BEG-CEE 5th Mid-Year Meeting

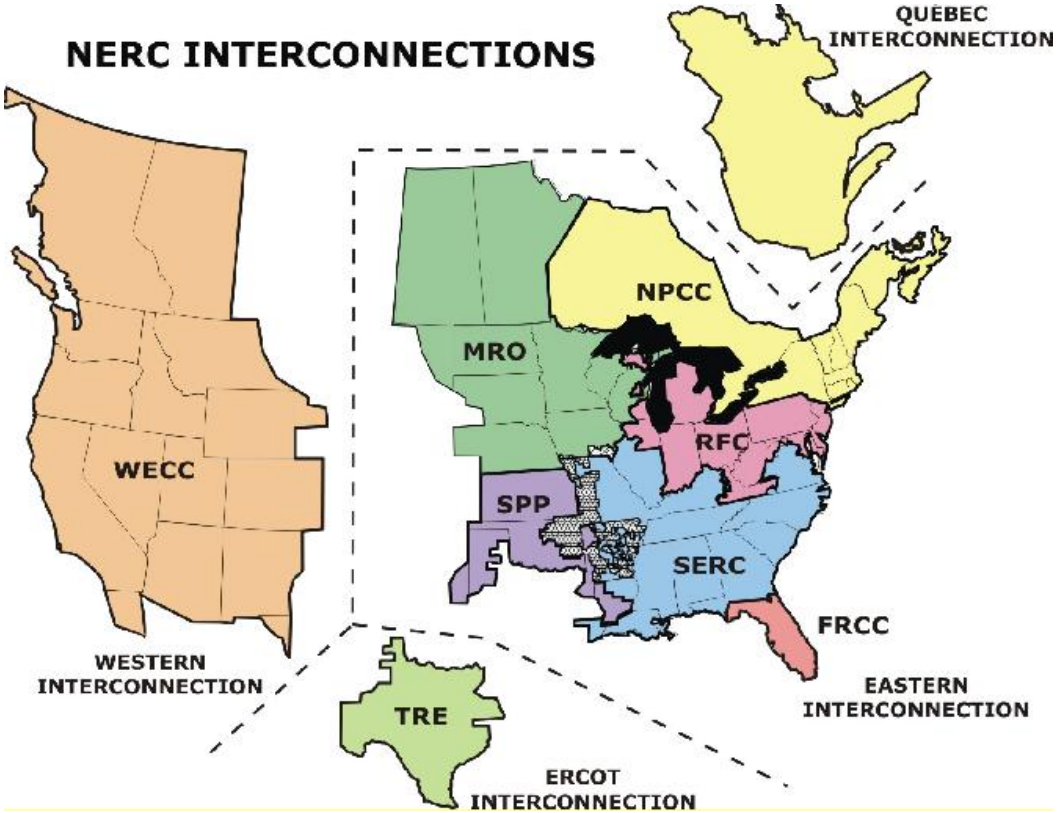
June 1, 2017

Evolution of "Energy Policy" in the U.S.

Joseph Fontana, Ernst & Young


US Energy Markets-
Intersection of Federal &
State Authority
June 2017

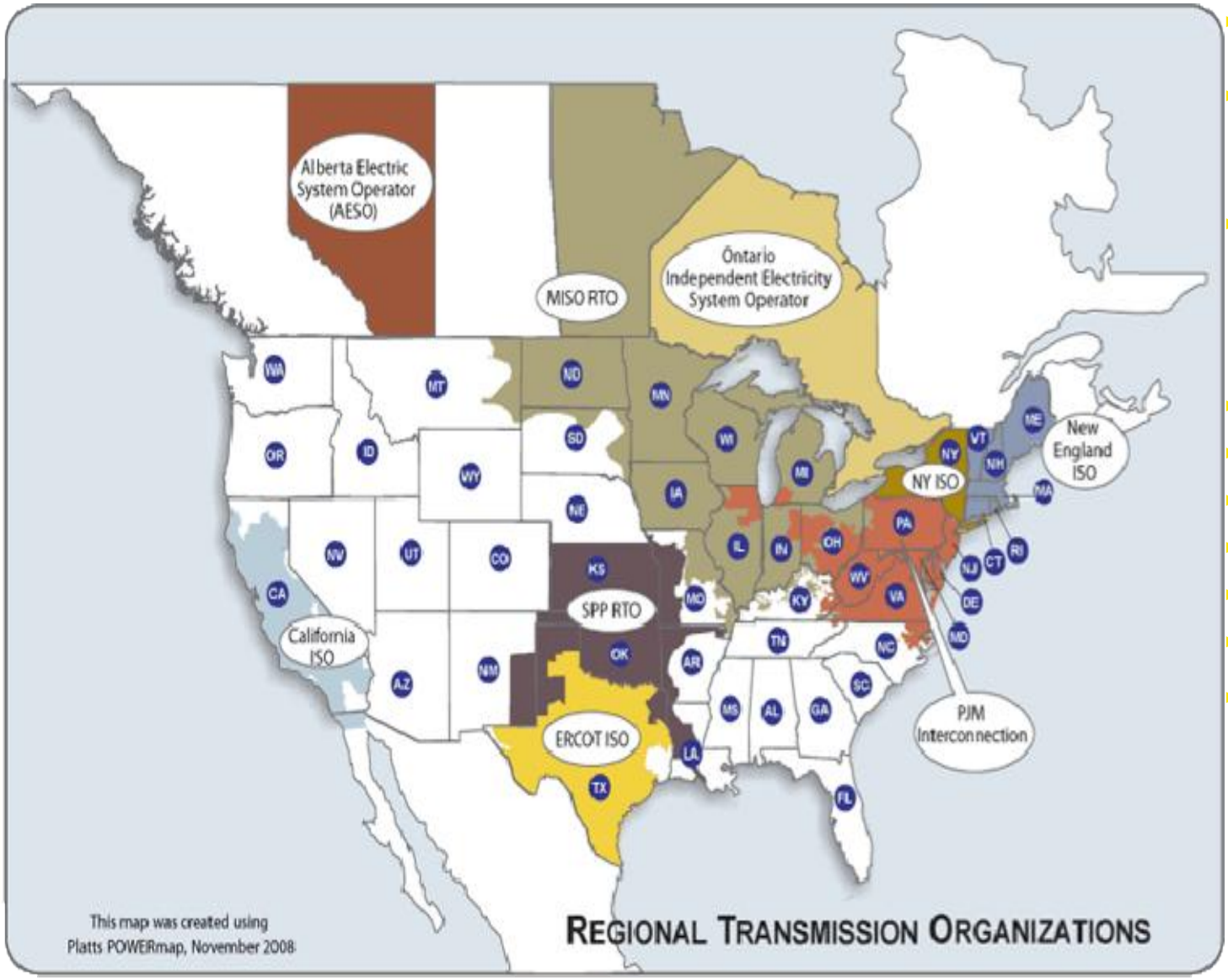
US Transmission grid- Really Three Grids



- **FRCC**: Florida Reliability Coordinating Council
- **MRO**: Midwest Reliability Organization
- **NPCC**: Northeast Power Coordinating Council
- **RFC**: *ReliabilityFirst* Corporation
- **SERC**: SERC Reliability Corporation
- **SPP**: Southwest Power Pool
- **TRE**: Texas Regional Entity
- **WECC**: Western Electricity Coordinating Council

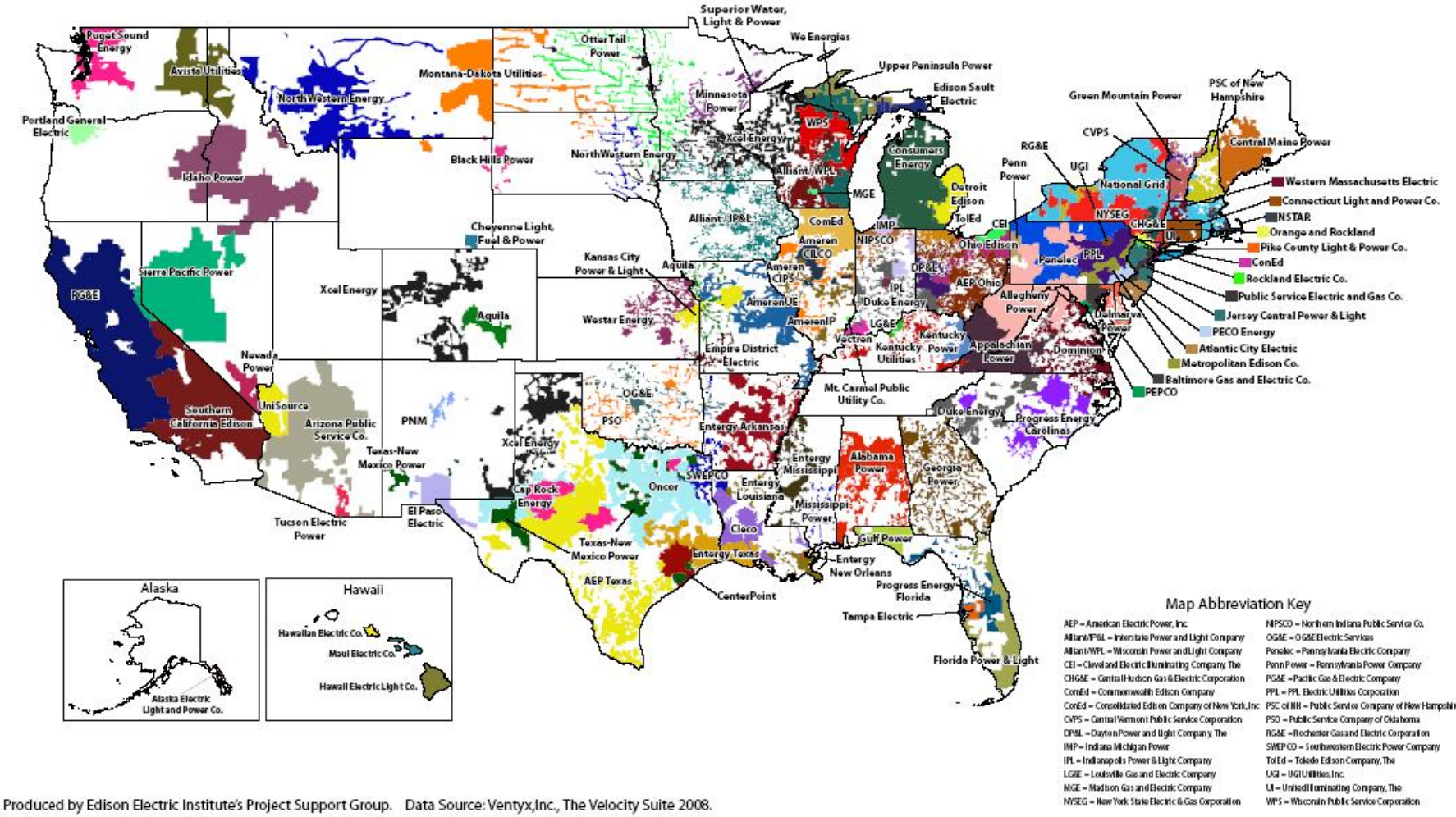
- **North American Electric Reliability Corporation (NERC)**
  - NERC was formed in 1968 due to Northeast blackout in 1965 to promote reliability of the bulk power systems of North America.
  - Enforcement of NERC Reliability Standards is overseen by FERC.
- **Federal Energy Regulatory Commission (FERC)**
  - 1996: FERC urged but did not require formation of Independent System Operators, or ISOs (Open Access rule, Order No. 888)
  - 1999: FERC urged but did not require formation of larger ISOs: Regional Transmission Organizations, or RTOs (RTO rule, Order No. 2000)

US Transmission grid- Really Three Grids



- The RTOs & ISOs grew out of FERC orders
- Regional transmission pools which aimed to provide non-discriminatory transmission access
- On a regional-basis, RTOs administer their regional wholesale electric market, provide transmission service, and perform transmission planning.
- New England ISO
- PJM Interconnection
- NY ISO
- Mid Continent ISO
- ERCOT ISO
- California ISO
- Southwest Power Pool

Today's US Electric Utilities



Map Abbreviation Key

AEP = American Electric Power, Inc.
Alliant/IP&L = Interstate Power and Light Company
Alliant/WPL = Wisconsin Power and Light Company
CEI = Cleveland Electric Illuminating Company, The
CHG&E = Central Hudson Gas & Electric Corporation
ComEd = Commonwealth Edison Company
ConEd = Consolidated Edison Company of New York, Inc.
CVPS = Central Vermont Public Service Corporation
DP&L = Dayton Power and Light Company, The
IMP = Indiana Michigan Power
IPL = Indianapolis Power & Light Company
LG&E = Louisville Gas and Electric Company
MGE = Madison Gas and Electric Company
NYSEG = New York State Electric & Gas Corporation
NIPSCO = Northern Indiana Public Service Co.
OG&E = OG&E Electric Services
Penelec = Pennsylvania Electric Company
Penn Power = Pennsylvania Power Company
PG&E = Pacific Gas & Electric Company
PPL = PPL Electric Utilities Corporation
PSC of NH = Public Service Company of New Hampshire
PSO = Public Service Company of Oklahoma
RG&E = Rochester Gas and Electric Corporation
SWEPCO = Southwestern Electric Power Company
TolEd = Toledo Edison Company, The
UGI = UGI Utilities, Inc.
UI = United Illuminating Company, The
WPS = Wisconsin Public Service Corporation

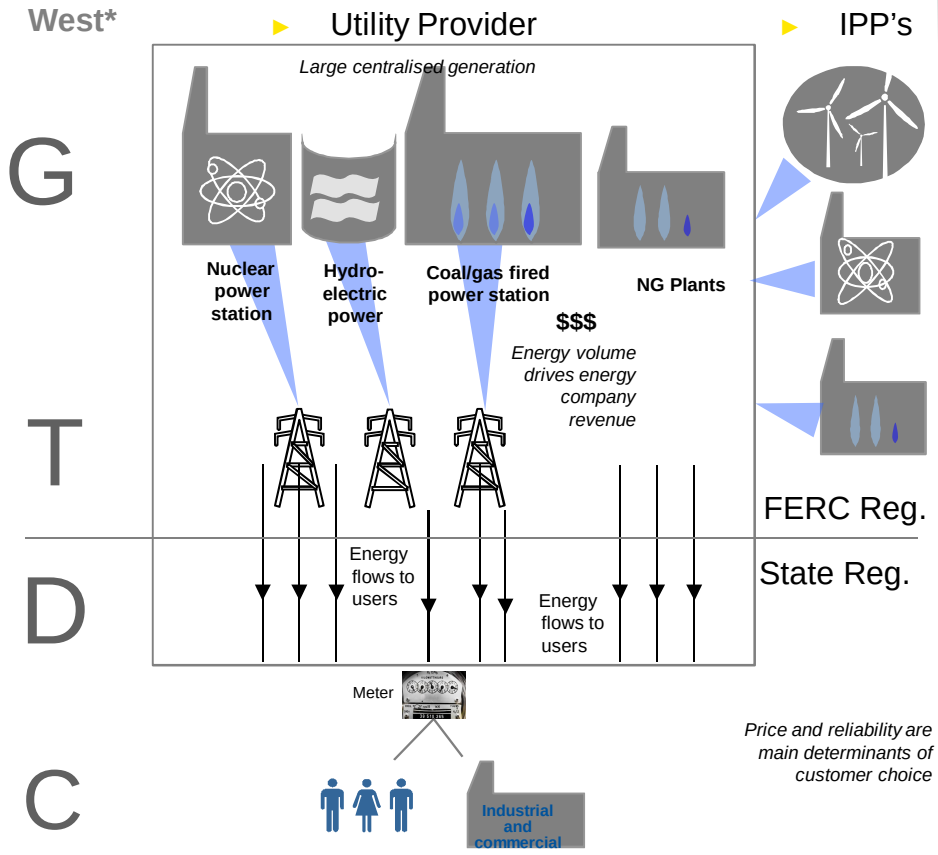
Produced by Edison Electric Institute's Project Support Group. Data Source: Ventyx,Inc., The Velocity Suite 2008.

The US Electric Market Place IS A Mix of Different Models Across the US

Traditional Integrated Service Offering- Supply Focus

Southeast

West*



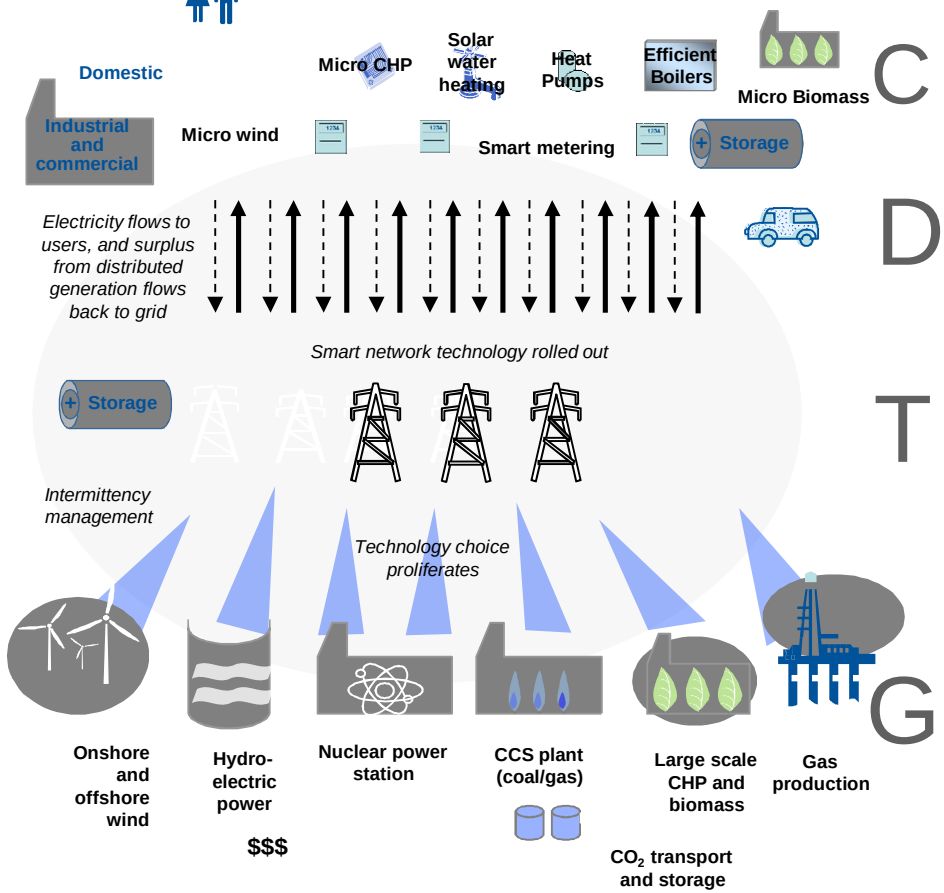
Characterized by: Supply Focus, Reliability, and Rate regulation

Retail Competition – Customer Focus

Northeast

Texas

Midwest



Characterized by Customers focus on price competition

- * Other than California

EY

But it Didn’t Start Out That Way-A Brief History of the U.S. Electric Industry

- Why Do We Have this Mix of Sector Structures?
- Why doesn’t the Southeast have their own RTO?
- Can the Federal Government Do Something to Create consistency in the Sector?

