Current Sustainable/Renewable Energy Reports (2019) 6:29–33
https://doi.org/10.1007/s40518-019-00123-6

ENERGY MARKETS (R SIOSHANSI AND A MOUSAVIAN, SECTION EDITORS)

Power Markets in Transition: Consequences of Oversupply and Options for Market Operators

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Abstract

Purpose of Review This paper explores the transition underway in competitive power markets in the USA and provides options for market operators to reliably manage through the current period of oversupply into a lower-cost, lower-carbon power system.

Recent Findings There are several structural factors, as well as some more recent and short-term dynamic factors, contributing to oversupply in the power system.

Summary Power market operators have options for thoughtfully managing the transition, which include updating resource adequacy frameworks and ensuring market product definitions remain technology neutral given emerging technologies. Load serving entities can also hedge on behalf of their customers by contracting for low-carbon, low-cost sources of grid flexibility.

Keywords Competitive power markets · Energy transition · Overcapacity · Grid flexibility · Wholesale power market design · Reliability

Introduction

There is an urgent imperative to reduce greenhouse gas emissions to avoid catastrophic climate change [1]. Electricity is responsible for more than a quarter of all greenhouse gases produced in the USA [2, 3] and can be used to displace direct burning of fossil fuels in transportation and buildings. Luckily, the costs of zero carbon electricity have fallen precipitously in recent years, and it is currently less expensive to build new zero carbon electricity sources than the continuing operating costs of existing coal power plants in many parts of the country [4]. And in some places, it is cheaper to aggregate price-responsive or dispatchable demand—or even to build grid storage—than to pay to keep natural gas peaker plants around [5, 6]. Meanwhile, total electricity demand in the USA has stopped growing and remains flat, due in large part to the success of energy efficiency programs, which save money and avoid pollution [7]. In analyses of future scenarios where electricity replaces direct burning of fossil fuels in transportation and buildings, these services can be met at a lower cost for customers by using new clean energy supply and taking advantage of flexible demand [8]. The availability of clean alternatives to fossil fuels is blossoming.

In about two-thirds of the USA, electricity is traded in competitive wholesale power markets [9]. These markets were designed to select the least cost portfolio of power generation resources during a time when total electricity demand was still expected to continue its historical growth trajectory, and when fossil-fueled power plants were the dominant source of electricity. But this country has entered a new period of flat demand and a plethora of cheap, clean electricity resources.

This period of transition has exacerbated a natural tendency toward oversupply in competitive power markets. This paper examines why the US power system is in an overcapacity situation, implications of current dynamics for the future of competitive power markets, and what can be done to support a low-cost, reliable transition to a low-carbon electricity system.

This paper is focused on system-level (or societal) impacts of overcapacity in power markets, rather than individual or firm-level impacts. Of course, there will also be serious firm-level impacts. Nevertheless, the economically efficient outcome of an oversupply situation is for some uncompetitive power plants to retire, thus bringing supply and demand back toward equilibrium.

This article is part of the Topical Collection on *Energy Markets*

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Structural Tendencies Toward Oversupply in Competitive Power Markets

Power markets have a structural tendency toward oversupply. There are five main structural drivers:

(1) Reliability is a top-level goal for the electricity system. Power outages can cause serious economic damages and can even cost lives. In theory, markets compare the incremental benefits of added reliability to the incremental costs of power generation capacity [10], but understandable conservatism causes policymakers, regulators, and utilities to err on the side of more electricity supply rather than less.

(2) Many policymakers desire to shape the electricity mix in their region, and subsidies for specific resources are a commonly used tool to accomplish this. The result is that all electricity generation resources are subsidized in many different ways, from some combination of federal, state, and local governments [11]. However, power markets and power system planners do not systematically take these subsidies into account, and often plan as if they were not there. This tends to support more resources in total than would be necessary to maintain reliability.

(3) Power system planners tend to overestimate future growth in electricity demand [12, 13]. Electricity demand growth has decoupled from economic growth in the USA, in part due to the success of energy efficiency policies in increasing energy productivity and in part due to a structural economic shift from manufacturing to services [2, 14]. These effects have not been adequately built into electricity planning, and the corresponding target reserve margins, in competitive power markets.

