US Power Markets Opportunities and Challenges

S&P Global Platts

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Cambridge Energy Solutions

A Provider of Information and Energy Solutions

About CES

- Cambridge Energy Solutions is a software company with a mission to develop software tools for the participants in electric power markets.

- CES-US provides information and tools to assist market participants in analyzing the electricity markets on a locational basis, forecast and value transmission congestion, and to understand the fundamental drivers of short- and long-term energy prices.

- CES-US staff are experts on market structures in the US, system operation and related information technology.

Discussion Outline

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Market History: Design

- The Energy Policy Act of 1992 established competitive markets to lower the cost of energy to consumers and increase efficient use of the bulk electric system and the Production Tax Credit for renewables.
  - Opened the door for competitive generation development through technological innovation to build new, efficient gas-fired power plants and retire older, dirtier plants
  - Established a set of policies and guidelines for the efficient and reliable operation of the transmission system while guaranteeing non-discriminatory access for prospective generation and load
  - Platform for development of financial products to support additional power system functions: transmission capacity auctions, generation capacity auctions, ancillary services market, etc.
- The establishment of Independent System Operators (ISOs) allowed for reliable operation of the system and coordinated planning.
  - Provided transparency into both the energy price formation as well as economic transmission development
  - Increased cross-company and inter-regional focus on the efficient use and development of the transmission system

Market History: Challenges

- Competitive market design had fundamental concepts that required significant technological innovation and infrastructure to implement.
  - Separate operational and planning policies, guidelines, and practices had to be consolidated into coordinated regional efforts.
  - Entire company financial structures, both internal and external, needed to be modified to accommodate the new market products.
  - All new Energy Management Systems (EMS) had to be created or modified to incorporate the complexities of Locational Marginal Pricing (LMPs) and the resulting changes to economic dispatch and commitment.
  - New, more complex tools and databases were required to model, study, and plan the transmission system. “8760” production cost models now had to be nodally extended with LMPs to capture the changing system states and congestion potential across all hours for an entire year.
  - Physical assets and hardware in the field, from transmission device standards to generation price-signal response and even communication protocols, required modification and standardization.
  - Drastic increase in data complexity in load (weather) forecasting and outage coordination/planning was required, along with an entirely new paradigm for data transparency and reporting requirements instituted for ISOs requiring further data coordination and standardization.

Market History: Development & Progress

- The markets became a proven success story in driving efficiency through transparency, accessibility, and competition. Continued development to meet evolving industry needs became routine.
  - The competitive, responsive nature of the markets led to industry-leading innovation and developments to address changing and evolving public policy and regulations.
  - Increasingly complex financial products were created to address and appropriately incentivize market needs.
  - Ensuring transparency, equitability, and efficiency with increasing complexity is a constant challenge in market design.
- The accessibility and competition in energy markets allowed for quick adaptation to public policy (e.g., PTCs, ITCs, and FERC orders) that incentivized further technological innovation in renewable generation resources.
  - The flexibility and resiliency of market design proved integral in the ability to accommodate a rapidly-changing generation profile with associated transformative utilization of the transmission system.
  - The already-increased focus on inter-regional operations and planning only became more pivotal as increasingly variable system conditions and dispatch heavily relied on the innovative market design and associated tools and software for reliable and efficient planning and operations.

Today's Renewable Era: Challenges

- While the markets were the perfect platform for the efficient development of innovative renewable energy resources, the rapid acceleration of renewable development led to a transformation of the power networks and several associated challenges.
  - Increased variability and intermittency of renewable generation resources requires consideration of incentives for reliable capacity development (capacity markets?) and/or focus on development of energy storage solutions (short- and long-term).
  - Increased focus on weather (particularly wind) forecasts is vital as now both load and system dispatch are responsive to changing weather conditions.
  - Markets were designed with price-responsive generation in mind. Renewable generation is not only typically unresponsive to normal pricing signals, but government incentives created further price pressure and transmission stress, resulting in negative offer pricing.
  - Reliance on generation resources clustered around strong renewable source availability is increasing. This places more stress on remote parts of the transmission system and causes increased stability concerns because these renewable source clusters are typically far from load centers. This creates a greater need for wider, regional coordination of transmission and generation resources.
  - Interconnection requests and studies have seen a dramatic increase. New policies, regulations, and practices had to be established to ensure accuracy and efficiency in evaluating system impacts.

