ECONOMIC CONSIDERATIONS OF UTILIZING SMALL WIND GENERATORS

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Free power from the wind? The wind may be free, but certainly not the power, as anyone knows who has tried to capture a few of these "free" kilowatts.

The usual motivation for considering a small wind generator is economy. That is, the prevailing notion is that wind power can be easily exploited and, therefore, must be a most economical form of power generation.

The purpose of this paper is to provide a practical guide to the system designer to enable him to make a decision as to whether a wind generator is a practical solution. Only small generator plants up to 5 kilowatts are considered.

If the object of considering a wind generator is economy, then the designer should have an appreciation of the alternate power systems that are available, the costs, and the pros and cons of each.

In our industrialized society, most inhabited areas have commercial power, therefore, we can eliminate these areas from consideration. Even those uninhabited areas where commercial power can be brought in reasonably are not good candidates for small-scale wind power generation.

These limitations do not mean that wind generators are not practical. On the contrary, there are numerous applications in remote, isolated sites where wind-power generation certainly does provide a practical solution. A good example is the powering of marine aids to navigation signals. In most instances, these lights and sound signals are situated at remote, inaccessible locations. Other obvious applications are remote communication relay stations, weather data gathering stations, including weather buoys, cathodic protection, and water pumping.

These are five possible solutions available today to generate power in inaccessible remote locations: solar cells, primary batteries, thermoelectric generators, wind generators, and engine generators. Figure 1 shows the relative economics of these alternatives plotted as dollars per kilowatt-hour versus the average electrical load.

Of these five options, the primary battery is probably the least understood but the most widely used. The primary air cell has been around for some 40 years, ever since it was used to power our first radios in rural America. The air cell consists of a container with a zinc anode and an air breathing porous carbon cathode. The cell electrolyte is usually sodium or potassium hydroxide. These cells are characterized by a very low self-discharge and can be employed in series and parallel to provide up to several years of power. The cost of the cells yields energy at about $12 per kilowatt-hour. The weight is approximately 11 pounds per kilowatt-hour.

The primary air cell can be used to solve almost any remote power problem and, therefore, can be used as a basis for evaluation of any other system. For example, a 1-watt load would consume 8.76 kilowatt-hours per year. The cost of primary cells would be $12 x 8.76 = $105 per year. The weight transported to the remote site would be 96 pounds. These figures, although high per kilowatt-hour, are so reasonable that no serious consideration of a more complicated system should be entertained. The only possible exception would be where the cost of transporting the batteries to the remote site is so high as to change the economics drastically. In some cases where environmental considerations prohibit on-site disposal of spent batteries, the additional cost of disposal would also affect the economics.

The following assumptions form the basis for determining the costs per kilowatt-hour shown in figure 1.

Solar cells:	Amortization	Cells, 5 years Batteries, 5 years Housings, 5 years
Primary battery:	Amortization	Batteries, 1 year Housings, 5 years
Thermoelectric:	Amortization	Generator, 3 years Batteries, 5 years
	Fuel	25¢ per gallon
Wind generator:	Amortization	Generator, 3 years Batteries, 5 years Housings, 5 years
Diesel generator:	Amortization	Engines and Generators, 2 years Housings, 5 years
	Fuel	25¢ per gallon

An annual interest charge of 8 percent is assessed to all systems. All the systems considered are continuous power systems. Each is capable of handling intermittent loads equal to several times the average. All use battery storage to provide continuous power except the diesel generator. The solar cell economics were generated assuming a 30° latitude and 10 days storage in the secondary battery. The assumptions for the thermoelectric system were propane fuel from tanks, with the tanks transported to the site. The battery storage is ten hours. The wind generator system assumes a 10 mph annual wind velocity. The battery storage is 10 days. All secondary batteries are industrial type, low-discharge, lead calcium. The diesel generator consists of two complete plants, housing, and automatic controls for unattended operation and switchover.

The amortization periods are conservative and no doubt proponents would argue that their machines would or could operate much longer. However, no attempt has been made to add the cost of transporting equipment, fuel, and men to the remote site. Obviously these costs could greatly influence the cost per kilowatt-hour of any system. Since they vary considerably with the location, each installation requires separate evaluation.

The chart (fig. 2) shows clearly that for loads up to 10 watts, the primary air cell has the advantage. In cases where transported weight is a problem, the solar cell or small wind generator should be considered.

From 10 to 100 watts, either the thermoelectric or the wind generator are good selections. The wind generator has the advantage when transported weight is considered.

The 100 to 1000 watt range certainly favors the wind generator. In this range, the load is too light for effective use of a diesel generator, although at about 500 watts the diesel engine begins to look favorable. In this range the weight of propane for the thermoelectric becomes unreasonable. A 1000-watt average load requires 12600 gallons or 53000 pounds of fuel per year.

