a limited sensitivity analysis using higher tariff rates to test the impacts on the production cost savings if rates were to increase significantly in the future. For this sensitivity analysis we used a June through September wheeling charge of $21.18/MWh and an October through May wheeling charge of $9.70/MWh in an effort to "bookend" – or capture the possible range of – the expected impact of additional export related charges. We found that the added wheeling fees reduced the SCT project measured annual ERCOT production cost savings by $20 million (an approximate 11.5% reduction) to a resultant savings of $153 million for the SCT Only scenario. There was a $25 million (approximately 7%) reduction in production cost savings, with a resultant production cost savings of $340 million for the SCT + 2000 MW Wind scenario. In these high tariff rate cases the consumer benefit was measured to increase by 24% to 36%. In addition, the sensitivity case for the higher export related charges also shows a decrease in the benefits associated with the export related charges themselves from $65 million to $57 million for the SCT Only scenario and from $68 million to $59 million for the SCT + 2000 MW Wind scenario.

Q47. DOES THIS CONCLUDE YOUR DIRECT TESTIMONY?

A. Yes, it does.

ELLEN WOLFE

SUMMARY

Ms. Wolfe is President of Resero Consulting and has more than 28 years' experience with electric utilities and in the energy industry. She provides expert strategic support to individual clients and works in multi-stakeholder environments performing large studies and policy assessments. She has been responsible for performing market structural analyses; contributing to market designs and performing market power studies. Ms. Wolfe has extensive experience in Western markets and in ERCOT: works with market participants to set strategy in the CAISO and ERCOT markets, evaluated benefits and costs associated with the RTO-West; WestConnect, ERCOT and SPP; developed tariffs and implementation processes for ERCOT and other ISOs. She has represented clients in a number of industry forums, led extended seminars on market design details, is an adept facilitator of diverse stakeholders, and serves as an expert witness on critical wholesale energy matters.

Prior to forming Resero, Ms. Wolfe was a Director with CRA International and a Vice President with its predecessor firm, Tabors Caramanis and Associates, where she directed teams of consultants in the performance of studies and analyses.

Prior to joining Tabors Caramanis & Associates, Ms. Wolfe was a Senior Consultant for Henwood Energy Services Inc. Her work there included quantitative analysis to support strategic decisions about energy purchases and sales, forecasting of future energy prices, and policy support in the California restructuring arena.

Ms. Wolfe worked as a System Scientist at Lawrence Livermore Laboratory, providing quantitative and qualitative support addressing a wide variety of government and private policy issues.

Ms. Wolfe also worked as a Plant Engineer for the Sacramento Municipal Utility District overseeing maintenance and design upgrades for a wide variety of plant electrical distribution and instrument and controls systems, as well as working as a shift technical advisor to the Operations department and holding the role of Senior Licensing Engineer. She holds a Bachelor's degree in Electrical Engineering from the University of California, Davis, and Masters' degrees in Management, and Technology and Policy from the Massachusetts Institute of Technology. Ms. Wolfe is a registered Electrical Engineer in the state of California.

EDUCATION

Decision Analysis and Dynamic Systems, graduate coursework, Stanford University, 1992-1993.

M.S. in Technology and Policy, Massachusetts Institute of Technology, 1991.

M.S. in Management, Massachusetts Institute of Technology, 1991.

B.S. in Electrical Engineering, University of California, Davis, 1984.

EXPERIENCE HIGHLIGHTS

President, Resero Consulting, Granite Bay, CA, March 2005 – present. Leads efforts to resolve critical utility industry issues, including executive strategic support, policy advocacy, electric system modeling and analysis, and acting as an expert witness.

Director, Charles River Associates, Granite Bay, CA, Nov 2004 – March 2005. Directed large-scale restructuring policy evaluations, advises clients on critical ISO/RTO matters, including serving as expert witness.

Senior Consultant and Vice President, Tabors Caramanis & Associates, Cambridge, Massachusetts, 1997 – Nov 2004 (acquisition by CRA). Involved in setting restructuring policy and working with market participants in CA, NV and ERCOT; led large-scale cost-benefit studies; performed other modeling analyses.

Senior Consultant, Henwood Energy Services, Inc., Sacramento, California, 1995-1997. Responsible for quantitative analysis to support strategic decisions, and for policy support in the California restructuring arena.

Systems Scientist, Lawrence Livermore National Laboratory, Livermore, California, 1991-1995. Provided quantitative and qualitative support addressing a wide variety of government energy and environmental programs.

Senior Licensing Engineer, Shift Technical Advisor, Plant Engineer, Sacramento Municipal Utility District Rancho Seco Nuclear Generating Station, Sacramento, California, 1982-1989. Provided a wide range of power plant support.

FIELDS OF EXPERTISE

- Market Structure Design
- Energy Analysis and Modeling
- Market Participation in Restructured Environments
- Multi-Stakeholder Policy Making
- Quantitative Modeling, including decision analysis, risk assessment and simulation
- Power Plant Operations

MAJOR PROJECTS

Electricity Industry Strategy & Restructuring

Strategic Decision Making: Structure and bring industry knowledge to high-level strategic decisions. Served as consultant to CEO of Valley Electric Association in their strategic decision making regarding renewable buildout, variable resource management and transmission and operating costs in its decisions regarding joining the CAISO; and served as liaison designing a transition mechanism into the CAISO.

Market Redesign Advocacy, Expertise and Support: Have supported clients on strategic and transitional issues, including serving as the Western Power Trading Forum's market redesign consultant. Performed valuation and strategic support to clients through Congestion Revenue Right allocation and auction processes. Developed and led seminars throughout the U.S. on Locational Marginal Pricing and Congestion Revenue Rights. Provided analyses on contract matters related to market redesign.

Litigation Support: Provided testimony, expert litigation support and served as witness on matters ranging from contract interpretation, contract pricing terms under alternative market designs, market participant software valuation, regulatory policy and tariff cost/rate allocation issues.

Cost-Benefit Studies: Project manager for four large-scale, high-profile restructuring cost-benefit studies in SPP, ERCOT, WestConnect, RTO West. Efforts included substantial quantitative and qualitative analysis.

Energy Modeling: Modeled transmission system flows, energy pricing and profitability for cost-benefit studies and market power studies in a restructured environment. Valued expected congestion and losses in locational marginal pricing markets and assisted clients to maximize value of transmission rights. Modeled forward energy prices in restructured environments in the Western US and supported clients on strategy for power plant development, contract renegotiations and other strategic decision-making.

California Wholesale and Retail Settlements and Scheduling Support: Conducted service to evaluate complex ISO bills and represent clients on settlement matters. Represented clients on billing dispute matters.

ERCOT ISO Restructuring Support: Led team to develop draft protocols for filing at the Public Utilities Commission of Texas. Developed draft protocols, and worked with stakeholders to gain consensus and resolve policy issues.

Restructuring Support: Ongoing support for two large market participants to design market rules and infrastructure as part of a Nevada and CA restructuring stakeholder processes. Drafted relevant settlement processes and reached consensus on such with other stakeholders. Wrote RFP for Mountain West ISA major systems and served on vendor selection team. Developed, and proposed retail settlement policies.

Power Plant Operations

Licensing Support: Represented a utility on all aspects of plant operation with the Nuclear Regulatory commission and other regulatory agencies.

Operations Advisor: Served as engineering advisor to power plant operating crews, ensuring nuclear safety and effective operation.

PAPERS, PUBLICATIONS, EXPERT SUPPORT AND TESTIMONY

Wolfe, E., Expert Report November 2015: Analysis of winder curtailment in contract dispute for wind producer in the Southwest Power Pool market. US District Court, Western District of Missouri, Springfield Division, MO.

Wolfe, E., Expert Report October 2015 and Amended Expert Report November 2015: Analysis of winder curtailment in contract dispute for wind producer in the Southwest Power Pool market. US District Court, Western Division of Missouri. Kansas City, MO.