But it Didn't Start Out That Way-A Brief History of Regulation in U.S. Electric Industry

- In early 1900's, public utility commissions were established by various states with the authority to regulate prices and service
  - Utilities are provided monopoly status to ensure they have access to capital to build out infrastructure
  - In the dawn of the 1900's most utilities are located within a single state and Federal government has little oversight

- However, by the 1920's, consolidation occurs at a fast pace as owners realize the power of scale
  - Small municipals, utilities and street rail companies are absorbed by larger utilities
  - Utility service areas are expanded from across cities and state lines

- Holding Companies become the preferred structure with almost 73% of IOU's controlled by Holding Companies by the early 1930's
  - With a $27 million capital investment, Sam Insull controlled $500 million of assets
  - However, abuses are commonplace and include selling subsidiaries within holding company structure at inflated values, profits on services provided between subsidiary businesses not related to utility service

But it Didn’t Start Out That Way-A Brief History of the U.S. Electric Industry

- Individual states have limited ability to regulate holding companies with activity outside of the state
- The Great Depression puts extreme pressure on highly levered holding companies and a number of holding companies fail
  - Sam Insull, the father of the utility holding company structure, sees his Middle West Utility Company enter bankruptcy
- Congress passes the Public Utility Holding Company Act of 1935 in reaction to one of the perceived causes for the 1929 crash and control the excesses witnessed in the utility sector:

  Kills most holding companies except those of contiguous service territories

  Requires registration with SEC for any remaining holding company

  Prevented companies from owning 10% or more of a utility as it would be considered a holding Company

  Title II enacts, The Federal Power Act

But it Didn’t Start Out That Way-A Brief History of the U.S. Electric Industry

- The Federal Power Act authorizes the Federal Power Commission, (forerunner to Federal Energy Regulatory Commission) to regulate:
  - Transmission of electric energy in interstate commerce
  - Sale of electric energy at wholesale in interstate commerce by public utilities
- Based upon the statute and numerous court decisions, FPA provides FERC with exclusive jurisdiction of both the
  - the transmission and sale of electric energy at wholesale and
  - All facilities that transmit and generate the electric energy

Comparison of States Rights to Regulate Energy markets vs Federal Rights to Regulate

State Authority

- Local distribution of electric energy
- Sale of electricity to end uses
- Siting and construction of generation and transmission facilities, with certain limitation
- Safety matters

Federal Authority

- Transmission of electric energy rates, terms and conditions
- Sale of electricity at wholesale inclusive of rates, terms and conditions of sale
- Accounting by public utilities
- Reliability
- Corporate actives and transactions by public utilities- mergers, securities issuances, interlocking directorates

EY

Comparison of States Rights to Regulate Energy markets vs Federal Rights to Regulate

State Authority

- Net Metering
- Renewable Portfolio Standards
- State Tax Incentives
- Retail Choice

Federal Authority

- Public Utility Regulatory Policy Act of 1978, (“PURPA”)
- Approval of Independent System Operators
- Tax Incentives for certain types of generation
- Approval of Generation & Transmission asset sales

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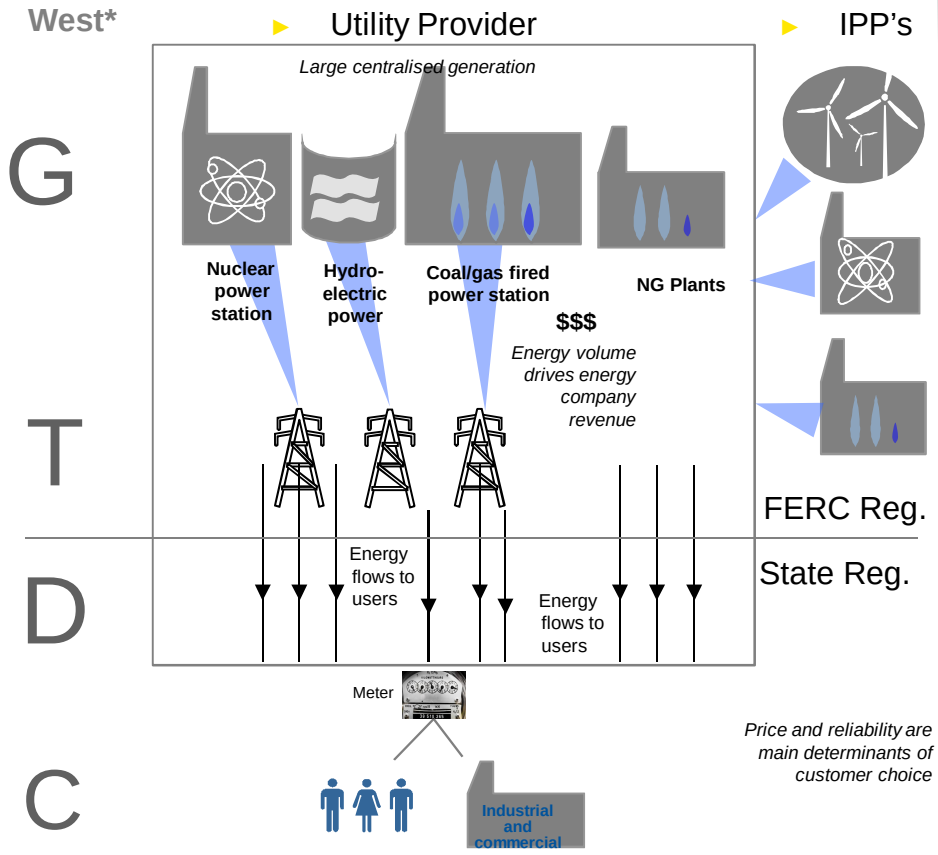

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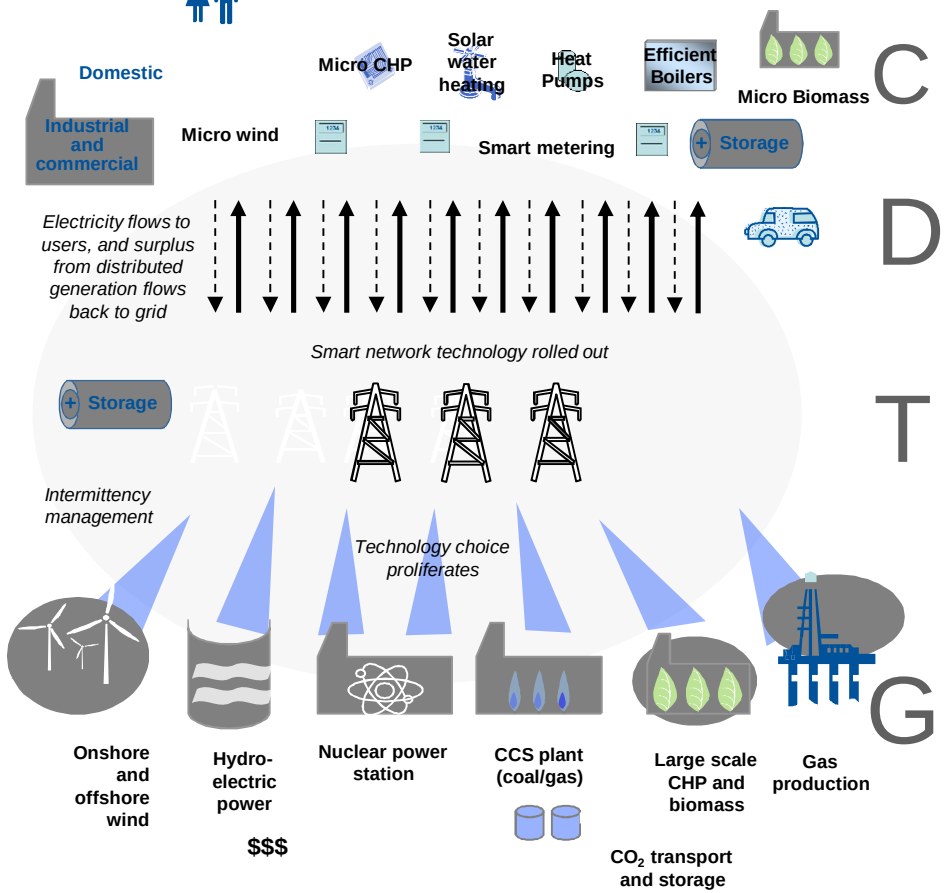
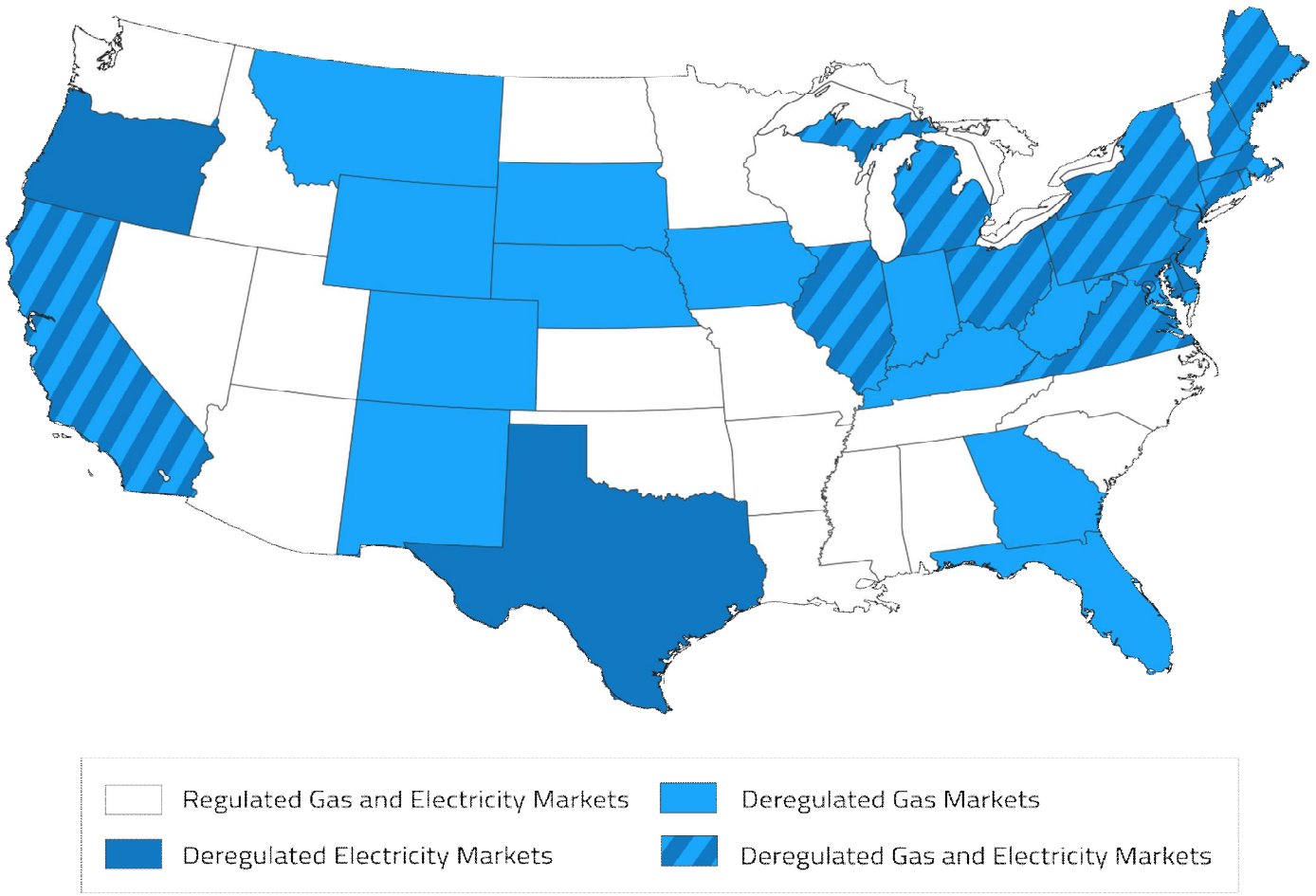


Characterized by Customers focus on price competition

* Other than California

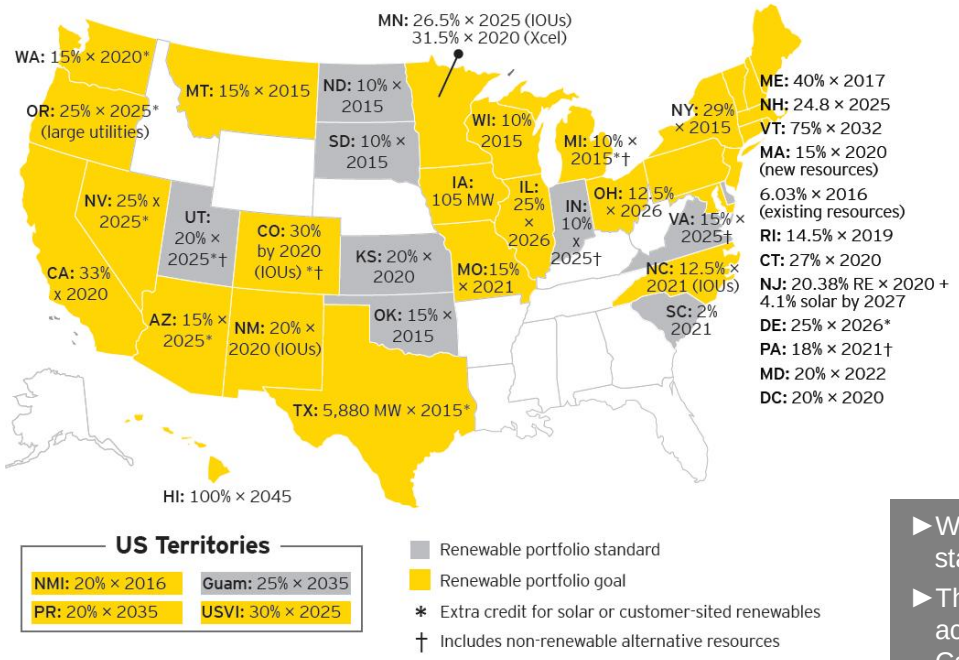
Retail Deregulation by States- Non-Utilities Selling Natural Gas or Electricity



- Although 28 states offer some form of gas and or electric retail deregulation, each state varies considerably in how consumers are permitted to access services from non-utility providers.
- For instance in Michigan, retail access is permitted only up to 10% of the utility's sales the state.
- Texas provides the most access with 85% of the state having access to energy choice.

Renewable Portfolio Standards

RPS – State-Level Renewable Energy Targets



Source: Database of State Incentives for Renewables & Efficiency

- ►In addition to mandatory or voluntary RPS targets, some states have specific power offtake support regimes in place, from feed-in tariffs and state-level tax breaks, to auctions, to net metering and capital subsidy programs.
- ►The risk of not achieving state-level RES targets - and its impetus as a driver of deployment - continues to diminish as other facts such as cost reductions and tax credit phase out accelerate investment.

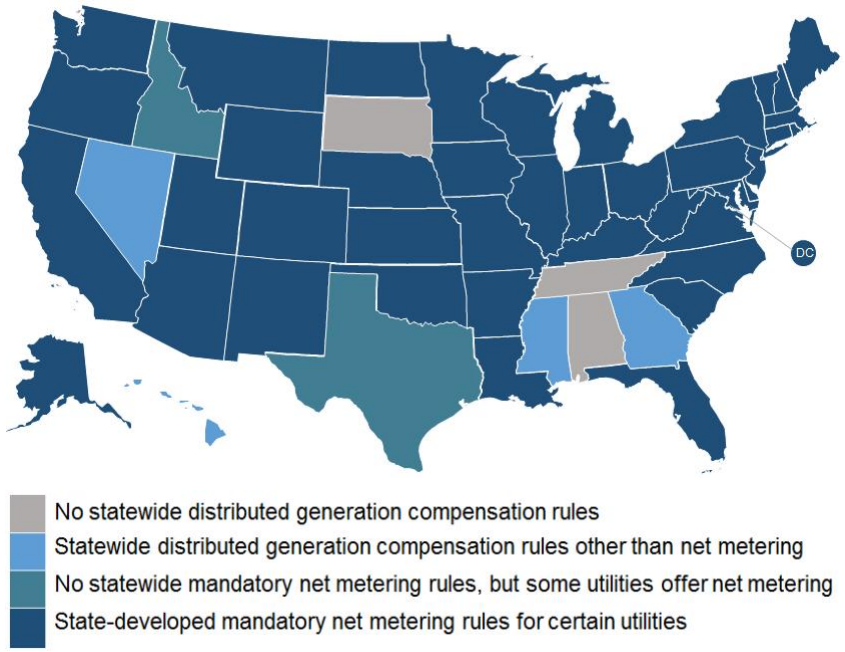
State RPS Changes 2015-2016

States with expanded RPS	States with weakened RPS
California: 50% by 2030	Kansas: 20% mandate changed to voluntary goal
New York: 50% by 2030	Mandates expired in 2015 in MI, MT & WI
Oregon: 50% by 2040	Unclear whether Ohio will maintain or repeal frozen RPS post 2016
Vermont: 75% by 2032	

- ►Wind and solar growth are outpacing the targets set in most states, and utilities have typically met their quotas in advance.
- ►The top five states for RES-driven demand from 2016 to 2025 account for two-thirds of the RES wind power outlook and include California, New York, Illinois, Minnesota and Colorado.
- ►Expanded RES targets largely occur post 2025 and may therefore only have a modest impact on the 10-year outlook, although interim renewables plans in New York and California may generate earlier traction.
- ►Advocates are pushing for further RES expansions in states such as Michigan, Maryland, Illinois and Wisconsin, which may see increases within the next two years, although many lawmakers are awaiting the final outcome of the CPP.

