POSSIBILITIES OF USING WIND POWER IN HUNGARY

By

M. Blahó

Department of Fluid Mechanics, Technical University, Budapest

Received July 2, 1980

Presented by Prof. Dr. T. Szentmártony

1. General Aspects of Utilizing Wind Power

Wind power is a very challenging source of energy. Without speaking of old windmills, several recent attempts have been made for utilizing it, using different types of wheels, having different gear systems, different safety devices against overload, pumping water or producing electricity, storing the energy in water tanks, batteries or compressed air vessels, etc. But we have to realize that there is a problem in every approach to utilization. These problems are the reason why no unique system has been evolved as yet.

Let us inspect the advantages and disadvantages of wind energy.

The advantages are:

1. It is a perfectly renewing energy (as long as the sun exists).
2. It is practically infinite.
3. It is available all over the world.
4. It cannot be used for other purposes, like oil or brown coal.
5. It is a mechanical energy, easy to transform.
6. It does not contaminate the environment like radioactive waste.
7. There are no transportation costs.

The disadvantages are:

1. It changes in time. One must have a storage or a very wide network (continental size).
2. It is not concentrated; exploiting requires large dimensions.
3. There are high peak values, limitation- and safety problems.

As for the types of windmills the two basic types are: the one with a vertical shaft and the one with a horizontal shaft.

The vertical shaft type has the great advantage that it functions regardless of the wind direction. The vertical shaft can be led down to the surface directly and the generator can be arranged on the ground level.

But some disks or spokes are necessary to hold the vanes, and centrifugal force will bend them. There is a big bending moment on the shaft root unless the top of the shaft is fixed by cables, which is inconvenient to arrange.

A very interesting solution is the Darrieus-turbine (Fig. 1) which has two or three narrow steal bands for vanes. The disadvantages mentioned above are eliminated by this construction but I cannot imagine that the vertical shaft type will ever serve for big power-plants.

The horizontal shaft, or propeller type can run at a higher speed and drive the generator directly. The vanes can be fixed to the hub directly and centrifugal force gives tension stress only. The profiles of the vanes can be set at optimum performance at each radius.

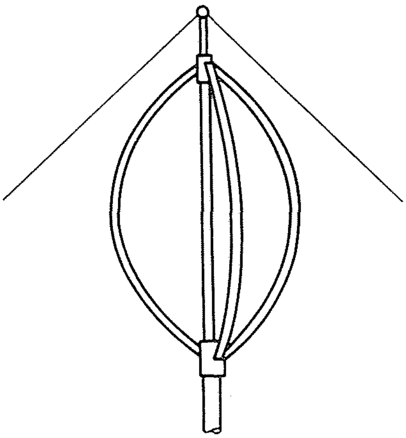

Fig. 1.

For producing electricity we must have as high speed as possible. A speed-up gear is practically no solution because of the high torque on the low speed shaft. A more realistic solution is the multipole generator which also has its technical and economical limits.

Thus the speed and the torque on the shaft limit the diameter of the wheel.

Let us suppose a speed ratio of $\lambda = 6$, a wind speed of $v = 10$ m/s, and a wheel diameter of $D = 20$ m. The speed ratio means that the tip-speed of the wheel is 6 times the wind speed (a fairly high value), i.e. 60 m/s in our case. The angular velocity of the wheel is 6/s and the speed nearly 60 r.p.m.

If we want to generate an alternating current of period 50/s we need

$\frac{3000}{60} = 50$ pair of poles. This is possible but requires a big and heavy generator and can be regarded as an upper limit.

The power that can be gained from this wheel is about 80 kW at a wind speed of 10 m/s.

The average power produced by the wheel would be much less than 80 kW, in Hungary about 1/5 of it (as it will be shown later).

This calculation shows that for a big power plant we must use many windmills of not more than about 20 m in diameter each. These can be assembled on one big structure which must be turned always against the wind.

Another problem is the changing speed of the windmill. Neither the voltage, nor the period can be kept constant in this case. The current can be transformed by electrical means but it involves further installation and losses. This problem does not arise if the power is used for heating. Heating is by far the easiest application; the heated water serves for energy storage too, but the precious mechanical energy is turned into heat energy. Nevertheless, a great portion of the present electrical energy is used for heating anyway.

