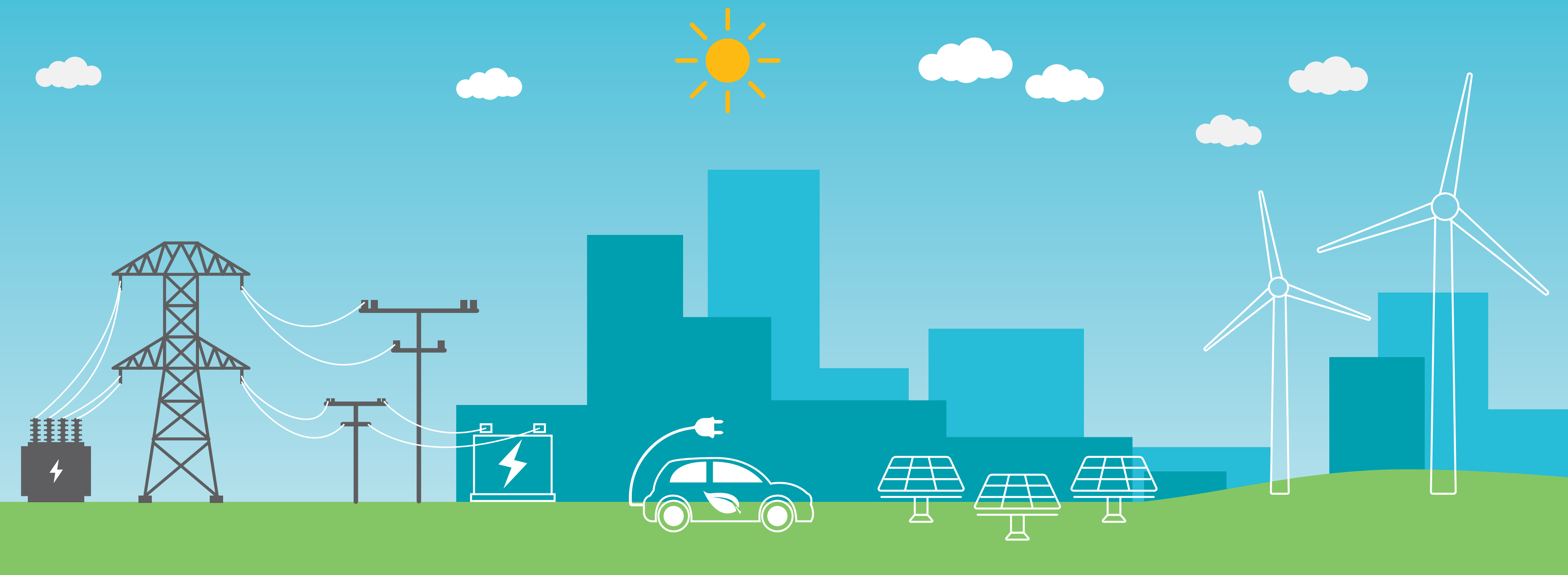

DON'T STOP BELIEVIN'

THE SCOTTMADDEN ENERGY INDUSTRY UPDATE

Volume 18 - Issue 2

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View from the Executive Suite

EXECUTIVE SUMMARY
DON'T STOP BELIEVIN'

Belief (noun): "the feeling that something is real and true; trust; confidence"

Believe in (phrasal verb): "to have faith in the existence of; to feel sure of the value or worth of"

A strong domestic economy, evolving regulations and policies, continued technology development, and ongoing interest in developing new energy resources are shaping the energy landscape. Energy and utility companies are pursuing growth and are developing and modernizing needed infrastructure while being responsive to stakeholders with disparate interests and concerns.

The theme, "Don't Stop Believin'," characterizes customer and regulator interest in reliable and reasonably priced energy, environmental objectives for fewer emissions from energy resources, and utilities' goals of growth and bolstering the energy ecosystem. However, with so many "believers"—energy companies and other stakeholders—there are bound to be frictions, which are showing up across the energy ecosystem.

In this issue of *The ScottMadden Energy Industry Update*, we look at some of the emerging and continuing trends in the industry, helping energy and utility industry leaders move from "believin'" to realization.

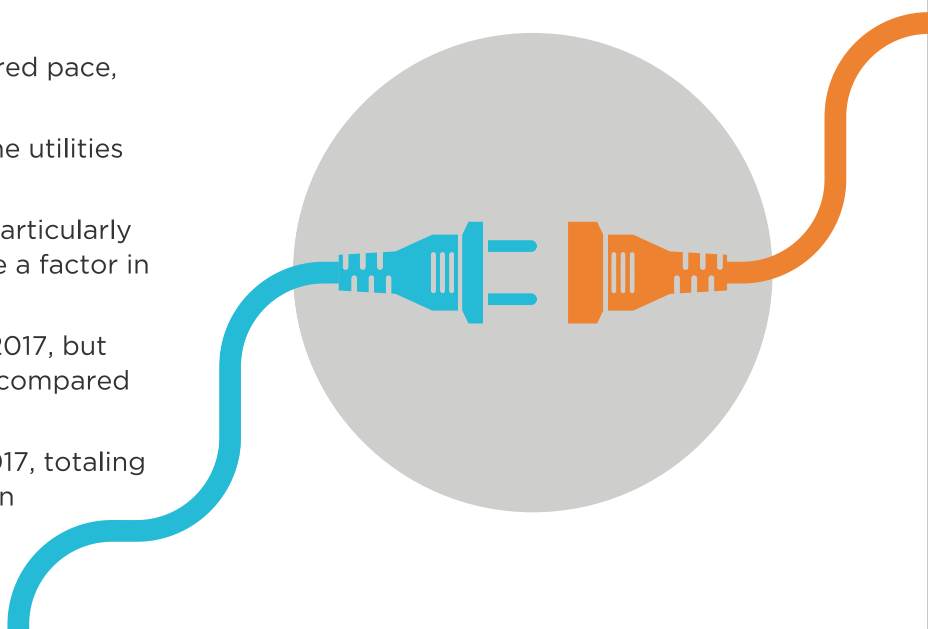
Some Highlights of This ScottMadden Energy Industry Update	
Believin' in Growth	▪ Companies across the gas and power value chains continue to entertain growth through both company and asset acquisitions, while recent merger activity has been mostly characterized by a few large transactions ▪ With growing interest by some in decarbonizing the energy sector, both the electric sector and environmental communities are promoting increasing electrification of activities historically fueled by carbon-based fuels, but the limits of electrification are still unclear ▪ Electric vehicle sales forecasts get rosier each year, and while some electricity sales growth is expected along with those sales, where and when charging occurs could create localized impacts where electric vehicle sales are concentrated
Believin' in the Grid	▪ Utilities around the United States have been proposing and implementing grid modernization initiatives. Drivers of those efforts are varied: replacing aging equipment, improving resilience, and preparing for increasing levels of distributed energy resources, potentially "Smart Grid 2.0" for the distribution system ▪ Federal policy toward infrastructure development is in flux. In power transmission, as FERC's Order 1000 continues to play out, competitive transmission continues to face hurdles, and FERC is re-examining financial incentives that have been in place for years
Believin' in Energy Resources	▪ Driven by increasing supply, gas pipeline development has been continuing, although there has been active opposition to some projects. Divergent opinions at a divided FERC on gas pipeline approval criteria could mean a more difficult path for investment ▪ U.S. and Canadian liquefied natural gas export capacity is growing and, along with North American production, appears poised to serve increasingly more global gas demand ▪ Solar photovoltaic (PV) power linked with battery energy storage is garnering attention as a way to manage temporal variations in solar output, but how storage is configured and linked to the grid and to the PV system affects both value to the system owner and to the grid

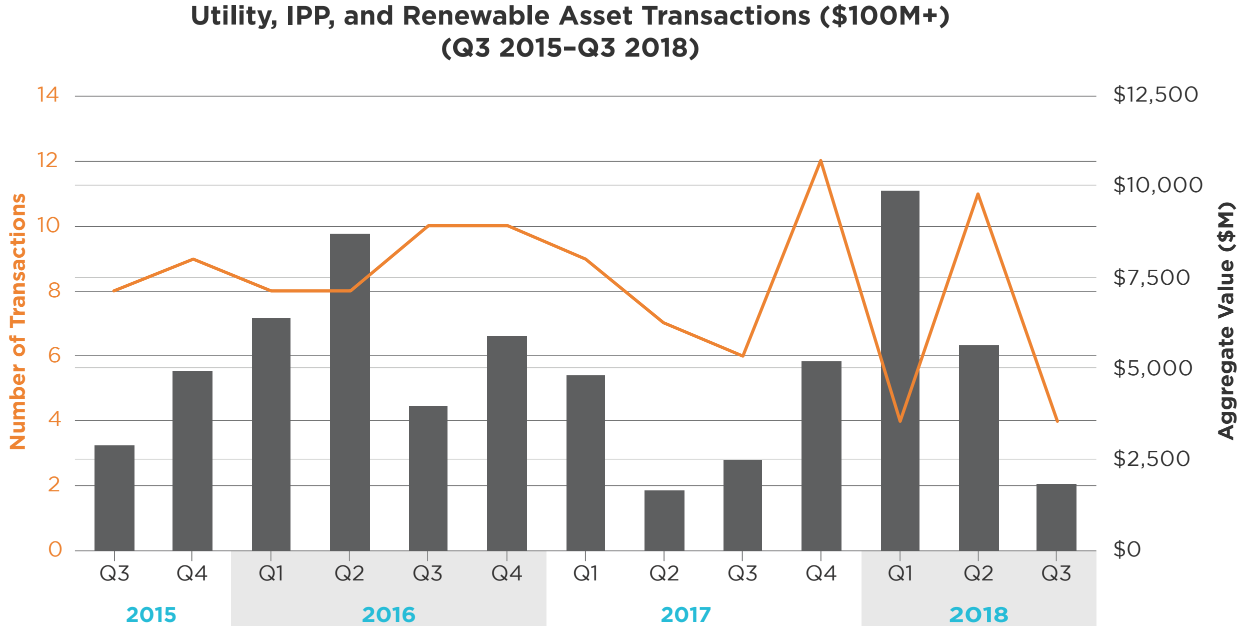
MERGERS AND ACQUISITIONS
THE DEALS KEEP COMING

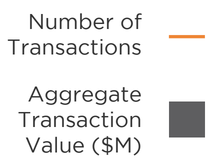
Energy and utility companies place some measured bets to grow their business.

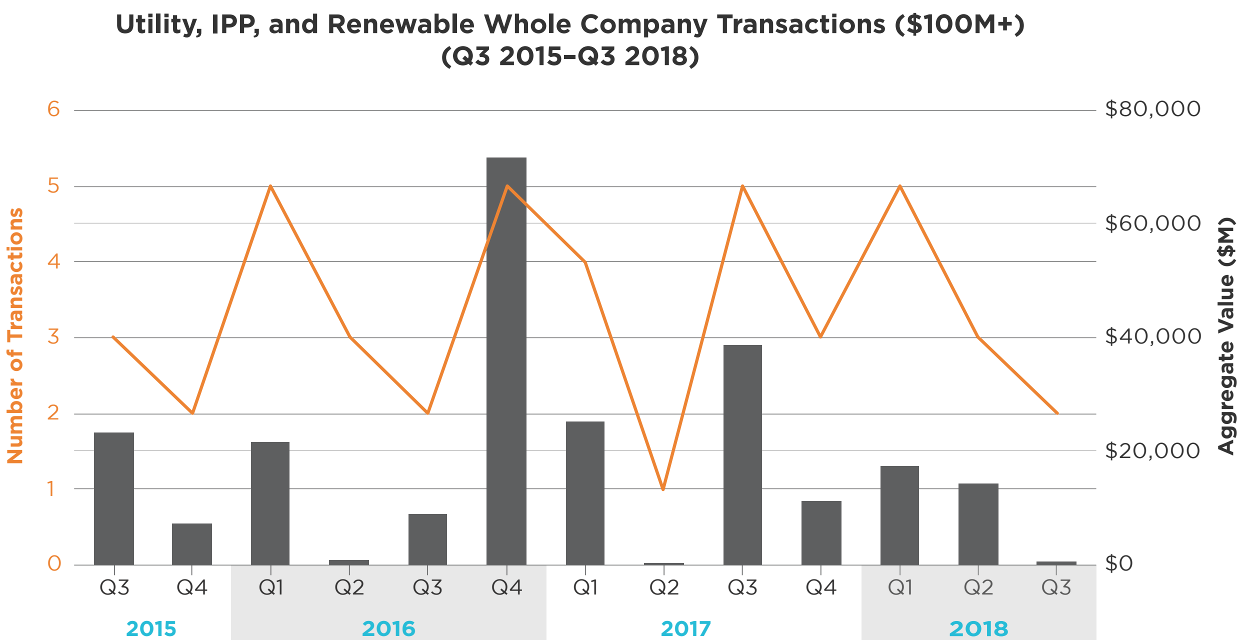
Merger Activity Continues, But No Boom

- North American energy and utility industry merger activity continues at a measured pace, reflecting both strategic ambitions and relatively high valuations
- A few large mega-deals accounted for significant aggregate deal value both in the utilities sector as well as gas midstream and upstream sectors
- Despite still relatively low interest rates, increasing clarity on federal tax policy, particularly additional capital needs to offset write-downs of deferred tax assets, may also be a factor in slower transactional activity
- Corporate deal activity overall has been roughly on par with the same period in 2017, but aggregate announced deal value for larger (>$100M) deals year-to-date is $32B compared with Q1–Q3 2017 of more than $64B
- Larger asset deal activity has been greater in YTD 2018 compared with Q1–Q3 2017, totaling $17B versus $9B, largely for acquisition of both renewable and thermal generation









Note: Q3 2018 through early August

Source: S&P Global Market Intelligence

KEY TAKEAWAYS

- **Merger and acquisition activity continues, but it has been dominated recently by a few mega-deals**
- **Further oil and gas consolidation, especially in the upstream sector, is expected as smaller players in high-cost basins seek to exit**
- **Utilities face near-term balance sheet challenges, rising interest rates, and an evolving regulatory environment, which may keep mergers and acquisitions to a measured pace**

Selected Significant Proposed Energy and Utility Merger and Acquisition Transactions Since January 2017

Acquiror	Seller	Target	Target Sector	Target Region	Announced/ Closed	Transaction Value*
NextEra Energy	Southern Co.	Gulf Power Co.	Electric utility	Southeast	May 21, 2018/ Pending	$5.66B
NextEra Energy	Southern Co.	Pivotal Utility Holdings, Inc.	Gas utility	Southeast, Mid-Atlantic	May 21, 2018/ July 29, 2018	$0.53B
South Jersey Industries, Inc.	Pivotal Utility Holdings, Inc.	Elkton Gas, Elizabethtown Gas companies	Gas utility	Mid-Atlantic	Oct. 16, 2017/ July 1, 2018	$1.7B
Energy Transfer Equity, L.P.		Energy Transfer Partners, L.P.	Oil & gas midstream	National	Aug. 1, 2018/ Pending	$66.14B
Investor group	Discovery Midstream Partners, LLC	TPG Capital Management, L.P.	Oil & gas midstream	Denver-Julesberg Basin (Colorado)	July 30, 2018/ Pending	$1.17B
Government of Canada	Kinder Morgan, Inc.	Trans Mountain pipeline system & expansion project	Oil & gas midstream	Western Canada	May 29, 2018/ Pending	$3.46B
Enbridge Inc.		Enbridge Energy Partners, L.P.	Oil & gas midstream	Midwest, Upper Midwest	May 17, 2018/ Pending	$13.92B
Cleco Corporate Holdings, LLC	NRG Energy, Inc.	South Central Generating, LLC	Electric utility	South-central Mississippi Valley	Feb. 7, 2018/ Pending	$1.0B
Global Infrastructure Management, LLC	NRG Energy, Inc.	NRG's renewable energy business	Independent power producers	National	Feb. 7, 2018/ Pending	$8.08B
Vistra Energy Corp.		Dynegy Inc.	Independent power producers	National	Oct. 30, 2017/ Apr. 9, 2018	$10.39B
Diamondback Energy, Inc.		Energen Corp.	Oil & gas production	Permian Basin (Texas, New Mexico)	Aug. 14, 2018/ Pending	$9.25B
CenterPoint Energy, Inc.		Vectren Corporation	Combination utility	Midwest	Apr. 23, 2018/ Pending	$8.13B
Dominion Energy, Inc.		SCANA Corporation	Combination utility	Southeast	Jan. 3, 2018/ Pending	$14.35B
Sempra Energy		Oncor Electric Delivery Company, LLC	Electric utility	Texas	Aug. 21, 2017/ Mar. 9, 2018	$16.48B
Eversource Energy		Connecticut Water Service, Inc.	Water utility	Northeast	Apr. 5, 2018/ Pending	$0.77B
Investor group		Calpine Corporation	Independent power producers	National	Aug. 18, 2017/ Mar. 8, 2018	$16.49B
Hydro One Limited		Avista Corporation	Electric utility	Pacific Northwest	July 19, 2017/ Pending	$5.3B
ONEOK, Inc.		ONEOK Partners, L.P.	Gas utility; oil & gas midstream	Central United States	Feb. 1, 2017/ Jun. 30, 2017	$16.84B
AltaGas Ltd.		WGL Holdings, Inc.	Gas utility	Mid-Atlantic	Jan. 25, 2017/ July 6, 2018	$6.9B

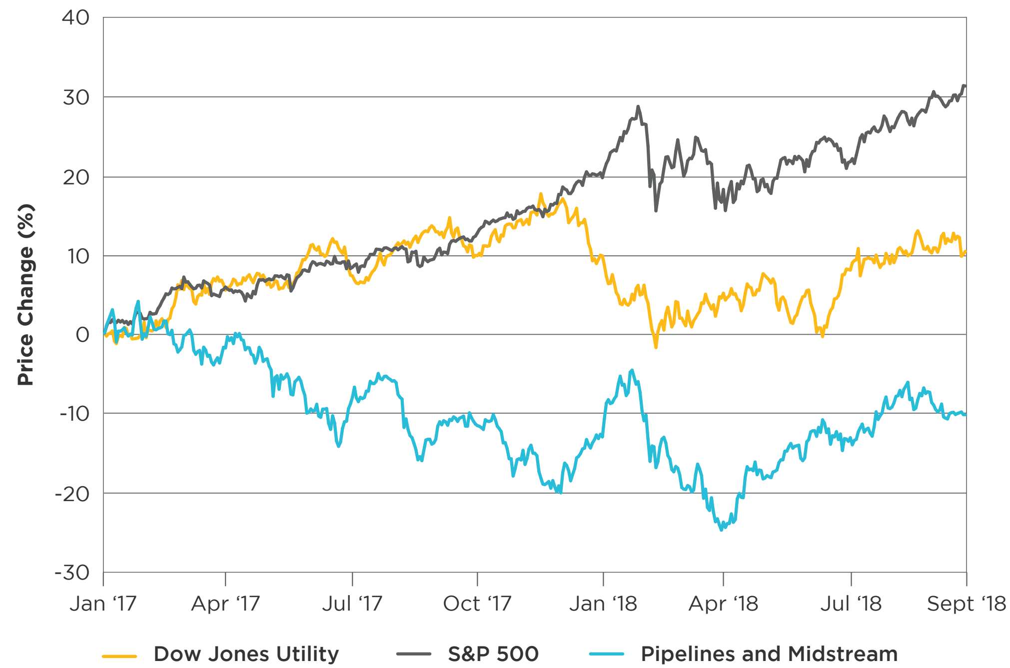
Notes: *Information as of late August 2018; **Purchase price plus assumed debt

Sources: S&P Global Market Intelligence; ScottMadden research

Different Sectors, Different Drivers

- Merger activity is being pursued in different sectors for varying reasons
- For electric investor-owned utilities, rationales include:
  - Rebalancing the business portfolio
  - Broadening the territorial footprint
  - Strengthening the balance sheet by monetizing assets
  - Expanding into the renewables sector
  - Making measured bets in areas such as technology
- Some large midstream acquisitions have been driven by an interest in simplifying and restructuring existing master limited partnership (MLP) arrangements, which had been seen as undervalued
  - Simplification permits sponsors to return cash to MLP unit holders
  - In addition, cash payouts formerly payable to general partners can now be used for business reinvestment
  - Importantly, tax law changes reduced the attractiveness of MLPs as did FERC's March 2018 decision not to permit pipeline MLPs to recover income tax allowance in pipeline cost-of-service rates, a decision that has since been eased
- Growth through regulated gas distribution utility exposure continues to be of interest (e.g., Alta Gas/WGL, CenterPoint/Vectren)
- In upstream gas (and oil), an emerging trend is for players in higher cost-per-acre plays like the Permian to seek opportunities for consolidation and cost reduction (e.g., Diamondhawk/Energen)

Price Change of Selected Stock Indexes (Dec. 30, 2016–Sept. 21, 2018)



Source: S&P Global Market Intelligence

Valuations

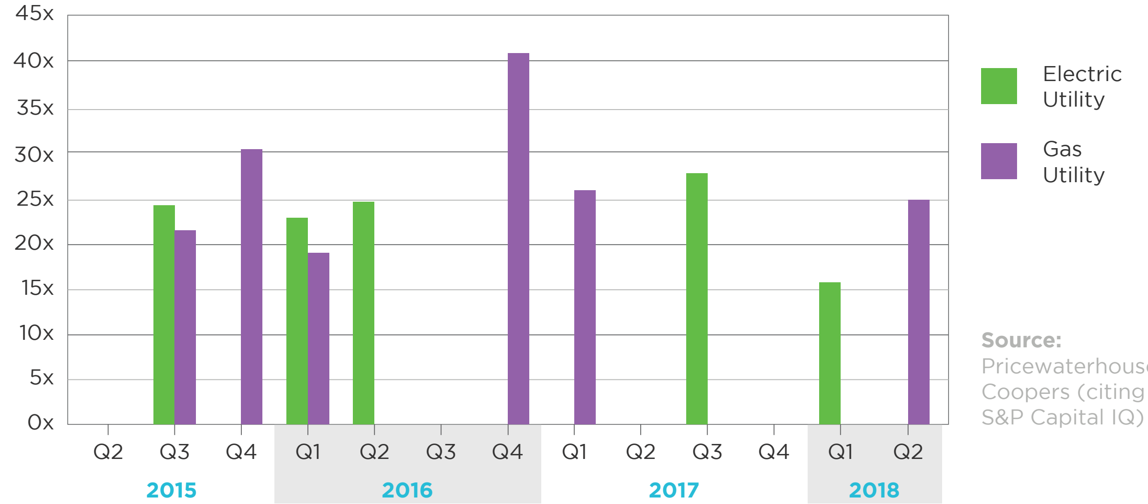
- For recent large, strategic transactions in the utility sector, announced deal values range from 1.3 to nearly 3.2 times book value, implying idiosyncratic value opportunities for some acquirors
- Transaction multiples for electric utilities have ticked down in 2018, while roughly holding steady for gas utility deals (see chart at right)
- Overall, market valuations are not getting cheaper with the Dow Jones Industrials trading recently near 19 times earnings, but large, diversified utilities' trailing year price-earnings ratios have fallen back below their five-year average of 21.4, and price-to-book values hover around their long-term average of 1.9 times
- A key question is whether financial overhang from tax law adjustments, pending Federal Reserve-driven interest rate increases, and an evolving regulatory environment will temper future deal activity

IMPLICATIONS

While utility valuations are not exorbitant by historical standards, a better play for some acquisitive utilities may be to look out for modest-sized deals—assets or companies—that round out the resource portfolio (e.g., renewables) or some regulatory or geographic diversification in the core business.

