A Practical Analysis of the Merits of Wind Power on Glebe (Magic) Mountain

The aesthetic and environmental aspects of wind power development have been hotly debated in recent years. As I have little to add to that debate, I will focus on a practical analysis of wind power. It is clear that the ordinary citizen who wants to assess the merits of wind power on a practical basis needs information that is almost always left out of public discussion. As a scientist I always find it disturbing that the public is often required to make important decisions in the absence of real data.

Due to the unpredictable nature of wind, the market value of electricity produced by wind is quite low, at something less than 2.5 cents per KiloWatt-Hour. Given the high cost of construction and maintenance of windmills such as those proposed, one can reasonably expect the actual cost of the power generated to greatly exceed its true market value, probably costing in the vicinity of 9-10 cents per KiloWatt-Hour. Clearly wind power is not a practical endeavor and cannot be expected to yield economic benefits to the public as a whole.

To understand why CVPS is proposing a system as hopelessly inefficient as wind power, one needs to understand the bizarre economics of regulated utilities. Unlike competitive enterprises that make money by reducing their expenses, regulated monopolies such as utilities increase their long-term profits by increasing their costs. This is why CVPS expects to find a customer for the Glebe project--so the buyer can inflate their costs, raise their rates and increase their profits--all in the name of renewable energy.

In engineering terms, wind power belongs to a class of energy sources referred to as "low-grade energy." In other words, wind power is not a concentrated form of energy, but is rather dispersed or "dilute," since the actual energy of wind "per square foot" is quite low. Utilization of low grade energy is a classical engineering problem that is well understood, having long been realized to be impractical. Wind energy was made obsolete by the advent of the steam engine over a century ago. No factor has changed to alter that simple fact.

Since the energy of wind "per square foot " is so low, one is tempted to construct large devices to extract what might be useful amounts of energy. After all, if one calculates the total energy in a windstorm covering many square miles of sky, the resulting number is huge and tempting--until one gets real numbers.

The reality of extracting energy from the wind is a daunting one. On the one hand, one needs to construct large windmills that are inherently fragile in the face of a storm, and on the other hand the windmill will produce no power whatsoever unless there is enough wind to turn it fast enough to synchronize with the ac power of the electrical grid. As a result, windmills are inoperable a large part of the time, even when the wind in blowing at high velocity. Anyone who has observed the windmills on Equinox Mountain would have noticed how rarely they operated, whether the wind was blowing or not. This is the reason why.

It may be worthwhile to consider the actual operation of a windmill to better grasp the issues. Before a windmill can start generating power it must wait until the wind is blowing fast enough such that the blades will be able to turn its gearbox and in turn spin a generator (alternator) fast enough to synchronize with the ac electric grid. If the rpm of the generaotor is even slightly out of synch with the grid, the results are a burden, not a benefit to the grid. Synchronization with the electric grid is a significant technical issue and should not be taken lightly. At this minimum wind velocity, all the energy is consmed by losses due to air friction and friction losses in the gearbox and generator. It is only when the wind velocity exceeds this minimum value that the windmill even starts to produce more energy than it consumes.

On the other end of the windmill's power curve, there is a limiting wind speed above which a windmill cannot or should not operate. This limiting speed depends upon the robustness of construction of the windmill that is specific to the design. Since the design is a compromise of cost and efficiency, the engineer must make a decision as to what the allowable upper limit of wind stress should be. The engineer is likely to select a modest velocity in the range of 25-30 mph, since designing a windmill strong enough to produce power in an infrequent event such as a hurricane would be wasteful.

To bring the windmill up to rpm, the windmill must turn to face the wind and twist the blades so that they oppose the flow of the wind. It must sense the rpm of the blades and control that rpm precisely to acquire synchronization with the electrical grid. Once synchronization is achieved and connection is made to the grid, the angle of the blades must be adjusted to increase the load on the blades to maximize wind power extraction and maintain synchronization to the grid. All of this must be achieved as the wind changes direction and velocity as it naturally does. As an alternative, one can use a dc generator on the windmill and later invert and synchronize the ac power to the grid, but this method also has losses and expenses associated with it.

Although it may be obvious that the above system is inherently expensive to build, it may be less obvious that there will be ongoing, high maintenance costs, as this kind of device is under considerable stresss and subject to mechanical wear, particularly in the blades, gearbox and generator. The centrifugal and gyroscopic forces on a large windmill are prodigious. As the wind blows the blades bend. All structures that bend will eventually succumb to bending fatigue. This means that the blades will need to be replaced on a regular and hopefully predictable basis to avoid catastrophic faiulre of the windmill. As an example, helicopter blades are replaced about every 3-6000 hours, depending upon the design. Since windmill blades do not need to be as light as helicopter blades, they can be designed to have a longer expected lifetime, but that lifetime is a compromise of cost and efficiency. Thus one would be surprised if the blades of a modern windmill lasted more than ten years. Note that a blade failure occurred on Equinox Mountain much earlier than that.

