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ADDRESSING WIND POWER INTERMITTENCY IN THE ERCOT AND SPP REGIONS

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I. Introduction

This Article explores efforts to address challenges involving wind power intermittency in two United States power regions: the Southwest Power Pool ("SPP") and the Electric Reliability Council of Texas ("ERCOT"). SPP and ERCOT are good case studies regarding these issues because each has among the strongest wind resources in the country, most of which are in isolated, sparsely populated areas and need long transmission lines to reach major load (electricity consumption) centers. Those circumstances increase the challenge of integrating intermittent wind generation into the electric system (grid).

Each type of power generation has advantages and disadvantages compared to other types. For instance, wind power burns no fuel, provides air quality and water conservation benefits, and is not subject to fuel-cost volatility.[1] On the other hand, the fact that wind power is intermittent, or variable, causes important challenges for grid operation when compared to conventional generation. As discussed in this Article, those challenges include:

- Actual wind power output is harder to predict.
- Wind generation provides significantly less capacity compared to its nameplate rating.
- As wind penetration (the proportion of wind power in the system generation mix) increases, the system needs more capacity reserves from thermal generation that can increase or reduce output quickly to offset the combined impact of changes in wind power output and load.
- Wind contributes less to stabilizing frequency after a disturbance and provides less voltage support.
- Higher wind penetration requires traditional thermal units to provide ancillary services ("AS") more frequently and to ramp up and down more often, increasing the cost of maintaining and operating thermal units.
- Wind generation is typically offered at a lower price, displacing thermal generation, which reduces long-term incentives to invest in thermal generation.

The gap between wind generation and traditional generation in the respects described above is narrowing due to improvements in wind forecasting and wind turbine technology, addition of electric energy storage, and other positive developments, but challenges remain. This Article summarizes those challenges and some solutions being considered or used in ERCOT and SPP to address those challenges.

1. *E.g.,* Pub. Util. Comm'n of Tex., *Commission Staff's Petition for Designation of Competitive Renewable-Energy Zones*, Docket No. 33672, at 46–47 (Oct. 7, 2008) (order on rehearing), http://interchange.puc.texas.gov/WebApp/Interchange/application/dbapps/filings/pgSearch_Results.asp?TXT_CNTR_NO=33672&TXT_ITEM_NO=14x23.

II. Intermittency Challenges and Related Law

A. *Regulatory Context*

SPP has members in nine states: Arkansas, Kansas, Louisiana, Mississippi, Missouri, Nebraska, New Mexico, Oklahoma, and Texas.[2] Although SPP's regional boundaries can be defined in different ways and are changing, in broad terms SPP territory includes all of Oklahoma and Kansas and parts of the other states (e.g., most of the Texas Panhandle).[3] The ERCOT region is limited to Texas and comprises the entire state except the El Paso area, most of the Texas Panhandle, and part of East Texas.[4]

In addition to being multi-state, SPP is part of the Eastern Interconnection that comprises much of the eastern half of North America.[5] Thus, as in most of the United States, the Federal Energy Regulatory Commission ("FERC") regulates wholesale power sales and transmission rates and service in the SPP region. In short, FERC policies on wholesale power and transmission issues that are relevant to wind power intermittency apply to SPP. The SPP region is also subject to the electric reliability regulatory programs of FERC and of the North American Electric Reliability Corporation ("NERC") and SPP Regional Entity regarding reliability functions FERC delegated to them.

In contrast, because ERCOT is wholly intrastate, the federal scheme administered by FERC does not generally govern ERCOT.[6] Electric regulation is primarily by the State of Texas: the Legislature, the Public Utility Commission of Texas ("PUCT"), and ERCOT.[7] Authority is clear and direct: ERCOT operates under PUCT oversight, and both operate under direction of the Texas Legislature, expressed chiefly in the Public Utility Regulatory Act ("PURA").[8]

However, ERCOT remains subject to certain federal electric reliability standards administered by FERC, NERC, and Texas Reliability Entity ("TRE").[9] The region is also subject to the separate, somewhat

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2. *See* Southwest Power Pool, SPP Footprints 5 (last updated Dec. 20, 2013), http://www.spp.org/publications/SPP_Footprints.pdf.

3. *See id.*

4. *See ERCOT Region map*, ERCOT, http://www.ercot.com/content/news/mediakit/maps/ERCOT_Region_map.jpg (last visited Feb. 7, 2014).

5. *See* N. Am. Elec. Reliability Corp., *NERC Interconnections*, NERC, http://www.nerc.com/AboutNERC/keyplayers/Documents/NERC_Interconnections_Color_072512.jpg, (last visited Feb. 8, 2014).

6. Hammack v. Tex. Pub. Util. Comm'n, 131 S.W.3d 713, 718 n.4 (Tex. App—Austin 2004, pet. denied); *see also Commission Staff's Petition for Designation of Competitive Renewable-Energy Zones*, *supra* note 1, at 49.

7. *See Quick Facts*, Elec. Reliability Council of Tex. ("ERCOT") 2 (May 2013), http://www.ercot.com/content/news/presentations/2013/ERCOT_Quick_Facts_May%202013.pdf [hereinafter *Quick Facts*].

8. *See generally* Public Utility Regulatory Act ("PURA"), Tex. Util. Code Ann. tit. 2 (West 2007).

9. *See Quick Facts*, *supra* note 7, at 2.

different electric reliability requirements of ERCOT, enforced by the PUCT.[10]

ERCOT is not synchronously interconnected outside the state.[11] ERCOT is a single Balancing Authority ("BA") Interconnection—in NERC terms—and cannot generally rely on any neighboring BAs in the Eastern and Western Interconnections when responding to system events and emergencies.[12]

B. *Resource Considerations in ERCOT and SPP*

1. Generation Mix

SPP and ERCOT have some of the strongest wind resources in the country.[13] ERCOT's best wind resources are in West Texas and the Panhandle, and along the Texas Gulf Coast between Corpus Christi and Brownsville.[14] Texas's vast population and industrial centers, however, are concentrated in the eastern half of Texas. Most of ERCOT's wind generation development has occurred in West Texas and the Panhandle, in areas with low population.[15]

SPP's best wind resources are in the western and northern parts of the region.[16] SPP's population is densest in the southeast part of the region.[17]

SPP's 75,864 megawatts ("MW") of generating capacity is 42% gas/oil, 40% coal, 6% dual fuel, 4% hydro, 4% wind, 3% nuclear, 0.5% pumped storage, and 0.5% biomass.[18] Thus SPP's generation mix is dominated by gas/oil and coal; only 4% is wind.[19] There are times of

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10. *See* PURA, TEX. UTIL. CODE ANN. § 39.151(a), (c)–(d), (h)–(k) (West Supp. 2013).

11. *Id.* § 31.002(5).

12. ERCOT, *ERCOT Concept Paper: Future Ancillary Services in ERCOT*, Draft version 1.1, at 6 (2013), http://www.ercot.com/calendar/2013/10/20131024-ASWork shop (Draft ERCOT Ancillary Services Concept Paper) [hereinafter *ERCOT Concept Paper*].

13. *See* National Renewable Energy Laboratory, *Wind Resource Assessment*, NREL: WIND RESEARCH–WIND RESOURCE ASSESSMENT, http://www.nrel.gov/wind/resource_assessment.html (last updated July 2, 2013) [hereinafter *Wind Resource Assessment*].

14. PUB. UTIL. COMM'N OF TEX., R.R. COMM'N OF TEX. & STATE ENERGY CONSERVATION OFFICE, TEXAS ENERGY ASSURANCE PLAN 69 (Nov. 2012), http://www.puc.texas.gov/industry/electric/reports/energy_assurance/Energy_Assurance_Plan-Texas.pdf [hereinafter TEXAS ENERGY ASSURANCE PLAN].

