

**Abstract** – Here is a 100% solar and wind power simulation for ERCOT:

The 100% renewables simulation for ERCOT <http://ercot.com> uses hourly historical wind and solar data and hourly loads from 2010-2012. Simulating a 2017 future peak demand of 71119 MW, here is what is required to achieve 100% energy from wind and solar. 68 GW wind, 76 GW solar, 50 GW storage with 330 hour (~14 days) energy at full output, 5.15 GW nuclear (existing), and a small amount of gas peaking capacity needed to reach a loss of load expectation (LOLE) of 0.1 days per year. At one point the storage drops to a low value of just 5 hours. Storage frequently hits the 50000 MW capacity limit charging. The highest power ramping rates are about 60000 MW per hour. The amount of renewables has the potential to produce 10% more than needed to cover the entire load. However, the storage being limited to 50000 MW must discard about 20% of the overall renewable energy because the renewable power is much higher than the combination of load and storage capacity at times. For details see <http://egpreston.com/CASE6.TXT>. Case 6 is not likely to be affordable or workable. Another scenario with a lesser amount of renewables (Case 4) has been created with 24 GW wind, 24 GW solar, and no storage. Only 38% of the total energy is supplied by renewables, so this scenario is not a zero CO<sub>2</sub> case. The details are posted at <http://egpreston.com/CASE4.TXT>. Thanks to NREL solar and wind data being posted at <https://www.solaranywhere.com/Public/SelectData.aspx> a detailed renewables analysis is now possible anywhere in the US. It's important to use the NREL actual historical hourly data rather than synthetic solar and wind data as has been used in Mark Jacobson's study <http://www.gizmag.com/united-states-renewable-energy-2050/37938/> My modeling of Mark Jacobson's 100% renewables plan shows his recommendations provide a false sense of hope to regulators and citizens, which is not only unethical as a PE, but may be dangerous to our society. Gene Preston, PE, PhD May 28, 2015, updated June 11, 2015

Nuclear is removed in CASE7. <http://egpreston.com/CASE7.txt> which causes energy costs to rise. Gene Preston, PE, PhD June 16, 2015.

**Details** of the computer simulations:

In Case 6 wind is broken down to 24 GW Coastal, 12 GW Panhandle, and 32 GW other wind, mostly in west Texas (68 GW total wind). Solar is broken down to 22 GW central Texas (Austin), 22 GW south central Texas (San Antonio), and 32 GW west Texas (Pecos)(76 GW total solar). The 50 GW storage is assumed to be spread across ERCOT. The cost of storage in flow batteries is about \$6600 billion. I doubt ERCOT will ever be able to finance such a large amount of storage, thus case 6 is probably not feasible. Energy storage in microgrids might be affordable before grid storage simply because the cost promised by Elon Musk is only about 25% that of current grid storage, which I estimate at \$1/W and \$.4/Wh. see <http://spectrum.ieee.org/energy/the-smarter-grid/the-rise-of-the-personal-power-plant> It remains to be seen if this system will be stable and operable.

In Case 4 there is 24 GW wind, 24 GW solar, and no storage. Fossil fuel capacity is reduced by 17.7%, or by 13534 MW. Case 4 produces 38% of the total ERCOT energy from renewables. Most of the useful data is at the bottom of files case4.txt and case6.txt. Case 4 is border line operable. More importantly it does not move us off fossil fuels any significant amount.

### The need for new nuclear power:

The ERCOT system is going to need some new nuclear power. The ERCOT grid needs inertia from spinning generators in order to keep the frequency from dropping too fast when a power plant trips off line. Wind generators don't provide this inertia. Solar plants don't provide inertia. Spinning flywheels can provide the inertia, but who is going to pay for them? I doubt the market will generate enough revenue through enhanced ancillary charges to pay for spinning flywheels. We don't want to keep gas and coal plants on line running just to get the inertia. The answer is to build a few more nuclear plants.

But what kind of nuclear plants should be built and how are they to be financed? Well it's clear the present energy market is not going to be able to finance new nuclear plants. Likewise we do not want to implement the so called capacity market since that is not likely allow financing nuclear plants either. At this time no utility wants to commit to building a new nuclear plant in ERCOT because there is no way to finance it. However, I have suggested that microgrid owners can be set up so they can enter into individual investments in nuclear power and the host utility provider simply acts as an accounting agent between the nuclear plant and the homeowner investors. This is probably the only way a new nuclear plant can be financed in ERCOT, through a whole lot of individual microgrid owners.

