CONFIDENTIAL

15 Years of Surprise and Uncertainty: The Texas Electricity Restructuring Story

December 2017

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What Surprises?

- ERCOT's mad "Dash for Gas"
- The unpredictable shale revolution
- The "Texas Wind Rush"
- "Sustainable" reserve margins amid low prices

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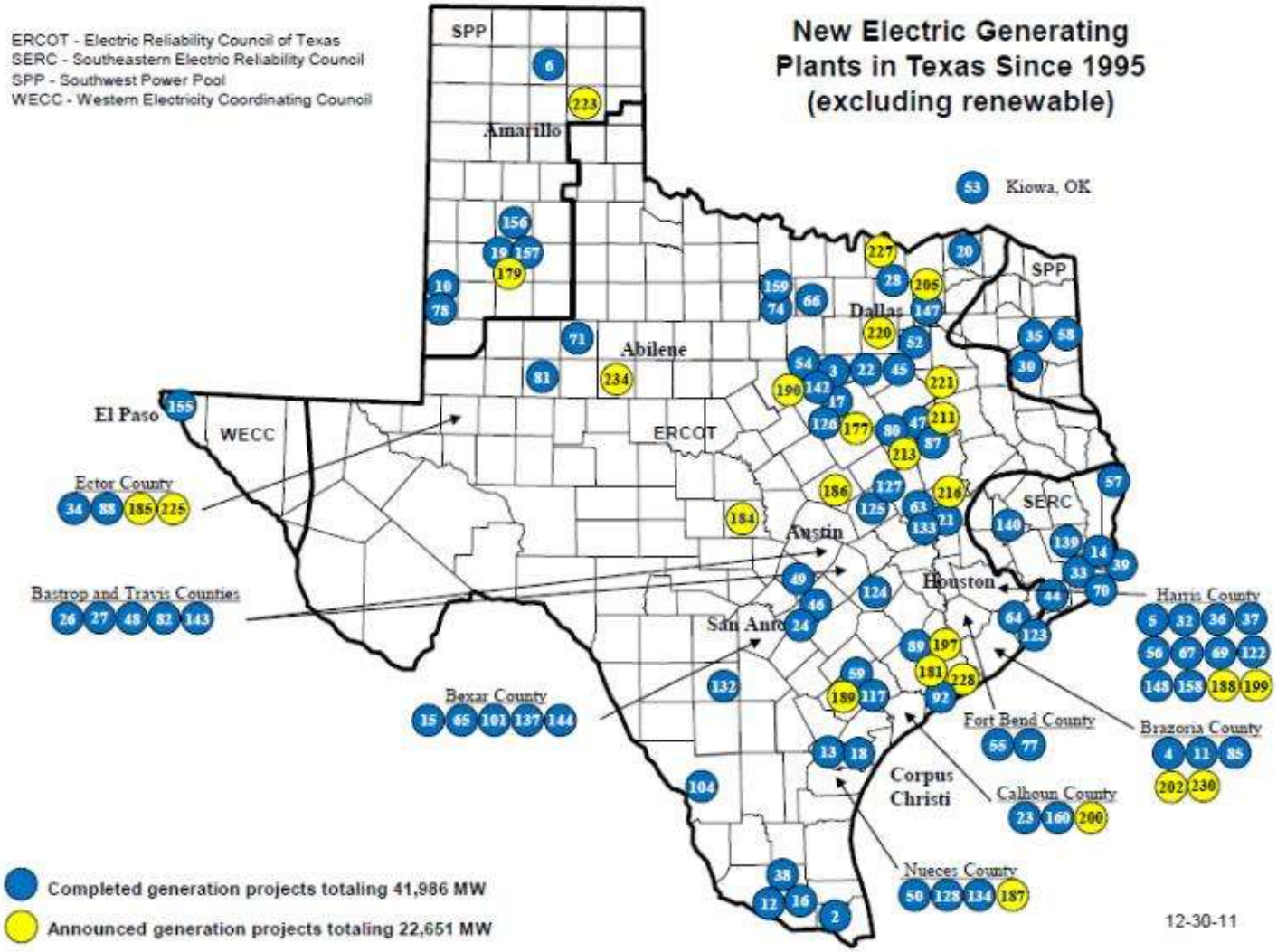
Since 1999, Texas Has Seen 22 GW of New Plants and $20 Billion In New Electric Generation Investment



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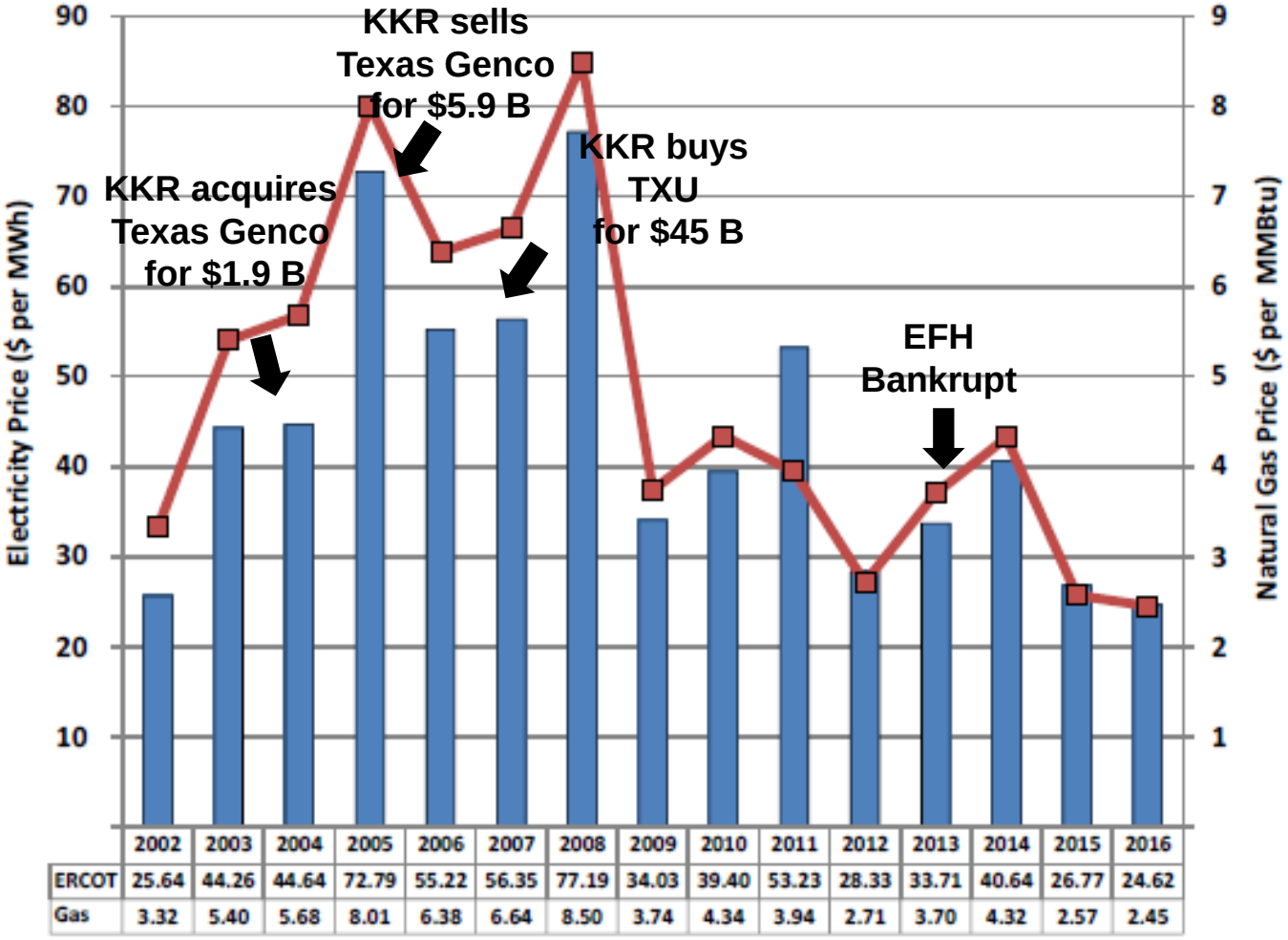
Impact of Natural Gas Prices on ERCOT

Figure 2: ERCOT Historic Real-Time Energy and Natural Gas Prices



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
ERCOT	25.64	44.26	44.64	72.79	55.22	56.35	77.19	34.03	39.40	53.23	28.33	33.71	40.64	26.77	24.62
Gas	3.32	5.40	5.68	8.01	6.38	6.64	8.50	3.74	4.34	3.94	2.71	3.70	4.32	2.57	2.45