(4) Some of the competitive power markets in the USA trade capacity alongside energy and ancillary services (e.g., PJM Interconnection and ISO New England), with the theory being that if competitive markets employ price caps (as most do), there is some "missing money" that generators need to earn to remain viable [15]. Some market operators use a capacity mechanism to help achieve desired reserve margins and maintain resource adequacy, and market operators continually adjust capacity market mechanisms to increase clearing prices for capacity [16], even when real reserve margins are above target reserve margins [17].

(5) Many states, even in regions with competitive power markets, still allow regulated utilities to own power plants (e.g., the Midcontinent Independent System Operator and the Southwest Power Pool). In these regions, utilities earn a rate of return above their cost of capital for investments in power plants [18]. Since it is profitable for utilities to build power plants, there is a tendency to overbuild—this is a well-known phenomenon in the utility world, known as the Averch-Johnson effect. These plants are often "self-scheduled" and run many more hours than they would if they followed market-based economic dispatch signals, in part to justify to state commissions that they be allowed to remain open and continue to collect revenue [19].

Though not the focus of this paper, it is worth noting that all of these structural drivers also support oversupply in vertically integrated regions under cost of service regulation aside from number 4.

Recent Dynamics Exacerbating Oversupply in Competitive Power Markets

In addition to the structural drivers of oversupply, there are two more recent developments that are contributing to oversupply during this period of transition in the energy system.

First, new options have become available to manage peak demand in the power system. Demand response is a relatively new tool to actively adjust electricity consumption patterns to better match the availability of electricity supply. Previously, electricity demand was treated as an unalterable target to be met with dispatchable power plants. But now, electricity demand can be aggregated and shifted via time of use rates actively pre-cooling buildings, pre-heating water, or other methods. Demand response can reduce peak electricity demand at scale, very inexpensively [20]. Very few regions around the USA are yet adjusting peak demand and associated planning reserve margins to reflect newly emerging demand response.

Second, all-in costs of new wind power plants—and increasingly new solar power plants—are now lower than the continuing operating costs of many old coal plants [4]. To be clear, this is not just marginal cost compared with marginal cost—it is all-in cost to build and operate new plants in certain areas compared with ongoing operating costs of existing plants in those areas. This cost crossover has profound implications for the US power sector. For example, this cost dynamic means that it is economically rational for more clean power capacity to enter the market, and economically efficient for uncompetitive coal plants to exit the market. This is because total system reliability requirements can now be met with a cheaper set of resources; thus, a well-functioning, efficient competitive market would see these cheaper resources enter the mix, lower wholesale market clearing prices, cause more expensive resources to fail to recover sufficient revenue to cover their costs, and consequently see those more expensive resources exit the market. However, the structural factors described above can serve to delay power plant retirements, even when they are economically efficient.

These two dynamics are exacerbating the structural oversupply situation in competitive US power markets.

Dangerous Consequences of Oversupply in Competitive Power Markets

These five structural and two dynamic factors have led to an oversupply situation in most competitive markets across the USA. Table 1 shows each market's target reserve margin, followed by the real reserve margin (as anticipated by the North American Electric Reliability Corporation) and then reports the difference between targets and realized margins [17].

For 2018, the Electric Reliability Council of Texas (ERCOT) is the only competitive market that does not have a reserve margin greater than its target. This may be due in part to the fact that Texas does not allow regulated utilities to own power plants and earn a rate of return on them (as MISO, SPP, and parts of PJM and CAISO do; see structural factor 5), as well as the fact that Texas does not have a parallel market for capacity (as PJM, ISO-NE, MISO, and NYISO do; see structural factor 4). Of course, another complicating factor that makes it difficult to compare competitive power markets across the USA is the existence of underlying federal, state, and local subsidies for all of the different resources participating in the markets. Many of these subsidies come in the form of tax breaks, which can make them harder to track and compare. Coal receives multiple federal tax breaks including an energy production tax credit for refined coal and Indian coal, for example [21], natural gas is eligible for multiple severance tax exemptions and other certified tax exemptions in Texas and similar subsidies in other states [22], and wind receives a federal production tax credit (though that federal subsidy is on a predetermined decline schedule and will drop to zero in 2020) [23]. Because the size and structure of these subsidies vary widely across regions and across resources, their existence makes it difficult to compare markets based solely on the markets' overall structures (such as whether they exist in states that allow utilities to own generation or not).

All competitive power markets in the USA, aside from ERCOT, are currently oversupplied. Economically efficient power markets should naturally correct for this oversupply via low clearing prices, which should put pressure on relatively expensive power plants to exit the market and bring supply and demand back into equilibrium. However, due to a mix of the structural and dynamic factors described above, oversupply is common in competitive power markets.