2. Wind Power available in Hungary

Wind speed data of 17 meteorological stations (Fig. 2) have been processed by Mr. A. Ledács-Kiss, the greatest pioneer of utilizing wind energy in Hungary. Unfortunately, most observations were not representing the wind power properly. The wheels of the instruments were at a height of 10 m above the surrounding surface and trees and buildings of nearly the same height were around them. The most reliable data come from Siófok where the observatory is just on the shore of the lake Balaton, and from Pápa, another well situated observatory. It would be better to have data from a higher altitude (say 30 m) because the extrapolation of wind power to a greater altitude is uncertain.

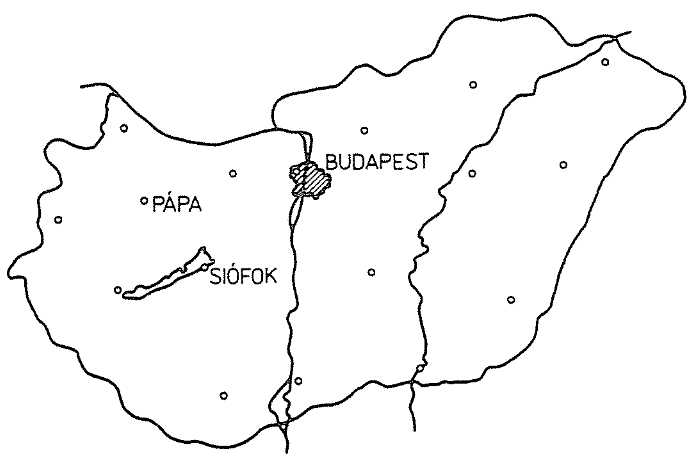

Fig. 2.

The hourly values of wind speed on the 1st of April 1964 at Pápa can be seen in Fig. 3. The graph also shows the power that can be gained from the wind with an overall efficiency of 0.7, i.e. a power coefficient of 0.42, in W/m^2 (dotted line). The next graph shows the same for the 2nd of April etc. There was no wind except at night on the 4th.