RPS and Net Metering

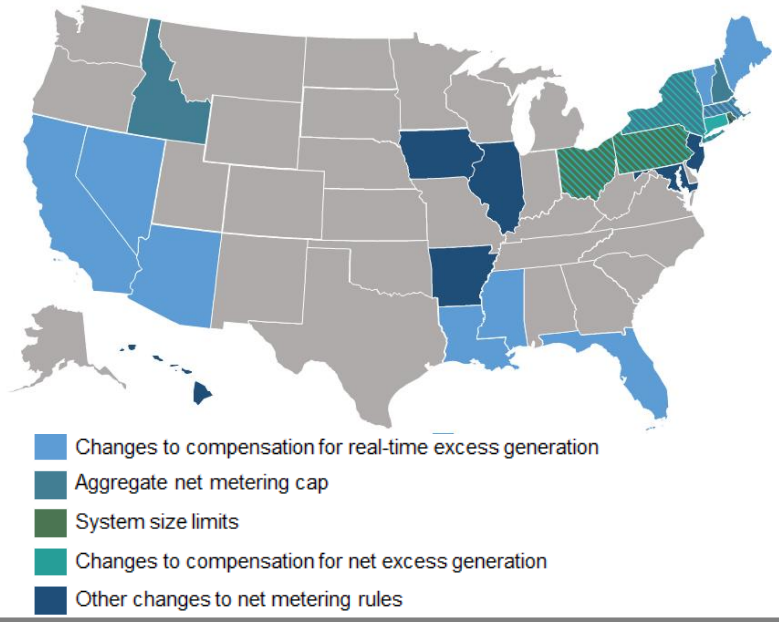
Net Metering & Distributed Generation – Policies



Some states are facing growing pressure from utilities to amend net metering policies or increase monthly grid fees for home solar users, to avoid fixed costs being spread across the smaller remaining pool of customers

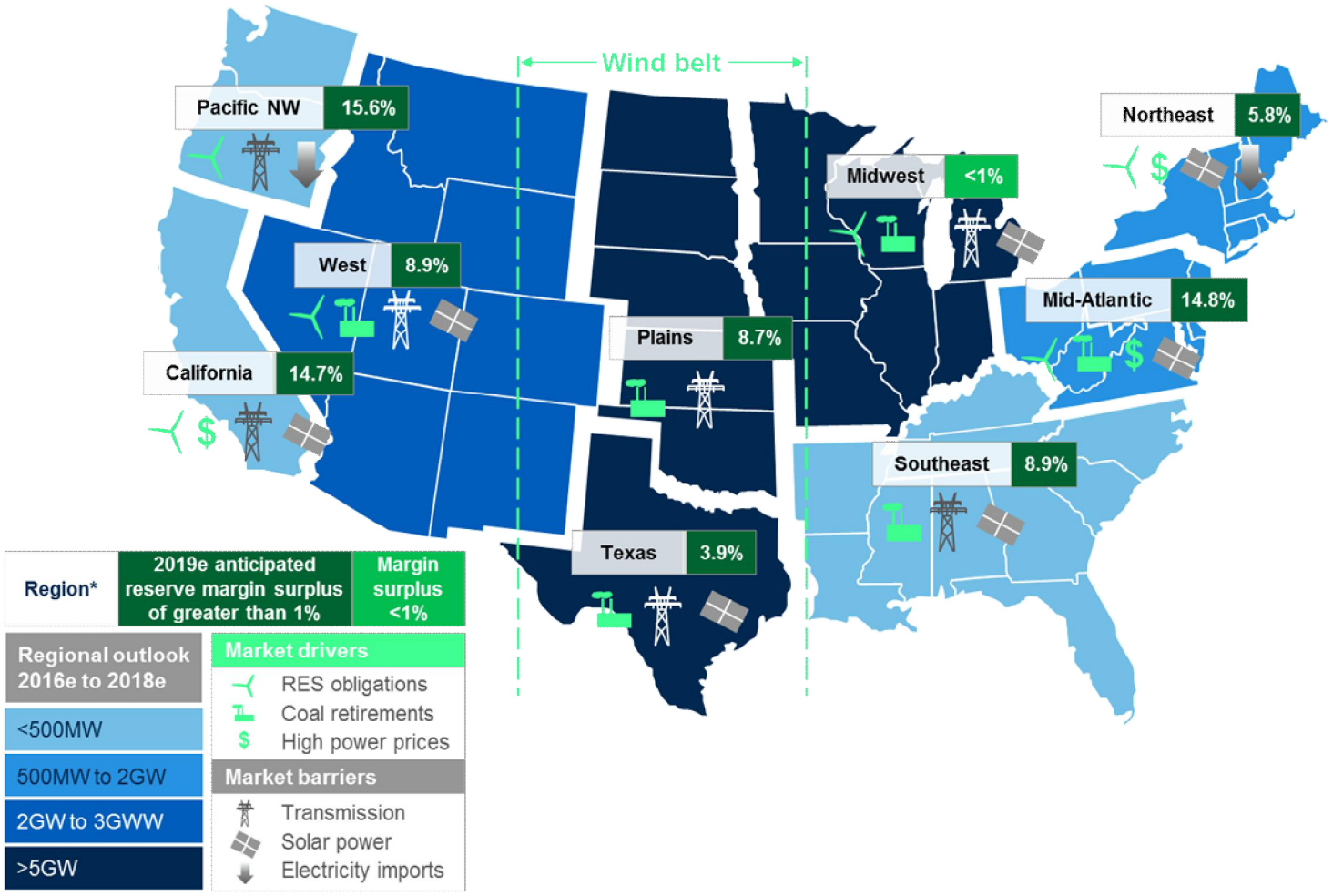
Examples - Updates in early 2016
Nevada – Regulators retroactively eliminated all net metering in the state in a manner that denied the "grandfathering" of existing projects. Projects receive compensation for excess generation at the wholesale rate instead of retail rate. Industry groups suing, but SolarCity and SunRun have already existed the state.

Net Metering Policies – Q1-16 Proposed/Enacted Changes



Examples - Updates in early 2016 (continued)
California – Regulators effectively voted to extend existing regulations to preserve net metering, albeit with small modifications. This was viewed as a major positive for the solar industry.
Massachusetts – Achieved after long periods of uncertainty that impacted the market in the state. Net metering was preserved, but at lower rates for commercial projects (residential & municipal projects were left unchanged).
Hawaii – Eliminated net metering altogether (although grandfathered in existing projects). The utility has proposed two new tariffs to replace net metering but it remains to be seen how these tariffs will impact the market.

Wind – Key Regional Drivers and Barriers

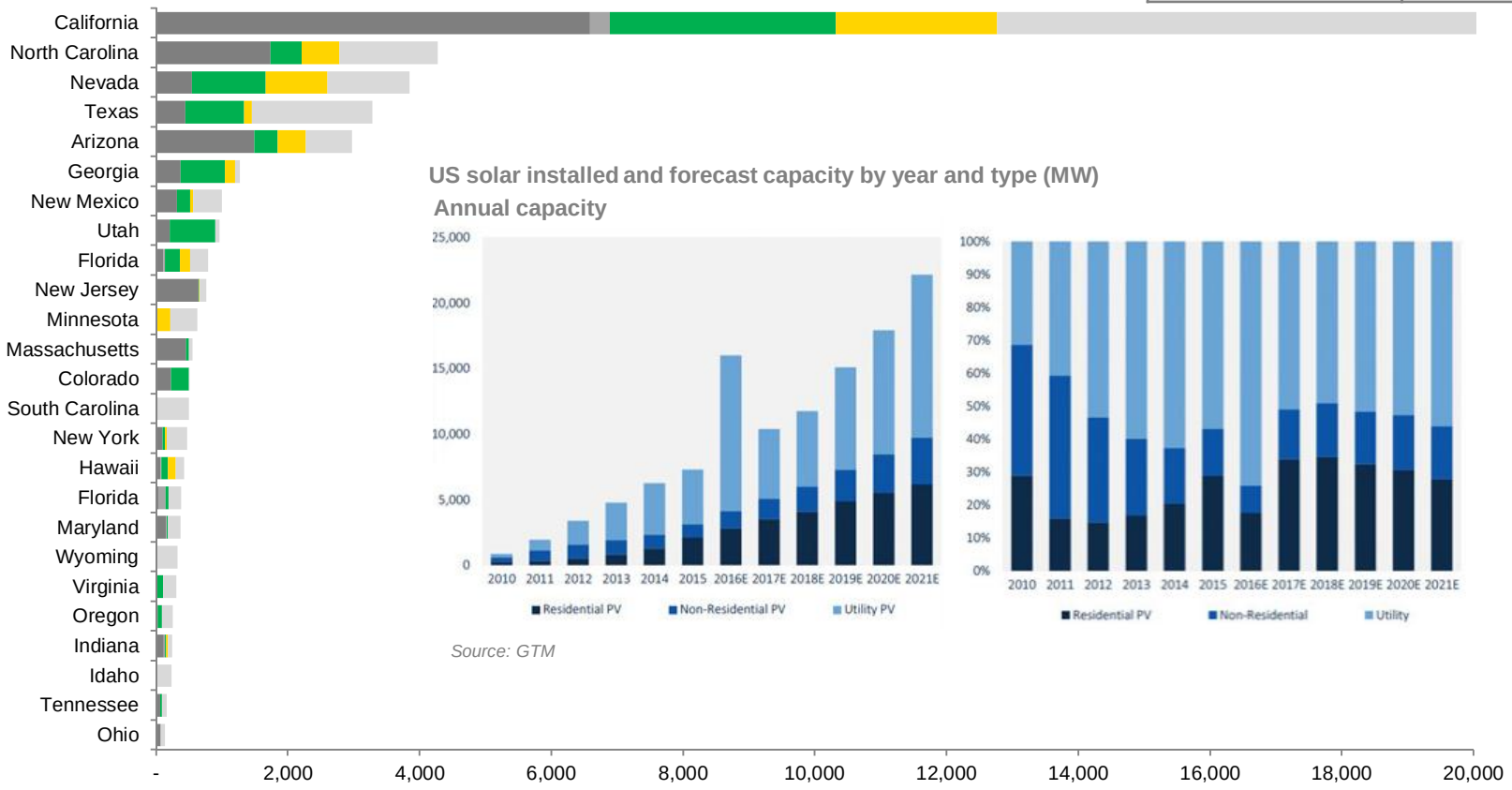


Source: make

Solar – Capacity Pipeline and Forecasts

Installed (end of 2015)	MW
Utility PV	14,316
Residential PV	5,446
Commercial PV	6,223
TOTAL	**25,985**

Installed and Pipeline Solar PV Capacity (MW) – Top 25 States



US solar installed and forecast capacity by year and type (MW)

Annual capacity

Source: GTM

Source: EY analysis of BNEF data

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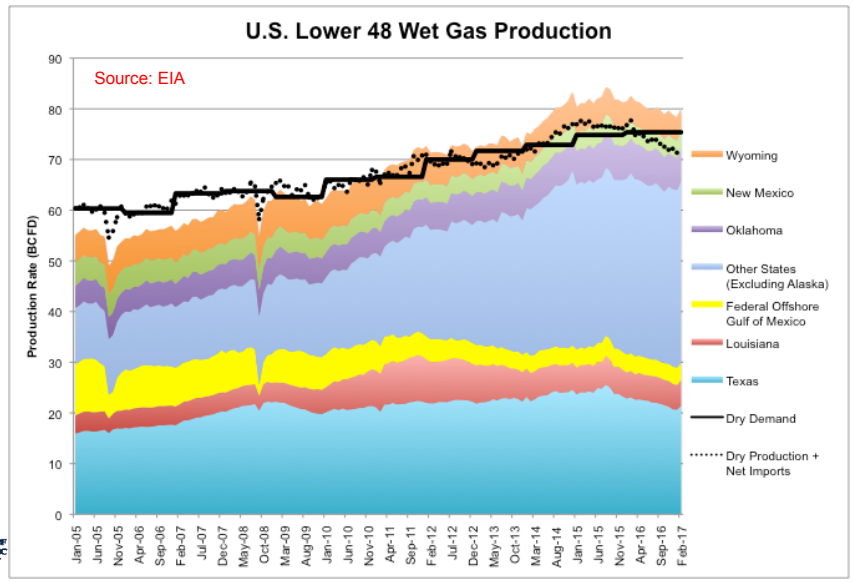
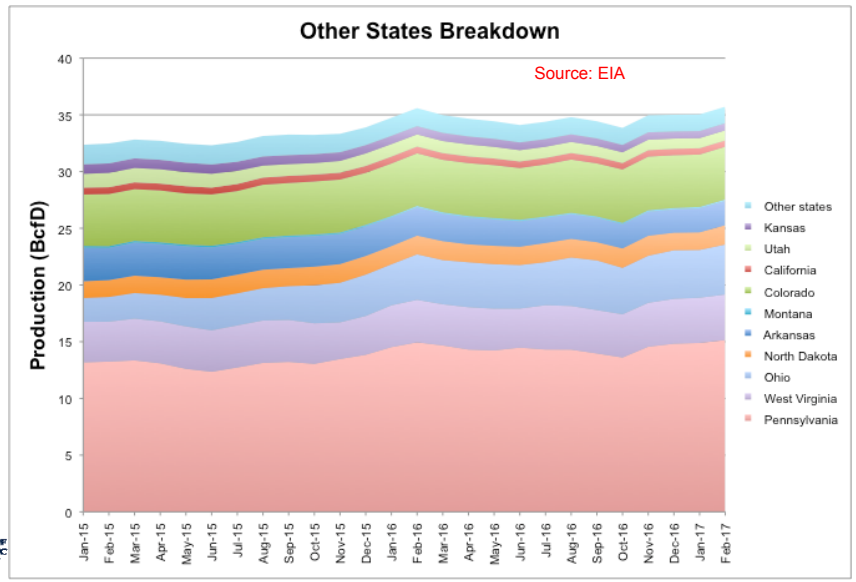
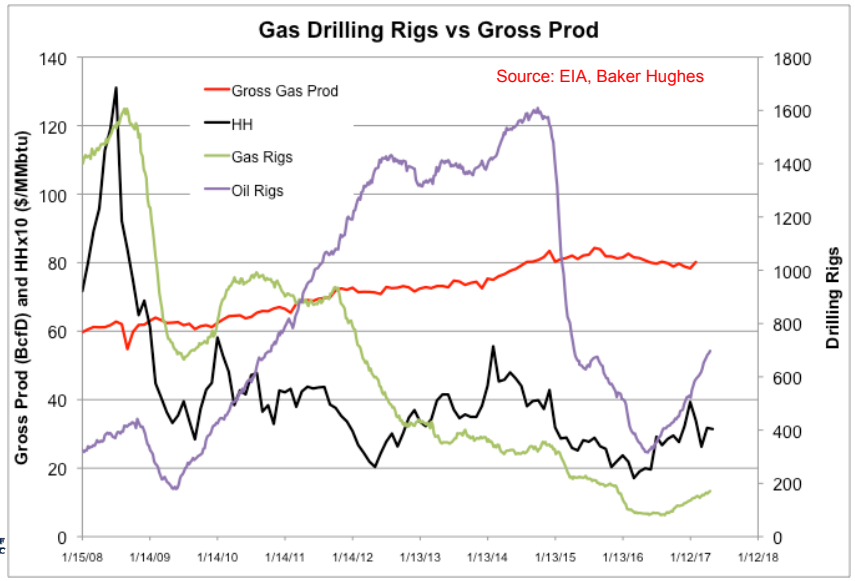
Natural Gas Deliverability: The Future of U.S. Shale