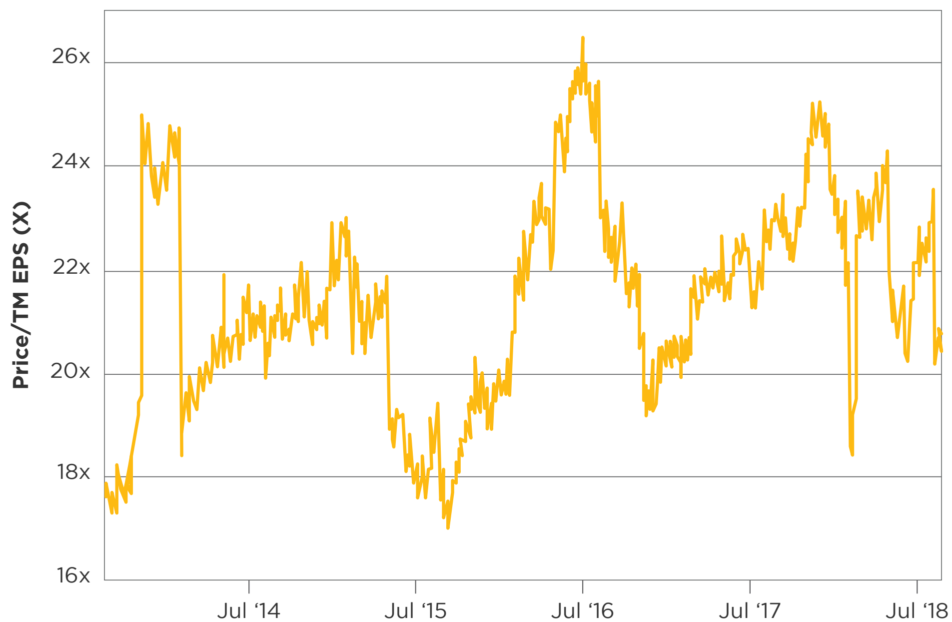
Sources: *The Wall Street Journal*; S&P Global Market Intelligence; industry news; company presentations; PricewaterhouseCoopers; S&P Capital IQ; ScottMadden analysis

Electric and Gas Utility Price-Earnings Multiples (Deals $50M+) (Q2 2015–Q2 2018)



Source: Pricewaterhouse Coopers (citing S&P Capital IQ)

SNL Energy Large Diversified Utility Index Price-to-Latest Twelve Months Earnings Ratio (Aug. 2013–Aug. 2018)



Source: S&P Global Market Intelligence

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Energy Supply, Demand, and Markets

EFFICIENT ELECTRIFICATION
THE ELECTRIC INDUSTRY SEES A GROWTH OPPORTUNITY

Electrification could grow energy sales, but by how much?

A Working Definition

- Electrification is the process of switching from the combustion of non-electricity fuel (e.g., natural gas or propane) to using electricity to provide a comparable service
- Electrification can affect most energy usage sectors (buildings, industrial, and transportation), albeit to differing degrees
- The Electric Power Research Institute (EPRI) recently prepared a national electrification estimate, selected results of which are outlined later
  - The electrification of the transportation sector is widely seen as having the largest potential increase in electricity usage
  - Space and water heating are also seen as having a high electrification potential but face potentially slower electric adoption, at least for retrofits, due to initial fixed costs (to purchase and install new equipment) and generally long useful lives of existing stock

Utility Electrification: Examples for Selected Customer Segments	
Transportation	California's regulated utilities were recently authorized to spend a collective $738M to support the electrification of the transportation sector through the installation of electric vehicle supply equipment
Residential	Dakota Electric Association and Great Rivers Energy partnered with a homebuilder to install grid-interactive electric water heaters
Industrial	Tennessee Valley Authority incentivizes the switch from ICE forklifts to electric forklifts

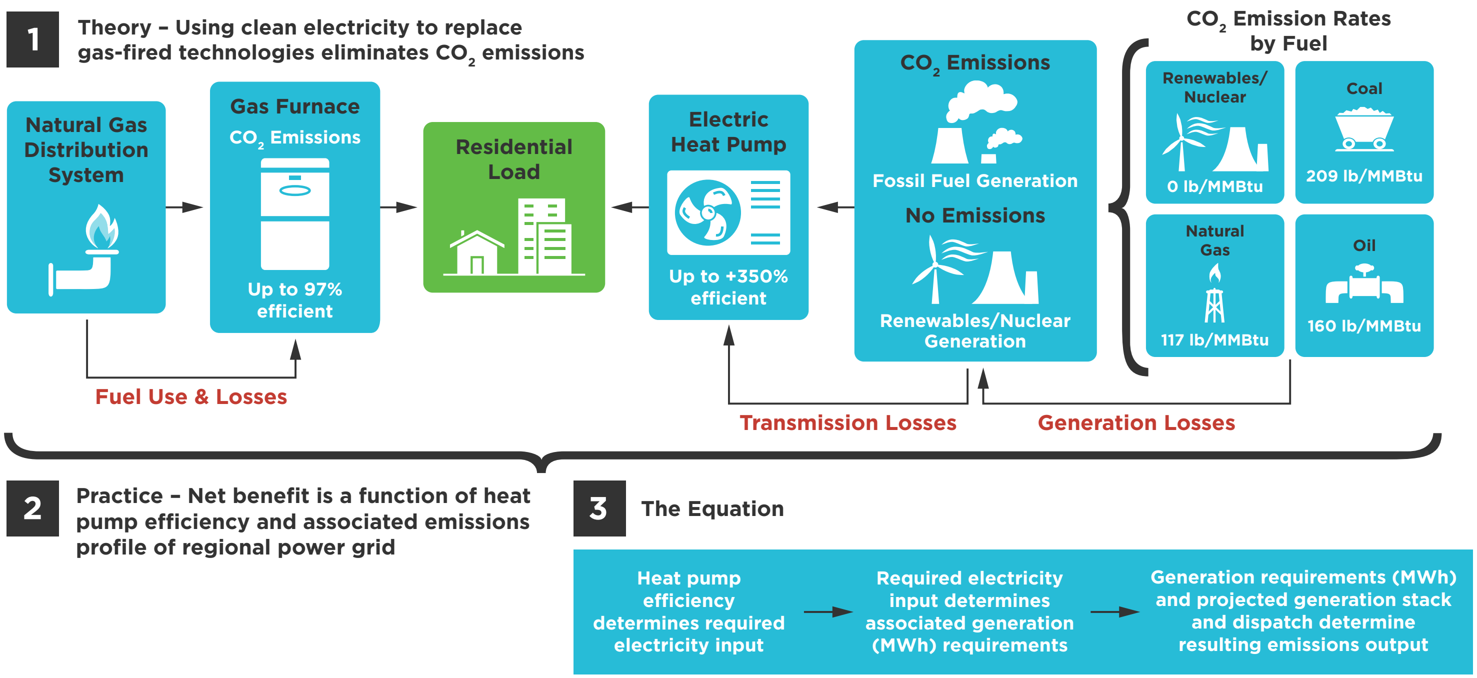
Different Players, Different Interests in Electrification

- In the face of declining loads due to efficiency gains and a less energy-intensive economy, electricity providers see electrification as a source of increased load
- Environmental and climate change advocates see environmental benefits from electrification, along with the decarbonization of electric generation, as a key component for cost-effective reduction in global emissions
- Local governments are interested in electrification (electric public transportation and limits on non-electric vehicles) to reduce local air pollution

Some Hurdles to Electrification

- Environmental benefits of electrification depend upon some key premises or assumptions: increasing energy efficiency (offsetting consumption growth) and a relatively less carbon-intensive power production resource mix
- In addition to high fixed costs for space and water heating, low natural gas costs may impede adoption of electric technology applications, although relatively higher fuel oil and propane prices (depending upon efficiencies) may make some applications better candidates for conversion
- Location matters for some "electrified" applications, such as heat pumps, which have historically not performed as well in very cold climates (although there have been some efficiency improvements) and often require a supplemental heat source

Residential Electrification Theory (AGA's View)



Source: Adapted from AGA

KEY TAKEAWAYS

- **EPRI believes that electrification of non-electric end uses is expected to increase electricity's share of final energy from 21% today to 32% to 47% of final energy in 2050**
- **The transportation sector has the highest and most immediate potential of electrification, while electricity could continue to displace natural gas in the buildings sector**
- **Grid planning and modernization will be especially critical for grid operators as electrification is expected to change load profiles in addition to increasing peak loads and load factors**
- **High upfront costs, low natural gas prices, incumbency technology advantages, and technological challenges may prevent the widespread electrification of some applications**

Any electrification scenario depends upon assumptions about technology, prices, and behavioral responses.

EPRI's U.S. National Electrification Assessment: Key Points and Issues

Findings and Scenario Results	Assumptions	Issues to Consider
Electricity growth: 32% electricity growth between 2015 and 2050 (0.8%/year); compare 1.2% for Transformation scenario	**Natural gas price:** $4/MMBtu natural gas price over next 30+ years; higher ($6/MMBtu cost by 2050 in Transformation scenario yields more electrification)	Predicting fluctuations and trajectory of natural gas prices is notoriously difficult
Energy: Overall energy consumption (all fuels) decreases by 22% by 2050	**Carbon price:** No carbon price in base case; starts at $50/ton in 2020 in Transformation scenario	Cost of electricity is a key variable and differs by region, affecting electric adoption
Transportation: Electric share of transportation (rail, truck, bus) grows from 1% today to 40% by 2050	**ICE vehicles efficiency:** 50 miles per gallon by 2050 for internal combustion engines	Space heating is highly dependent upon heat pump performance improvements and availability of relatively inexpensive power
Electric vehicles: Electric and hybrid vehicles reach 40% of new vehicle sales by 2030 and 75% by 2050	**VMTs:** Electric vehicles comprise 25% of vehicle miles traveled by 2030, rising to 70% by 2050	Upfront capital costs can be significant and may pose a barrier to retrofitting, although new stock might be amenable to increased electric applications
Buildings: Heat pump space heating grows from 15% of square footage today to 50% by 2050; increases driven by growth in warmer climates and availability of gas backup in colder climates	**EV battery:** Li-ion battery costs for electric vehicles assumed to decline to about $50/kWh by 2050	Consumer behavior is uncertain and multi-faceted: price, incentives, inertia, income all play a role
	Generation fuel mix: Increasing shift from coal-fired to gas-fired power generation (including carbon capture and sequestration) and increased solar and wind	Role of mandates and incentives must be defined, including any cost of greenhouse gas emissions, as well as implications for utility rates and rate design
		Interaction of increased power demand (time, amount, location) and related gas demand may yield unforeseen market outcomes
		Transition time is uncertain and may depend upon a technology adoption "tipping point"

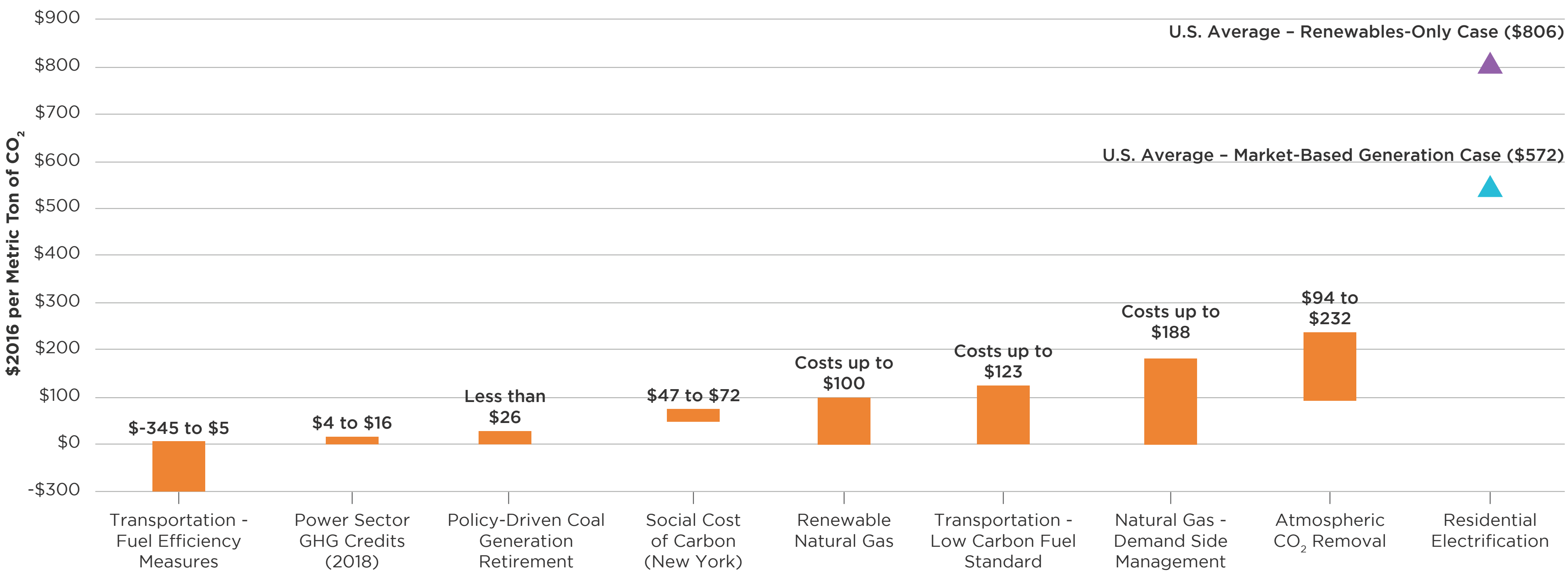
Sources: EPRI Electrification Reference scenario; ScottMadden analysis

A key question: How much work is performed using how much primary energy and producing how much in emissions?

Gas Utilities May Have a Different View of Electrification, Especially for Residential Customers

- The American Gas Association (AGA) recently studied potential impacts of "policy-driven" electrification of the residential sector
- Their key conclusions are summarized below:
  - ***Magnitude of emissions savings:*** With residential natural gas sector CO_2 emissions less than 4% of total, payoff from electrification may be limited
  - ***Shifting emissions:*** Electrification will lead to higher power sector emissions
  - ***Grid use changes:*** Changes in power use will lead to winter peaks and higher grid utilization, which AGA says would require incremental grid and energy resource investment
  - ***Customer costs:*** Total energy costs for customers, including incremental amortized appliance and grid costs, would increase by 38% to 46%
  - ***Expensive GHG reduction:*** AGA's analysis pegs GHG emissions reduction costs of $572 to $806 per metric ton, higher than other emissions reduction options
  - ***Not addressed – gas distribution stranded costs:*** AGA's analysis did not look into cost implications of lower residential direct use of gas (e.g., fixed-cost allocation to gas customers)

Comparison of Cost Ranges for GHG Emissions by Reduction Mechanism (AGA Estimates)



Source: AGA

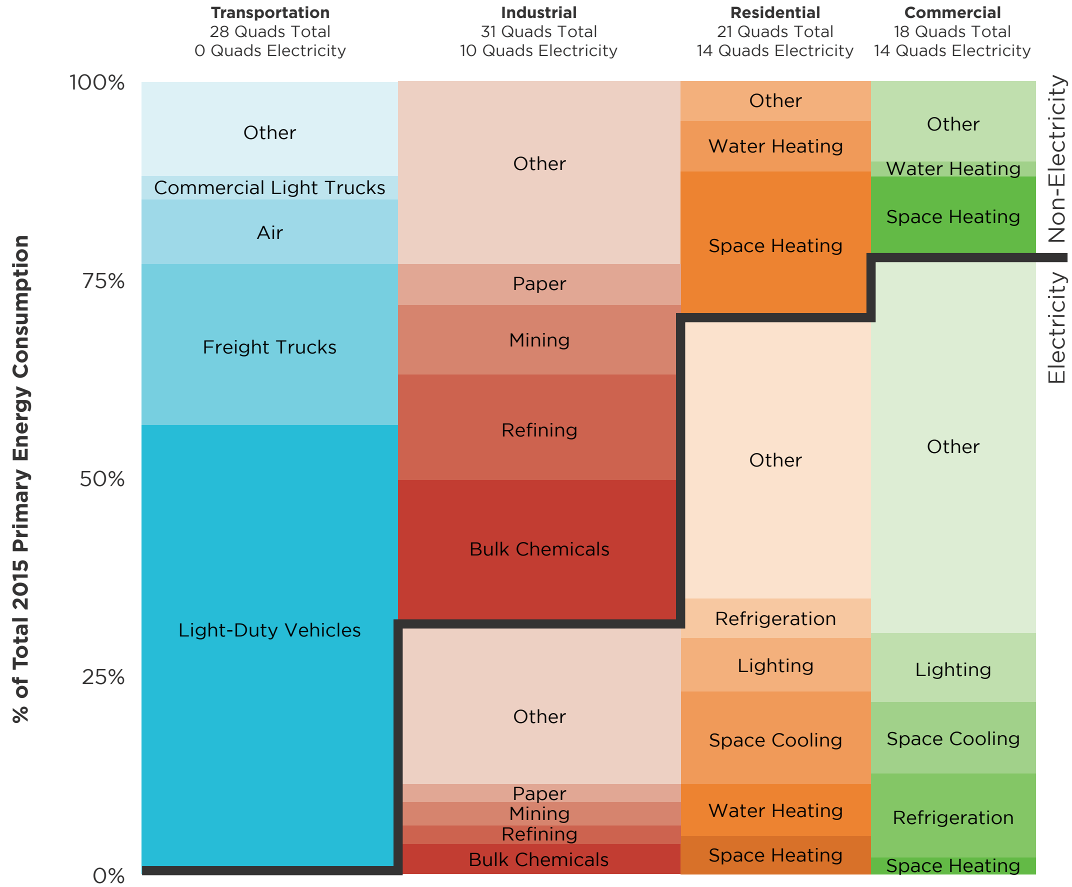
Policymakers to Contemplate Their Role

- Regulators will view electrification through a cost-benefit lens and are reluctant to intervene absent a market failure or impediment
- Regulatory-driven electrification would modify policy focus from energy efficiency to GHG emissions reduction, requiring broader, end-to-end emissions analysis
- Broad free-rider problems may appear if utilities "electrify" at a local or state level while the rest of the world does not
- There appears to be some consensus that transportation electrification, especially electric vehicles, is where market adoption is more imminent
- For other technologies, a key question: should public policy "push" electrification, or should markets drive technology evolution and adoption?

