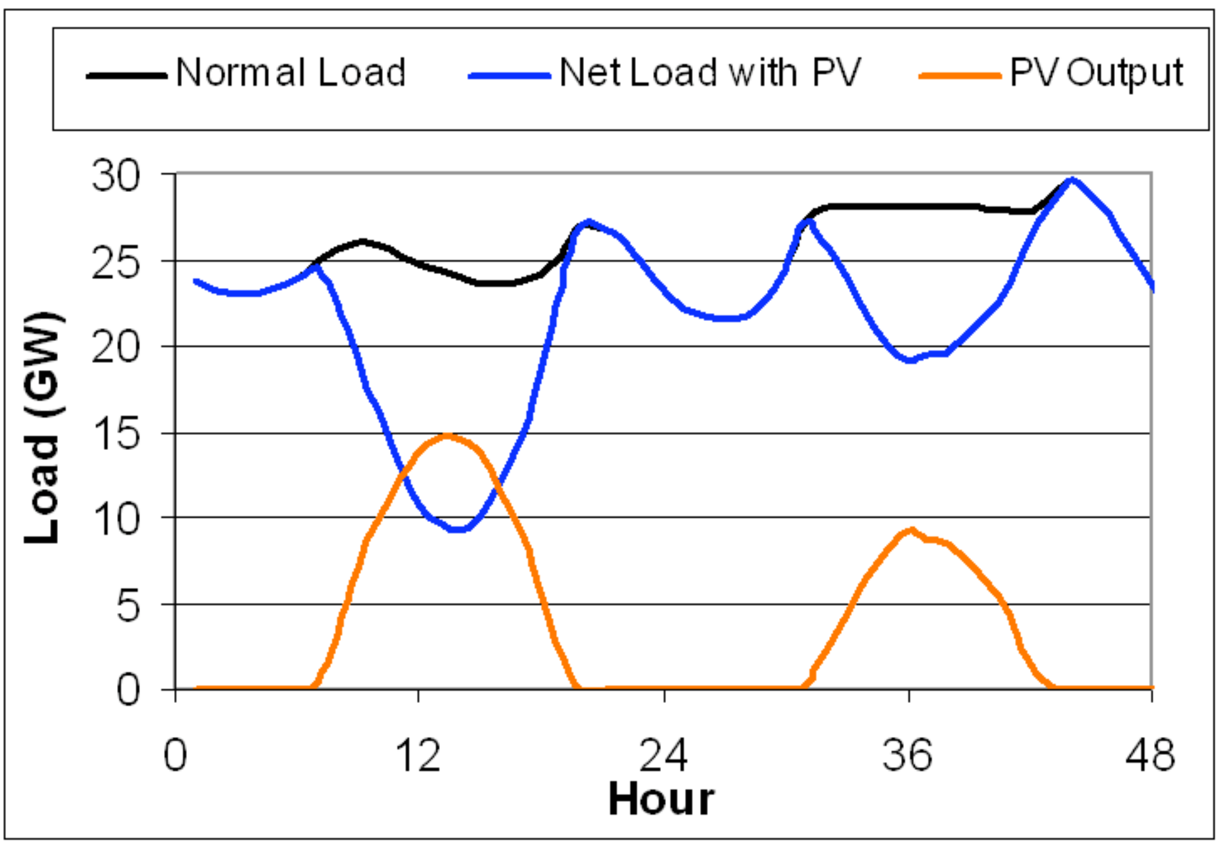
A Foundation for Understanding the Importance of a Smart National Grid

From: willstewart@rstarmail.com (Will Stewart)
Subject: Re: [LCCSS] Al Gore group urges Obama to create U.S. power grid
Date: November 9, 2008 7:08:13 AM EST
To: lccss@deciph.com,

Your response to the national unified smart grid is not unexpected from those who hear of large undertakings without having a sufficient understanding of why such an undertaking is important. As an electro-mechanical engineer who powers his house with solar PV (and can go off-grid at a moment's notice), I'll give a short explanation that should provide a foundation for understanding the importance of a smart national grid.