Wolfe, E., Oral Testimony and Analysis: International Institute for Conflict Prevention and Resolution, arbitration involving contract dispute for wind producer in the Midcontinent Independent System Operator market. Indianapolis, IN, April 2014.

Wolfe, E., Expert Analysis, April 2013. Analysis in support of FERC California power market investigation. (Report not filed given confidential settlement.)

Wolfe, E., Expert Analysis, 2013. Analysis in support of FERC California power market investigation. (Report not filed; ongoing investigation.)

Wolfe, E., et. al. "Cost Benefit Analysis of Entergy and Cleco Power Joining the SPP RTO", Report to the Federal Energy Regulatory Commission, September 2010.

Wolfe, E., Oral Testimony: Superior Court of the State of California, County of San Diego, California Department of Water Resources v. Sempra Energy Resources. (Case GIC 789291), December 2009.

Wolfe, E. et. al. "Update on the ERCOT Nodal Market Cost-Benefit Analysis," Final Report Presented to Public Utilities Commission of Texas, December 2008.

Wolfe, E., Testimony Expert Report Affidavit, May, 2007. American Arbitration Association involving contract dispute for power purchase agreement in California.

Wolfe, E., Ralph Luciani. Testimony Presented to the State Corporation Commission of the State of Kansas regarding the costs and benefits of the implementation of an Energy Imbalance Service, July 2005.

Wolfe, E., "Barriers to Systems Dynamics Deployment in Business and Policy Making: Lessons Learned through Assessing Electric Utility Restructuring Policy," *Proceedings: Systems Dynamics Society Conference,* Boston, MA, July 2005.

Wolfe, E., Ralph Luciani. Testimony Presented to the Public Service Commission of the State of Arkansas regarding the costs and benefits of the implementation of an Energy Imbalance Service, May 2005.

Wolfe, E. Testimony: Expert Report Affidavit, May, 2005. American Arbitration Association involving contract dispute for power purchase agreement in California.

Wolfe, E. et. al. "Southwest Power Pool Cost-Benefit Analysis," Final Report Presented to the Regional State Committee, April 2005.

Wolfe, E. Testimony: Expert Report Affidavit, February, 2005. Affidavit regarding sellers' choice contract delivery points in CA ISO markets. (Not filed given confidential settlement.)

Wolfe, E. et. al. "Market Restructuring Cost-Benefit Study," Final Report Presented to Electrical Reliability Council of Texas, November 2004.

Wolfe, E. Testimony: Federal Energy Regulatory Commission, Docket No. ER00-565-000, ER00-565-03, November, 2004. Settlement of Turlock Irrigation District's Schedule Coordinator Services agreement with Pacific Gas & Electric regarding the allocation of CA ISO charges.

Wolfe, E. Testimony: Expert Report Affidavit, July, 2004. Expert opinion regarding CA ISO Scheduling and settlement software. (Record sealed due to confidential settlement).

Wolfe, E. Testimony: Federal Energy Regulatory Commission, Docket No. EL00-95-000, -048,-075, et. al., March 20, 2003. Consistency of Coral Power, L.L.C.'s market behavior with CA ISO tariff.

Wolfe, E. et. al. "RTO West Cost-Benefit Study," Final Report Presented to RTO West Filing Utilities, March 11, 2002

Wolfe, E. and Shreedevi Thacker, "Electric Restructuring Brings New Critical Business Requirements," *WorldPower 2002,* February, 2002

Wolfe, E., "ERCOT Summer 2001 Congestion Pricing: Primer, Results, Implications," *Proceedings: Congestion Pricing Conference,* Washington, D.C., November 16, 2001.

Wolfe, E. Testimony: Federal Energy Regulatory Commission, Docket No. ER00-2383-000, May 23, 2000. CA ISO separate "inc" and "dec" pricing and Target Price proposal.

Wolfe, E. Testimony: United States of America Bonneville Power Administration, BPA Docket WP-02, November 1999. Functionalization of Reactive Support.

Banaghan, E., "Market Power Measurement and Mitigation Analysis in the Face of Restructuring," *Proceedings: Energy Market Pricing Conference,* Vail, Colorado, August 10, 1999.

Banaghan, E. A., "California: What's Working and What's Not," *Proceedings: Buying and Selling Electricity in The Western Wholesale Power Market,* The Energy Institute, Las Vegas, Nevada, Summer 1998.

Banaghan, E. A., "California FTRs: The Market Perspective," *Proceedings: Buying and Selling Electricity in The Western Wholesale Power Market,* The Energy Institute, Las Vegas, Nevada, Winter 1998.

Banaghan, E. A., P.E., Testimony: Superior Court of the State of California for the County of Los Angeles, January 1997. QF contract dispute between wind energy producers and Southern California Edison regarding the start of the fixed price capacity payment period.

PROFESSIONAL DEVELOPMENT, AFFILIATIONS AND AWARDS

Registered Professional Electrical Engineer, California

Taking Heart in Tough Times, Joanna and Fran Macy, Hartland, VT. 2008

The Work that Reconnects, Joanna Macy, Hartland, VT. 2006

Executive Leadership Program, Institute for Women's Leadership, 2006-2007

Donella Meadows Fellow (www.sustainabilityinstitute.org/fellows)

Kent Wheatland Memorial Award for outstanding utility industry contribution, 2007

Negotiation and Conflict Resolution, University of California, Davis, 1993.

Licensed Nuclear Reactor Operator (expired)

CONTACT

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RESERO CONSULTING LCG CONSULTING

Economic Impacts of Southern Cross Transmission Project—2015 Analysis February 23, 2016

Ellen Wolfe

ewolfe@resero.com; 916-791-4533

Resero Consulting

Objective of study and presentation

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- To refresh and report on results for the Southern Cross Transmission ("SCT") project interconnection to SERC
  - Updated independent assessment of ERCOT market effects
    - Included effects of SERC markets on the SCT project flows and economics
  - Comparisons with results of earlier 2010 assessment completed in collaboration with ERCOT's RPG shown where helpful

Summary of Assumptions and ERCOT-Annual Results

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		2015 Analysis (2020 case, SCT Only)	2015 Analysis (2020 case, SCT + 2000 MW Wind)	2010 Analysis (2015 case, full project)
Assumptions	Project Capacity	2000 MWs	2000 MWs	3000 MWs
	Project Termination	Rusk in ERCOT, NW Alabama	Rusk in ERCOT, NW Alabama	Rusk in ERCOT to terminations in NE MS and NW AL
	Study Year/Tranmission Case Year	2020	2020	2015
	Date Transmission Case Was Developed	2015 ERCOT; 2014 SERC	2015 ERCOT; 2014 SERC	2010
Results	Average ERCOT LMP Reduction	$0.42/MWh	$0.80/MWh	$1.18/MWh
	ERCOT Annual Consumer Energy Benefit	$162M	$306M	$701M
	Production Cost Savings (Less Cost of Net Imports)	$173M	$365M	$73M

- Fully integrated ERCOT–Eastern Interconnect model used
- Results show ERCOT exports significant energy across the SCT project, especially during high wind periods
- During high load hours, energy is imported across the SCT project into ERCOT and reduces LMPs in ERCOT
- Benefits reported in 2015 dollars
- Additional revenues to ERCOT ratepayers of $65M (expected wind SCT case) or $68M (2000 MW Wind case) from export related charges collected across the SCT project
- SCT project line capacity of 2,000 MW after losses, delivered east to west, and west to east

Outline

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- General description of analysis approach
- ERCOT–Eastern Interconnect model footprint and assumptions
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ERCOT–Eastern Interconnect model footprint and assumptions