Transportation Sector Transformed by Light-Duty Vehicles in EPRI Electrification Scenarios

- EPRI sees transportation electrification as the leading driver of efficient electrification
- EPRI's Reference scenario sees electricity's share of transportation energy increasing from a meager 0.1% in 2016 to 25% in 2050
- Lower operating costs (fuel and maintenance) of light-duty PEVs outweigh the higher upfront costs, incentivizing customers to choose PEVs over traditional ICEs, but this growth segment assumes those buyers drive at least 18,000 miles per year (50% greater than average)
- Electric heavy-duty vehicles have an opportunity for higher savings compared to ICEs, as utilization factors of heavy-duty vehicles are much higher than light-duty vehicles

Primary U.S. Energy Consumption Shares in 2015: Where Opportunities (or Limits) Might Lie for Electrification



Source: NREL

Building Efficiency Outweighs Electrification

- By 2050, EPRI expects that efficiency gains will offset any increase in electricity end use (in different building applications), decreasing electricity consumption for building end uses by 20% by 2050
- EPRI's electrification analysis projects additional heating applications
  - Electric heat pumps are expected to heat 50% of residential space heating by 2050, increasing from approximately 15%
  - Heat pump water heaters are expected to serve more than half of households by 2050, but this growth is dependent on the continuation of declining heat pump costs and an increasing displacement of electric resistance heating and non-electric fuels

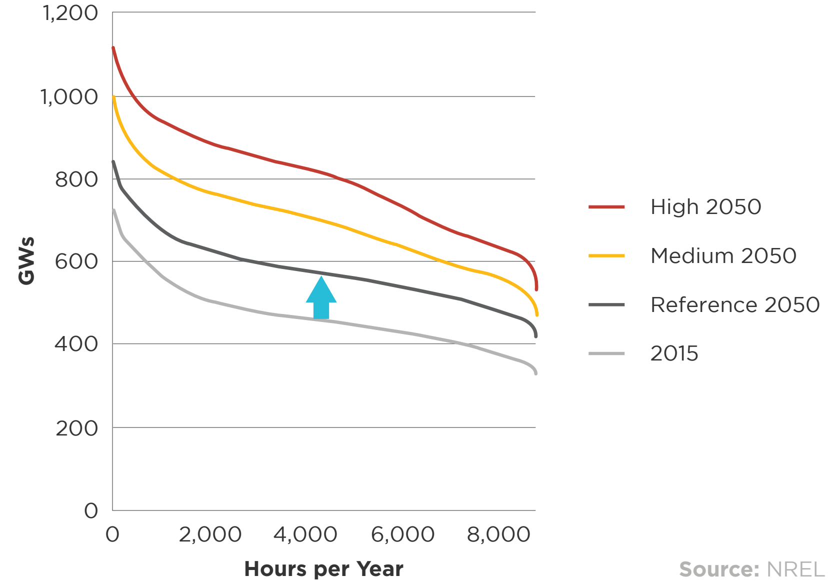
Electrification Increases Productivity of Industrial Sector

- EPRI contends that the electrification of industrial processes (induction melting and infrared drying) can improve product quality, productivity, and working conditions
- Industrial vehicles are also opportunities: for example, there has been widespread electrification of forklifts (currently two-thirds of U.S. forklifts are electric)

NREL's View: Increased Peak Demand and Other Potential Grid Impacts

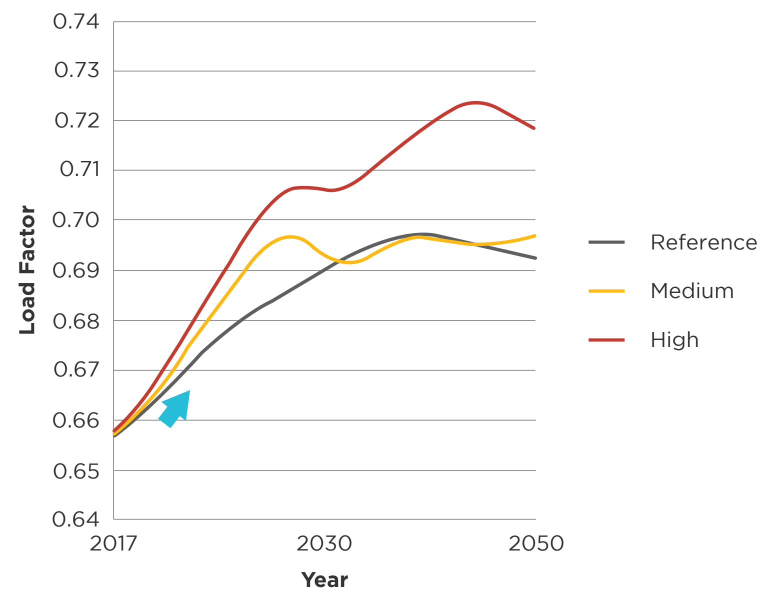
- National Renewable Energy Laboratory (NREL) performed analysis similar to EPRI's, studying three electrification scenarios
- NREL projects that winter demand will increase faster than summer demand due to the increased use of electric space heaters and heat pumps for space heating
- By 2050, due to the electrification of electric space heating, a greater fraction of the top 100 load hours during the year for southeastern states occurs during winter months; however, the absolute peak still occurs in the summer
- Load factor, the ratio of average-to-peak demand, is expected to increase due to electrification, possibly impacting the current generation mix
- Electrification, along with electric vehicle charging flexibility, could result in more uniform load (higher load factor) and possibly result in more consistent use of generation sources

Load Duration Estimates for NREL Electrification Scenarios (Current and in 2050)



Source: NREL

Load Factor Estimates for NREL Electrification Scenarios (2017 to 2050)



Note: Moderate technology advancement projections shown. Profiles shown include estimated impacts of flexible load as modeled. **Source:** NREL

Economics, Technology, and Regional Issues, Among Other Things, Could Restrain Widespread Electrification

- There is a significant amount of necessary investment in electric vehicle supply equipment (e.g., charging stations) to enable the adoption of the forecasted PEVs
- Additionally, challenges with electrifying large vehicles (vehicle range, battery size, added weight, and charging duration) and the continued low price of diesel fuel could limit the market for heavy-duty PEVs, compared to light-duty vehicles
- In some regions, increased electric load (particularly when supplied by gas-fired resources) could complicate fuel availability issues, especially in winter
- Adoption of electric technologies may be slowed by increased efficiencies in current technologies (e.g., ICEs) and by gas efficiency programs
- Non-electric technologies (mainly natural gas-fired) in the building sector have an installed base and some economic advantages depending upon technology. Widespread adoption of electric heat pumps is limited by upfront costs and lower efficiency than conventional cold-climate fuel-oil furnaces
- Electrification of industrial boilers offers little benefit to industrial facilities, many of which rely on fuel-fired boilers or cogeneration for a substantial amount of industrial energy end use; electric boilers provide only a marginal increase in productivity compared to the electrification of other industrial end uses

IMPLICATIONS

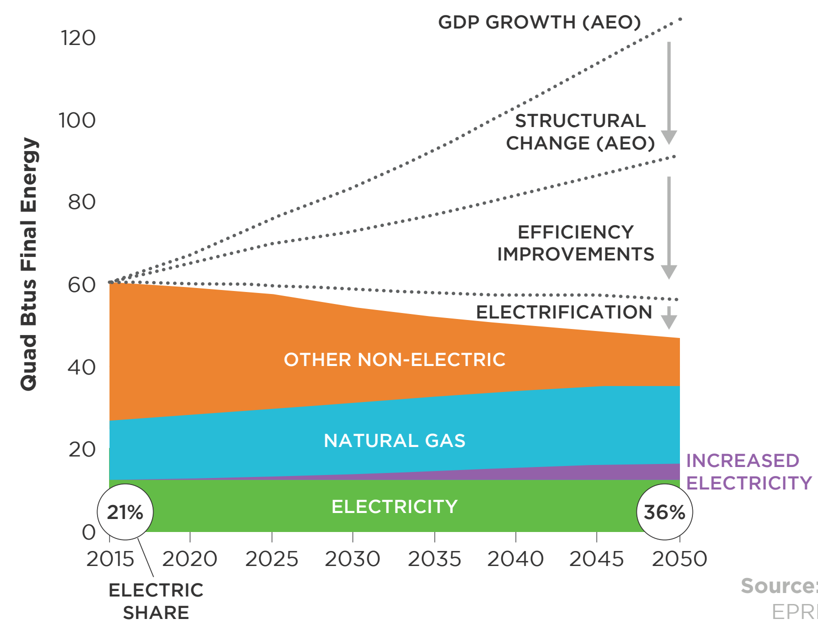
Efficient electrification may prove to be a growth strategy for electric utilities. Utilities and policymakers considering efficient electrification initiatives will need to look carefully at technology applications, potential adoption rates, customers' economic trade-offs, and grid and resource implications to assess costs and benefits, both financial and environmental.

Notes: GHG means greenhouse gas; ICE means internal combustion engine; VMT means vehicle miles traveled; PEV means plug-in electric vehicle. For additional discussion of electric vehicles, see relevant section at page 31 of this Energy Industry Update.

Sources: Electric Power Research Institute, U.S. National Electrification Assessment (April 2018); National Renewable Energy Laboratory (NREL), Electrification Futures Study: Scenarios of Electric Technology Adoption and Power Consumption for the United States (July 2018); American Gas Association, Implications of Policy-Driven Residential Electrification (July 2018); National Regulatory Research Institute, Electrification: The Link between Markets, Consumer Behavior, and Public Policy, Report No. 18-02 (January 2018); S&P Global Market Intelligence; industry news; ScottMadden analysis

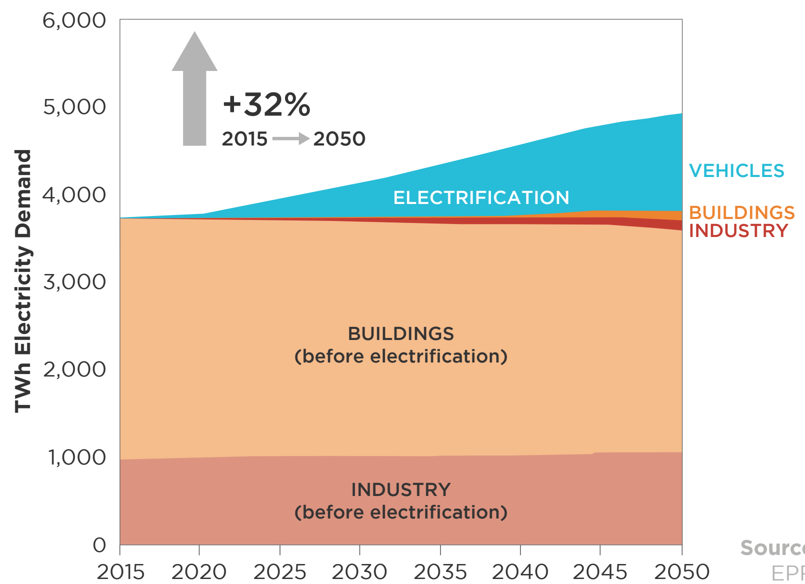
EPRI's Reference Scenario Projections for U.S. Total Final Energy by Fuel and Electricity Demand

Total Energy by Fuel (Quadrillion Btus) and Drivers



Source: EPRI

Electricity Demand (TWh) by Sector



Source: EPRI

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LIQUEFIED NATURAL GAS EXPORTS BEGIN RESHAPING BOTH DOMESTIC AND INTERNATIONAL MARKETS

The United States is on the cusp of being a major global LNG player.

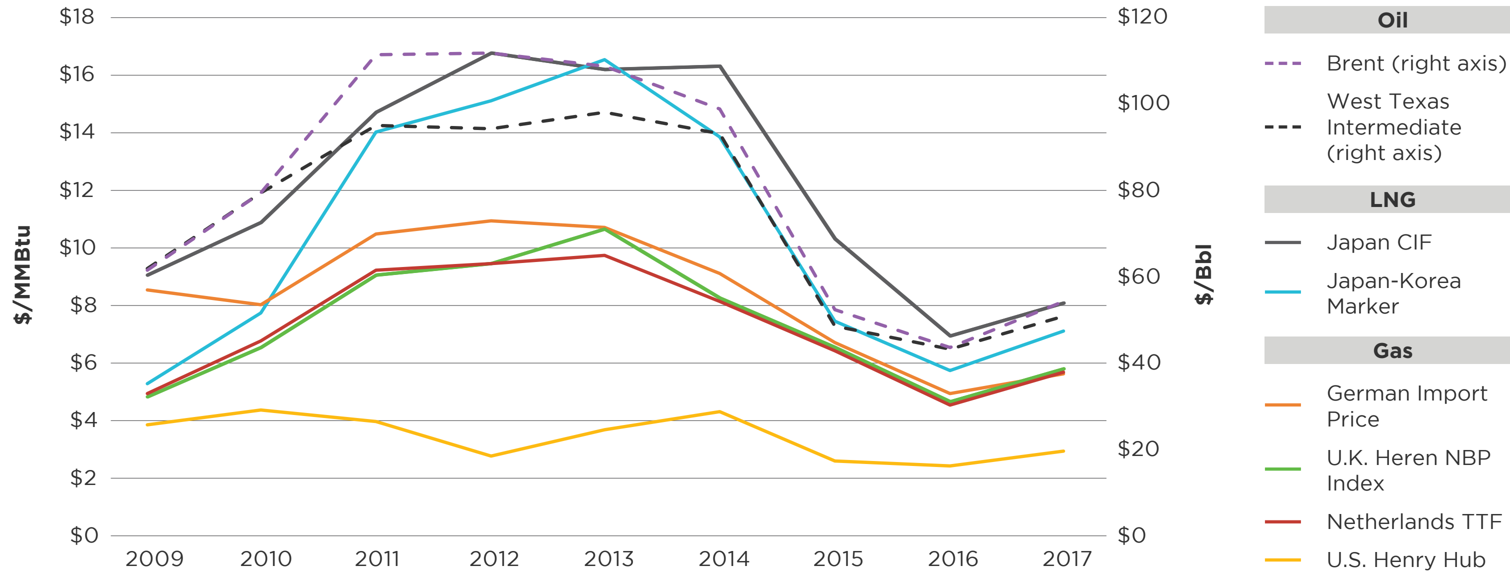
2017 Begins Wave of Increased U.S. Exports

- In 2017, U.S. liquefied natural gas (LNG) operational export capacity reached 1.94 BCF/day and operated at 91% utilization
- As of early September 2018, there were five operational trains in the United States, operating at 3 BCF/day (>23 MTPA)
  - Cheniere Energy's Sabine Pass: Four trains in Louisiana
  - Dominion's Cove Point: One train in Maryland
- In 2017, three countries received more than half of U.S. LNG exports: Mexico (20%), South Korea (18%), and China (15%)
- Exports from the United States to Asia were partially driven by a decline in Henry Hub gas prices—to which certain LNG prices are indexed—versus crude oil prices, which serve as a benchmark for Asia LNG
- Due to delays in the construction of pipelines connecting it to the United States, Mexico increased its reliance on U.S. LNG to satisfy gas demand from its power generation sector
- About 60% of exported U.S. LNG was transacted on the spot market, and the price of exported LNG averaged $4.65/MCF in June 2018 and had a range of $3.65/MCF to $6.44/MCF from June 2016 through June 2018

KEY TAKEAWAYS

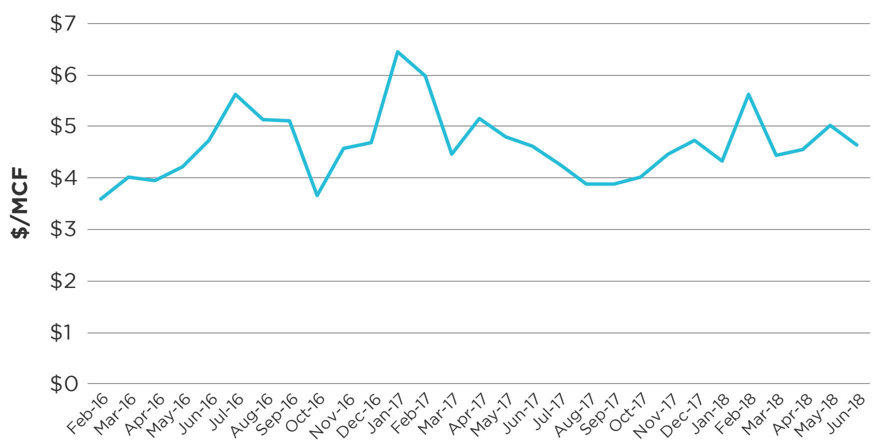
- **Increased global demand for LNG, especially in Asia, is responsible for the majority of last year's increase in global LNG trade, with this trend expected to continue over the next 20 years**
- **The United States and Australia are both poised to meet growing demand for LNG**
- **Completion of LNG export terminals currently under construction will more than triple U.S. export capacity in the next two years to 10 BCF/day, volumetric equivalent to 13% of average daily natural gas consumption in 2017**
- **Due to the overwhelming number of export terminal applications, FERC has made operational changes in an attempt to review applications in a reasonable timeframe**

Average Annual Global Gas and Oil Prices (2009–2017) ($/MMBtu and $/Bbl)



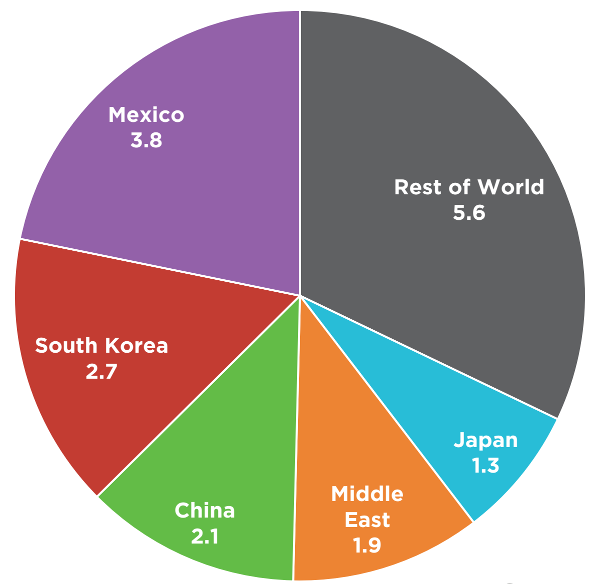
Source: BP

Monthly Average Price of U.S. LNG Exports (Feb. 2016–June 2018) ($/MCF)



Source: EIA

2017 U.S. LNG Exports by Destination Country/Region (Incl. Re-Exports) (in Billion Cubic Meters)



Source: BP

U.S. LNG Export Projects (Under Construction)

Facility and Train	Owners	Location (State)	Capacity (MTPA)	Latest Announced Start Year		
				2018	2019	2020
Elba Island LNG T1-6	Kinder Morgan, EIG Global Energy Partners	GA	1.5	✓		
Cameron LNG T1	Sempra, Mitsubishi/NYK JV, Mitsui, ENGIE	LA	4.0		✓	
Corpus Christi LNG T1	Cheniere	TX	4.5		✓	
Freeport LNG T1	Freeport LNG, JERA, Osaka Gas	TX	5.1		✓	
Sabine Pass LNG T5	Cheniere, Blackstone	LA, TX	4.5		✓	
Cameron LNG T2	Sempra, Mitsubishi/NYK JV, Mitsui, ENGIE	LA	4.0		✓	
Elba Island LNG T7-10	Kinder Morgan, EIG Global Energy Partners	GA	1.0		✓	
Corpus Christi LNG T2	Cheniere	TX	4.5		✓	
Freeport LNG T2	Freeport LNG, IFM Investors	TX	5.1		✓	
Cameron LNG T3	Sempra, Mitsubishi/NYK JV, Mitsui, ENGIE	LA	4.0		✓	
Freeport LNG T3	Freeport LNG	TX	5.1			✓

Source: IGU

U.S. Export Terminal Construction: The Trains Keep Rollin'

- In the next two years, the following projects are expected to become commercially operational: Elba Island LNG (Georgia) and Cameron LNG (Louisiana) in 2018, Freeport LNG (Texas) and Corpus Christi LNG (Texas) in 2019, and Sabine Pass (border of Louisiana and Texas), with more than 7.1 BCF/day peak LNG terminal capacity expected in service by the end of 2019
- A total of 11 liquefaction trains on the U.S. Gulf Coast are projected to come online in the next five years, increasing domestic export capacity to almost 10 BCF/day (76 MTPA) by 2020, and more than 11 BCF/day (85 MTPA) by 2023, which could result in U.S. LNG exports comprising about 20% of global LNG exports by 2023 and potentially making the United States the world's swing LNG supplier
- For reference, U.S. dry gas production totaled 27.3 TCF, or about 74.8 BCF/day; 11 BCF/day would be the equivalent of nearly 15% of U.S. dry gas production
- Of the 92 MTPA liquefaction capacity under construction worldwide in March 2018, more than half (49 MTPA) was in the United States, which should propel the United States to be the largest source of incremental liquefaction capacity through 2023
- Alaska Gasline Development Corporation, a state-sponsored developer, recently signed a deal with Exxon Mobil to help supply its three-train (20 MTPA) LNG terminal, which could come online in 2024

Global LNG Market Demand Is Growing

- LNG is the fastest growing gas supply source globally
- Led by Asian countries, which represented 74% of the increase, global LNG trade increased 10% (3.5 BCF/day) in 2017, reaching 38.2 BCF/day
- Driven by record-high demand due to environmental regulations focused on reducing air pollution, China's imports of LNG increased 1.6 BCF/day (46%) in 2017 to an average of 5 BCF/day, surpassing South Korea to make China the world's second largest importer of LNG, behind Japan's imports of 11 BCF/day
- Japan and South Korea continue to import LNG for power generation to offset low nuclear power production

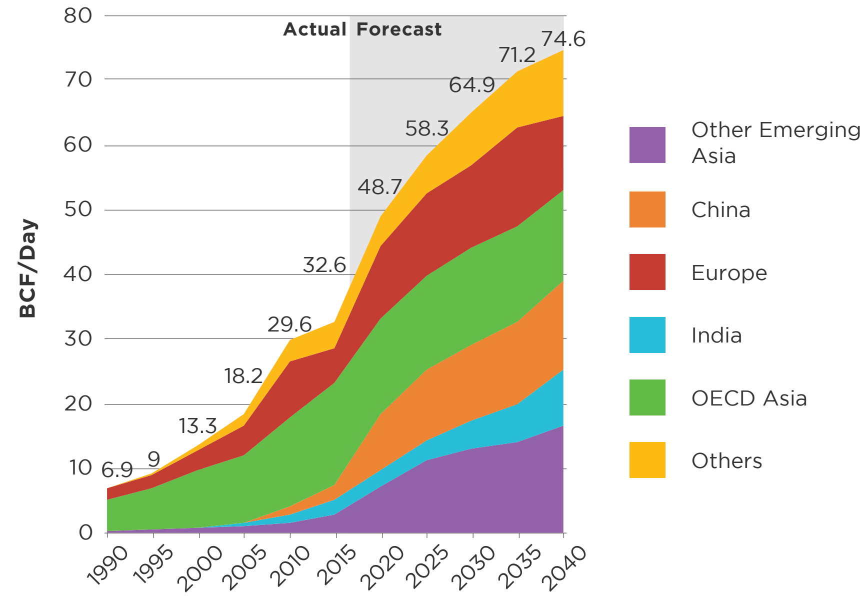
United States Poised to Supply Much of That Growth

- Australia, Russia, and the United States added a combined 3.4 BCF/day of export capacity in 2017, with Australia and the United States comprising the two largest increases in exports (adding 2.7 BCF/day of capacity in 2017)
- In the next three years, U.S. export capacity is expected to surpass 10 BCF/day, which would be about 10% of U.S. gas demand

