DECOMMISSIONING WIND TURBINES

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INTRODUCTION

Wind Power as an industrial activity generates waste that need to be recycled or disposed. At the manufacturing stage solvents, paint, metal and wire waste may be generated. During the operational stage waste lubricant oil and replaced electrical components constitute waste. At the end of their useful lifetime of twenty tears or earlier, disposal of the structural towers, foundations, electrical components and the rotor blades become a concern. The access roads and drainage ditches must also be reclaimed.

The cost of decommissioning, recycling and disposal is included in the price of the electricity produced. Funds must be deposited in an escrow account for the disposal and recycling at the end of the useful production period.

ABANDONED WIND FARM SITES

Even though the wind resource is free, wind power production is a labor intensive industry where the Operation and Maintenance (O&M) costs are approximately half of the average wholesale rate of electric power at the electrical trading sites.

Existing utility scale designs of wind turbines are net importers of about 5 kWe of power from the electric grid to remain on a standby basis with their controls kept unfrozen in the winter and ready to catch the wind. This makes them useless in the case of a power blackout. Alternate designs using forms of energy storage such as flywheels and permanent magnets are needed.

Wind farms must be established in locations with rich wind resources otherwise their operation would become uneconomic, leading to their abandonment.

Carefully written wind farm land leases call for removal of all equipment and foundations and restoration to approximate original grade. In some unfortunate cases these leases were not honored as the companies involved went bankrupt.

A proposed alternative is to require the establishment of an escrow account financed from the wind turbine income to be established with an independent financial institution for the eventual decommissioning of the turbines and the associated access roads, foundations, electrical cabling and steel equipment after the useful lifetime of the wind turbine.

Figure 1. Decaying abandoned truss tower style wind turbine in California.

Driving by some established wind farm sites in California one can notice that about 1 in 4 wind turbines are non-operational. The problem is sometimes bad siting. The location, may be perfect for wind, but could be treacherous for work and support equipment. Even on a flat terrain, like in Texas or Iowa, performing maintenance operations at great heights is not an easy matter.

Many of the non-rotating turbines are not necessarily non-operable. Some of the electrical capacity could be held in reserve. Some hydroelectric turbines could sit idle during periods of low demand such as at night. This also is used to prolong the useful life of generators. Worry about unused generation capacity is only warranted on peak demand days when the generation capacity is operating around 70 percent. Fifty percent operating capacity does sometimes occur.

Current designs of wind turbines actually work better in low wind conditions. At high wind conditions they are "furled" with their pitch controls eliminating the lift on the blades and the yaw mechanisms turning the turbine away from the wind and protecting it. That is a reason some turbines are seen stopped under high wind conditions.

A poorly written permit allowing windmills to be built at Palm Springs, California did not include a decommissioning clause, so that they sat there as rusting skeletons at the end of their useful life of about 20 years. Palm Springs decided that if windmills are going to exist around the city, they must be operational. A city that has welcomed windmills since it was first approached about them in the early 1980′s found that many of those windmills are no longer working and it wants them fixed. The situation raised the issue of who is responsible for fixing or decommissioning them. Florida Power and Light (FPL), the owner of the inoperable windmills, was allowed to install and operate the local windmill farms under a conditional use permit (CUP) stipulating that if the windmill does not run for six months, it is declared a public nuisance, and without a hearing, must be abated.

DEFUNCT COMPANIES

Carefully written wind farm land leases call for the removal of all equipment and foundations and restoration of the ground to approximate original grade. In some unfortunate cases these leases were not honored as the companies involved went bankrupt.

Political opposition has arisen lamenting the condition of the Zond Company, a subsidiary of the defunct Enron Company that was acquired by the General Electric Company, wind power sites:

> "Throughout the Tehachapi-Mojave area look for turbines without nose cones, turbines without nacelles (blown off and not replaced), oil leaking from blade-pitch seals, oil leaking from gearboxes, road cuts in steep terrain, erosion gullies, non-operating turbines, and "bone piles" of junk parts. One Zond bone pile of abandoned fiberglass blades is visible on the east side of Tehachapi-Willow Springs Rd. near Oak Creek Pass. (Kern County does not permit on-ground disposal of fiberglass.) While touring wind farm sites look for blowing trash and litter (plastic bags, soft-drink cups, bottles, electrical connectors, scrap bits of metal, and so on). These all reflect management's attention to maintenance and general housekeeping. At the better sites, you won't see any of this."