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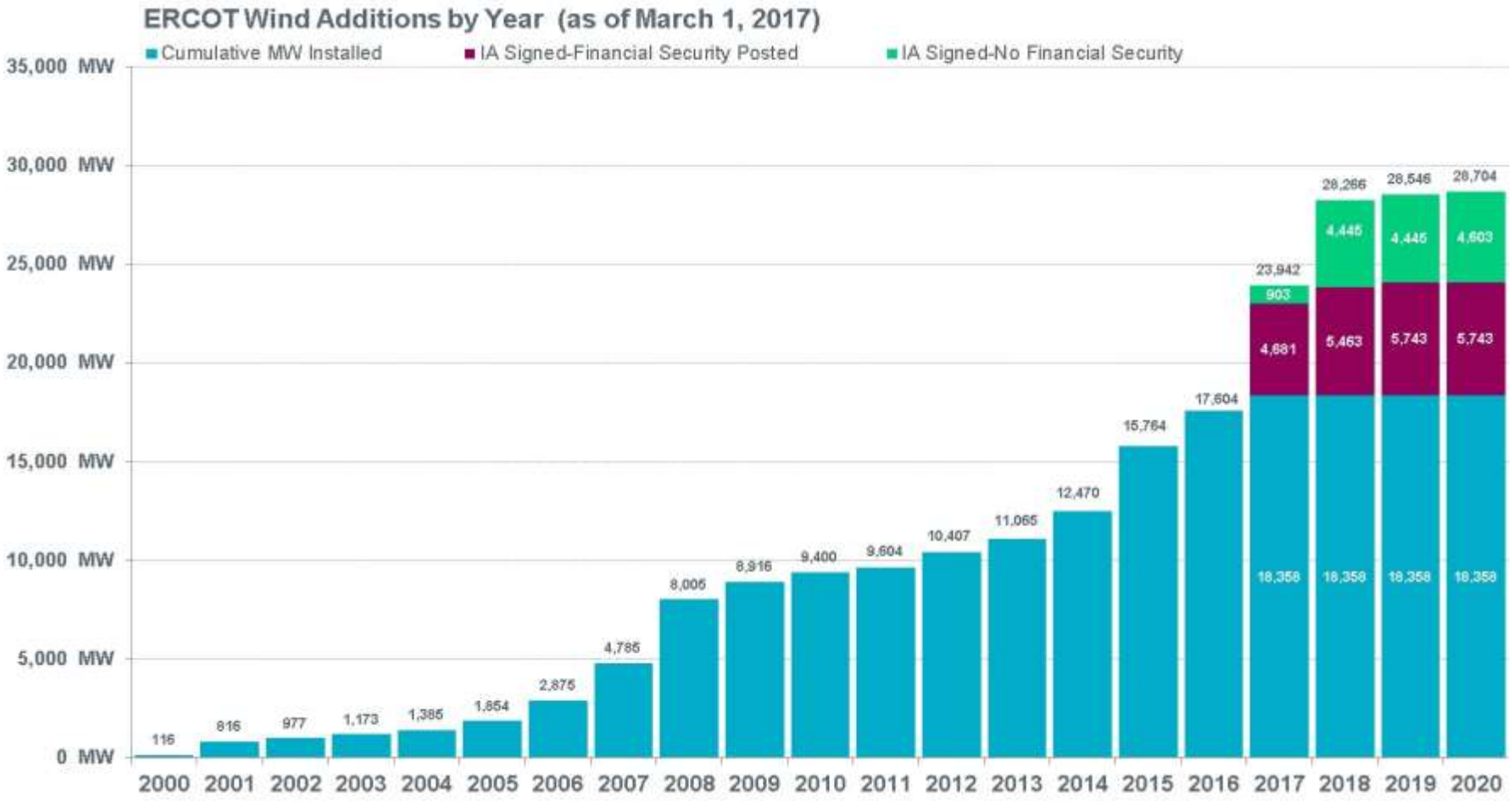
ERCOT Wind Capacity



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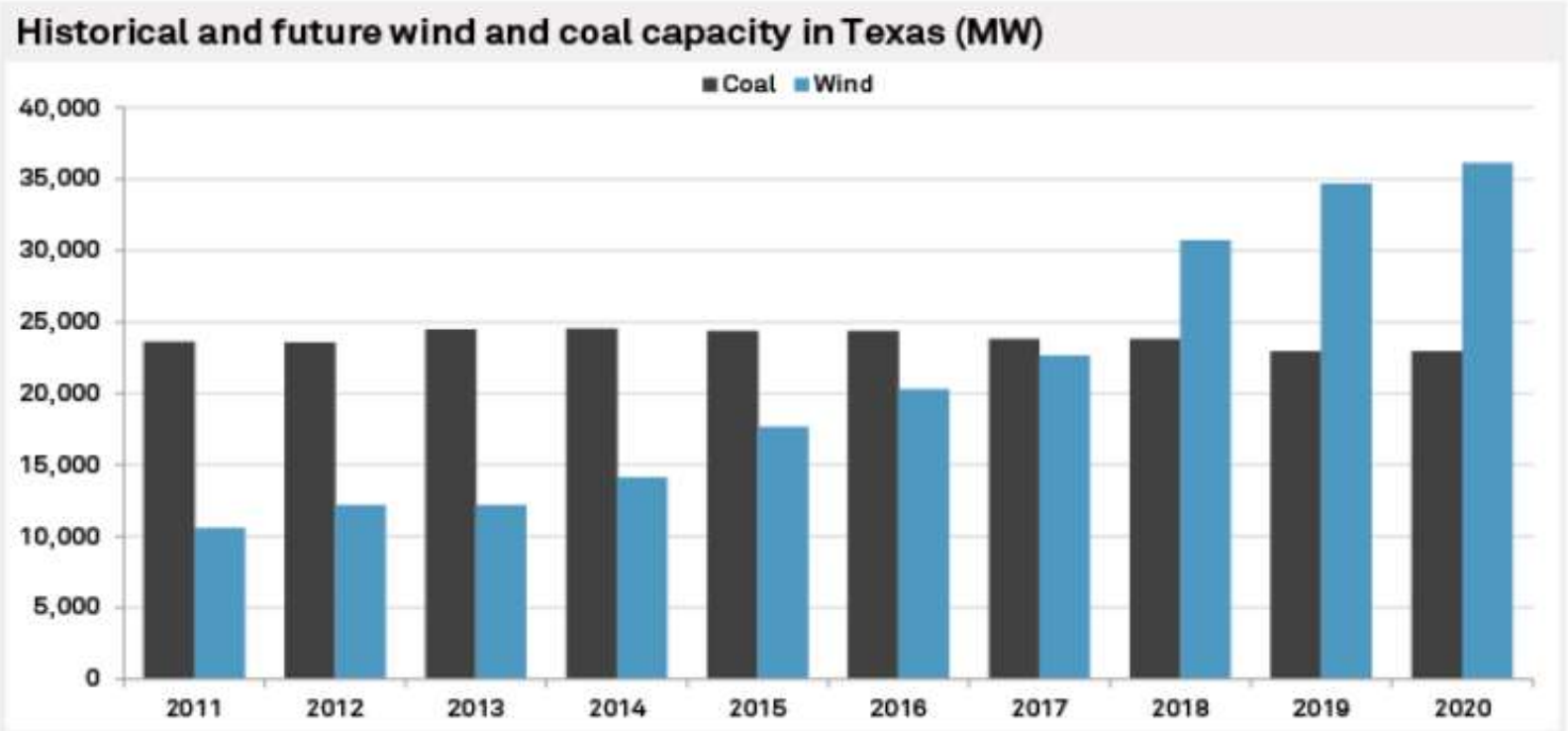
ERCOT Wind v. Coal Capacity



As of Oct. 30, 2017.
Future capacity is based on actual planned/under construction projects and is not based on any projections of unreported new developments or retirements.
Yearly capacity totals for future years based on 2016 operating capacity plus announced generation projects offset by announced unit retirements.
Retirements are removed from capacity aggregates the year following retirement.
Source: S&P Global Market Intelligence

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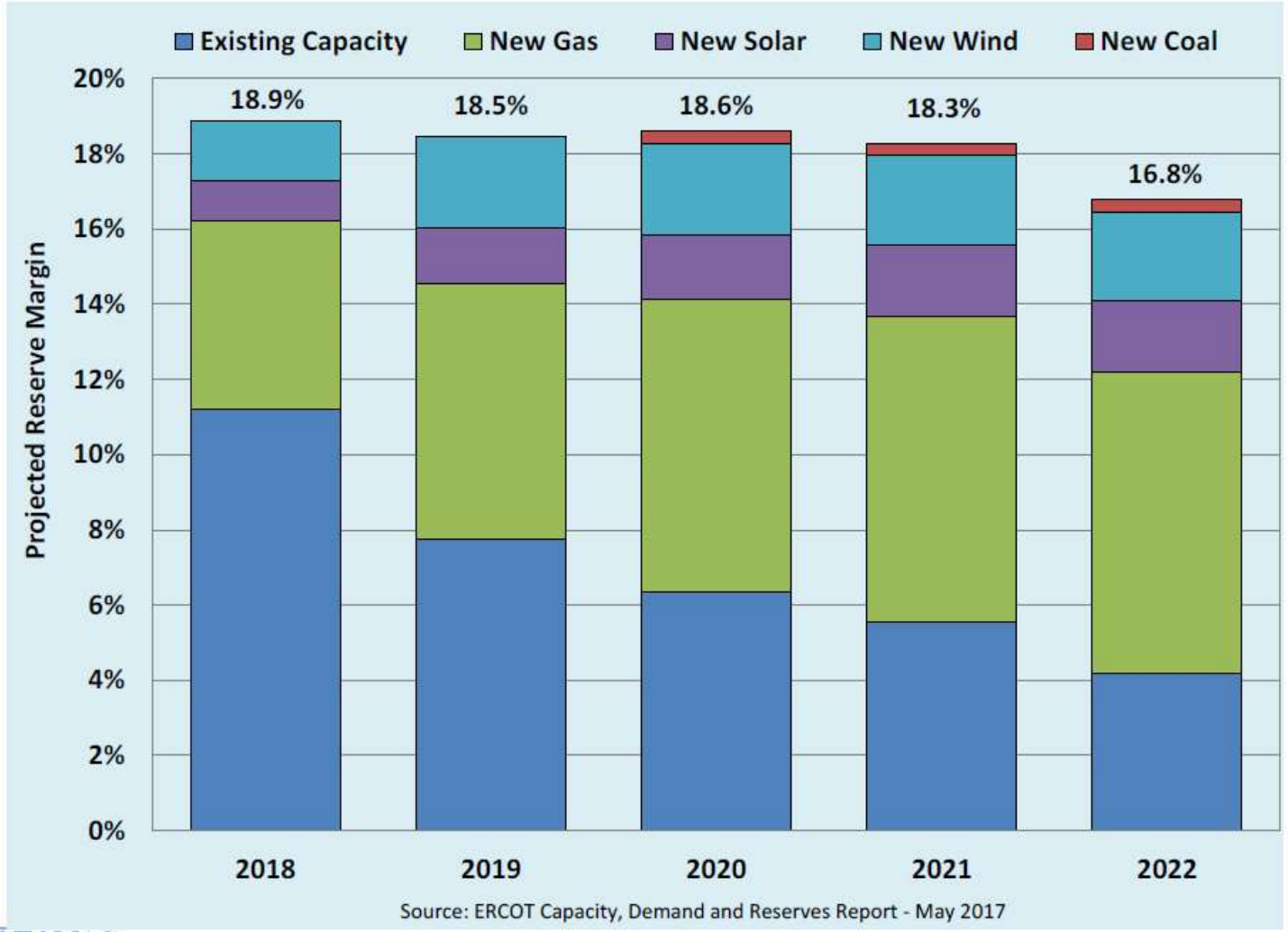
ERCOT Reserve Margins



New Uncertainties

- Never before seen ERCOT price volatility?
- Massive renewables at grid parity?
- Will dramatic reductions in costs drive energy storage growth?
- Will the rise of distributed energy become the new power development model?