Monitoring Domestic Price Impacts

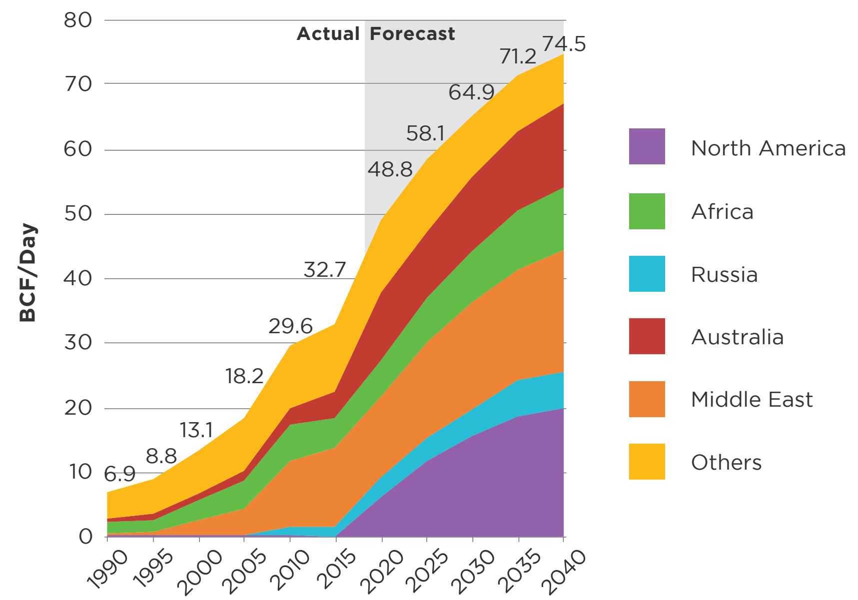
- Increasing LNG exports have led some U.S. agencies to re-examine the potential for impacts on domestic natural gas prices
- The DOE and the CFTC did independent, scenario-based studies of this issue and came to divergent conclusions
  - The CFTC study found that increasing exports could increase domestic gas prices anywhere from negligibly to up to 20% (for reference: in 2017, the average natural gas price at Henry Hub was $2.99/MMBtu)
  - The DOE study found that increasing LNG exports leads to only small increases in gas prices by 2040
  - DOE's reference case estimated domestic gas prices in a range of $5 to $6.50 per MMBtu (in 2016$), even with increased exports
  - Both reports noted that price impacts were highly dependent upon domestic production response

Actual and Forecast LNG Imports by Region (BCF/Day)



Source: BP

Actual and Forecast LNG Exports by Region (BCF/Day)

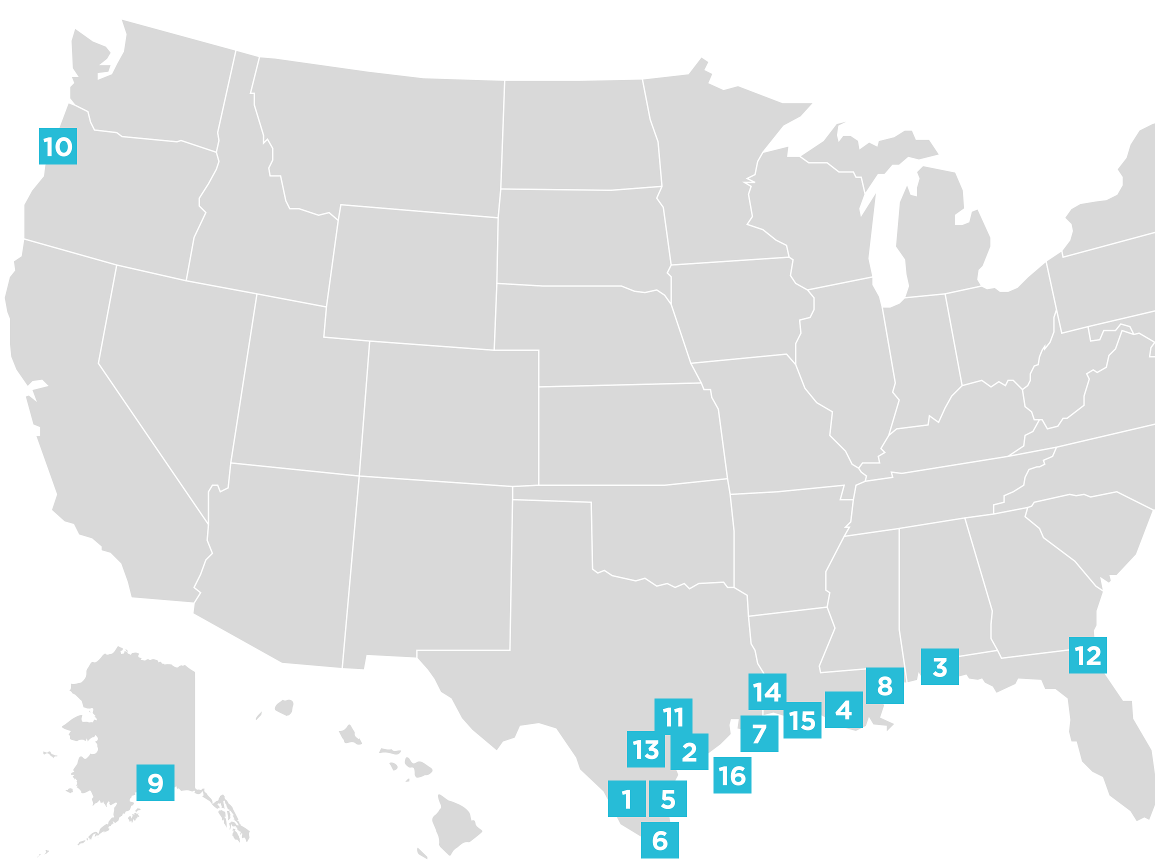


Source: BP

FERC Streamlines LNG Applications to Reduce Lag

- In response to long review times for LNG terminal applications and the issuance of revised notices of schedule for two projects, FERC recently addressed its review process in an attempt to streamline LNG project applications
- On August 31, FERC issued environmental schedules for 12 LNG terminal applications, which, according to Chairman Kevin McIntyre, are nine to 12 months shorter due to FERC's improvements in their regulatory process
- Also on August 31, FERC released information on steps it had taken to improve the LNG application process
  - FERC and PHMSA agreed to coordinate the siting and safety reviews of LNG facilities, requiring the approval of safety standards from PHMSA prior to FERC's review if the project is in the public's interest
  - Addition of FERC staff focused on LNG
  - An outside contractor will assist in construction inspections
  - Third-party contractors may review non-proprietary application information

Proposed U.S. LNG Export Plants (as of June 2018)



	Location	Size (BCF/d)	Company
	PENDING FERC APPLICATIONS		
1	Brownsville, TX	3.60	Rio Grande LNG — NextDecade
2	Port Arthur, TX	1.86	Port Arthur LNG
3	Pascagoula, MS	1.50	Gulf LNG Liquefaction
4	Cameron Parish, LA	1.41	Venture Global Calcasieu Pass
5	Brownsville, TX	0.90	Annova LNG Brownsville
6	Brownsville, TX	0.55	Texas LNG Brownsville
7	Calcasieu Parish, LA	4.00	Driftwood LNG
8	Plaquemines Parish, LA	3.40	Venture Global LNG
9	Nikiski, AK	2.63	Alaska Gasline
10	Coos Bay, OR	1.08	Jordan Cove
11	Freeport, TX	0.72	Freeport LNG Dev
12	Jacksonville, FL	0.13	Eagle LNG Partners
	PROJECTS IN PRE-FILING		
13	Corpus Christi, TX	1.86	Cheniere — Corpus Christi LNG
14	Cameron Parish, LA	1.18	Commonwealth, LNG
15	LaFourche Parish, LA	0.65	Port Fourchon LNG
	PROPOSED TO U.S.-MARAD/COAST GUARD		
16	Gulf of Mexico	1.80	Delfin LNG

Source: Platts (citing FERC)

IMPLICATIONS

The race to build export terminals is in stark contrast to 2005 when import facilities were being constructed and the EIA estimated that the United States would import 18 BCF/day by 2025. A high level of North American LNG export facility construction activity is focused in a few select regions: Gulf Coast, U.S./Canada West Coast (British Columbia and Alaska), and Nova Scotia. There is a diversity in U.S. export markets with 24 countries already having received U.S. exports in 2018, but it is highly concentrated with three countries (Mexico, South Korea, and China) comprising half of total U.S. exports; thus, any change to one of these markets could have a significant impact.

Notes: LNG means liquefied natural gas; DOE means U.S. Dept. of Energy; CFTC means U.S. Commodity Futures Trading Commission; PHMSA means U.S. Pipeline and Hazardous Materials Safety Administration; MTPA means million metric tons per annum; BCF means billion cubic feet; MCF means thousand cubic feet; TCF means trillion cubic feet; Bbl means barrel. One BCF/day roughly equals 7.6 MTPA. An LNG "train" is a natural gas liquefaction and purification unit.

Sources: U.S. Energy Information Administration; U.S. Dept. of Energy; U.S. Federal Energy Regulatory Commission; U.S. Commodity Futures Trading Commission; S&P Global Market Intelligence; Platts; Bloomberg New Energy Finance; RBN Energy; *Natural Gas Week*; International Gas Union (IGU), 2018 World LNG Report (July 2018); BP, 2018 Energy Outlook (Feb. 2018); BP, Statistical Review of World Energy (June 2018); R. Hickman, Royal Dutch Shell, "The Growing Importance of U.S. Petroleum and LNG Exports," presented at 2018 EIA Energy Conference (June 2018)

Infrastructure and Technology

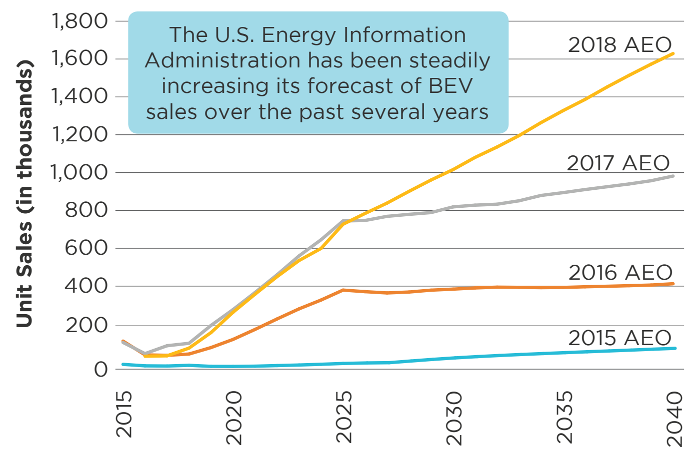
ELECTRIC VEHICLES
TIME FOR UTILITY ENGAGEMENT AND PLANNING

As electric vehicles gain traction, utilities should consider possible infrastructure needs.

Plug-In Electric Vehicle Sales Are Growing Steadily in Distinct Markets

- The term "plug-in electric vehicles" (PEVs) includes plug-in hybrid electric vehicles (PHEV) and battery electric vehicles (BEVs)
- PEV sales are concentrated among urban, higher income, and more educated car buyers along the East and West Coasts
- September 2018 marked the 36th month of consecutive year-over-year gains in monthly PEV sales, with more than 40 different vehicle models sold in 2018
- Cumulatively, nearly 1 million PEVs have been sold in the United States as of September 2018; California accounts for roughly half of all U.S. PEV sales
- In 2017, the Edison Electric Institute forecasted that by 2025:
  - Annual PEV sales will exceed 1.2 million vehicles and account for 7% of annual vehicle sales
  - The stock of PEVs on the road will be 7 million, accounting for roughly 3% of all registered cars and light-duty trucks, and will need to be supported by 5 million charge ports

Improving News: Light-Duty BEV Annual Sales Forecasts (EIA Annual Energy Outlooks 2015–18)



Source: EIA

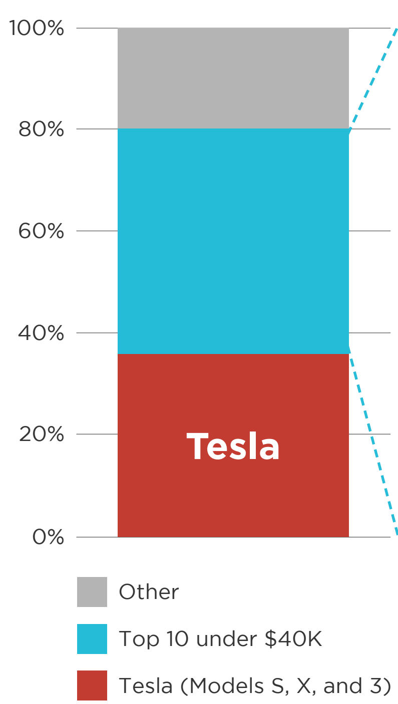
KEY TAKEAWAYS

- Light-duty PEV sales are growing and are forecasted to continue growing at an accelerated pace in certain markets; an increasing number of models are becoming available to consumers
- While most attention is focused on light-duty vehicles, medium- and heavy-duty vehicles will have a larger grid impact per vehicle and tend to concentrate load by charging at depots
- The number and scope of utility engagement opportunities is expanding and is larger than just public charging infrastructure
- With sufficient penetration of light-duty and heavy-duty PEVs, grid operators will need to study and anticipate potential changes to system demand, as illustrated by the “dragon curve”

Growing Number of Vehicles—Not Named Tesla—Being Purchased by Consumers

- Tesla dominates electric vehicle headlines and accounted for 35% of PEV sales in the first half of 2018
- However, despite that accomplishment, the cheapest Model 3 currently available (with a long-range battery) starts at $49,000, far from the highly touted Model 3 base price of $35,000
- Consequently, consumers shopping for new PEVs are finding—and purchasing—a growing number of makes and models available for less than $40,000
- Just 10 PEVs, all starting below $40,000, accounted for 45% of electric vehicles sales in the first half of 2018 (see below)
- As possible harbinger of the future PEV market, more than 70% of vehicles in this subset were PHEVs; thereby allowing owners many of the advantages of electric vehicles without the downside of range anxiety
- Longer term, many auto manufacturers have announced ambitious plans. This includes the following targets:
  - 2020: 12 PEV models from Hyundai-Kia and 10 PEV models from Toyota
  - 2022: 40 PEV models from Ford
  - 2023: 20 PEV models from GM
  - 2025: 80 PEV models from Volkswagen and 25 PEV models from BMW

1H 2018 PEV Sales by Type (% of Total)



Top 10 (in 1H 2018 Sales) PEVs Available under $40,000

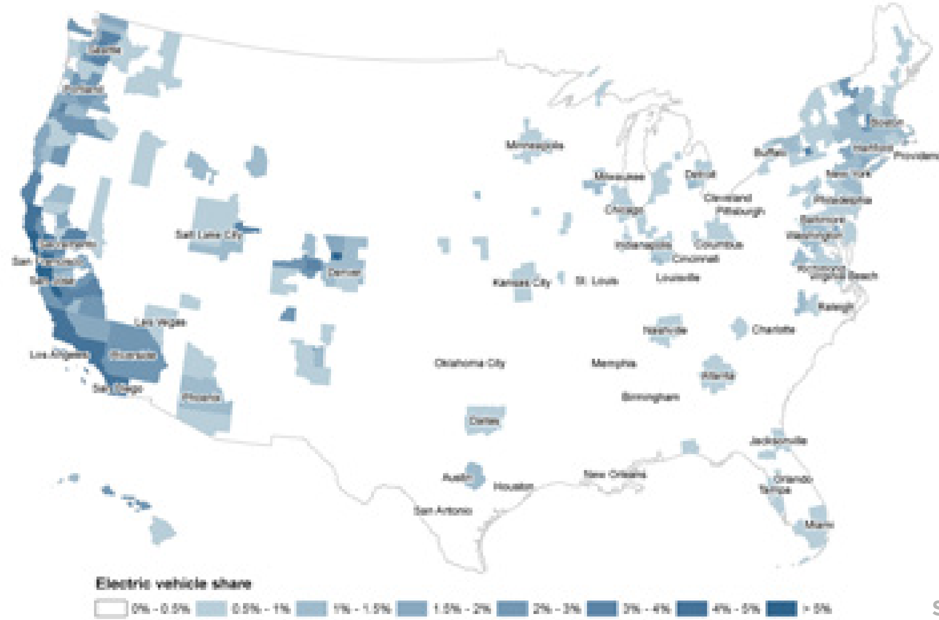
Brand	Model	PEV Type	Vehicle Sales (1H 2018)	PEV Market Share (1H 2018)	Starting MSRP	Total Range (Miles)
Toyota	Prius Prime	PHEV	14,255	11.5%	$27,300	640
Chevrolet	Bolt	BEV	7,858	6.3%	$37,495	238
Chevrolet	Volt	PHEV	7,814	6.3%	$34,095	420
Honda	Clarity PHEV	PHEV	6,669	5.4%	$33,400	340
Nissan	LEAF	BEV	6,659	5.4%	$29,990	151
Ford	Fusion Energi	PHEV	4,302	3.5%	$33,400	610
Chrysler	Pacifica Hybrid	PHEV	3,090	2.5%	$39,995	570
Mitsubishi	Outlander PHEV	PHEV	1,956	1.6%	$34,595	310
Fiat	500e	BEV	1,420	1.1%	$32,995	84
Kia	Niro PHEV	PHEV	1,247	1.0%	$27,900	560

Sources: insideevs.com; EPA; ScottMadden analysis

Rising PEV Sales Means More KWhs… with Limits

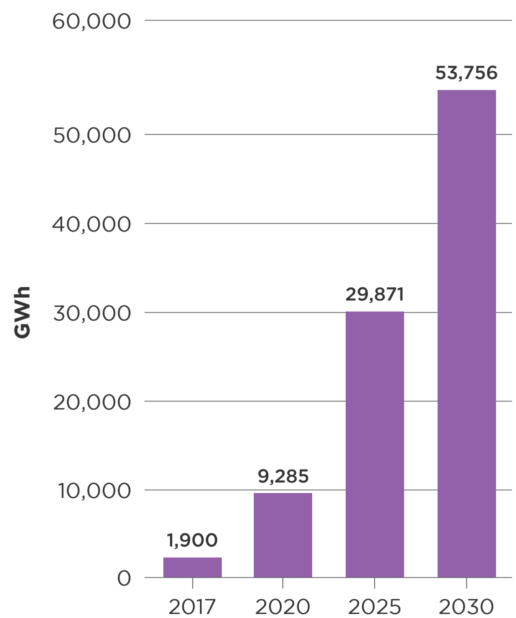
- With increasing PEV sales, electricity consumption for charging is expected to grow as well
- The EIA's most recent Annual Energy Outlook forecasts electricity demand from light-duty vehicles growing to more than 48,000 GWh by 2030
- A key question for utilities: Will this constitute meaningful load growth?
  - Efficient electrification is increasingly of interest to the electricity industry as well as environmental advocates
  - Some recent studies show that widespread transportation electrification, including medium- and heavy-duty vehicles, will spur electricity growth, but perhaps limited to around 1% annual load growth or less depending upon the study and scenario
- Location and timing of usage will matter
  - Similar to early adoption (see map), the advance of PEVs will likely be uneven across the United States, impacting individual utilities with different penetrations along varying timelines
  - Even if load growth is minimal, it will be important to consider PEVs contribution to peak load as unmanaged charging may be concentrated in evening and overnight hours

PEV Share of New 2017 Vehicle Registrations by Metropolitan Area



Source: ICCT

PEV Consumption (GWh)
(2017 Actual and 2020–30 Projected)



PEV KWh Consumption in Context:
How PEV Consumption (2017 Actual and 2020–30 Projected) Compares to Household Consumption and Total Retail Sales

	2017	2020	2025	2030
Equivalent to Number of U.S. Households	0.2 M	0.9 M	2.8 M	5M
Percentage of Electricity Sales	0.1%	0.2%	0.8%	1.3%

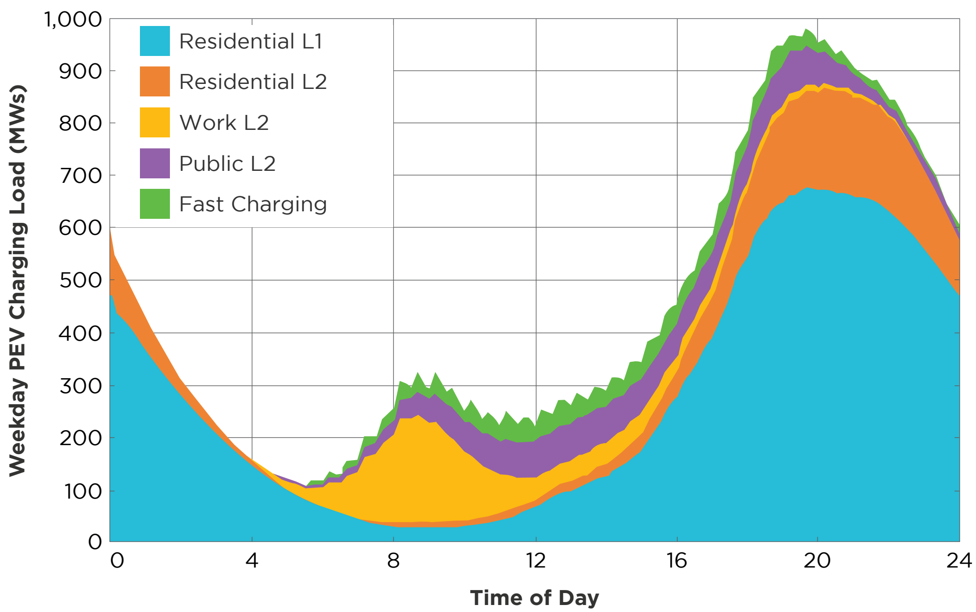
Sources: EIA; Argonne Nat'l Lab; ScottMadden analysis

Anticipating Grid Impacts: PEVs Will Require Public Charging, but 80% to 90% of Charging Will Occur at Home