Today's Renewable Era: Opportunities

Resource Development

- Generation developers have been able to take advantage of competitive market design in pursuing renewable development incentives and fulfilling aggressive state clean-energy goals.
  - Solar development, initially driven by incentives, has seen technological innovation and economies of scale play a huge role in dramatically driving down development costs to the point of now being independently economic. Development opportunity continues with increased focus on technological innovation with higher efficiency panels, multi-axes solar tracking, and bi-facial panels.
  - Onshore wind generation continues to experience improvements in design and construction with increased size and efficiency while still having a lower production cost than the older turbines at lower wind speeds. This can significantly expand the suitable geographic regions for wind development and increase investment opportunities.
  - Offshore wind has incredible potential as a renewable resource with its high capacity factor and more reliable generation profile. While there are development, integration, and maintenance challenges with offshore wind, several East Coast states are pursuing aggressive offshore wind development targets that ensure strong incentives and investment opportunities for those willing to take on the challenge.
  - Energy Storage solutions are critical to the continued successful reliable integration of both grid-scale and distributed renewables. Proper incentivization and state/federal goals are currently ramping up and paramount to the continued development and technological innovation of energy storage.

Today's Renewable Era: Opportunities

Grid Modernization

- Competitive energy markets and rapid renewable development, both grid-scale and distributed, has had a substantial and transformative impact on both the transmission and distribution systems.
  - As grid-scale renewable generation continues to grow in both individual scale and market penetration, the focus on transmission projects continues to widen towards larger and more coordinated regional projects with large investment potential.
    - Offshore wind alone requires very large and complex DC & AC solutions for reliable integration with the existing grid in areas of the network that were once considered load-service endpoints (coastal cities).
  - Advances in DC line technology can drive economic, regional DC lines capable of transmitting large amounts of renewable energy from strong geographic resource areas.
    - Potential exists for the development of DC networks for more reliable, efficient, and coordinated renewable sources for both onshore and offshore applications.
  - Distribution systems will soon see transformative changes with increasing distributed renewable generation as the huge cost reductions in grid-scale solar development trickle down to consumers combined with the paradigm-shift towards electric vehicles. This currently untapped development opportunity offers incredible potential for smart grid investment, micro-grid solutions, demand-side control systems, DC integration, and much more.

Today's Renewable Era: Opportunities

Technological Innovation

- The ever-evolving generation mix and resulting impacts to the transmission and distribution networks creates a strong need for continued technological development in the areas of software and infrastructure solutions.
  - Constant opportunity to improve the accuracy of and ability to forecast weather and extreme weather events along with the tools to optimize the intermittency of renewable generation with the operation of existing thermal generation and growing energy storage capacity (better software and algorithms).
  - Focus on proactive, large-scale regional transmission investment solutions supported through strong economic analysis driven by advanced market-tuned forward-looking modeling tools and datasets (Dayzer Platform).
  - Continue developing and improving transmission and distribution smart networking technology with intelligent load balancing, adaptive protection schemes, and advanced telemetry/analytics to increase the reliable and efficient use of transmission and distribution capacity.
  - Develop the guidelines, hardware, middleware, and software systems to support the integration of consumer-side distributed generation and demand-response into the wholesale market. Create design and implementation strategy for distribution-level market pricing.
    - Directly support electric vehicle charging infrastructure with software integration into the wholesale market with consideration for commuting/transportation patterns. Develop optimal battery charging/discharging software to allow system operators or consumers to use EV batteries as backup or dispatchable resources
  - Improve cybersecurity for utilities as more automation and data collection is needed to operate the transmission and distribution systems. Control of these systems must ensure data privacy and be protected against failure as well as malware.
    - Secure consumer-pricing-responsive vehicles and appliances against privacy/hacking concerns.

The Clean Future: Challenges

- The goal of decarbonizing the energy sector by 2035 will require a monumental effort and investment to conquer the challenges ahead of us, not only by the power industry, but by all Americans.
  - Following the landmark Energy Policy Act of 1992, the effort and vision needed to transform the energy industry to a competitive market was immense, but at that time, it was focused on industry-internal changes with the goal of reducing customer costs while increasing efficiency. Decarbonizing by 2035 would require a similar transformative effort, but not *just* internal to the industry.
    - Extremely large-scale AC & DC transmission integration studies and projects would need to be coupled to aggressive state and federal renewable development targets (CREZ, MVP, public policy projects, etc..)
    - Operational and planning coordination would need to expand to include cross-market, super-pool regional coordination with a hierarchical structure to support proper focus and situational awareness.
    - Regulations and guidelines surrounding the integration of distributed consumer generation and demand response into the wholesale market pricing signals would need to be coupled with the development and standardization of the hardware, software, and communication protocols required.
    - Grid-scale and distributed energy storage solutions would need to be aggressively incentivized and/or state/federal policy-supported to ensure reliable capacity for dramatically increased renewable penetration.
    - Comprehensive distribution modeling and analysis would need to ensure local systems are capable of the transformative variable loading/injection patterns possible with significantly increased distributed generation.
    - There would need to be a dramatic increase in the infrastructure and industry supporting the design, construction, maintenance, and disposal of renewable generation components and assets.