Supply Profiles:

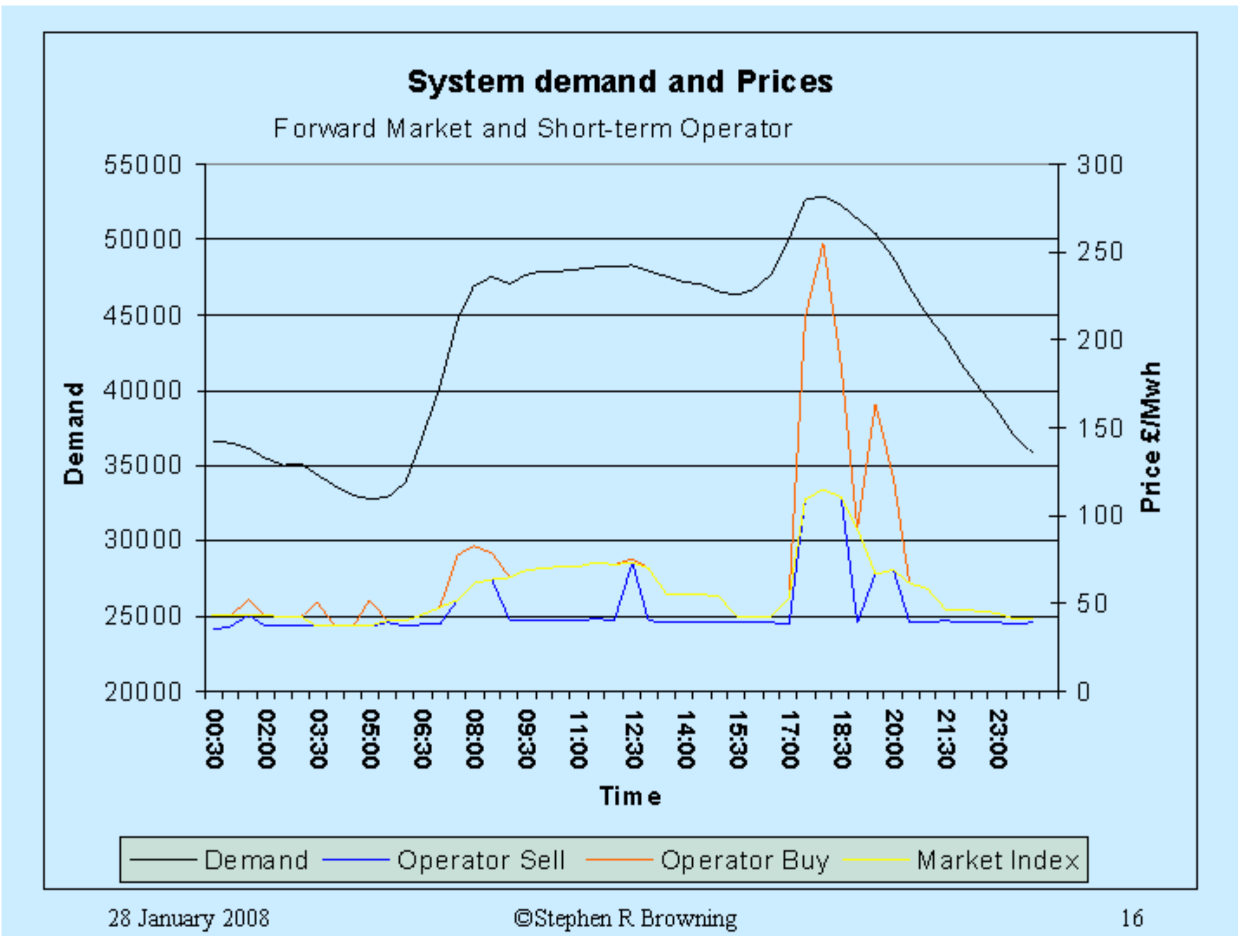
On a sunny day, my solar array produces power roughly proportional to the orange line on the graph you see below. As the sun comes up, the PV array starts generating power, reaching a peak at noon, and then declining back to zero in the late afternoon to early evening.



