Power from the Wind

K. S. Fernando

Deputy General Manager, Wind Energy Unit, Water Resources Board

It is widely believed that by the turn of the century the cost of a barrel of oil would exceed US $ 100.00. This means that oil which served man for decades would be beyond the reach of a large number of developing countries and would be a costly source of energy even for the developed countries. Besides the fact that oil is a fast depleting resource, the volatile political situation in the Middle East which supplies the major volume of the world's oil requirements could seriously influence the future oil supplies and its price factor. In this context, the urgent need to search for alternative sources of energy to fulfil the energy demand of the country cannot be overemphasized. Harnessing the infinite quantum of energy in the wind is only one such alternative. This paper outlines briefly the state of the art in a global context and describes the approach of the Water Resources Board in this direction.

Wind Power

The source of wind is in the atmospheric temperature differences generated by the sun which in turn gives rise to pressure differentials. The wind is a mechanism for dissipating as kinetic energy the potential energy accumulated in those pressure differences.

For centuries, mankind has used wind as a source of power to propel his boat, draw water from the ground, to grind his cereals and for various other needs. There is evidence that the ancient Egyptians used windmills as early as 3600 B.C. to pump water to irrigate their arid fields and to grind grains.

But, with the invention of more efficient machines which have a higher power to weight ratio, obviously, the ancient windmills got gradually pushed aside as a source of power. As this happened in the very early stages of the development of science and technology, not many scientific studies were made on windmills. However, the beginning of the 20th century witnessed several renewed attempts to revive this technology with the help of the then available scientific knowledge derived mostly from the aircraft industry. But as the industrialised countries at that time had a strong political and economical control over the oil producing countries, the need to develop alternatives was not taken as a matter of serious concern. Thus these attempts which were mostly initiated by enthusiastic influence failed to gather momentum, mainly due to the lack of governmental support. However, though at the lower level of activity, research on wind power was continued throughout the past few decades. As a result, today the use of windmills could be considered both technically and economically a viable proposition, specially for such small scale application as water pumping and domestic lighting in rural areas.

Wind Energy Utilisation Project

During the past two years, the Wind Energy Unit of the Water Resources Board has been conducting a research programme with a view to introduce the technology of windmills to Sri Lanka and thus promote its wide use for small scale power needs in various economic activities in the country. This project is assisted by the Government of the Netherlands through the Netherlands Steering Committee on wind energy for developing countries by way of providing expertise and equipment.

Objectives of the programme could be classified as follows:

(1) Assessment of the wind potential in different regions of the country.

(2) Carry out feasibility studies for the use of wind power as an alternative source of energy for water pumping in the rural agricultural sector in Sri Lanka.

(3) Design and develop windmills for water pumping for local manufacture using local raw materials to a maximum.

(4) Introduce the technology of windmills to Sri Lanka and thereby promote its manufacture and application through an organised extension service.

(5) To organise a technical body and train its personnel in Sri Lanka for further development of the technology of windmills, locally.

Though wind power could be used for a variety of power needs, its application to agriculture was given priority as this sector still plays a dominant role in the economy of Sri Lanka.

Wind Potential in Sri Lanka

During the period from May to September, the entire Dry Zone experiences strong winds, the monthly average speed of which lies between 4 to 5 metres per second. The Hambantota District which records the highest windspeed in the country, experiences such winds almost throughout the year. Table I attached gives the monthly average windspeeds of a few selected areas of the country.

MEAN WIND VELOCITY

Table I

Units: meters/second

Station	*Jan.*	*Feb.*	*Mar.*	*Apr.*	*May*	*June*	*July*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*	*Year*
Hambantota	5.73	5.47	4.36	4.00	4.76	6.62	6.40	6.62	6.49	5.11	3.82	5.16	5.38
Puttalam	3.22	3.28	2.66	2.97	5.17	5.91	6.10	5.71	4.75	3.18	2.08	2.78	3.98
Mahiyangana	0.92	1.10	1.06	1.03	1.56	2.94	3.10	2.98	1.79	1.36	1.21	1.08	1.68
Trincomalee	1.58	1.38	1.36	1.43	1.45	5.02	5.25	4.70	3.07	1.94	1.33	1.29	2.48
Jaffna	2.23	1.96	1.88	2.46	6.31	7.29	4.71	4.21	4.31	2.71	2.22	2.22	3.54
Polonnaruwa	1.70	1.42	1.43	1.50	2.77	4.22	4.53	4.08	2.56	1.84	1.82	1.79	2.47
Mannar	4.13	3.38	2.00	2.89	4.13	4.58	4.13	4.13	4.22	3.16	2.98	3.96	3.64

The power output of a windmill is directly proportional to the third power of the windspeed. There fore, when the windspeed doubles, the power output of a given windmill increases by eight times. This shows that a reasonable prediction of the output of a windmill requires an accurate long term analysis of the windspeeds of the particular area. As windspeeds vary from region to region, the small windmill under identical pumping conditions would give varying outputs in two different regions thus making the cost of pumping a variable factor. Therefore, when designing windmills much attention has to be paid to the aspect of matching the pump with the windmill taking into consideration the prevailing local windspeeds.

