Why Battery Storage Does Not Solve the Renewable Energy Problem

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The Base Load Problem

- Current Power Generation Breakdown

Natural Gas	42%
Nuclear	20%
Coal	19%
Wind	7%
Hydro	7%
Biomass	2%
Solar	2%
Geothermal	1%

- The intermittent producers (wind and solar) only produce 9% of generation
- That means that the grid is essentially the battery.

The Base Load Problem

- The US load duration curve shows that about 40% of generation has to be base loaded to meet demand.
- This load has traditionally been met with coal and nuclear power
- Even last year coal and nuclear generated 39% of US electric power
- This year, the price of gas has increased significantly. As a result, coal fired generation increased 16% over last year during the winter.
- Difficulty in siting and building new gas pipelines has caused a number of proposed gas pipelines to be cancelled.
  - There is a shortage of pipeline capacity in New England
  - The Atlantic Coast pipeline was cancelled

The Base Load Problem

- Presuming that the nuclear power plants are somehow kept in operation through 2035, they would supply 20%, or less, of total generation.
- Presuming that the coal and gas plants are all shut down and that hydro and geothermal are geographically limited, the other 20% is purported to be solar and wind, supported by batteries.
- There could be some additional biomass generation, but again, there are limits to the amount of land, etc. that can be dedicated to biomass for power generation.
- It has also been stated that the last 20% will be the most difficult to decarbonize.
- The following analysis will demonstrate some of the issues.

The Base Load Problem

- For purposes of this analysis, I will be using solar PV as the “renewable technology”. This is admittedly a worst case scenario since wind has a better capacity factor than solar.
- This will be a “rough’ capital cost analysis, using published costs for solar PV and battery system. Think of it as, at best, a 2 significant figure analysis. In fact, this is more like a “sanity check” than an investment analysis.
- Utility financing will be used, anchored by a capital charge rate. The capital charge rate is a one significant figure number that converts capital cost to operating cost, taking into account the many types of uncertainties associated with accounting items such as interest rates, return of capital, taxes, insurance, inflation, depreciation, risk, and others. It lumps all of our ignorance of these factors in the future into one number, in this case, 20%.

The Base Load Problem

- What we want is reliable power, 24/7, 8760 hours per year. We are considering that last 20% of base load power. For solar PV (or solar in general), we get rated capacity at noon. The rest of the time, we get less.
- For this analysis, we will assume 12 hours of daylight and 12 hours of darkness.
- We can purchase a solar PV system for $5,000/Kw (peak), all in cost. That includes inverters, wiring, connections, controls, support systems, etc. The panels themselves only cover about 10 – 15% of the total cost. Thus, any further reductions in panel cost will have a minimal impact on this analysis. Further, due to supply disruptions and other problems, panel costs are starting to turn up.
- With our 12 hour day, we get 0.5 Kw average output for 12 hours (ie zero at 6 am, 1 Kw at noon, and zero at 6 pm. Thus, to get 1 Kw, we need to purchase 2 Kw in order to get 1 Kw continuous output for daytime.

The Base Load Problem

- Battery power is expected to pick up the slack for night time operation and any reduced output during the daytime.
- Batteries can be purchased for very short term operation or for more sustained operation, currently 4 hours.
- For the 4 hour battery, the cost is $2500/Kw output. The round trip efficiency is 85%. Thus, 1.2 Kw has to be used to charge the battery in order to get 1 Kw output for 4 hours.
- The shorter duration batteries are cheaper in capital cost, but have much less output. These are used for frequency control and other “ancillary services”. Today, that is the only application that cost effective, in spite of the claims.

The Base Load Problem

- For the 12 hours of darkness, we need at least 3 batteries with 4 hours capacity. These will need to be charged with additional capacity of solar PV
- Again, to steadily charge these batteries during the daytime, we need at least 3.6 Kw of steady output from the solar PV, which, in turn implies the need for 7.2 Kw of solar panels at 50% average capacity. In addition, since we get very little power early in the morning and later in the evening, we need another battery to operate during those periods, or another 2.4 Kw.
- This analysis only covers a sunny day. For the moment, we will round up to 10 panels to cover the 4 batteries and 2 panels to cover the daily output, or 12 Kw total solar installation and 4 Kw of batteries. That should take care of any interruptions during the day, but does not cover any cloudy, rainy, or snowy days.

The Base Load Problem

- That leads us to a total system cost or a reliable full day at 1 steady Kw as follows:
    - 12 Kw of solar PV at $5,000/Kw = $60,000
    - 4 Kw of batteries at $2,500/Kw = $10,000
    - Total cost = $70,000

- Next we apply the capital charge rate of 20%. Which gives us an annual cost of $14,000/Kwyr.
- We assumed that this system would operate every day of the year. Of course, that is unrealistic. The current capacity factor for solar PV in New England is 11%.