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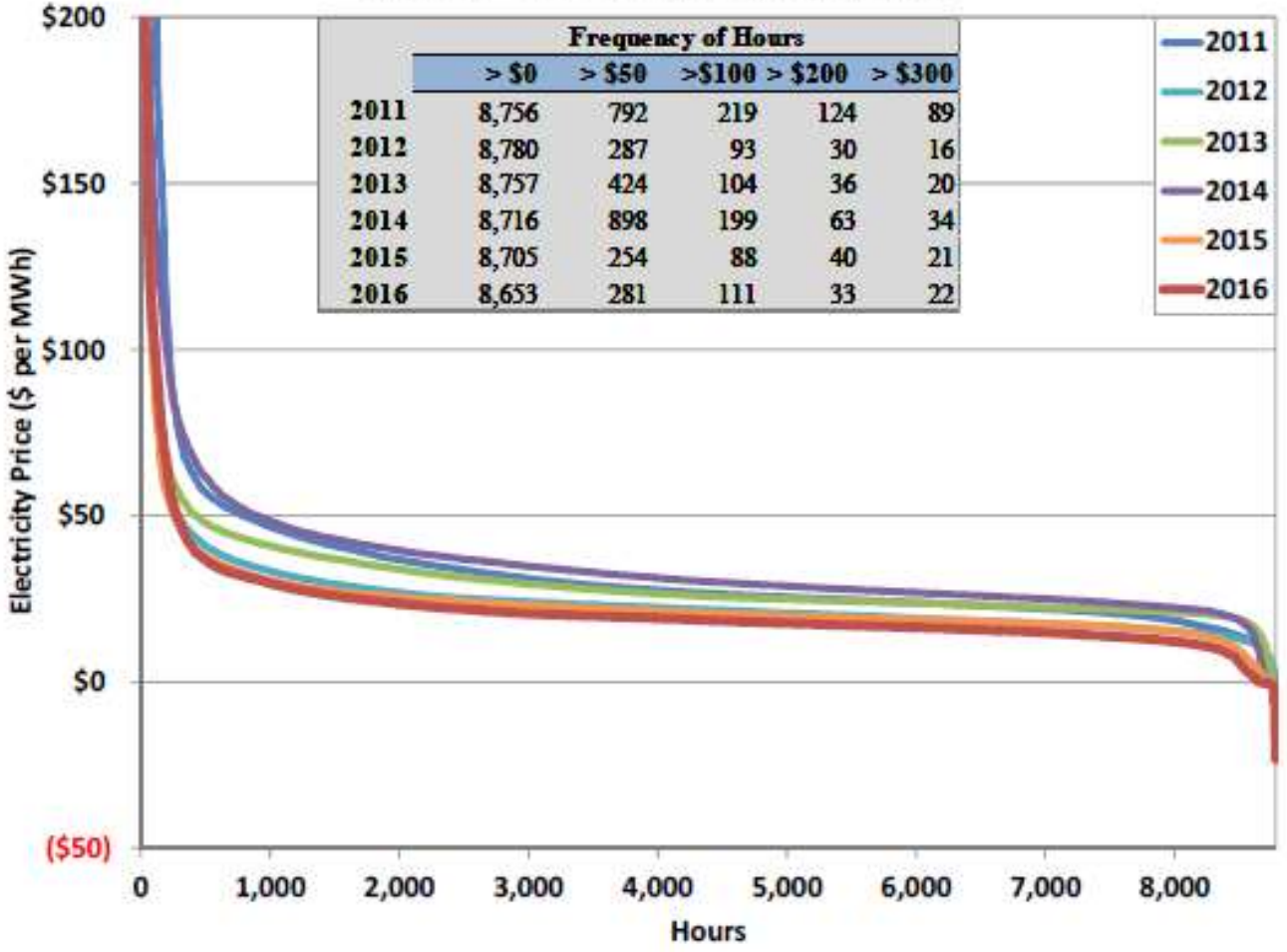
ERCOT Price Volatility: Has Complacency Set In?

Figure 7: ERCOT Price Duration Curve



	Frequency of Hours				
	> $0	> $50	>$100	> $200	> $300
2011	8,756	792	219	124	89
2012	8,780	287	93	30	16
2013	8,757	424	104	36	20
2014	8,716	898	199	63	34
2015	8,705	254	88	40	21
2016	8,653	281	111	33	22

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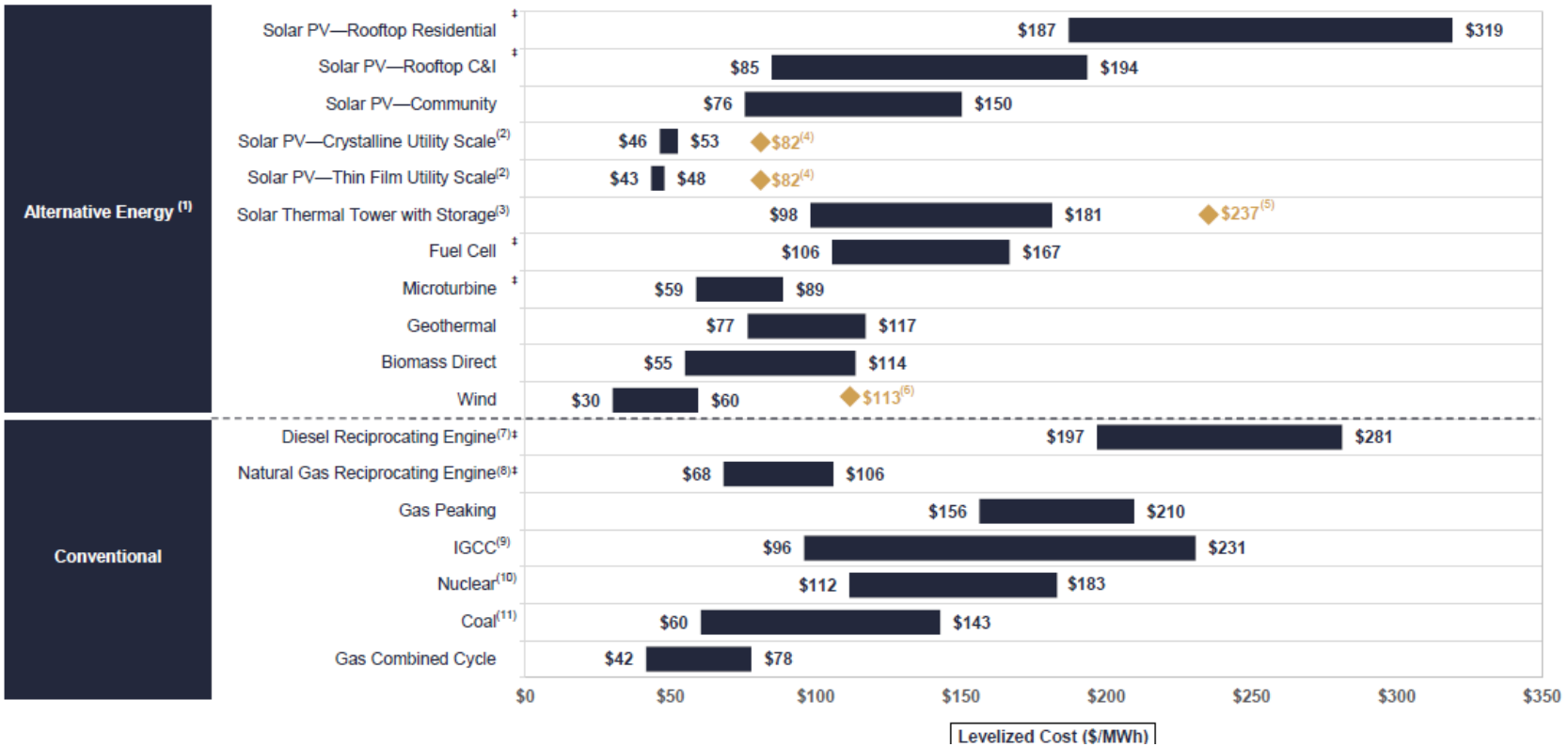
Renewable Generation Cost Trends

Unsubsidized Levelized Cost of Energy Comparison

Certain Alternative Energy generation technologies are cost-competitive with conventional generation technologies under some scenarios; such observation does not take into account potential social and environmental externalities (e.g., social costs of distributed generation, environmental consequences of certain conventional generation technologies, etc.), reliability or intermittency-related considerations (e.g., transmission and back-up generation costs associated with certain Alternative Energy technologies)



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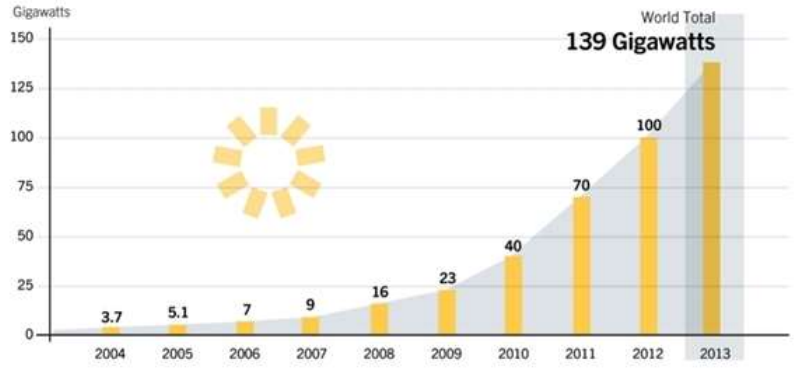
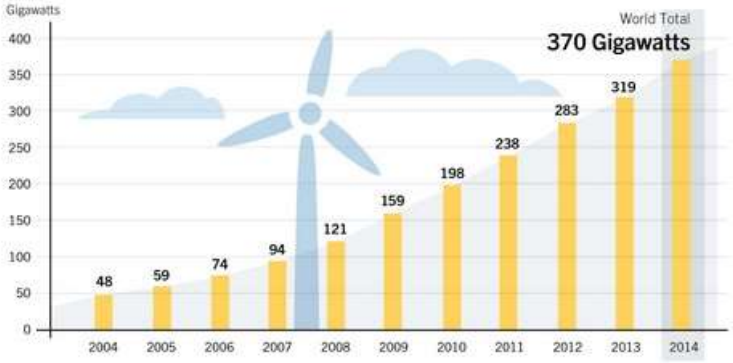
Enormous Quantities of Low Price Renewable Electricity

