How Much do Wind and Solar Cost?
Norman Rogers
5 December 2020

The cost of electricity from wind or solar is about $80 per megawatt hour. If batteries are added to the wind or solar plants, as is now the fashion, the cost of the electricity increases dramatically. The real cost has little relation to the advertised price in industry press releases. Those prices are much lower than the real cost. Subsidies make the difference.

The analysis here is intended to be illustrative rather than an economic treatise on the wind and solar industry. The intention is to show that the renewable portfolio laws, or mandates, have a huge economic effect because they affect risk and who is at risk.

Calculating the cost of wind and solar without subsidies is very difficult, because there would be no utility scale wind or solar without subsidies and mandates, except perhaps as demonstration projects or as corporate virtue signaling. Mandates, forcing utilities to buy wind and solar, are a not usually considered a subsidy, but they surely are a subsidy because they change the economic parameters of the project.

The people using unsubsidized wind or solar are mainly back to nature people that live off the electric grid. They have no choice but to make their own electricity. But it is not a valid comparison to compare those small home installations to gigantic, utility scale plants.

In principle the cost of wind or solar is mostly the initial cost of building the plant properly allocated to the electricity generated. A wind farm or a solar farm is usually a business, an enterprise. The developers invest capital and expect a return over the life of the enterprise from the sales of electricity. This is the model of a wind or solar farm that provides a

framework for economic analysis. If the enterprise is to make a profit, or at least break even, the price of the electricity has to provide a return on the investment.

Wind and solar farms are typically built and owned by independent developers that contract with electric utilities. There are also instances where utilities build the farm itself, but it is more difficult to use that case as a basis for analysis. The stand-alone business model, contracting with a utility, is the model that can be used to most easily tease out the true cost of renewable electricity.

The usual relation between the developer and the utility is a long-term power purchase agreement (PPA). A typical PPA specifies the price per megawatt hour to be paid for the electricity and the term of the agreement, typically 25 years. Why does the utility agree to a 25-year contract? The reason is that no developer is willing to invest hundreds of millions of dollars without a guaranteed market for the electricity. These developers are large corporations that understand exactly what they have to do to make a large profit.

The direct subsidies for wind and solar come from the federal government. There is a tax credit, equivalent to cash. This credit, according to recent law, is declining from 30 percent of the cost of the project and is scheduled to phase down to ten percent by 2022. Another subsidy called tax equity finance involves manipulation of tax rules with a highly taxed partner to utilize depreciation to move money from the U.S. Treasury to the project developer. No tax cheating is involved. This scheme was enacted by congress to subsidize the industry, while obscuring the giveaway of taxpayer money. These two subsidies may pay for half the project cost but are declining unless the industry convinces to congress to reverse the scheduled decline.

But, surprisingly, the most important subsidies are not these large federal subsidies. Renewable energy is not competitive even at half price. The most important subsidy is the effect of the state mandates that require the purchase of renewable electricity, usually called renewable portfolio laws. The influence of these requirements is why there are 25-year power purchase agreements. When the developer has a 25-year guarantee from a credit worthy utility everything changes. His busines is no longer a speculative enterprise. It is now a conservative investment quality property.

If an entrepreneur or company is going to enter a business, they will have a rate of return in mind. Perhaps 15 percent for a business with a lot of risk. If the risk is less, they might anticipate a 10 percent return. If there is very little risk, say the purchase of a corporate bond, they might accept a return of three or four percent. Risk free investment, such as treasury bonds, may only have a rate of return of two percent.

The developer of a wind or solar farm knows that if he has a 25-year contract for the purchase of the electricity, the risk is very low, so he will bid the project anticipating a modest rate of return on his investment, probably seven to nine percent. At the development stage there is still some risk. The solar panels might be defective, or he might be sued by local residents that don't like his project. But once the project is up and running for a few years the risk becomes even less that something will go wrong. At that point the project is a prime investment property with very low risk of default. The entire project can be sold to an infrastructure investment fund that expects a return of only five or six percent because it only buys conservative, safe investments.