The Base Load Problem

- Using the 8760 hours/yr and $14,000 annualized cost, we can calculate the cost per Kwhr.
  - $14,000/8,760 = $1.60/Kwhr
- Recognize that this is only generation cost. There is no estimate here for transmission and distribution. Right now, on my electric bill, generation cost is $0.08/Kwhr and T&D cost is $0.12/Kwhr.
- That means that the true cost of generation using this system is 20 times the current generation cost in CT, which is one of highest in the country.
- Again, this cost assumes that the solar PV system operates every day. We know that is not the case. Certainly, there are many times throughout the year where the sun doesn’t shine for 3 or 4 days. This additional downtime is not accounted for in this analysis.

The Base Load Problem

- This analysis is only a sanity check. However, I think it illustrates the basic problem for providing true baseload power.
- Even if my cost estimates are off somewhat, the base problem remains. Batteries need to be charged up. A battery system needs to include the required generation equipment to charge up the battery, as well as the battery itself. Ignoring that part of the problem just confuses the issue.
- Admittedly, solar is the worst case. As I pointed out, solar PV in New England has a capacity factor of 11%. Wind power in New England runs about 30 – 33% capacity factor. Sometimes the wind blows at night, which reduces some of the load on the solar battery system.
- Even so, cut the costs by a factor of 3 and they are still way too high.

The Base Load Problem

- The other problem for wind is that there are many periods where the wind is not strong enough to turn the generator. These can be up to 2 weeks.
- If that level of storage were needed, something like 84 batteries would be needed with appropriate charging equipment.
- That is the main reason for looking at something besides a battery for longer term storage. Today, that storage is handled by fuel storage.
  - A coal fired plant typically has a 90 day coal pile
  - Oil storage is being used in New England in case there is a natural gas shortage in the winter, since we don’t want to build any new gas pipelines.
  - The gas pipeline system is the major storage source for natural gas.

The Base Load Problem

- This is one of the reasons to look at CCS. If CCS were available, some fossil fuels could still be used for baseload power generation with the bulk of the CO2 captured and stored (or utilized).
- That is consistent with the estimates of 17 – 20% CCS as part of the “net zero” carbon world in 2050 (or later).
- Ten years ago, when Alstom was still developing the chilled ammonia process for CCS, a small demonstration unit (30 Mw) was tested at an AEP power plant.
- With the successful operation of that test plant, AEP announced that it could now bracket the incremental cost of deploying CCS at its coal fired power plants to a range at that time of perhaps 50% - 80% of its current generation cost, which was lower back then (4 – 5 cents/Kwhr).

The Base Load Problem

- That cost estimate of an additional 2 – 4 cents/Kwhr compares very favorably to the $1.60/Kwhr estimated cost for solar PV plus batteries.
- Again, there will be some potential offsets in terms of transmitting power from one location to another, etc. but that brings us back to the grid system being the essential battery.
- This analysis used regulated utility financing. That is typically one of the lowest cost means of financing outside of grants and subsidies or municipal ownership. It assumes that the owning entity will be making a profit, but a regulated one. This type of financing was developed because power plants were high capital cost facilities and a reduced cost of capital was needed to promote the use of electricity.

The Base Load Problem

- There are other arguments for battery power. These include emergency generation, “behind the meter” power supply, peak shaving, and potentially power arbitrage (shifting generation from high cost periods to lower cost periods).
- Thus far, these additional “benefits” have not been realized. Yes, some people can justify to themselves the cost of a Tesla Powerwall to provide emergency generation in the event of a power outage. It does tend to be expensive power.
- An emergency propane generator costs around $250 – 300/Kw. Double that cost for installation and hook up. Of course, there is fuel cost in the form of propane for that machine. However, given that unit will only be used for emergency generation, the actual cost per Kwhr will be quite high. The justification is convenience and comfort during adverse weather conditions.

The Base Load Problem

- Assuming one power outage per year for 100 hours (not the case for hurricane Ida), the annualized cost would be something like $0.60/Kwhr, assuming a personal 10% capital charge rate. If the homeowner only charges the current interest rate on savings accounts (0.1%), the capital cost comes out less than a penny per Kwhr, leaving only fuel and O&M on the engine.
- That is why there is a backlog on home emergency generators of 3 – 6 months.

The Base Load Problem

- Conclusions:
  - We have done a “back of the envelope” analysis of the problem of trying to produce fully reliable, 24/7, base load power using solar PV and batteries. The results show that the cost of such as system is exceptionally high.
  - We see that the problem results from the need to charge up the batteries and have them ready to operate when needed. This means additional generation capacity on the part of the solar system that is needed to charge the batteries.
  - The current power discharge capacity for modest storage periods is 4 hours. Multiple batteries are needed to cover even a modest period of time (like night time in the case of solar).
  - This analysis did not estimate the additional costs for longer duration periods than overnight, which will only add to the costs.
  - The cheapest storage option today is fuel storage.