Solar PV Output vs Electrical Power Demand

Demand Profiles:

Throughout a typical day, electrical power requirements change based on a relatively predictable cycle (the black line in the graph above). In the early morning hours, electrical demand rises as people wake up, turn on coffee makers, and take showers, etc. The electrical load continues to climb as they make their way to offices, turning on computers, lights, and the building HVAC kicks in. This continues to ramp u through the day towards noon, as restaurants and cafeterias consume power preparing lunch. Then, as people get home and their setback thermostats kick the A/C back on (and they prepare dinner, turn on the TV, computer, lights, etc), demand often is higher at the 5-6:30pm timeframe, as you can see in the black line in the chart above. The difference between what my solar array produces and what I might consume is shown with the blue line. The chart below also shows the same type of information with a little more detail.



The amount of power needed on a regular basis (the nighttime amount) is generally supplied by baseload power plants that can provide reliable, steady power, such as nuclear plants, coal plants, and hydro-electric.

So there are times when I can't directly power the typical profile you see above. So either I use batteries, change my habits, or purchase power to cover the shortfall.

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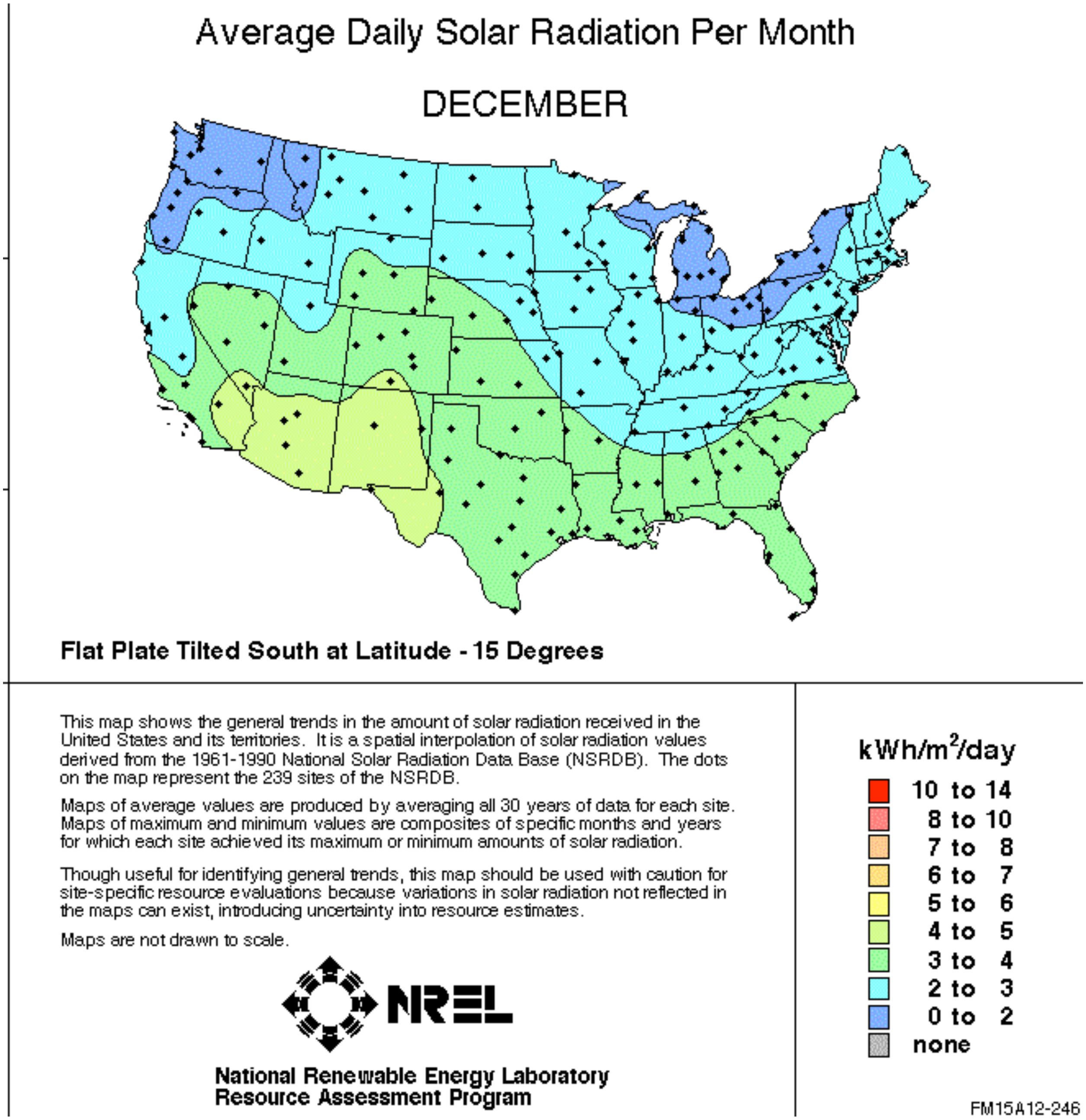
I do have **batteries**, though they only have so many charge/discharge cycles in them before they have to be replaced, which can be expensive, takes huge amounts of energy to produce/recycle, and is dependent on rather nasty lead mining. So I normally net-meter, which means that I sell my excess to the grid, and buy during times that I do not produce enough (early evening through early morning).