Prolonged oversupply slows decarbonization of the power sector, since coal plants stick around longer than is economically efficient, crowding out cheaper clean energy resources and delaying clean energy build-out [24].

From the perspective of responsible grid planning and management, another dangerous consequence of overcapacity is that a market awash in generation mutes the price signal for grid flexibility. Power systems have always operated flexibly—with demand moving up and down based on anything from factory schedules to sporting events, and with traditional power plants scheduling planned outages or dealing with unplanned outages [25]. But if wind and solar continue to undercut coal and nuclear on cost, and more of the remaining large power plants begin to retire, the value of grid flexibility may quickly become much higher without much transition time.

In other words, when markets are oversupplied and generation capacity is sitting idle, there is (rightly) low or zero value for flexibility in the market. But many of the large generators (which are each individually many hundreds of megawatts) can no longer compete with low-cost, low-carbon alternatives, so large, lumpy retirements might produce transition periods lacking needed flexibility unless the transition is proactively managed.

Options for Managing Competitive Power Markets in Transition

There are at least three concrete options for power market operators and one option for load serving entities (those who

Table 1 2018 reserve margins in America's competitive power markets

Market	2018 target reserve margin (%)	2018 real reserve margin (%)	2018 capacity above reserve margin (% of total capacity)	2018 capacity above reserve margin (MW)
MISO	17.10	19.10	2.00	2400
ISO-NE	16.80	26.10	9.30	2400
NYISO	15.00	29.20	14.20	4500
PJM	16.10	32.80	16.70	23,900
SPP	12.00	32.40	20.40	10,500
ERCOT	13.80	10.90	− 2.90	− 2000
CAISO	22.50	15.00	7.50	4000

buy energy resources on behalf of customers) to smooth the transition from the current oversupply situation to a new lower-carbon, lower-cost market equilibrium. These options aim to better expose the value of grid flexibility, if and as the market corrects for oversupply and more flexibility becomes needed.

First, the competitive markets that trade capacity could update their procurement mechanisms. Today, capacity is procured for future years in 12-month increments, and enough capacity (i.e., megawatts) clears the market to meet the highest peak anticipated for any time of the year. But electricity demand and supply vary considerably throughout the year. For example, any electricity demand that provides a thermal service—such as air conditioning or refrigeration—is well-suited to be controlled in aggregate, and actively shifting the time that these units cycle on and off can provide the same level of service to customers while offering grid operators a new option to manage system peaks. On the supply side, solar supply can be greater in summer months while wind supply can be greater in the winter, and natural gas combustion turbines have seasonal ratings due to significant performance variations based on ambient temperature. Procuring capacity to meet a single annual peak obscures these seasonal variations and can result in paying for more overall capacity than is economically efficient [26]. Clearing the forward capacity market on time increments shorter than 1 year would enable seasonal resources to compete to provide needed capacity, resulting in lower overall costs and less annual overcapacity. Clearing the market on a seasonal or monthly basis could better reflect system conditions, meeting demand reliably and more affordably as the power system becomes less dominated by baseload and peaker plants, and shifts more toward variable wind and solar supply and more dispatchable demand.

Second, grid operators could review definitions of ancillary services to ensure they remain technology neutral as new technologies emerge that can provide flexibility to the grid. For example, the California Independent System Operator has created a “non-generator resource” category to provide a way for new technologies to participate in the existing market for ancillary services [27]. It may seem like these ancillary service markets have very little value during the time of oversupply, but economic theory suggests it will serve markets well to have these appropriate technology-neutral structures in place when large power plant retirements start to come, and the value of flexibility increases.

Third, if after the procurement mechanisms are updated and the ancillary services reviewed, grid operators and policymakers remain uneasy about resource adequacy, they could consider a strategic reserve [28]. Power plants in the strategic reserve would not participate in the normal energy, ancillary service, or capacity markets, but would be remunerated separately [29]. Paying a limited number of power plants outside the market could provide a kind of backstop insurance for the grid in case of extreme events. It is critical, though, to remove power plants in the strategic reserve from the normal functioning of the primary markets, so that their presence does not dampen the important market signal for flexibility needed as the energy mix transitions. And if a strategic reserve is adopted to provide this kind of additional security through the grid’s transition, it would be important to build in periodic review of the program, to examine how often the power plants are being called on, and whether it remains in the public interest to continue to pay them to remain available.