15. PUB. UTIL. COMM'N OF TEX., 2011 REPORT TO THE 82ND TEXAS LEGISLATURE: SCOPE OF COMPETITION IN ELECTRIC MARKETS IN TEXAS 71 (Jan. 2011) http://www.puc.texas.gov/industry/electric/reports/scope/2011/2011scope_elec.pdf [hereinafter 2011 SCOPE REPORT].

16. *See Wind Resource Assessment*, *supra* note 13.

17. *See* SOUTHWEST POWER POOL, SPP MEMBER AND CUSTOMER DEMOGRAPHICS 12 (Oct. 20, 2009), http://www.spp.org/publications/SPP_Demographics_Oct_2009.pdf [hereinafter SPP DEMOGRAPHICS].

18. SOUTHWEST POWER POOL, SPP FAST FACTS 2, http://www.spp.org/publications/SPP_Fast_Facts.pdf [hereinafter SPP FAST FACTS].

19. *Id.*

high wind and low load, however, when wind penetration in SPP is very high. For example, on October 10, 2013, wind generation served 32.8% of SPP load.[20]

Texas has experienced a rapid and significant addition of renewable energy generation in recent years, primarily large-scale wind generation resources ("WGRs").[21] ERCOT's approximately 11,000 MW of wind generation exceeds that of any other state in the nation.[22] In 2012, wind power accounted for 13% of ERCOT's generation capacity and 9.2% of its energy use.[23] On May 2, 2013, ERCOT set a new wind generation record of 9,674 MW, 28.05% of its load at the time.[24]

ERCOT projects that its future generation fleet may be more dependent on natural gas than its existing fleet, because low natural gas prices are expected to limit the development of thermal generation that uses other fuel sources.[25] ERCOT also projects increased development of renewable generation under a range of future potential market conditions.[26]

2. Characteristics of Types of Generation

In operating an electrical network, the level of energy produced must at all times, within a narrow tolerance, match the level of energy demanded by customers.[27] This matching is achieved by increasing or decreasing generation output as demand changes.[28] To maintain this balancing act, grid operators must rely on adequate supply of electric generation to meet demand, a concept known as resource adequacy.[29] They must also maintain capacity reserves to help support grid reliability should shortfalls occur. Traditional generation falls into three main functional categories. Base load plants operate continuously to serve the minimum level of energy demanded.[30] Cycling plants begin to operate and increase their output as the level of demand increases daily or seasonally.[31] Peaker plants only operate when demand reaches very high levels.[32]

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20. Southwest Power Pool, *Fast Fact: New Wind Generation Peaks*, SOUTHWEST POWER POOL ELEC. ENERGY NETWORK-KEEPING THE LIGHTS ON, http://www.spp.org/ (last visited Feb. 7, 2014).
21. TEXAS ENERGY ASSURANCE PLAN, *supra* note 14, at 70.
22. *ERCOT Concept Paper*, *supra* note 12, at 8.
23. *See Quick Facts*, *supra* note 7, at 1.
24. *Id.*
25. ERCOT, LONG-TERM SYSTEM ASSESSMENT FOR THE ERCOT REGION 8 (Dec. 2012), http://interchange.puc.texas.gov/WebApp/Interchange/application/dbapps/filings/pgSearch_Results.asp?TXT_CNTR_NO=33577&TXT_ITEM_NO=19.
26. *Id.*
27. TEXAS ENERGY ASSURANCE PLAN, *supra* note 14, at 71.
28. *Id.*
29. *See* ERCOT, *Resource Adequacy*, http://www.ercot.com/gridinfo/resource/ (last visited 2014).
30. TEXAS ENERGY ASSURANCE PLAN, *supra* note 14, at 71.
31. *Id.*
32. *Id.*

Unlike traditional generators, which can be ramped up and down to meet ever-changing demand, wind generators only produce when the wind is blowing. Due to this non-dispatchable nature, wind generators are generally assigned discounted capacity values when calculating reserve requirements. For example, ERCOT ascribes a capacity value to wind equal to 8.7% of nameplate capacity, intended to represent the amount of wind available during annual peak load.[33] However, in light of recent studies on the effective load contribution of wind production, the ERCOT Technical Advisory Committee has recommended that the ERCOT Board increase this value to 14.2% for non-coastal wind resources and 32.9% for coastal wind resources (the substantial difference in the capacity values assigned to coastal and non-coastal wind is discussed later in this Article).

As wind plants are generally regarded as must-run units, they also function as negative loads, displacing other marginal resources to meet overall consumer demand.[34] As such, during peak demand wind production frequently displaces high-cost combustion turbines and gas or oil peaking units.[35] Conversely, during off-peak times plants with lower operating costs, such as coal or combined cycle gas plants, may be displaced.[36]

Other significant differences in the grid impacts of different types of generation relate to frequency stability and voltage support. Increasing penetration of non-synchronous resources, such as wind generation, leads to economic displacement of some synchronous generators that would otherwise be committed to serve a given load.[37] Because non-synchronous resources are electrically connected to the system through an electronic inverter, they typically do not contribute inertia to the system, leading to overall reduction in system inertia.[38] Decline in inertial response leads to faster frequency decay and lower frequency nadir during a generation resource forced outage and more severe changes in frequency due to normal load and generation variations.[39] It will also result in larger frequency deviation for smaller unit trips and potentially trigger under-frequency load shedding more often.[40]

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33. *See* Newell et al., *ERCOT Investment Incentives and Resource Adequacy*, at 19 (June 1, 2012) http://www.ercot.com/content/gridinfo/resource/2014/mktanalysis/Brattle_ERCOT_Resource_Adequacy_Review_2012-06-01.pdf.

34. Yih-huei Wan, Analysis of Wind Power Ramping Behavior in ERCOT 2 (Mar. 2011), http://www.nrel.gov/docs/fy11osti/49218.pdf.

35. *See Appendix B: Overview of the U.S. Electric System*, EPA 3 (Apr. 28, 2011), http://www.epa.gov/statelocalclimate/documents/pdf/overview_paper_4-28-2011.pdf.

36. *Id.*

37. *ERCOT Concept Paper*, *supra* note 12, at 9.

38. *Id.*

39. *Id.* at 10.

40. *Id.*

Increased wind generation capacity thus requires traditional thermal units to provide AS more frequently.[41] Moreover, ramping thermal units up and down can increase their costs of maintenance and operation.[42]

3. Key Trends

In 2008, the PUCT approved a major ERCOT transmission expansion plan to deliver 18,456 MW of existing and additional wind generation output from West Texas and Panhandle competitive renewable energy zones ("CREZs") to load centers in the eastern half of Texas.[43] Virtually all of the CREZ transmission construction was completed by the end of 2013.[44]

In 2009, the PUCT observed:

> The level of wind development has raised concerns about ERCOT's ability to manage the electric network during periods of high wind and low ERCOT load. One concern is the need for additional capacity reserves to compensate for the intermittent nature of wind generation. These capacity reserves are typically provided by quick-start natural gas units that come on line when the wind falls off. . . . Wind generation output can change dramatically over a period of several hours. . . . Even if the changes in output can be forecast, the system operators will still need to have the ability to call on thermal generating resources to increase or reduce output to offset the combined impact of changes in wind generation output and load.[45]

A 2012 report by the PUCT and other Texas energy agencies concludes:

> It has been feasible to incorporate wind energy into the electric system operations at the relatively low levels of penetration of wind capacity that have occurred up to now. Today, wind resources constitute about 15% of the total capacity in the ERCOT region, but the completion of the CREZ transmission plan and the associated wind farms will roughly double the wind capacity in ERCOT. . . . When wind production reaches a percentage of 20 to 30% of total system load, operational problems are increasingly likely to affect system reliability.[46]

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41. *Commission Staff's Petition for Designation of Competitive Renewable-Energy Zones*, *supra* note 1, at 17.