One could change their **habit**s, and indeed we have a very energy conserving lifestyle at our house, which lowers demand overall. With a Smart Grid, prices will reflect the amount of energy that is available and price accordingly. Normally, demand spikes are covered by turning on natural gas turbine generators, which is one of the more expensive electricity sources. As you see on the chart above, the spikes in consumption have a corresponding higher price. If that price is passed on to the consumer with real-time pricing, the consumer can choose whether or not they will pay the premium for turning on their AC or plasma TV at 6pm vs 8pm (or they may choose a more energy efficient HVAC or TV to mitigate costs).

Now a *local* grid can operate in this manner, though during times of little to no sun, either power is supplied from somewhere (i.e., coal, nuclear, or natural gas power plants), or people simply don't use power then. The latter seems unlikely in our power addicted society (you might try it sometime), so we would need to utilize these power plants. If our objective, however, is to expand renewable sources of electricity, then we have not met this objective.

Where are the best sources of reliable **solar energy**? As you can see in the chart below, the US Southwest hardly ever has a cloudy day, and is nearer the equator, so abundant, reliable solar resources there can be sent to other parts of the US.



Why not use **geothermal power**, one might ask. In Virginia, geothermal power potential is weak (see below), with minor possibilities near Hot Springs, but the vast majority of this power type is out west, and will be developed there for decades before we develop it here. And note that the few tiny hotspots we have in Virginia are not near Loudoun County, and would require grid infrastructure to reach us with appreciable power levels.