Finally, load serving entities could hedge against forthcoming lumpy retirements by proactively procuring low-carbon sources of flexibility, such as aggregated demand response, energy storage, or imported clean energy with a generation profile complementary to their local resources. This is not out of the normal course of business for buyers, who already have bilateral contracts with all different kinds of grid resources [30]. The impact of this kind of hedging would be greater if power market operators allow these new technologies to qualify for resource adequacy, perhaps using new metrics for resource adequacy.

These four options can support thoughtful management of power systems in transition.

Conclusion

US power markets have a structural tendency toward oversupply, which is being exacerbated by a set of newly emerging resources that can now be built and operated for less money than the ongoing operating costs of existing resources. But old power plants that can no longer compete should—and will eventually—retire. When this happens, economic theory suggests the value of grid flexibility will increase. Market operators and load serving entities can get in front of this by improving capacity procurement mechanisms, ensuring power market product definitions are technology neutral, considering a strategic reserve outside of the main markets, and adding flexibility to load serving entities’ contract portfolios.

Compliance with Ethical Standards

Conflict of Interest Sonia Aggarwal declares no potential conflicts of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

References

1. International Panel on Climate Change. Global warming of 1.5° C: Special report 15. [homepage on the Internet]. c2018 [cited 2018 Nov 6]. Available from: http://www.ipcc.ch/report/sr15/
2. Peterson D. Link between growth in economic activity and electricity use is changing around the world [homepage on the Internet]. c2017 [cited 2018 Nov 6]. Available from: https://www.eia.gov/todayinenergy/detail.php?id=33812
3. Harvey H, Orvis R, Rissman J, O'Boyle M, Busch C, Aggarwal S. Designing climate solutions: a policy guide for low-carbon energy. San Francisco: Island Press; 2018.
4. Lazard. Levelized cost of energy 2017 [homepage on the Internet]. c2017 [cited 2018 Nov 6]. Available from: https://www.lazard.com/perspective/levelized-cost-of-energy-2017/
5. Dyson M, Engel A, Farbes J. The economics of clean energy portfolios [homepage on the Internet]. c2018 [cited 2018 Nov 6]. Available from: https://rmi.org/insight/the-economics-of-clean-energy-portfolios/
6. Denholm P, Margolis R. The potential for energy storage to provide peaking capacity in California under increased penetration of solar photovoltaics [homepage on the Internet]. c2018 [cited 2018 Nov 6]. Available from: https://www.nrel.gov/docs/fy18osti/70905.pdf
7. Energy Information Administration. Annual energy outlook 2018 with projections to 2050 [homepage on the Internet]. c2018 [cited 2018 Nov 6]. Available from: https://www.eia.gov/outlooks/aeo/pdf/AEO2018.pdf
8. Vibrant Clean Energy. Minnesota's smarter grid [homepage on the Internet]. c2018 [cited 2018 Nov 6]. Available from: http://www.vibrantcleanenergy.com/wp-content/uploads/2018/10/MNSmarterGrid-MNPUC_30Oct2018.pdf
9. Federal Regulatory Energy Commission. Electric power markets - national overview [homepage on the Internet]. No date [updated 2017 Apr 13; cited 2018 Nov 6]. Available from: https://www.ferc.gov/market-oversight/mkt-electric/overview.asp
10. Prada JF. The value of reliability in power systems: pricing operating reserves [homepage on the Internet]. c1999 [cited 2018 Nov 6]. Available from: http://web.mit.edu/energylab/www/pubs/el99-005wp.pdf
11. Energy Information Administration. Direct federal financial interventions and subsidies in energy in fiscal year 2016 [homepage on the Internet]. c2018 [cited 2018 Nov 6]. Available from: https://www.eia.gov/analysis/requests/subsidy/pdf/subsidy.pdf
12. Gimon E, Aggarwal S. Driving blind: the worst examples of outdated data skewing renewable energy projections [homepage on the Internet]. c2015 [cited 2018 Nov 6]. Available from: https://www.greentechmedia.com/articles/read/are-policymakers-driving-blind-with-yesterdays-electricity-cost-numbers#gs.5nns5_s