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- Modeling approach used integrated ERCOT–Eastern interconnect footprint
  - Original 2010 analysis (2015 case, full project)—Eastern Interconnect market run independently, then interconnected to ERCOT via "supply curves"
  - In this analysis, the two markets (ERCOT and the Eastern Interconnect) have been fully integrated for modeling—a possibility only since the improvements of computing power
- Eastern Interconnect market assumptions from publicly available data and LCG proprietary predictions
  - Topology from 2014 series Summer Peak Power flow case for 2020; extends east well into Eastern Interconnect (service areas modeled also shown in appendix)
  - LCG-forecast SERC gas prices; Henry Hub 2020 commodity price $3.20/mmBTU
    - As-delivered burner-tip price is approximately $3.53/mmBTU (simple average of gas prices by month and by Eastern Interconnect state)
  - Load from NERC ES&D database, FERC Form 714
  - Wheeling/hurdle rates (non-MISO Eastern Interconnect regions) based on OATT tariff rates
    - Southern Company (service area of SCT interconnect) hurdle rate used was $5.237/MWh
  - ERCOT market assumptions shown on next slide

ERCOT market assumptions

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	2015 Analysis (2020 case)	2010 Analysis (2015 case, Full project)
Transmission Model	ERCOT - 2015SSWG Summer Peak Power flow case for 2020, Oct 2015; SCT terminus at Rusk SERC - 2014 series Summer Peak Power flow case for 2020; Terminus at MS/AL 500 kV system	Single year, 2015, modeled ("2010 5YTP 2015 Economic Case 08122010.xls"); SCT – multiple terminals in SERC
Foot print	Integrated ERCOT-Eastern Interconnect Model	ERCOT model with derived SPP/SERC "Supply Curves"
SCT Capacity	2000 MW	3000 MW
Results	2020 simulation year; $2015	2015 simulation year; $2010
Cases	1. Base Case – ERCOT status quo, no SCT (68.4 TWh total wind production, 20,144 MW wind capacity) 2. SCT Only Case – Base Case + SCT project 3. SCT + 2000 MW Wind Case – Base Case + SCT project added + 2000 MW added wind in the Panhandle (900 MW), Caprock (195.5 MW), I-20 (426 MW) and South Texas (478.5 MW) areas	1. Base Case – ERCOT status quo, no SCT (36.7 TWh wind production, 11,352 MW wind capacity) 2. SCT Case ("SC Case") – Base Case + SCT Project added 3. SCT High Wind Case ("SC HW Case") – SC Case + 3000 MW added wind (47.5 TWh wind production)
Gas prices	LCG forecast. Basis differentials based on historical price (ERCOT delivered average: $3.12, 54% decrease relative to '10 assumption).	ERCOT gas price from file 2010_5YTP_Gas_Prices.xls (ERCOT average: $6.75)
Load	ERCOT - 50-50 Non-coincidental peak forecast, Sep 2014, 2014 RTP Economic case load profiles by weather zone; SERC - NERC ES&D database, FERC Form 714	Load from ERCOT File 2010 5YTP 2015 Economic Case 08122010.xls
Wheeling	ERCOT (per MWh) export-related charges ($10.87 pk months; $9.28 offpk months); SPP/SERC wheeling costs from utility tariffs, no added wheeling costs for SCT	ERCOT export-related charges; SPP/SERC wheeling costs from utility tariffs, no added wheeling costs for SCT

ERCOT generation, based on ERCOT planning assumptions

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- Additions based on ERCOT Monthly System Planning Report (all units with standard generation interconnection agreements that meet all Planning Guide 6.9 requirements)
- Forced and planned generation outages included
- No other administrative or "placeholder" additional units added
- Planned retirements and derates from ERCOT

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SCT project flow impacts: more exports and fewer hours of imports than in 2010 study

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- ERCOT primarily exports energy given high level of renewables and low ERCOT gas prices
- ERCOT imports minimal energy during summer high load periods, although less than in the 2010 study, given significant increases in renewables, lower ERCOT gas prices, and increased transmission buildout since 2010
- ERCOT's reduction in LMPs due to SCT is lower in this study, given lower gas prices and additional renewable buildout in the Base Case based on ERCOT's planned generation interconnections

SCT project flows—monthly peak/off-peak averages (MW/h) for SCT Only and SCT + 2000 MW Wind cases

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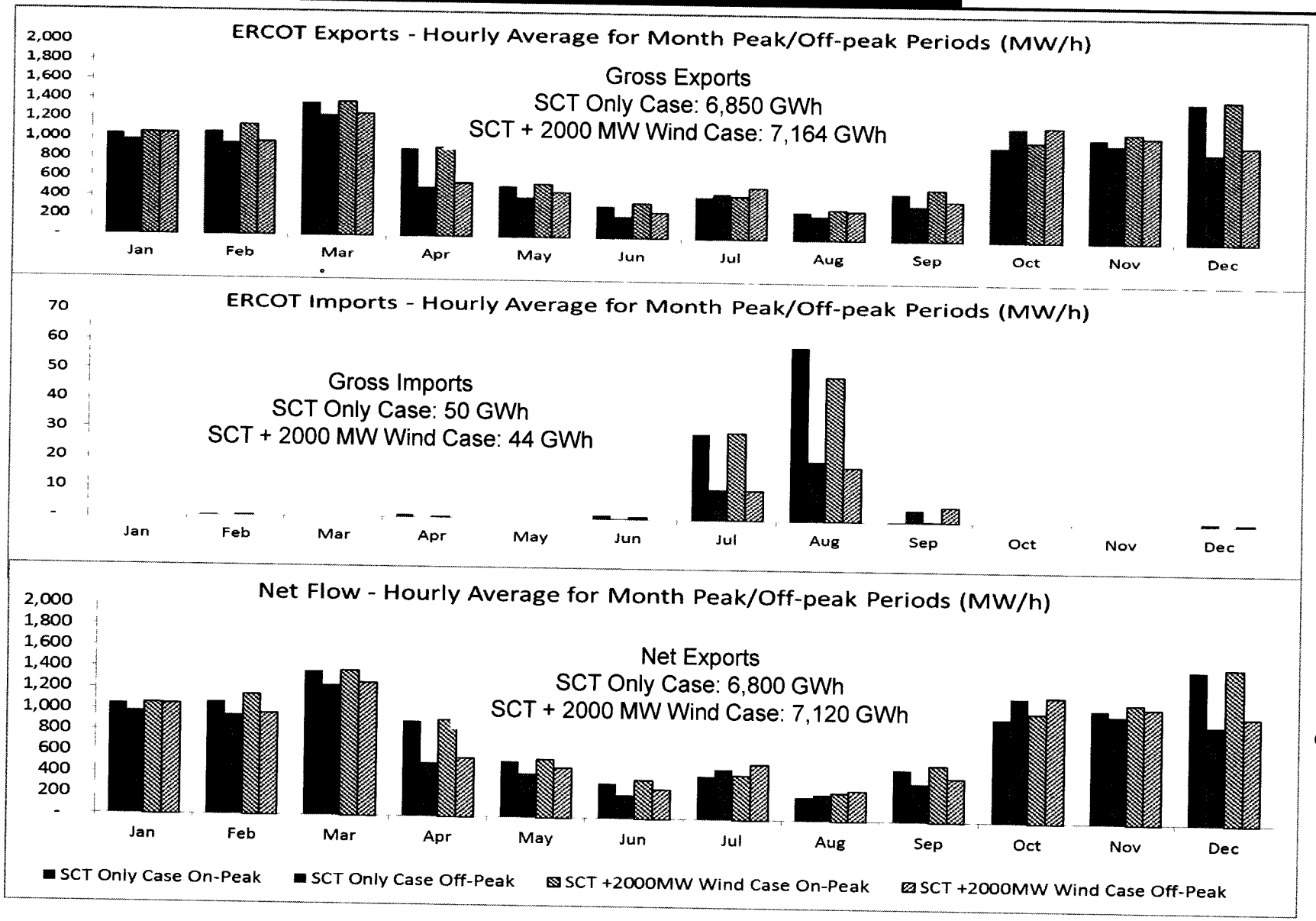