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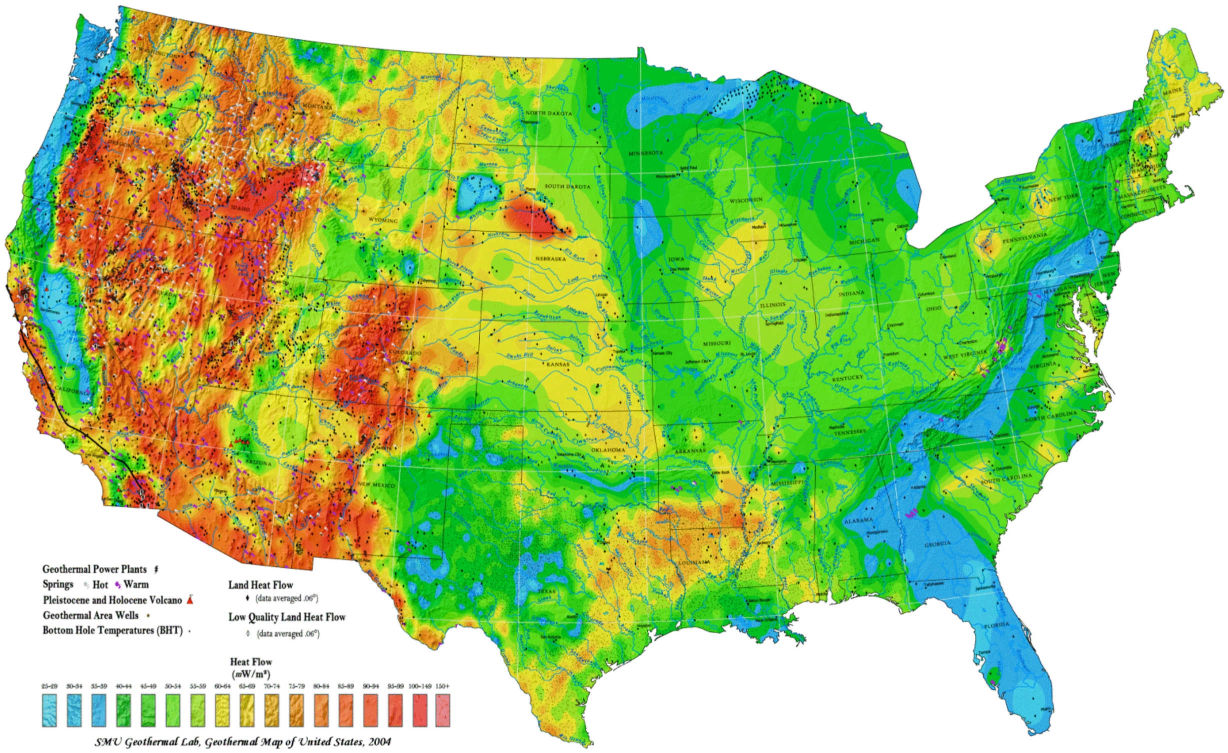
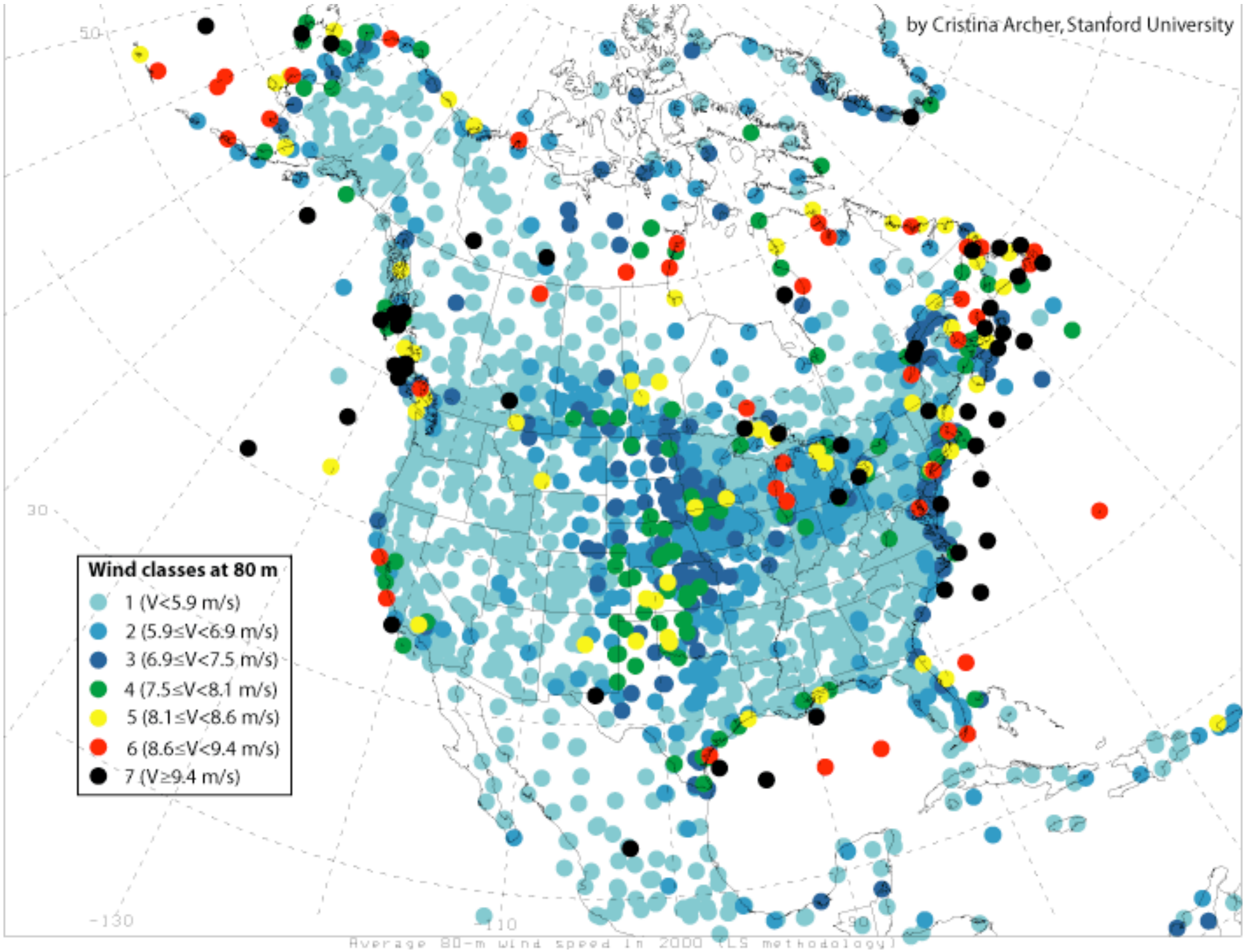