42. *Id.*

43. *Id.* at 1–2.

44. *See* RS&H, COMPETITIVE RENEWABLE ENERGY ZONE PROGRAM OVERSIGHT: CREZ PROGRESS REPORT NO. 13 (OCT. UPDATE) 234–236 (Oct. 2013), http://www.texascrezprojects.com/systems/file_download.aspx?pg=355&ver=2.

45. PUB. UTIL. COMM'N OF TEX., REPORT TO THE 81ST TEXAS LEGISLATURE: SCOPE OF COMPETITION IN ELECTRIC MARKETS IN TEXAS 34 (Jan. 2009), http://www.puc.texas.gov/industry/electric/reports/scope/2009/2009scope_elec.pdf.

46. TEXAS ENERGY ASSURANCE PLAN, *supra* note 14, at 71.

As of December 2012, ERCOT had more than 20,000 MW of active, wind-generation requests under review.[47]

Another important trend involves the adequacy of overall ERCOT generation capacity compared to ERCOT load. In response to ERCOT forecasts that its reserve margin in 2014 and beyond would fall below the target reserve margin of 13.75% set by the ERCOT Board of Directors, the PUCT began to investigate and to address factors causing generational development to lag behind expected growth in demand of electricity.[48] The PUCT designated the resource adequacy issue as its top priority.[49] The PUCT has taken several steps to improve the signals that the competitive wholesale electric market is sending to attract generation investment to Texas and is analyzing other steps to take.[50]

Another trend of increasing importance is distributed generation and demand-side resources. ERCOT projects that both generation and demand-side resources on the distribution system (non-networked circuits operating below 69 kilovolts ("kV")) may become increasingly prevalent on the system, resulting in a need to evaluate the potential impacts of distributed resources on transmission-system operations.[51]

C. *Grid Considerations in ERCOT and SPP*

1. Transmission Capacity

Beginning in 2001, the rapid development of wind power in West Texas showed that wind farms can be built more quickly than transmission.[52] Based on concepts formulated during the 79th Texas Legislature, which took place in 2005, the PUCT was required to designate CREZs based on showings of sufficient renewable energy resources, suitable land area and generator financial commitment, and to develop a plan to construct transmission capacity to deliver electric out-

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47. *See Quick Facts*, *supra* note 7, at 1.

48. PUB. UTIL. COMM'N OF TEX., REPORT TO THE 83RD TEXAS LEGISLATURE: SCOPE OF COMPETITION IN ELECTRIC MARKETS IN TEXAS 1 (Jan. 2013) http://www.puc.texas.gov/industry/electric/reports/scope/2013/2013scope_elec.pdf [hereinafter 2013 SCOPE REPORT].

49. *Id.*

50. *Id.* at 5–6; *see also* Filings in *Commission Proceeding to Ensure Resource Adequacy in Texas*, PUB. UTIL. COMM'N OF TEX., http://interchange.puc.texas.gov/WebApp/Interchange/application/dbapps/filings/pgControl.asp?TXT_UTILITY_TYPE=A&TXT_CNTRL_NO=40000&TXT_ITEM_MATCH=1&TXT_ITEM_NO=&TXT_N_UTILITY=&TXT_N_FILE_PARTY=&TXT_DOC_TYPE=ALL&TXT_D_FROM=&TXT_D_TO=&TXT_NEW=true.

51. ERCOT, *supra* note 25, at 8–9.

52. PUB. UTIL. COMM'N OF TEX., REPORT TO THE 80TH TEXAS LEGISLATURE: SCOPE OF COMPETITION IN ELECTRIC MARKETS IN TEXAS 18 (Jan. 2007), http://www.puc.texas.gov/industry/electric/reports/scope/2007/2007scope_elec.pdf [hereinafter 2007 SCOPE REPORT].

put from the CREZs to customers.[53] The PUCT's 2008 order adopted CREZs (three in West Texas and two in the Texas Panhandle) and a transmission expansion plan to deliver 18,456 MW of existing and additional output from the CREZs to customers in other parts of the state.[54] Almost all of the CREZ transmission is 345 kV.[55]

Transmission capacity and wind integration concerns were important to the PUCT's decision as to how large a CREZ transmission expansion plan to approve. At the time the PUCT made that decision, West Texas wind generation was experiencing chronic and severe transmission congestion.[56] In adopting an intermediate transmission expansion plan over smaller and larger plans, the PUCT found that:

- The smaller plans left little or no room for wind generation expansion after 2008.
- ERCOT could maintain system reliability under the adopted plan by scheduling additional thermal units and curtailing wind generation when there is no lower-cost alternative.
- From a reliability standpoint, the evidence did not support selection of the larger plans.[57]

To connect Panhandle wind generation to the ERCOT grid, the CREZ transmission extends deeply into SPP territory but is interconnected only with ERCOT.[58] To avoid possibly subjecting ERCOT to FERC jurisdiction, a wind generation facility may not interconnect simultaneously with ERCOT and electrical grids outside ERCOT.[59] Thus in the Panhandle, output from a wind generation facility may be carried via an SPP line to SPP load, or via an ERCOT line to ERCOT load, but not both.

Partly to transmit wind output, SPP also has a significant FERC-approved transmission build-out underway.[60] Other transmission planning and construction is ongoing in ERCOT and SPP.

2. System Stability

Historically, wind generators have not contributed to stabilizing frequency following a disturbance or provided the same degree of voltage support compared to conventional generation.[61] However, as

53. *See* PURA, TEX. UTIL. CODE ANN. § 39.904(g) (West Supp. 2013).
54. *Commission Staff's Petition for Designation of Competitive Renewable-Energy Zones*, *supra* note 1, at 1–2.
55. *Id*. at 40, 42.
56. *Id*. at 43.
57. *Id*. at 10–11, 17–18, 20.
58. *Id*. at 49, 62.
59. *Id*. at 23, 49.
60. Southwest Power Pool, *Integrated Transmission Planning*, SOUTHWEST POWER POOL ELECTRIC ENERGY NETWORK-KEEPING THE LIGHTS ON, http://www.spp.org/section.asp?pageID=129 (last visited Feb. 7, 2014).
61. TEXAS ENERGY ASSURANCE PLAN, *supra* note 14, at 73.

discussed later in this Article, improved wind generation technology is bringing those capabilities closer to those of traditional generation.

D. *Load Considerations in ERCOT and SPP*

SPP accounts for 13% of the country's land area but only 7% of its population.[62] SPP's 63,000 MW of generation serve a population of 15 million.[63] On August 1, 2012, SPP's peak demand was 53,984 MW.[64]

ERCOT comprises 85% of Texas's electric load and 75% of its land.[65] ERCOT's 88,227 MW of generation serve a population of 22 million.[66]

Significant load growth has occurred recently in the oil and gas producing regions of ERCOT.[67]

ERCOT's load varies from a peak of slightly below 70 gigawatts ("GW") in the summer to a minimum of 22 GW during off-peak seasons.[68] The combination of huge seasonal variances in system load and high penetration of wind and other intermittent renewable resources increases ERCOT's operational challenges significantly.[69] Nevertheless, ERCOT has been successfully operating the system with high wind penetration.[70]

III. Intermittency Solutions and Related Law

A. *Transmission and Distribution Improvements*

In its December 2012 Long-Term Assessment Report, ERCOT concluded:

- Higher voltage transmission solutions appear cost-effective in future scenarios with significant increases in renewable generation to connect low-cost resources that are concentrated at a significant distance from major load centers.
- Scenario analysis indicates that both natural gas generation and renewable resources are likely to be competitive across a broad range of potential future market outcomes. The prevalence of renewable generation technologies in many future scenarios indicates a need for further study of system requirements to reliably integrate variable generation. As a component of this analysis, ERCOT is currently using grant funding provided by the Department of Energy to implement a new analytical model

62. *See* SPP Demographics, *supra* note 17, at 9.
63. *Id*. at 3.
64. *See* SPP Fast Facts, *supra* note 18, at 2.
65. *See Quick Facts*, *supra* note 7.
66. *Id.*
67. ERCOT, *supra* note 25, at 10.
68. *ERCOT Concept Paper*, *supra* note 12, at 8.
69. *Id.*
70. *Id.*

> that will assess the impact of future resource additions on the system's frequency response capability.[71]

ERCOT noted that those conclusions are based on high-level assumptions and are intended to inform the five-year planning process, which provides a more detailed review of specific transmission projects.[72]

ERCOT's Panhandle CREZ system presents particular voltage stability and grid strength challenges.[73] ERCOT's transmission to serve the Panhandle CREZs reaches deep into SPP territory but is not interconnected with SPP. It is wind-dominated and far from ERCOT load centers.[74] It has minimal to no local load and minimal to no sync generation.[75] No near-term ERCOT transmission projects in the Panhandle are being developed after the 2013 completion of the CREZ transmission.[76]

In 2012, ERCOT projected that in the Panhandle area, wind generation will exceed the existing CREZ design capacity based on the CREZ reactive study initial build recommendations.[77] As of October 2013, 11 GW of Panhandle wind capacity were going through ERCOT's generation interconnection process.[78] ERCOT concluded that if the northwestern-most portion of the Panhandle CREZ system becomes over-subscribed, voltage stability limits will constrain the Panhandle wind power export to 2.6 GW.[79]

To address this concern, ERCOT initiated a Panhandle Renewable Energy Zone ("PREZ") study to identify potential system improvement projects to accommodate additional generation resources in the area, and triggers for when to recommend those projects.[80] Upgrades that the PREZ study identifies are not considered "approved" and will require further review at ERCOT.[81] Other parts of the ERCOT region may also require further studies for potential thermal and stability challenges.[82]

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71. ERCOT, *supra* note 25, at 3.

72. *Id.*

73. ERCOT, PANHANDLE RENEWABLE ENERGY ZONE (PREZ) STUDY PRELIMINARY RESULTS 17 (Oct. 22, 2013), http://www.ercot.com/content/meetings/rpg/keydocs/2013/1022/PanhandleStudy_RPG_10222013_r1.pdf [hereinafter PREZ STUDY PRELIMINARY RESULTS].

74. ERCOT, PANHANDLE RENEWABLE ENERGY ZONE (PREZ) STUDY–SCENARIO 1 PRELIMINARY RESULTS 10 (June 25, 2013), http://www.ercot.com/content/meetings/rpg/keydocs/2013/0625/PanhandleStudy_scenario_1_RPG_06252013_r1.pdf [PREZ STUDY SCENARIO 1 PRELIMINARY RESULTS].

75. PREZ STUDY PRELIMINARY RESULTS, *supra* note 73, at 17.

76. *Id.* at 15.

77. PREZ STUDY SCENARIO 1 PRELIMINARY RESULTS, *supra* note 74, at 3, 5.

78. PREZ STUDY PRELIMINARY RESULTS, *supra* note 73, at 17.

79. PREZ STUDY SCENARIO 1 PRELIMINARY RESULTS, *supra* note 74, at 3, 11.

80. *Id.* at 5.

81. PREZ STUDY PRELIMINARY RESULTS, *supra* note 73, at 3.

82. *Id.*

B. *Forecasting, Planning, Market Design and Grid Operation*

1. ERCOT

In December 2010, ERCOT implemented its Nodal Market, whereby resource scheduling and dispatch are resource-specific, rather than portfolio-based as they were under ERCOT's previous Zonal Market.[83] The Nodal Market's resource-specific dispatch with five-minute resolution lets ERCOT closely follow net load variations and is one of the main reasons ERCOT has been able to integrate intermittent renewable generation into its system with minimal increase in AS capacity.[84]

Improvements in ERCOT's wind production forecasting have also led to more efficient and effective utilization of wind resources:

> ERCOT has acquired state-of-the-art forecasting tools to forecast wind generators' output. Wind generators are now required to use the wind production forecast provided by ERCOT in their daily resource plan submittals rather than rely on their own forecasts, which can have varying degrees of sophistication and accuracy.
>
> Even with state-of-the-art forecasting of wind production, there is still some disparity between the forecasted production and actual production. The risks of load forecast error, wind forecast error and outages of the thermal generation and transmission facilities are mitigated by acquiring generation reserves that may be called into operation when needed, and it may become necessary for the system operator to quickly deploy these resources when a sudden change in wind production occurs.[85]

2. FERC and SPP

In 2012, FERC issued Order No. 764[86] to integrate variable energy resources ("VERs").[87] FERC explained that:

> [FERC] takes this action now recognizing that the composition of the electric generation portfolio continues to change. VERs are making up an increasing percentage of new generating capacity being brought on-line. New wind generating capacity accounted for 35% of all newly installed generating capacity from 2007-2010.[88]

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83. *ERCOT Concept Paper*, *supra* note 12, at 8.

84. *Id.*

85. TEXAS ENERGY ASSURANCE PLAN, *supra* note 14, at 72.

86. Integration of Variable Energy Resources, 77 Fed. Reg. 41,482 (July 13, 2012) (to be codified at 18 C.F.R. pt. 35), *available at* http://elibrary.ferc.gov/idmws/common/OpenNat.asp?fileID=13013217.

87. *Id.* FERC defined a VER as "a device for the production of electricity that is characterized by an energy source that: (1) is renewable; (2) cannot be stored by the facility owner or operator; and (3) has variability that is beyond the control of the facility owner or operator." *Id.* This definition includes, inter alia, wind-generating facilities. *Id.*

88. *Id.* at 41,485.

FERC adopted reforms to remove barriers to VER integration and "to ensure that the rates, terms, and conditions for FERC-jurisdictional services provided by public utility transmission providers are just and reasonable and not unduly discriminatory or preferential."[89]

Specifically, FERC required public utility transmission providers to offer "customers the option of using more frequent transmission scheduling intervals within each operating hour, at [fifteen]-minute intervals."[90] FERC found that, "over time, implementation of intra-hour scheduling will allow public utility transmission providers to rely more on planned scheduling and dispatch procedures, and less on reserves, to maintain overall system balance."[91] FERC determined that "by moving from hourly to fifteen[-]minute scheduling intervals, the amount of imbalance energy for which the source balancing authority is potentially responsible [can] be reduced."[92] FERC noted that this reduction in the imbalance of energy needed "can lead to a corresponding reduction in the amount of capacity held to provide that energy and, in turn, lower reserve-related costs for the source balancing authority, and ultimately consumers."[93]

In Order No. 764, FERC also adopted reporting requirements designed to support the development and deployment of power production forecasting by public utility transmission providers.[94] FERC explained that, as with intra-hourly scheduling, power production forecasts can enable transmission providers to manage the variability of VER generation more efficiently through the unit commitment and dispatch process, rather than through the use of reserves, which can be more costly.[95] To this end, FERC required new large interconnection customers whose generating facilities are VERs to provide to the public utility transmission provider with which the customer is interconnected meteorological and forced outage data consistent with the power production forecasting employed by the transmission provider, if any, to manage reserve commitments.[96] FERC required new large interconnection customers having wind as the energy source to "pro-

89. *Id.* at 41,482.

90. *Id.* at 41,483.

