Price Impacts of Extreme Weather | Botched FERC Policy on Natural Gas Infrastructure

IECA Meeting

November 13, 2018 | Arlington VA

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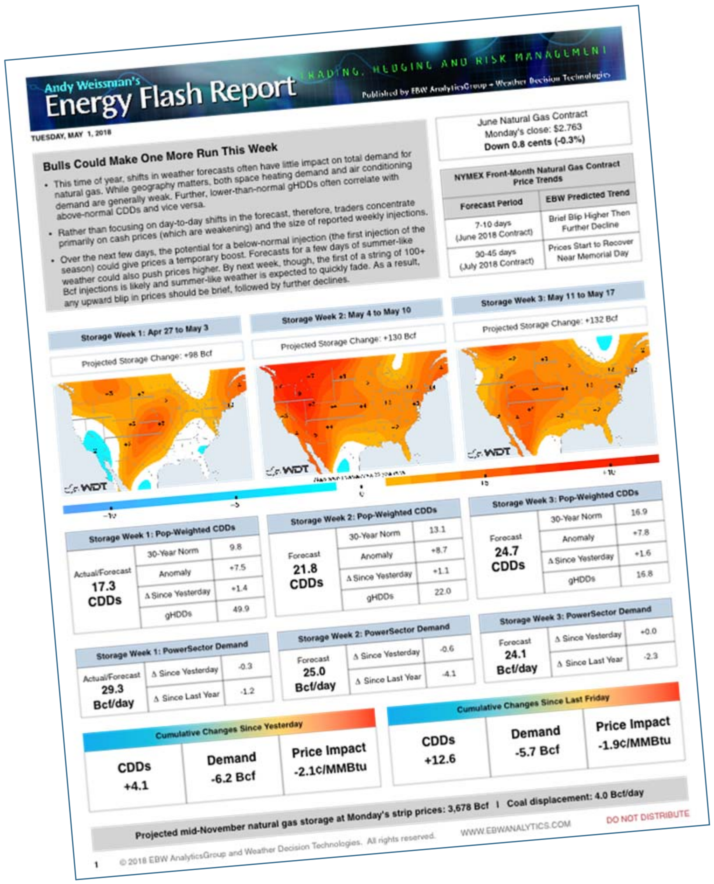
About Andy Weissman

- **CEO, EBW AnalyticsGroup**
  - Premier energy market analysis service since 2003; publishes:
    - **Market Quick Takes**, weekly snapshot of the nexus between weather and the cost of natural gas and electricity
    - **Energy Risk Report**, the only analysis designed specifically to aid energy procurement professionals
    - **Energy Flash Report,** a daily analysis with the latest changes to weather and the natural gas supply/demand balance
  - To learn more, please visit **www.EBWAnalytics.com**
- **Senior Counsel at Pillsbury Winthrop Shaw Pittman**
  - 30+ years experience providing strategic advice at C-suite level
  - Highly regarded energy regulatory attorney and Clean Air Act expert
  - Couples legal expertise with deep industry expertise
- Major role in transforming U.S. energy and environmental policy
- Helped to pioneer emissions trading in United States
- Connect with me on LinkedIn “Andy Weissman”

Energy Flash Report

- Natural gas demand and weather changes and forecasts
- Forecasts for current and following two natural gas storage weeks
- Delivered daily before the bell



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Energy Risk Report

- The only publication with *specific procurement recommendations* for large energy users
- Designed to assist buyers with optimizing timing of electricity and natural gas purchases
- Delivered in four easy-to-read issues each month: National, MISO + ISO-NE, ERCOT + CAISO, and PJM + NYISO


NATIONAL ISSUE

FEBRUARY 15, 2018

Energy Risk Highlights

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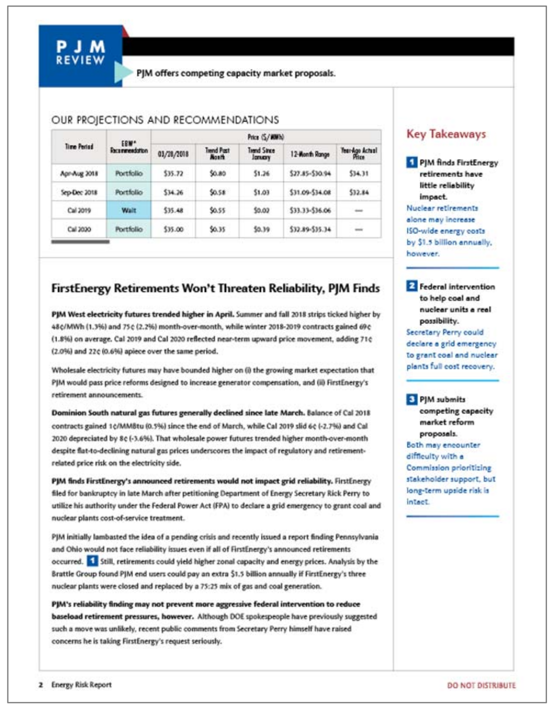
Andrew D. Weissman, Editor in Chief


PJM REVIEW

PJM offers competing capacity market proposals.

OUR PROJECTIONS AND RECOMMENDATIONS

Key Takeaways

FirstEnergy Retirements Won't Threaten Reliability, PJM Finds

2 Energy Risk Report

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NATURAL GAS

NATIONAL OVERVIEW

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Overview

- Presentation addresses:
  - Near-term natural gas price forecasts
  - Longer-term issues re natural gas price, supply and infrastructure
- Key themes and conclusions:
  1. Range of potential price outcomes this winter: off the charts
  2. Natural gas and electricity prices likely to plunge later in 2019
  3. New market paradigm emerging
     - Availability of low cost gas in ground no longer the issue
     - Keys have become:
       - Risk of extreme weather
       - Severe infrastructure deficiencies
         - Stems in part from FERC's failure to take an integrated approach to regulating natural gas and electricity markets
       - Potential variability of demand for LNG

Overview (cont'd.)

- Despite availability of huge amounts of natural gas in the ground, frequency and severity of natural gas price spikes could be even greater than in the past
- Even if natural gas prices remain low, costs for electricity could rise sharply
- Natural gas prices at Henry Hub may no longer be a useful proxy for the market

Natural Gas Price Shocks

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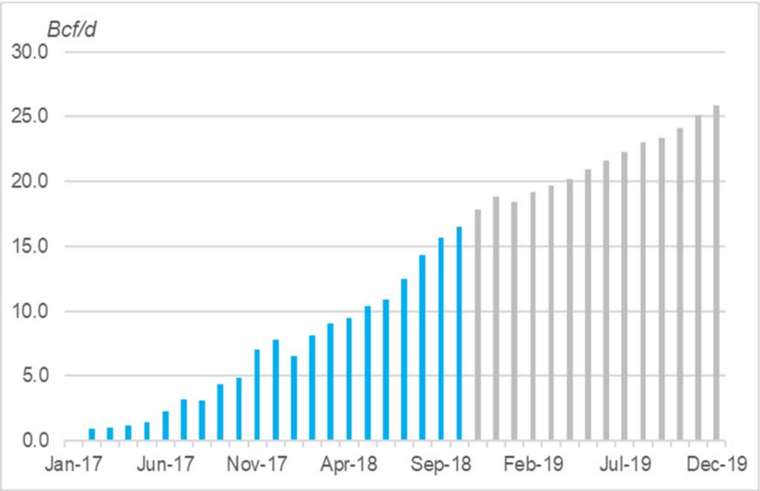
Availability of Low-Cost Supply Not Issue

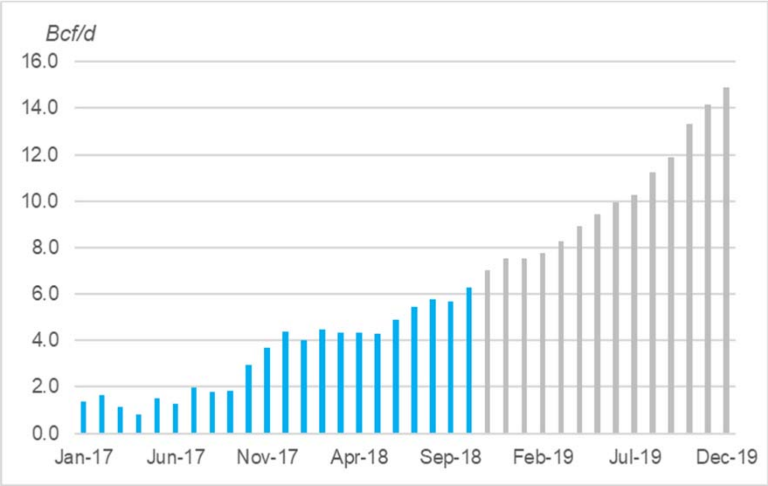
- Natural gas production growing at unprecedented rate
- In a normal-weather scenario, growth in supply would vastly outpace growth in demand
- Even more rapid increases possible, but require
  - Adequate lead time
  - Major increases in pipeline capacity
  - Major increases in available storage capacity

Growth in Dry Gas Production, January 2017 – December 2019 (Bcf/d)



Source: EIA, EBW Analytics

Lower 48 Natural Gas Demand, January 2017 – December 2019 (Bcf/d)

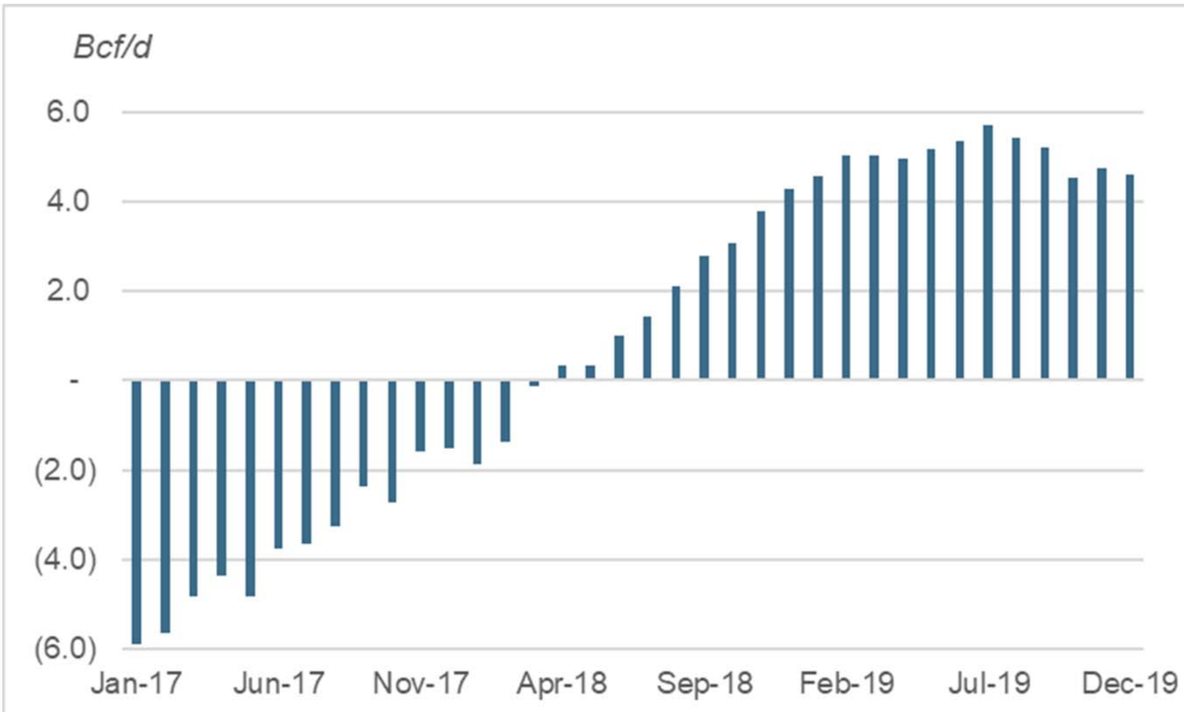


Source: EBW Analytics

Strong Bearish Shift in Supply/Demand Balance

- In normal weather, natural gas market far better supplied than at any time in the past

