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*The Power Markets Project studies and promotes market policies that align with clean energy goals. It is a project of PaulosAnalysis, with financial support from the Heinrich Böll Foundation, the Cynthia and George Mitchell Foundation, and the Rockefeller Brothers Fund. Thanks to this support a delegation of German energy officials and experts was able to go on a fact-finding tour of the United States that included visits to Texas, PJM, and Washington, DC.*

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## Aligning Markets with Clean Energy Policy

*The pace of adoption for wind and solar power will hinge on whether market design policies can be changed to welcome them and accommodate their rapid growth. A key question at the top of Germany's policy agenda is whether the current energy-only market is up to the task of ushering in the Energiewende without causing economic catastrophes for market participants.*

*Bentham Paulos*

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### I. Introduction

Germany's drive toward more renewable energy, energy efficiency, and low carbon emissions – the *Energiewende* – is not an isolated incident. On the contrary, many places around the world are seeking the energy independence, technological advancement, and clean environment that clean energy can deliver.

**B**ut because Germans are out front and have a technologically advanced, first-world economy, the eyes of the

world are upon them. And being in the vanguard, they are the first to discover what works and what doesn't, and to face the problems that arise.

One fundamental discovery<sup>1</sup> of the *Energiewende* has been that wind and solar electricity are going to be the workhorses of the future. They are cheap and getting cheaper, they have a large resource to tap, they are domestic energy sources, and they don't pollute. Other renewable sources, like biomass, hydropower and geothermal energy, are either largely

exploited already, are more expensive, have other uses like providing heat or transportation fuels, need more time to develop, or have limited potential.

Other options have limits, too. Germany has committed to phasing out nuclear power by 2022, in response to public opposition over safety issues. Coal is not likely to square with Germany's carbon reduction goals, given its significant carbon footprint and a public unease about carbon sequestration.

This leaves natural gas, which is almost entirely imported, with Russia the largest source. Current political tensions in Russia and Ukraine are a clear reminder of the energy security threat that comes with natural gas.

Another finding from the *Energiewende* is the fundamental importance of improving energy efficiency. Reduced demand can solve many of the concerns about sufficient capacity, as well as reduce pollution and save money for consumers. Efficiency and other demand-side approaches can also help integrate wind and solar.

Given the alternatives, using wind and solar to supply a more efficient system looks like the best bet. But wind and solar are only available when the weather commands, while electricity is needed around the clock and demand must be met at all times, or the system collapses. To make such a system work, two sets of problems must be solved – engineering and finance.

### A. Technical tasks

It is starting to look like the technical issues of integrating wind and solar are not really an impediment. Grid operators have many tools in their toolbox<sup>2</sup> to keep the lights on as wind and solar production increase.

Dispatchable power plants have always been the first option for integration, and will remain so, whether powered by

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renewable or other fuels. They will have to be cleaner and more flexible, and they can be.

Better transmission links not only connect remote renewables to cities, they also reduce variability by moving power around in real time and tapping a bigger pool of both demand and supply.

The demand side of the system is becoming increasingly interactive, as appliances, lighting, and motors can be controlled using Internet and wireless communications. Converting surplus electricity into thermal storage, such as by

pre-heating water or pre-cooling buildings, has vast potential.

Excess wind and solar output can also be redirected into making other products, like hydrogen or synthetic fertilizer. They can even be curtailed when necessary.

And electricity storage – often touted as the only solution for variable renewables – is an increasingly viable option. Grid-connected batteries are seeing better cost and performance thanks to advances made for electric vehicles. Large-scale storage using water and compressed air are mature technologies.

These options are generally well understood by grid operators. Not all are cost-effective or valued by markets or system planners, especially in our current system. But in a future system that is heavily reliant on solar and wind, and in which carbon emissions are capped, these many tools will be put to work.

### B. The money problem

Perhaps the bigger problem with a power system dominated by wind and solar is the money problem. While some economists have pointed to what they call “the missing money” problem, renewables are causing a different disruption.

In an energy-only market, producers are paid enough to cover their own operating costs, but not enough to incentivize new

power plants, according to the “missing money” theory.<sup>3</sup> Only when there is scarcity, and prices rise during periodic spikes, is there enough incentive to build new plants. But price spikes can be a sign of market manipulation, and are unpopular with the public, so regulators implement caps that prevent them. Hence, there is no price signal, there is “missing money” in the market, and no new plants getting built.