What kinds of nuclear plants are available?

- 1) The conventional light water reactors such as at STP and Comanche Peak nuclear plants.
- 2) New failsafe designs such as the Westinghouse AP1000 <http://en.wikipedia.org/wiki/AP1000> .
- 3) New metal cooled [http://en.wikipedia.org/wiki/PRISM\\_\(reactor\)](http://en.wikipedia.org/wiki/PRISM_(reactor)) that uses waste as its fuel.
- 4) New high temperature low cost design by Per Peterson using off the shelf components. <http://thebreakthrough.org/index.php/programs/energy-and-climate/cheap-nuclear>

It's easy in my model to get a hybrid no CO<sub>2</sub> plan to work that uses some nuclear power and accommodates ERCOT's present wind fleet and a considerable amount of new solar, such as 36 GW solar, and a modest amount of storage. If we have a high penetration of wind and solar in the ERCOT system as is expected and being planned for as described recently in ERCOT documents:

<http://texaselectricnews.com/ercot-seeing-large-increases-in-wind-solar-development-interest/>

Then we will by necessity need more nuclear plant capacity of Per Peterson's design than the others simply because his nuclear plant is capable of responding quickly to a rapidly changing need for the plant output power whereas the others are not. I must say that although ERCOT expects to see a lot of solar and wind additions, they don't yet have a solution as to how to maintain grid stability when the amount of wind and solar power becomes too large to manage. That is the challenge, keeping the grid up and running as more and more wind and solar are added. Soon the entire operation is going to voltage collapse unless we engineer in some solutions.

Gene Preston PE, PhD 6/11/2015

### **Eliminating 5150 MW Existing Nuclear Power in ERCOT:**

CASE 7 is a variation off CASE 6 with zero CO<sub>2</sub> (which also has zero CO<sub>2</sub>) and retires the 5150 MW nuclear capacity in ERCOT, has been created and posted at <http://egpreston.com/CASE7.txt> .

Here are the steps used to create this simulation with a minimum amount of wind solar and storage. The nuclear provided 13% of ERCOT's energy. So the generation from West Texas wind and from West Texas solar would need to be increased so that the total renewable generation is increased from 110.875% of ERCOT load to 123.875% of load, i.e. lost nuclear energy is replaced. We could try to increase the size of the battery but that is the most expensive component so its best to just generate more energy in wind and solar, the same amount of energy that the nuclear plant generated. By trial and error it was determined that adding 8 GW West Texas wind and 8 GW West Texas solar provides a total energy produced of 123.55%, close enough to the desired 123.87%. The next step is to check to see if fossil fuels are generating and they are. So the storage capacity had to be increased by 4.2 GW so that the nuclear capacity of 5.15 GW is also covered. Note since that the additional storage capacity is less than the nuclear capacity, the additional solar and wind are providing that additional capacity. Now the next step is to reduce the storage hours until fossil fuels are again needed. That was determined to be 350 hours storage or an additional 20 hours over the 330 hours in case 6. The last step is to set the LOLE to 0.10 and that is accomplished by having a small amount of gas generation standby. That amount is about the same value as in case 6.

So now we can compare the cost of adding new wind and solar compared to retiring nuclear. The incremental cost of nuclear is about 1 cent per kWh. The cost of the new wind and solar energy will be about 4 cents per kWh. However we also need to invest in new storage. The 4.2 GW is a \$4.2 billion dollar investment for the capacity or electronics. The extra battery storage is not 20 hours but  $20 \times 350 / 330$  hours = ~21.2 GWhrs. At a cost of \$.4/wh this is an investment of ~\$8.5 billion. So by retiring the nuclear capacity we get to build 16 GW of new wind and solar with an extra cost of about 3 cents per kWh over the nuclear as well as purchasing new storage at a cost of \$12.7 billion. How could the retirement of existing nuclear be a wise investment decision?

Gene Preston, PE, PhD 6/16/2015