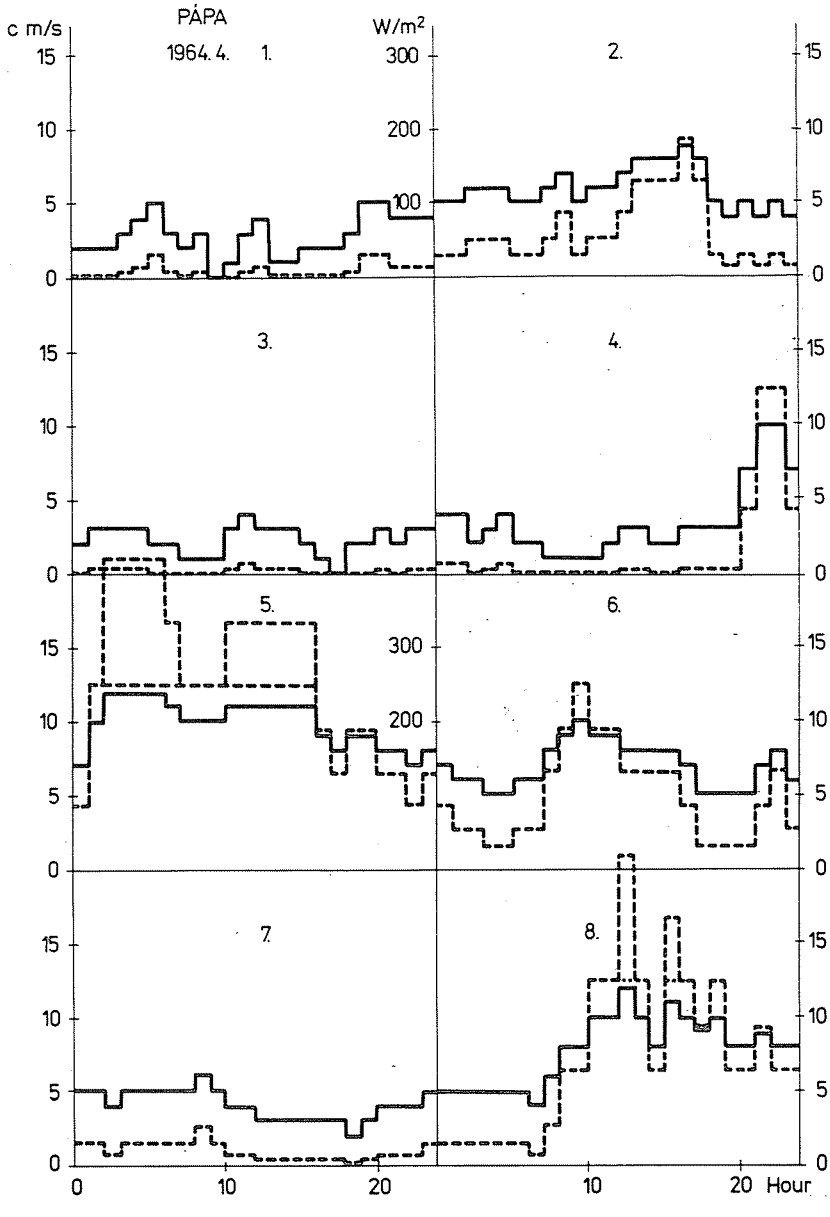

Fig. 3.

The 5th and 6th, both were very windy days, while the 7th had low wind. The 8th was windy again.

Calculating the average of each day, disregarding the power under 5 m/s wind speed and limiting the power at 250 W/m², corresponding to a wind speed of 10 m/s, we get the graph in Fig. 4. It can be seen that storing the energy for about 10 days is necessary unless there are several wind power plants all over the country, possibly a network connected with the neighbouring countries. The coincidence of low wind days is characterized by the graph in Fig. 5, giving the variation of the sum of wind power at the 17 observatories scattered all over Hungary. The longest low-wind period lasted 4 days only.

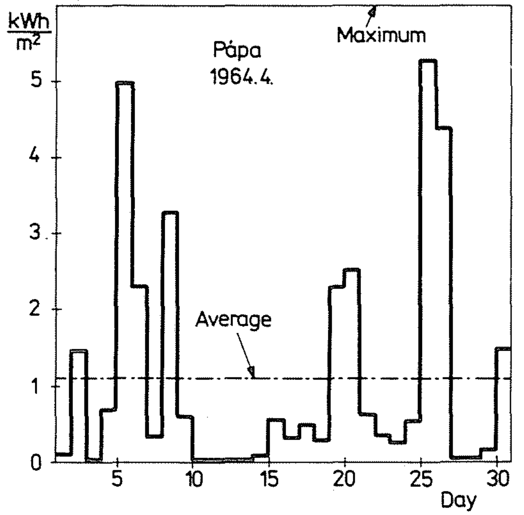

Fig. 4.

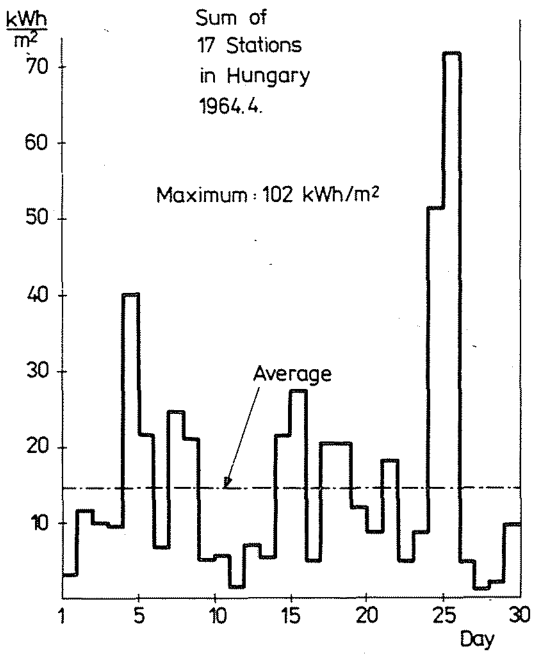

Fig. 5.

The monthly variation is shown in Fig. 6 for the year 1970, at Siófok. The windy season seems to be the spring, except of the peak in July which was probably a random case.