**R**enewables are causing a different money problem.

A typical energy market selects bids from generators, from lowest price to highest in each hour, ensuring the least overall cost. The output from wind and solar generators is always accepted first into the grid, because they cost nearly nothing to operate once they are built. In economics terms, they have a near-zero marginal cost. This is called the “merit order” and is the most economically efficient way to choose suppliers in a market.

Germany has discovered that the daily path of the sun and great storm-driven gusts of wind, already able to meet up to two-thirds of electricity demand, have the ability to flood the market with cheap power, driving costs on the energy spot market to zero or even into negative territory – where generators are penalized for putting power onto the grid. This is good for consumers, but it can create problems for producers.

In the past, power plant owners made the most money during

peak demand times. Peak prices were typically many times those of off-peak prices, and because all generators get the same “market clearing” price, all would benefit from big peaks. But since solar power coincides pretty well with peak demand periods, the peak has been flattened out and prices are no longer high.

Also, conventional thermal plants need to be able to turn down or off during low- and

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negative-price periods to avoid prices that are below their operating (marginal) costs. Yet steam-driven power plants, especially nuclear plants, have a minimum level that they must maintain. If the equipment cools off, it can take many hours or even days to start up again. These inflexible plants cannot get out of the way of solar and wind, and will pose an ongoing obstacle to the growth of renewables. (In this regard, the forced retirement of nuclear plants will help solve this technical problem.)

Combined heat and power (CHP) plants also cause flexibility

problems, especially when used for district heating systems. They are operated to produce heat in the winter, with the electric by-product sold into the grid when available.

Low prices are also wreaking havoc on the balance sheets of thermal plant owners. European utilities E.ON, RWE, GDF Suez, and Vattenfall all saw major losses<sup>4</sup> in 2013. RWE has called it “a crisis in conventional power generation.”<sup>5</sup> RWE has closed 12,600 MW of capacity since the start of 2013, while German utilities have requested permission to shut down<sup>6</sup> almost 15 GW of additional conventional power plants.

Ironically, given the carbon goals of the government, the power plants that are surviving the best are the dirtiest, those that burn domestic, low-energy lignite coal. These plants, built at the mouths of coal mines, are beating out modern, highly efficient, and flexible natural gas plants, and driving up carbon emissions. Declining demand for coal in the U.S. is also increasing “hard” coal exports to Europe at low cost.

Plants like this are supposed to be squeezed out by the Europe-wide cap-and-trade system for carbon. But because of the slowing economy, the over-allocation of carbon credits, and the rapid growth of zero-emission renewables, producers are well under their carbon caps, making tradable carbon credits nearly worthless. Even though coal power operators must buy many

carbon credits, the low price has no effect on their operations. Until caps are tightened or floor prices are implemented, carbon emissions will continue to be too high.

A second problem is that markets need to pay explicitly and perhaps more for the kinds of technical tools described earlier that are needed to integrate wind and solar. Energy markets can be designed to increase flexibility, through more frequent clearing times (such as every 5 or 15 minutes). Capacity markets could require all bidders to meet minimum standards for operational flexibility, and could give a “flexibility premium” to capacity resources that offer even better flexibility.

Lastly, and perhaps most importantly, markets for ancillary services could be greatly expanded. Ancillary services are all of the functions necessary to run the grid, such as maintaining voltage, providing fast-acting reserves, and ramping up and down. They are typically a very small amount of the money in a market, but as the need increases to deal with variability, they should be more highly valued. Because many markets lack these features, flexible resources like fast gas turbines and demand response are undervalued, underused, and underinvested.

A third problem is currently only a potential problem. Low power market prices don't just affect conventional generation;

they would also cause problems for wind and solar producers. If the price is zero when they are producing the most, they don't get paid. But under current German policy, renewable producers are shielded from the market, paid by a 20-year fixed rate called a feed-in tariff (FiT).

The German parliament recently passed legislation<sup>7</sup> to reform the feed-in tariff system, phasing it out for large producers

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over the next few years. The idea is to gradually expose renewables to greater market forces, transitioning to support policies that float with market conditions.

The new approach will result in two benefits. First, it will provide a price signal to investors to build new renewable generators that produce at times and places where they have a higher value, such as west-facing solar panels. Secondly, renewable generators will recover at least some of their costs from energy markets, though this will be trued up with a “FiT premium” or “contract for difference.” Still, if wind and

solar essentially kill their own market price when they are producing the most, they will need to be paid largely through non-market mechanisms.