US Geothermal Power Resource Potential

Why not use **tidal power** or **wave power**? Virginia has little of either of these (tidal requires large estuaries with narrow openings be converted with barrages, and waves off of the Virginia coast are small and intermittent in size). If we did have substantial power from these resources, it would require significant levels of new/upgraded grid infrastructure to bring it inland to us.

Why not use **wind power**, one might ask. In our area, the best wind shows up in January, February, and early March. But even then, it is not reliable, as one night might be blowing fiercely and the next a lull. Now there *are* areas where the wind is more reliable and/or stronger, as you can see on the map below, but as you can see, Loudoun is somewhere in the class 2-3 range, which is too low for commercial wind generation. Small homeowner wind generation is possible in Loudoun, though not sufficient by a long shot for stablilizing a local micro-grid.



North American Wind Power Potential at 80 meters

So then how *do* we meet our objective of converting to clean, renewable energy? The interesting thing about this energy is that often, when it is cloudy in one area of the US, it is always sunny somewhere else. The same goes for wind power, though summertime can have low levels around most areas of the US. This is mitigated by higher amounts of solar energy during the summer. And, this is important, **hydro power** from different parts of the country (and large amounts from Canada) can be used for baseload power and to store excess amounts of solar and wind power to help cover demand peaks or during times when insufficient amounts of wind and solar power are available (i.e. a cloudy lull). Hydro power can act like a energy storage medium, and indeed Virginia has 3 hydro storage facilities that help to level out demand peaks and supply valleys.

Virginia's Grid

Virginia has a grid currently that has minor connections to other regional grids, though does not have the necessary amount of capacity to import (or export) significant amount of renewable energy. Our grid is designed to provide electricity straight to its customers from its coal and nuclear plants, with very slight load leveling amounts exchanged with other control areas.