Regarding the Kamaoa Wind Farm in Hawaii:

> "Built in 1985, at the end of the boom, Kamaoa soon suffered from lack of maintenance. In 1994, the site lease was purchased by Redwood City, CA-based Apollo Energy.
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> Cannibalizing parts from the original 37 turbines, Apollo personnel kept the declining facility going with outdated equipment. But even in a place where wind-shaped trees grow sideways, maintenance issues were overwhelming. By 2004 Kamaoa accounts began to show up on a Hawaii State Department of Finance list of unclaimed properties. In 2006, transmission was finally cut off by Hawaii Electric Company."

Figure 2. Abandoned and cannibalized Kamaoa wind farm turbines, Hawaii.

Figure 3. Hubs awaiting recycling.

THE MAINTENANCE ISSUE

Wind power is a labor-intensive industry with rotating and electrical machinery that requires continuous maintenance. Lack of maintenance will inevitably lead to failures. A crew of about three personnel is required for every 6 wind turbines. Changing oil filters and seals and electrical parts at great heights is a demanding and hazardous job.

Gearboxes or transmissions have been failing in wind turbines since the early 1990s and need to be replaced every 5 years on-average over the 20 years design lifetime of a typical wind turbine. Only the gearless designs of wind turbines have escaped the epidemic. This is leading to a second generation of gearless wind turbines with multi-pole electrical generators replacing the first generation of wind turbines using gearboxes.

The problem reached epidemic proportions with a massive series failure of gearboxes in the NEG Micon company wind turbines that had to be replaced in large numbers. The NEG Micon brand at some time was the most popular wind turbine in the world. The problem brought the company to its knees causing it to be taken over by its rival Vestas, the present world's largest wind turbine manufacturer. Vestas itself is still challenged by gearbox and rotor failures.

The Der Spiegel magazine reports that the German Insurance Association was upset about the gearboxes as well as rotor blades failures:

> "'In addition to generators and gearboxes, rotor blades also often display defects,' a report on the technical shortcomings of wind turbines claims. The insurance companies are complaining of problems ranging from those caused by improper storage to dangerous cracks and fractures. The frail turbines coming off the assembly lines at some manufacturers threaten to damage an industry that for years has been hailed as a wild success.
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> After the industry's recent boom years, wind power providers and experts are now concerned. The facilities may not be as reliable and durable as producers claim. Indeed, with thousands of mishaps, breakdowns and accidents having been reported in recent years, the difficulties seem to be mounting. Gearboxes hiding inside the casings perched on top of the towering masts have short shelf lives, often crapping out before even five years is up. In some cases, fractures form along the rotors, or even in the foundation, after only limited operation. Short circuits or overheated propellers have been known to cause fires. All this, despite manufacturers' promises that the turbines would last at least 20 years."

Vibrational problems challenge the designers of rotor blades. The vibrational mode due to the vertical wind shear is a design difficulty of large wind rotor blades. The blade going over the top of its circular path sees a drag and lift that increase as the square of the wind speed; but going over the near ground point the wind speed is lower, resulting in both an axial blade bending, a thrust bearing load oscillation as well as a torsional blade bending and a circumferential acceleration mode all at the constant rotation frequency. This could lead to a variable frequency vibration mode; which complicates the design of the blades from the perspective of fatigue lifetime.

Wind power is not immune to the principles of sound engineering management. It must be accepted that maintenance costs are 90 percent of the cost of most engineering systems. It takes dedicated people to keep a technology base operational. The older engineering systems get, the more expensive is the maintenance cost as people and the technology base get older and retire from the work force. As some age, engineering systems are retired under wear conditions to be replaced by more modern efficient alternatives.

Successful maintenance requires a motivated management keeping the teams focused, staffed, trained, supplied, and responsive to unexpected conditions. With thousands of complex wind turbines scattered over the landscape, wind power requires a large amount of maintenance per unit of energy produced than other sources of energy.

DISPOSAL AND RECYCLING ISSUES

The amount of wind turbine blades slated for waste disposal is forecast to quadruple over the next fifteen years as a great deal more blades reach their 15-20 year lifespan. The size and length of the newly installed wind turbine blades are now twice as large as they were 20-30 years ago.

Wind turbine blades are built of fiberglass composites, epoxy, polyvinyl chloride foam, polyethylene terephthalate foam, balsa wood, and polyurethane coatings. Styrene and other solvents leak as fiberglass ages. Most any boat owner who moors a boat year round is familiar with fiberglass blistering, where osmotic pressure builds within the fiberglass as these chemicals slowly dissolve, eventually breaking free.

The use of graphite instead of fiber glass in the manufacturing of rotor blades would add strength hence reducing size and allowing disposal by burning in coal boilers as a fuel.