Taking the data from Pápa (the next best data) as featuring the available wind energy of the whole country, the total electric energy produced from wind

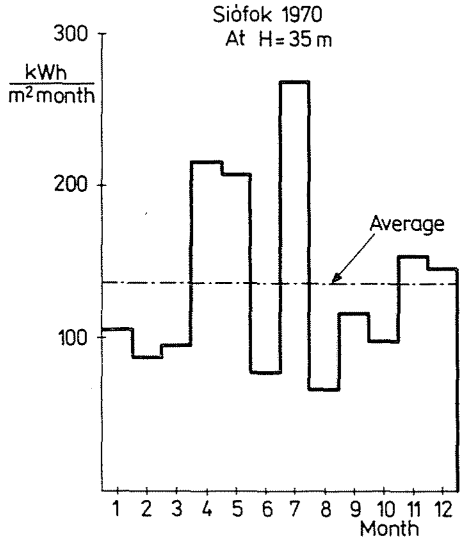

Fig. 6.

power at the above restrictions, but extrapolated to a height of 35 m, is about 850 kWh/m^2, year.

Imagining a power plant having 18 wheels of 20 m diameter each, an area of 5650 m^2 would be covered. This power plant would produce about 4.8×10^6 kWh energy a year. The consumption of Hungary being presently 27×10^9 kWh/year, 5600 such power plants would be necessary for covering all the requirements from wind energy only. This would be an immense number of big windmill assemblies but bearing in mind the sophisticated and expensive devices necessary for a heat power-plant, and the advantages listed above, it cannot be rejected. I want to point out that the wind power-plant practically does not take any useful area of the ground as the lowest points of the wheels can be at a height of 10 or 15 m.

3. Cost Estimation

There are two questions which make the cost estimation very uncertain, if not impossible:

1. Do we regard the wind power network as a separate power supply system, or as a fuel saving device for the heat power-plants? In the first case the

wind power system has to cover the peak consumption and has to store all the necessary energy for the low-wind periods. In the second case the same quantity of heat power-plants have to be installed to cover all possible momentary consumption (if there is no wind) and the installation cost of the windmill must be less than the cost of only the fuel saved.

2. For how many years can we use the wind power-plant once installed? Since there are no fuel and very little maintainance cost, the cost of the produced energy depends practically only on the installation cost for one year. Now, the working period of a windmill seems to be infinite, with regular overhauling of the bearings. There is no heat load as in a heat power-plant, and the material of the wheel must withstand the weather conditions only which is no problem nowadays. On the other hand, many of the windmills hitherto constructed were spoiled by some accident or a big storm within one year, or so.

In order to have some idea of the economics, in spite of the above difficulties, let us take a fuel saving windmill. The fuel cost of a heat power-plant based on coal is about $\frac{1}{4}$ of its yearly amortization calculated for 25 years. This means that the fuel saving wind power-plant cannot be economical in present times unless its installation cost is about $\frac{1}{4}$ of that of a heat power-plant of the same capacity which does not seem possible. By this I do not want to say that we should not make pilot wind power-plants for the future.

4. What has been done until now in Hungary

A book was written by Mr. Ledács-Kiss and having worked out the meteorological data, an essay was prepared about the possibilities of using wind power in Hungary.

Beside these theoretical steps there have been only a few private attempts.

The constructions of Mr. Ledács-Kiss were the following: Up to now 3 windmills were made all for a maximum power of 1 kW. The first one was exhibited at the Trade Fair of Budapest in 1969. This had a speed-up gear and a direct current generator. It had to be installed on places surrounded by trees. Because of this and of the gear it never generated enough voltage to load the battery unit. The second windmill was offered to the Town Council of Kecskemét for supplying the field schools in the hamlet settlements around that city. It was made of aluminium to propagate the production of this metal. The wheel worked well but the guide-vane was not sufficient for keeping it against the wind. It was abandoned after the Town-Council had decided to use petrol engine aggregates.

The third one has just been finished in recent days. It is meant for heating purposes in the Alumina Factory at Mosonmagyaróvár. If good results are