Change in Natural Gas Supply/Demand Balance Since Beginning of November 2016 Annual Storage Cycle (Bcf/d)



Source: EBW Analytics

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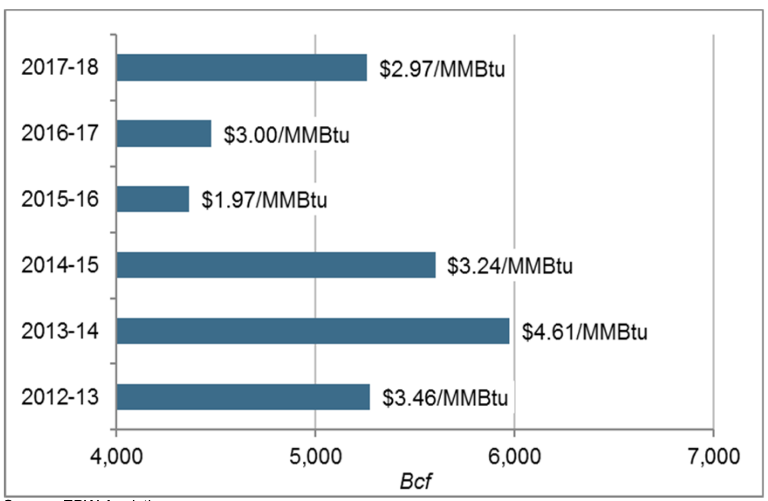
Weather, Weather, Weather

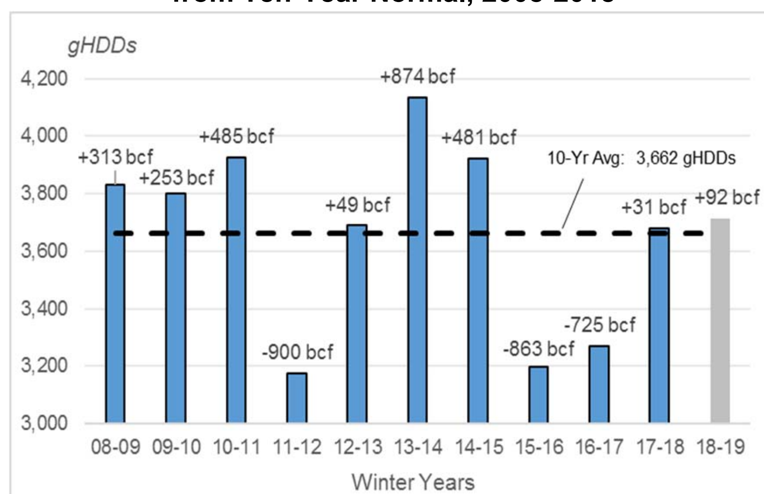
- **HUGE** impact on demand – and therefore prices
- Weather forecast uncertainty and magnitude of potential price impact not fully appreciated
  - Should **never** rely on a single point forecast
  - Uncertainty greatest before start of winter and again before start of summer
  - Macquarie not far off the mark in recent prediction that "one touch" price this winter could be as high as $6.50/MMBtu or as low as $1.95/MMBtu

Space Heating Demand (Bcf) and Average Henry Hub Price ($/MMBtu), Last Six Winters



Source: EBW Analytics

Winter gHDDs and Space Heating Deviation from Ten-Year Normal, 2008-2018

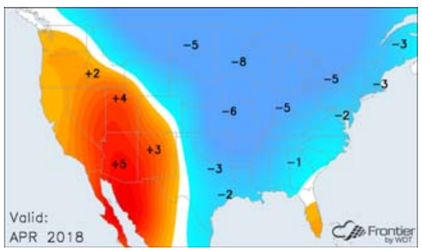


Source: Weather Decision Technologies, EBW Analytics

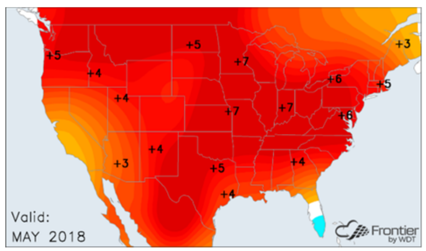
Seven Straight Months of Extreme Weather

- Since injection season began in April, weather has been near record levels nearly every month
  - Net impact: 520 Bcf of above normal demand for natural gas
    - Average increase of 6.5 Bcf/d

April 2018



May 2018



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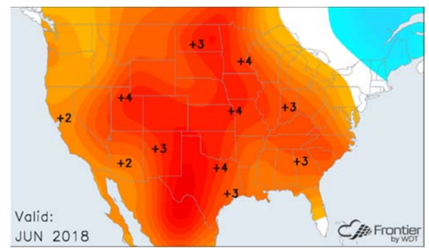
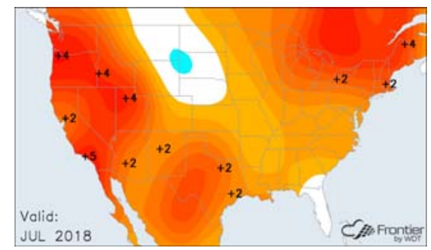
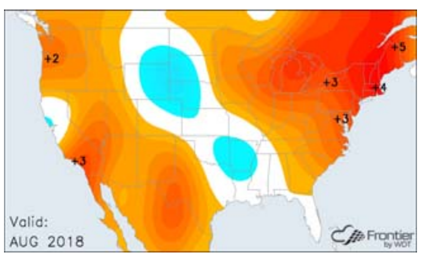


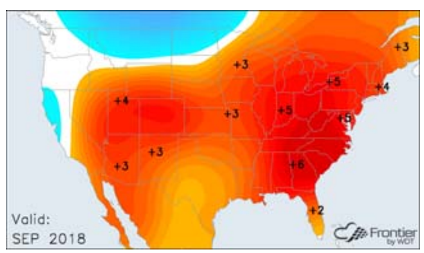
July 2018



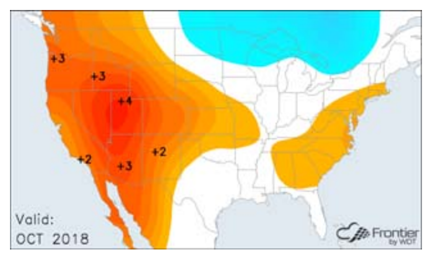
August 2018



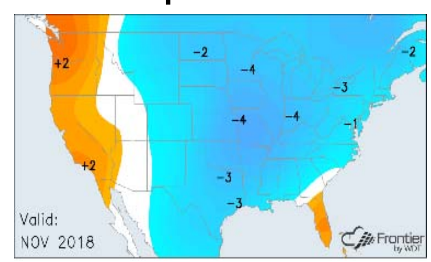
September 2018



October 2018



April 2018



Source: Weather Decision Technologies

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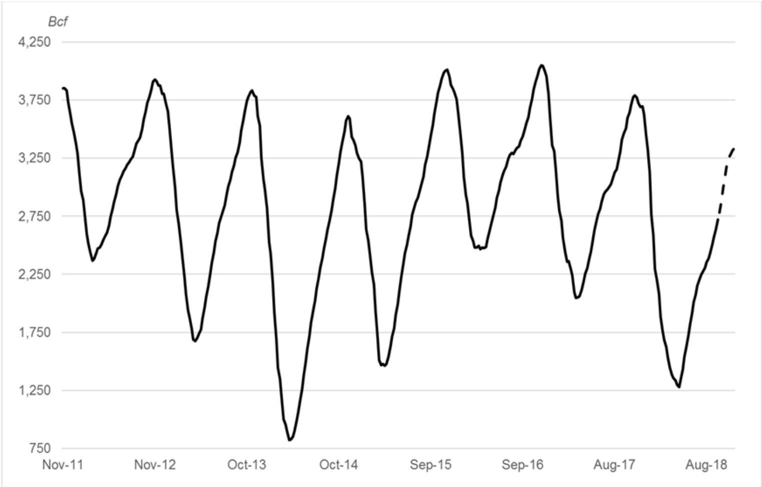
Storage Drives Natural Gas Market

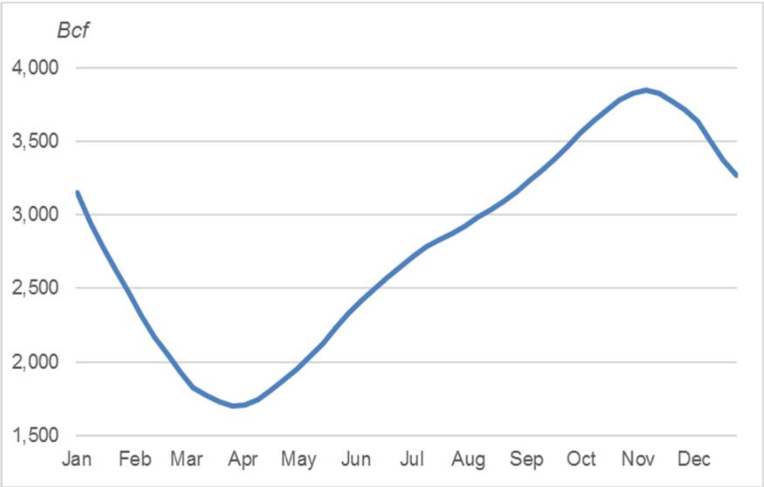
- Key factor driving market is need to keep storage at reasonable levels
- Demand for natural gas varies greatly seasonally
  - But in an efficient market, production is flat
- Primary function of storage is to manage seasonal swings in gas demand
  - Prices go up or down in order to keep storage trajectory at reasonable levels

