What happens to EE/DSM when it stops being valuable to save electricity most of the time? And what does this mean for heating electrification?



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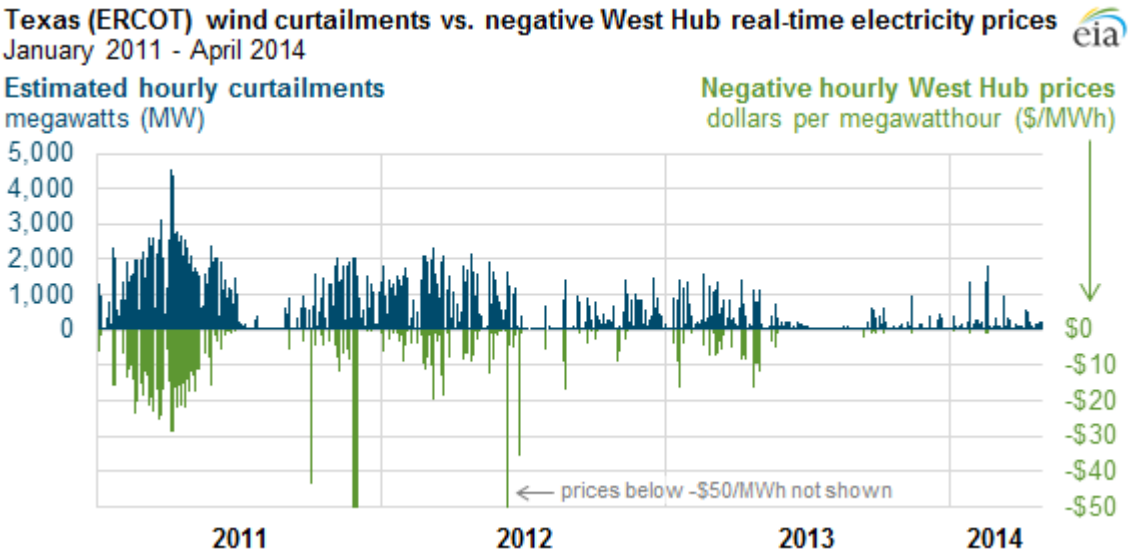
I've been thinking about these questions mostly in the context of heating electrification for a paper I'm working on, but there are important implications for energy efficiency and DSM on the whole.

We expect that with rising renewable penetration, we will have many more times when the marginal value of electricity produced and consumed is near 0. It won't be news that electricity prices in Germany or Texas turned negative during times of plenty of renewable electricity, but more what is to be expected when we have a renewables-focused system sized to produce as much as it can during times of renewable energy shortage.



I dug up this 2019 opinion piece from Utility Dive, with some similar conclusions:

We should be expecting the value of electricity during times of plenty to drop even more, while the value of electricity during times of constraint increases. Nearly all of the value of electricity being consumed and generated will be derived during times of constraint, when we have to put equipment to use that is rarely if ever used. You might think of a typical price for most hours, a top-1000 hour constraint, a top-100 hour constraint, and a top-10 hour constraint, each with different levels of additional equipment required and different increasing value of electricity and electricity savings.

So if we're going to have all of this worthless electricity produced without emissions, why should we bother trying to save it?

Energy efficiency and DSM will need to focus more on saving electricity during constrained times in the future and value savings accordingly. We already do this, to some extent, by splitting impacts into peak demand impacts and energy impacts and apportioning value differently in our cost-benefit calculations for energy consumed during peak times, and during different costing periods. In the future, we'll need a somewhat different framework with different costing periods that align more with seasonal availability of renewables and alignment with demand. Many of the same energy efficiency resources will still be valuable in this future world. For example, measures that save energy by reducing loads or increasing efficiency all of the time, like lighting and insulation, will save energy just as well (or better) during times of constraints. But some measures, like controls that reduce consumption during off-peak hours, will have much lower value.

What does this mean for heating electrification?

People promoting heating electrification frequently focus on high efficiency, cold-climate heat pumps for utility program promotion. Almost every utility energy efficiency program promoting heat pumps today focuses on these technological wonders. These heat pumps save a lot of electricity compared to a standard efficiency heat pump, but that comes at substantial cost. In addition, the actual efficiency improvements of these heat pumps comes primarily at part load, NOT full load.

What matters for the heat pump savings in this future world is how much electricity the heat pump consumes during grid-constrained hours with high demands. The value of savings the rest of the year is near 0.

Every heat pump displacing the same amount of fossil fuel in a near 100% renewables grid saves about the same amount of greenhouse gas emissions, so the standard heat pump and the cold climate heat pump displacing the same amount of gas save the same amount of greenhouse gas in this scenario. Unfortunately, most of the high efficiency heat pump savings over standard heat pumps occur during those unconstrained hours, during mild conditions, when they can run extremely efficiently at part load, so the value created will be much reduced in a renewables-powered world. Annual electricity consumption doesn't make as much sense as our objective function in the design of high efficiency equipment in the future. Instead, we should focus on saving during these times of constraint, when the wind doesn't blow and the sun doesn't shine and we have high heating demands at the same time.

So what should we be doing to promote heating electrification?

Promote ALL heat pumps, including partial displacement of gas heating with standard heat pumps.

As a result of all of this, I've come around to the idea of promoting partial displacement of gas heating with standard efficiency heat pumps combined with some kind of time-of-use (TOU) rate (like my friends at Fort Collins use) or some other rate with low marginal off-peak electricity prices and high peak charges to incent high value heating electrification across the board. A partial displacement scenario takes advantage of all of that low cost, low value zero carbon electricity without adding significantly to future grid needs during constrained times.

My early calculations show that something like 50-70% of residential gas heating could be displaced with standard heat pumps in a way that benefits everybody.

A standard heat pump costs very little more than a standard AC (less than $200 difference in price), so there isn't much incremental cost over a traditional AC. Large greenhouse gas reductions can be realized. By virtue of using more electricity off-peak, overall rates can be

lowered for both participants and non-participants, and the owners and operators of generation, transmission, and distribution equipment can enjoy higher system utilization, selling more electricity.

What about the rest of the heating load?

While this might not get us all the way to where we want to be in terms of aggressive climate targets, pushing (and perhaps requiring) heat pumps in combination with gas-burning equipment would arguably have just as large an impact as efforts to electrify the transportation sector, while building market awareness and acceptance of heat pumps. At the same time, we can work on developing products that can cost-effectively deal with times of high loads and low renewable availability. And if the renewable gas advocates are correct, then the optimum arrangement might be to use renewable gas to meet the last 10-20% of the load, with larger heat pumps sized to meet the large majority of the load, rather than electric resistance heat and massive grid upgrades.