions, a tower height of 7 - 12 meters is probably adequate. However, if a commercial windmill is being purchased, in light of its comparitively high cost, it may be better to accept the manufactors recommendations on tower height which, although possibily higher than necessary for the normal operation of the windmill, will maximize the use of the wind.

Where obstructions exist, most commerical windmill companies recommend that the bottom of the rotor be 5 - 6 meters above the level of the obstruction.

5. Stroke Length - Stroke length is the distance the pump rod moves up and down. For commerical windmills the stroke length is either initially set or there exists a possibility of varying the stroke length. The stroke length to be used for a given pump diameter depends on the water pumping head and the wind strength. Shortening the stroke allows the windrotor load to be reduced but at the expense of a reduced pumping rate.

6. Pump Rods - Pump rods are either produced of wood or galvanized steel. Wood may be considered although it is prone to rot, particularly the end that dips into the water, and is prone to attack by insects.

7. Water Storage Tank - Although commercially produced water storage tanks are available, it is an item that can be constructed from locally available materials. Welded steel tanks are assembled at Akaki. The storage volume required will depend on the water requirement, availability of water, and the regularity of the wind.

8. Pump Size - For a given windmill the pump size will be determined by the water requirement, water depth, and the wind strength. Although the windmill is sometimes purchased prior to the well drilling, the pump size cannot be determined before the borehole has been completed. Most suppliers will air freight the pump.

9. <u>Site Considerations</u> - Where to locate the windmill is generally dictated by where the water is. However, general considerations are listed below.

A. Locate the windmill away from obstructions as trees, buildings, etc. Most windmill companies recommend 150 to 200 meter distance.

B. Prime consideration should be given to minimize, where possible, the height the windmill must lift the water. As an example, it may be more advantageous to drill a borehold in a valley where a shallow well can be obtained, than to drill on the top of a mountain where there is more wind but where the height the water must be lifted is greatly increased.

If the lift-head is halved, twice the amount of water is obtained at the same power.

C. Site Selection should include the wishes of the local people.

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In summerizing these considerations, the data needed to determine the basic components of a windmill are:

1. The best wind data available.
2. The standing level of the water.
3. The amount of water required.
4. Site considerations.

Windmills in Ethiopia

Windmills have been used in some places in Ethiopia for many years and the older windmills have usually been built here. One such windmill can still be seen in Waldia near the Commerical Bank there.

American Presbterian Mission have built 19 windmills and are presently constructing as many as 80 more. These small windmills, built on site, are used for pumping water from the Omo River to irrigate garden plots on the river bank. Their small size, 1[illegible] [illegible]. windrotors, and simple contruction make them quite suited for small plot river irrigation. The cost of these windmills is estimated to be Eth $700 per windmill. Further information on these windmills can be obtained by contacting the A.T. Unit.

Under the direction of Mr. Karl Jensen, the Mechanical Engineering Department Head, the Faculty of Technology of the Addis Ababa University has done research on many types of windmills and pump. They are presently designing and testing a windmill which can be used for borehole pumping and can be produced locally. The Faculty of Technology should be considered an important resource for anyone involved in windmills.

Professor Gouin and Mr. Phillipino of the Geophysical Observatory have developed an experimental, vertical axis wind rotor. Vertical axis rotors typically are most feasible for smaller units. Data on this particular unit should be available in the future.

Information on the other existing windmills is welcomed by the A.T. Unit.

Cost of Commercial Windmills

The only comparative cost data presently available at the A.T. Unit is from a Dar Es Salaam University report published in 1974. The price, for a similar windmill, was compared between four major commercial windmill companies. The conclusions can be summerized as follows:

a. The least expensive windmill was the Dempster.
b. Southern Cross was second and was more than twice as expensive as the Dempster.
c. Comet, which was third, was approximately 8% more than the Southern Cross.
d. The Lubing windmill cost triple that of the Comet.

The above cost comparison was for a small windmill but the order remains basically the same for other size windmills, with the Dempster being the least expensive and the Lubing being the more expensive. Of course each of these windmills is unique.

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A Southern Cross Windmill composed of a 21 ft. diameter rotor on a 45-55 ft. tower delivered to Djibouti will presently (Sept. 1975) cost approximately Eth $19,000. This does not include the pump or other excessories. The company representative indicated that this size windmill is capable of pumping water from a depth of approximately 190 meters, assuming the wind is adequate.