Natural Gas Storage Inventories (Bcf), 2011-2018



Source: EIA, EBW Analytics

Five-Year Average Natural Gas Storage Inventory Levels (Bcf), 2013-2017



Source: EIA, EBW Analytics

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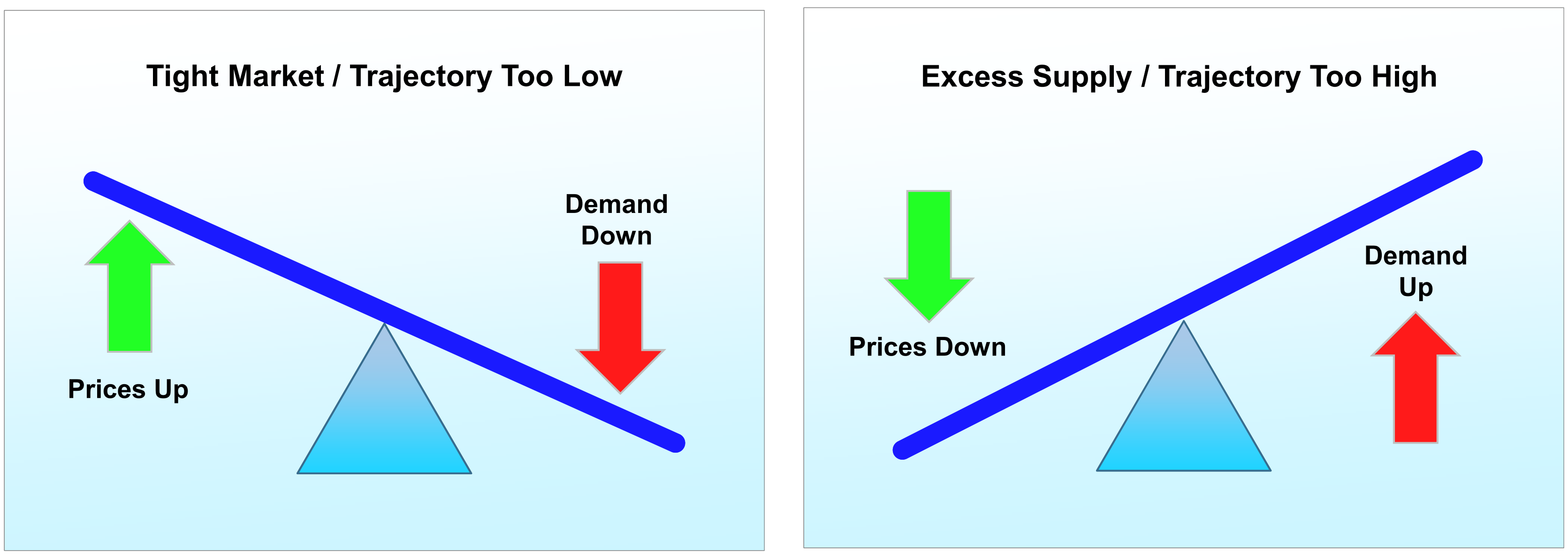
Primary Adjustment Mechanism = Coal Displacement

- Largest – and most price-sensitive – source of demand:
  - Changes in relative use of natural gas-fired generation and coal
    - Dispatch changes automatically as a function of price

Adjustment Mechanism



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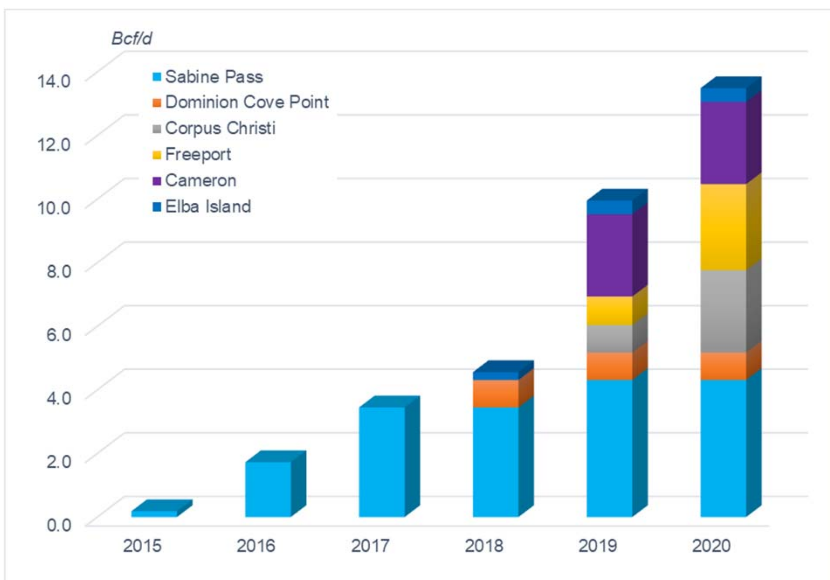
Huge Price Impact Due to Abnormal Weather

- Production grew more rapidly than expected when injection season began
- In a normal-weather scenario, injection-season prices could have averaged as little as $2.36 and still kept end-of-season storage above 3,300 Bcf
  - Instead, averaged more than $3.00
- Winter-month contracts might currently be selling in a range between $2.45 and $2.71/MMBtu
  - Instead, prices have soared

Actual and Forecast Liquefaction-Related Gas Demand by Project, 2015-2020 (Bcf/d)

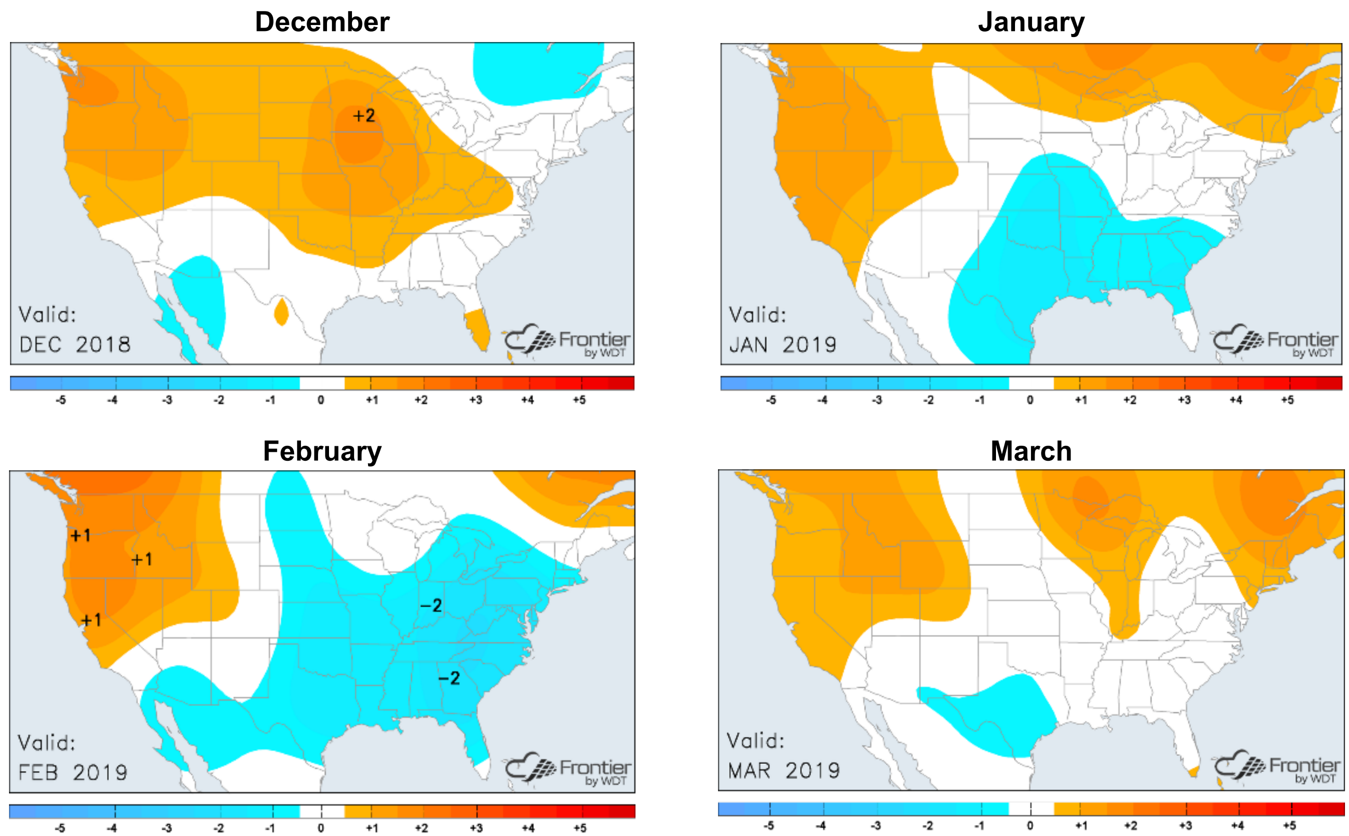


Source: EBW Analytics

Weather Will Be Even More Critical This Winter

- Wide range of outcomes possible
- In current most-likely weather scenario, gas prices might soften soon—and then collapse before winter ends
  - If December is milder than forecast, gas prices likely to head lower even more quickly

December 2018-March 2019 Temperature Anomaly Maps



Source: Weather Decision Technologies

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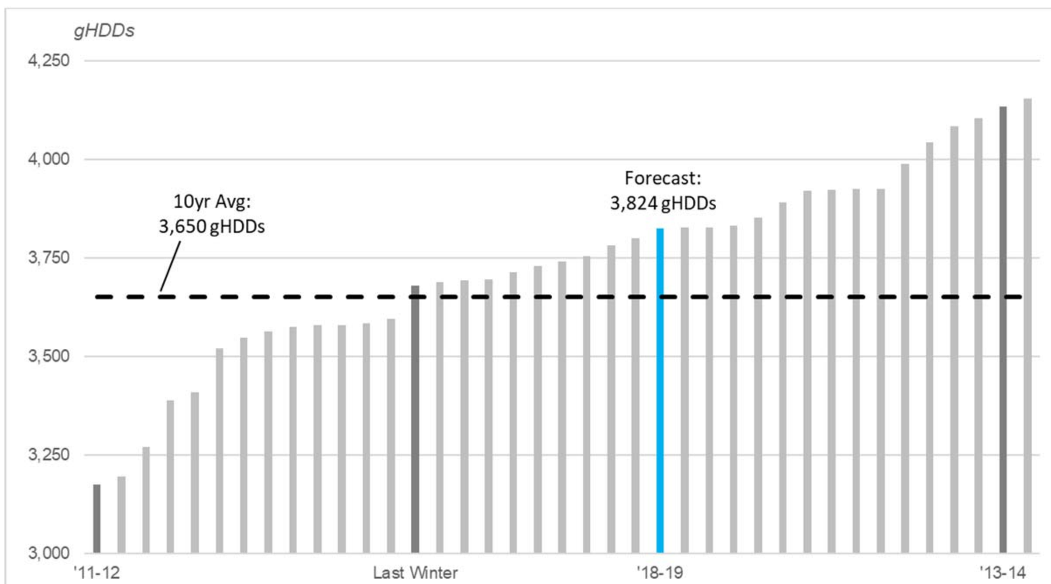
But High Risk of Severe Natural Gas Price Spikes