Solar PV Total Global Capacity, 2004–2013

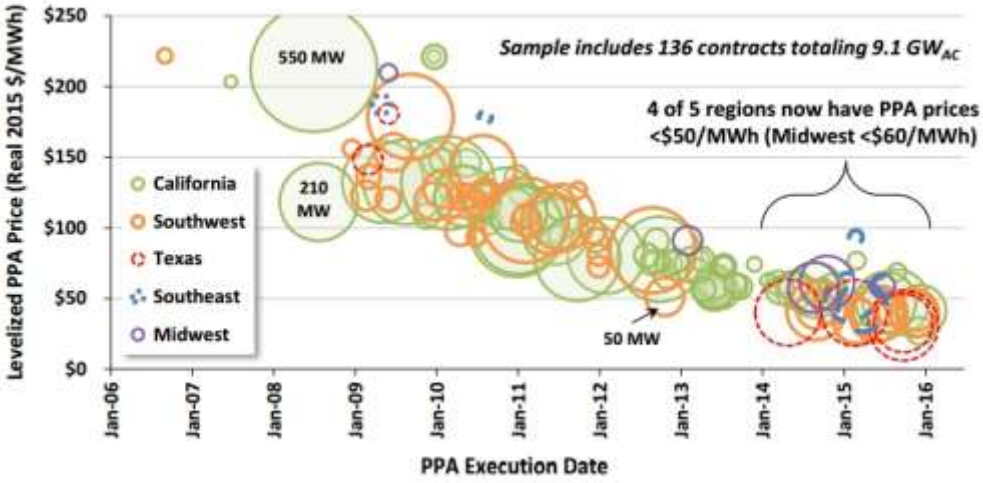


REN21. 2014. *Renewables 2014 Global Status Report* (Paris: REN21 Secretariat).

Wind Power Global Capacity, 2004–2014



REN21 *Renewables 2015 Global Status Report*



Over next five years, there will be continued dramatic cost decreases in energy storage

	Slow	Median	Fast
Flow Battery			
CAGR	-3%	-9%	-16%
5 Year	-14%	-38%	-58%
Flywheel			
CAGR	-1%	-2%	-12%
5 Year	-5%	-10%	-47%
Lead			
CAGR	-1%	-5%	-16%
5 Year	-5%	-24%	-58%
Lithium			
CAGR	-2%	-12%	-13%
5 Year	-10%	-47%	-50%
Zinc			
CAGR	0%	-1%	-7%
5 Year	0%	-5%	-30%

<u>Technology trends & opportunities</u>

Flow Battery
- Designing out high cost materials, and scale
- Improved manufacturing and design will improve performance – Size/thickness reduces current flow
- Integration time for manufacturing

Flywheel
- Reducing required high cost materials
- Improving control and response time to increase usable range of operation
- Improvements in operation sustainability – ability to remove heat, higher efficiency motor/generator

Lead
- Improvements in competitive cost position from increases in capability / performance
- Material additives such as carbon is increasing the usable energy and capability envelope
- Design changes to reduce lead requirement

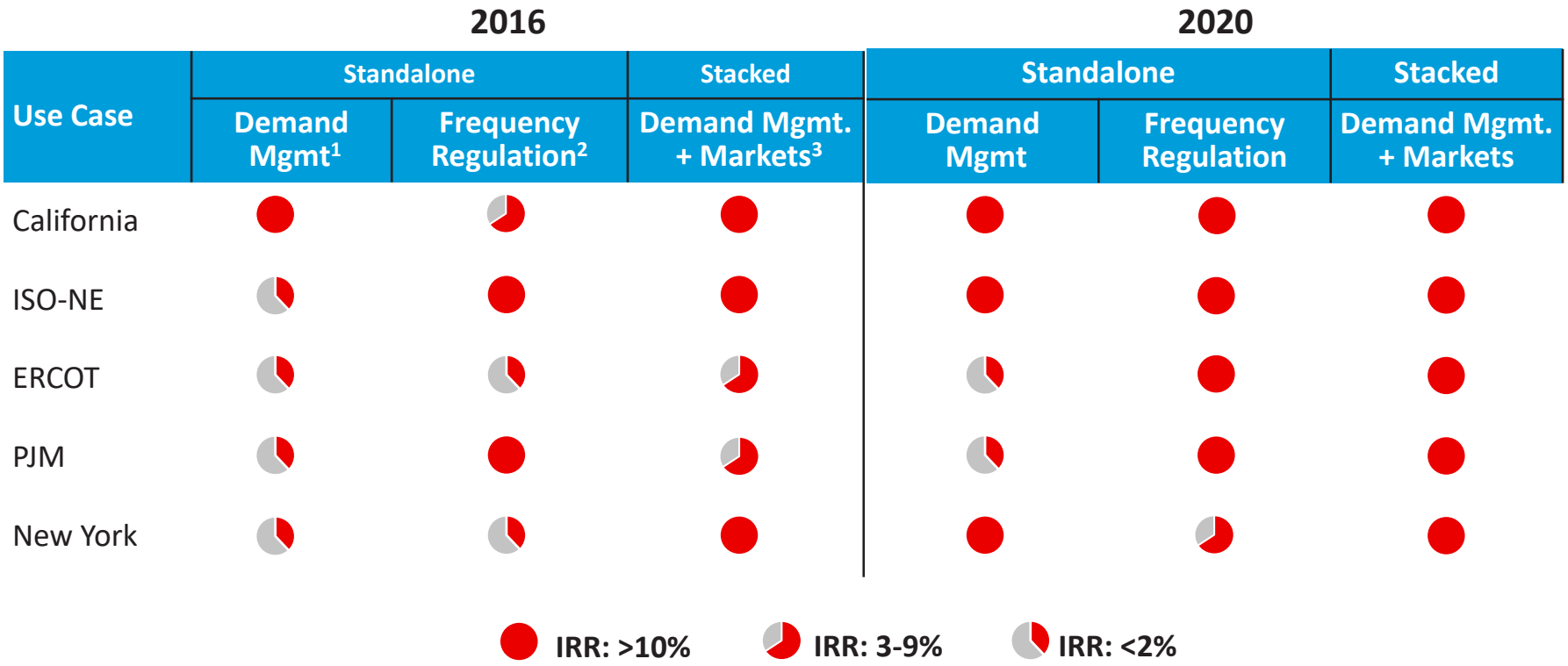
Lithium
- Scale manufacturing lowering cost (g)
- Design improvements reducing needed materials
- Chemistry improvements increasing capability of battery, increases usable energy and range of operation

Zinc
- Cost reduction depends on manufacturing at scale
- Design improvement to reduce high cost sub-components
- Chemistry improvements will increase lifespan and range of operation

Source: Enovation Partners, Lazard LCOS survey

BTM storage project economics will improve…

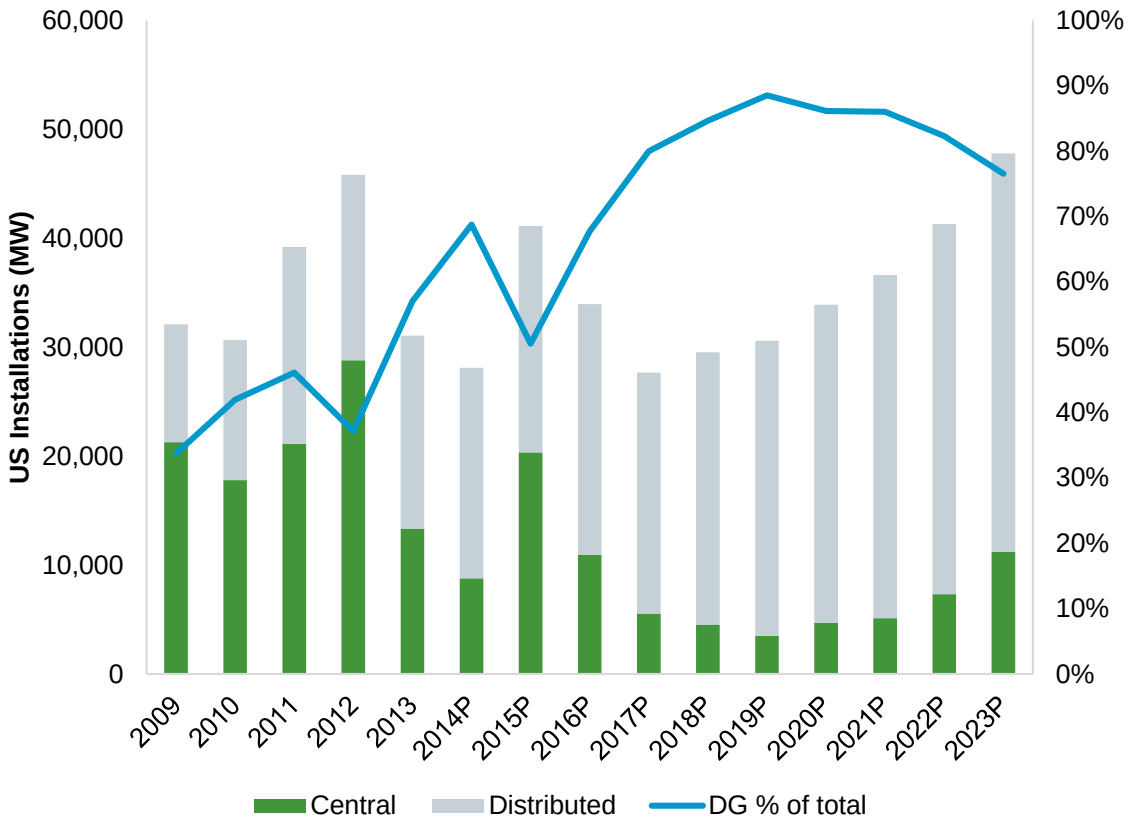
Evaluation of Market Attractiveness for BTM Storage*