National Smart Grid

First, what does **smart grid** mean? As discussed above, electricity demand can be moderated by charging more in real-time when demand begins to exceed supply, by choosing not to use (or reducing usage of) certain electrical devices during that period, or by deferring energy use until sufficient power is available (i.e., dishwasher, clotheswasher, charging electric car, etc). This is already occurring in some parts of the country, where some electrical loads such as HVACs and electric hot water tanks can be set up to be adjusted by the electrical utility during high demand (or low supply) times. Customers who sign up receive lower electricity rates, and agree to have their AC, hot water, etc adjusted to lower power levels during such time periods. Indeed, this spot efforts have resulted in significant avoidance of peak supply requirements.

With fairly accurate 24-72 hour wind and sun projections from our weather service, utilities can plan ahead how to utilize different sources of power, and have projected prices by the hour. Consumers can then choose to pay for premiums when power is pricier, defer such use, or demur from consuming significant amounts of energy during those periods.

If we created such a grid on a national level, we could load level demand and supply across a wide base of suppliers and consumers, greatly levelizing renewable energy peaks and valleys, which improves reliability and increase the overall renewable energy penetration levels possible (i.e, from 10% to over 70%) when used in conjunction with demand management. So far, the effort has been piecemeal.

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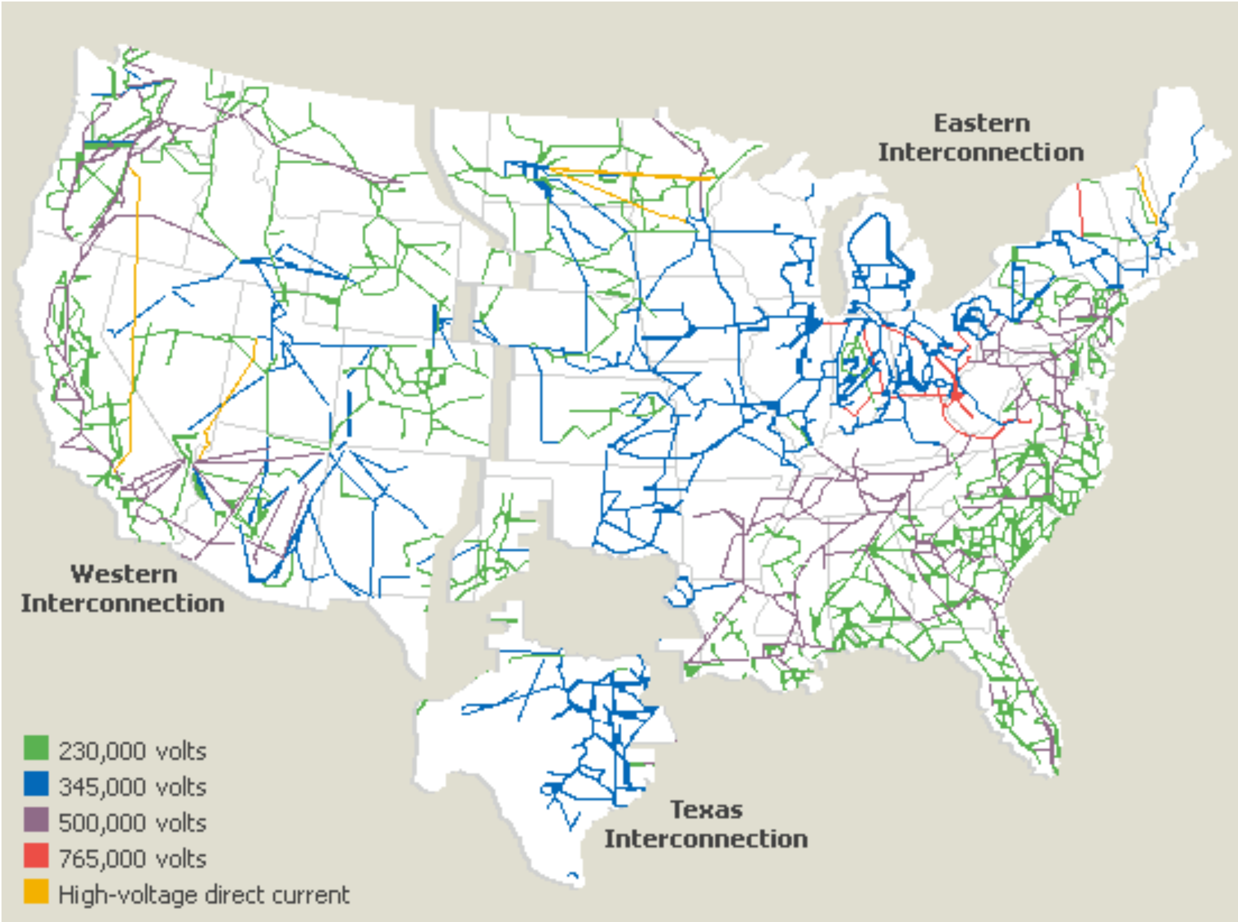