SCT project flows—net exports compared with 2010 study

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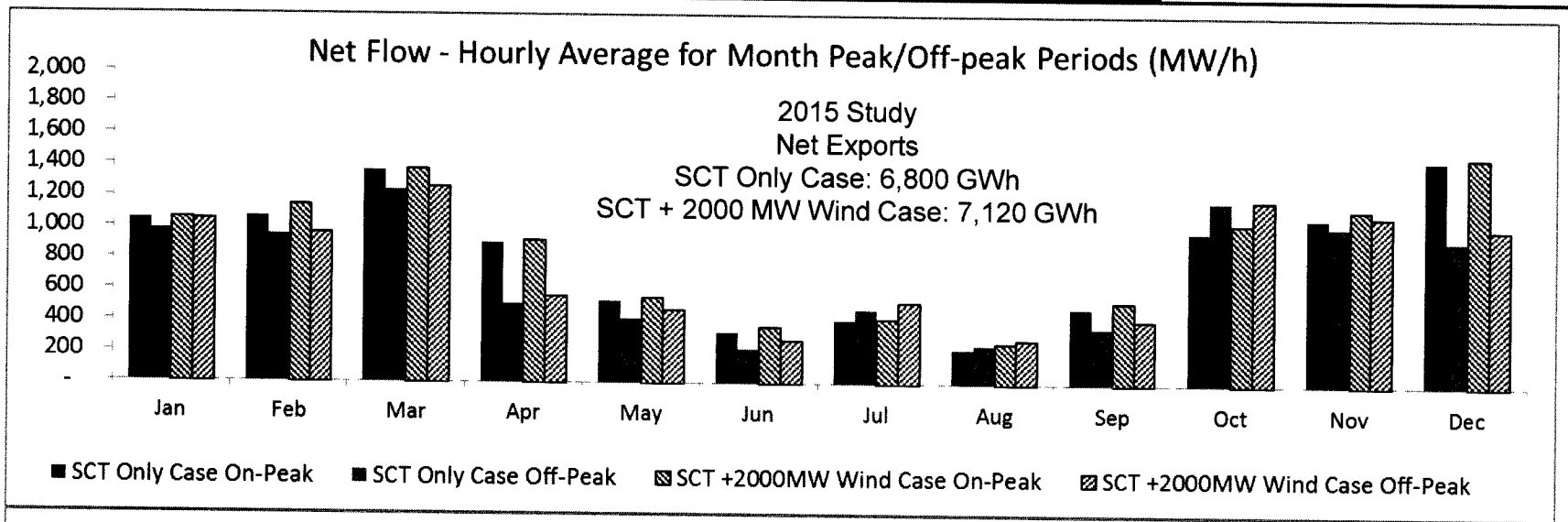

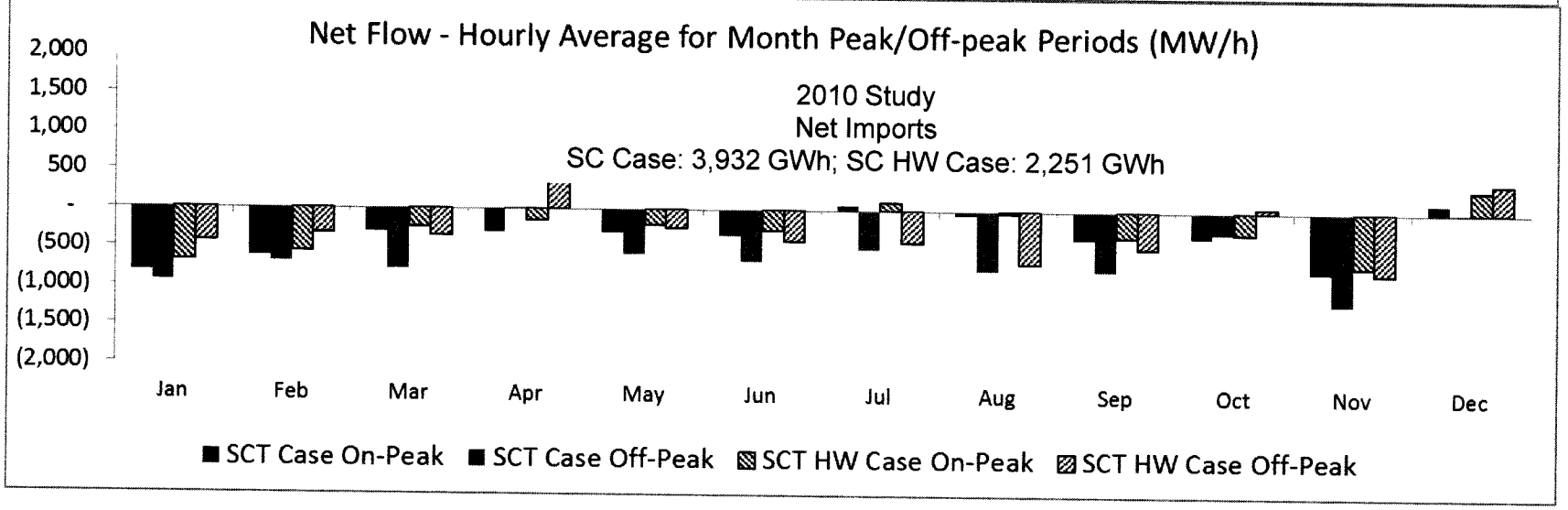

Hourly flow behavior: how to interpret the hourly distribution of flows on the SCT project

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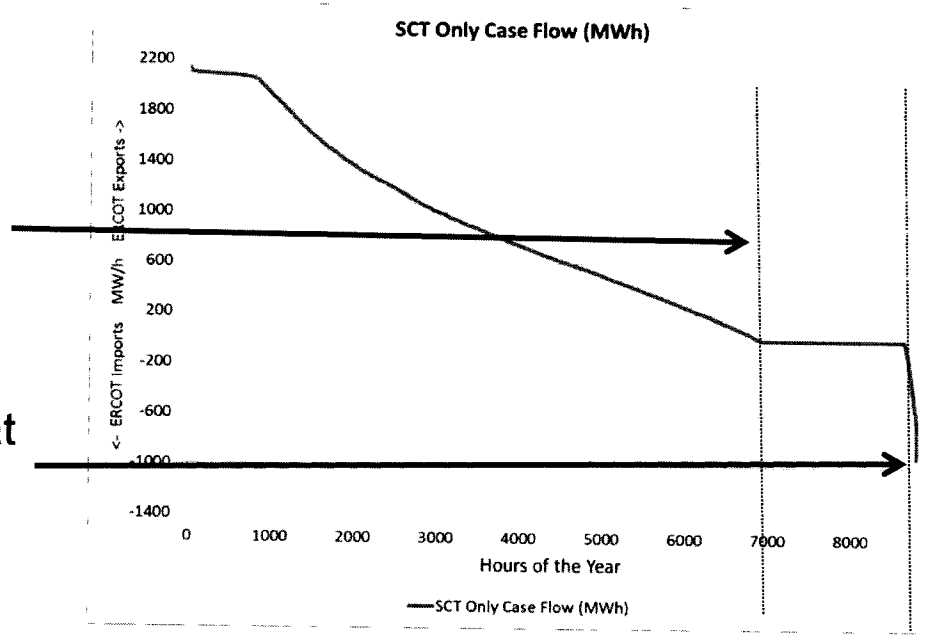
- The next slide shows the hourly distribution of the SCT Phase 1 project flows measured during the simulation
- The graphic shows the hourly distribution in the form of a "duration curve"
  - Often used to represent price distributions (e.g., "price duration curve")
- The flow duration curve records the hours of the year during which the flow is above the level indicated on the left-hand axis
- For example, the curve will show the number of hours of the year ERCOT was exporting over the SCT project
- Similarly, it will show the hours that the project was importing