1. 1. Demand Management: C&I system designed lower demand charges, 2. Frequency Regulation: C&I system designed to rapidly charge and discharge to provide frequency regulation; 3. Demand Management + Markets: Large scale C&I system designed to provide capacity, spinning reserve, and non-spinning reserve in addition to demand management
2. * See Appendix for detailed assumptions
3. Sources: Lazard LCOS (2015); CA SGIP Handbook; PJM Data Miner; NSTAR rate schedules; CA IOU rate schedules; CA IOU DR Filings; ISO-NE FCM; NYISO ICAP; Con Edison DR Programs; ERCOT; PJM RTO/ISO Market Comparison (2015), PJM Market Monitor (2015); EP analysis

DG's share of total capacity additions is large and growing

Central vs Distributed Capacity Additions

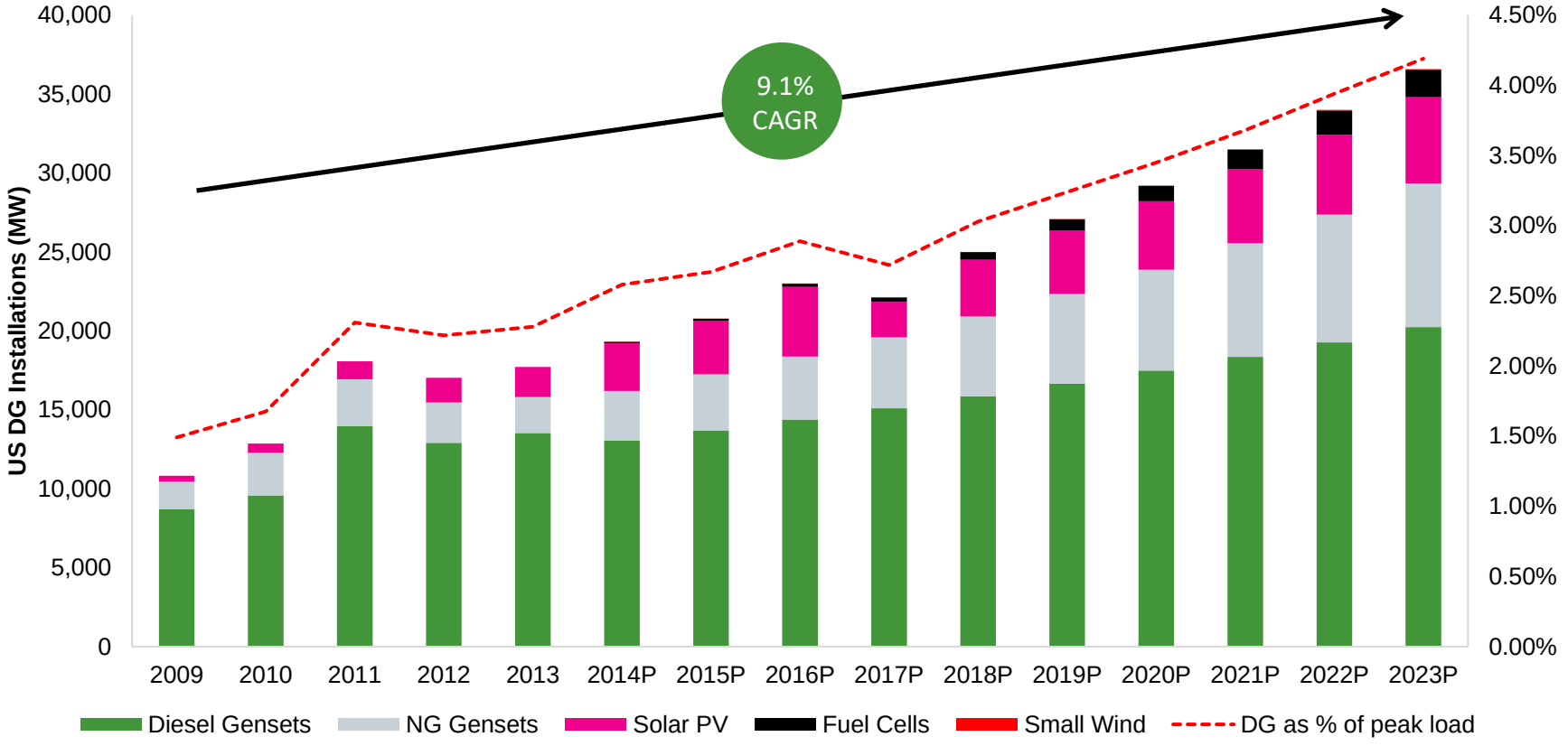


- DG gains share of total capacity additions well into the next decade – from ~50% to nearly 90%
- Absolute growth in DG is impressive at over 9%
- Diesel and gas recips remain dominant type of DG, but Solar PV grows from <5% to ~20%
- Note: Breakthrough in micro turbines, storage, fuel cells could increase share of gas-fired DG
- Decreased central station additions, despite optimistic demand assumptions, MACT-driven capacity replacement (but no 111D)

Source: Power Systems Research, SEIA, EGSA, Navigant, EIA, Enovation Partners

DG additions, excluding storage, microturbines and fuel cells

Distributed Gen Capacity Additions



Source: Power Systems Research, SEIA, EGSA, Navigant, Enovation Partners

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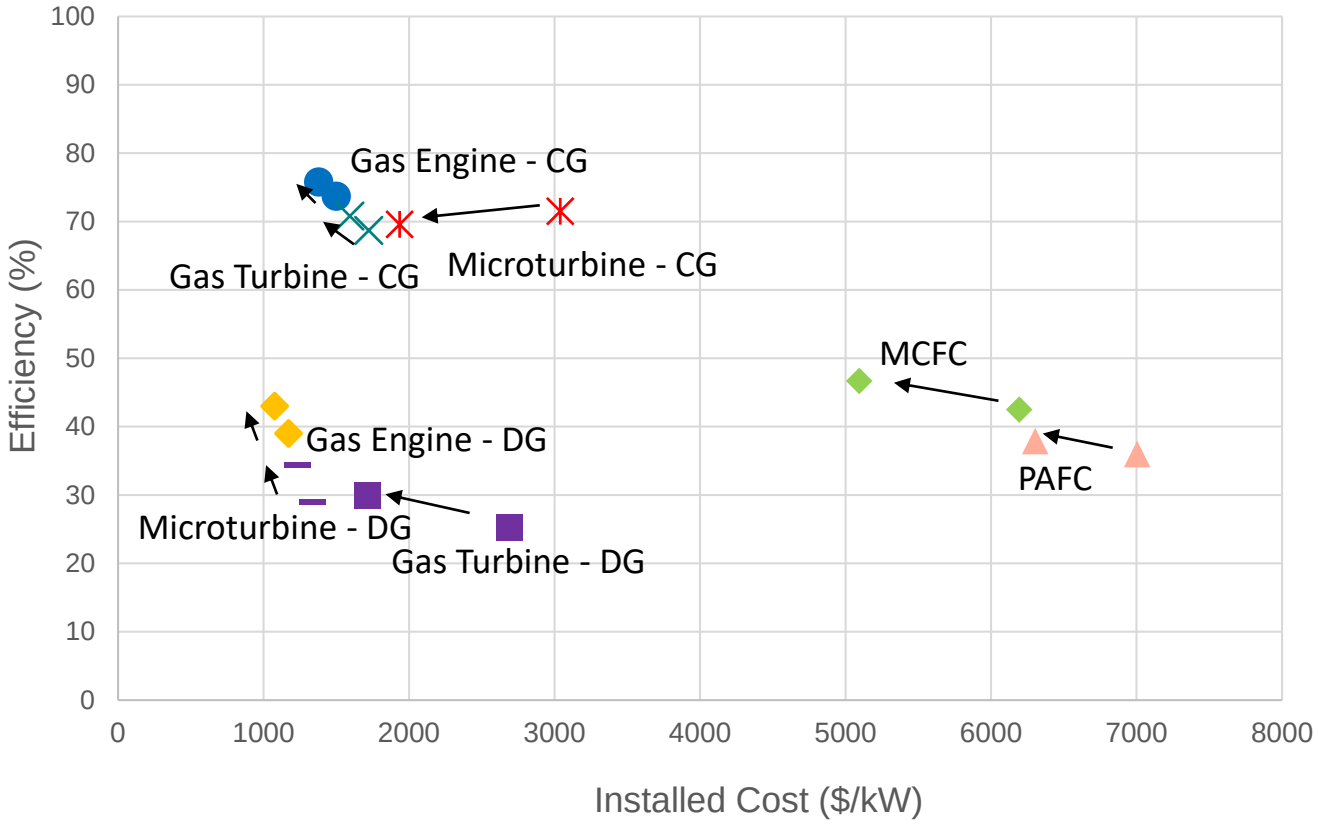
Economics of alternative technologies are improving and converging

Expected Evolution in Selected DG Technology Economics 2010 to 2020



Assumed capacity: Gas engines 3 -5 MW; Gas turbines 5 – 20 MW; Micro turbines 65 – 200 WW; Phosphoric Acid Fuel Cell 400 kW; Molten Carbonate Fuel Cell 300 kW

Source: GTI, Enovation Partners

DER: Future of the Power Industry?