Design and Development Work

The design work carried out by this unit during the past two years has enabled this unit to produce two prototype windmill pumps. The following criteria were used as guidelines for the design of these prototypes:

(a) Maximum use of locally available materials

(b) Simplicity of the machine which makes manufacture possible with the basic machine tools which are normally found in workshops in remote areas.

(c) Designed windspeed to be matched with the average windspeed prevalent during the windy season in the Dry Zone. The basic parameters of the two prototypes developed within these constraints are given below :—

	I/2	II/2
(1) Rotor diameter (M)	3	5
(2) Tip speed ratio (—)	2	2
(3) Tower Height (M)	6/9	6/9
(4) Pump Diameter (M)	0.1	0.1
(5) Stroke variable upto (M)	0.15	0.25
(6) Output with a lift head of 10 metres at an average wind speed of 4½ metres per second	25-35 cu. metres per day	65-95 cu.m. per day

As the output of a windmill depends not only on the average windspeed but also on the speed fluctuations over the day, a generalised output prediction could only be made through long term field testing.

The tower of the windmill is a four legged bolted angle iron construction and curved G.I. sheets are being used as rotor blades. The tail vane mounted on an inclined hinge keeps the rotor always facing the wind. The machine is coupled to a simple reciprocating pump via a long pump rod which is properly guided inside the rising pipe. A reciprocating type of pump was selected for this purpose mainly because of the simplicity of manufacture and maintenance. However, its dynamic behaviour and the high starting torque makes its use possible only with slow speed windmills.

Economics of wind power

The power output of a given windmill depends entirely on the windspeed. The output of a windmill under identical conditions in two different regions varies with the prevailing windspeeds. Hence the cost of a 1000 gallons of water pumped for example in Hambantota is different from that in Batticaloa. Recently, a theoretical study was made by us to compare the cost of pumping with wind power with that by conventional kerosene pumps under identical pumping conditions. This study revealed that on the basis of annual costs, wind power is an economical alternative for water pumping in most parts of the country. However, with the escalating fuel prices, the relative cost of windpower would be on the decline, thus making it more and more attractive as an alternative source of power for water pumping. But the comparatively high capital cost of a windmill pump unit is the main factor retarding its wide application, specially at the level of the small scale farmer, who should be the ultimate beneficiary of this programme. Much attention is now being paid to this aspect of the project and it is believed that a scheme could be worked out in the future to provide financial assistance to farmers through banks. Reliability, performance and durability of these pump units are the key factors which have to be thoroughly studied under field conditions before any recommendation could be made to the banks to provide financial assistance for the purchase of windmills. In order to fulfil this, the Wind Energy Unit now carries out preparatory work in establishing a series of pilot projects in different areas of the country where there is a favourable wind potential.

Extension Services

Unlike the engines or motor driven pumps, the performance of the windmill pump is clearly defined by the local conditions such as terrain, wind speeds, existing buildings, trees, etc. Therefore, even the most efficient windmill when poorly matched with the load or badly located would give a low output. This is one of the reasons for the failure of several early attempts of using wind power in Sri Lanka.

Therefore, it is considered very vital to advise the public through an extension service unit, the proper matching and locating of windmills so that the highest possible energy extraction is obtained from a given windmill thus making it an economically viable unit.

Future plans of the project

After having gained sufficient experience in designing and manufacturing of small slow running windmills, the plan envisages the development of fast running and slightly larger windmills. Such machines with higher outputs would be more suitable for group activities such as lift irrigation projects or large scale farms. But the development of such machines would undoubtedly confront a whole series of new technical problems that are not normally found in slow running machines. It is unlikely that such a design would be available for commercial manufacture before 1985.

The Unit also plans to broaden its network of windspeed measurements in order to carry out an almost islandwide survey of the wind potential. The significance of such a survey is that it forms the basis for prediction of wind energy output in different regions of the country, which in turn determines the economic viability of the use of wind power.