Hourly flow behavior: SCT project flow duration curve

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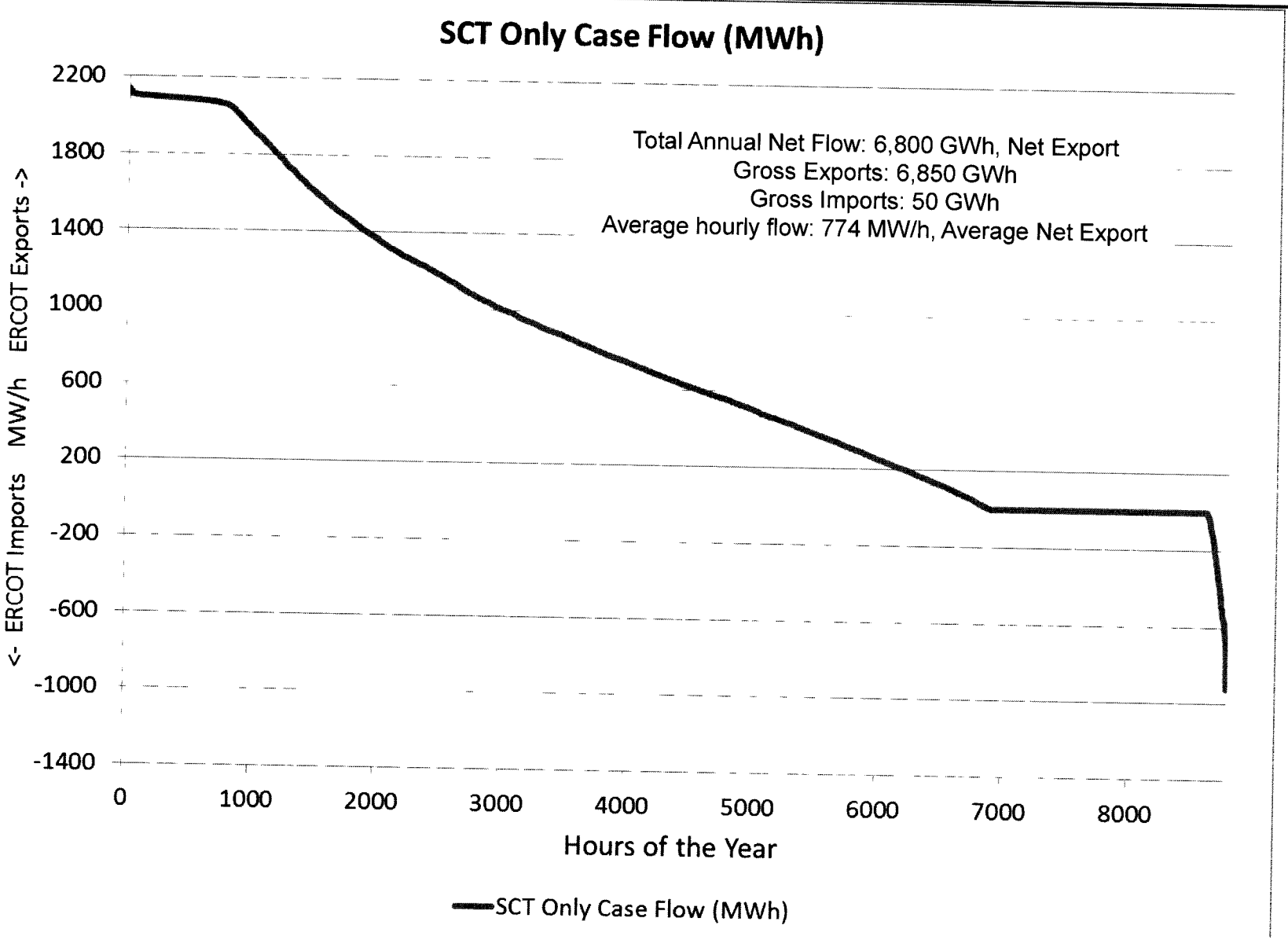

Hourly flow behavior: SCT project flow duration curve

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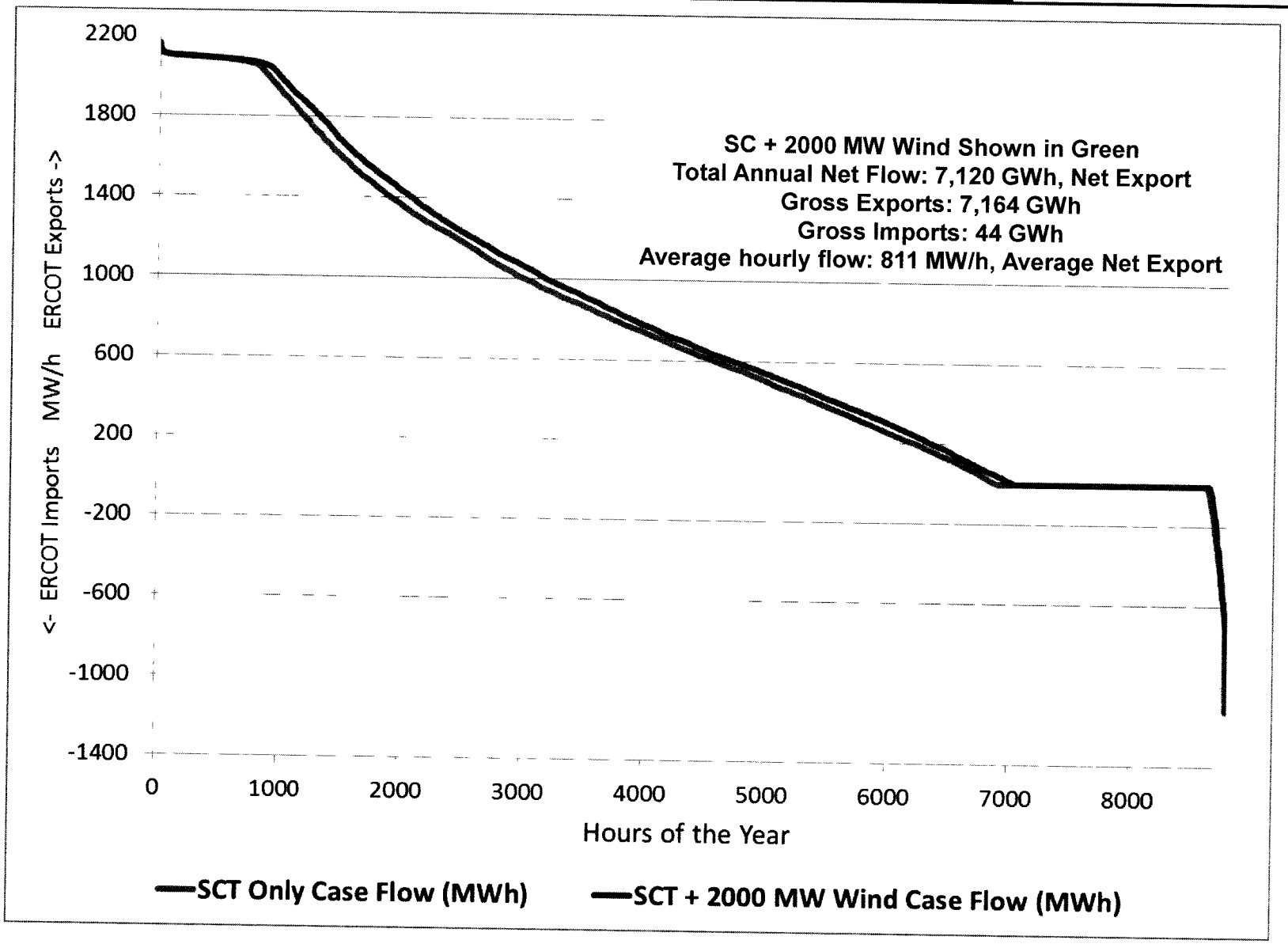