From 1000 watts and up, the diesel generator has a definite advantage. True, the systems are complex and, hence, prudence dictates redundancy. However, the low cost per generated kilowatt-hour makes their consideration mandatory.

All the systems except the engine suffer from being modular. That is, they consist of a parallel arrangement of units or cells so that increasing their size by increasing the number of the same size cells affords little saving per kilowatt-hour. It is the battery that is required with the wind generator that causes the cost to level out at about $1.50 per kilowatt-hour.

If the storage battery can be eliminated from the wind generator system for applications such as cathodic protection, water pumping, or possibly the electrolysis of water, the cost per kilowatt-hour is much less. This is particularly true for larger machines. For example, a 10-meter machine could easily generate 12000 kilowatt-hours per year. The cost of the machine and tower would be about $12000. Therefore, using the same 3-year amortization and interest, the cost is only 43¢ per kilowatt-hour, a figure very comparable with small diesel plants.

In summary, small wind generator plants offer an attractive alternative to primary battery systems and constantly running engines to generate power in remote areas. They are particularly advantageous where the costs of transporting fuel or batteries are high. The limitation is an annual average wind velocity of at least 9 to 10 mph. The presently available units are most useful in the average load range of 10 to 1000 watts.

DISCUSSION

COMMENT: I object to your making these look so favorable in areas where the cost of diesel fuel may run from 50 cents to a dollar a gallon. I don't think there is this large a difference in costs. I think Clews' calculations did not agree with yours.

A: I used 25 cents. Actually, the cost of fuel is quite small compared with the cost of the amortization of the machine.

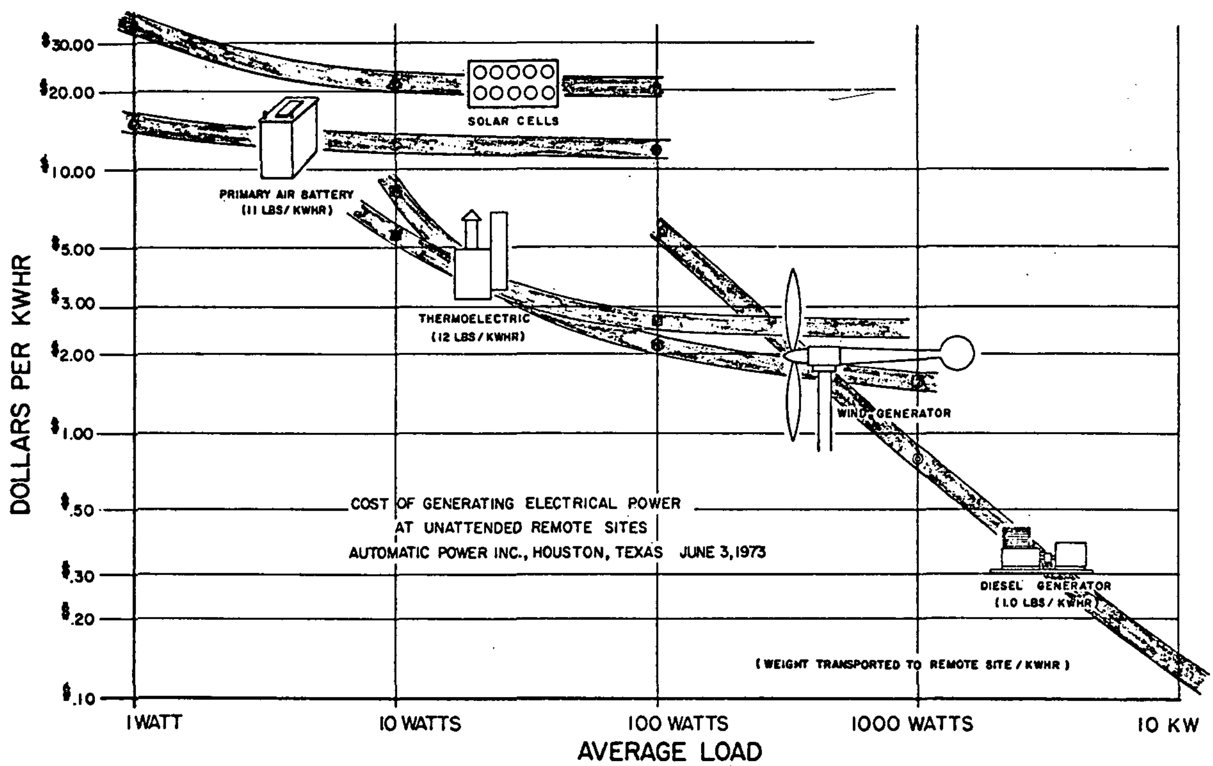

Figure 1