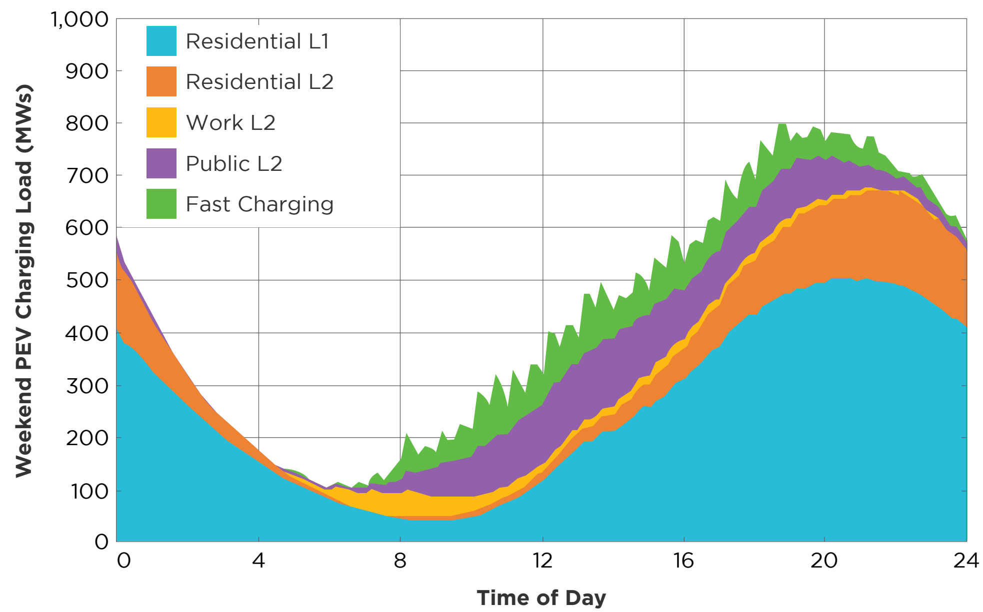
- California has been aggressively promoting EV expansion, where officials have approved nearly $1 billion in ratepayer-backed EV-charging investments, and Gov. Brown has proposed an additional $2.5 billion program to further a goal of 5 million zero-emissions vehicles by 2030
- Anticipating increasing uptake of PEVs, the California Energy Commission and the National Renewable Energy Laboratory recently estimated the number of chargers required for California to support 1.3 million PEVs by 2025
- The analysis found 229,000 to 279,000 chargers would be required at work places, public destinations, and multi-unit dwellings; these figures do not account for chargers at single-family homes
- The analysis also forecasts the timing of PEV charging, finding nearly 900 MWs of residential charging demand occurring at 8 PM on weekdays (see chart below)
- While public infrastructure has received considerable attention, the findings from California reveal how electric utilities must consider and plan for the behaviors and impact of large-scale residential charging, which is largely not visible to electric utilities
- Managed charging, which enables utilities to control the charging of PEVs, will be a “must-do” rather than “can-do” activity for electric utilities
- Some utilities, such as DTE Energy and Duke Energy, have proposed customer incentives for Level 2 chargers with certain communication protocols (e.g., OPCC and OpenADR) to allow visibility and control of residential charging

Enter the Dragon (Curve): Late Afternoon Power System Ramping Could Be Exacerbated by PEV Charging

California Statewide Aggregated PEV Electricity Load for a Typical Weekday



California Statewide Aggregated PEV Electricity Load for a Typical Weekend



Source: California Energy Commission

A Broad Array of Actions to Maximize Value from PEVs

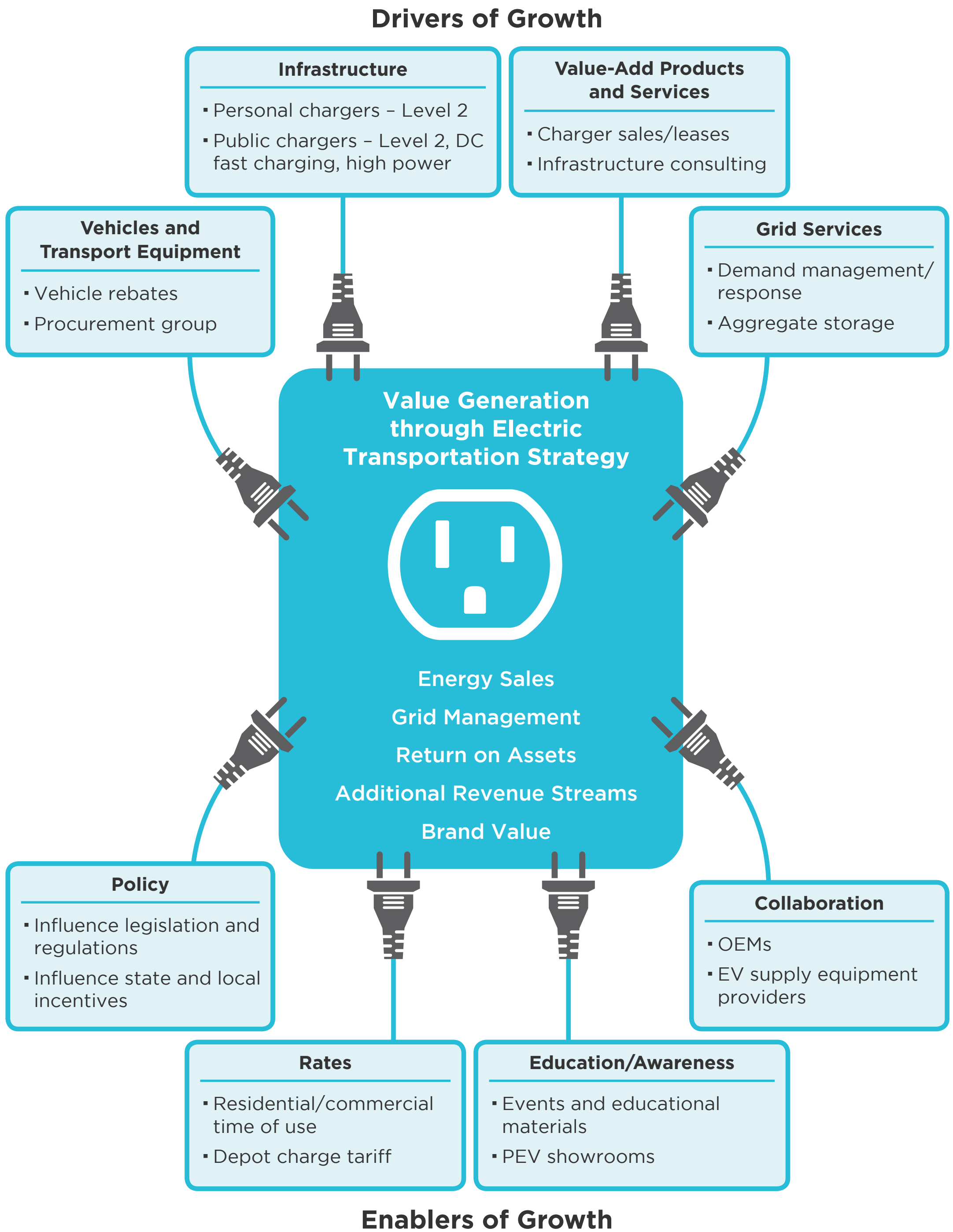
- In order to realize the benefits of transportation electrification, electric utilities need to determine their role (or roles) in the PEV ecosystem
- Maximizing long-term value may require developing strategic engagements across multiple engagement channels (see graphic at right)
- A broad assessment of all engagement channels ensures a holistic strategic approach that considers the utilities' capabilities, market dynamics, and long-term desired role

More than Kilowatt-hours: Utilities Should Consider Multiple Value Opportunities

- ***Energy sales:*** PEVs can mitigate declining load growth by providing additional electricity sales
- ***Grid management:*** Managed charging with current technology allows load shifting and demand response; vehicle-to-grid technology not ready for mass adoption
- ***Return on assets:*** A number of utilities have been able to rate base PEV charging infrastructure and earn a return on those assets
- ***Additional revenue streams:*** Additional products and services (e.g., retail charger sales/leases) represent opportunities for utility revenue growth
- ***Brand value:*** Enhanced customer offerings can also increase brand value with customers and regulators

Don't Forget Heavy-Duty Vehicles

- Most incentives and targets are for light-duty vehicles
- However, light-duty vehicles only account for a portion of vehicle emissions
- Discussions of transportation electrification should include medium and heavy-duty vehicles, which will have a larger per-vehicle emissions impact



IMPLICATIONS

There is significant opportunity for utilities to identify strategic engagements and proactively plan for PEVs.

Note: OEMs are original equipment manufacturers

Sources: California Energy Commission; International Energy Agency; International Council on Clean Transportation; U.S. Environmental Protection Agency; Edison Electric Institute; Argonne National Laboratory; U.S. Energy Information Administration; InsideEVs.com; National Renewable Energy Laboratory; S&P Global Market Intelligence; auto manufacturer websites; industry news; ScottMadden analysis

POWER TRANSMISSION
MUCH PLANNED, BUT TAILWINDS ARE ABATING

Industry and regulators are trying to find the right incentives.

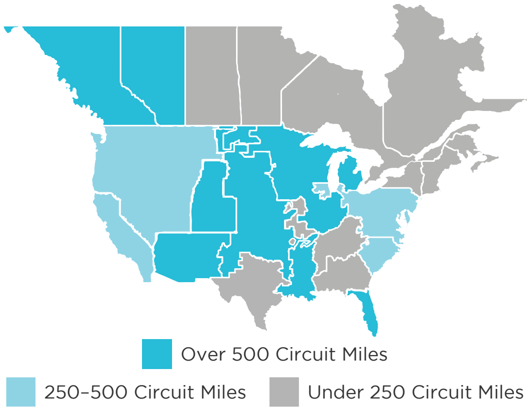
Planned Transmission Continues Apace

- Despite low or flat load growth, about 6,200 circuit miles of new transmission is planned throughout the 2018–2022 assessment period with more than 1,100 circuit miles currently under construction
- Increasing levels of intermittent resources are requiring new transmission facilities and devices, such as static VAR compensators or synchronous condensers
- And while nearly 80% of the 6,200 miles of planned additions are for reliability, about 13% are for renewable resource integration, and many of the miles are planned for the Midwest, as well as the Rocky Mountain West and Mid-Atlantic, and other areas with high amounts of wind penetration (see figure at right)

But Project Completion Has Been Slowing

- Completed miles of transmission lines have declined year over year from 2013 to 2017
- NERC says that lead times can be up to 15 years to permit, site, and construct expansion projects
- Together, electric transmission and distribution expenditures are expected to account for about 46% of electric utility spending from 2018 to 2020
- From 2017 to 2018, transmission rate base growth* slowed to 9.3%, a significant decrease compared to the previous three years: 13.1% from 2016 to 2017, 15.8% from 2015 to 2016, and 19.0% from 2014 to 2015

NERC Assessment Areas with High Levels of Prospective Transmission Additions



Source: NERC

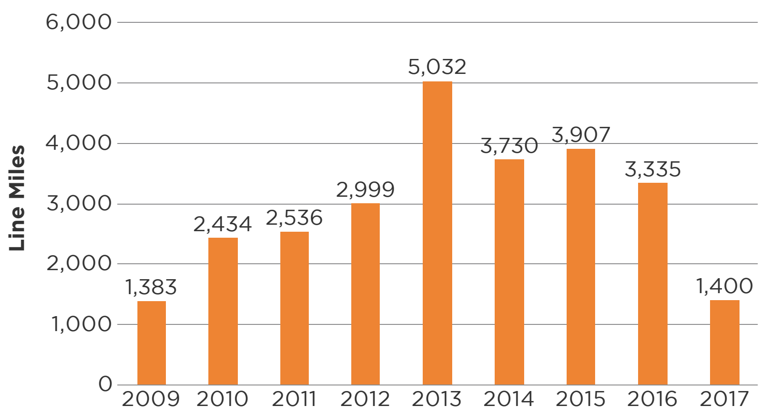
KEY TAKEAWAYS

- While transmission spending has increased (albeit at a declining rate of growth), miles of completed transmission has declined since 2013
- Large transmission projects continue to face state and local challenges, especially where local benefits are unclear
- Competitive transmission continues to face headwinds, as non-incumbents appear to have few successes in the transmission development process, although non-incumbents are getting bidding opportunities, at least in RTO regions
- At least one FERC commissioner has suggested reconsidering financial incentives for transmission, questioning whether the enhanced returns, among other incentives, are truly providing motivation for building transmission

All Politics, and Projects, Are Local:
Some Noteworthy Large Projects Have Faced Local and State Opposition

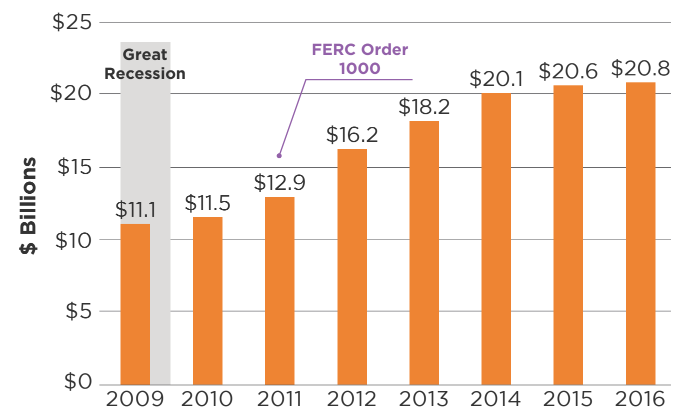
- Northern Pass, a project intended to bring hydro power from Canada to New England, was stymied after New Hampshire officials refused to issue a siting permit, as well as by other grassroots challenges that the project hindered "orderly development" of the region and adversely impacted wilderness with few local benefits
  - Massachusetts' electric utilities (NSTAR, Unitil, and National Grid) moved on from Northern Pass after the New Hampshire decision, seeking certainty of supply for their mandated clean energy acquisition
  - The electric utilities pivoted to the Northern New England Clean Energy Connect, a 145-mile, $950 million project, which will, when completed, deliver Canadian hydropower through Maine
- Grain Belt Express Clean Line, a 780-mile, $2.3 billion project, aims to carry Kansas wind power through Missouri and Illinois into Indiana and the Midcontinent ISO and PJM markets
  - The Missouri Supreme Court ruled that the Public Service Commission had wrongly denied the project a construction permit, sending the project back for consideration
  - The project has been embroiled in county-by-county consideration in Missouri as two Missouri counties vow to deny permits to the project
- In another setback, DOE ended its partnership with the troubled Clean Line Plains & Eastern project in March, which would have moved 4,000 MWs from Oklahoma to Tennessee via Arkansas
- A common theme among projects that have faced stiff opposition is the lack of sufficient perceived benefit for local residents beyond construction jobs from installation of the power lines, especially for projects "passing through" a state to provide power elsewhere

Completed U.S. Transmission Projects by Year (2009–2017) (in Line Miles)



Sources: S&P Global Market Intelligence; ScottMadden analysis

Construction Expenditures for Transmission by Investor-Owned Utilities (2009–2016) (Real 2016$ Billions)

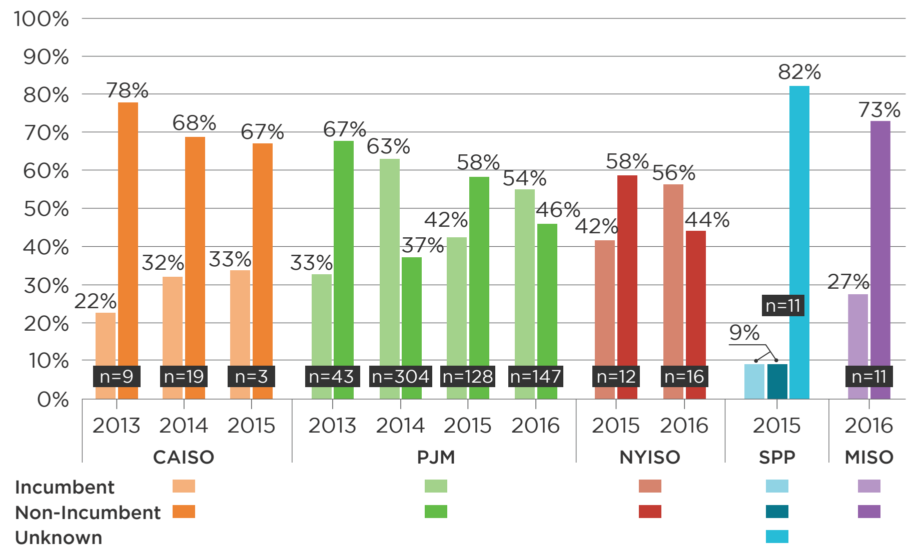


Source: EEI

Is Competitive Transmission Working?

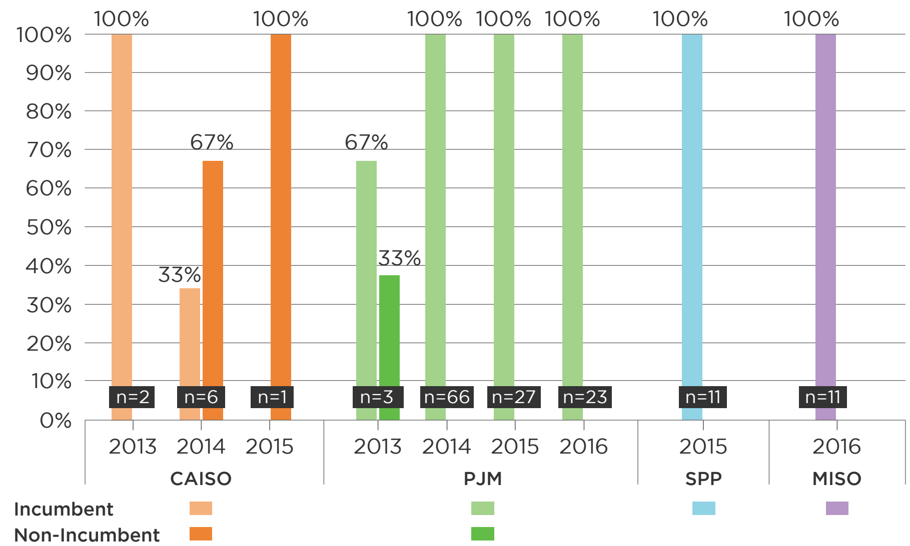
- FERC Order 1000, issued in 2011, made reforms in regional planning, cost allocation, and non-incumbent participation in transmission development with a view to encourage broader participation in development, more creative solutions to transmission issues, and greater cost control of transmission projects
- FERC has been monitoring whether and how non-incumbent transmission providers (both merchants as well as utilities operating outside of their native footprints) have been participating in transmission development opportunities, particularly in regions with independent system operators or regional transmission operators. A few key findings:
  - **Non-incumbent participation has regional attributes:** Between 2013 and 2016, 47% of all proposals submitted in CAISO's, PJM's, NYISO's, and MISO's competitive transmission development process came from non-incumbents
  - **And non-incumbents have had less success:** In transmission planning areas with competitive proposal windows, non-incumbents had no proposals selected in 2016, which is a decline from 3% in 2015, 6% in 2014, and 20% in 2013**
  - **PJM is different:** PJM receives a high number of proposals each year from a relatively low number of developers, and 2016 results showed that PJM received more than 10 times the number of proposals than did CAISO
    - This might be attributed to its sponsorship model
      - That model opens up the early planning process to developers (including non-incumbents) for varied solutions in which each proposal is compared to others, first and foremost, as to whether they solve the need and can be timely sited and approved
      - By contrast, non-sponsorship models involve non-incumbents later, bidding out a predetermined project in a cost-driven solicitation
    - Second, PJM may solicit solutions to multiple, smaller reliability standard violations rather than a comprehensive solution
- Except in CAISO, non-incumbents are less successful in winning projects (see charts at right), which raises the broader question of whether Order 1000 and competition in transmission have delivered FERC's hoped-for results

Competitive Proposals by Incumbents vs. Non-Incumbents for Selected RTOs/ISOs (2013–2016)



Source: FERC

Number and Percentage of Awards Made to Incumbents and Non-Incumbents for Selected RTOs/ISOs (2013–2016)



Source: FERC

Revisiting Transmission Incentives: What Signals Should Be Sent?

- After passage of the Energy Policy Act of 2005 and three years after the Northeast Blackout of 2003, FERC issued Order 679 in 2006, which aimed to promote transmission investment through increased returns on equity (ROE) and other incentives based upon project type, risk, participation in an RTO/ISO, and other considerations
- In 2012, FERC issued a Policy Statement providing guidance to firms seeking transmission incentives, as well as clarifying that it expected applicants to take steps to mitigate risks prior to applying for incentives
- A 2014 FERC opinion (No. 531) allowed for transmission ROEs to be set between the median and the upper end of a "zone of reasonableness," although there is some debate whether that FERC approach suppresses ROEs

Recently Awarded FERC Transmission Incentives (2017–2018)

	Projects											
Order 679 Incentives	NextEra Energy Transmission (PJM, MISO, NYISO, SPP)	NextEra – Empire State Line – NY	Transource (MD & PA) – Project 9A	GridLiance West – VETA HVTS	GridLiance West – Bob Tap Project	So Cal Edison – Aberhill, Eldorado (E-L-M)	So Cal Edison – Mesa 500kV SS	Dairyland – Middleton-Hickory Creek	ITC Midwest – Huntley-Wilmarth	Citizens & SDG&E – Sycamore	NY Transco – AC Project	Republic Transmission – Duff-Coleman
Construction Work in Progress (CWIP)		100%	100%		100%	100%	100%				In rate base	
Hypothetical Capital Structure	60/40		60/40					45/55		50/50		55/45
Recovery of 100% of Costs of Abandoned Facilities		100%	100%			100%		100%	100%	100%	100%	100%
ROE Adder for Risk and Challenges, RTO Adder, and Transco Adder	50 bp RTO adder	50 bp risk adder, 50 bp transco adder		50 bp RTO adder							50 bp risk adder, 50 bp congestion relief	50 bp RTO adder
Regulatory Asset	✓		✓	✓								✓

Source: AVANGRID

Revisiting Transmission Incentives (Cont'd)

- FERC Commissioner Richard Glick has recently expressed interest in FERC re-examining transmission incentives, specifically adders for stand-alone transmission companies
  - Commissioner Glick questioned whether ROE adders are necessary in light of reforms under Order 1000 and the lower cost of capital since their introduction. He also questioned whether standalone transmission companies, whose participation was encouraged by enhanced ROEs, are leading to greater investment and producing "meaningful benefits for consumers"
  - State regulators are also interested, as their retail customer constituencies must pay those rates
  - However, incentives may not be the most important issue, given the challenges in transmission siting, enhancing resilience, and accommodating a different energy resource mix
- FERC has a number of rate-of-return cases to clear before it can address incentives prospectively, but those decisions may provide some hints as to any evolution in its thinking on this matter

IMPLICATIONS

Utilities, transmission operators, system planners, transmission developers, and regulators will need to carefully examine the impediments and incentives for transmission development and arrive at an equitable approach to allocating costs and rewards for power transmission development.