91. *Id.* at 41,498.

92. *Id*. at 41,499.

93. *Id.*

94. *Id.* at 41,510.

95. *Id.* at 41,483, 41,511.

96. *Id.* at 41,483, 41,511. FERC defines large generators as those resources that produce more than 20 MW. Standardization of Generator Interconnection Agreements and Procedures, 69 Fed. Reg. 15,932, 15,933 (Mar. 26, 2004) (to be codified at 18 C.F.R. pt. 35), 70 Fed. Reg. 265, 266–67 (Jan. 4, 2005) (to be codified at 18 C.F.R. pt. 35), 70 Fed. Reg. 37,661 (June 30, 2005) (to be codified at 18 C.F.R. pt. 35); *Nat'l Ass'n of Regulatory Util. Comm'rs v. FERC*, 475 F.3d 1277 (D.C. Cir. 2007), *cert. denied*, 552 U.S. 1230 (2008).

vide, at a minimum, site-specific meteorological data including: temperature, wind speed, wind direction, and atmospheric pressure."[97]

Although FERC had preliminarily found that a generic tariff schedule would remove barriers to VER integration by eliminating uncertainty regarding cost recovery, FERC was concerned that this reform could inhibit the flexibility of a public utility transmission provider to design capacity services that aligned with its practices or needs.[98] Thus, FERC declined in Order No. 764 to adopt a generic tariff schedule for generation regulation service.[99] FERC stated that it will continue to evaluate proposed generator regulation service charges associated with VER integration on a case-by-case basis.[100] FERC provided guidance for public utility transmission providers and their customers regarding the development and evaluation of these proposals.[101]

In April 2013, SPP submitted to FERC tariff revisions adopting the data requirements set forth in Order No. 764 with slight modifications.[102] In addition to requiring wind-powered VERs to provide temperature, wind speed, wind direction, and atmospheric pressure, as mandated by Order No. 764, SPP's tariff revisions also required these VERs to provide additional information related to the relative humidity, and site specific geographic data including location (latitude and longitude) of the Variable Energy Resource and location (latitude and longitude) and height of the facility used to provide the meteorological data.[103] FERC found these tariff revisions consistent with, or superior to, the compliance requirements of Order No. 764 and therefore conditionally accepted them.[104]

In November 2013, SPP filed tariff revisions to comply with the remaining requirements of Order No. 764.[105] In this filing, SPP noted that its current scheduling system already complies with Order No. 764's intra-hour schedule submission and modification and that SPP currently accommodates intra-hour schedules and modifications when requested.[106] Thus, SPP asserted that the tariff changes submitted in

97. Integration of Variable Energy Resources, 77 Fed. Reg. 41,482, 41,512 (July 13, 2012) (to be codified at 18 C.F.R. pt. 35).

98. *Id.* at 41,519.

99. *Id.* at 41483, 41,519.

100. *Id.* at 41,483, 51,524, 41,525.

101. *Id.* at 41,519.

102. Submission of Tariff Revisions to Adopt Data Requirements Pursuant to Order No. 764 at 5, Southwest Power Pool, Inc., No. ER13-1292-000 (Apr. 16, 2013), http://elibrary.ferc.gov/idmws/common/OpenNat.asp?fileID=13234472.

103. *Id.* at 5–6.

104. Southwest Power Pool, Inc., 143 FERC ¶ 61,285 para. 12 (June 27, 2013) (order).

105. Submission of Order No. 764 Compliance Filing at 3, Southwest Power Pool, Inc., No. ER13-1292-001 (Nov. 12, 2013), *available at* http://elibrary.ferc.gov/idmws/common/OpenNat.asp?fileID=13392635.

106. *Id.* at 4.

the filing already reflected SPP's current practices.[107] Further, SPP noted that its system allows for intra-hour scheduling of less than fifteen-minute increments and therefore concluded that its tariff provides scheduling options for transmission customers that are superior to those required under Order No. 764.[108] This filing is still pending before FERC.

C. *Ancillary Service Products*

1. ERCOT

In 2012, ERCOT began considering "rethinking" its entire existing set of AS.[109] According to a draft ERCOT concept paper, reasons for this initiative include:

- The current AS construct was based on the market design of the late 1990s.
- In the last 15 years ERCOT's generation mix has changed, from large steam generators being the main generation type to large-scale utilization of gas-fired combined cycle plants and non-synchronous wind generation and introduction of electric energy storage.
- Some new resources expected to be added to the ERCOT system present additional challenges; some have new capabilities in providing AS. For example, the frequency response provided by a battery or wind generator is controlled by inverter electronics and has the potential to respond faster than that of conventional generators.
- New FERC/NERC regulatory requirements applicable in ERCOT are on the horizon.
- A new AS approach will better utilize the capabilities of existing and new resources and let ERCOT more efficiently provide the expected reliable and secure operations.
- Improved ways to procure AS, improved performance specifications for resources providing AS, and implementation of "pay for performance" settlement methods similar to those outlined in FERC Order 755, will likely lead to a more efficient way to acquire and deploy AS.[110]

ERCOT's draft concept paper is limited to physical aspects of operations related to frequency control currently addressed by the Regulating, Responsive Reserve and Non-Spin AS.[111]

The concept paper recommends a transition to the following AS products plus an additional AS that would be used during some transition period:

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107. *Id.*
108. *Id.*
109. *ERCOT Concept Paper*, *supra* note 12, at 5.
110. *Id.* at 5, 8–9.
111. *Id.* at 5–6.

- ***Synchronous Inertial Response Service*** ("SIR"). Maintains minimum rate of change of frequency; provides sufficient time for primary frequency response.
- ***Fast Frequency Response Service*** ("FFR"). Supplement to inertial response; improves rate of change of frequency after FFR deployment; improves frequency nadir, provides sufficient time for primary frequency response.
- ***Primary Frequency Response Service***. Arrests frequency decay and reset frequency close to 60Hz; improves frequency nadir; meets NERC standard requirements.
- ***Up and Down Regulating Reserve Service***. Matches generation and demand between each Security Constrained Economic Dispatch interval; restores PFR reserve, meets NERC standard requirements.
- ***Contingency Reserve Service***. Covers the Most Severe Single Contingency, restores other AS reserve.
- ***Supplemental Reserve Service***. Covers the loss of generating capacity; compensates for net load forecast error and/or forecast uncertainty. Similar to ERCOT's current 30-minute Non-Spin Service, to be used during a transition period.[112]

The above AS set would add and/or redefine AS products currently used in ERCOT, and subsume different elements within the current Responsive Reserve and Non-Spin Service into several of the newly defined AS.[113]

The proposed new AS are expected to help the ERCOT system counteract reliability risks from intermittent wind generation. For example, with less synchronous generation online, ERCOT needs FFR to supplement the inherent inertial response from synchronous machines.[114] They may also allow wind generation to provide specific AS for which it qualifies. For instance, several manufacturers provide inverter-based wind turbine generators with synthetic inertia capability, i.e., capability to inject active power into the system initiated through control system action following a disturbance, such as a generator trip.[115] ERCOT is considering whether such synthetic response could be used to provide SIR.[116]

The recommendations in ERCOT's AS concept paper will require further review in ERCOT's stakeholder process.[117] Implementation of any major transition to a new AS set would be expected to take at least two or three years.[118]

112. *Id.* at 6, 30–35.
113. *Id.* at 6.
114. *Id.* at 19.
115. *Id.* at 16.
116. *Id.* at 17.
117. *Id.* at 6.
118. *Id.* at 7.