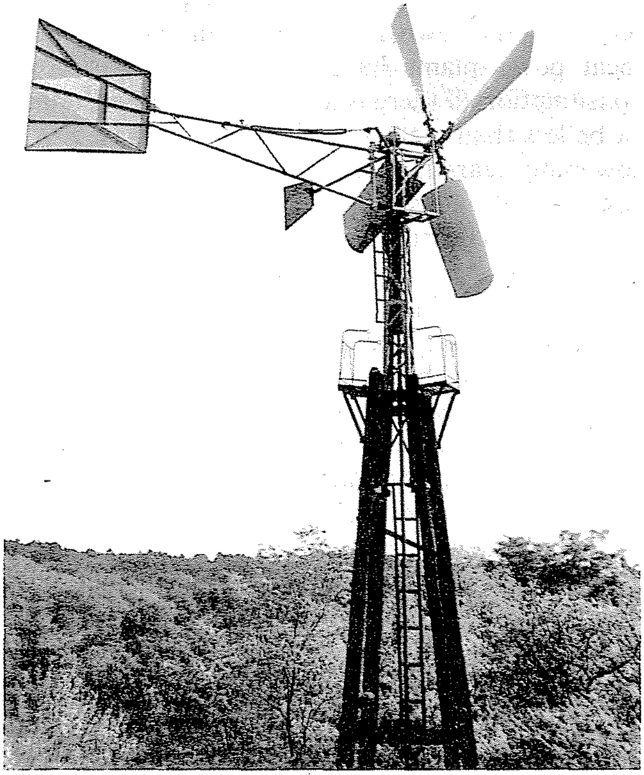

Fig. 7.

achieved a 70 kW unit will be built and later on as many of these units as are needed for all the heat requirement of the factory.

Another engineer, Mr. F. Sárközy, constructed a 1.2 kW unit in Biatorbágy (Fig. 7). It is still working and the maximum power measured was 0.9 kW. Mr. B. Dóri constructed a double wheel windmill.

For shaft an old rear axis of a car was used and the power was available on the vertical Cardani shaft. Unfortunately, the lines fixing the mast were of cables of less strength envisaged in the design and the mast broke off in a storm.

These were the individual constructions. About installing windmills for the power supply of the country there is no decision as yet.

Summary

General aspects of utilizing wind power. Wind speed measurements and available wind energy in Hungary. Some data on the costs of power from wind energy. Achievements and future plans in Hungary.

dr. Miklós Blahó, H-1521 Budapest

REMARKS ABOUT THE PAPER OF MR. DR. BLAHÓ: POSSIBILITIES OF USING WIND ENERGY IN HUNGARY

Dr. Blahó has been supporting the investigation of wind energy as a new source of power for a long time. He was always ready to help us both in theoretical and constructional problems. Still, in his paper he was pessimistic about the present and future possibilities of utilizing wind energy. The reason is that atomic energy is in view to solve our energy production problems and no official program has been made yet for research work in wind energy. Without individual research we cannot have any experiences, not even theoretical considerations.

Unfortunately, the available meteorological data are merely sufficient for rough calculations concerning energy. On this basis it can be estimated that our only natural energy source, wind energy, is sufficient for handling all the requirements of country if we can make use of it. In our paper: "The Possibilities of Using Wind Energy in Hungary" (Wind Energy Work Committee, 1976—77.) we proved that providing Hungary with wind energy was possible. Wind power is no longer regarded as an Utopian dream but as a realistic program, and the first steps for realizing it have been taken.

The next considerable developments can be expected in the following two fields:

The first is producing heat energy from wind instead of from coal. According to the fourth chapter of the paper, the total heat requirement of Hungary can be fulfilled by wind energy. This work has been started in the Motim Works in Mosonmagyaróvár. Following the example of the Motim Works, all heating plants in the country can be changed over to wind energy, thus saving about 20% of the national coal consumption.

The second field is to meet the water consumption of agricultural areas. This was the aim of the 1 kW windmill made at the "Vasmegyei Vas-, Fém- és Gépipari Vállalat" in Szombathely. Its output is sufficient to irrigate an agricultural are of 1 ha. Many years of work were put into this windmill and some problems, not referred to in the literature, were eliminated.

During our experimental work we have found the following:

1. One has to supply the windmill automatically with sufficient momentary load following all the change in the wind energy.

2. The windmill must not have parts to be maintained or changed at intervals.

3. It should utilize all the wind energy to the maximum output of the wind energy equipment with the best efficiency.

The cost of energy produced by such a windmill will be lower than any other kind of energy. Having no fuel costs, the windmill will work at a constant price independent of inflation.

Thinking of all that has been said, I cannot be pessimistic. Though we are progressing slowly, depending mostly on ourselves, the rate of progress is increasing as time goes on, as it generally happens when researches become increasingly realistic.

The 29th October 1978. Aladár Ledács-Kiss