Notes: *Per Regulatory Research Associates, based on a 94-utility sample. **FERC staff categorized joint ventures and consortia that included both incumbents and non-incumbents as incumbents if the project was located in the incumbent's retail distribution service territory or footprint. Therefore, in some cases, the joint venture associated with a selected proposal may include a non-incumbent.

Sources: Industry news; S&P Global Market Intelligence; Wilkinson Barker Knauer; company websites; NERC, 2017 Long-Term Reliability Assessment (Dec. 2017); FERC Office of Energy Projects, Energy Infrastructure Updates (Dec. 2010–Dec. 2017, June 2018); EEI, Transmission Investment: Revisiting the Federal Energy Regulatory Commission's Two-Step DCF Methodology for Calculating Allowed Returns on Equity (Dec. 2017); EEI, Statistical Review of the Electric Power Industry (May 2018); FERC, 2017 Report on Transmission Investment Metrics; AVANGRID, "Transmission Financial Incentives under EPACT 2005 and Order 679—Room for Improvement?" presented at WIRES Summer Meeting 2018 (July 31, 2018); ScottMadden analysis

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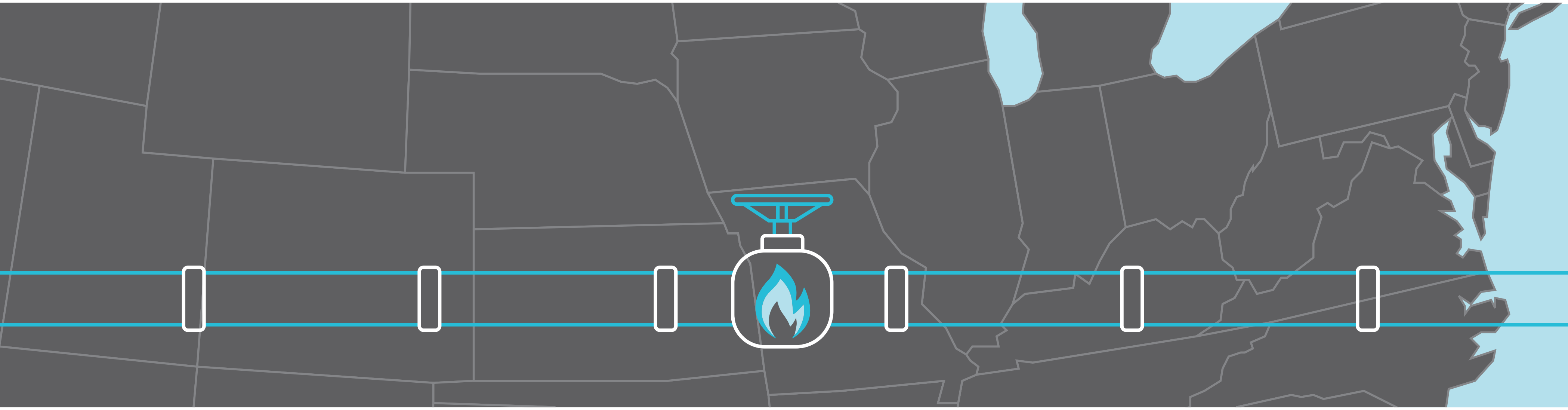


GAS PIPELINES
PROJECTS PROCEED, BUT RESISTANCE REMAINS

Can stakeholders find common ground?

Gas Pipeline Development Liberates Production

- According to EIA, gas pipeline projects totaling more than 28 BCF/day and nearly $25 billion are under construction in the United States, excluding projects on hold
- Many recent additions of pipeline capacity provide transportation from the productive Permian, Marcellus, and Utica shale basins to market areas
- Dry gas production in Permian, Marcellus, and Utica shales has grown by 71%, 26%, and 65%, respectively, in just two years (July 2018 vs. July 2016). Most recent figures have those plays producing about 7, 20.4, and 6.3 BCF/day, respectively. Combined, this is the equivalent of 46% of 2017 U.S. dry gas production
- As LNG export facilities on the Gulf Coast begin to come online, additional pipeline capacity is expected to provide feedstock for the liquefaction facilities (6.1 BCF/day of LNG export capacity comes online in 2018 and 2019 alone)

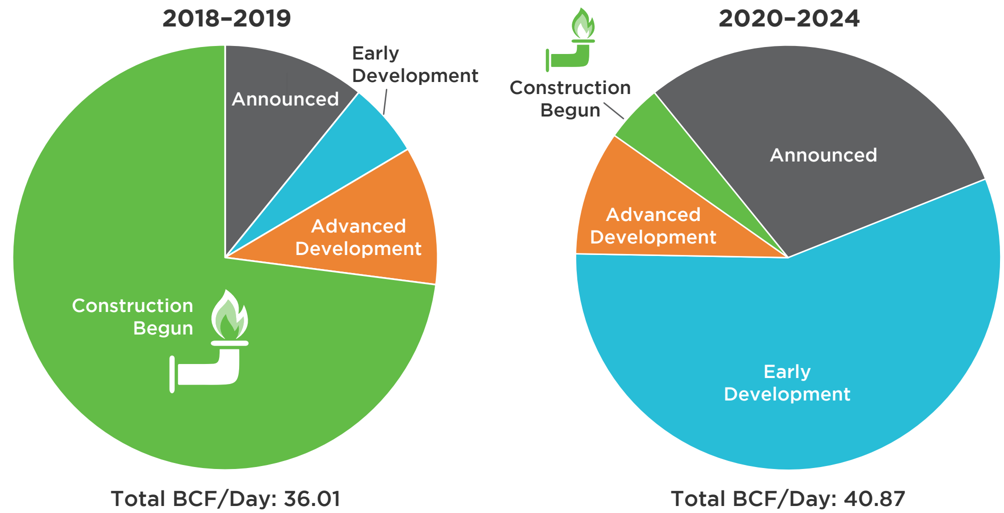
Mixed Views on Whether Pipeline Development Will Continue at the Same Scale

- Some industry observers believe that since the industry has pursued a number of large greenfield projects and Marcellus takeaway capacity issues are beginning to be addressed, smaller brownfield projects will constitute the bulk of projects in the near to medium term
- However, a key industry organization forecasts significant future investment in natural gas pipeline capacity of nearly 57 BCF/day (totaling 26,000 miles of transmission and more than 88,000 miles of gas gathering) between 2018 and 2035, driven by LNG exports, North American gas-fired generation, pipeline exports to Mexico, and increases in U.S. petrochemical activity (fertilizers, refining, and methanol production)

Mixed Views (Cont'd)

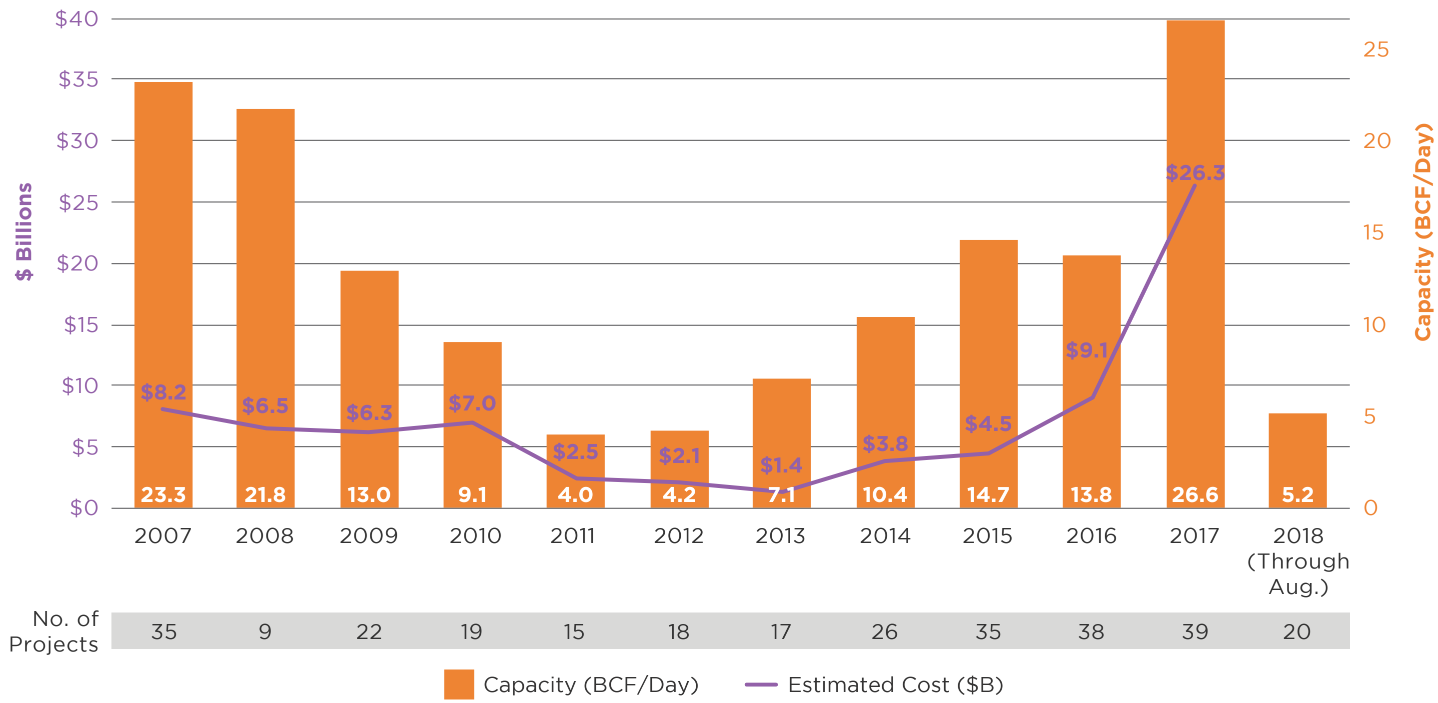
- Capital expenditures for gas gathering and transmission are projected to total $279 billion through 2035
- About 36 BCF/day of new U.S. pipeline capacity is projected to come into service during 2018–2019
- Increased gas gathering capacity will become more important as shale plays expand

U.S. Gas Pipeline Development Projects (by Expected Year in Service)



Source: S&P Global Market Intelligence

Major Gas Pipeline Projects Approved by FERC (2007–2018 YTD)



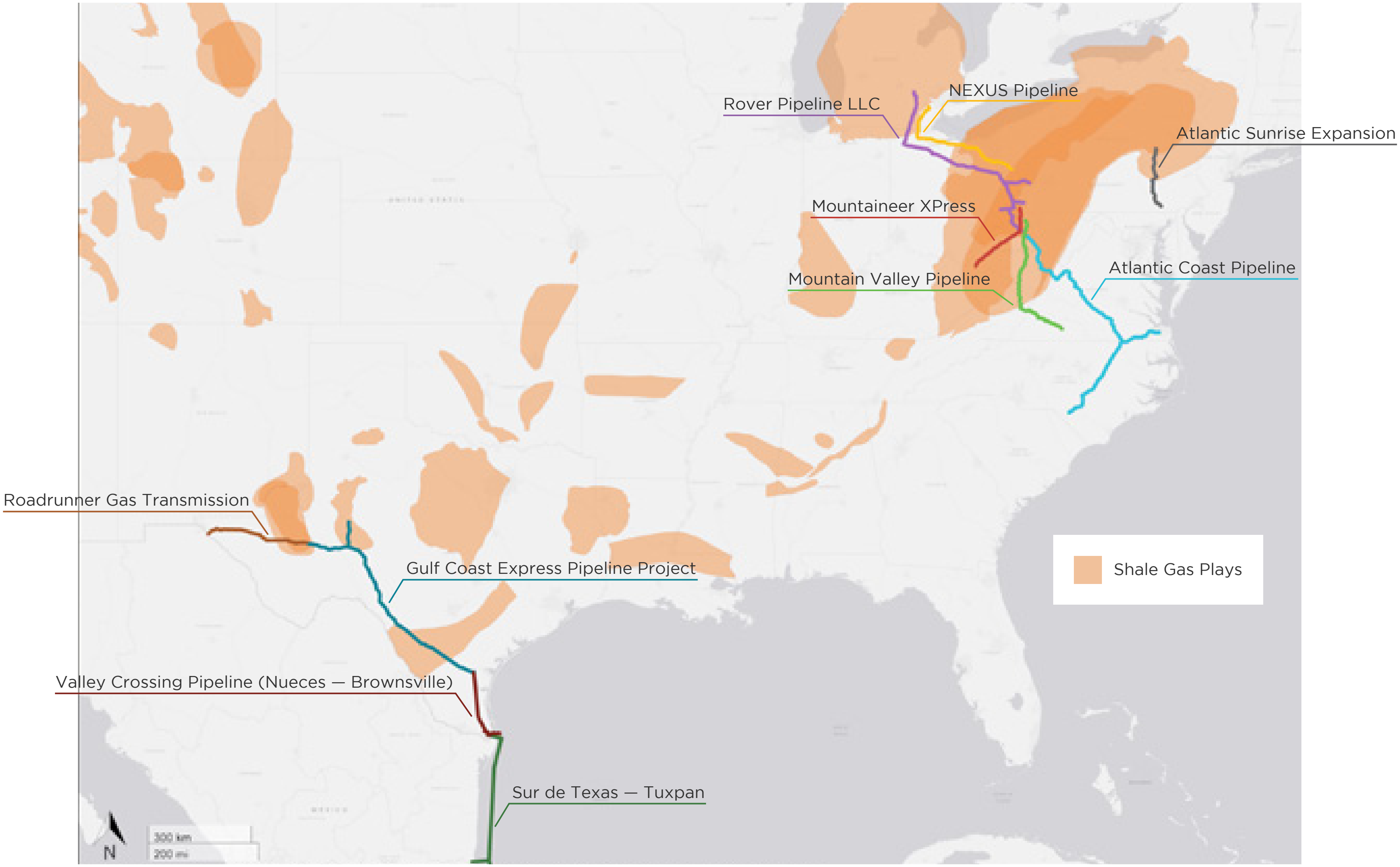
Sources: S&P Global Market Intelligence; ScottMadden analysis

KEY TAKEAWAYS

- **Growing dry gas production from prolific plays like the Marcellus and the Permian, and the need to move supplies to markets, continues to motivate a number of large greenfield pipeline projects**
- **Increasingly, however, opposition and growing interest in greenhouse gas impacts (and resistance to gas as a "bridge fuel") are posing hurdles to development**
- **If those issues can be overcome, expected expansion of LNG exports, as well as exports to Mexico and greater gas usage for power generation may continue to drive additional gas infrastructure expansion**
- **FERC is considering policy changes that may affect pipeline certifications, but the market will continue to drive (or constrain) project development**

A handful of large pipeline projects are concentrated near the Marcellus and Utica plays and the Permian Basin.

U.S. Natural Gas Pipelines (>100 Miles Long) under Construction and Shale Plays as of Early September 2018



Sources: S&P Global Market Intelligence; ScottMadden analysis

Working through Challenges: Projects Run the Gauntlet

Project	Capacity	Est. Cost	Issues
PennEast	1.1 BCF/day	$1B	▪ NJ seeks FERC reconsideration of project approval ▪ Project still in advanced development
Mountain Valley	2 BCF/day	$3.7B	▪ Parts of project under FERC stop-work orders, with other WV portions able to continue ▪ VA's water control board, in a close 4-3 vote, retained stream-crossing permits ▪ Work resumed, but in-service date pushed back to Q4 2019
Atlantic Coast	1.5 BCF/day	$6B to $6.5B	▪ NC regulators object to FERC-awarded 14% return on equity ▪ After challenge, FERC re-engages U.S. Fish & Wildlife Service on further biological analysis ▪ Construction suspended
Atlantic Sunrise	1.7 BCF/day	$3B	▪ Environmentalists challenge FERC approval, PA water quality certificate ▪ Scheduled for Sept. 2018 in-service; 0.5 BCF/day now in service
Sabal Trail	1.1 BCF/day	$3.2B	▪ DC federal court upholds decision to vacate FERC approval of Southeast Market Pipelines project, including operational Sabal Trail pipeline

Sources: Industry news; ScottMadden research

Opposition to Projects Intensifies

- Despite identifying opportunities and securing initial approvals for projects, many proposed pipeline projects continue to face opposition
- Some communities perceive environmental risk from construction of projects through wilderness areas, with many issues focused on water quality considerations, typically within the purview of state agencies
- Much of the organized environmental opposition is part of a broader "keep it in the ground" debate over expansion of hydrocarbon infrastructure
- Implications for the projects are more information requests and meetings/hearings, additional regulatory, legal, and compliance cost, and delay in project in-service dates

Whither New England?

- While gas pipeline capacity into New England is needed for power reliability, especially in winter, there has been little or no movement on proposed projects
- Kinder Morgan's Northeast Energy Direct project was cancelled for lack of contractual commitments, while Enbridge's Access Northeast proposal was indefinitely postponed pending review of recent Massachusetts court decisions
- But other, more modest projects have moved forward or become operational, including Portland Natural Gas Transmission/TransCanada's Portland Xpress and Continent-to-Coast projects and Tennessee Gas' Connecticut Expansion

Harder Look at Necessity

- Given the number of projects proposed, FERC continues to review the process to determine necessity (contracts, demand forecast, reliability, etc.)
- FERC is also re-examining its historical certification approach to determine whether a refresh is needed (see next page)
- Some developers, such as Dominion, have noted that local outreach can be part of an efficient permitting process and should be considered in FERC's process review

In April, FERC initiated a notice of inquiry (NOI) on potential modifications to its 1999 policy governing gas pipeline certifications. The following summarizes the NOI, current policy, and some illustrative comments on FERC policy.

Scope of FERC's Inquiry	Current Policy	Some Initial Reactions and Viewpoints
The NOI establishes the following areas for consideration: ▪ **Need:** FERC's methodology for determining whether there is a need for a proposed project, including its consideration of precedent agreements and contracts for service as evidence of such need ▪ **Local interests:** FERC's consideration of the potential exercise of eminent domain and of landowner interests related to a proposed project ▪ **Environmental impact:** FERC's evaluation of the environmental impacts of a proposed project ▪ **Process improvements:** Input on whether there are specific changes FERC could consider to improve the efficiency and effectiveness of its certificate processes, including pre-filing, post-filing, and post-order issuance	▪ **First screen:** If a proposed project's anticipated public benefits outweigh its residual adverse effects on economic interests, FERC will analyze environmental impacts ▪ **NEPA review:** Environmental impact assessment is per National Environmental Policy Act and includes direct GHG emissions impacts, but more indirect upstream or downstream GHG impacts are not considered as they are deemed speculative and unknown ▪ **No cross-subsidization:** Developer must financially support the project without relying on subsidization from its existing customers ▪ **Adverse impact inquiry:** Developer must minimize impact on (1) existing customers, (2) existing pipelines in the market and their captive customers, and (3) landowners and communities affected by the proposed project ▪ **Balance vs. benefits:** FERC balances adverse impacts with benefits, including meeting unserved demand, typically demonstrated by subscription or "precedent agreements" (no market analysis required)	▪ "I am hopeful the review of FERC's procedures… will result in more efficient and timely decisions." *– Rep. Upton (R-MI)* ▪ "Are you willing to work with us…[on legislation] that makes folks feel…that they actually have input…?" *– Rep. Griffith (R-VA)* ▪ "Unsubstantiated accusations of improprieties in favor of affiliates [under precedent agreements] are frequently made by anti-pipeline organizations…" *– Seneca Resources Corp.* ▪ "Monetization of climate damages is appropriate…to facilitate any comparison of alternatives, including the required alternatives analysis under NEPA as well as the review of public convenience and necessity under the Natural Gas Act." *– Environmental Defense Fund, et al.*

Sources: FERC; NOI intervenor comments; S&P Global Market Intelligence

Refreshing the Pipeline Rules: Different Views at FERC

- Recent pipeline cases at FERC have brought to a head a difference of opinion on pipeline certifications
- Increasingly, there is a split between commissioners on the reviews, especially environmental, that FERC should perform on prospective gas infrastructure projects, more specifically, whether it should perform more extensive analysis of upstream and downstream GHG emissions
  - Commissioners LaFleur and Glick argue for more extensive analysis of end-use GHG emissions as part of the certification process
  - Commissioner McIntyre indicates neutrality on the need for change, while Commissioner Chatterjee has signaled that the existing approach, while amenable to refresh, provides FERC needed flexibility
- Another point of contention is whether there should be a broader, regional assessment in evaluating the need for a new project
- FERC's NOI regarding its pipeline certification policy (see above) occurs in the context of a White House goal of expediting infrastructure decisions (a two-year timeline for approvals), an issue on which there is a partisan divide in Congress
- Key questions: what does the Natural Gas Act allow or require, and will Congress weigh in?

IMPLICATIONS

Gas pipeline developers, and end-user beneficiaries of these facilities, will need to be increasingly engaged in communities and political and regulatory arenas conveying the benefits of increased gas access.