2. FERC and SPP

In 2011, FERC issued Order No. 755.[119] In this Order, FERC explained that frequency regulation service—or secondary frequency control—is one of the tools regional transmission organizations ("RTOs"), such as SPP, and independent service operators ("ISOs") use to balance supply and demand on the transmission system, and thus to maintain reliable operations.[120] FERC noted that the faster a resource can ramp up or down,[121] the more accurately the resource can respond to a transmission system operator's automatic generator control ("AGC") signal to balance supply and demand.[122] FERC found inter alia, that the then-current frequency regulation "compensation [methods] for regulation service in RTO and ISO markets [failed] to acknowledge the inherently greater amount of frequency regulation service being provided by faster-ramping resources" such as flywheels.[123] FERC also found that "certain practices of some RTOs and ISOs result in economically inefficient economic dispatch of frequency regulation resources."[124]

To remedy these issues, in Opinion No. 755, FERC "require[d] RTOs and ISOs to compensate frequency regulation resources based on the actual service provided."[125] This compensation would consist of a two-part payment to each cleared frequency resource: (1) a capacity payment at the uniform clearing price that includes the marginal resource's opportunity costs; and (2) a market-based performance payment for service that reflects the accuracy with which the resource responds to the system operator's AGC dispatch signal.[126] FERC explained that in many instances, it would "leave to the individual RTOs and ISOs how best to meet these requirements."[127]

In June 2013, SPP submitted to FERC revisions to its tariff pursuant to Order No. 755.[128] SPP proposed, inter alia, to establish a two-part methodology for offers and compensation of Regulation-Up, which

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119. Frequency Regulation Compensation in the Organized Wholesale Power Markets, 76 Fed. Reg. 67,260 (Oct. 31, 2011) (to be codified at 18 C.F.R. pt. 35), *available at* http://elibrary.ferc.gov/idmws/common/OpenNat.asp?fileID=12795708.

120. *Id.*

121. FERC explained that the ability to "ramp" is traditionally defined as the ability to change the output of real power from a generating unit per some unit of time, usually measured as megawatts per minute (MW/min). *Id.* at para. 2 n.3. Ramping up places more energy on the system, while ramping down reduces energy on the system. *See id.*

122. *Id.* at 67,260–61.

123. *Id.*

124. *Id.*

125. *Id.*

126. *Id.* at 67,260, 67,270, 67,272, 67,283.

127. *Id.* at 67,270.

128. Letter to the Secretary of the Federal Energy Regulatory Commission Re: Southwest Power Pool, Inc., Docket No. ER13-1748-000, Order No. 755 Compliance Filing, at 1 (June 21, 2013), http://elibrary.ferc.gov/idmws/common/OpenNat.asp?file ID=13288112.

increases energy output, and Regulation-Down, which reduces energy output.[129] The capacity component of the offer and price would be based on SPP's current FERC-approved methodology.[130] The performance component would be based on a resource's Regulation-Up and Regulation-Down Mileage.[131] Mileage would be measured for each five minute dispatch interval and would be equal to the sum of the absolute value of movements by a Resource in response to Regulation Deployment instructions provided through AGC every four seconds.[132] As SPP's Integrated Marketplace ("IM") is scheduled to begin on March 1, 2014, SPP has requested an effective date of March 1, 2015, consistent with FERC's directive that SPP implement its Order No. 755 compliance no later than one year after SPP's IM start-up.[133] On March 7, 2014, FERC issued a deficiency letter to SPP, requiring additional information to process SPP's June 21, 2013, filing.[134]

In 2013, FERC issued Order No. 784.[135] In this Order, FERC revised its regulations to enhance competition and transparency in AS markets.[136] FERC determined that the restriction on third-party sales of ancillary services at market-based rates to public utilities seeking to meet their ancillary service obligations has proved to be an unreasonable barrier to entry and has unnecessarily restricted access to potential suppliers.[137] Thus, Order No. 784 generally allows, inter alia, a resource with market-based rate authority for sales of energy and capacity to sell at market-based rates imbalance services and operating reserve services to public utility transmission providers in areas that have implemented intra-hour scheduling.[138]

In addition, building off Order No. 755, FERC required in Order No. 784 each public utility transmission provider to take into account speed and accuracy of regulation resources in determining reserve requirements.[139] Finally, FERC revised its accounting and reporting requirements to better account for and report transactions associated with the use of energy storage devices in public utility operations.[140]

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129. *Id*. at 3.
130. *Id.* at 10.
131. *Id.*
132. *Id.*
133. *Id.* at 1–2.
134. Southwest Power Pool, Inc., Docket No. ER13-1748-000 (Mar. 7, 2014), http://elibrary.ferc.gov/idmws/common/opennat.asp?fileID=1347842.
135. Third-Party Provision of Ancillary Services: Accounting and Financial Reporting For New Electric Storage Technologies, 78 Fed. Reg. 46,178 (July 30, 2013) (to be codified at 18 C.F.R. pts. 35 & 101), *available at* http://elibrary.ferc.gov/idmws/common/OpenNat.asp?fileID=13309391.
136. *Id.*
137. *Id*. at 46,180–81.
138. *Id*. at 46,187.
139. *Id*. at 46,178–79.
140. *Id*. at 46,179.

Requests for clarification of Order No. 784 are currently pending before FERC. In December 2013, SPP filed tariff revisions to comply with Order No. 784.[141] SPP requested an effective date of March 1, 2014, for the tariff revisions, consistent with the effective date of SPP's Integrated Marketplace.[142]

D. *Wind Generation Technology Improvements and Reliability Requirements*

1. PUCT Proceedings

In a 2012 report, the PUCT and other Texas energy agencies commented:

> Wind generators historically have not contributed to stabilizing frequency following a disturbance as conventional generators do. As a result, when conventional generation is displaced by wind generation, the potential for more severe frequency disturbances increases because the remaining conventional generation has to overcome the disturbance without help from the wind generation. Technological improvements have brought a partial solution to this problem, and new wind turbines now come equipped with technology that allows these turbines to help restore the standard system frequency after a disturbance. New wind generators are now required by ERCOT rules to be equipped with such technology, and existing generators are required to retrofit their units if feasible.
>
> Similarly, wind generators have not provided the quality of voltage support provided by conventional generators that is needed to reliably maintain the flow of electricity through transmission lines. Technology is available to address this issue, and the new technology to address voltage support is now required of all new wind installations in ERCOT.[143]

Disputes between ERCOT and wind generators about what ERCOT reactive power requirements should apply to certain wind generation facilities have led to two contested cases at the PUCT. One of these cases was resolved when the PUCT adopted a settlement that, for purposes of reactive power requirements, allowed multiple wind generation units to be treated as a single WGR if they are connected to the same transmission bus.[144] The other case involved an ERCOT procedure requiring WGRs that cannot be retrofitted to provide Primary Frequency Response under a new ERCOT requirement

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141. Submission of Order No. 784 Compliance Filing, Southwest Power Pool, Inc., No. ER14-866-000 (Dec. 27, 2013), *available at* http://elibrary.ferc.gov/idmws/common/opennat.asp?fileID=13427104.

142. *Id.* at 1.