- Natural gas storage cushion has been eliminated
- A 215 gHDD increase in demand could drive end-of-season storage to 850 Bcf or below
  - Market would not tolerate
  - Well freeze-off could exacerbate risks
  - Severe price spikes likely
    - Ability to displace natural gas with coal already near its limits
- Resulting price spikes likely to stun market

Winterlong gHDDs, 1982 to Current Winter Forecast



Source: WDT, EBW Analytics

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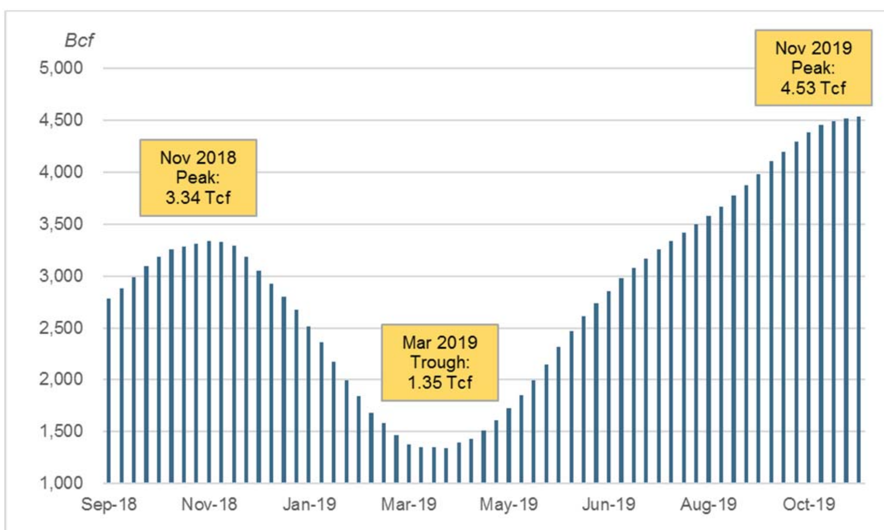
National Natural Gas Market Likely to Face Severe Oversupply Later in 2019

After Winter Passes, Market Focus Will Shift to Avoiding Storage Glut in 2019

- Market risks flip 180º after potential winter storage squeeze fears pass
  - Turn to averting November 2019 glut
- Continued supply growth in most-likely scenario suggests vastly oversupplied market for 2019
  - Current mid-November 2019 storage outlook is 4.5 Tcf — 1.2 Tcf above 2018
  - Spot prices may have to fall under $2.00/MMbtu at Henry Hub, with prices at Dominion South falling to $1.50/MMBtu or below

Projected Storage Trajectory at Current NYMEX Futures, Most-Likely Weather and Production



Source: EBW Analytics

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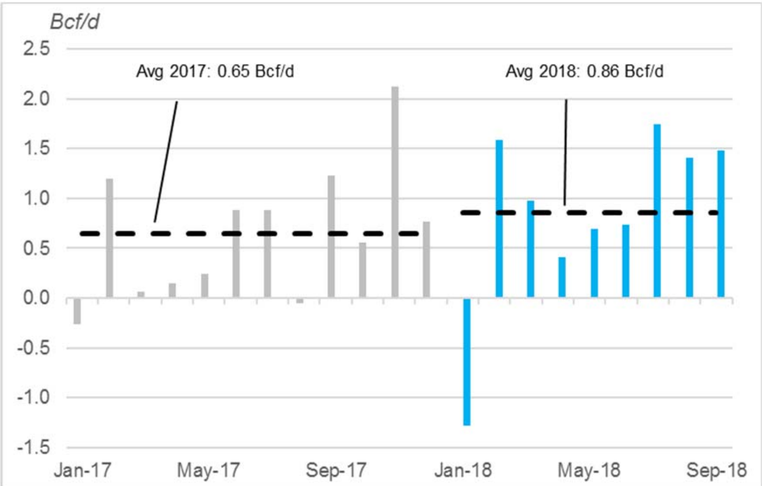
Several Dynamics May Influence Depth of Gas Glut

- Production a key risk
  - Higher near-term output to fill pipelines raises risk of glut nationally in 2019
  - Extra 1.0 Bcf/d of production may require breakeven prices to fall 30¢ (all else equal)
- Import/export balance poses key risks
  - Uncertainty regarding timing and possible delays to start-up for new LNG terminals
  - Falling imports from Canada
  - Rising exports to Mexico
- Weather risks increasing
  - Hot summer can boost demand 300-400 Bcf—and hot is the new normal

Most-Likely Scenario: Prices Sink to Low $2.00s/MMBtu

- Upside winter risks dissipate this fall with incrasing natural gas production and lack of extreme cold weather forecasts
- Production growth continues near recent rate
  - Faster growth in Appalachia neutralizes slower growth in Permian
- Hot summer 2019 inline with five-year average

Month-over-Month Natural Gas Production Gains Accelerate (Bcf/d), Jan 2017 – Sep 2018



Source: EIA, EBW Analytics, Platts, Bloomberg

Even if demand grows 4.0 Bcf/d, 8.0 Bcf/d of production growth increases oversupply by 4.0 Bcf/d.

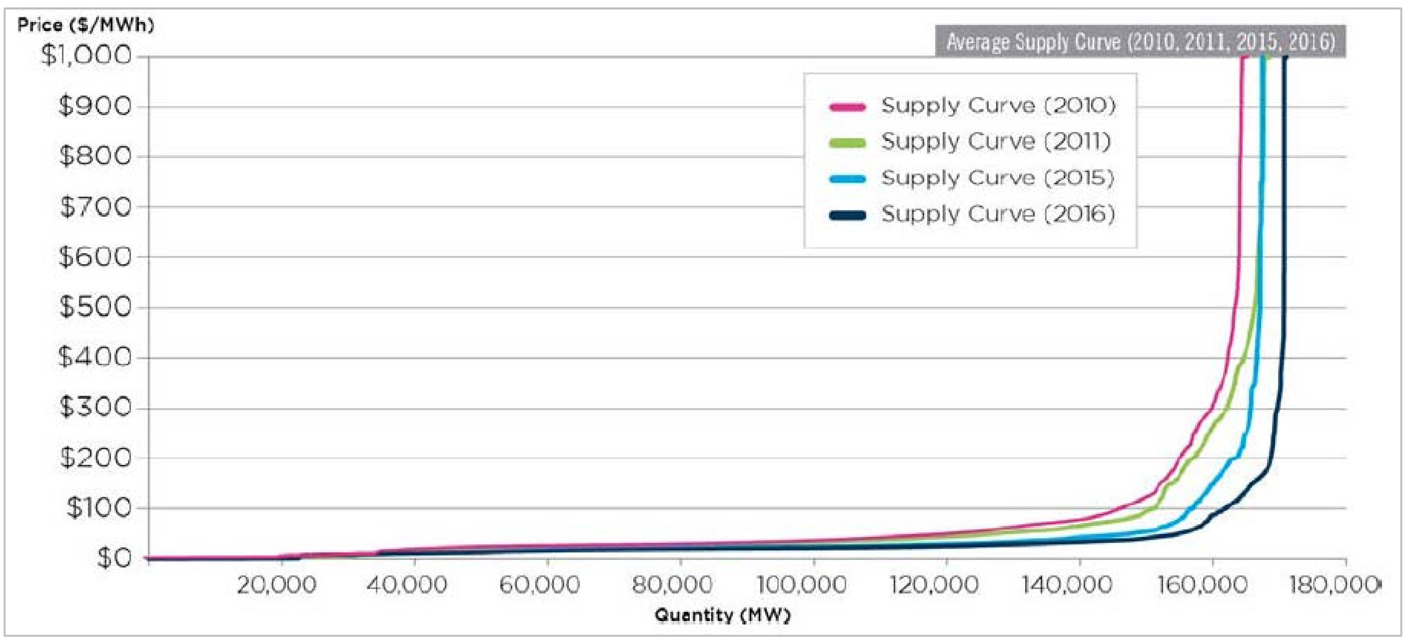
Scenario #2: Glut Averted – But Upside Risk Still Muted

- Multiple factors can avert oversupply in 2019:
  - End of winter storage at only 1,000 Bcf (instead of 1,350 Bcf)
  - Hot summer adds 300 Bcf demand
  - 2.0 Bcf/d of lower production growth
  - Net imports 1.0 Bcf/d below current expectations
- Prices still remain near $2.75/MMBtu

Balance Cal 2019: Gas Weighs on Electricity Prices

- Very low nat gas prices may keep electricity prices near or below recent years
- Shifting generation mix away from high marginal cost coal and toward low marginal cost combined cycle, renewables similarly weigh on prices
  - 15,700 MW of combined-cycle capacity added from January 2018 to June 2019
- Unlikely for weather to be as bullish as 2018 records