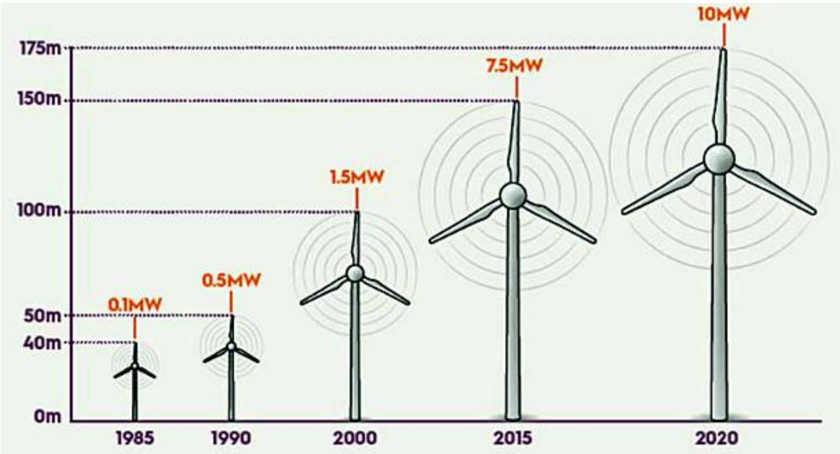

Figure 4. Trending increasing size of wind turbines.

Figure 5. Transportation difficulty of large size rotor blades at roads intersections, bridges and overpasses.

> "Hundreds of giant windmill blades are being shipped to a landfill in Wyoming to be buried because they simply can't be recycled. Local media reports several wind farms in the state are sending over 900 un-reusable blades to the Casper Regional Landfill to be buried. While nearly 90 percent of old or decommissioned wind turbines, like the motor housing, can be refurbished or at least crushed, fiberglass windmill blades present a problem due to their size and strength."

Figure 6. Manufacturing of carbon fiber.

Figure 7. Wooden and fabric wind turbine in Holland.

DECOMMISSIONING COST MISMANAGEMENT: RUNAWAY TURBINE

An example of epic unfortunate uninformed failure decommissioning mismanagement is by the Akron-Westfield (A-W) School Board. This is Akron in Iowa, not in Ohio. Having not established an escrow account for the decommissioning cost, it was faced by about $220,000: $183,000 for disassembly and disposal of the wind turbine; and $37,000 for foundation removal/disposal, dirt fill and seeding of site.

It also did not allow for the replacement cost of the gear box that needs rebuilding or replacement every five years. The wind turbine became not operational since the gear box failed in 2009.

The wind turbine was originally projected to provide an additional $87,000 annually in revenue for the school district. For its first 10 years of operation, the district would have annual loan payments of approximately $85,000. But after the loans were paid off, the wind turbine was to generate the equivalent of about two teachers' salaries per year.

Feasibility studies conducted by the high school science teacher, and his students, were based on the original agreement between the City of Akron and the Akron-Westfield School District. Per this agreement, the school district would not have had any electricity bills from the City of Akron, and the City of Akron would have paid 2 cents per kilowatt hour on the excess electricity the turbine generated. The school district was not going to be charged an electrical demand fee.

In February 1999, the 600-kilowatt turbine became operational. It came from Denmark through Vestas American Wind Technology Company. The engineers were Prohaska & Associates of Omaha, Nebraska. Then followed a history of further legal and financial mismanagement. According to a report then Business Manager Jodi Thompson gave to the school board in December 2008, reviewing its nearly 10 years of operation [2]:

> "2000: It was discovered that the agreement between the city council and school board had never been ratified by the city council.
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> 2001: The city sued the school district for the electricity the district hadn't paid for since the wind turbine began operation.
> Feb. 20, 2001: Noted Dec. 12, 2000, Judge ruled in favor of city, school board appealed decision.
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> June 11, 2003: Wind turbine lawsuit officially ends as both sides agree on settlement. The school district owed the city approximately $163,000. In addition, the school district would have to pay electrical demand charges.
> Therefore, instead of saving the district about $87,000 annually, it only saved the district about $40,000.
> This savings didn't take into account the wind turbine's service agreement and repair costs. The service agreement cost the school district between $10,000 and $12,000 annually, said Thompson. Between July 10, 2002 and Aug. 13, 2008, the school district spent $83,739.95 on the wind turbine's service agreement payments and repairs. Of that amount, $17,073.28 were for repairs.
> By adding in the service agreement and repair costs, the wind turbine generates about one-fourth of what its original projected revenue was, she said.
> The district was receiving between $24,000 and $40,000 annually from Heartland Public Power District for the wind turbine's power generation.