143. TEXAS ENERGY ASSURANCE PLAN, *supra* note 14, at 73.

144. Pub. Util. Comm'n of Tex., *Appeal and Complaint by Iberdrola Renewables, Inc. et al of ERCOT Decision to Approve PRR 830*, Docket No. 37817, at 5 (June 14, 2012) (order), http://interchange.puc.texas.gov/WebApp/Interchange/application/dbapps/filings/pgSearch_Results.asp?TXT_CNTR_NO=37817&TXT_ITEM_NO=80.

to submit an attestation of technical feasibility with ERCOT that their wind projects cannot be retrofitted to meet the new standard, exempting those assets from the requirement.[145] The WGRs appealed to the PUCT ERCOT's denial of their request for permanent exemptions.[146] That case has been abated for settlement talks.[147]

2. FERC Orders

In 2005, FERC issued Order Nos. 661 and 661-A in which it required all public utilities that own, control, or operate facilities for transmitting electric energy in interstate commerce to establish standard technical requirements for the interconnection of wind plants larger than 20 MW.[148] These technical requirements included those on reactive power. FERC required wind plants to maintain a power factor within the range of 0.95 leading to 0.95 lagging, measured at the Point of Interconnection, if the transmission provider's system impact study shows that such a requirement is necessary to ensure safety or reliability.[149] FERC also required, inter alia, wind plants to provide sufficient dynamic voltage support if shown by the system impact study to be needed for safety or reliability.[150]

In 2011, FERC issued an order directing FERC Staff to commence a technical conference to examine whether the Commission should reconsider or modify the reactive power provisions of Order No. 661-A.[151] The order stated that, "as part of that technical conference, Staff should examine what evidence could be developed under Order No. 661 to support a request to apply reactive power requirements more broadly than to individual wind generators during the interconnection study process."[152] FERC held this technical conference on

145. Pub. Util. Comm'n of Tex., *Appellants' Appeal and Complaint Concerning ERCOT's Denial of Exemption Requests Under Protocol 5.9.1.3 and Requests for Related Relief*, Docket No. 39034, at 1 (Jan. 6, 2011) (order no. 1 setting procedural schedule and adopting protective order), http://interchange.puc.texas.gov/WebApp/Interchange/application/dbapps/filings/pgSearch_Results.asp?TXT_CNTR_NO=39034&TXT_ITEM_NO=6.

146. *Id.*

147. Pub. Util. Comm'n of Tex., *Appellants' Appeal and Complaint Concerning ERCOT's Denial of Exemption Requests Under Protocol 5.9.1.3 and Requests for Related Relief*, Docket No. 39034, at 1 (Oct. 29, 2013) (order no. 9 granting abatement), http://interchange.puc.texas.gov/WebApp/Interchange/application/dbapps/filings/pgSearch_Results.asp?TXT_CNTR_NO=39034&TXT_ITEM_NO=30.

148. Interconnection for Wind Energy, 70 Fed. Reg. 34,993 (June 16, 2005) (to be codified at 18 C.F.R. pt. 35), Interconnection for Wind Energy, 70 Fed. Reg. 75,005 (Dec. 19, 2005) (to be codified at 18 C.F.R. pt. 35), *available at* http://elibrary.ferc.gov/idmws/common/opennat.asp?fileID=10594521.

149. Interconnection for Wind Energy, 70 Fed. Reg. at 34,999.

150. *Id.* at 35,001.

151. Cal. Indep. Sys. Operator Corp., 137 FERC ¶ 61,143 at 5 (order denying rehearing and conditionally accepting compliance filing) (Nov. 17, 2011), http://elibrary.ferc.gov/idmws/common/opennat.asp?fileID=1290104.

152. *Id.* at 5–6.

April 17, 2012. Items discussed at the conference included: the technical and economic characteristics of different types of reactive power resources, including synchronous and asynchronous generation resources, transmission resources and energy storage resources; the design options for and cost of installing reactive power equipment at the time of interconnection, as well as retrofitting a resource with reactive power equipment; other means by which reactive power is currently secured such as through self-supply; and how a technology that is capable of providing reactive power but may not be subject to the generation interconnection process (e.g., FACTs) would be analyzed.[153] FERC Staff was also interested in gathering information on methods used to determine the reactive power requirements for a transmission system, and how system impact and planning studies take into account changes in system connected technologies.[154] Comments have been filed on these issues and are currently pending before FERC.

E. *Electric Energy Storage*

Electric-energy storage receives electricity from the grid, storing it in the form of potential energy—such as compressed air in compressed air energy storage ("CAES"), chemical energy in batteries, or kinetic energy in flywheels—and regenerating it as electricity for delivery to the grid at a later time. The various storage technologies each share those attributes but differ from each other in several respects. For example, when compared to batteries and flywheels, CAES is similar to traditional generation in that CAES:

- Must be sited where a suitable natural resource—such as a salt cavern—is available;
- Requires a larger up-front capital investment;
- Takes longer to construct/install;
- Requires a few minutes to respond to grid needs rather than a few seconds;
- Provides electricity in bulk—hundreds of MW rather than 1-50 MW; and
- May provide electricity without interruption for longer periods—hours, days, or more—rather than for an hour or less.

These generalized summaries of storage technology characteristics are useful, they may fail to capture distinct capabilities and attributes of individual projects and ongoing improvements.

The many possible applications of electric energy storage include making intermittent-renewable resources function more like firmer electric generation. In PUCT's 2009 report to the Legislature, the PUCT observed:

153. Reactive Power Res., Docket No. AD12-10-000, Notice of Technical Conference at 1–2 (Feb. 17, 2012), http://elibrary.ferc.gov/idmws/common/opennat.asp?fileID=12894578.

154. *Id.* at 2.

> Because of the intermittent nature of wind energy, fossil fuel units must be kept in reserve to meet customers' needs in the event of a drop in production of wind energy. Large-scale energy storage technologies have the potential to offset changes in wind energy production, rather than relying on thermal generation units for this purpose. Storage devices could also permit wind energy to be delivered to customers with a lower level of investment in transmission and allow wind energy to be stored and delivered when electrical demand is high.[155]

In PUCT's 2013 report to the Texas Legislature, the PUCT noted:

> Storage could provide the flexibility to adjust energy production or consumption to offset changes in wind and solar power production, allowing energy output and demand to be matched. Storage could also provide an economical means of relieving transmission constraints or meeting demand during peak periods.[156]

As the above descriptions suggest, storage can perform some transmission/distribution functions and some generation functions. To protect against anti-competitive conduct, however, ERCOT's competitive market structure prohibits an investor-owned facility from performing both transmission/distribution (utility) functions and generation (competitive) functions. In a January 2011 report to the Texas Legislature, the PUCT explained:

> The competitive model in Chapter 39 of PURA contemplates a separation of transmission and generation, so that a regulated utility would not own generation facilities. . . . While storage is capable of providing multiple services, it is difficult to assign it a role in a competitive environment, in which utilities have been unbundled. Issues relating to cross-subsidization, competition, and discrimination could arise if storage served multiple roles or functions at the same time. Requiring a storage facility not to perform some of the functions of which it is capable could address these concerns but could also render storage devices uneconomical or result in their underutilization.[157]

For example, since 2010 an investor-owned transmission utility, Electric Transmission Texas ("ETT"), has owned and operated a 4-MW battery in the southwestern corner of ERCOT. The PUCT classified the utility's battery as a transmission asset whose cost is recoverable through rates. The PUCT explained: "This NaS battery allowed the utility to defer the planned replacement of a 69-kV transmission line that is the sole source of electricity for Presidio."[158] The PUCT ruled that: "ETT's proposed use of the NaS battery is appropriate for a transmission utility because the battery system provides benefits as-

155. 2007 Scope Report, *supra* note 52, at 80.
156. 2013 Scope Report, *supra* note 48, at 10.
157. 2011 Scope Report, *supra* note 15, at 94, 75.
158. *Id.* at 77.

sociated with transmission service operations, including voltage control, reactive power, and enhanced reliability."[159] The transmission asset classification reflected the battery's intended transmission function, and the transmission utility's agreement not to buy, sell, or take title to the unmetered, unaccounted for energy stored in the battery.[160]

In Spring 2011, the Texas Legislature clarified that electric energy storage that functions as generation is a generation asset that a power generation company ("PGC") can own. PURA now expressly:

- Defines "PGC" to include a person who generates electricity that is intended to be sold at wholesale, including the owner or operator of electric energy storage equipment or facilities that are intended to provide energy or ancillary services at wholesale;
- Classifies as generation assets electric energy storage equipment or facilities that are intended to be used to sell energy or ancillary services at wholesale;
- Requires that an owner or operator of such equipment or facilities register with the PUCT as a PGC; and
- Clarifies that the owner or operator of such equipment or facilities is entitled to interconnect and to obtain transmission service for the equipment or facilities, and to use them to sell electricity or ancillary services at wholesale in a manner consistent with PURA provisions and PUCT rules applicable to a PGC or exempt wholesale generator.[161]

The Legislature expressly did not disturb the PUCT's 2010 order ruling that a storage facility that functions as transmission and whose energy is not sold at wholesale is a transmission asset that an investor-owned transmission utility can own and include in its rate base. The Legislature also did not change PURA Chapter 39 provisions precluding the same storage facility or equipment from providing both generation and transmission/distribution functions in ERCOT's retail choice areas.