PJM Supply Curve Shifts Right



Source: PJM

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Longer-Term Picture

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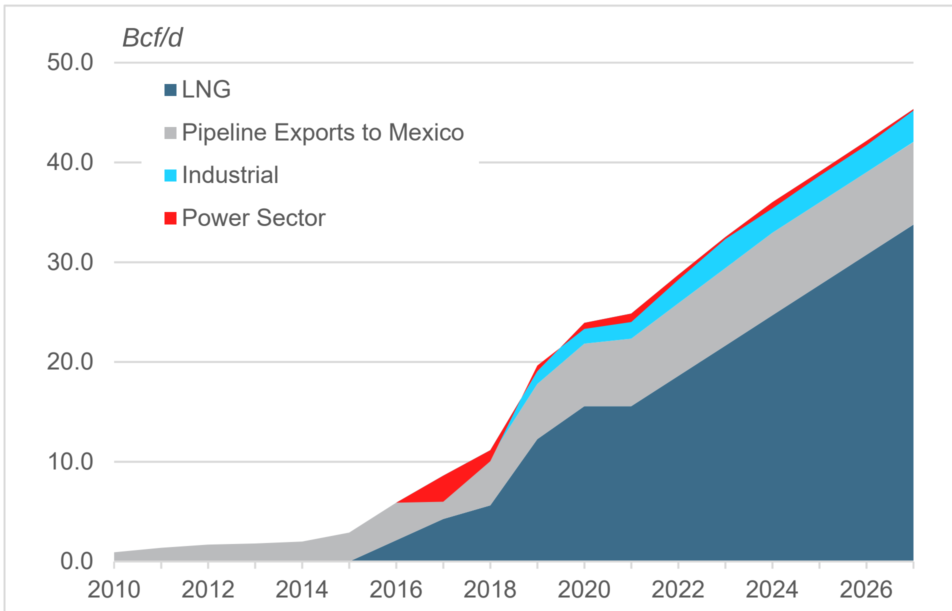
Unprecedented Growth in Demand

- Driven primarily by four factors:
  - Pipeline exports to Mexico
  - LNG exports
  - Strong growth in industrial demand
  - Continued growth in power sector demand

Natural Gas Demand for LNG and Exports to Mexico Plus Net Growth in Industrial and Power Sector Demand from 2016 Onward, 2010-2027 (Bcf/d)



Source: EIA, EBW Analytics

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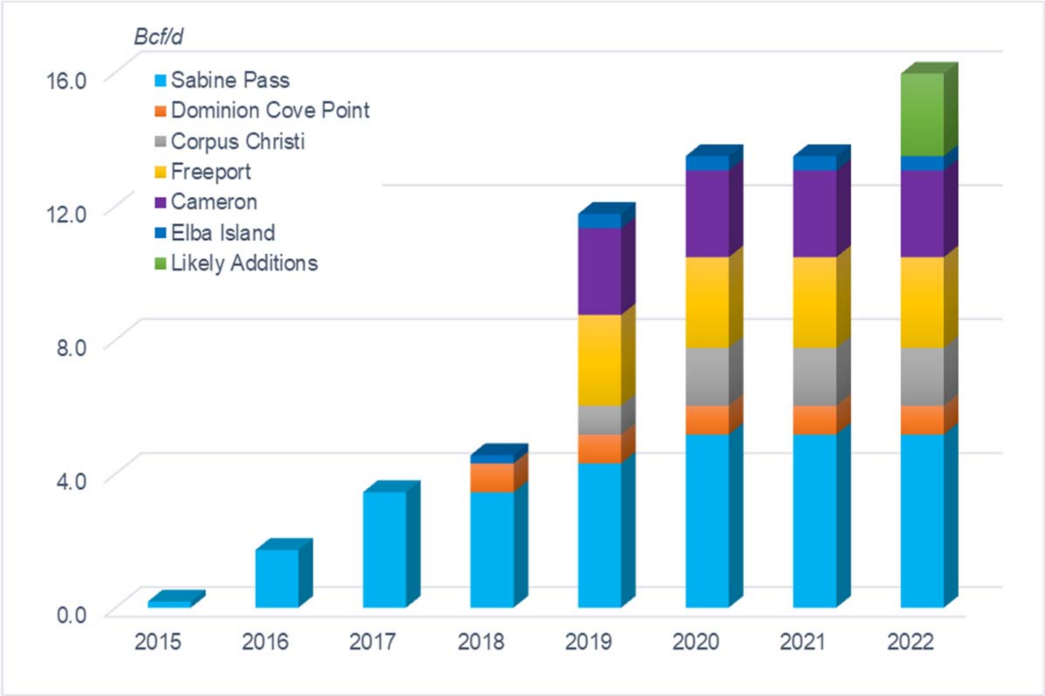
LNG Exports Most Important Driver

- US LNG projects largest single source of demand
  - In five years, US likely to be largest exporter in the world
- US also likely to become net exporter to Canada
- Rate of production growth may still overwhelm those outlets

Liquefaction-Driven Natural Gas Demand by Project, 2015-2022 (Bcf/d)

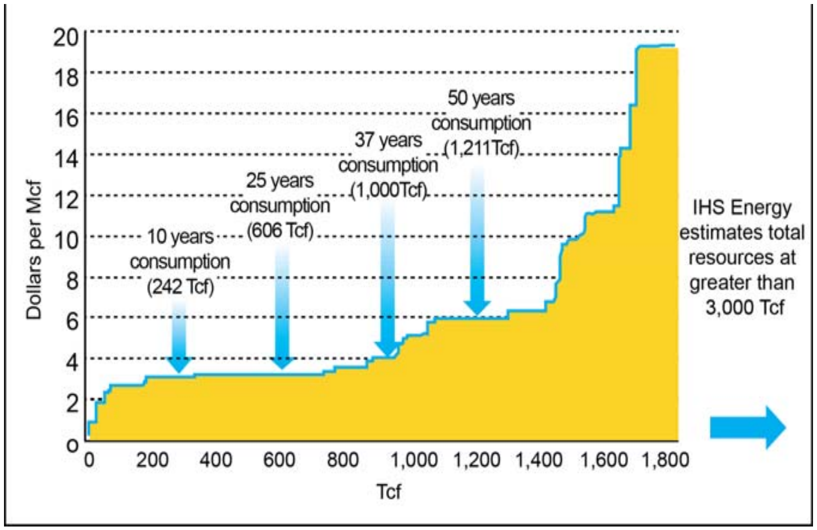


Source: EBW Analytics

Adequacy of Supply Not Likely to be a Major Issue

- Current resource base sufficient to supply 100 Bcf/day for 75-150 years at moderate cost
  - Nearly certain to expand
  - Multiple zones in many shale plays
- Significant efficiency gains likely every year
  - Digital Intelligence (DI) could be the next game changer

Break-Even Henry Hub Price for Natural Gas Resources in 17 Analyzed Unconventional Plays



Source: IHS/CERA

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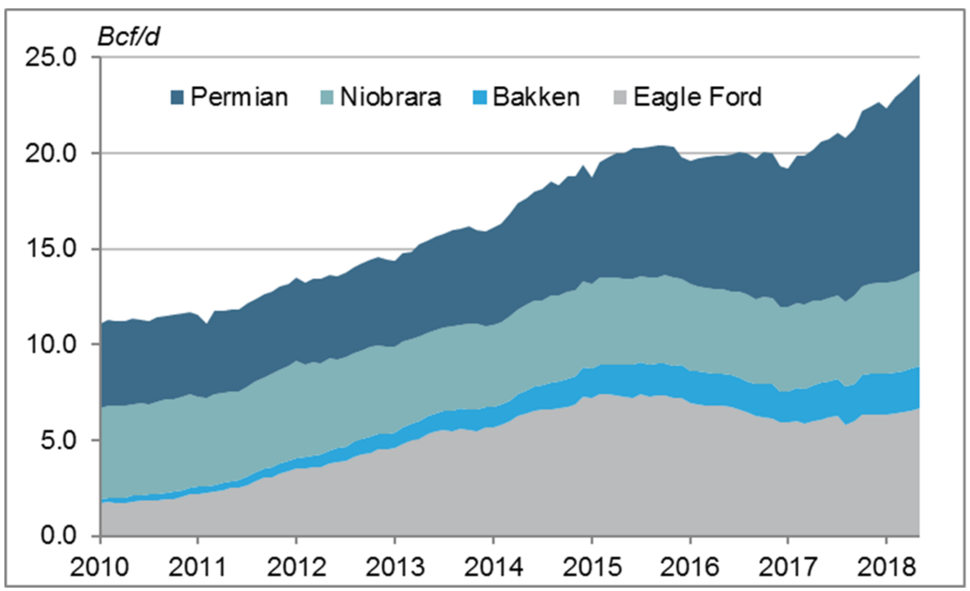
Abundant Resource

- Factors that could keep natural gas prices moderate next 5-10 years:
  - Vast increases in production of associated gas
    - Much lower decline rate than previously expected
    - Could reach 30 Bcf/day from Permian Basin alone
  - Ability to tap additional sources of supply still at an early stage in development
    - High Alpine
    - Canada
  - Continued improvements in technology
    - Future costs for Tier II and III reserves could prove to be inline with current Tier I
  - Enhancing future production from existing wells
  - Development of multiple seams

Associated Gas Production in the Four Largest US Shale Oil Plays, 2010-2018 (Bcf/d)

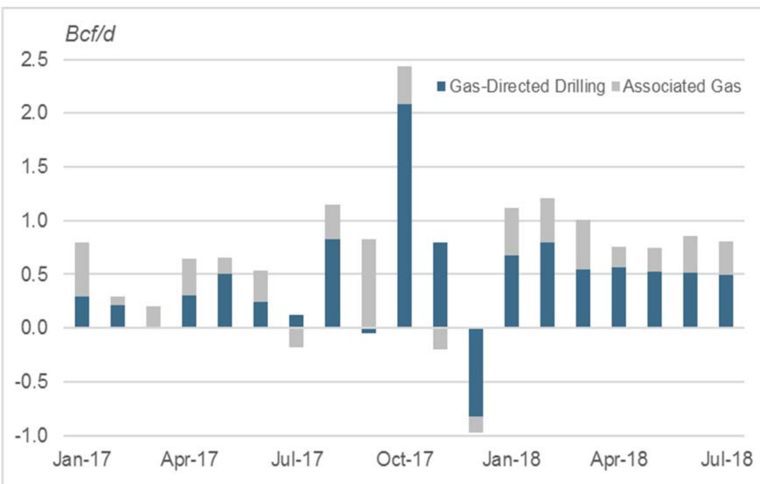


Source: EIA DPR

Associated Gas Does Not Respond to Gas Prices Alone

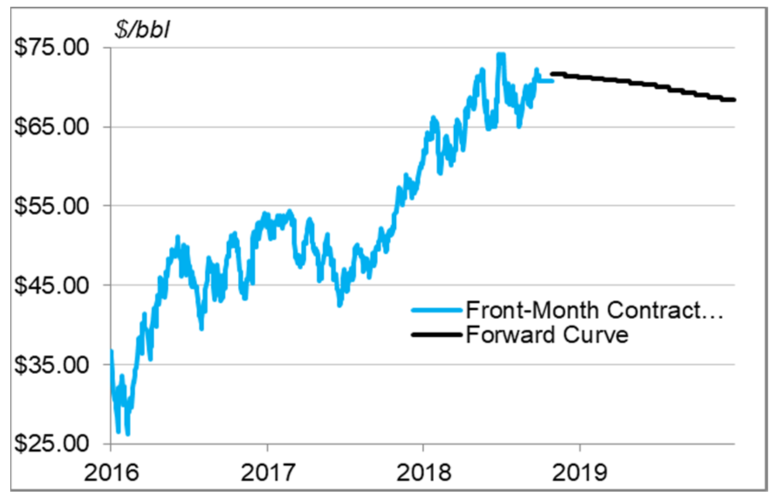
- Associated gas—a byproduct of oil-directed drilling—is more responsive to the price of oil than the price of gas
  - Associated gas has been responsible for ~half of production growth over past 18 months
- Even if natural gas prices crater, associated gas supply can continue to rise
- This may force gas-directed drilling to halt or even shut-in production
  - Prices may have to fall lower than commonly realized