Current US Electrical Grid Network

Energy Efficiency

The gains in energy efficiency at the Repower America site refer to improvements in energy efficiency of new buildings, industrial process improvements, appliances, and HVAC systems, predominantly. Efforts like the AIA 2030 program incentivize new or renovated buildings that approach net zero energy use through better insulation, ventilation, passive solar inputs, highly efficient appliances/HVAC, onsite PV/wind, etc. For example, the house I've designed and have been living in for 10 years incorporates aspects of all the above.

Conclusion

We can utilize renewable energy resources such as solar, wind, geothermal, hydro, tidal, wave, etc to supply large percentages of our power requirements **IF** we are able to deliver these renewable resources to customers and provide pricing and/or demand management incentives to moderate power use during time of high demand or low supply.

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This is a brief overview (I haven't mentioned *dispatchable supply* or *microgrid stabilization*, for example), and some aspects of these subjects may be relatively new to many of you. I can go into much more detail on any portion of this subject area, and will be more than happy to do so. I realize this seems at odds with some power line curtailment efforts, though **it is important to note** which power lines are intended for interconnecting different regional grids (control areas) and those that are simply unnecessary expansions of short range lines (such as the WO&D Trail segment). This is an important distinction that must be taken into consideration whenever we choose to support or resist any particular transmission line proposal.

Returning to the Repower America website with this perspective should help make the pieces of the puzzle come together.

Best regards,

Will Stewart

On Sat, 2008-11-08 at 01:37 -0500, Rob Jones wrote:

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Well, around here for a few years it seemed that any time we had
anything resembling a thunderstorm we could count on a blackout. Often
from trees falling across the lines. Terrorist trees, mind you.

At the Repower America website,
http://www.repoweramerica.org/elements/analysis/,
there are two charts to illustrate energy-production scenarios that
break power generation systems by percentages. Note that the proposal
assumes a 28% gain labeled as "efficiency", also described as "Energy
efficiency policies and programs". Is this achievable? For one thing, an
across the board reduction in demand has to be paid for by someone, and
is it realistic to expect that the cost of home and commercial
structural upgrades to achieve a 28% savings will be embraced by the
owners? It's a great vision, but I'm not quite sold on the economics.

Then there is the "national unified smart grid ... like the interstate
highway system and railroads before it, investing in modernization of
the grid will create thousands of jobs for American workers." OK, more
jobs is always a key benefit, especially if we get coal miners and oil
riggers out of the drilling business and into the clean power business.
Setting aside the idea of where the paycheck comes from, though, I am
not clear on how the new technology will make copper wire more
efficient, which is the challenge of running long-haul transmission
lines. Or why we would want to launch a system that is comparable to
rail or highway infrastructure that basically serves consumption of
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resources rather than conservation.

Perhaps this comes across as clean power heresy, but as much as I admire Al Gore and believe in his 10 year vision, the whole concept of a national smart grid is, to me, yet another mass-production venture that is kin to the industries that got us into climate trouble in the first place. Pretty soon we'll be talking about peak copper along with peak oil. I'm with the folks that want to get off-grid and invest in smart local solutions, as much as possible ... although convincing my 4-yr old that we have to get rid of the TV to save the planet is a hard sell...

Cheers,

Rob Jones

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