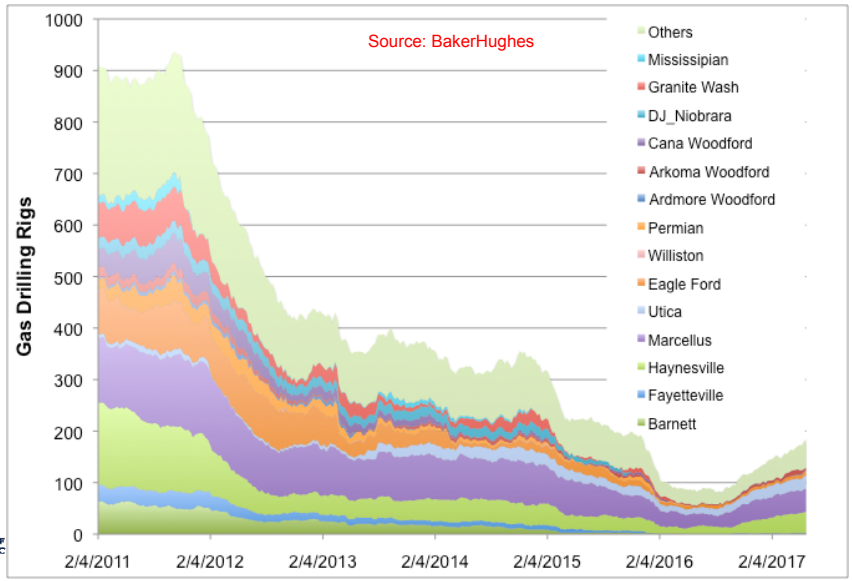
John Browning, BEG

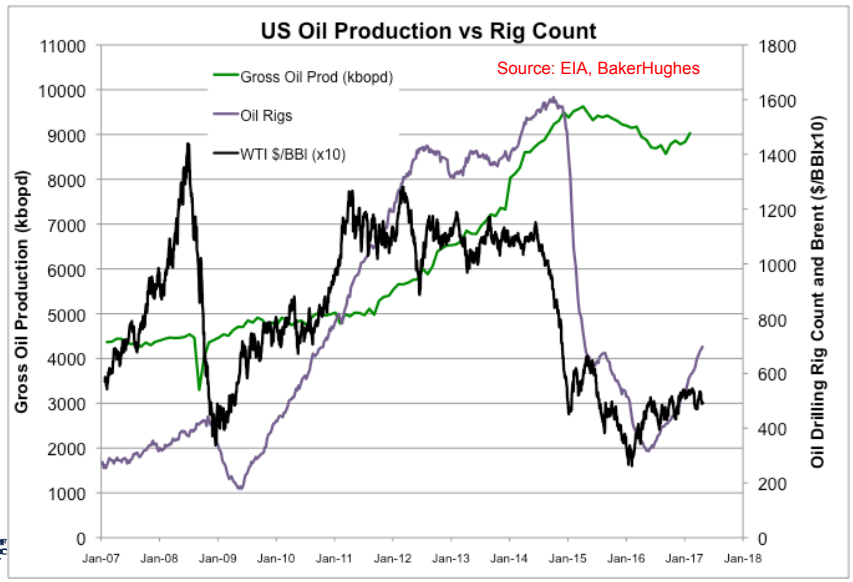
Recent Supply Trends



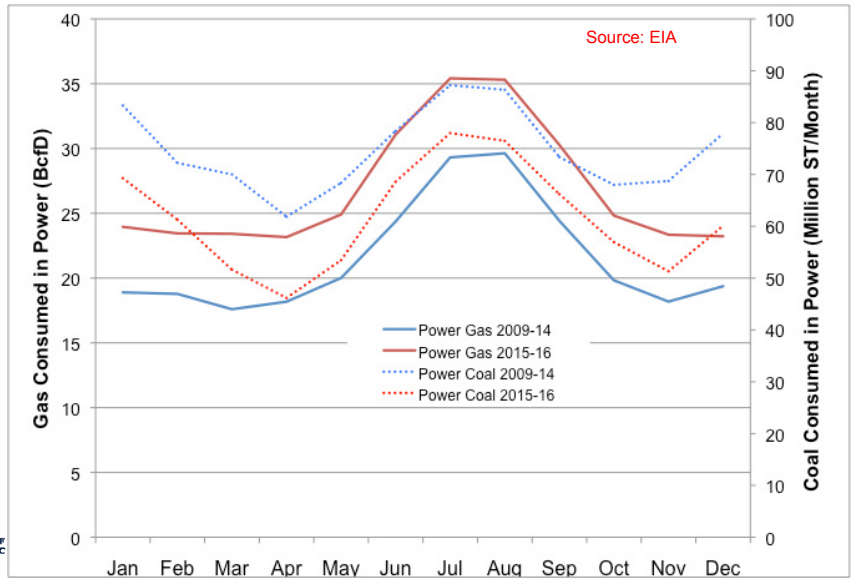


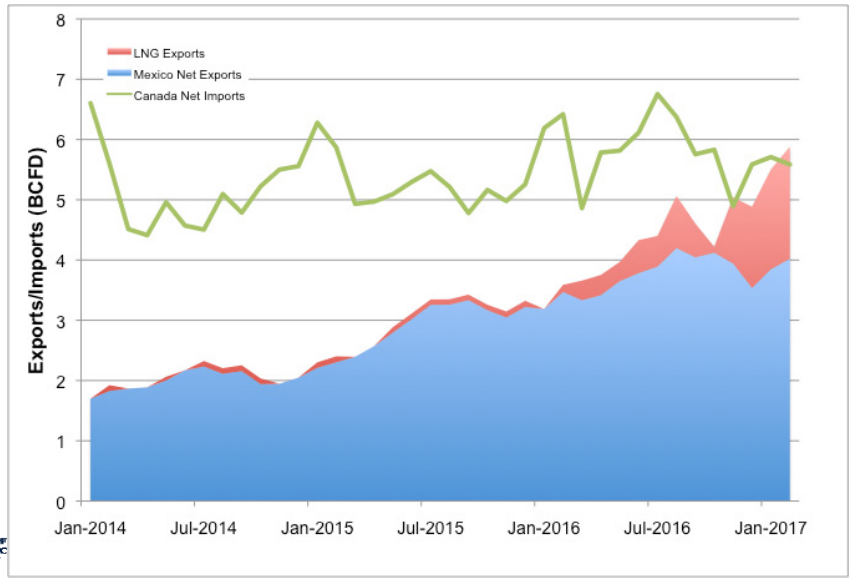


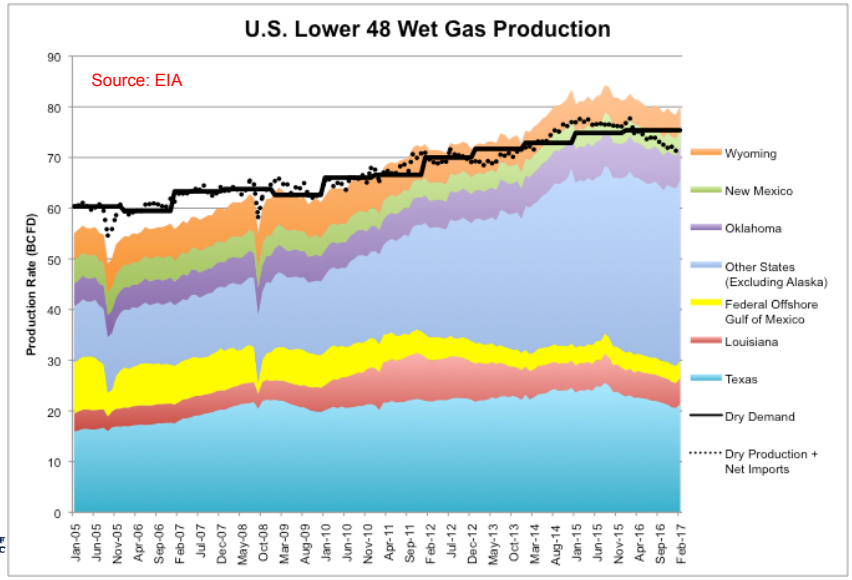


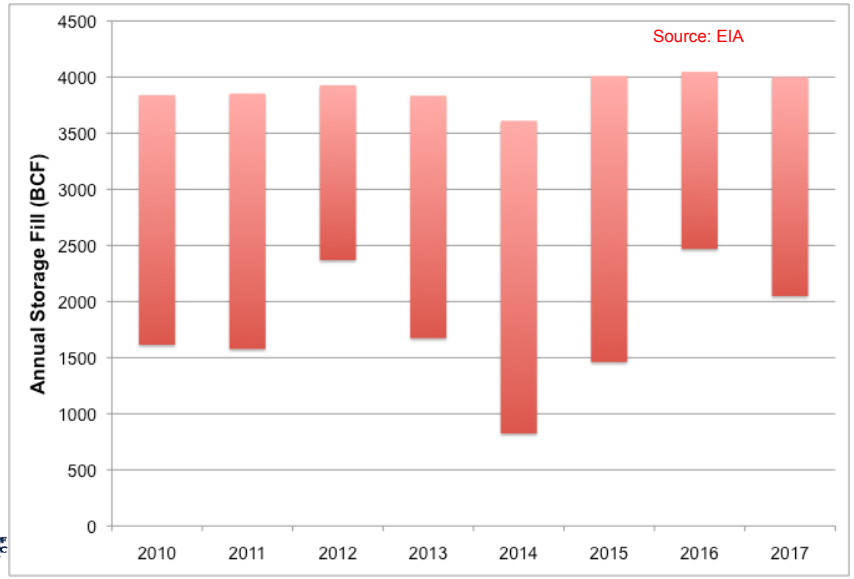


Near Term Supply and Demand

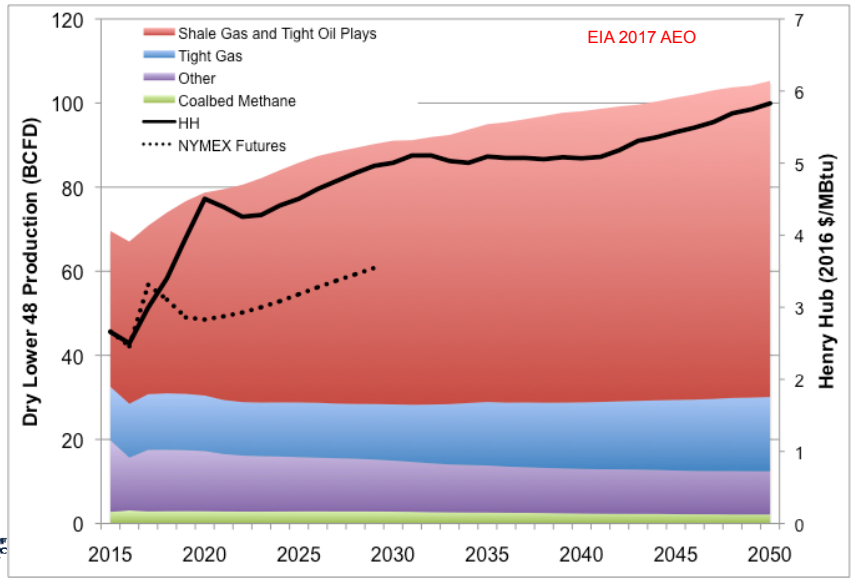

Source: EIA
Gas Consumed in Power (BcfD)
Coal Consumed in Power (Million ST/Month)
Power Gas 2009-14
Power Gas 2015-16
Power Coal 2009-14
Power Coal 2015-16
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec


LNG Exports
Mexico Net Exports
Canada Net Imports
Exports/Imports (BCFD)
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017

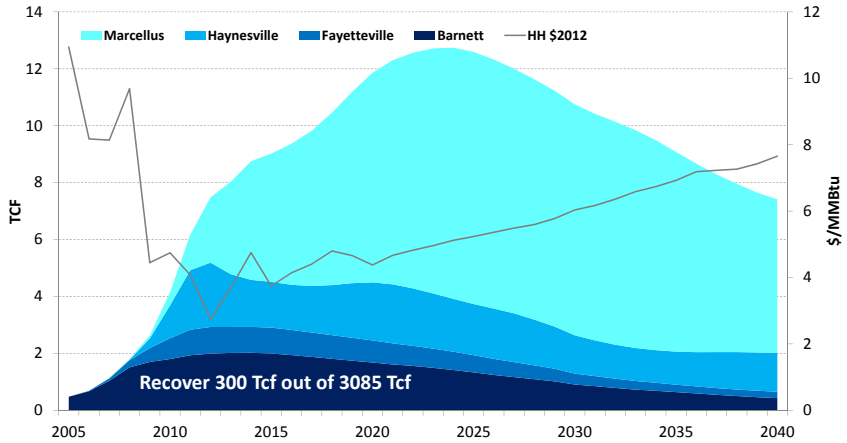

U.S. Lower 48 Wet Gas Production
Source: EIA
Production Rate (BCFD)
Wyoming
New Mexico
Oklahoma
Other States (Excluding Alaska)
Federal Offshore Gulf of Mexico
Louisiana
Texas
Dry Demand
Dry Production + Net Imports

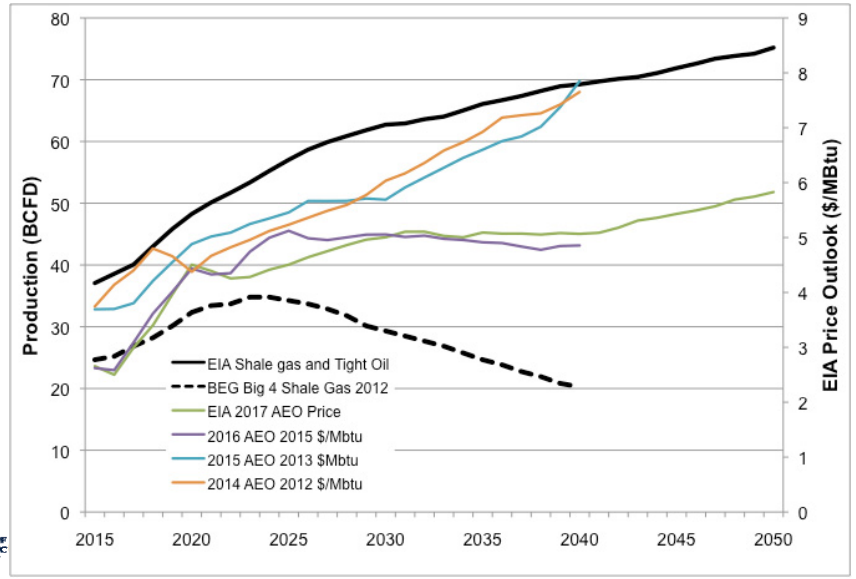

Source: EIA
Annual Storage Fill (BCF)
2010
2011
2012
2013
2014
2015
2016
2017

Long Term Supply and Demand

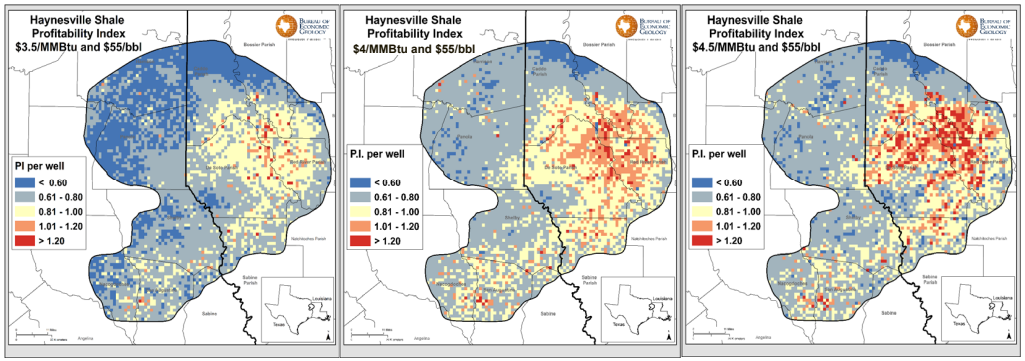


Shale Gas Supply (EIA 2013 price scenario and BEG analysis)

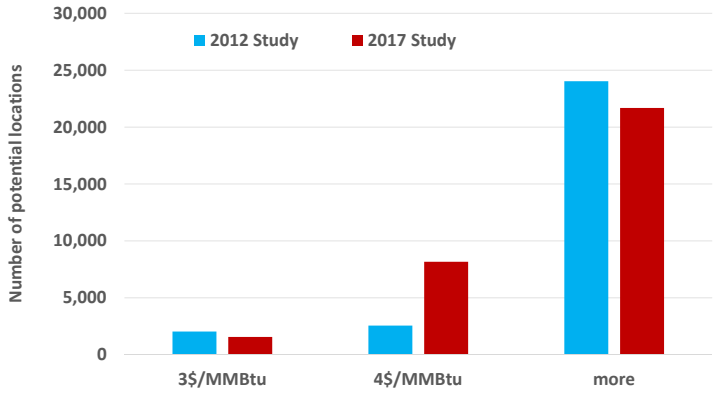




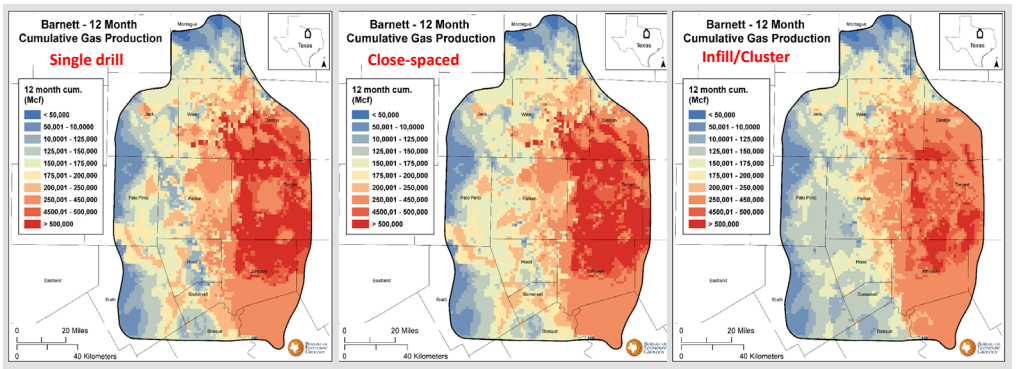
Profitability



Change in Productivity and Profitability: Haynesville Example



Drilling Approach and Results

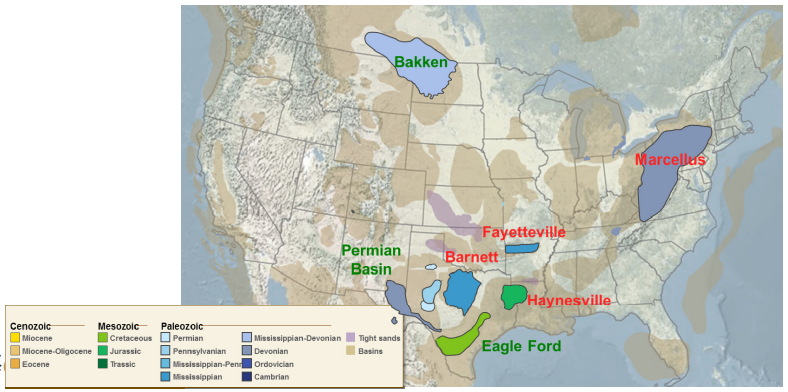


Observations

- Current market under supplied and price has not driven rig count sufficiently
- Upward price pressure may be needed for adequate supply to meet demand
- Export demand is progressing regardless of general interest economics
- Technology (?) improvements primarily length, frac size and market forces have improved economics and moved many locations to attractiveness
- Using current approach adequate pace could continue for a decade at EIA price outlook
- Price increase or newer technology approach may be needed in later outlook

Background

In 2011 supported by the Sloan Foundation, BEG's team of geoscientists, engineers, statisticians and economists started an inter-disciplinary study of shale gas & oil resources. We continue with support from DOE, state and industry.