Commercial windmill Companies

Aeromotor Windmill
Broken Arrow
Oklahoma
USA 74012

- A multiple bladed rotor type windmill

Climax Windmills
Wyatt Bros.
Ltd, White Church
Salop,
England

- A multiple bladed rotor windmill (There is reportedly a number of climax windmills in Sudan)

Comet Windmills
Sidney Williams & Co. Ltd.
P.O.Box 22
Dulwich Hill, N.J.W.
Australia 2203

- A multiple bladed rotor type windmill

Dempster Windmills
Beatrice
Nebraska
U.S.A.

- A multiple bladed rotor type windmill (American Mission has installed two Dempsters on the Omo River)

Lubing Windmills
Maschinea Fubrik
Lubwig Benins
2847 Barnstort
Postfach 171,
Germany

Addis Ababa Agent
Jos. Hansen and Soehne
Tel. 44 72 00

- A high speed runner type windmill with three fibreglass propellers.

Comment: Most suitable for supplying electricity or household water, or draining or irrigating small areas of land. It can be used for deep well pumps not exceeding 10 meters. Only small diameter rotors are produced.

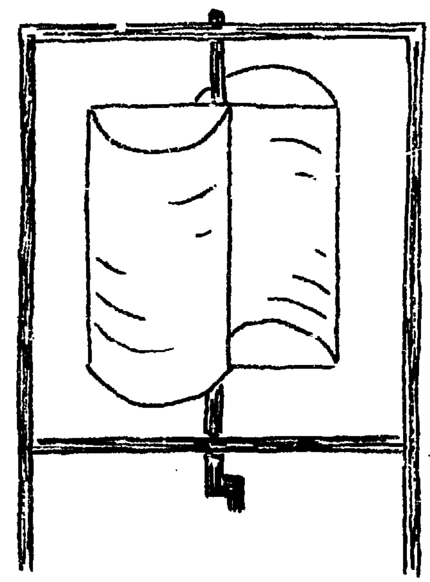
Southern Cross Windmills
P.O.Box 424
Toowomba
Queensland
Australia 4350

Addis Ababa Agent
Ato Girma W. Georgis
Tel. 15 33 92
11 47 05

- A multiple bladed rotor type windmill (One Southern Cross has been installed at Meki. The Relief and Rehabilitation have reportedly been given 6 which are not yet installed. World Vision of Ethiopia have purchased six for the Sidamo area. The Catholic Secretariat has purchased six.)

The Savonius Rotor Windmill

The Savonius Rotor Windmill, many times made of metal oil drum halves welded together around a shaft, has received much publicity as an easy to build, inexpensive, do-it-yourself windmill.



However, this type of windmill is quite limited due to the fact that it is much less efficient than other type windmills and therefore will pump much less water in a given wind strength for a given size machine.

Other disadvantages include a high construction cost for the power output, compared with other type windmills, and for larger units there is many times a balancing problem.

For comparison of work performance, it would take a Savonius Rotor with a projected area of approximately 400 square ft. to do the same work as a 20 ft. diameter multiple bladed rotor.

The Faculty of Technology have done extensive testing of the Savonius Rotor if more information is desired. The American Mission have also experimented with three Savonius Rotors on the Omo River, The Beaufort Wind Scale

Description	Kilometers per hour	Miles per hour	Specifications for estimating speed over land
Calm	<1	<1	Calm; smoke rises vertically.
Light air	1 - 5	1 - 3	Direction of wind shown by smoke-drift but not by wind vanes.
Light breeze	6 - 11	4 - 7	Wind felt on face; leaves rustle; ordinary vanes moved by wind.
Gentle breeze	12 - 19	8 - 12	Leaves and small twigs in constant motion; wind extends light flag.
Moderate breeze	20 - 28	13 - 18	Raises dust and loose paper; small branches are moved.
Fresh breeze	29 - 38	19 - 24	Small trees in leaf begin to sway, crested wavelets form on inland waters.
Strong breeze	39 - 49	25 - 31	Large branches in motion; whistling heard in telephone wires; umbrellas used with difficulty.