The Clean Future: Public Policy

- Public Policy must be crafted to properly incentivize both the immediate steps towards our decarbonized future using existing technology as well as the most promising avenues of technological development.
  - How do we balance the policies that provide incentives to facilitate building more renewables and associated infrastructure without significantly increasing the burden on consumers and the economy?
  - Is it possible to fully decarbonize by 2035 without equaling or possibly exceeding the effort required during the “Space Race”? Is that an economic cost we are willing to pay for the potential societal and environmental benefits?
- Achieving the ambitious renewable goals with competitive market forces but with policies to reduce investment and operating risks of all new projects, generation, transmission, storage, projects, etc.. (subsidies, fixed PPAs).
  - Many states already have green energy standards with specified target dates and use a combination of policies to implement through direct subsidies, indirect subsidies or taxes (carbon cap and trade program), renewable energy credits (offshore and onshore wind), zero emission credits, and/or storage capacity requirements, etc.
  - These programs might have the same objective of increasing clean energy and reducing environmental impact but differ significantly in terms of who pays for these programs (consumers or government/tax payers), where the money goes (producers or tax agency or entity), and the impact on the economy overall.
  - This degree of conflicting priorities, incentive fragmentation, and complex financial models required to model both investment and societal/economic impact becomes counterproductive and a direct hinderance to the coordinated regional effort required to design and implement these large scale energy solutions. Federal agencies must coordinate with the federal and state governments to provide clarity and focus if any aggressive goals are to be met.

The Clean Future: Public Policy Continued

- No public policy with this large of a societal and economic impact can be possible without a concerted effort to engage and educate the public on the importance and value of this monumental effort.
  - Instead of focusing solely on negative aspects, include a focus on the exciting new technologies and modernization of aging power infrastructure.
    - Describe and illustrate a future of advanced smart home features combined with a smart grid and electrification of the transportation sector.
    - Engage forward-thinking tech giants already invested and passionate about decarbonization to support and promote this future outlook with consistent positive messaging and illustration.
  - Address layoff and/or tax revenue concerns for small communities with a positive focus on programs to train workers for the large influx of new jobs and tax revenue created by these massive renewable projects and the associated infrastructure required to support them (an entire industry in it's own right).
- As the energy industry has been undergoing rapid transformation, public policy must be prepared to continue addressing new issues.
  - As extreme weather events have recently been increasing in both frequency and severity, additional policies and regulations must be considered to address the requirements and costs associated with additional system hardening.
  - It is important to educate the public on the economic costs incurred by directly addressing extreme environmental factors in comparison to their likelihood (risk tolerance) and potential innovative alternatives (demand response, distributed generation).

The Clean Future: Opportunities

- Humanity has shown time and again that when it puts its focus toward solving a difficult challenge and is willing to expend the effort necessary, we will find the solution. There are no end of future opportunities that can help us reach our ambitious clean energy goals.
  - The need for continued innovation in energy storage technology is a driving force in the energy industry. Any breakthrough in the energy density, production cost, production capacity, or battery-alternative technology (hydrogen, compressed air, etc.) would be transformative for the industry overnight.
  - Similarly, in the effort to provide reliable base-load capacity with no carbon emissions, the development of 4th generation modular nuclear reactors has the potential to offer a safe, semi-distributed, long-term reliable backbone of capacity for extended periods of renewable intermittency.
  - Low cost Carbon removal technologies
  - Currently the distribution system and consumer-facing technologies are almost entirely isolated from the larger electric industry and markets. Developing the full set of complex hardware and software solutions required to integrate consumer and commercial renewable, storage, and demand-response devices into a single optimized power solution with pricing and data transparency is yet another monumental but necessary effort to reach a truly energy-efficient decarbonized future.
  - Additional considerations to improve existing/on-going issues
    - Clean-coal improvements, carbon removal/sequestration, reforestation
    - Recyclable renewable components: turbines, blades, panels, and batteries