Note: MMCF means millions of cubic feet

Sources: Industry news; S&P Global Market Intelligence; Regulatory Research Associates; U.S. Energy Information Administration; Federal Energy Regulatory Commission; *Pipeline & Gas Journal; Oil & Gas Journal*; Utility Dive; Natural Gas Intelligence; Northeast Gas Association; INGAA Foundation, North America Midstream Infrastructure Through 2035: Significant Development Continues (June 18, 2018); ScottMadden analysis

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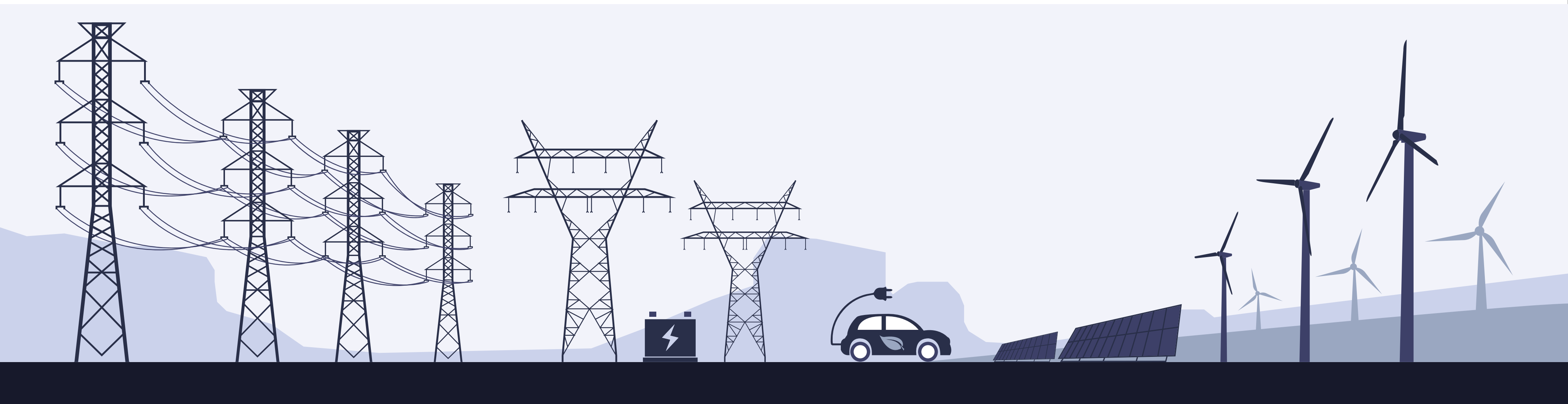
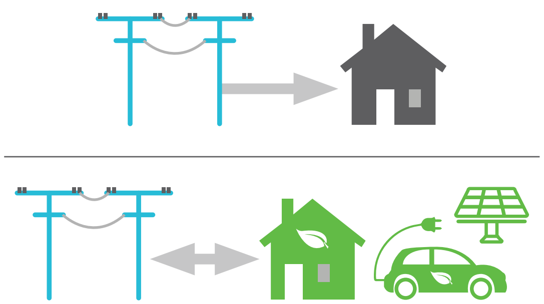
Rate and Regulatory Issues



GRID MODERNIZATION
STATES AND UTILITIES TEST THE WATERS

Electric utilities propose upgrades to the grid, while regulators seek frameworks to evaluate those costs.

Grid Modernization: A Working Definition



- Grid modernization is a term frequently used but not consistently defined
- A working definition would include investments—some of which may be considered foundational and/or DER-enabling—that improve the reliability, resiliency, efficiency, and automation of the T&D system
- Such investments can include a broad array of technology, including:
  - Sensors, data, systems, and communications networks that enable enhanced visibility and understanding of the distribution system and control of devices and resources connected to it
  - Technologies and equipment that facilitate greater customer engagement regarding energy usage and alternatives
  - The underlying systems, data management, and analytics that facilitate situational awareness, asset management, contingency and risk analysis, outage management, and restoration
- These necessary core investments underpin the required focus on grid reliability, visibility, and resiliency. They provide the basis for increased operational flexibility, provide customers with greater insights and more options to manage their energy usage, can enable efforts toward achieving state policy goals, such as the integration of various types of DER, and are beneficial for any resource mix

Threshold Questions for Utilities Considering Grid Modernization Initiatives

Key Questions	Considerations
▪ What is the delivery utility trying to achieve through grid modernization?	▪ There is no one-size-fits-all ▪ Clear goals make prioritization decisions easier
▪ What is a "modern" vs. "traditional" grid?	▪ New does not mean modern (e.g., new poles) ▪ Agreed-upon definitions with the regulator build trust
▪ Where is the line between grid modernization and DER enablement? Is there one?	▪ State policy goals for DER enablement ▪ Projects with synergies that support both DER and traditional grid operations (e.g., GIS)
▪ What is the line between grid modernization-related efforts and enterprise-wide efforts for initiatives, such as cybersecurity, analytics, etc.?	▪ Accelerating existing programs or projects ▪ Clear boundaries make for a more effective narrative
▪ What is considered a foundational grid modernization investment, and foundational to what?	▪ Sequence of investments based on priorities, required capabilities, and interdependencies ▪ Is the standard of cost effectiveness different?
▪ What cost-effectiveness framework should be applied to these investments, individually and as a portfolio?	▪ Relevant commission frameworks ▪ Least cost vs. greatest societal benefit

Source: ScottMadden analysis

KEY TAKEAWAYS

- **Grid modernization activity continues across the United States and is not limited to bellwether jurisdictions like California, New York, and Hawaii, but is also happening in places with less fanfare, including Ohio, Massachusetts, Illinois, and Rhode Island**
- **Distribution investment has been growing at almost 6% per year since 2012, with more investment ahead**
- **Utilities are not getting a "blank check" for grid modernization, but require more rigorous cost-benefit justification**
- **Some jurisdictions are beginning to look at performance-based ratemaking approaches as alternative incentives to tie utility expenditures on grid modernization to system and customer benefits**

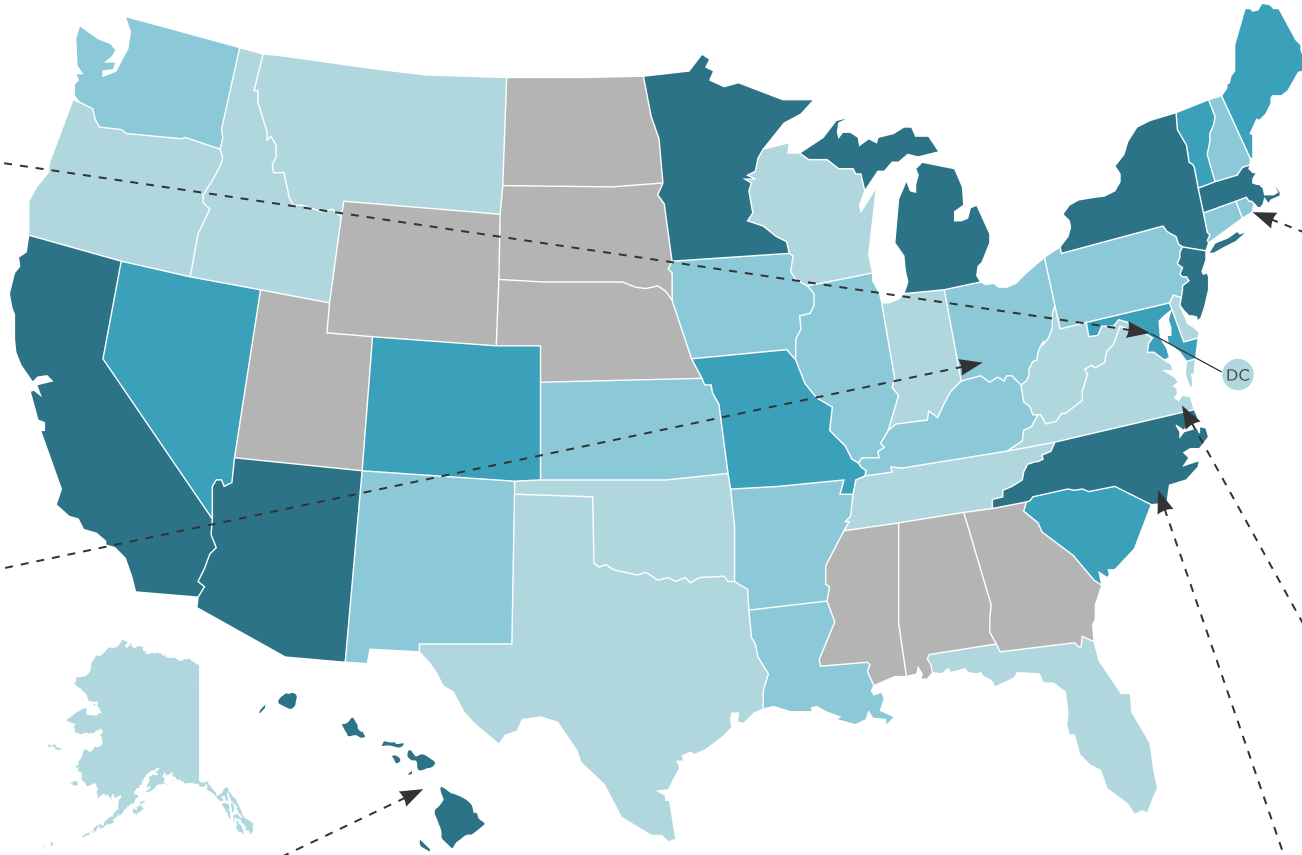
What's Happening: Selected Activity on Grid Modernization

Q2 2018 Legislative and Regulatory Action on Grid Modernization

DC PSC approves six working groups for its MEDSIS initiative, including areas of non-wires alternatives, microgrids, data access, and rate design. This follows an April DC council proposal to create a Distributed Energy Resources Authority (Aug. 2018)

Ohio regulators propose PowerForward initiative focused on resilient, optimized, and efficient grid that is also a secure open-access platform. Dockets to be established in early 2019 with utilities filing "grid architecture status reports" on status and investment required for future grid capabilities (Aug. 2018)

Hawaiian Electric proposes $86M grid mod program (Phase 1: 2019–2023) for advanced meters, meter data management, and telecom. This follows April legislation that transitions utilities entirely to as yet undetermined performance-based rate structures (Aug. 2018)



302 Policy and Deployment Actions Related to Grid Modernization in Q2 2018

Sources: NC Clean Energy Technology Center; ScottMadden research

RI regulators approve Power Sector Transformation Initiative, establishing a framework to move from traditional utility business model to performance-based model. Narragansett Electric plan includes advanced metering, grid modernization, EV infrastructure, and storage/solar demonstrations (Aug. 2018)

Dominion Energy Virginia proposes $0.8B grid mod plan (Phase 1: 2019–2021) for smart meters, customer information platform, intelligent grid devices, DERMS, and security pursuant to VA's Grid Transformation & Security Act (Jul. 2018)

NC regulator rejects proposed settlement and "grid rider" for Duke Energy's Power/Forward grid investments (Jun. 2018)

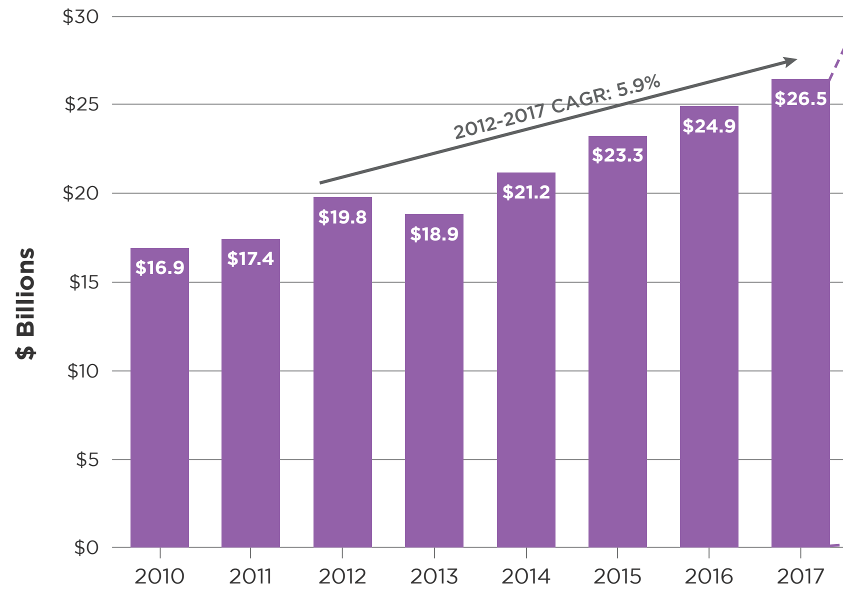
Grid Investment Continues to Grow

- Increasingly, utilities are looking at the energy delivery business (and related technology deployment) as an earnings growth opportunity
- Even traditionally "generation-heavy" utilities like Duke and AEP are developing significant grid modernization plans
- For the past five years, electric distribution spending (among electric and combination utilities) has been growing at nearly 6% per year
- In the most recent year, conductors and station equipment totaled about 50% of distribution additions, while meters comprised about 6.7%
- A significant amount of distribution spending may still lie ahead, especially as multi-year grid mod plans unfold

New York Demonstration Projects Pilot Varied Technologies and Features

- New York's Reforming the Energy Vision initiative required its utilities to file in July 2018 distributed system integration plans (DSIPs), many of which include innovative pilots to test various grid modernization technologies and functionalities
- ConEd, for example, is testing mobile energy storage in its Transportable Energy Storage System (TESS), comprised of a 500-kW, trailer-mounted system with li-ion batteries and power conversion and thermal control systems
- National Grid is demonstrating a Distributed System Platform (DSP) project that can determine locational energy value through a "Locational Marginal Pricing+Distribution+Environmental" model
- Other pilot projects involve electric vehicles, community solar, and DER forecasting
- Time will tell whether these pilots will be successful and scalable

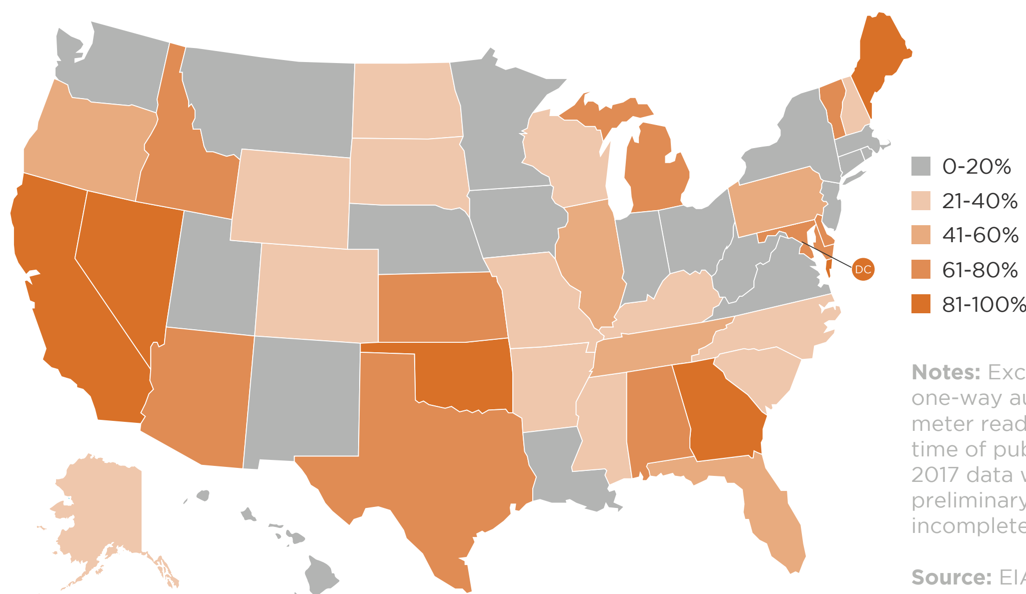
Total Distribution Additions (2010–2017) for Electric and Combination Utilities ($ Billions)



2017 Addition Categories ($B)	
Land & Land Rights	0.10
Structures & Improvement	0.38
Station Equipment	3.94
Storage & Battery Equipment	0.09
Poles & Fixtures	3.57
Overhead Conductors	4.59
Underground Conduit	1.49
Underground Conductors	4.55
Line Transformers	3.42
Services	1.50
Meters	1.76
Customer Installations	0.21
Leased Property	0.01
Street Lighting	0.85
Asset Retirement Costs	<.01

Sources: S&P Global Market Intelligence; company FERC Forms 1; ScottMadden analysis

2016 Advanced Metering Infrastructure Deployment (%) of All Meters



Notes: Excludes one-way automated meter reading. At time of publication 2017 data was preliminary and incomplete.

Source: EIA Forms EIA-861, EIA-861S

Identifying Grid Modernization Investments and Developing a Roadmap: An Illustrative 20-Year Approach

Areas	Definition	Example Investments	2020–2024	2025–2029	2030–2034	2035–2039
Foundational Systems and Infrastructure	Foundational IT and OT systems, equipment, and capabilities required to support other grid modernization technologies and use cases	▪ Advanced metering infrastructure (AMI) ▪ Geographic information system ▪ Advanced distribution management system (ADMS) ▪ Communications infrastructure	▪ ADMS ▪ AMI ▪ DSCADA ▪ Communications infrastructure ▪ Data management hardware ▪ IT/OT integration	▪ AMI ▪ Communications infrastructure ▪ Data management hardware	▪ Communications infrastructure	▪ Communications infrastructure
Distribution Automation	Distribution automation uses digital sensors and switches with advanced control and communication technologies to automate feeder switching, voltage and equipment health monitoring, and outage, voltage, and reactive power management	▪ Smart switches ▪ Load tap controllers automatically managed with Volt-VAr optimization (VVO) ▪ SCADA-capable voltage regulators	▪ SCADA switches ▪ Power flow controllers ▪ Breakers ▪ VVO	▪ SCADA switches ▪ Power flow controllers ▪ VVO	▪ SCADA switches ▪ Power flow controllers	▪ SCADA switches ▪ Power flow controllers
Grid Edge Sensing	Smart devices deployed across the grid that communicate with central operations and provide better visibility and situational awareness of the system	▪ Environmental sensors ▪ AMI edge devices	▪ Line sensors ▪ Transformer health sensors ▪ Environmental sensors	▪ Line sensors ▪ Transformer health sensors ▪ Environmental sensors	▪ Environmental sensors	
Tools and Analytics	Collection and analysis of large quantity of data to provide meaningful information to support real-time and predictive decision making	▪ Analytics platform ▪ Data management hardware ▪ Asset health monitoring ▪ Power quality monitoring ▪ Outage impact analysis ▪ Work management optimization	▪ Asset health analytics ▪ Work management analytics	▪ Outage analytics ▪ Power quality analytics		
Flexible Resources	Resources that allow a system operator to better manage the grid while sourcing electricity from a more diverse supply mix, including distributed energy resources and intermittent generation	▪ Distributed energy resource management system (DERMS) ▪ Energy storage ▪ Microgrids ▪ Electric vehicle (EV) infrastructure	▪ EV supply equipment ▪ DERMS ▪ Energy storage ▪ Community solar	▪ EV supply equipment ▪ Energy storage ▪ BTM storage controls ▪ Community solar	▪ DERMS market functionality ▪ EV supply equipment ▪ Energy storage	▪ EV supply equipment ▪ Energy storage
Costs	Note: Orange shading represents relative magnitude of investment over time					

Source: ScottMadden analysis

Regulators Temper Spending, Seeking "Bang for the Buck"

- While many jurisdictions are pursuing policies intended to evolve the electric grid through advanced technologies, some utilities are facing pushback on the price tag of some proposals
- For example, both Massachusetts and New Mexico rejected AMI proposals by utilities, citing insufficient customer benefits, among other concerns
- Kentucky also rejected a joint proposal to install almost 1.3 million smart meters, deciding that the utilities failed to prove that smart meters wouldn't be "wasteful duplication"
- Moreover, grid riders—which allow utilities to recover costs outside of traditional rate cases and are useful as technologies change—have been challenged in North Carolina and Ohio, as some parties object to potential system "gold plating" without sufficient cost-benefit analysis

IMPLICATIONS

Given the scrutiny and potential resistance to rate increases, utilities should spend a meaningful amount of time understanding their objectives, scoping potential technology test beds, identifying and prioritizing the potential sequencing of investments, and carefully analyzing costs versus customer benefits as they engage regulators and other stakeholders in grid modernization initiatives.

Notes: DERs means distributed energy resources; T&D means transmission and distribution; MEDSIS means Modernizing the Energy Delivery System for Increased Sustainability; li-ion means lithium-ion; SCADA means supervisory control and data acquisition; DSCADA means distribution supervisory control and data acquisition; EV means electric vehicle; IT/OT means information technology/operational technology; BTM means behind the meter

Sources: North Carolina Clean Energy Technology Center; Greentech Media; S&P Global Market Intelligence; Regulatory Research Associates; Hawaiian Electric Company (HECO); company FERC Forms 1, surveys, and press releases; industry news; utility commission websites; ScottMadden analysis

One State's Approach: Hawaii Employs a Variant of DOE's DSPx Cost-Effectiveness Framework for Grid Modernization Project Proposals

Expenditure Purpose Category	Methodology
A. Standards and Safety Compliance Grid expenditures required to ensure reliable operations or comply with service quality and safety standards, including both ongoing asset management replacement of aging and failing infrastructure and relevant grid modernization	Least-cost, best-fit
B. Policy Compliance Expenditures that are needed to comply with state policy goals like the renewable portfolio standard, or direction to interconnect and enable customer adoption of DER	Least-cost, best-fit
C. Net Benefits Expenditures that are not required for standards and safety compliance or policy but would provide positive net benefits for customers	Benefit-cost analysis
D. Self-Supporting Expenditures incurred for a specific customer (e.g., interconnection), with costs directly assigned to those specific customers	Only for projects that do not shift a cost burden to non-participants – this category does not require benefit-cost justification

Source: Adapted from HECO, Modernizing Hawaii's Grid For Our Customers, at p. 42 (Aug. 2017)

Clean Tech and Environment

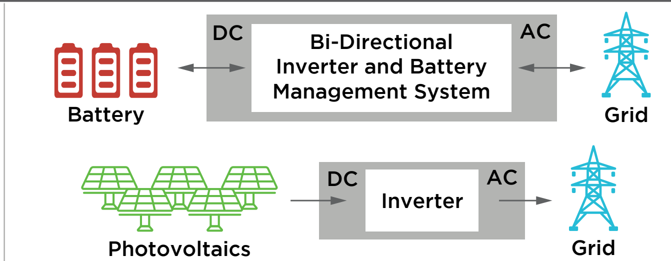
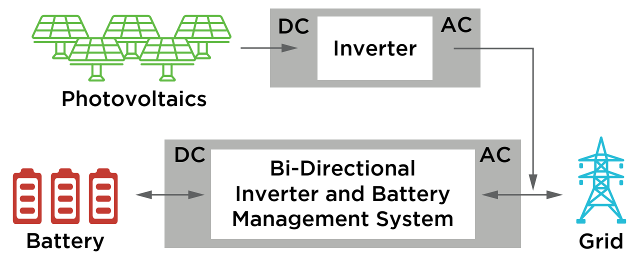
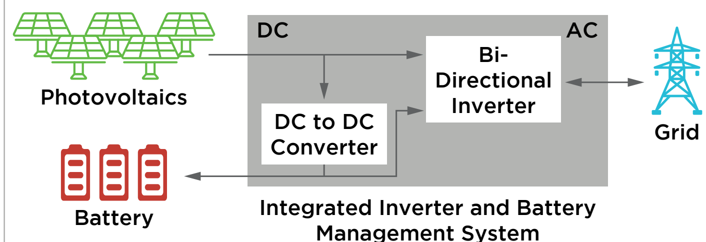
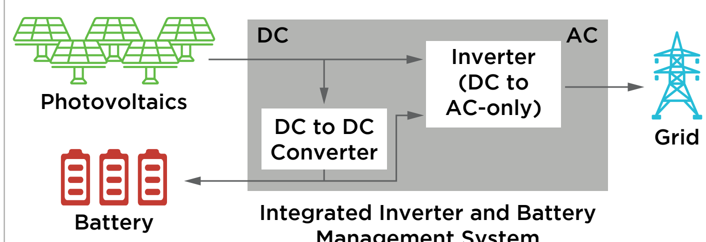
SOLAR PLUS STORAGE
SYSTEM CONFIGURATION IMPACTS OPERATIONAL FLEXIBILITY AND ECONOMIC VALUE

Solar power coupled with energy storage, and its linkage with the grid, gains interest.