13. Howland J. Comments to Rhode Island Division of Public Utilities and Carriers and Office of Energy Resources' notice of inquiry into distribution system planning: appendix 2 [homepage on the Internet]. c2017 [cited 2018 Nov 6]. Available from: http://www.ripuc.org/utilityinfo/electric/PST_DSP_NOI_Acadia.pdf
14. Goodwin N, Harris J, Nelson J, Roach B, Torras M. The structure of the United States economy. Boston: Tufts University; 2006.
15. Spees K, Newall S, Pfeifenberger J. Capacity markets—lessons learned from the first decade, Economics of Energy & Environmental Policy [serial online] 2013 [cited 2018 Nov 6]; 2: 1–26. Available from: JSTOR.
16. Calpine Corporation et al v. PJM Interconnection: Docket nos. ER18–1314-000, −001 [homepage on the Internet]. c2018 [cited 2018 Nov 6]. Available from: https://www.pjm.com/-/media/documents/ferc/filings/2018/20181002-capacity-reform-filing-w0172181x8DF47.ashx
17. North American Electric Reliability Corporation. 2018 summer reliability assessment [homepage on the Internet]. c2018 [cited 2018 Nov 6]. Available from: https://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/NERC_SRA_05252018_Final.pdf
18. Kihm S, Lehr R, Aggarwal S, Burgess E. Moving toward value in utility compensation [homepage on the Internet]. c2015 [cited 2018 Nov 6]. Available from: https://americaspowerplan.com/wp-content/uploads/2016/07/CostValue-Part1-Revenue.pdf
19. Daniel J. Out of merit generation of regulated coal plants in organized energy markets: presentation to United States association for energy economics [homepage on the Internet]. c2018 [cited 2018 Nov 6]. Available from: http://www.usaee.org/usaee2018/submissions/Presentations/Out-of-Merit%20Dispatch%20In%20organized%20Energy%20Markets%20Final.pdf
20. Alstone P, Potter J, Piette MA, et al. 2025 California demand response potential study - charting California's demand response future: final report on phase 2 results [homepage on the Internet]. c2017 [cited 2018 Nov 6]. Available from: https://drrc.lbl.gov/publications/2025-california-demand-response
21. Legal Information Institute. U.S. Tax Code: Title 26, subtitle A, chapter 1, subchapter A, part IV, subpart D [homepage on the Internet]. No date [cited 2018 Dec 5]. Available from: https://www.law.cornell.edu/uscode/text/26/45
22. Texas comptroller. Natural gas production tax [homepage on the Internet]. No date [cited 2018 Dec 5]. Available from: https://comptroller.texas.gov/taxes/natural-gas/
23. North Carolina Clean Energy Technology Center. Renewable electricity production tax credit program overview [homepage on the Internet]. c2018 [cited 2018 Nov 6]. Available from: http://programs.dsireusa.org/system/program/detail/734
24. del Rio P, Janeiro L. Overcapacity as a barrier to renewable energy deployment: the Spanish case. J Energy. 2016;2016:1–10. https://doi.org/10.1155/2016/8510527
25. Pierpont B, Nelson D, Posner D, Goggins A. Flexibility: the path to low-carbon, low-cost electricity grids [homepage on the Internet]. c2017 [cited 2018 Nov 6]. Available from: https://climatepolicyinitiative.org/publication/flexibility-path-low-carbon-low-cost-electricity-grids/.
26. Chen J. Is capacity oversupply too much of a good thing? Nat Gas Electr. 2017;34:15–21.
27. California Independent System Operator. Non-generator resource regulation energy management project implementation plan [homepage on the Internet]. c2012 [cited 2018 Nov 6]. Available from: http://www.caiso.com/documents/non-generatorresourceregulationenergymanagementimplementationplan.pdf
28. Lehmann P, Brandt R, Gawel E, Heim S, Korte K, Löschel A, et al. Capacity payments to secure electricity supply? On the future of Germany's power market design. Energ Sustain Soc. 2015;5:15.
29. Nicolosi M. Necessity and design options of a capacity mechanism for Germany [homepage on the Internet]. c2012 [cited 2018 Nov 6]. Available from: https://www.umweltbundesamt.de/publikationen/notwendigkeit-ausgestaltungsmoeglichkeiten-eines
30. Hausman E, Hornby R, Smith A. Bilateral contracting in deregulated electricity markets: synapse report to the American public power association [homepage on the Internet]. c2008 [cited 2018 Nov 6]. Available from: http://citeseerx.ist.psu.edu/viewdoc/download;jsessionid=D312AF0B9279226D4D0EDC653CFAD604?doi=10.1.1.179.1344&rep=rep1&type=pdf