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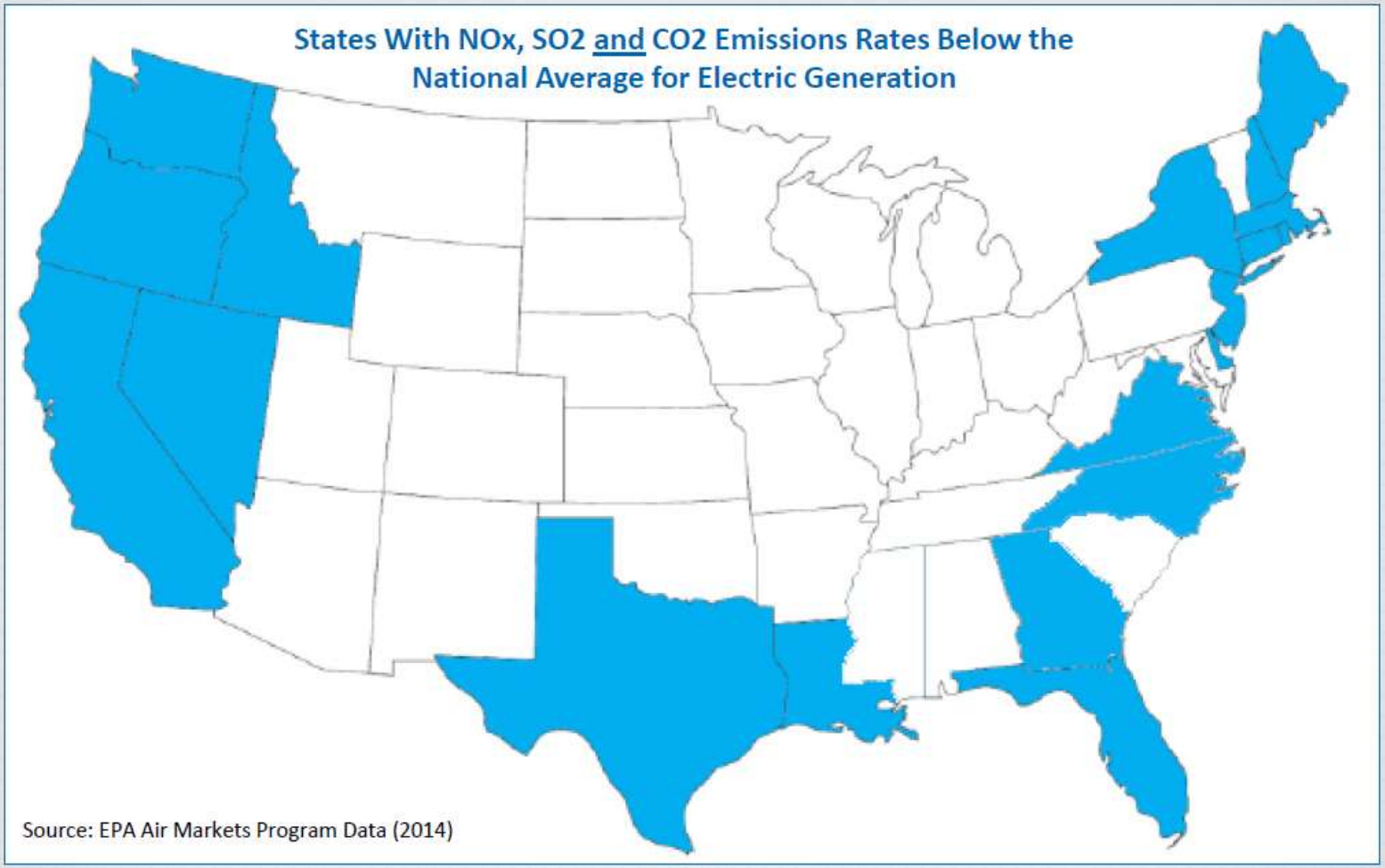
ERCOT Emissions Rates



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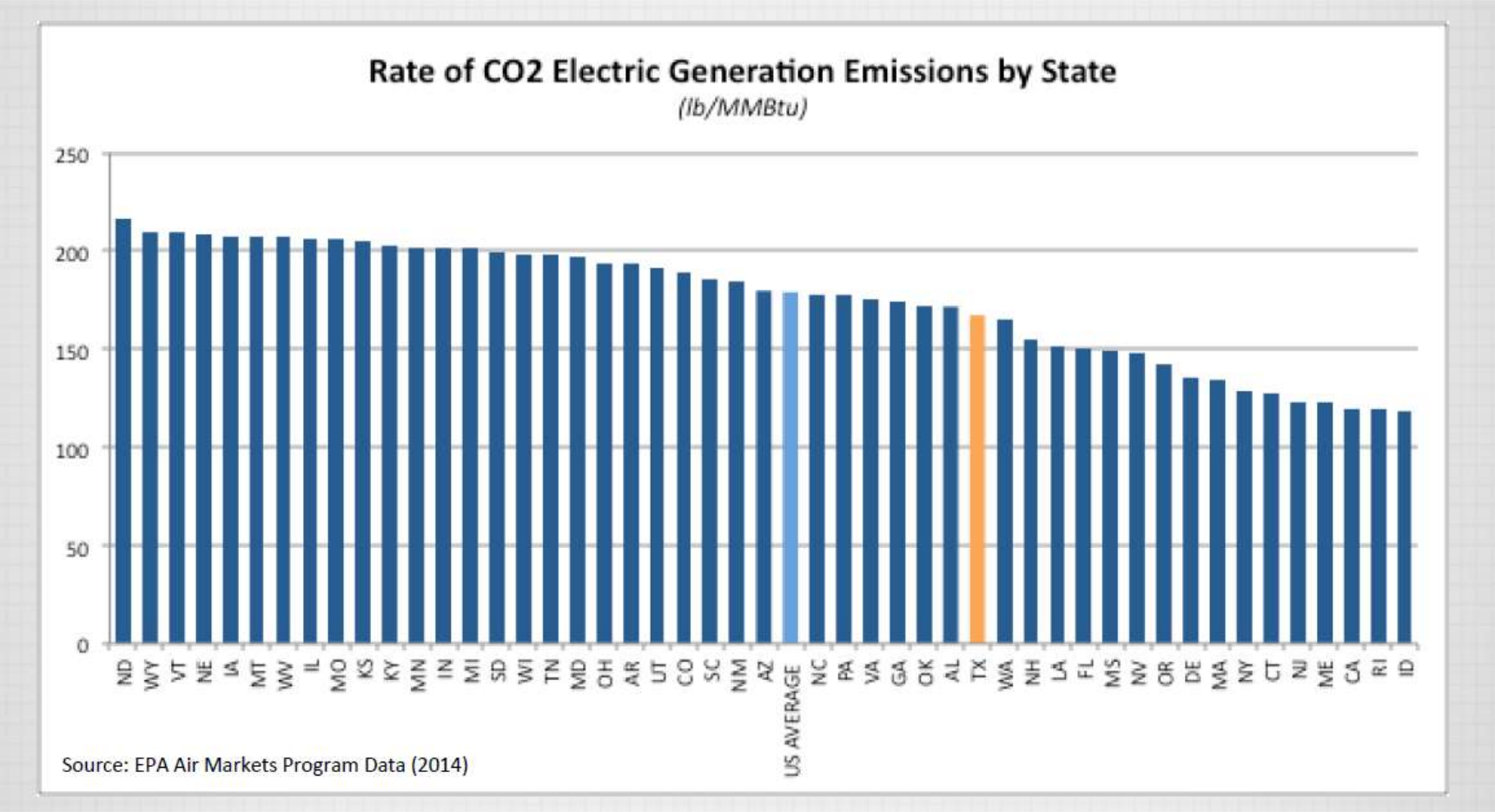
CO2 Emissions Rates



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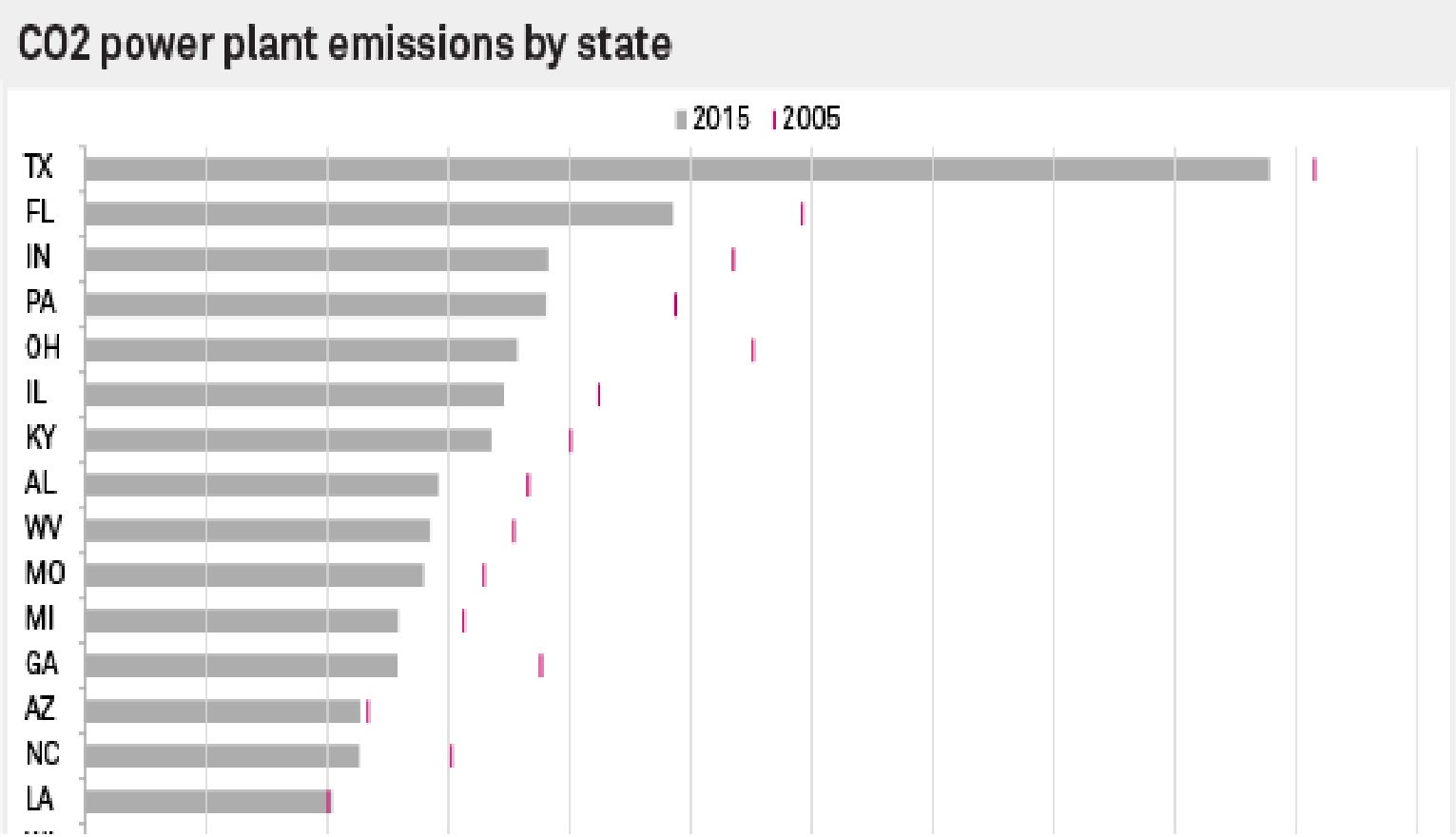
CO2 TOTAL Emissions