And while the recent reforms may be an improvement, they do not really solve the zero and negative price problem. Wind and solar must produce when they do, regardless of market prices. As they grow, their impact on market prices will also grow. Experts predict that Germany will see periods of 100 percent wind and solar as soon as 2020, and 1,000 hours per year of negative prices by 2025. The market design of today will break down as the *Energiewende* bears full fruit.

## II. Questions and Some Potential Solutions

These problems have put the question of market design at the top of the *Energiewende* policy agenda. Policymakers are asking whether the current energy-only market is up to the task of ushering in the *Energiewende* without causing economic catastrophes for market participants.

- Does Germany need a capacity market? If so, what variants on it would further the goals of the *Energiewende* – retiring nuclear, retiring coal, expanding renewables and efficiency, and limiting carbon emissions?
- How can the market buy the dispatchable and flexible resources needed to maintain

reliability as wind and solar grow to 50 percent or more of the power supply?

- How can the energy market work for producers when wind and solar increasingly create zero and negative prices in the power exchange?

Some stakeholders in Germany, especially owners of conventional power plants, are pushing for a capacity market similar to the one offered by the PJM Interconnection in the United States. PJM is the world's largest power market by sales volume, serving 61 million people from the East Coast to Chicago. Such a mechanism would reduce investor risk by providing at least some certainty in future years.

Others think an energy-only market is the most economically efficient and creates the most robust competition. In the United States, the Electric Reliability Council of Texas (ERCOT) has the purest energy-only market.

A few leading market models have emerged in the debate in Germany. Agora Energiewende, a Berlin think tank, surveyed experts<sup>8</sup> on different models.

A "focused capacity market"<sup>9</sup> would give a capacity payment only to new resources and existing resources at risk of retirement. Flexibility and low emissions would be important parameters in assessing bids. Existing power plants that are profitable, that run a lot,

and have high emission rates, would be excluded from the capacity market, and would rely just on energy payments.

The "decentralized capacity market" would require all electric retailers to supply sufficient capacity for their customers, instead of a central agency specifying the amount and quality of capacity needed. Each retailer would

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*A 'decentralized capacity market' would require all electric retailers to supply sufficient capacity for their customers.*

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have to hold "performance certificates" proving it has capacity, and these certificates would be tradable. A small balancing market would make up for any shortfalls.

The "comprehensive capacity market" would provide capacity payments for all generators and demand-side resources. A central authority would determine the amount of capacity and availability needed five to seven years in advance, and award contracts to both supply- and demand-side resources, with all winning bidders getting the market

clearing price. All resources would have to meet technical requirements to provide flexibility, and flexibility would be rewarded through the short-term balancing market.

Finally, a "strategic reserve" would pay a small fleet of backup power plants, perhaps 5 percent of total peak demand, to run only when energy price caps were hit or in emergency situations when the security of supply is threatened. These plants would not participate in the energy-only market. Like the focused capacity market, it would give capacity payments to only a small share of capacity, rather than for the entire fleet of resources, as in a comprehensive market. The federal network agency (BNetzA) already operates a "winter reserve" of power plants that run only when supplies are tight. This system sunsets in 2017, but could evolve into a "strategic" reserve.

The German economics ministry (BMWi) recently published a set of four studies<sup>10</sup> evaluating the need for market reform, and possible designs. The debate is so far critical of comprehensive capacity markets, and suggests that incremental improvements may be taken first.

### III. A Capabilities Market

Others have gone straight toward the bottom line: if Germany needs flexibility above



all, what policies will reward operational flexibility?

The Regulatory Assistance Project (RAP), which has written extensively<sup>11</sup> about market design, starts by looking at the “net demand” for electricity, which is the remaining demand after generation from wind and solar is subtracted.

Figure 1 shows the net demand for a winter period in Denmark that had high wind and CHP output. Denmark gets 30 percent of its power from wind, on average, though has periods where wind output exceeds demand<sup>12</sup> for the entire country. The net load curve, which looks quite different than a standard “gross demand” curve, is what will have to be

met using other resources. A market designed for conventional baseload, intermediate, and peaking plants, instead of this net-demand paradigm runs the risk of “driving needlessly costly and unstable outcomes.”

RAP recommends expanding the discussion beyond capacity markets to consider three market mechanisms that can provide flexibility at least cost:

1. Enhanced services market mechanisms: Ancillary services are the moment-by-moment activities that keep the grid functioning, such as fast-acting reserves and voltage support. In a world with faster and bigger changes in net demand,

there will be more demand for such services, and for new ones, like the ability to ramp up and down quickly.