Hourly flow comparison: 2015 analysis (2020 case, 2,000 MW project) compared with 2010 analysis (2015 case, 3,000 MW project)

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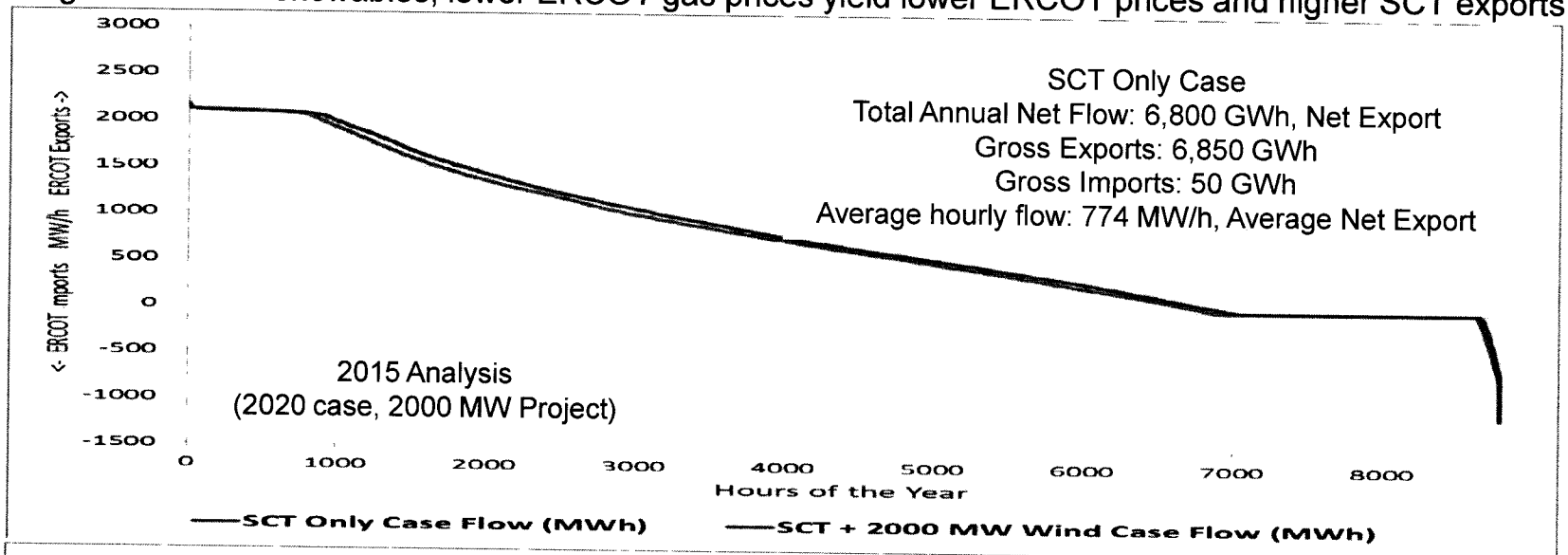
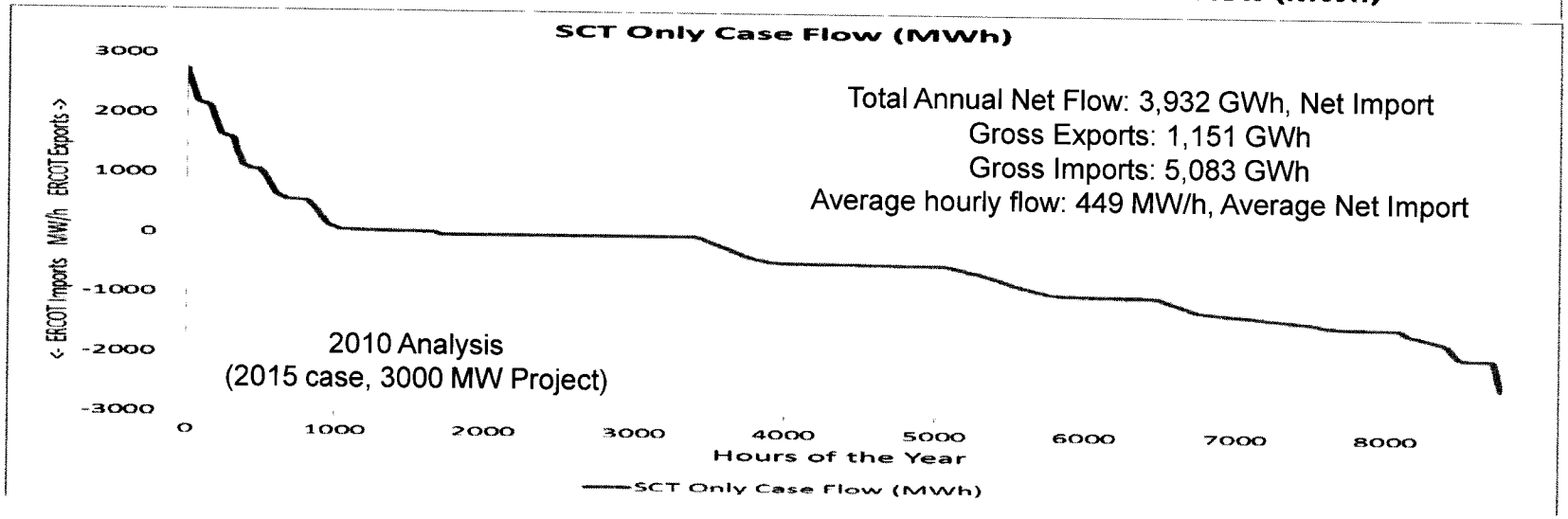
Higher ERCOT renewables, lower ERCOT gas prices yield lower ERCOT prices and higher SCT exports





Outline

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SCT project results in lower average annual LMPs across all regions; price reduction lower than in 2010 study

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Average annual load weighted LMPs

ZONE	2015 Analysis			2010 Analysis		
	Base Case ($/MWh)	SCT Case ($/MWh)	SCT Case - Base Case ($/MWh)	Base Case ($/MWh)	SCT Case ($/MWh)	SCT Case - Base Case ($/MWh)
Houston	$ 30.83	$ 30.57	$ (0.27)	$ 50.34	$ 49.26	$ (1.08)
North	$ 35.52	$ 34.90	$ (0.62)	$ 50.54	$ 49.20	$ (1.34)
South	$ 30.14	$ 29.96	$ (0.19)	$ 50.45	$ 49.38	$ (1.07)
West	$ 31.93	$ 31.11	$ (0.82)	$ 49.87	$ 48.66	$ (1.21)
ERCOT	**$ 32.43**	**$ 32.02**	**$ (0.42)**	**$ 50.41**	**$ 49.23**	**$ (1.18)**

ERCOT fundamental metrics were calculated in the recent analysis

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- Production-cost savings: reflects the change in the total cost of production, namely fuel and variable operations and maintenance costs; is adjusted for cost of purchases from neighboring areas and the value of sales to neighboring areas
- Consumer energy benefit, or change in cost to serve load: reflects the energy cost impacts on load-serving entities and ultimately on downstream consumers
  - Cost to serve load is measured as the LMP at each node times the quantity of energy delivered at the node, and then summed over all of ERCOT and adjusted for changes in flows with neighboring balancing areas
- Producer Benefits and Generator Margin: Not particularly measures of the merits of one case or another; rather reflects the revenue impacts to ERCOT's generation owners

Resulting ERCOT annual economic metrics, also comparing recent analysis with 2010 analysis