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Retail Electricity Prices

	January 2017			December 2001	
Service Area	Average Fixed-Price Offer (12-month term, no usage fees/credits)	Lowest Fixed-Price Offer (12-month term, no usage fees/credits)	Lowest Variable Price Offer Available	Dec. 2001 prices, not adjusted for inflation	Dec. 2001 prices, adjusted for inflation
AEP Texas Central	**9.4¢/kWh**	5.0¢/kWh	7.9¢/kWh	**9.6¢/kWh**	12.8¢/kWh
AEP Texas North	**9.4¢/kWh**	5.6¢/kWh	7.9¢/kWh	**10.0¢/kWh**	13.3¢/kWh
CenterPoint Energy	**8.8¢/kWh**	4.8¢/kWh	7.8¢/kWh	**10.4¢/kWh**	13.8¢/kWh
Oncor	**8.2¢/kWh**	4.4¢/kWh	7.0¢/kWh	**9.7¢/kWh**	12.9¢/kWh
TNMP	**8.6¢/kWh**	5.0¢/kWh	7.8¢/kWh	**10.6¢/kWh**	14.1¢/kWh

Sources: PUC Historical Data, Bureau of Labor Statistics Inflation Calculator (33.0% inflation since December 2001); www.powertochoose.org offers as of January 2, 2017

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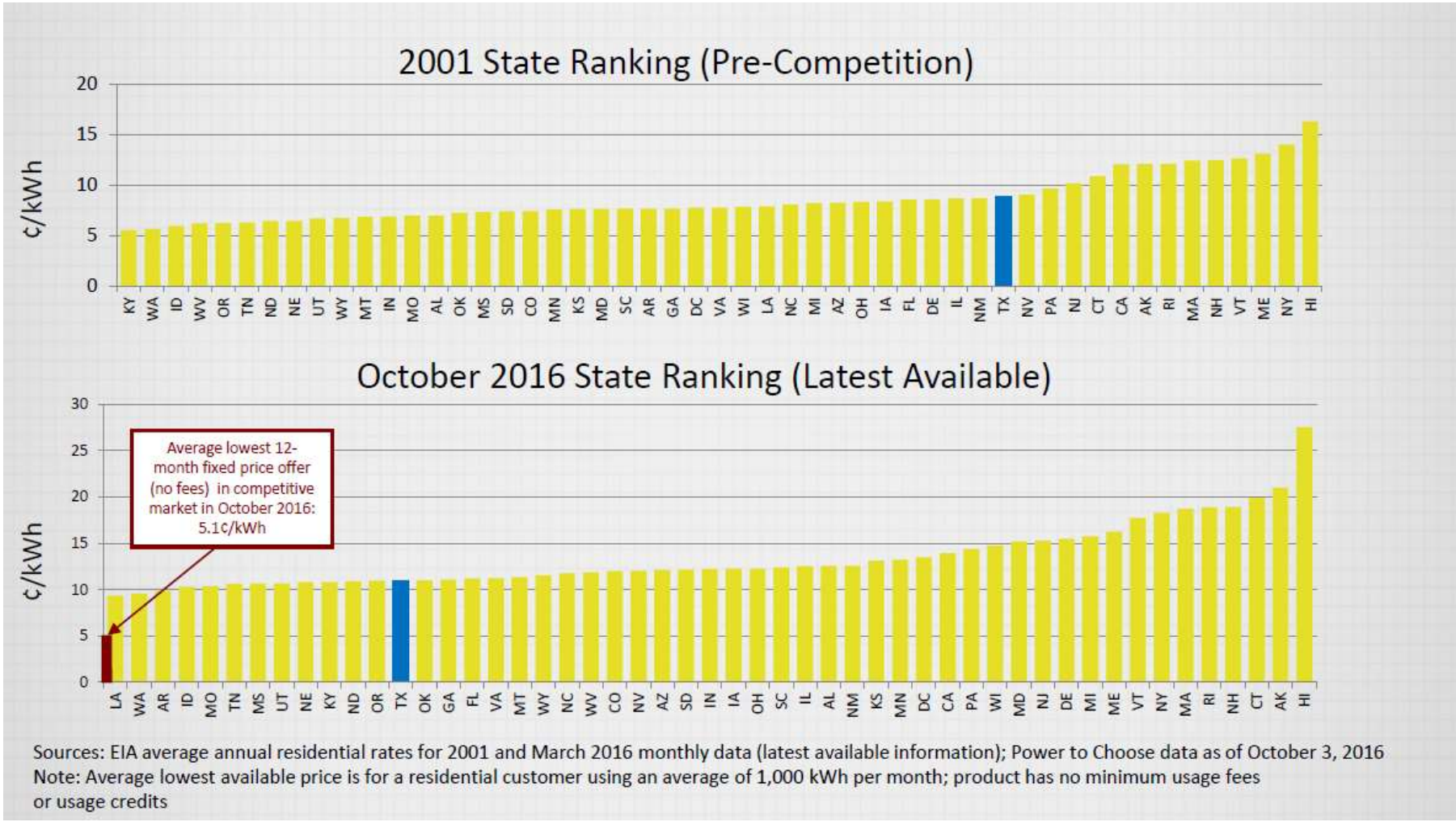
Retail Electricity Prices by State



Sources: EIA average annual residential rates for 2001 and March 2016 monthly data (latest available information); Power to Choose data as of October 3, 2016
Note: Average lowest available price is for a residential customer using an average of 1,000 kWh per month; product has no minimum usage fees or usage credits

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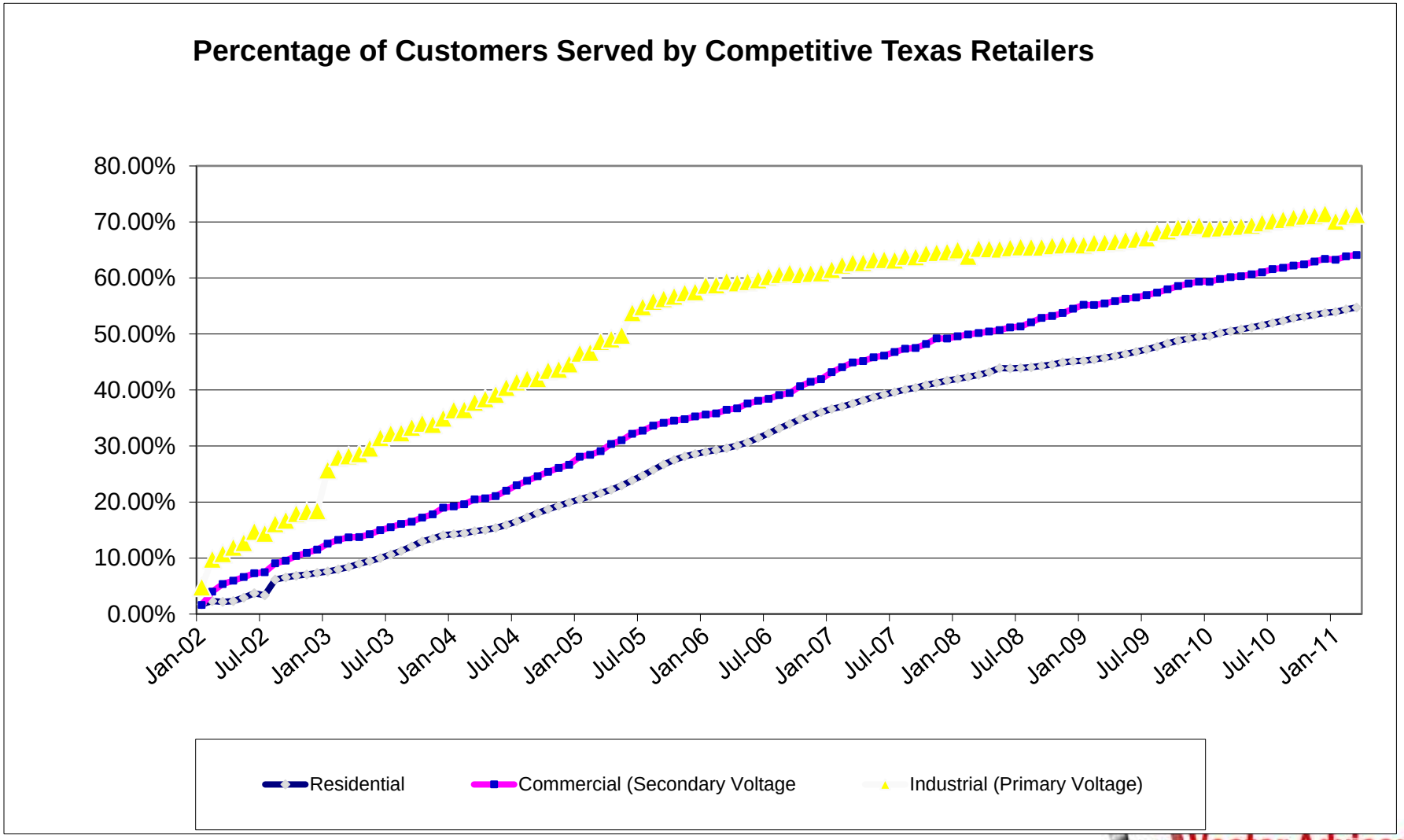
… Most Texas Retail Customers Have Switched



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Best Practices in Electricity Restructuring

- Create an independent organization to manage the transmission system
- Open wholesale markets to competition by lowering barriers to entry (easy interconnection rules, allow all power to flow and work out congestion economically).
- Follow global “best practice” in wholesale market design (Harvard Prof. Bill Hogan’s model of nodal markets with locational marginal prices)
- Create a code of conduct to govern interactions between regulated entities and affiliates
- Create cost based utility rates
- Unbundle utility rates and services to open opportunities for new service providers
- Move to retail competition

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Pluses and Minuses in The Texas Electricity Story

Positive

+ Choice
+ Risks shifted to shareholders
+ Fleet efficiency
+ Many new firms & offers
+ Vigorous Competition
+ Vigorous participation
+ Service improvements
+ Renewable generation
+ New investment leading to new jobs

Negative

- Increasing n
- Gas dependency
- Need for new capacity
- Initial Customer confusion
- Increased customer complaints