From June 15, 2007 to July 15, 2008, the district's electric bill was $93,177.61 and Heartland paid the district $43,387.30, which is based on the amount of kilowatts the wind turbine produced.
However, during the same time period, the district spent $23,344.30 on wind turbine repairs, the maintenance agreement fee and other wind turbine maintenance fees.
For this period, the overall savings for the district with the wind turbine was $20,043.12.
Without the wind turbine, another revenue source will be needed to make up that annual savings or the budget cut, concluded Thompson.

June 2, 2008: School Board approved final loan payment on the wind turbine. It had been financed with two loans: Iowa Energy Center Alternative Energy Revolving Loan Program Series A and B. One was an interest-free loan of $250,000 and the other was $450,000.

Dec. 10, 2008: School Board learned wind turbine needed a new gear box. Cost was estimated at $229,149. This was the second time the gear box had failed. The first gear box had failed early on, and had been covered by the turbine's warranty.

January 2009: School officials were trying to determine who was responsible for paying for the gear box repairs: Vestas American Wind Technology, the company who designed the wind turbine, the district's insurance company or the district itself. The gear box was replaced.

Oct. 21, 2009: The gear box failed a third time. School officials toured the wind turbine, seeing its damaged areas. They decided to just let it continue operation until it quit, which happened in October or November 2010.

2012: School Board enters six-month contract with Joe Graham of BlueSkyWind LLC of New York to find solution for inoperable wind turbine.

Oct. 3, 2012: School Board enters contract with First Priority Consulting Group to find a solution to the inoperable wind turbine.

Feb. 4, 2014: Wind turbine's brakes failed, causing it to be a "runaway" turbine as the district had no control over the turning blades.

March 26, 2014: School officials noted the brakes had been fixed but the brakes' failure had stalled any potential buyers' interest in purchasing it.

May 22, 2014: School Board approved agreement with Joe Graham of BlueSkyWind LLC of New York to come up with plan to have someone purchase it and operate it on-site. Again, there was little interest because the wind turbine's design was obsolete.

Feb. 6, 2017: At a special work session for A-W's third bond attempt, the wind turbine project was considered as a bond project:

"There still is no solution for the district's inoperable wind turbine. It appears the only solution will be for the district to cough up the money to dismantle and remove it, then remove its large concrete base and restore the land to its original condition. Two years ago, the cost was estimated at $300,000, according to A-W Shared Superintendent Randy Collins, explaining the Wind Turbine Project cost was not figured into these bond options.
"There needs to be money set aside to get rid of the wind turbine," said Board Member Jodi Thompson. "It's just deteriorating more. We need, as a board, to make a decision and be done with it. It's not a pleasant decision but it needs to be addressed."
Board Member Cory Tucker thought with the $5.2 million bond option, the Wind Turbine Project could be included but it might have to be done in two phases.
The Wind Turbine Project would be an Annual (Summer) Project and probably have a high priority on the Long Term Facilities Plan, said Board Member Nick Mathistad, adding the Long Term Facilities Plan's projects are fluid – moving up and down in priority."

2020: Purchase Power Agreement with Heartland Consumer Power District expires but there is no need for renewal."

The following comment was made about the amateur project by Jeff Walther: "Squared and cubed. Ron Wilmot may have been a science teacher but he was clearly no kind of engineer. Completely ignoring maintenance costs is a rookie mistake. None of his bright-eyed students thought to ask what it costs to own? Had none of them ever seen their parents pay for a car repair?"

DISCUSSION

To say that things will only get worse as time goes by is certainly counterintuitive and against the history of nearly all young industries. Technology evolves and improves as the needs of modern society vary.

Coal power plants in the USA produce well over 100 million tons of toxic coal ash per year alone; about 40 percent of it is reused for other purposes but the rest is straight waste.

For two thousand years, windmills were built from recyclable or reusable materials: wood, stone, brick, canvas, metal. When modern wind turbines appeared in the 1880s, the materials did not change. Only since the arrival of cheaper fiberglass plastic composite blades in the 1980s that wind power has become the source of a waste product that ends up in landfills.

Generator blades for both large and small wind turbines can be made from wood, graphite, titanium or aluminum that have better fatigue failure properties and that are easier to recycle than fiber glass and foam. Rotor blades are being ground into chocolate chip-sized pellets. They can be used for decking materials, pallets and piping. A startup opened its first processing facility in central Texas this year, and it is leasing a second space near Des Moines, Iowa. Blade recycling can blossom into a local industry. And for rural areas looking for an economic boost, such recycling just might pay off.

REFERENCE

1. Erik Vance, “The ‘Wind Rush’: Green Energy Blows Trouble into Mexico,” The Christian Science Monitor, January 26, 2012.
2. Julie Ann Madden, “A-W wind turbine removal may become budget item,” The Akron Home Towner, October 11, 2019.