Monthly Production Changes in Gas-Directed and Associated Gas Output, Jan 2017 – Aug 2018



Source: EIA, EBW Analytics

WTI Front-Month Contract Price, January 2016-September 2018 and Forward Curve Through 2019 ($/bbl)



Source: Bloomberg

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Major Price Risks

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Major Upside Price Risks Not Primarily Due to Limitations on Available Supply

- Most significant risk factors:
  - **WEATHER**
  - Failure to build-out adequate infrastructure in timely manner
  - Inability to deliver sufficient natural gas to key regional markets in winter
  - Potential for runaway basis differentials at Henry Hub
  - Volatility of demand for US LNG exports
    - Bidding wars possible with some of the deepest pockets in the world

Severity of Winter Weather Key Near-Term Issue

- Current odds only 5% for repeat of 2013-2014 Polar Vortex winter
  - BUT market-distorting effects increase impact on PJM winter risk premiums
- A repeat of a very cold 2009-2010 winter close to 15%
- Meteorological factors to keep an eye on:
  - El Niño Southern Oscillation and location of warmest water pools
  - Quasi-Biennial Oscillation (QBO) is rising, which may suggest less cold
  - Snow cover over Eurasia in coming weeks may increase cold risks

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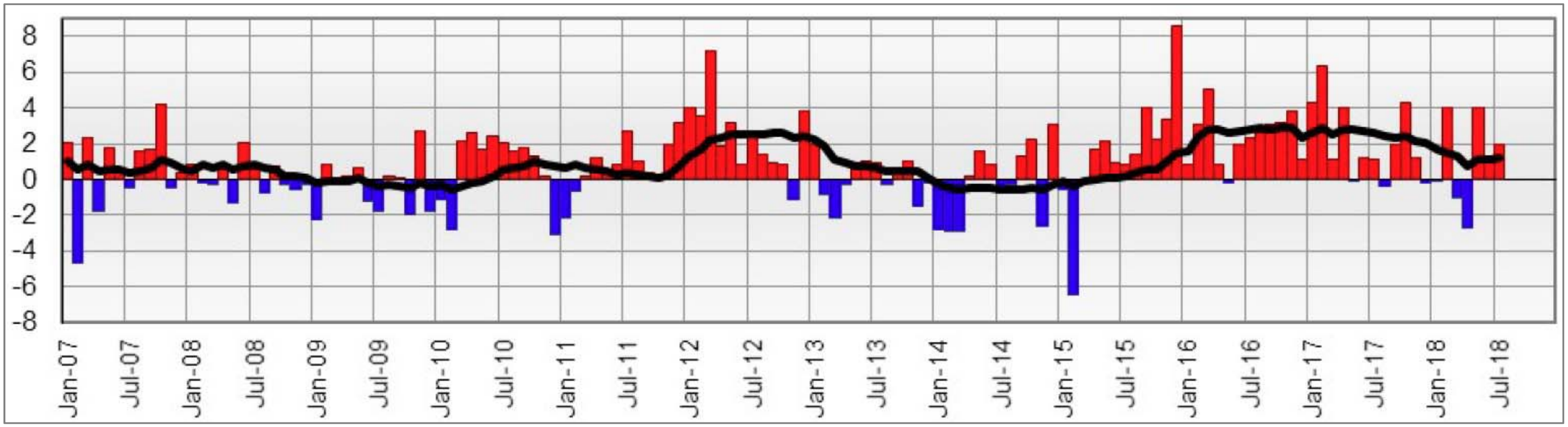
Severity of Winter Weather Key Near-Term Issue

- Extreme weather becoming increasingly common
  - Often much hotter than normal – but not always

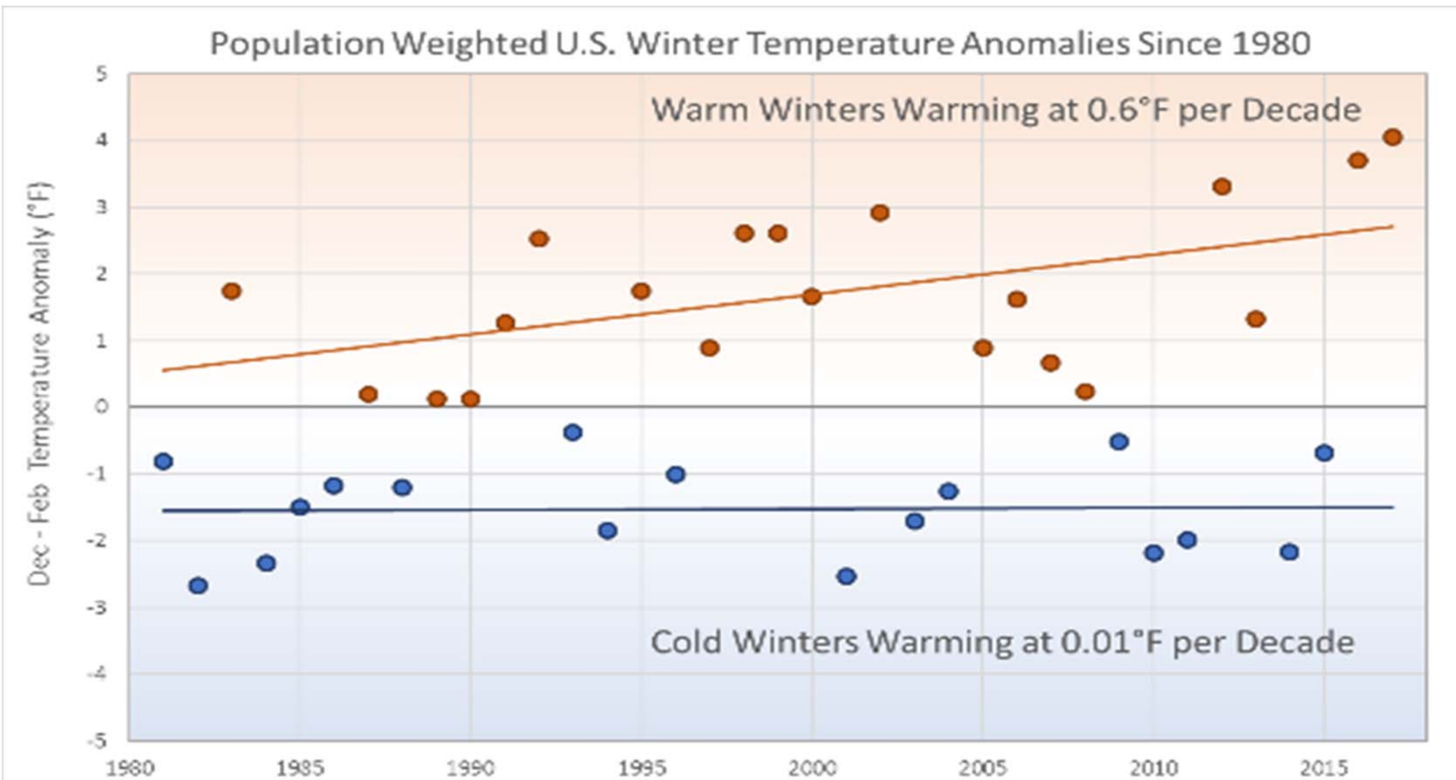
Monthly Temperature Deviation from Normal, 2007-2018



Source: WDT

But Cold Winters Just as Cold

- Extreme weather becoming increasingly common
  - No apparent warming trend
  - Could be exacerbated by expected solar minimum this winter

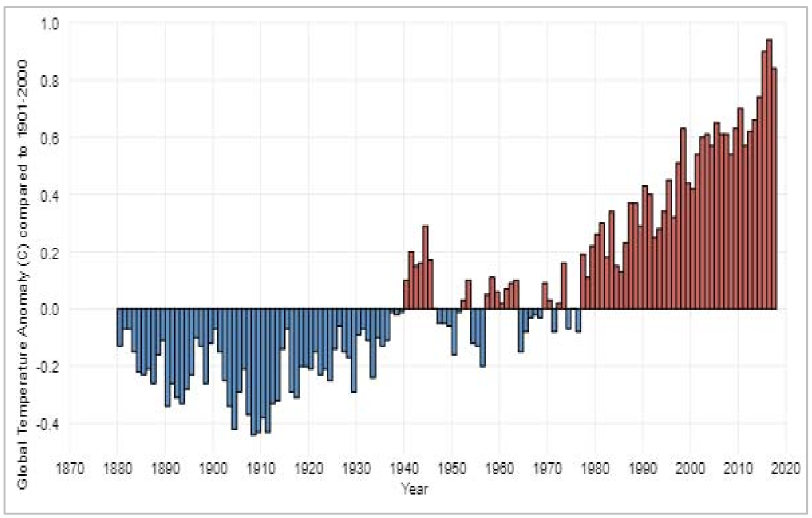


Source: WDT

Potential Impact of Climate Change Should Not be Ignored

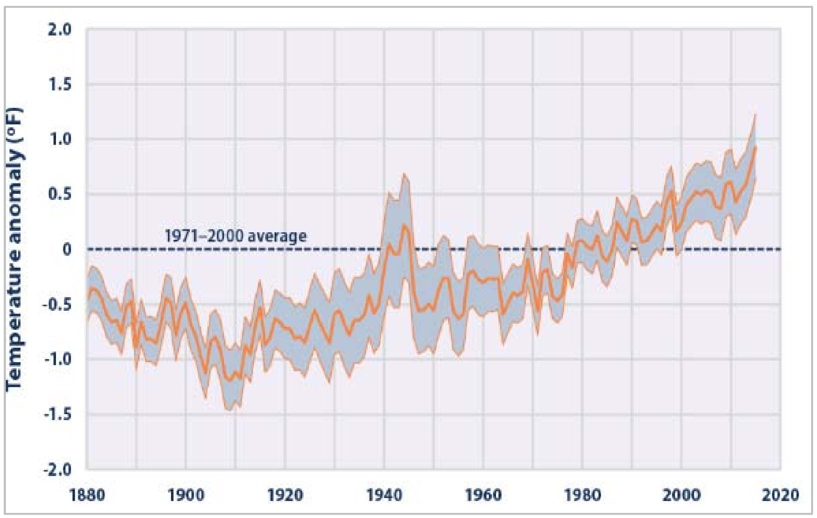
- Near-term impact of climate change much greater than anticipated
  - Could accelerate
- Pressure for action by state and local governments increasing
- Control over federal government could change in two years
- Potential outcome difficult to assess
  - But no longer prudent to ignore potential for stiff new restrictions