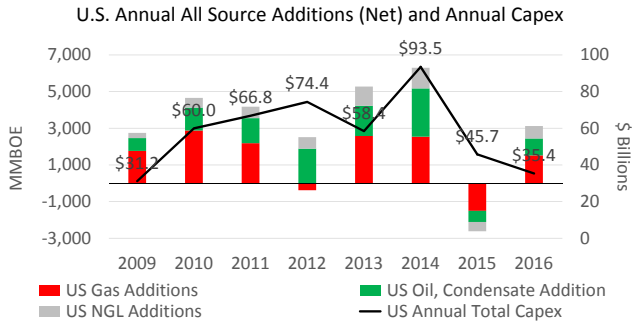


Upstream Matters

Danny Quijano

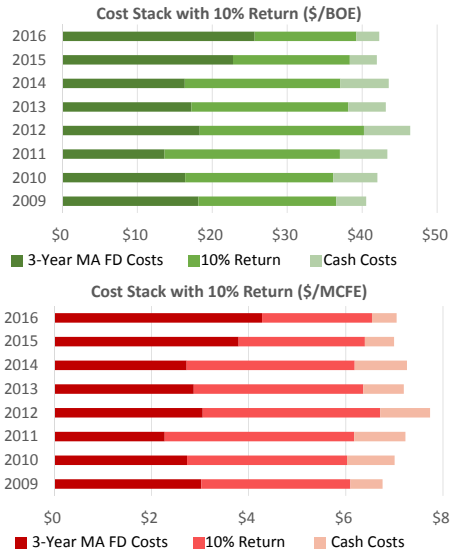
Producer financial health & capital markets: 2016 update on CEE Upstream Matters

Our sample:
- **16** publicly traded companies
- **19%** of U.S. natural gas production
- **24%** of U.S. oil production.



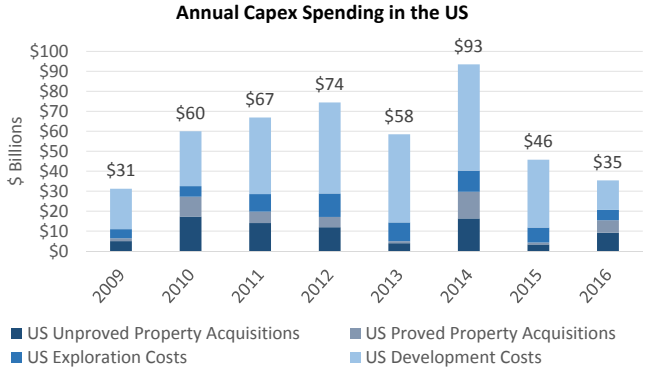
Computing Returns

- FD Capex increasing on a $/BOE basis despite cuts in spending
- Production cost efficiencies?
- **$42/BOE to achieve 10% return**… Great news, right?



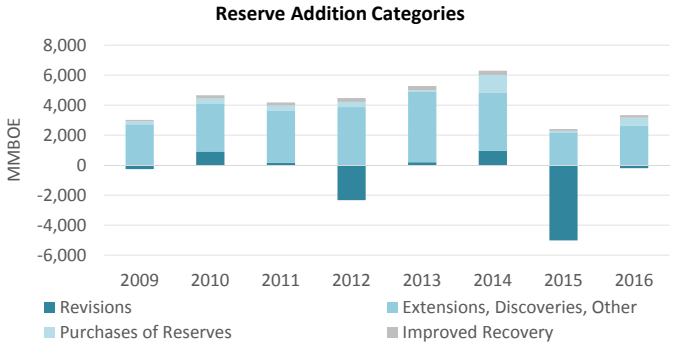
How much spending?

Shifting priorities: Property acquisitions up, exploration and development down



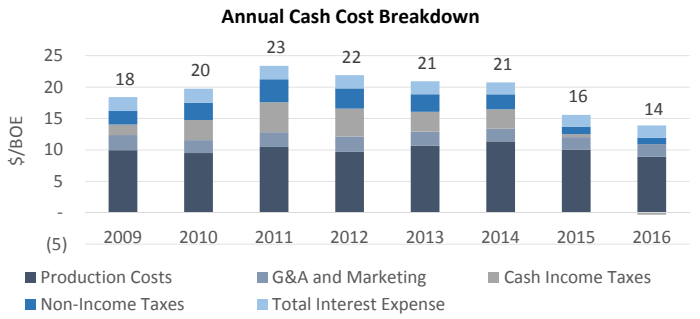
With what results?

Revisions are volatile - reserves must be recoverable under the *existing economic environment*

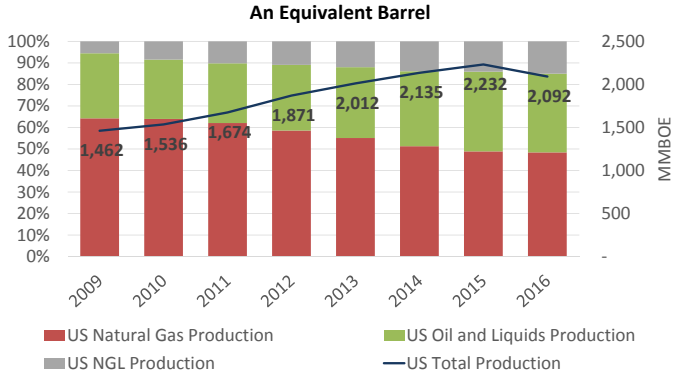


Cash Costs

- Cash costs decreased 13%
- Production costs, the most significant component of cash costs, reached 66% of total opex in 2016.
- Where are the efficiency gains?

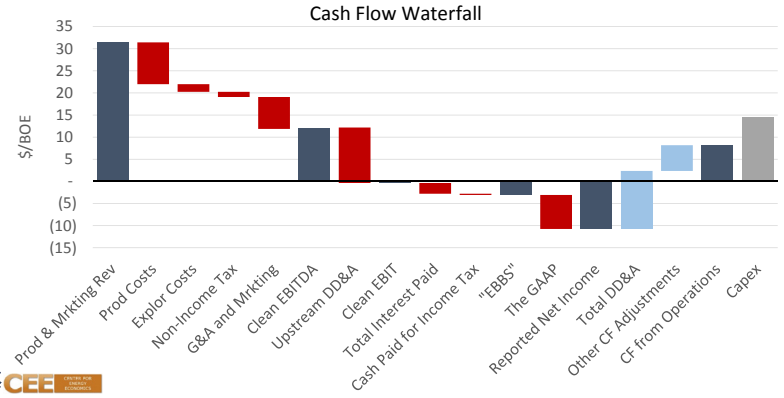


Production Trends



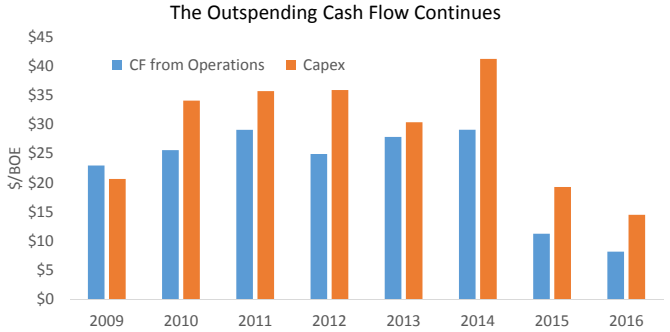
Cash Flow Waterfall

Companies have spent well above cash flow from operations (**77% more** in 2016) to replace production and improve leasehold positions. ***With lower oil prices companies are working to adjust capital spending to fall within cash flows…***



Cash Flow Negative

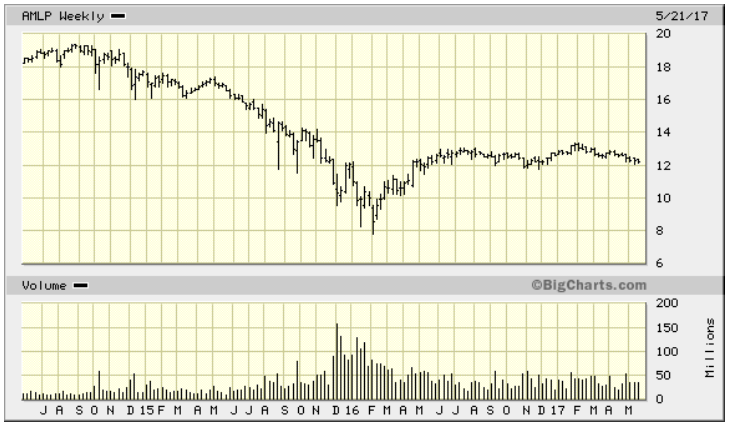
… However, the negative cash flow trend pre-dates 2009 and is widespread through the U.S. upstream sector, which suggests the industry is **heavily dependent upon capital markets**.



Midstream: the New Normal

Deniese Palmer-Huggins

MLPs New Normal?



Source: AMLP ETF 3 years

New Environment for MLPs

- Consolidation in the MLP space continues: 124 companies in 2014 v 110 so far in 2017
- Emphasis still on simplification and elimination of IDRs
- Now, it takes ~$75 million in EBITDA to go public whereas it used to take ~$50 million
- Pension funds, newer investors, are willing to hold assets longer than P/E funds
- Still a lot of dry powder ($) for infrastructure: $60 billion among 74 funds raised in 2016
- Earlier stage of investing where yields are better

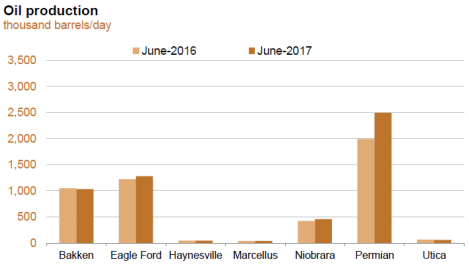
New Challenges: Fight shifts to Funding

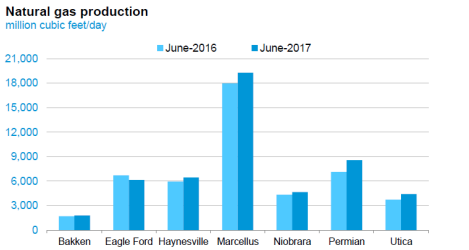
- "DefundDAPL" impacts:
  - BNP Paribas USA, Dutch ING and Norway based DNB all sold their shares of DAPL loan.
  - Private Investor Storebrand and Odin Fund Management, both in Norway, sold shares in companies linked to the project.
  - ABM-AMRO stopped providing credit to a parent company of ETP.
  - City of Seattle voted to cut ties with Wells Fargo, one of the participating banks in DAPL loans
- DAPL Protestors started a "GoFundMe" account to finance their activities—raised $2 million
- "Stopspectra.org/spectra-projects"
- Friendsofnelson.com
- Protectanddivest.weebly.com

Source: Friendsofnelson.com

New Geographies

- Follow E&P: it's where the opportunities will be for midstream projects
- Permian: developed already but niche opportunities, e.g., wellhead gathering
- Marcellus: if local/state opposition can be overcome
- SCOOP/STACK: as E&P focus on this area, the midstream will follow. (EnLink and Enable)
- Rockies may be on the horizon for crude infrastructure
- Investors like single basin companies that know the structure and can manage the asset well





New Attitudes?

- Landowners in Greely, CO actually sued to BUILD a pipeline for crude oil as they preferred it over noisy trucks
  - Enterprise Oil & Gas pulled back from its promise to build a pipeline
- Faster permitting under new administration
- Possible opening of Federal lands?
- Tax reform…could negatively impact MLPs?
- Sabine decision is a non-event now?

Same old resistance

- Constitution – NY state denied water permit-continuing
- Northern Access Project – April 2017, NY Dept of Environment denies permit
- Penn East Pipeline – NJ Dept of Environmental Protection
- Atlantic Coast Pipeline – FERC still holding hearings on new route proposed in hopes of appeasing environmental groups but opposition continues
- Access Northeast – high court in MA refuses to allow project to pass cost on to rate payers
- State of CT has cancelled new procurement of any natural gas project in favor of renewables

Natural Gas Demand: Power Sector

Chen-Hao Tsai

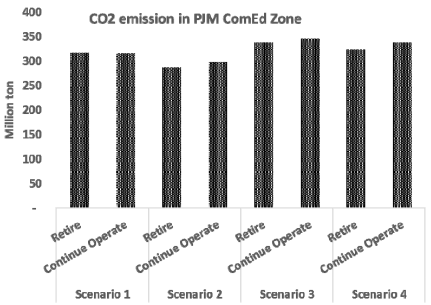
NG burn for power generation should continue to grow, but there is a 8.5-TCF (23-BCFD) range among scenarios

8.8 – 11.8 TCF (AEO 2017 range), excluding 6 TCF under low OGR

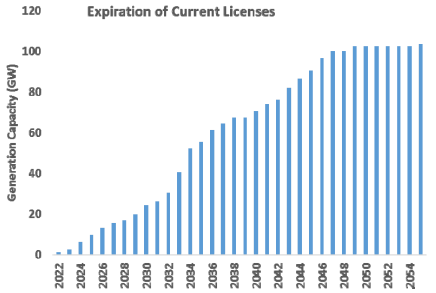
For details, see Tsai & Gülen, "**Natural Gas Use in Electricity Generation in the United States: Outlooks to 2030.**" *The Electricity Journal*, Vol 30, Issue 2, March 2017.

States are saving baseload nuclear plants through Zero Emission Credits (ZECs); is this the right rationale?

Saving nuclear does not necessarily mean reduction in emission

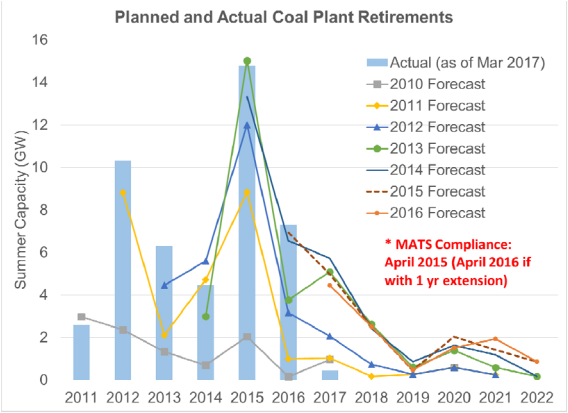


Big wave of nuclear capacity retirement will start in 2030s, if plant owners can not justify 2nd license renewal (to 80 yr)



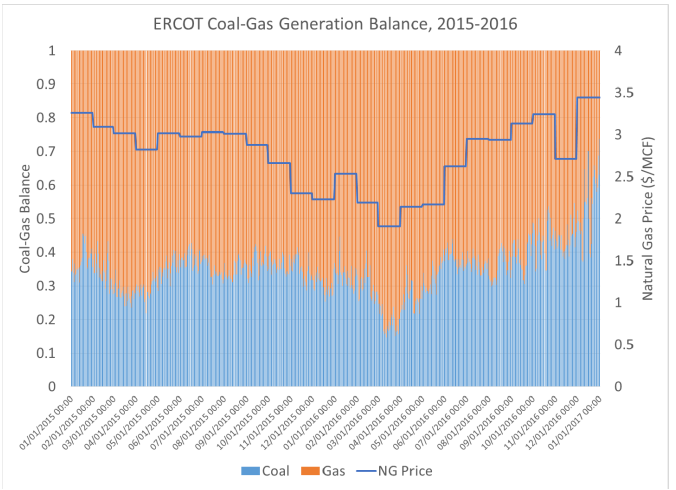
For details, see Tsai & Gülen, "**Are zero emission credits the right rationale for saving economically-challenged U.S. nuclear plants?**" *The Electricity Journal*, (forthcoming July 2017).

Coal plant retirements have slowed down; many of plants have also completed retrofits for MATS compliance.