Likewise the gearbox can be expected to be an unpredictable and expensive source of trouble. Again there is a tradeoff between cost and performance. As the gearbox and generator are located in the nacelle directly behind the hub of the windmill, the designer naturally would like the gearboxes to be as light and energy efficient as possible. This would call for a planetary gearbox. Unfortunately planetry gearboxes tend to be more expensive and rather noisy, as they have an additional degree of vibratory freedom inherent to their design. All gearboxes eventually fail, never seeming to do so at a convenient time. Generators will fail for similar reasons. One need only consider the task of replacing blades, gearboxes and generators at 330 feet in the air to grasp the high maintenance costs associated with wind power. Historically most windmills are eventually abandoned when the owner is faced with the costs of ongoing maintenance. Note that CVPS chose to do this when the windmill on Granpa's Knob experienced blade failure some years ago.

It is quite simple to assess the economic value of electricity produced by wind power. Since wind power cannot be expected to produce power whenever the consumer desires it, some other conventional power source must exist to provide power as needed. Whenever the windmill is operating, the conventional power source can, in some cases, be throttled back, saving fuel that would have been burned. The cost of the fuel saved is the maximum that a utility might rationally be expected to pay for the wind power generated--if it operated in a competitive environment.

The cost of fuel saved naturally depends upon whether it is coal, oil, gas, hydro or nuclear. Since the fuel costs of hydro and nuclear power are essentially zero, it makes no sense to use wind power as a substitute for these power sources. As oil and natural gas have no future as fuel for power generation, the price of coal is the factor that will determine the value of energy generated by a windmill. Roughly speaking, one pound of bituminous coal yields about one KiloWatt-Hour of electricity. Given that bituminous coal currently sells for about fifty dollars a ton, this means that wind-generated power has an economic value of at most 2.5 cents per KiloWatt-Hour. Since coal supplies in the US are bountiful and expected to last at least 200 years, it is reasonable to expect the price of coal under long term contract to remain stable far longer than a windmill would endure on the top of a mountain.

The precise cost of power generated by windmills that might be installed on Glebe Mountain is considerably harder to estimate than the economic value per KiloWatt-Hour of the power that might be generated. Whereas the manufacturer may be willing to state a price for their equipment, they will never offer a long term warranty or fixed cost maintenance contract, as they would not want to advertise the costs, nor could they bear the risks. These risks will inevitably be borne by the consumer. With some luck, the maintenance costs may be less than $1 million in the first year, probably reaching several million dollars per year as the windmills reach the end of their "useful" lives.

We need only examine CVPS's own projections to realize how impractical the Glebe project is. Their estimated cost for the project is $58 million, with a peak power output of only 50 MegaWatts (50,000 KiloWatts). The actual average output, by their numbers, would be only 50 x 0.332 = 16.6MW. This is an appallingly expensive project given its modest output. For comparison, CVPS has a small backup gas turbine generator in Ascutney VT that is probably comparable to this output.

CVPS's estimate of power generated is only 117,785 MegaWatt-Hours per year. This means the total value of the power generated per year is less than $3 million (117,785 x $ 0.025 = $2,944,625). Since the windmills amount to $31.1 million of the projected $58 million total, this amount is not even enough to cover annual depreciation expense on the windmills alone, over an optimistic 10 year useful life ($31.1 million x 0.1 = $3.1 million per year depreciation). Depending on how the project owner chooses to depreciate the assets, the total annual depreciation would exceed the depreciation on the windmills considerably. One would expect total depreciation expense to be between $4 and $5 million per year.

If CVPS were somehow able to finance the project at 5% (not even vaguely possible), the annual interest expense alone would probably roughly equal the value of the power produced ($58 million x 0.05 = $2.9 million).

Given the high financial risk associated with this venture, a lender would be unwilling to accept the wind project itself as collateral. A sensible lender would demand other assets as security. This eliminates CVPS as the potential owner of the project, as they are too small and incapable of surviving failure of the project. They will try to sell the project permits to another, probably out-of-state utility.

If one totals the above annual expenses, it becomes clear that the Glebe project will produce less than $3 million worth of electricity at a cost of more than $11 million per year. The question naturally arises, "Why would anyone want to do this?" The answer is that regulated utilities are not like competitive enterprises. Their rates are set by public service boards, which set the utility rates to allow for a "reasonable rate of return." In other words, whatever it costs the utlity to provide service, they are allowed a profit above their costs. This means utilities have only a short term interest in controlling costs until their next rate increase. If a utility can persuade the regulators to allow them to build a a boondoggle like a wind power project, it doesn't hurt them financially. On the contrary, it inflates their costs, revenues and profits--all at the expense of the consumer.

Wind power is an idea that is appealing to the imagination. It sounds like a "free" source of energy that would be non-polluting and stable in cost. I am an optimist, and I love technology. If I thought for one moment that windmills would be a source of low cost energy, I would be building them. The reality is quite the contrary--wind power is wasteful of human and natural resources.

Some will say that clean air is priceless, and that wind power should be pursued regardless of cost. But there will never be any environmental dividend from wind power. The human and natural resorces consumed to build and operate windmills will greatly exceed the fuel saved by wind power.

Some people want to conceal the true costs of wind power by government subsidy and by dilution through commingling wind power with other power sources, but concealing the true costs only conceals the source of the pain.

Utility companies are keenly aware that wind power is impractical. Unfortunately some utilities are willing to exploit the impracticality of wind power, as they see an opportunity to profit at the expense of consumers.

When told that the people of France were starving for lack of bread, Marie Antoinette said, "Let them eat cake dough!" Wind power is the Marie Antoinette solution to the low cost of coal--an abundant resource.

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