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	2015 Analysis (2020 case, SCT Only)	2015 Analysis (2020 case, SCT + 2000 MW Wind)	2010 Analysis (2015 case, full project)
Consumer Energy Benefit	$162M	$306M	$701M
Production Cost Savings (Less Cost of Net Imports)	$173M	$365M	$73M

- Decrease in consumer benefit relative to 2010 analysis, given general reductions in overall LMPs in conjunction with lower gas prices and relief of some significant transmission constraints
- Production cost benefits primarily due to increased sales of excess wind across SCT project
- Collected wheeling-out fees result in an additional $65M in revenues to ERCOT ratepayers in the expected wind case and $68M in revenues in the SCT + 2,000 MW wind case

Producers' Benefits – minimal impacts to producers

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- Producers' benefit between the scenarios is the difference of the Generator Margin of the change case and the Base Case
  - Generator Margin is the difference between the energy revenues received by suppliers in ERCOT and the production costs associated with the energy produced
- Note that the Producer's Benefit differs from the production cost savings in two respects
  - Producer's Benefit includes consideration of Energy Revenues and is thereby affected by changing market clearing prices
  - Production Cost savings also factor in the costs of purchases from neighboring regions and the sales to neighboring regions

	(Millions)		
	Base Case	**SCT Only Case**	**SCT + 2000 MW Wind Case**
Energy Revenue	$12,159	$12,156	$11,846
Production Costs	$9,082	$9,057	$8,876
Generator Margin	$3,077	$3,098	$2,970
Producers' Benefit		**$21**	**($107)**

- Changes in dispatch with the SCT project in place result in nominal (< 4%) impacts on ERCOT generators' annual margin

Generation by fuel type—only minor changes in fuel mix results

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FUEL TYPE	ERCOT GENERATION (GWh)		
	Base Case	SCT Only Case	SCT + 2000 MW Wind Case
OTHER	3,738	3,743	3,710
PETROLEUM	-	-	-
NATURAL GAS	204,986	206,162	201,422
COAL	70,493	71,101	69,521
OTHER RENEWABLES	489	486	476
HYDRO	491	489	485
SOLAR	3,112	3,149	3,163
WIND	68,475	72,832	79,541
NUCLEAR	41,214	41,214	41,214
TOTAL	**392,997**	**399,175**	**399,533**

- The SCT project, as reflected in the SCT Only case, produces a more efficient commitment and dispatch solution that results in reduced wind curtailment and a small amount (<1%) of additional fossil generation
- In the SCT + 2000 MW Wind case, wind production increases significantly and fossil fuel production is reduced by a small amount (<2%)

SCT supports additional renewable generation

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- SCT reduces wind curtailment by 6% and solar curtailment by 1%, allowing for over 4,350 GWh of additional wind to be produced in ERCOT

	Base Case		SCT Only Case	
	Generation (GWh)	Curtailment (%)	Generation (GWh)	Curtailment (%)
Wind	68,475	7.2%	72,832	1.2%
Solar	3,112	7.5%	3,149	6.4%

- Further, the SCT + 2000 MW Wind case results in 11,066 GWh additional wind generation in ERCOT relative to the Base Case

Outline

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What was not measured?

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- No reliability value was measured for the SCT project in the quantitative analysis
  - The SCT project likely would improve the reliability and ability for ERCOT and SERC/SPP to manage variability
  - No adjustments for operating reserves were made in the model
- Forward contracting for the SCT project capacity
  - Model assumed only spot market transactions

Summary of Assumptions and ERCOT-Annual Results

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		2015 Analysis (2020 case, SCT Only)	2015 Analysis (2020 case, SCT + 2000 MW Wind)	2010 Analysis (2015 case, full project)
Assumptions	Project Capacity	2000 MWs	2000 MWs	3000 MWs
	Project Termination	Rusk in ERCOT, NW Alabama	Rusk in ERCOT, NW Alabama	Rusk in ERCOT to terminations in NE MS and NW AL
	Study Year/Tranmission Case Year	2020	2020	2015
	Date Transmission Case Was Developed	2015 ERCOT; 2014 SERC	2015 ERCOT; 2014 SERC	2010
Results	Average ERCOT LMP Reduction	$0.42/MWh	$0.80/MWh	$1.18/MWh
	ERCOT Annual Consumer Energy Benefit	$162M	$306M	$701M
	Production Cost Savings (Less Cost of Net Imports)	$173M	$365M	$73M

- Fully integrated ERCOT–Eastern Interconnect model used
- Results show ERCOT exports significant energy across the SCT project, especially during high wind periods
- During high load hours, energy is imported across the SCT project into ERCOT and reduces LMPs in ERCOT
- Benefits reported in 2015 dollars
- Additional revenues to ERCOT ratepayers of $65M (expected wind SCT case) or $68M (2000 MW Wind case) from export related charges collected across the SCT project
- SCT project line capacity of 2,000 MW after losses, delivered east to west, and west to east

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APPENDIX: ADDITIONAL TECHNICAL DETAILS

Eastern Interconnect service areas modeled in the analysis

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PJM_AP
PJM_ATSI
PJM_AEP
SERC_OVEC
MISO_HE
MISO_DEI
PJM_DAY
MISO_SIGE
PJM_DEO&K
PJM_DLCO
MISO_IPL
MISO_NIPS
MISO_METC
MISO_ITCT
PJM_CE
MISO_WEC
MISO_MIUP
MISO_BREC
PJM_EKPC
ESS_EES-EAI
SERC_AECI
EES_LAGN
MISO_CWLD
SERC_CPLE
SERC_CPLW
SERC_DUK
SERC_SCEG
SERC_SC

PJM_DVP
SOCO_SOCO
TVA_TVA
EES_SMEPA
SERC_PS
EES_EES
SERC_YAD
SERC_SEHA
SERC_SERU
SERC_SETH
MISO_AMMO
MISO_AMIL
MISO_CWLP
MISO_SIPC
SERC_EEI
SERC_LGEE
SERC_OMUA
SERC_SMT
SERC_TAP
EES_CLEC
EES_LAFA
EES_LEPA
SPP_SWPA
SPP_AEPW
SPP_GRDA
SPP_OKGE
SPP_WFEC
SPP_SPS

SPP_OMPA
SPP_MIDW
SPP_SUNC
SPP_WERE
SPP_GMO
SPP_KCPL
SPP_KACY
SPP_EMDE
SPP_INDN
SPP_SPRM
MISO_XEL
MISO_MP
MISO_SMMPA
MISO_GRE
MISO_OTP
MISO_ALTW
MISO_MPW
MISO_MEC
SPP_NPPD
SPP_OPPD
SPP_LES
WAPA_WAPA
MISO_MDU
MISO_DPC
MISO_ALTE
MISO_WPS
MISO_MGE
MISO_UPPC

Eastern Interconnect service areas not modeled in the analysis

RESERO CONSULTING LCG CONSULTING

HQ_CORNWALL
HQ_TE
MHEB_MHEB
NEP_CT
NEP_ME
NEP_NH
NEP_NMABO
NEP_RI
NEP_SEMA
NEP_VT
NEP_WCMA
NY_CAPITAL
NY_CENTRAL
NY_DUNWOODI
NY_GENESEE
NY_HUDSON
NY_L ISLAND
NY_MILLWOOD
NY_MOHAWK
NY_NORTH
NY_NYC
NY_WEST
PJM_AE
PJM_BGE
PJM_DP&L
PJM_JCP&L
PJM_METED
PJM_PECO
PJM_PENELEC
PJM_PEPCO
PJM_PJM
PJM_PPL
PJM_PSE&G
PJM_RECO
PJM_UGI
SPC_SPC

Assumed ERCOT load

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2020 peak (MW) from 2014 ERCOT Long Term System Assessment; load shape based on actual 2006* hourly profiles by weather zone

Weather Zone	2020 Peak (MW)	Weather Zone	2020 Energy (GWh)
COAST	16,136	COAST	71,307
EAST	2,309	EAST	10,450
FARWEST	2,700	FARWEST	15,679
NORTH	1,448	NORTH	6,143
NORTHCEN	26,645	NORTHCEN	125,441
SOUTHCEN	11,689	SOUTHCEN	56,842
SOUTHERN	6,228	SOUTHERN	33,496
WEST	1,761	WEST	8,629
NON SELF SERVE (FLAT)	7,168	NON SELF SERVE (FLAT)	62,964
ERCOT (COINCIDENTAL)	**73,649**	**ERCOT**	**390,950**

* 2006 load shape year deemed by ERCOT to represent an average weather year.