Global Average Air Temperatures vs. 20th Century Average, 1880-2017



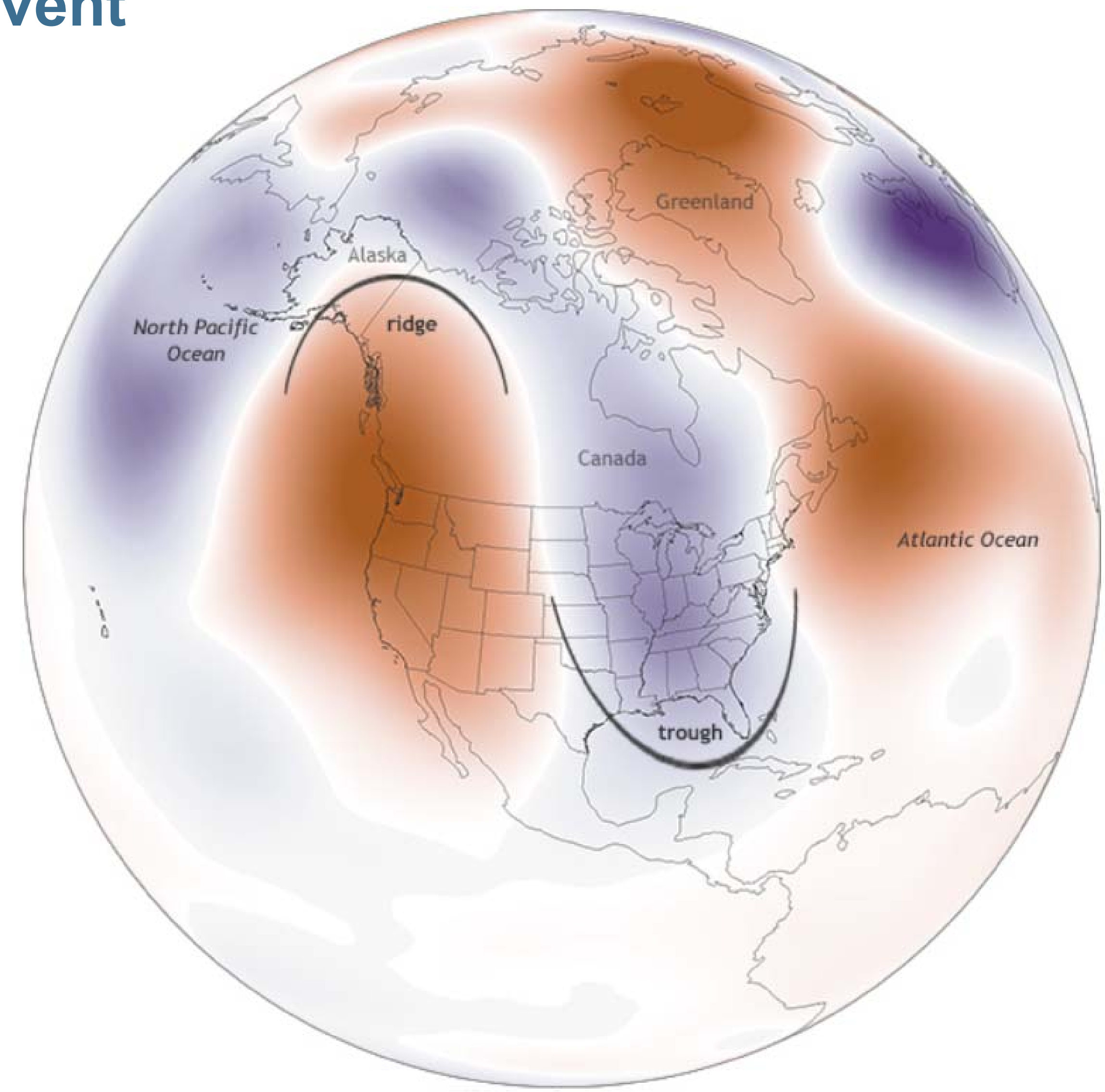
Source: NOAA

Average Global Sea Surface Temperature vs. 1971-2000 Average, 1880-2015



Source; NWS

High Level Ridge and Trough Pattern During 2014 Polar Vortex Event



Source: NOAA

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Lack of Adequate Infrastructure Just as Important a Risk Factor

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Bomb Cyclone

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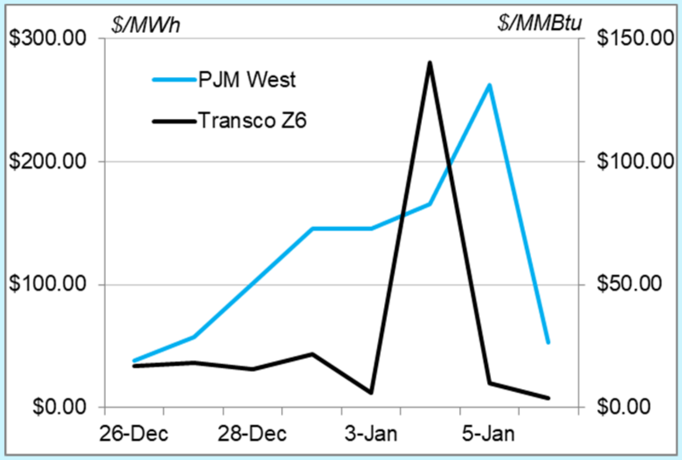
Day-Ahead Prices at PJM West and Transco Zone 6, December 26, 2017-January 8, 2018 ($/MWh, $/MMBtu)



Source: Bloomberg

January PJM Cold Snap Event

- **The Basics**
  - January 1 – January 8, 2018
  - Affected all three Northeastern ISOs
  - Prompted severe gas and electricity price spikes in PJM
  - $10 billion estimated cost
- **Similar to 2014 Polar Vortex**
  - $49 billion estimated cost
  - Even more severe
  - Impetus for Capacity Performance Product
- **Could Have Been Worse**
  - Highest demand day on the January 1 holiday
  - If it had occurred one day later and forced outage rate had been as high as it reached later in the week, major capacity deficit would have resulted

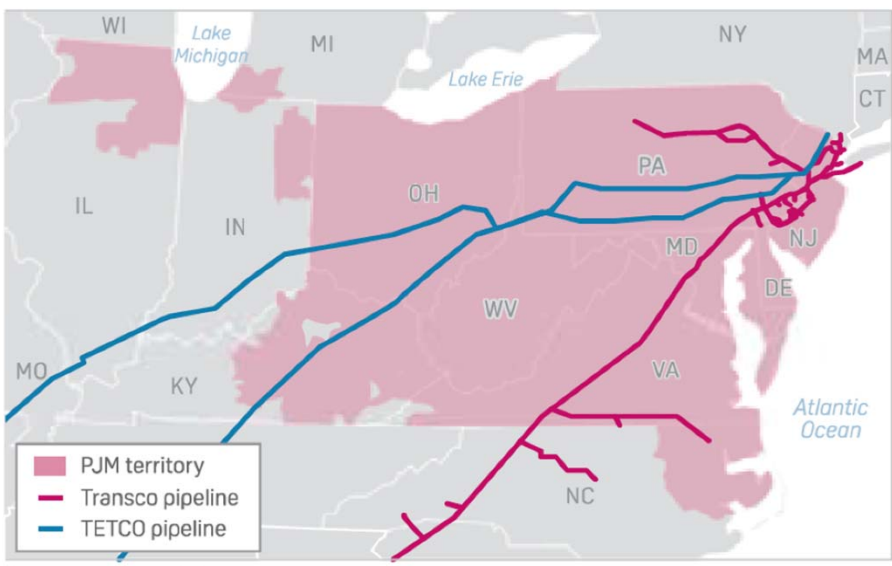
Conditions Could Easily Have Been *Much* Worse

- Any of a long list of factors could have reduced supplies available for power generation and/or required more generation to be dispatched
  - By comparison, $175/MMBtu price for natural gas and $300/MW+ prices for electricity would have seemed modest
- Factors that could have led to more severe crisis – none of which require extreme assumptions – include:
  - Coldest day occurring one day later, on January 2nd (a normal workday) vs January 1st holiday when nearly all commercial electricity users and some industrials were shut down
  - Colder temperatures (increasing space heating demand)
  - Future coal and nuclear plant retirements (including those already scheduled for next winter)
  - Multiple cold weather episodes that depleted on-site oil supplies at dual-fired plants that burned oil during the first week in January (when some plants were nearly running out of oil and system-wide on-site storage was reduced to 19% of maximum capacity)
  - Higher incidence of well-head or pipeline shutdowns
  - Higher forced-outage rate for coal and nuclear retirements
  - Firm commitments by producers in Marcellus Shale to ship gas to other regions
- Electricity and natural gas prices could have spiked to two to four times early January levels
  - Excess costs to end users could easily have been $50 billion or more
- Even *with* all-time record prices, the lights would have gone out over large portions of the Northeast

Debate Has Focused on Wrong Issues

- Main focus has been on:
  - Outage risks for different types of generation
  - Potential disruptions of interstate pipelines that bring gas into the region
  - Potential need to continue operating coal and nuclear units facing retirement to ensure adequate capacity reserves
- Real issue: limitations on maximum amount of gas that can be delivered to generators in PJM and other Northeastern ISOs on very cold days
  - Very cold weather tests capacity of pipeline system
  - Not enough capacity available to meet total space heating and power generation demand on coldest days

Major Natural Gas Pipelines in PJM Territory



Source: Williams, PJM, Spectra

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Gas Deliverability Most Critical Issue Facing Markets in Northeast and California

- Resilience NOPR profoundly misguided
  - Key issue = gas deliverability
  - Not yet being examined by FERC
    - PJM just starting
- RTOs in the Northeast pay massive amounts to ensure adequate total generation to meet peak demand – but nothing to ensure availability of gas to gas-fired generating units
- At height of this year's cold snap event, nearly 45,000 MW of gas-fired generation in three Northeast ISOs remained idle
  - Zero benefit to end users, despite tens of billions of capacity payments over past decade
  - "Paper" reserve margins were just that
  - PJM and other RTOs attribute ideal status to dispatch cost
  - In fact, even at record high natural gas prices, no supplies remained available to dispatch these units
- Under entirely plausible scenarios, Northeast could have been short as much as 20,000-30,000 MW of generation, with potentially catastrophic consequences