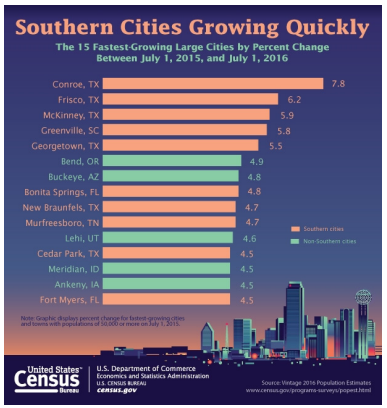


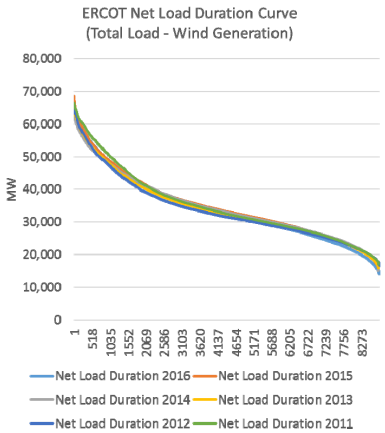
Most planned retirements are old units (50+ yr)

Higher NG price will help coal plants to stay online



Changes in demographics matter: Robust load growth in TX absorbed additional wind generation





Natural Gas Demand: Industrial Sector

Danny Quijano

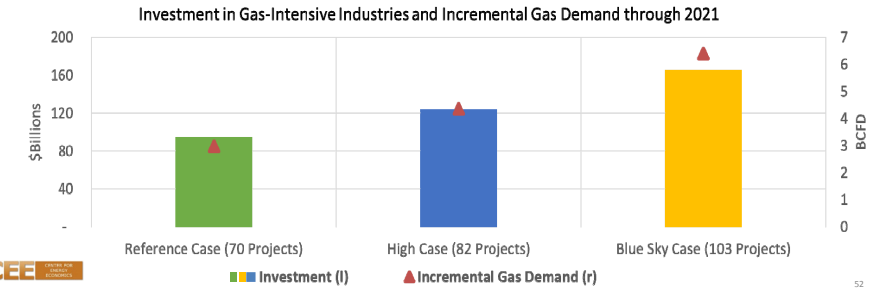
Three Cases

Under Consideration	Suspended	Planning	FEED	Permits	In Progress	Completed

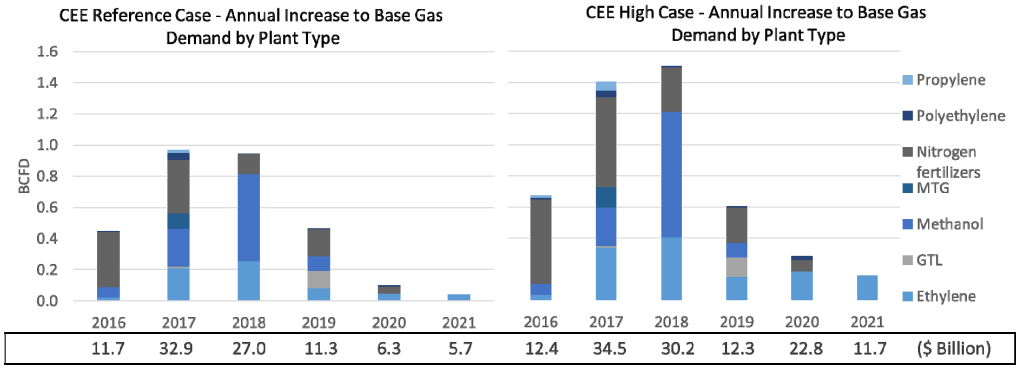
Using Low BCFD multiplier: **Reference Case**

Using High BCFD multiplier: **High Case**

Using High BCFD multiplier: **Blue Sky Case**

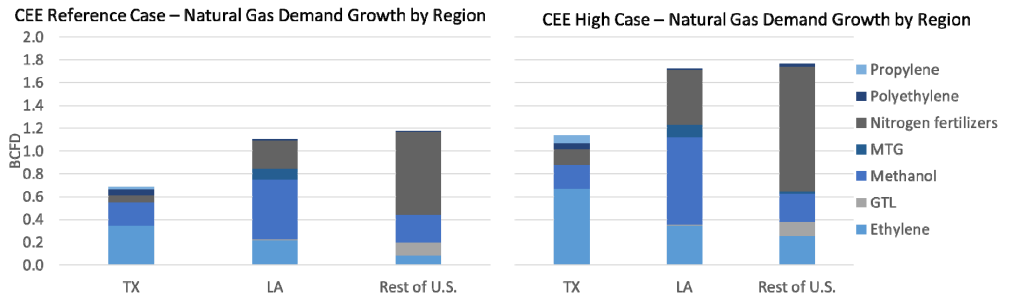


3-4.3 BCFD; $95-124 billion



11.7	32.9	27.0	11.3	6.3	5.7	12.4	34.5	30.2	12.3	22.8	11.7	($ Billion)

Ethylene, methanol in the Gulf Coast; fertilizers in the rest of the country



29.1	31.2	34.7	($ Billion)	41.2	34.3	48.4	

Natural gas exports

University of Texas
Center for Energy Economics – Bureau of Economic Geology

5th Mid-Year Meeting

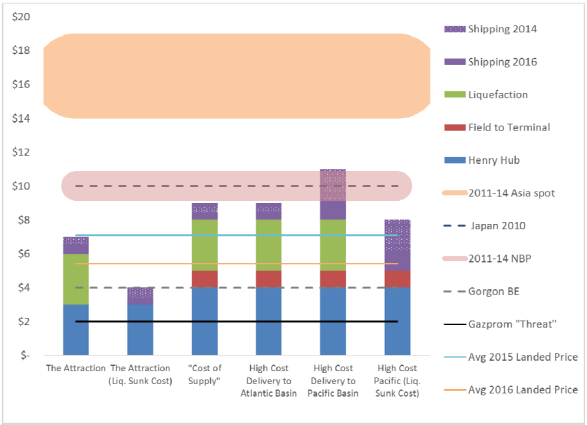
Guy Dayvault, CFA

1 Jun 2017 Houston, TX

Topical Outline

- Global LNG market over-supply => market is long
- Common views
  - Soft LNG demand will keep global spot LNG prices low for 2-3 years
  - Some US Gulf Coast (USGC) LNG supply may be idle in 2017-2019
  - Some Australian LNG supply may be idle due to local gas demand
- Demand could surprise to the upside with new FSRUs . . .
- New challenges exist and others could develop, example:
  - UK lost Rough Storage of 115 BCF working capacity (70% of system storage)
  - Equivalent to some 30 LNG cargoes serving in unique "peak-shaving" role
  - Could a speculator make a just-in-time inventory bet?
  - LNG supply from USGC could deliver LNG supply for this "new demand"
  - Liquid financial markets for HH and NBP allow managing the financial position, which arguably makes this a hedged position rather than naked speculation
- Traders & Commercial Experts will innovate
- **Possible Conclusions: spot price support & volatility**

Challenges Facing U.S. LNG Exports



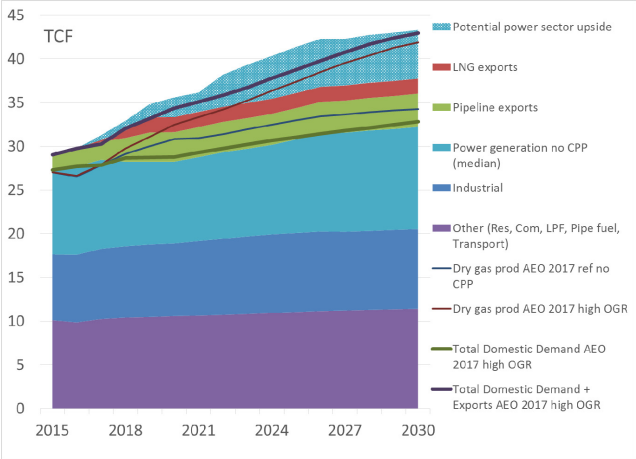
- "Low" demand growth (China, India, Japan, and others):
  - Coal, nuclear, renewables have priority - energy security
  - Not enough gas infrastructure (especially storage)
  - Low gas market readiness
  - Sluggish economic growth
  - Japanese energy policy: nuclear, renewables, efficiency
- "Surging" global LNG supply ➔ excess supply until the early 2020s
  - Unsubscribed U.S. liquefaction capacity
  - Parts of contracted volumes not tied to specific destinations

http://www.beg.utexas.edu/energyecon/template/IAEE%20Energy%20Forum_062116.pdf
http://www.beg.utexas.edu/energyecon/thinkcorner/CEE_Advisor_Research_Note-Andy_Flower_LNG_Supply_Outlook-Aug16.pdf
http://www.beg.utexas.edu/energyecon/thinkcorner/CEE_Research_Paper-China_and_India_Current_Future_Natural_Gas_Demand-Apr17.pdf

Natural Gas Demand: Putting it all Together

Gürcan Gülen

A Strong "Gas Demand Stack" Scenario v EIA AEO 2017



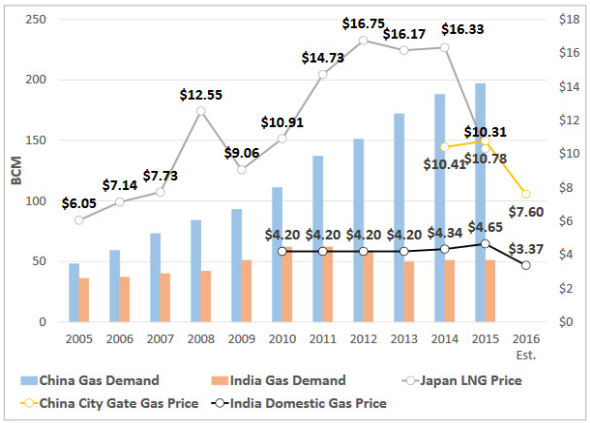
- Two largest uncertainties: Power generation and LNG exports
- Potential drivers:
  - Price of natural gas
  - Renewables generation
    - Declining costs
    - Federal subsidies?
  - Coal retirements
    - Env'l regulations?
  - Nuclear retirements
    - Aging fleet, rising costs, state subsidies
  - CO_2 prices
  - Load growth
    - EE, DER, DR

CEE analysis; EIA AEO 2017

Global gas demand uncertainties: China & India

Miranda Wainberg

China and India Gas Demand (BCM), Domestic Gas Prices (MMBtu) and Japan LNG Prices (MMBtu)

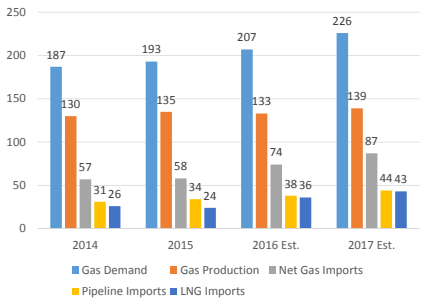


Sources: BP SR 16; Sen, A. April 2015; Paltsev, S., et.al., July 2015

Lower Prices ➔ Increased Demand and Imports Duration?

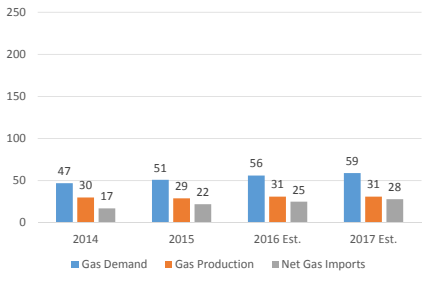
Natural Gas Demand, Production and Imports (BCM)

China



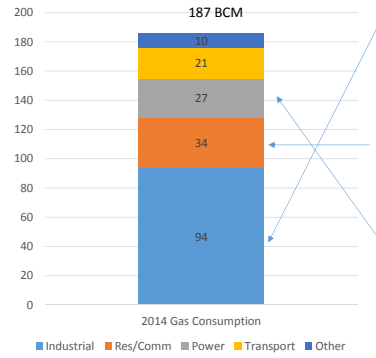
Sources: BP SR 2016, China National Bureau of Statistics. Estimates from BMI 2Q17 China Oil & Gas Report.

India



Sources: BP SR 2016, India Ministry of Petroleum and Natural Gas. Estimates from BMI 3Q17 India Oil & Gas Report.

Uncertainties re: Longer term gas demand and gas infrastructure growth in China



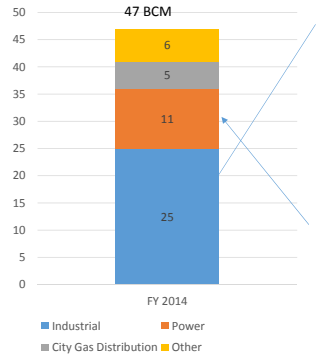
Industrial
- Excess capacity reductions
- Coal competition-72% of total industrial energy use vs. 6% gas
- Transition to less energy intensive services led economy
- Gov't reluctance to enforce coal to gas fuel switching in slowing economy
- Higher costs due to res/comm cross-subsidy

Residential/Commercial
- Subsidized low prices not sustainable
- Lack of storage to manage seasonal demand swings
- Requires further expansion of gas distribution infrastructure

Power
- Electric demand growth is slowing and decoupling from GDP growth
- Coal is lower cost absent significant carbon penalties
- Clean coal and nuclear plants to provide baseload generation
- Environmental issues to be addressed by large increases in renewables generation
- Gas role limited to load following/peaking? Current gas fleet utilization rate 30%

Source: National Bureau of Statistics China as revised by CEE.

Uncertainties re: Longer term gas demand and gas infrastructure growth in India



Industrial
- Largest gas consumer-urea fertilizer industry was 61% of total industrial gas use-requires large gov't subsidies to survive and prospects for significant capacity expansions are muted
- Progress toward a manufacturing-led economy is limited due to lack of capital investment
- Coal to remain cheaper than imported gas longer term
- Significant gas delivery infrastructure limitations and uncertain outlook for domestic gas supply growth

Power
- Coal to remain cheaper than imported gas longer term and could remain the dominant generation fuel
- Many electric distribution companies are technically bankrupt and unable to bear higher costs
- Significant gas delivery infrastructure limitations and uncertain outlook for domestic gas supply growth
- Gas role limited to load following/peaking?
- Environmental issues to be addressed by a strongly gov't supported growth in renewables generation

Source: India Ministry of Petroleum and Natural Gas as revised by CEE.

Commercial Framework Issues in China and India

- Inadequate gas delivery infrastructure, especially in India
- High degree of government intervention in the natural gas sectors in both countries
- Government administered gas pricing mechanisms in both the electricity and gas markets that do not respond to price movements in relevant markets or alternative fuels on a timely basis. Cross-subsidies among customer classes distorts demand patterns.
- Government administered allocation of gas supplies to consuming markets in both countries
- Limited open access to gas transportation in both countries; lack of transparency in gas transport rate setting
- All segments of the natural gas value chain dominated by state-owned companies in both countries
- These issues discourage private and foreign investment in the natural gas sector by limiting or delaying gas sector development

State policies, impact on wholesale & retail prices: the role of regulators

Ken Rose, Consultant

Future of Retail Electricity Markets

PJ Popovic, Direct Energy

Understanding cost of electricity: Bulk Market Price Formation & Generation Compensation

Pat Wood

Understanding Cost of Electricity: A Financing Perspective

Chris Micsak, Haddington Ventures, LLC

CEE: Mid-Year Meeting

A Financing Perspective; Looking Through A Glass Darkly

Chris Micsak

Haddington Ventures, LLC

Deflationary Trends Across Energy Space

- Upstream costs have fallen with technology, creating cheap thermal feedstocks
- Massive buildout of 'like' renewables drastically depressing real-energy prices across grid
- Short of subsidy, rate base, capacity payment or other such scheme, generation asset economics difficult to underwrite

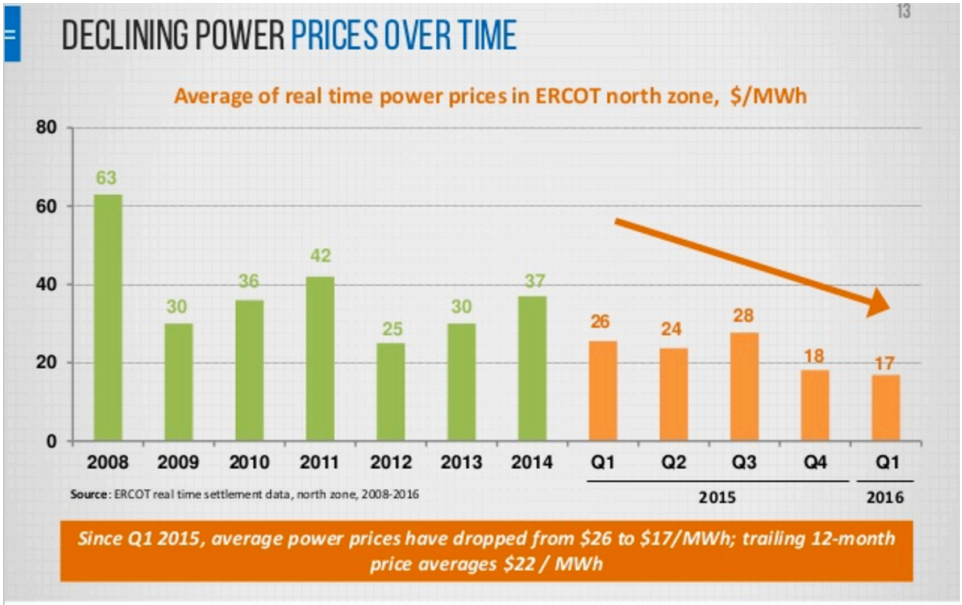
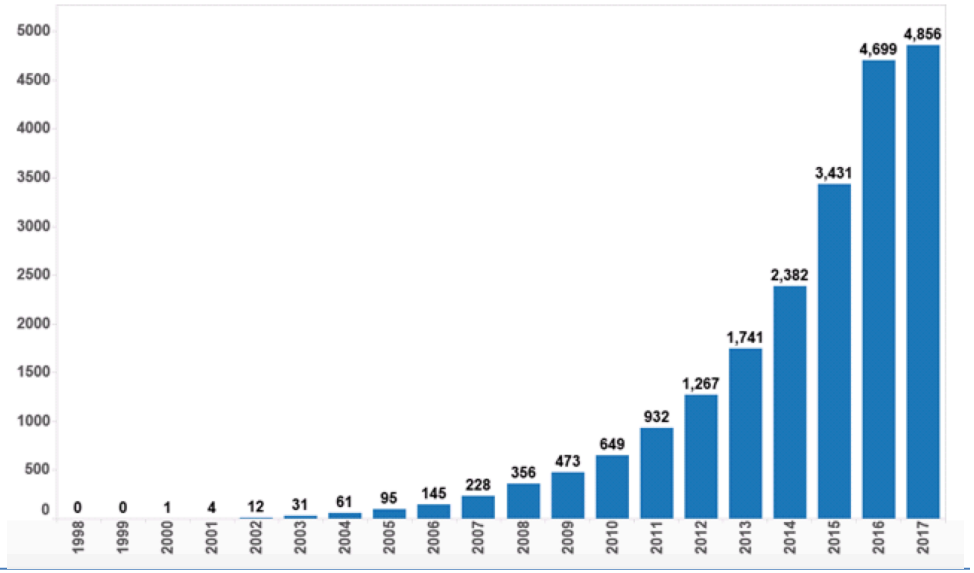


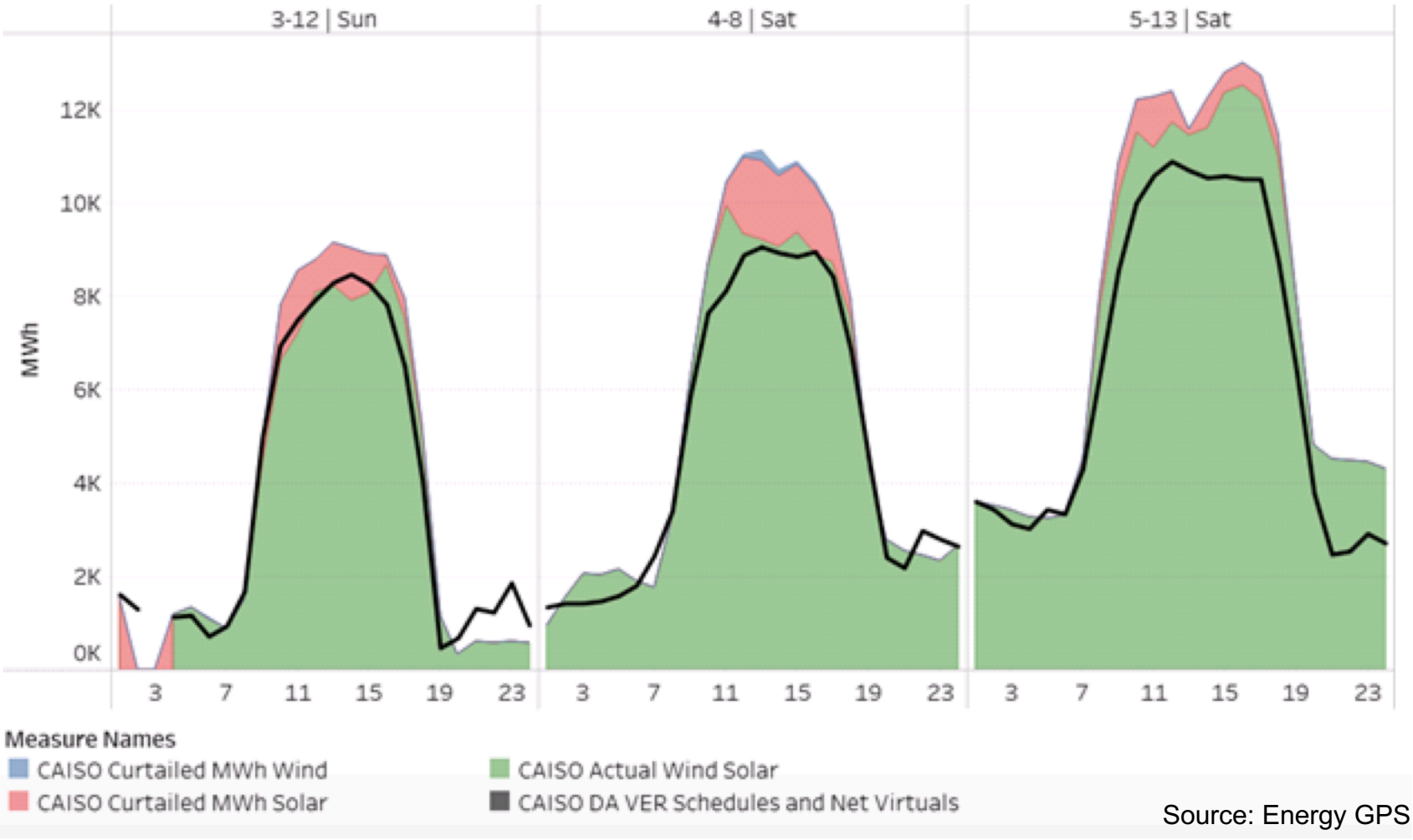
Figure 2 | California Rooftop Solar Capacity by Year (2017 is through February)



Source: ERCOT, Energy GPS

No Use Crying Over Spilled Renewables?