Assumed resource additions—generators with signed interconnection agreements (1 of 2)

RESERO CONSULTING LCG CONSULTING

GINR Reference Number	Project Name	County	Projected Date	Fuel	Zone	MW For Grid
12INR0070	Green Pastures W	Knox	Sep-2015	WIND	WEST	300
13INR0052	Los Vientos III	Starr	Sep-2015	WIND	SOUTH	200
06INR0022c	Baffin Wind	Kenedy	Oct-2015	WIND	SOUTH	202
11INR0057	Cameron County Wind	Cameron	Oct-2015	WIND	SOUTH	165
11INR0079a	Shannon Wind	Clay	Oct-2015	WIND	WEST	200
14INR0053	Spinning Spur W 3	Oldham	Oct-2015	WIND	WEST	194
14INR0072	Briscoe Wind	Briscoe	Oct-2015	WIND	WEST	150
12INR0059b	Barilla Solar 1B	Pecos	Nov-2015	SOLAR	WEST	7
14INR0025a	South Plains I	Floyd	Nov-2015	WIND	WEST	200
12INR0068	Sendero Wind	Jim Hogg	Dec-2015	WIND	SOUTH	78
13INR0055	Javelina Wind	Zapata	Dec-2015	WIND	SOUTH	250
15INR0021	Los Vientos V	Starr	Dec-2015	WIND	SOUTH	110
15INR0036	Downie Ranch Solar	Uvalde	Dec-2015	SOLAR	SOUTH	95
16INR0057	Sky Global One	Colorado	Jan-2016	GAS	SOUTH	51
14INR0038	PHR Peakers	Galveston	Mar-2016	GAS	HOUSTON	390
13INR0028	Antelope & Elk 1	Hale	Apr-2016	GAS	WEST	369
14INR0047	Wake Wind	Dickens	Apr-2016	WIND	WEST	299
15INR0032	Elk 2	Hale	Apr-2016	GAS	WEST	202
15INR0033	Elk 3	Hale	Apr-2016	GAS	WEST	202
14INR0025b	South Plains II	Floyd	Jun-2016	WIND	WEST	152
14INR0025c	South Plains III	Floyd	Jun-2016	WIND	WEST	148
14INR0031	Baytown Chiller	Chambers	Jun-2016	GAS	HOUSTON	270
14INR0040	Redgate G	Hidalgo	Jun-2016	GAS	SOUTH	225
14INR0057	Buckthorn Wind 1	Erath	Jun-2016	WIND	NORTH	48
14INR0057b	Buckthorn Wind 2	Erath	Jun-2016	WIND	NORTH	48
14INR0066	Lamar Power Upgrade	Lamar	Jun-2016	GAS	NORTH	130

Assumed resource additions—generators with signed interconnection agreements (2 of 2)

RESERO CONSULTING LCG CONSULTING

GINR Reference Number	Project Name	County	Projected Date	Fuel	Zone	MW For Grid
16INR0048	RE Roserock Solar	Pecos	Jul-2016	SOLAR	WEST	150
08INR0018	Gunsight Mt W	Howard	Aug-2016	WIND	WEST	120
16INR0052	Paint Creek Solar	Haskell	Aug-2016	SOLAR	WEST	110
14INR0045a	Torrecillas Wind A	Webb	Sep-2016	WIND	SOUTH	200
14INR0045b	Torrecillas Wind B	Webb	Sep-2016	WIND	SOUTH	200
15INR0037	Los Vientos IV	Starr	Sep-2016	WIND	SOUTH	200
15INR0070_1	West Texas Solar	Pecos	Sep-2016	SOLAR	WEST	110
11INR0082a	Val Verde Wind	Val Verde	Oct-2016	WIND	SOUTH	180
16INR0024	Hidalgo & Starr Wind	Hidalgo	Oct-2016	WIND	SOUTH	250
16INR0062	Electra Wind	Wilbarger	Oct-2016	WIND	WEST	360
11INR0054	Midway Wind	San Patricio	Dec-2016	WIND	SOUTH	161
11INR0062	Patriot Wind	Nueces	Dec-2016	WIND	SOUTH	180
13INR0005b	Colbeck's Corner W	Carson	Dec-2016	WIND	WEST	200
13INR0005c	Grandview W 3	Carson	Dec-2016	WIND	WEST	188
13INR0038	Swisher Wind	Swisher	Dec-2016	WIND	WEST	300
14INR0013	San Roman Wind 1	Cameron	Dec-2016	WIND	SOUTH	103
14INR0023b	Longhorn South	Briscoe	Dec-2016	WIND	WEST	160
14INR0041a	Redfish W 2a	Willacy	Dec-2016	WIND	SOUTH	115
14INR0041b	Redfish W 2b	Willacy	Dec-2016	WIND	SOUTH	115
14INR0062	Salt Fork 1 Wind	Gray	Dec-2016	WIND	WEST	200
15INR0059	Pecos Solar I	Pecos	Dec-2016	SOLAR	WEST	108
16INR0037	Blanco Canyon Wind 1	Floyd	Dec-2016	WIND	WEST	50
16INR0037b	Blanco Canyon Wind 2	Floyd	Dec-2016	WIND	WEST	150
16INR0055	Chapman Ranch Wind I	Nueces	Dec-2016	WIND	SOUTH	250
16INR0065	SP-TX-12	Upton	Dec-2016	SOLAR	WEST	180
16INR0073	East Pecos Solar	Pecos	Dec-2016	SOLAR	WEST	100
15INR0045	Oak Solar	Pecos	Mar-2017	SOLAR	WEST	100
16INR0003	Freeport LNG	Brazoria	Jun-2017	GAS	HOUSTON	11

Assumed ERCOT generation capacity by type

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Fuel Type	2020 (MW)
BIOMASS	165
HYDRO	522
SOLAR	1,717
DC TIES	1,250
NUCLEAR	5,161
COAL	18,921
WIND	20,144
NATURAL GAS	51,510
ERCOT TOTAL	**99,390**

Assumed ERCOT charges associated with exports

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	June - Sept Months ($/MWh)	Oct - May Months ($/MWh)
Transmission Charges - 2015	6.90	5.31
Expected increase in Transmission charges to 2020	0.75	0.75
Expected 2020 Transmission Charges	7.65	6.06
ERCOT Admin Charges - May 2015 Estimate	3.49	3.49
Adjustment down for lower current AS charges	-0.30	-0.30
Expected AS increase to 2020	0.03	0.03
Total Expected Wheeling Out Charges	10.87	9.28

- ERCOT charges associated with exports rates were derived from the ERCOT postage stamp rate with adjustments based on existing to, from and over ("TFO") transmission tariff rates on file at FERC, with a forecast increase to 2020 rates of $0.75
- ERCOT admin charges were based on Ancillary Service, ERCOT administration, losses, UFE, Blackstart, and miscellaneous Uplift costs of $3.49 as of May 2020, and were adjusted down based on a $0.30 decrease in Ancillary Service (AS) charges based on the year-to-date ERCOT market clearing prices as of the start of the study
- LCG tested expected increases in Ancillary Service charges projected to 2020, but found through simulation minimal changes in Ancillary Service costs