National Renewable Energy Laboratory (NREL) Explores Tradeoffs among Different Configurations

- As states like California continue to aggressively pursue carbon-free power generation and solar power penetration increases, more attention is being paid to solar plus storage systems to help manage temporal variations in output
- In an August 2017 report, NREL explored a variety of photovoltaic (PV) plus storage system configurations
- NREL's modeling exercise assumed a 50-MW, fixed-tilt PV system and 30 MWs/120 MWh of battery storage in Southern California. The PV system included an inverter loading ratio of 1.3, i.e., panel capacity exceeded inverter capacity. This common practice results in solar output being "clipped" or lost during peak production
- The report noted that traditional levelized cost-of-energy metrics will always be higher for solar plus storage systems because storage adds overall costs to the system; therefore, the study examined a benefit-cost ratio defined as the annualized benefits (energy revenue and capacity value) divided by the annualized cost (capital and operating expenses)
- Key factors driving the benefit-cost ratios of solar plus storage configurations include balance of system costs, operational flexibility, and the 30% federal investment tax credit (ITC)

Summary of Solar Plus Storage Coupling Options: Implications of Different Configurations

Independent PV and Storage Systems	▪ Systems operate at different locations and do not share hardware components ▪ Storage responds to overall grid conditions and stores energy from any grid source ▪ Configuration represents the vast majority of PV and storage systems currently operating	
AC-Coupled PV Plus Storage System	▪ Systems are co-located and share point of common coupling on the AC grid ▪ Reduces balance of system costs, including siting, permitting, engineering, and land costs ▪ With no common hardware components, storage system can store energy from <u>any</u> grid source and can act independently of PV system, but may not get ITC (see next page)	
DC-Coupled PV Plus Storage (Flexible Charging)	▪ PV and storage are coupled on the DC side of a shared bi-directional inverter ▪ Configuration allows storage system to charge from the grid and PV system ▪ Storage system can capture clipped solar output when panel capacity exceeds inverter capacity, but decreased operational flexibility due to single inverter (see next page)	
DC-Coupled PV Plus Storage (Tightly Coupled)	▪ PV and storage are coupled on the DC side of a shared DC to AC-only inverter ▪ Storage system can capture clipped solar output, but operational flexibility is further reduced as storage can only charge from the PV system ▪ Storage systems in tightly coupled configuration can receive full ITC	

Source: NREL

KEY TAKEAWAYS

- **Multiple solar plus storage configurations exist, with each configuration impacting system operations and value**
- **Tighter coupling of solar plus storage (i.e., tight DC coupling) can decrease operational flexibility but improve the value obtained from the ITC**
- **With higher solar penetrations, the value of standalone PV decreases, and solar plus storage provides a significantly better option**

Battery Storage Can Qualify for ITC

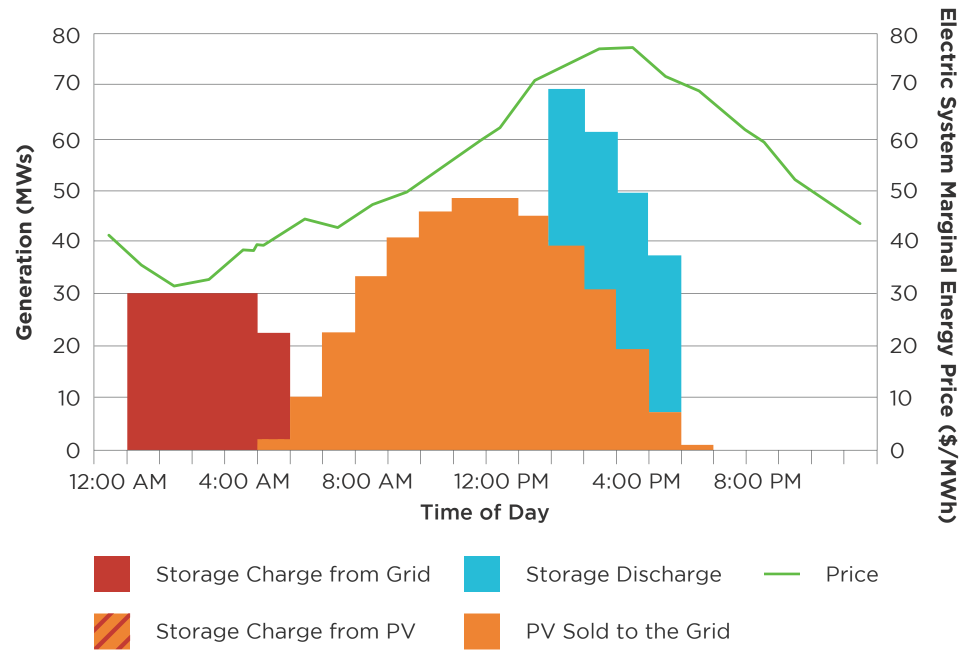
- Battery systems that are charged by a renewable energy system more than 75% of the time are eligible to leverage the federal ITC, per private letter rulings from the U.S. Internal Revenue Service
  - Battery systems must meet eligibility requirements (i.e., 75% renewable charging) on an annual basis for a period of five years
  - Eligible battery systems may claim an ITC value equal to the proportion charged from renewable energy (e.g., 80% renewable charging results in 80% of ITC), significantly improving battery project economics
  - If renewable charging drops below the benchmark of the first-year percentage, then the system may be subject to recapture provisions (i.e., system owner must pay back proportional amount of the tax credit claimed in earlier years)

Coupling Limits Storage Utilization and Results in Non-Optimal System Dispatch

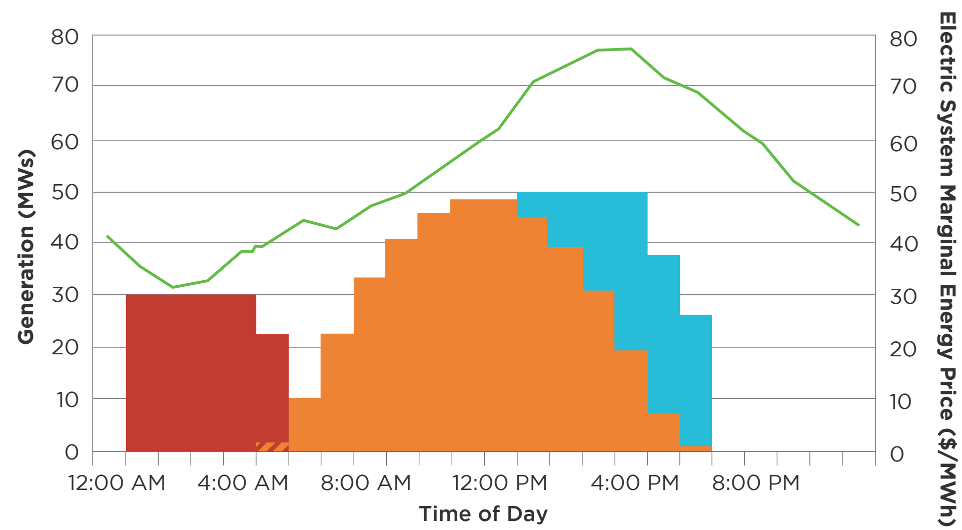
- The two NREL examples (see figures at right) illustrate how DC coupling of solar and battery storage can create times when storage cannot be fully utilized because of PV system operations
- In the independent configuration, the two inverters allow the solar and storage systems to operate separately, resulting in a combined output as high as 70 MWs
- Meanwhile, the DC-coupled system requires the solar and storage systems to share one inverter, thereby limiting total output to 50 MWs

DC Coupling May Limit Available Capacity from the Combined Solar Plus Storage Unit

Independent (July 1) – Can Always Use Full Storage Capacity

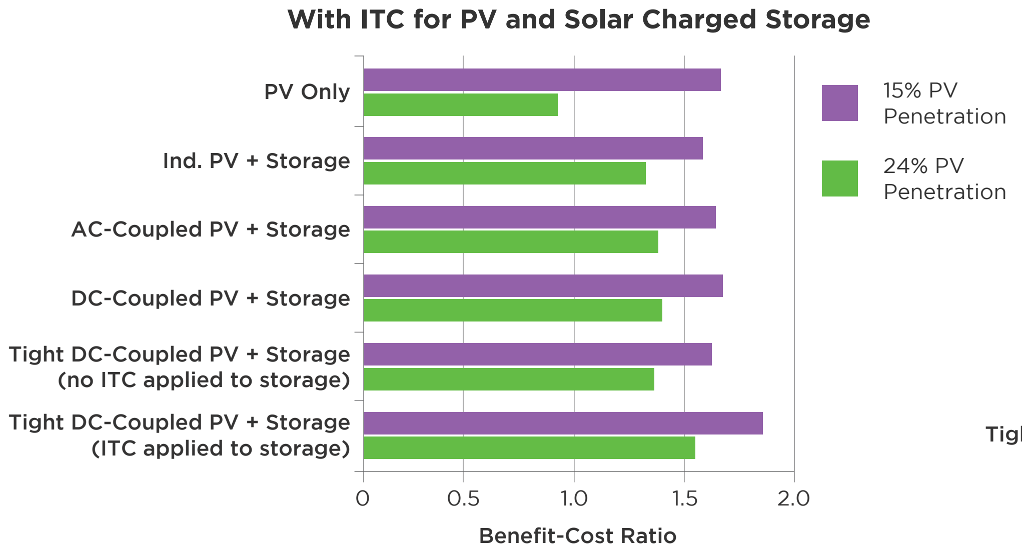


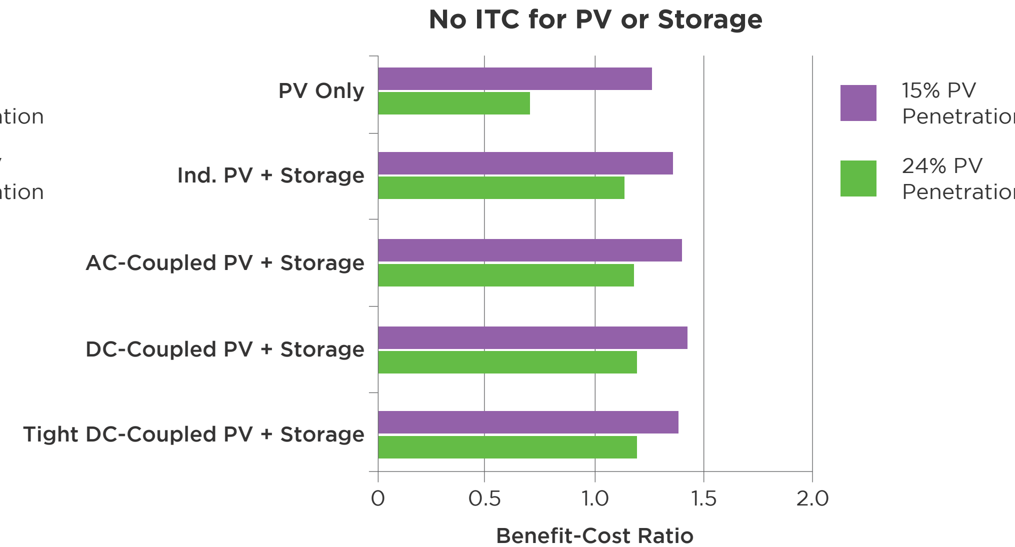
DC-Coupled (July 1) – Storage Output Restricted by PV Use of Inverter



Source: NREL

With ITC Available, Tightly Coupled PV Plus Storage Is Most Attractive in 2020 from a Cost-Benefit Perspective





Note: Values < 1 mean costs exceed benefits; values > 1 mean benefits exceed costs. **Source:** NREL

Despite Operational Limitations, Coupling Increased Value to System Owner

- NREL explored the benefit-cost ratio of solar plus storage in 2020 by examining two ITC scenarios (30% ITC and no ITC) and two different solar penetration scenarios (15% and 24% PV penetration)
- In the 30% ITC scenario (left chart above), tight DC coupling produced the greatest benefit-cost ratio as the storage system leverages full ITC value. In addition, the value of a PV only system collapses with 24% PV penetration, yet solar coupled with storage retained a favorable benefit-cost ratio
- In the no ITC scenario (right chart above), all coupling scenarios show a higher benefit-cost ratio than the comparable PV-only system design
- Driven by technology cost declines, the modeling results show many cases where solar plus storage is more favorable than standalone PV in 2020

IMPLICATIONS

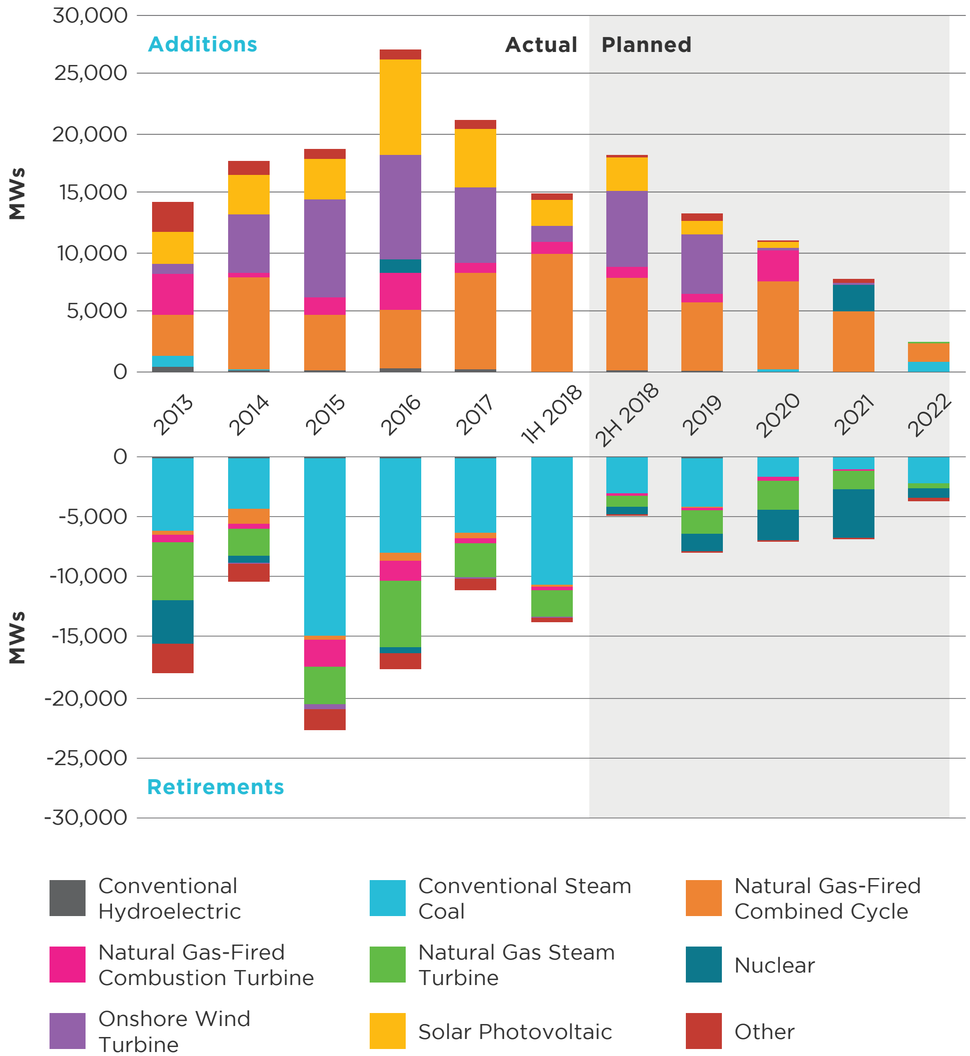
System configuration will be an important consideration as solar plus storage garners increased attention as a dispatchable resource.

Sources: Holland & Knight; *Renewable Energy World*; National Renewable Energy Laboratory, Evaluating the Technical and Economic Performance of PV Plus Storage Power Plants (Aug. 2017); ScottMadden analysis

The Industry in Charts

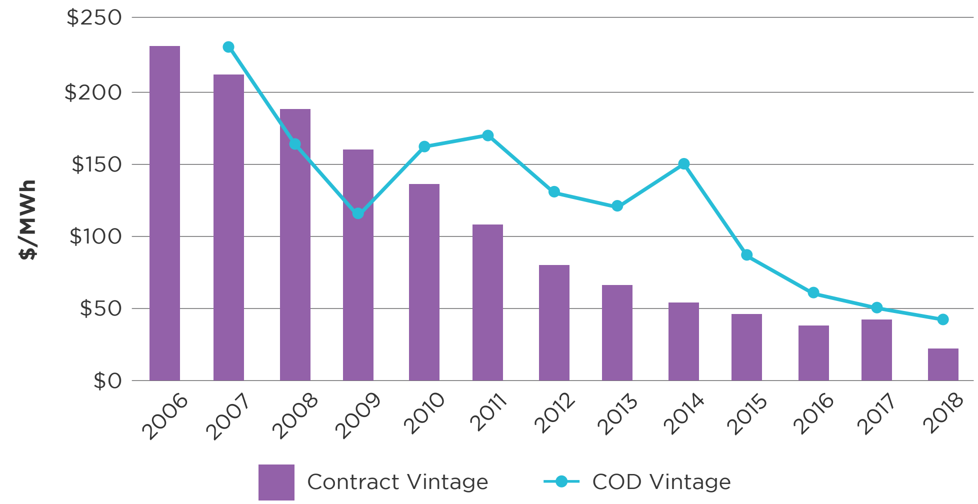
THE ENERGY INDUSTRY BY THE NUMBERS

U.S. Power Plant Additions and Retirements (Actual and Planned) by Technology Type (in Net Summer MWs)



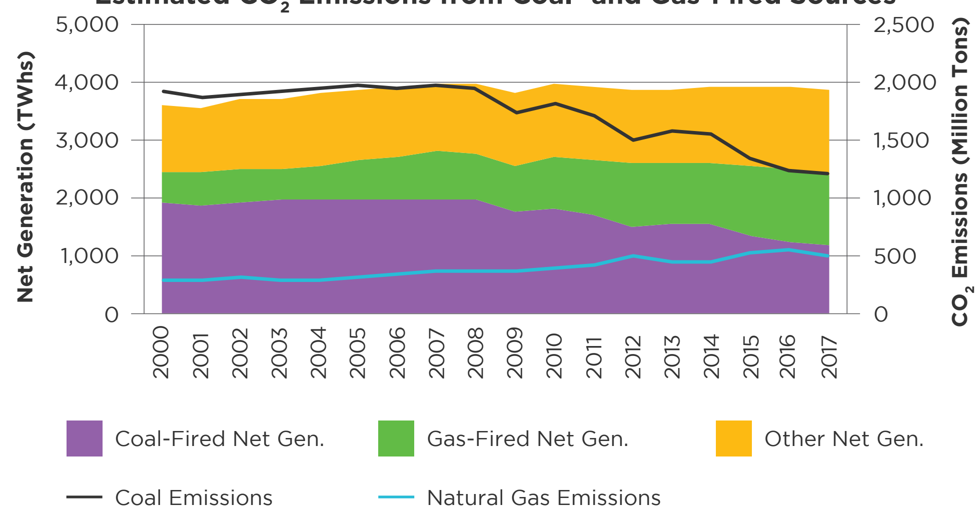
Sources: EIA; ScottMadden analysis

Average Levelized Utility-Scale PV Power Purchase Agreement Prices by Contract and Commercial Operation Date Vintage ($/MWh)



Source: Lawrence Berkeley Nat'l Lab

Selected Annual Electric Power Sector Net Generation by Fuel and Estimated CO_2 Emissions from Coal- and Gas-Fired Sources



Source: EIA

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Public Power & Electric Cooperatives	▪ Florida Power & Light to Purchase Vero Beach's Municipal Utility
Fossil Generation	▪ California's Combined Cycle Costs in the Age of the Duck Curve ▪ EPA Proposes Affordable Clean Energy Rule as Replacement for Clean Power Plan
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ENERGY PRACTICE
SCOTTMADDEN KNOWS ENERGY

About ScottMadden

We know energy from the ground up. Since 1983, we have served as energy consultants for hundreds of utilities, large and small, including all top 20 energy utilities. We have helped our clients develop strategies, improve operations, reorganize companies, and implement initiatives. Our broad and deep energy utility expertise is not theoretical—it is experience based.

Stay Connected

ScottMadden recently joined the Smart Electric Power Alliance in a fact-finding mission from October 14–19, to explore the powerful discoveries and course corrections of the United Kingdom's most recent energy innovations, including performance-based energy price schemes, transactive energy projects, and flexibility markets.

We look forward to presenting learnings and insights from the trip. If you are interested in receiving a copy of our key findings, please contact us at info@scottmadden.com.

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