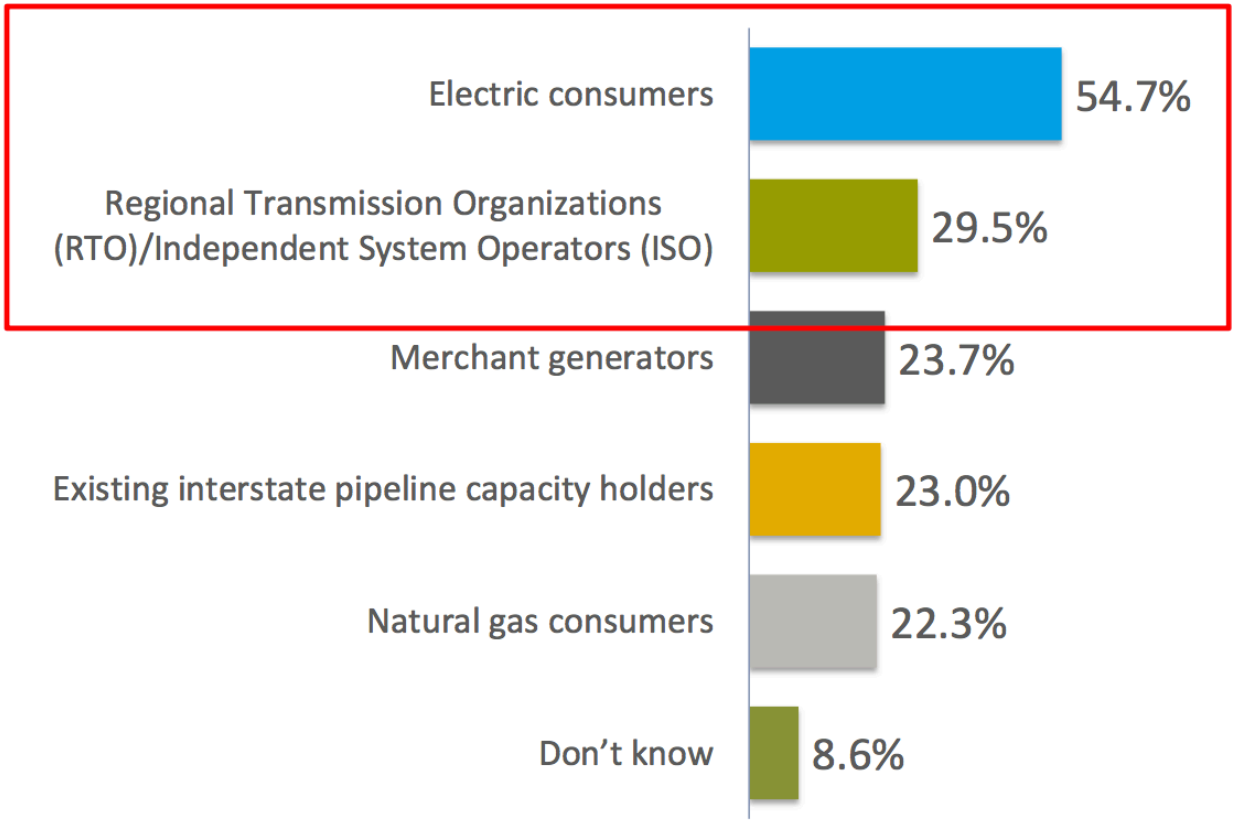
CAISO Solar and Wind Day-Ahead vs. Real-Time Renewables and Curtailments - Hourly



Source: Energy GPS

Shifting Customer Set

ELECTRIC CONSUMERS COULD UNDERWRITE GAS STORAGE AS PART OF RENEWABLE INTEGRATION PLAN



Additional outreach will be needed to encourage electric consumers and RTO/ISO that gas storage plays a critical role in portfolio and grid management

Source: Black & Veatch Strategic Directions Survey: U.S. Natural Gas Industry Report 2016

Q: If additional natural gas infrastructure is needed to serve the growth in power generation demand, who should bear the costs?

14

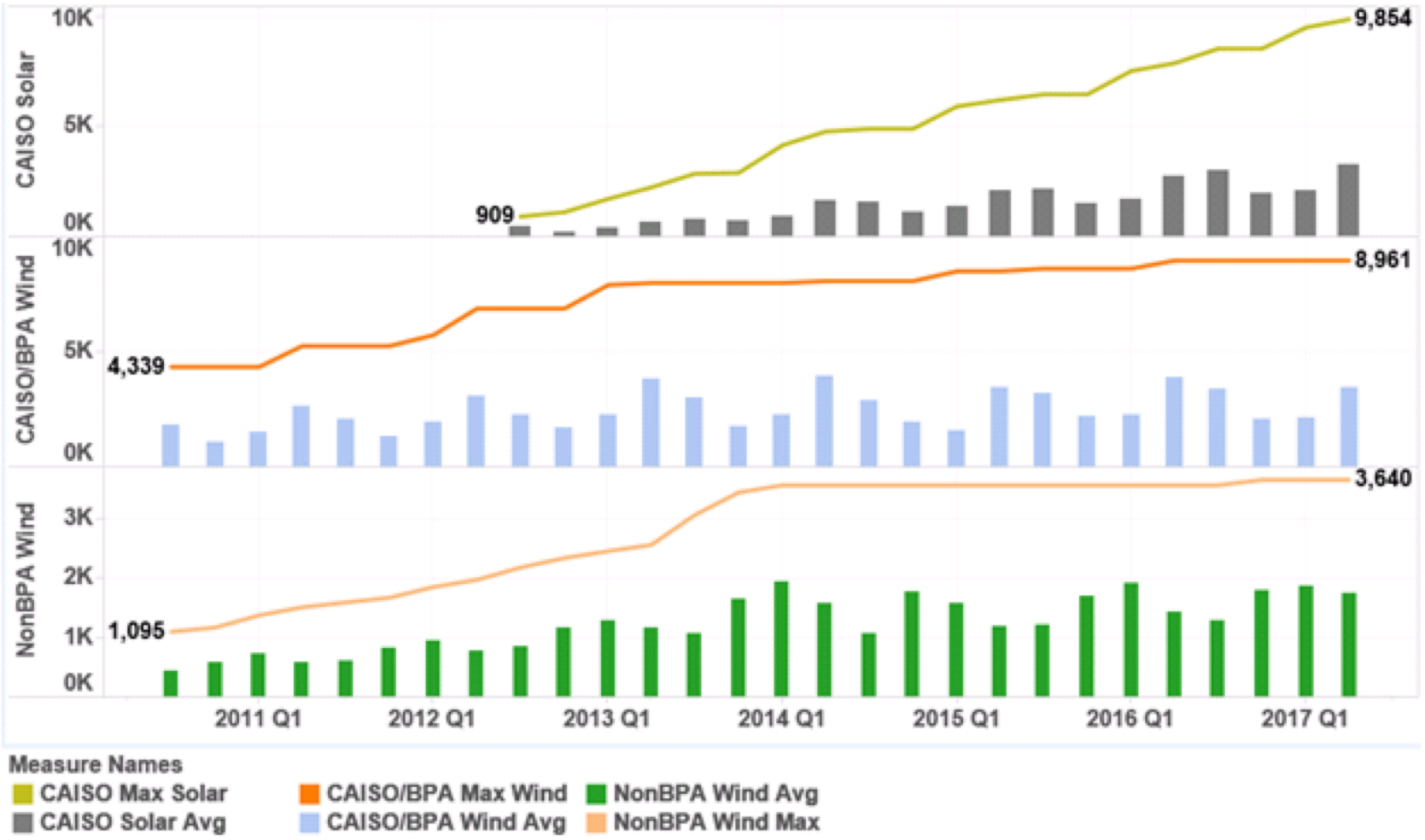
Source: Black & Veatch

Conclusions

- Deflationary energy price trends create risk aversion, particularly amongst project lending community
- Legislation currently does not prioritize quality of storage resource (duration), similar to relatively agnostic renewable development that creates large amounts of resource with similar dispatch profiles (ie West Texas wind or California solar)
- Capacity vs. Deliverability, not all generation is created equally
- Jurisdictions matter – leveraging existing assets/brownfield lower development risk
- Shifting customer trends to security supply and utility customers, away from marketing/trading entities

Appendix

Renewable Buildout Over Time



Source: Energy GPS

Financial state of the solar industry

Deniese Palmer-Huggins

The Industry Overview

Claymore Exchange-Traded Fund Trust 2 - Guggenheim Solar ETF (TAN) Tracks Global Solar Energy Index—Still Struggling

Source: Yahoo Finance

Source: quotemedia

Top Holdings Include: Xinyi Solar Holdings, GCL-Poly Energy Holdings, Ltd, First Solar, Inc., Atlantica Yield, PLS, Canadian Solar, Hannon Armstrong Sustainable Infrastructure Capital Inc., SolarEdge Technologies, Inc., TerraForm Power Inc., Meyer Burger Technology AG and SunPower Corp,

Solar Stress

- The stress in the solar industry has been across all sectors of the industry: residential installers, PV panel manufacturers, utility-scale solar developers and Yieldcos.
- The reasons for the stress vary but the main ones appear to be:
  - burdensome levels of debt,
  - overcapacity,
  - declining PV modules prices,
  - declining PPA prices supporting utility-scale solar power sales, and
  - changing state policies.

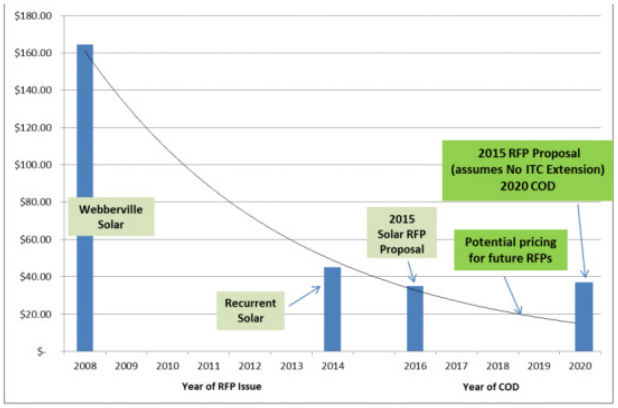
PV Manufacturer	DER Installer	Utility-scale Developer	Yieldco
Suniva* Solar World AG* Beamreach Solar* SolarWorld US Mission Solar SunPower Panasonic Eco Solutions Ten K Solar	Sungevity* Helio Power* SunRun SolarCity Vivant REC Solar	SunEdison* SunPower	Abenogoa*

* Filed for Bankruptcy. SunEdison assets were sold to NRG and GCL Poly Energy Holdings (China). Sungevity sold its assets to Northern Pacific Group. Beamreach filed for CH 7 or liquidation. As most other companies have only recently filed for bankruptcy, their assets have yet to be sold. Abenogoa filed for CH 15

Pricing Stress

- Price of CS solar cells (dumping allegation by Suniva) have declined by 30% this past year and is putting pressure on US and European manufacturers with many already filing for bankruptcy or closing operations
- Non manufacturing companies have had to write down inventory of solar panels due to impairment from the price decline or sell off excess inventory at lower prices
- If ITC investigation results in higher CSPV pricing ($0.78/watt has been proposed for 1st year) could result in more financial stress for solar industry putting strain on utility-scale projects and roof top installers
- PPA prices falling to less than $40/MWh (e.g. Austin Electric and Tucson Electric) which will squeeze economics of utility-scale power projects with rising component costs and declining price of power sold through PPA's

Austin Energy Solar PPA Pricing Dropping Since 2008



Source: June 29, 2015 Austin Monitor

Other Forms of Stress

- Recent cases in the U.S. district courts that challenge the criteria for a true lease, which could impact whether the structure of our residential lease program qualifies under the Cash Grant and investment tax credit.
- The Inspector General is working with the Civil Division of the DOJ to investigate the administration and implementation of the Cash Grant program, including potential misrepresentations concerning the fair market value of certain solar power systems submitted for Cash Grant, an important underlying assumption used by the solar industry ➔ could reduce eligibility and level of incentives and adversely affect profitability and cash flows. (SunPower 2016 10K Pg 32)
- SunRun & Solar City (installer) under investigation by SEC for not adequately disclosing number of customers cancelling solar contracts
- ITC is moving forward under Section 201 of Trade Act to investigate CSPV dumping complaint filed by bankrupt Suniva and now joined by SunWorld AG
- Many installers issue indemnities for tax credit to their customers and if it were to be repealed and/or reduced early, then these companies would incur sizeable cash payments to their customers as part of their indemnities.

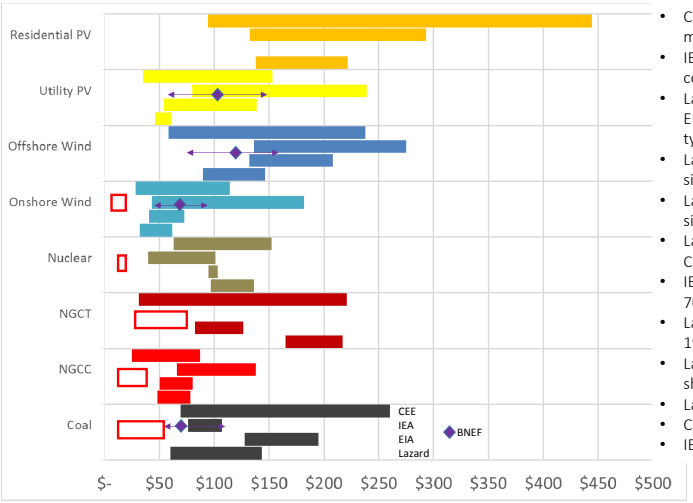
Peer Analytics for SunPower as of 12/31/16

Company	ROA	ROE	EPS-Diluted
Canadian Solar	1.21%	7.38%	$1.12
JA Solar Holdings	3.64%	10.73%	$2.12
NRG Energy	-2.55%	-37.92%	$-2.98
SunRun***	2.57%	13.62%	$0.86
Yingli Green Energy Holdings	-15.54%	N/A due to Negative Equity	$-16.28
NextEra Energy Inc	3.24%	11.96%	$8.22
First Solar	-5.2%	-6.87%	$-5.26
Sempra Energy	2.87%	10.59%	$5.81
SunPower	**-10.31%**	**-46.74%**	**($3.41)**
Trina Solar (ADRs)**	1.6%	2.1%	.02

Source: 2016 10K and analysis of company's financials
* Combined basis..**12/31/15 only available ***NI=$-214,904k

Shortcomings of LCOE

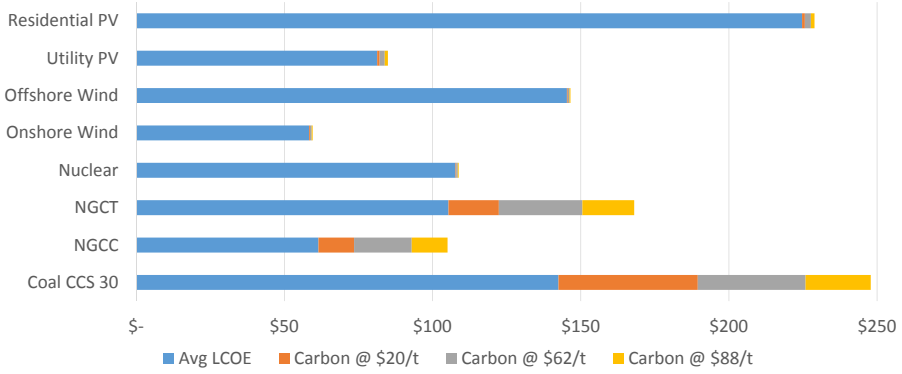
Gürcan Gülen



- CEE ranges are typically larger because we use most extreme U.S. values (multiple sources).
- IEA estimates are based on 181 plants in 22 countries (mostly OECD members).
- Lazard uses 9.6% WACC for all plants; IEA 7%; EIA 5.5%; CEE 5.5% to 9.6% depending on plant type and min-max cases.
- Lazard utility PV min is for 30-MW thin-film, single-axis
- Lazard utility PV max is for 30-MW crystalline, single-axis
- Lazard coal min is without CCS; coal max is 90% CCS
- IEA coal is without CCS, which would add 30-70% to shown estimates
- Lazard rooftop PV for C&I customers: $88-193/MWh (not shown)
- Lazard community PV: $78-135/MWh (not shown)
- Lazard natural gas price: $3.45/MMBtu
- CEE natural gas price: $2.33-5.00/MMBtu
- IEA gas prices are oil-indexed (much higher)

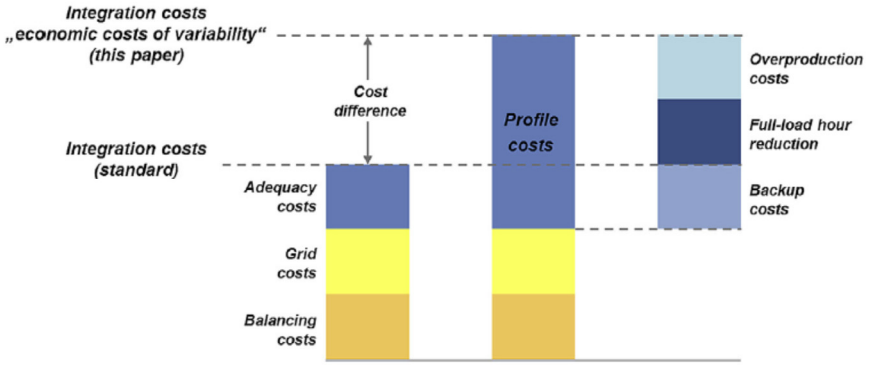
LCOE of existing plants is lower.