This difference, between, for example, an eight percent investment and a five percent investment is the key to making a large profit. At eight percent, an investment that returns $10 million per year has a value of

$125 million. But at 5 percent an investment that return $10 million per year has a value of $200 million. The actual computation is more complicated than this because a wind or solar farm wears out over time. But the point is clear, the state mandates forcing the purchase of renewable electricity make an opportunity for a developer to build the wind or solar farm with a low rate of return because the risk is low and then resell the farm as an investment property with an even lower rate of return and get a big exit profit for the developer.

In my calculations I assume the wind or solar farm has a lifetime of 25 years and no value at the expiration of the contract. Although the farms do wear and decline, they are still able to generate electricity but are probably near worthless because there is little incentive for the utility to extend the purchase contract unless in 25 years mandates are still in effect. The model I use is that of a 25-year fully amortized mortgage, easily computed with the Excel PMT function. A spreadsheet (solar) can be downloaded here. A spreadsheet for wind is here.

The solar spreadsheet is a model of a solar farm with single axis tracking and 100 megawatts DC nameplate capacity. I use the National Renewable Energy laboratory web based computational model PWATT and the NREL cost data base 220-ATB-Data for the costs. The capital cost per nameplate kilowatt DC is $1380 and for AC is $1680. The construction cost is $138 million. Annual maintenance is $19 per kW AC nameplate per year. If the rate of return is set to 8 percent, the sale price of the electricity must be **$83.99 per megawatt hour**. I have seen examples of systems similar to this selling the electricity for slightly over $30 per megawatt hour, while it might be expected that the price would be $42 if there were a 50 percent subsidy. The difference might be using a lower rate of return, lower cost for the farm, boosting return with low interest debt or a having a bigger return on the tax equity finance. Since these developers don't open their books it is not possible to precisely understand their finance stack.

In the spreadsheet the sale price and profit is estimated assuming the purchaser, an infrastructure investment fund expects five or six percent return. It is assumed that the farm is sold as soon as it is in operation, for simplicity of calculation, but the sale would realistically take place after a few years of operation. (The wind spreadsheet uses a similar approach.)

My mental model of an infrastructure investment fund is an organization that buys investments with a five or six percent return and boosts return with 50% leverage using borrowed money at 2 percent. The resulting shares in the fund are retailed to large institutional investors as safe investments yielding seven or eight percent. The ultimate investors would be organizations such as pension funds, sovereign wealth funds, endowments, or other large investors.

The secret sauce in this analysis is the utility guarantee consequent to government mandates. Given what is usually an extremely strong credit guarantee and the low cost of risk-free money, the cost of the electricity can be greatly reduced, turning an uneconomic proposition into a prime quality investment.

The risk in these projects has been moved from the developer to the utility and then to the consumers of electricity because the utility is allowed to pass on the cost of the electricity to its customers. The electricity is uneconomic because its true cost is at least $80 per megawatt hour while the alternative is operating backup plants more, at a marginal cost of $15 for fuel. Electricity worth $15 is being purchased for $80 by the various parties involved. But due to the PPA the utility is seemingly forced to continue overpaying for 25-years. There is a way for the utility to escape its obligations, bankruptcy. If a utility goes bankrupt it does not close down because that is unthinkable. Instead, stockholders and bondholders suffer losses, or

the government comes to the rescue of the utility. PG&E, the large California utility has gone bankrupt twice in the last 20-years. The first time was due to a refusal of the government to allow it to raise prices when the cost of the electricity skyrocketed. The second time, recently, was due to the government imposing strict liability for forest fires started by power lines. In the recent case, the utility suggested abrogating the renewable energy contracts, a liability of $40 billion. That may have contributing to the settlement of the bankruptcy. The California politicians are politically invested in renewable energy and a collapse of the renewable infrastructure would have been embarrassing and politically damaging. If those contracts had been cancelled the entire basis of the renewable energy racket, I mean business, would have been called into question.