2. Apportioned forward capacity mechanisms: Not all capacity resources have the same capabilities, such as changing rapidly, starting and stopping, reliability, and size. Rather than treating them all the same in one big auction, this mechanism would differentiate between different types of capacity services, and reward those most in demand.

3. Strategic reserves: Research by the Brattle Group<sup>13</sup> and others has found that an economically optimal reserve margin is smaller than the engineering standard of one outage every 10 years. A lower margin can save tens or hundreds of millions of dollars per year, but does run a greater risk of shortages and price spikes, which can be extremely expensive should they occur. Like the proposal mentioned above, a strategic reserve would be a small set of fast-acting resources that would be called on only when prices hit their caps, or there were emergency shortages.

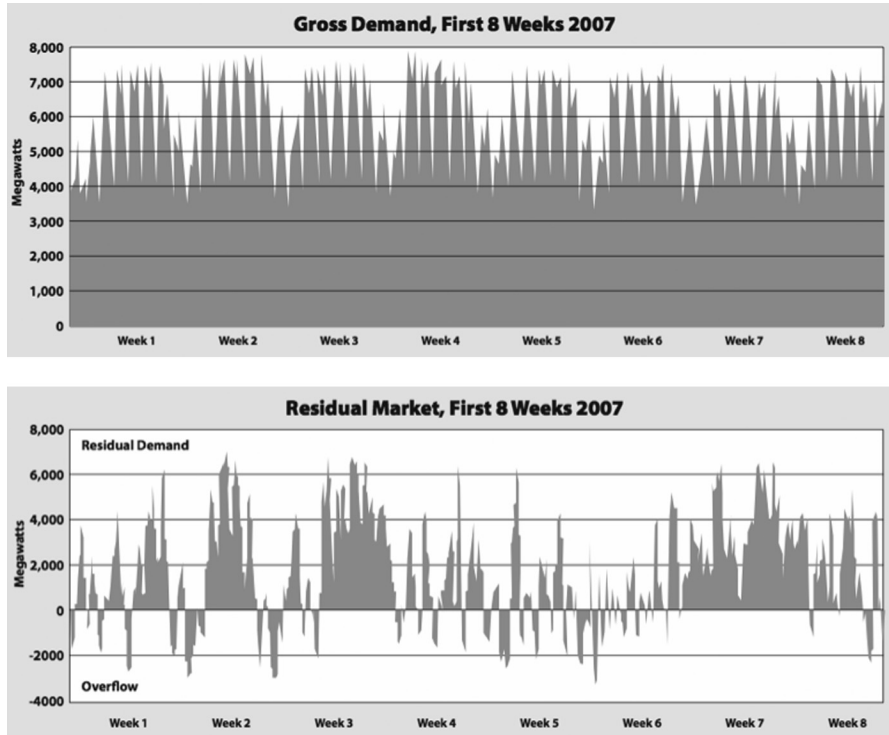


Figure 1: Looking at Net Demand

The top chart shows gross demand in Denmark in the winter of 2007, while the bottom shows the residual demand after wind and CHP electricity output are subtracted.

## IV. Learning from the American Experience

Like Germany, Texas has an energy-only, fully competitive market with growing amounts of variable renewables and very low market prices.

Stakeholders there recently went through a grueling debate on capacity markets. Consumer groups, including manufacturers and oil and gas producers, were strongly opposed to capacity payments, while utilities argued they were necessary to attract new investment. In the end, the state utility commissioned decided there were sufficient resources to keep the lights on for at least the next five years. They did raise the market price cap and introduce a mechanism to boost prices during times of scarcity (the Operating Reserve Demand Curve).

PJM has had a capacity market since 2004, holding annual auctions for existing and new capacity three years in advance. This market has encouraged a large amount of demand response, though most of the money has gone to incumbent coal and nuclear generators rather than to new resources. Reserve margins in PJM are currently over 25 percent, much higher than historical engineering standards require.

It may be too simple to say that either Texas or PJM is the “correct” approach to market design. Market design should reflect the priorities and values of the people served by the market, guided by their energy policies. Because these priorities and values change from place to place, it is all right and even likely for distinct choices to emerge in the market design for Germany.

The Power Markets Project seeks to shed light on the approaches and policies that can steer the *Energiewende* toward a successful outcome, which will teach the rest of the world how best to create a clean energy future. ■

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