Since then, the PUCT and ERCOT have taken actions to address unnecessary barriers to development of electric energy storage. For example, in 2012 the PUCT adopted a rule clarifying that electric energy purchased by storage facilities for purposes of charging should be classified as a wholesale transaction rather than as a retail transaction, storage facilities should be settled at the node when they are charging rather than zonally as consuming load is settled, and electric energy

159. *Id.*

160. Pub. Util. Comm'n, *Application of Electric Transmission Texas, LLC for Regulatory Approvals Related to Installation of a Sodium Sulfur Battery at Presidio, Texas*, Docket No. 35994, 10, 13 (Apr. 6, 2009), http://interchange.puc.texas.gov/WebApp/Interchange/application/dbapps/filings/pgSearch_Results.asp?TXT_CNTR_NO=35994&TXT_ITEM_NO=114.

161. PURA, Tex. Util. Code Ann. § 31.002(10) (West 2007); *Id.* § 35.152 (West Supp. 2013).

purchased by storage facilities for charging is generally not subject to AS and transmission service charges.[162]

Operational storage facilities in ERCOT now include not only ETT's 4-MW battery but also a 36-MW battery (developed by Xtreme Power) behind the meter of a wind generator (Duke Energy's No-Trees wind project).[163] Some other storage projects, including CAES, are under development.[164]

F. *Geographic Considerations*

While wind generation can be highly unpredictable on a minute-to-minute basis, it does follow certain long-term daily and seasonal trends.[165] By constructing new wind plants in wind regimes whose output is correlated with consumer demand, grid operators may be able to realize certain valuable benefits, such as peak shaving and the displacement of less efficient peaking resources rather than more efficient base load or cycling plants.[166] Alternatively, where new wind plants are constructed in regions whose output is anti-correlated with consumer demand, demand curves may be elongated, thereby exasperating the challenges faced by grid operators in meeting daily load variations.[167]

Further, as the quantity and especially the geographic diversity of wind plants increases, the variability of the output of those aggregated plants decreases.[168] This decrease in variability benefits grid operators as it lowers the balancing requirements needed to integrate such resources.[169]

1. ERCOT

In ERCOT, load tends to ramp during the morning, peak during the afternoon, and roll-off during the early evening.[170] These trends tend

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162. 16 Tex. Admin. Code §§ 25.501(m), 25.192(a) (2013) (Pub. Util. Comm'n of Tex., Rules Applicable to Electric Service), http://puc.texas.gov/agency/rulesnlaws/subrules/electric/25.501/25.501.pdf, http://puc.texas.gov/agency/rulesnlaws/subrules/electric/25.192/25.192.pdf.

163. *See* Kenneth W. Anderson, Jr., Flexible Transmission and Storage to Manage Wind 18–19 (Aug. 6, 2013), http://www.puc.texas.gov/agency/about/commissioners/anderson/pp/EPRI_080613.pdf.

164. *Id.*

165. *See* Wan, *supra* note 34, at 2.

166. *See* Gen. Elec. Int'l, Inc., Analysis of Wind Generation Impact on ERCOT Ancillary Service Requirements at 3-20 (Mar. 28, 2008), http://www.uwig.org/attchb-ercot_a-s_study_final_report.pdf.

167. *Id.*

168. Elec. Power Research Inst., DOE: Integrating Southwest Power Pool Wind Energy into Southeast Electricity Markets Final Report at 3-3 (Oct. 2011), http://www.uwig.org/doe_spp_wind2sem.pdf.

169. *Id.* at 3-4.

170. *See* Gen. Elec., *supra* note 166, at 3-4.

to be exacerbated during the summer, when the use of home cooling systems spikes during the afternoon hours.[171]

ERCOT includes two primary wind regimes with differing production characteristics: (1) West Texas (including the Panhandle); and (2) coastal South Texas. West Texas wind production tends to be anti-correlated with ERCOT's load characteristics, producing more during the evening through early morning hours, and thereafter rolling-off during the late morning through afternoon hours, when demand peaks.[172] Conversely, coastal South Texas wind tends to have more consistent output during the day, and tends to produce more during the afternoons as compared to the remainder of the day and evening.[173] Coastal wind production is also more reflective of seasonal load patterns in ERCOT, with production peaking during the summer months.[174]

As discussed previously, ERCOT assigns discounted capacity values for intermittent wind generation. The capacity value currently assigned to wind resources is 8.9%. In light of recent studies indicating that wind provides greater load carrying ability than currently attributed to it by ERCOT, which ability is further impacted by geographical considerations, the ERCOT Technical Advisory Committee has recommended that the ERCOT Board approve Effective Load Carrying Capabilities of 14.2% for non-coastal wind and 32.9% for coastal wind. The substantial disparity between the projected load carrying capacity of coastal versus non-coastal wind is consistent with coastal wind production's greater correlation with peak demand.

2. SPP

Unlike in ERCOT, where two distinct wind regimes exist (West Texas and coastal South Texas), correlation of output among wind plants in SPP's primarily flat terrain with no coastal outlets is relatively high.[175] As such, planners in SPP have less of an opportunity to match new wind projects with consumer demand as compared to ERCOT.

However, given SPP's expansive geographic footprint, wind projects may be sited in geographically dispersed locations. This greater geographic diversity can serve to mitigate the variability of aggregate wind generation, thereby allowing for easier integration of such resources.[176]

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171. *Id.*
172. *See* WAN, *supra* note 34, at 16.
173. *Id.*
174. *Id.*
175. *See* CHARLES RIVER ASSOCIATES, SPP WITF WIND INTEGRATION STUDY at 2-7 (Jan. 4 2010), http://www.uwig.org/CRA_SPP_WITF_Wind_Integration_Study_Final_Report.pdf.
176. *Id.* at 3-1.

IV. Conclusion

This Article explores efforts in the ERCOT and SPP regions to address challenges involving wind power intermittency. Each of the two regions has strong wind resources and at times high wind penetration. While significant work remains to be done, each region to date has addressed wind integration in an effective way. Solutions and proposals in one or both regions that help integrate wind power include:

- Market rules that encourage geographic diversity of wind projects, smoothing sharp and rapid weather-induced changes in wind generation output;
- Grid operation decisions based on more accurate wind forecasting, reducing wind integration challenges attributable to unreliable wind forecasts;
- Requirements that wind generation facilities incorporate new technology that assists in wind integration;
- Changes in laws, regulations, and market rules to encourage investment in and use of electric energy storage, quick start units, and other technologies that help the grid integrate wind power; and
- Transmission improvements that help the system utilize wind power while maintaining reliability.

As circumstances change, wind integration will continue to require ongoing analysis and timely response by regulators, grid operators, and the electric industry. Wind penetration in ERCOT and SPP is expected to increase over time. The challenges, proposals, and solutions discussed in this Article are only a snapshot of this dynamic area.