LCOE with externalities



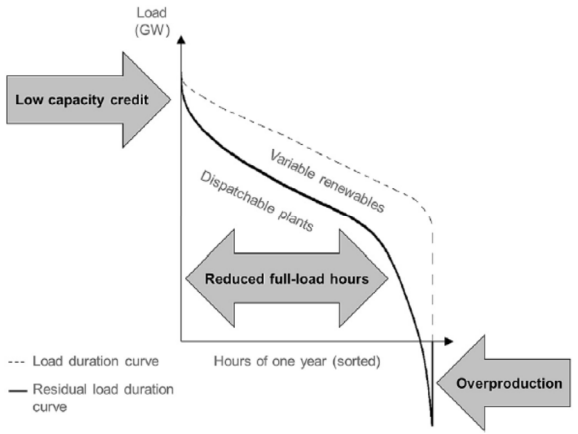
Avg LCOE is the average of middle estimates of Lazard, EIA and CEE from the first chart.
SO_X, NO_X, PM_{10}, and $PM_{2.5}$ emissions rates and costs are kept the same; only GHG costs in CO2-eq are modified.
GHG costs for wind and solar are one-time emissions, which are distributed over lifetime of expected generation.

Integration costs depiction from Ueckerdt et al (2013)

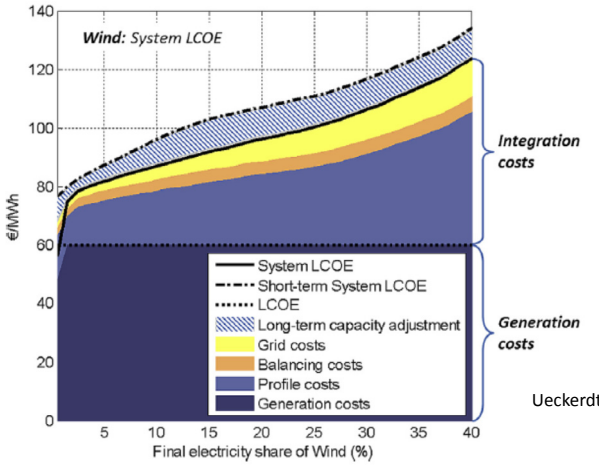


Profile costs from Ueckerdt et al (2013)

Load duration curve sorts hourly electricity demand (load) from the highest (peak) to the lowest across 8760 hours of a year.

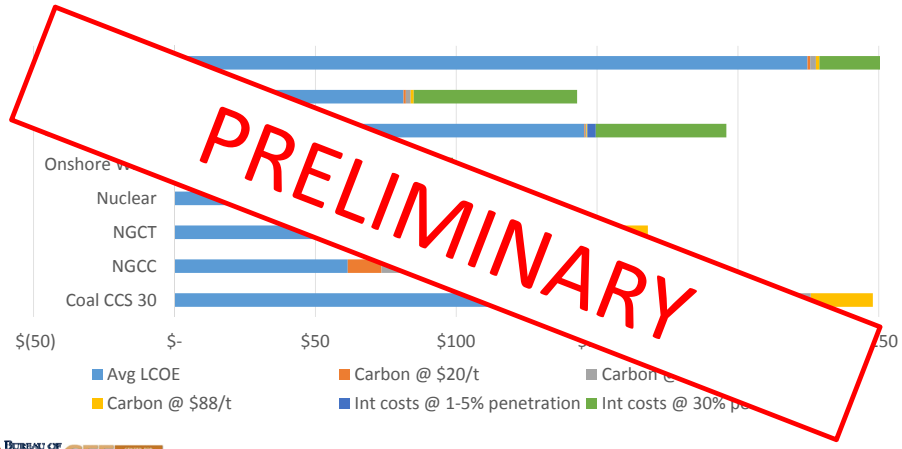


Typical thermal system in Europe



Ueckerdt et al (2013)

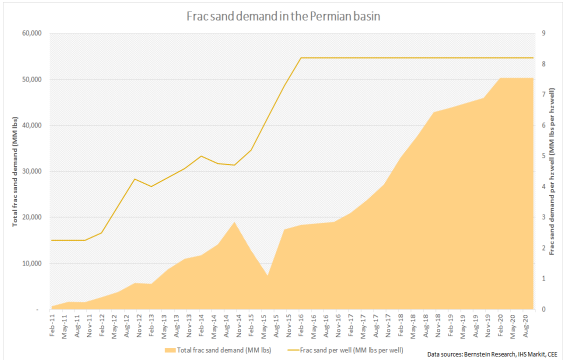
LCOE with externalities & integration costs



Economics of minerals resources

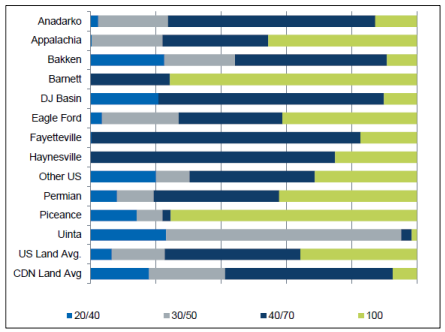
Rahul Verma

Sand demand forecast for Permian Basin



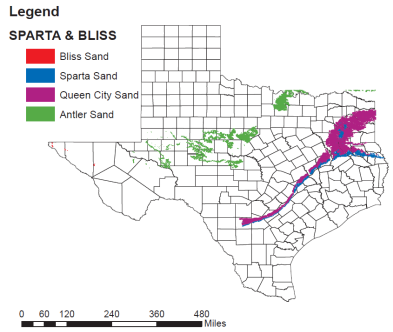
- Permian basin will require the highest volume of frac sand in Texas
- Factors leading to increase in total volume:
  - Greater volume per well
  - Increase in number of wells
- Frac sand demand in 2020 is expected to increase 5 fold from the peak in 2014
- Developing transportation infrastructure in the area will be crucial for reliable sand supply

Finer sand grades form the largest market share

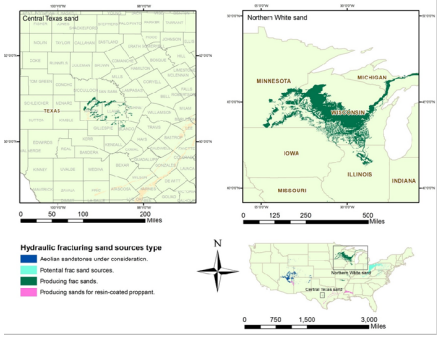


Source: IHS Markit

- Fine grain sand holds the majority of market share in almost all basins
- 80% of the Permian frac sand demand is for sand finer than 40 mesh size
- 40% of Permian demand is for fine 100 mesh sand
- Finer sand trades off permeability in fractures for greater reach



Source: CEE-BEG



Source: CEE-BEG

The only competitive advantage of using Texas sand is the lower transportation cost. Minegate cost of sand is approximately $25 per ton. The transportation cost for Texas frac sand is $30-40 per ton, compared to $80-100 per ton for northern white sand. The low cost sand will often be a trade off for quality. The qualitative research on Texas frac sand is under process

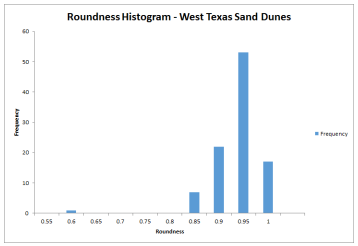
Qualitative analysis – Central Texas

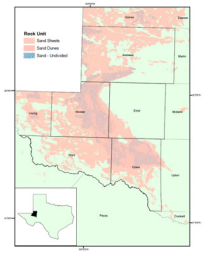
- Samples collected from frac sand mines in Central Texas
- Size fractions under study:
  - 20/40
  - 30/50
  - 40/70
  - 100
- The grains have good roundness and sphericity
- Crush tests are currently undergoing

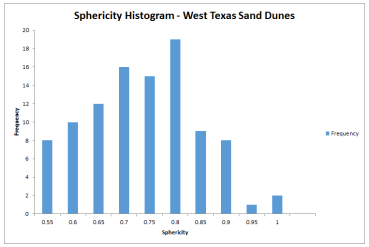
Central Texas 20/40

Source: CEE-BEG

Central Texas 100. Source





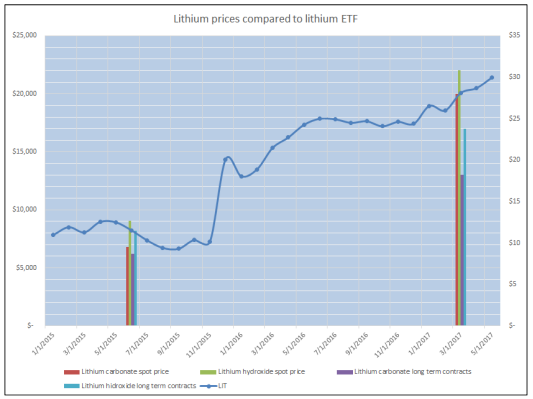


Qualitative analysis – West Texas sand

- Grains have moderate sphericity: 70% grains, higher than 0.70
- Grains have high roundness: 99% grains, greater than 0.85
- Crush tests are under process

Source: CEE-BEG

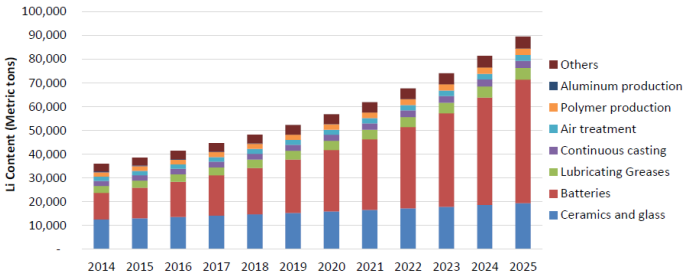
Lithium price, market size, investment size



Source: CEE; NYSEARCA; IndMin

- Lithium carbonate and hydroxide are the two largest lithium products that are traded, in terms of both volume and value
- Lithium is traded only in bilateral contracts and direct sales; no formal markets
- Spot price of lithium products have increased almost 4 fold in the last 2 years
- The price of exchange traded fund that tracks lithium market, LIT, has increased from about $11 to $28 in the past 2 years

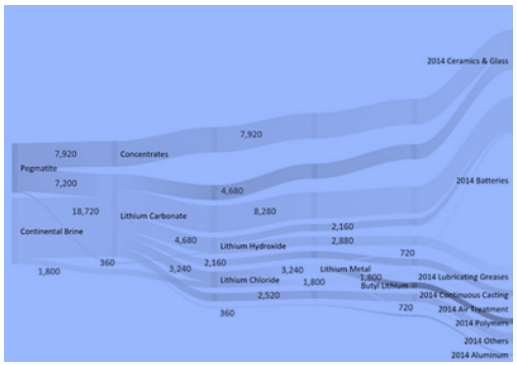
Consumption is consistent with CEE's base demand scenario



- More aggressive demand scenarios have been reported by other sources for 2025
  - Independent analysts: ~ 100,000 t Li content in 2025
  - BASF: 94,000 t Li content in 2025
- Batteries are expected to consume more than 55% of total lithium production in 2025

Lithium hydroxide over carbonate

- Lithium hydroxide is priced higher at approximately $20k-$24k per ton (spot price CIF China, Mar 2017)
- Lithium hydroxide was traditionally used in heavy duty lubricants, but is increasing importance in the electric vehicle batteries
- Battery chemistries, NCA and NMC, most popular for EV and other large scale batteries, prefer lithium hydroxide over carbonate
- Major brine sources produce hydroxide as a second product, after processing the first product, lithium carbonate
- A few hard rock producers have started producing lithium carbonate as the first product, bridging the cost gap in the final product



Brine is no longer the "best" resource

- Lithium extraction from salt brines is less capital intensive, but has a longer production cycle
- Several new projects in South America are struggling with the remoteness, high altitude, and unfavorable environmental conditions
- Meanwhile, conversion plants in China have brought down the cost of producing lithium carbonate from hard rock resources. Closer to $3,000 per t of lithium carbonate
- Producing lithium hydroxide as the first product keeps the overall costs close of brine source
- New hard rock project sites: Mt Cattlin, Mt Marion, Pilbara, Quebec

Argentina's growing relevance in the lithium play

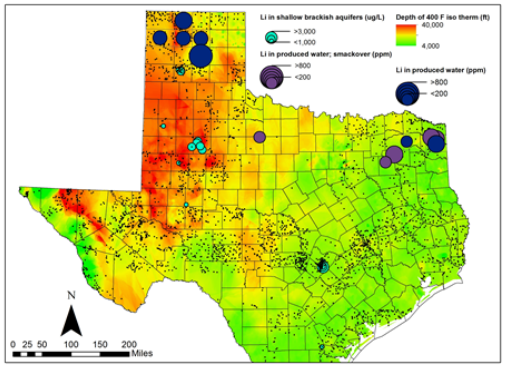
- Argentina has set a target to produce 145,000 t LCE in 2020, up from 29,000 t in 2016
- The effort will require approximately $1.5 billion in investments
- Major new developers:
  - Orocobre
  - Lithium Americas

Canadian producers have the hydroxide edge

- Hard rock resource in Quebec have shown a strong potential for development
- Major developers: Nemanska, Lithium Americas
- Explorations and pilot projects underway for oil field brines in Alberta

Lithium in Texas

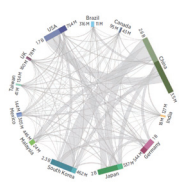
- More than 400 ppm lithium concentration has been observed in the Smackover formation in Texas
- Up to 600 ppm lithium concentration in several other well in the panhandle region
- For perspective, oil field brine pilot project in Alberta work are producing from 50-100 ppm
- Lithium brines in South America have 1,000 – 1,300 ppm concentration
- Major technical challenges include removing dissolved solids and organic content



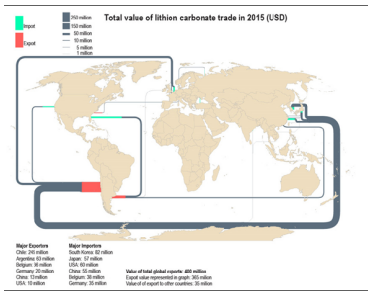
Source: CEE-BEG

The geographical aspect of the supply chain holds important over price

- China will play an increasingly important role in lithium
  - Large manufacturer and exporter of batteries
  - Chinese companies have secured supply contracts in South America and Australia
  - Conversion plants in China convert other lithium products to carbonate and hydroxide
  - The conversion plants provide a cost effective lithium production from hard rock resources
    - ~$3,000 per t for mine to final product
- New projects being developed in Australia, North America, and South America will be crucial for the geographical diversity
- Korea and Japan will remain large lithium consumers, given the battery manufacturing capacity in the two countries



Economy	Li-ion battery cells and subcomponents: Automobiles (all subcomponents) (Billion USD 2014)	Rechargeable Li-ion batteries: All applications (Billion USD 2014)
China	0.6	0.8
Germany	-0.3	-0.5
Japan	0.8	1.5
South Korea	0.7	1.8
United Kingdom	-0.1	-0.1
United States	-1.6	-0.9

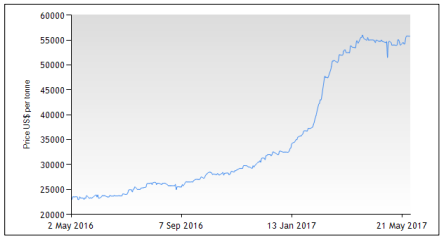


Source: CEE-BEG; CEMAC

The big 3 oligopoly is diluting

- Albermarle, FMC, and SQM produced only about 50% of the total lithium production in 2016
- Tianqi and Gangfeng, two major Chinese producers have acquired significant share of total production, each approximately 15%
- New developers, Nemanska, Orocobre, Galaxy Resources, will further diversify the market
- Geographical diversification also under way with new projects coming up in Australia, Canada, China, and Mexico

Other battery ripple effects



Source: LME

- Cobalt price have increased to $55,000 from $24,000 per t within the past year
- Most of the increased demand is expected to flow towards the lithium ion battery market
- The majority of world's cobalt manufacturing capacity is in China
- Cobalt production in DRC is also largely controlled by Chinese producers, with the exception of Switzerland based Glencore