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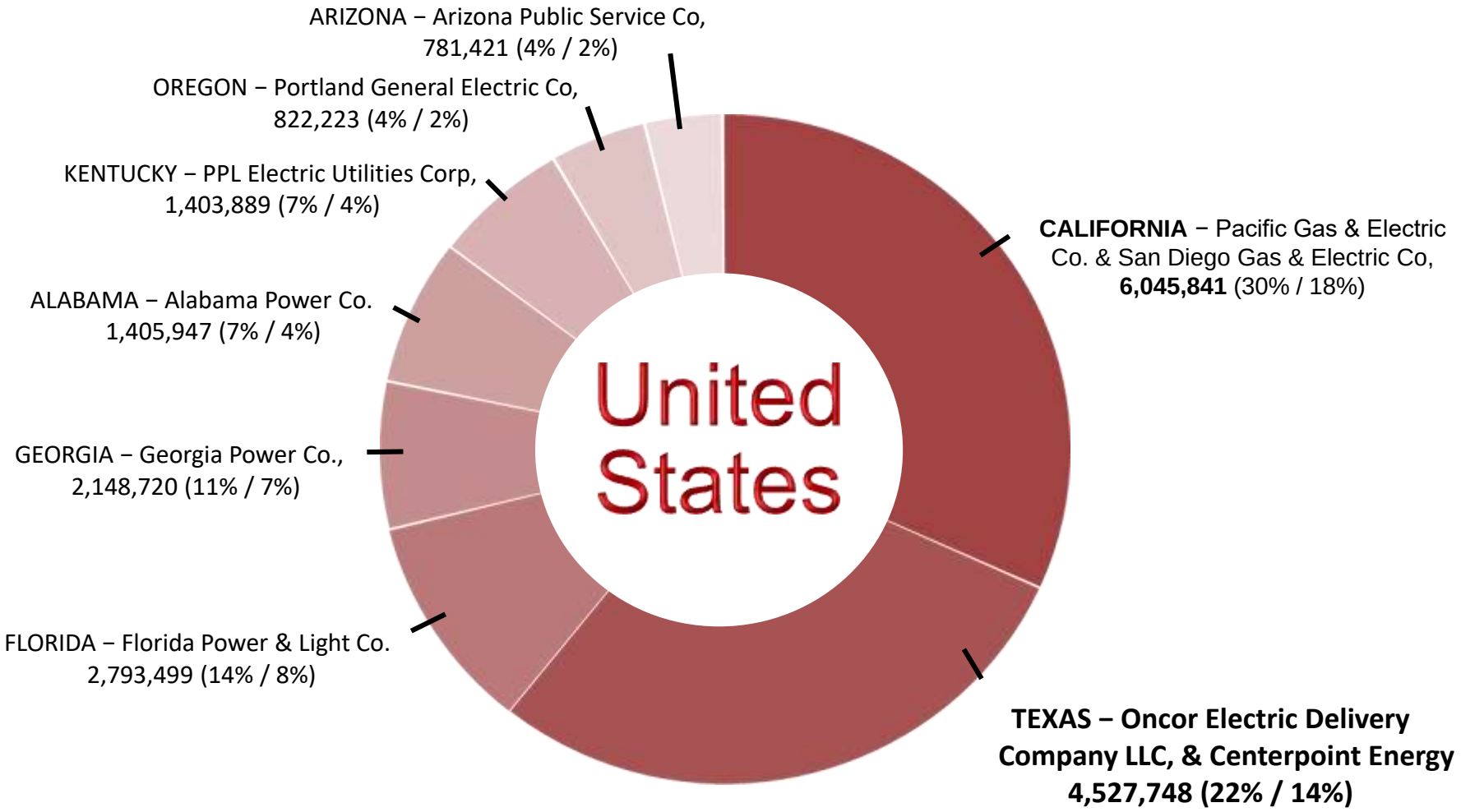
Texas Has One of the Largest U.S. Smart Meter Deployments



Source: U.S. EIA, form EIA-861 Data, 2011 (file 8)

Note: The analysis is current as of August 2012;includes utilities that did and did not receive American Recovery and Reinvestment Act of 2009 (ARRA) funds.

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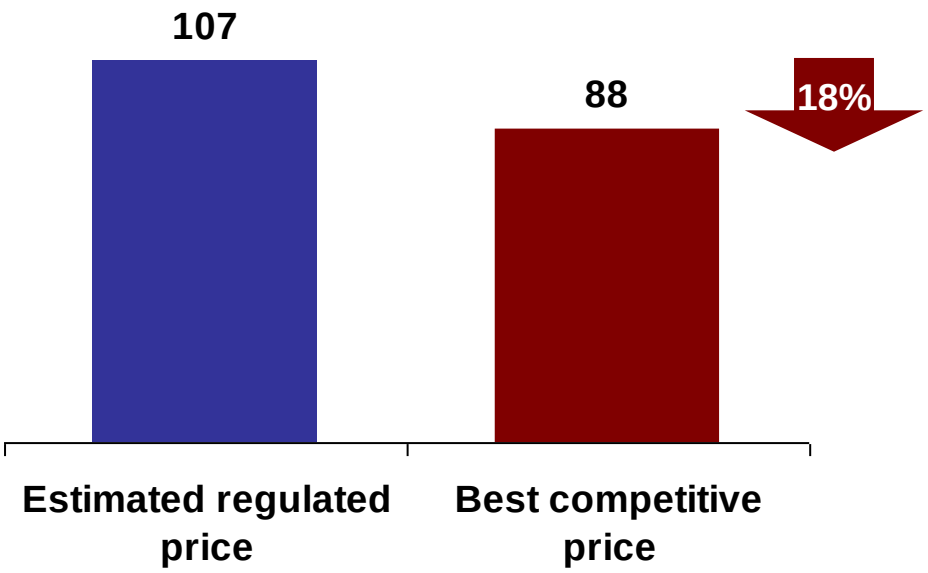
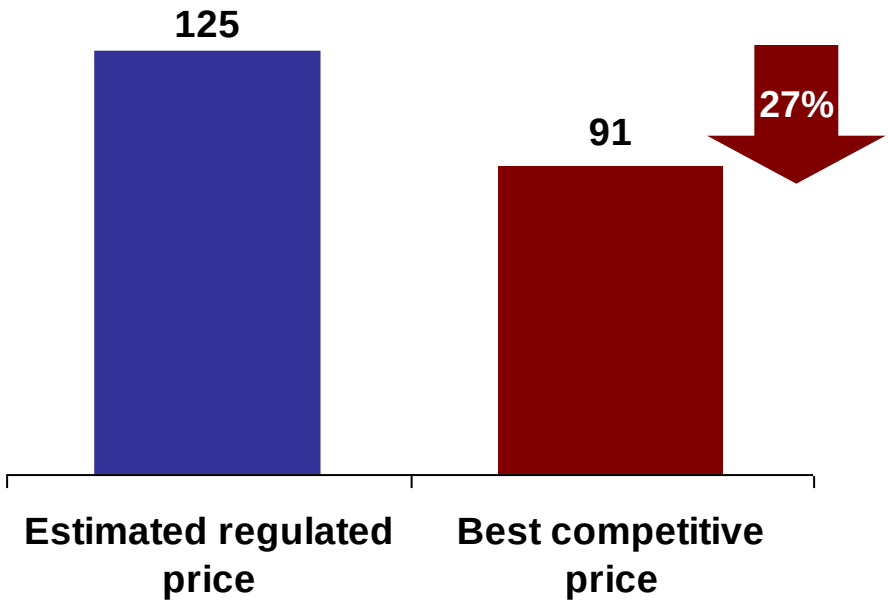
Deregulation Has Delivered Significant Consumer Savings

The PUC found that an average residential customer could have saved $800 in the Dallas area and $1,450 in the Houston area

North Texas average prices*
$/MWh



South Texas average prices*
$/MWh



*All prices are average yearly prices for residential customers using 1,000kWh per month
Sources: PUCT Legislative Report dated February 3, 2005; CERA Special Report: Beyond the Crossroads 2005

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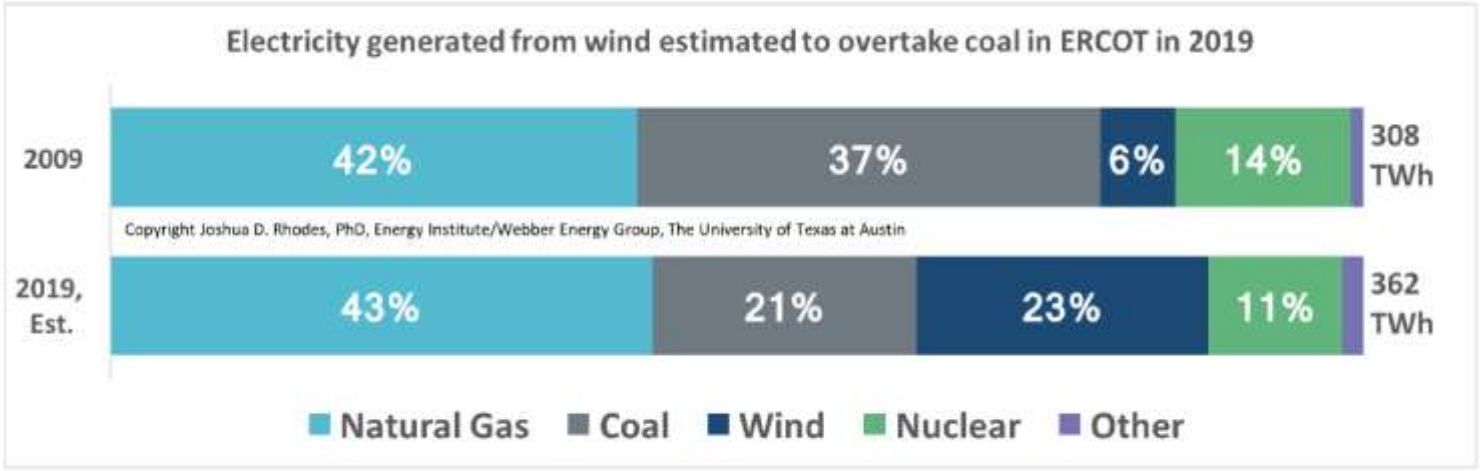
ERCOT Wind v. Coal



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