Total and Idle Gas-Fired Capacity by ISO, January 1-January 7, 2018

	PJM	NYISO	ISO-NE	Total (MW)
Idle Capacity (MW)	12,480	19,118	13,125	44,723
Total Gas-Fired Capacity (MW)	37,066	22,170	17,091	76,327
% Idle Capacity	33.7%	86.2%	76.8%	58.6%

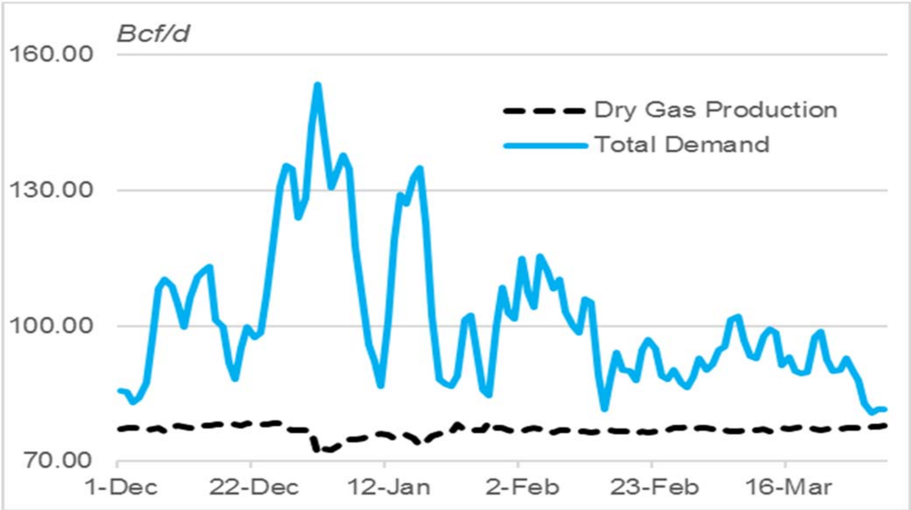
Source: ISO-NE, NYISO, PJM, EBW Analytics

At highest PJM capacity price in the last three years ($164.77/MW-day), the total capacity payment for the 44,723 MW of idle Northeastern gas capacity would be $7,369,009/MW-day, or $2.69 billion/MW-year.

Limitations on Maximum Deliverability

- Total demand for natural gas nationally reached all-time high
  - Twice same-day production
  - Pipelines into Eastern PJM maxed out
- Daily ability to withdraw gas from storage limited
  - Limited ability to transport to Eastern Seaboard
  - Limitations on daily withdrawal rates
    - Both underground reservoirs and aboveground peak shaving facilities

Total US Natural Gas Demand vs. Dry Gas Production, December 2017-March 2018 (Bcf/d)



Source: Platts

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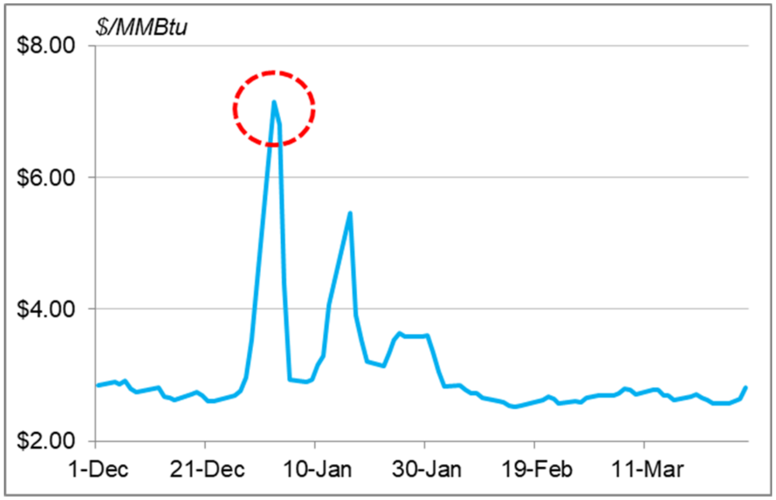
Low Storage Buffer Increases Susceptibility to Price Spikes

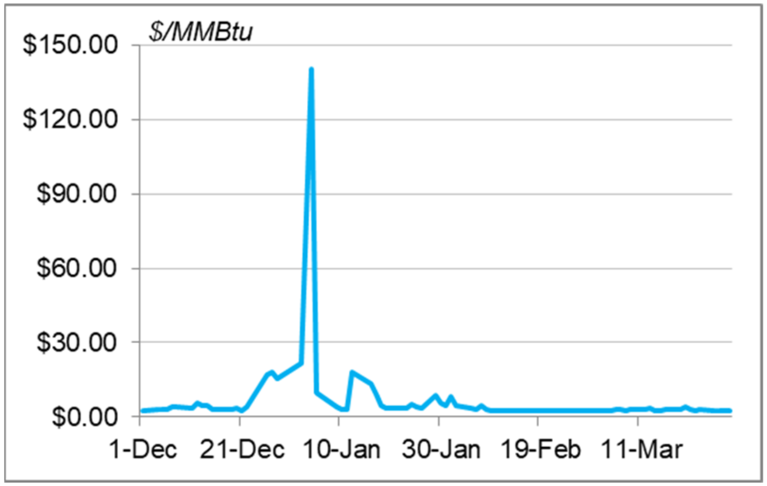
- Current end-of-winter trajectory 1,350 Bcf vs. five-year average of 1,634 Bcf
- In a very cold weather scenario, threat of storage squeeze increases
  - Threat alone can cause prices to rise sharply, as occurred last winter
  - Significant increases in early 2018 occurred as storage neared 1,100 Bcf, only 250 Bcf below current outlook
- Freeze-offs may limit production in a cold outcome
  - May result in a bullish trifecta with low supply, large withdrawals, and low storage

Henry Hub Spot Prices, December-March 2018 ($/MMBtu)



Source: Bloomberg

Transco Zone 6 Spot Prices, December 2017-March 2018 ($/MMBtu)



Source: Bloomberg

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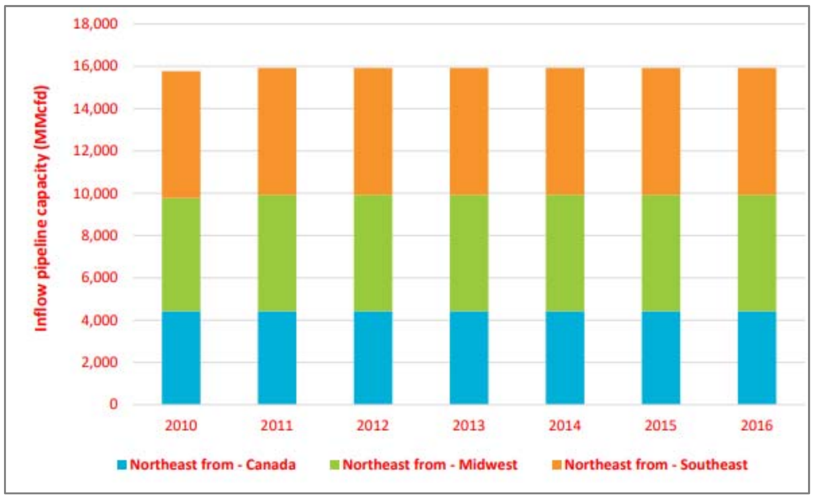
Ensuring Adequate Deliverability of Natural Gas on Peak Winter Days a Huge Challenge

- Needle peak in demand for natural gas three to four times steeper than mid-summer peak in electricity demand
  - On January 1st (the coldest day), total US demand for natural gas was twice total US production
  - Ratio even steeper in Northeast
    - Only 35-40% of gas utilized in the region obtained from wells in the Northeast
- Only remaining sources of supply were pipeline imports into the region + withdrawals from regional storage
  - Both were fully tapped out, limiting total supplies available for use in the three RTOs in the Northeast to 58-60 Bcf/day
- *All* of this gas was utilized for space heating and dispatch of small amounts of gas-fired capacity
  - No more gas available to operate 45,000 MW of idle gas-fired capacity
- Only way to balance supply and demand of gas was to bid regional prices for natural gas high enough so that these generating units were no longer in the money
  - Left *zero* generation available to be dispatched

Daily Natural Gas Demand (including exports), April 1 2017 to March 31 2018

Source: Platts

Pipeline Inflow Capacity into the Northeast, 2010-2016 (MMcf/d)



Source: Department of Energy National Energy Technology Laboratory

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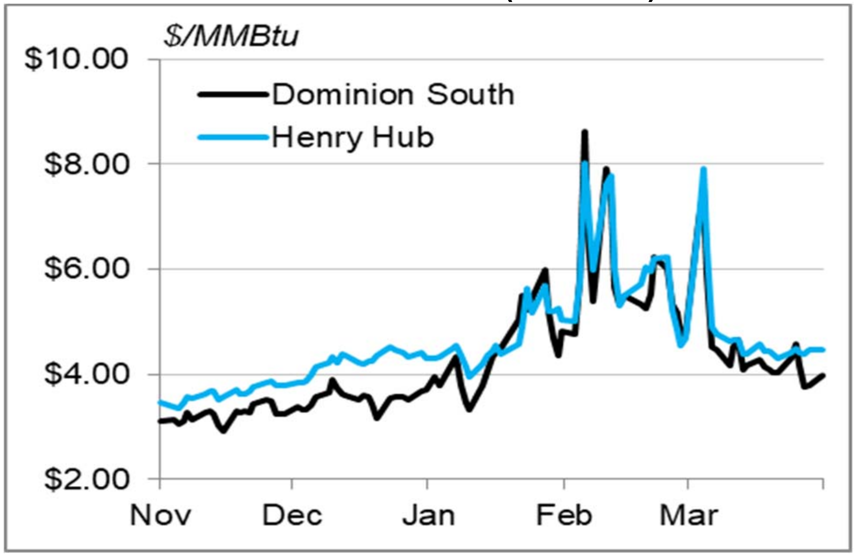
Storage Squeeze this Winter?

- If winter is among the coldest since 1980 (6^{th} coldest or colder) may be sufficient to tip gas market into rampant price spikes
  - Estimated 15% chance of occurring
  - Even perceived risk can cause prices to rise in attempt to preempt shortage
- Many factors can increase/decrease this rough estimate, including production freeze-offs, estimated production growth, and net imports

Henry Hub and Dominion South Spot Prices During Polar Vortex Winter ($/MMBtu)



Source: Bloomberg

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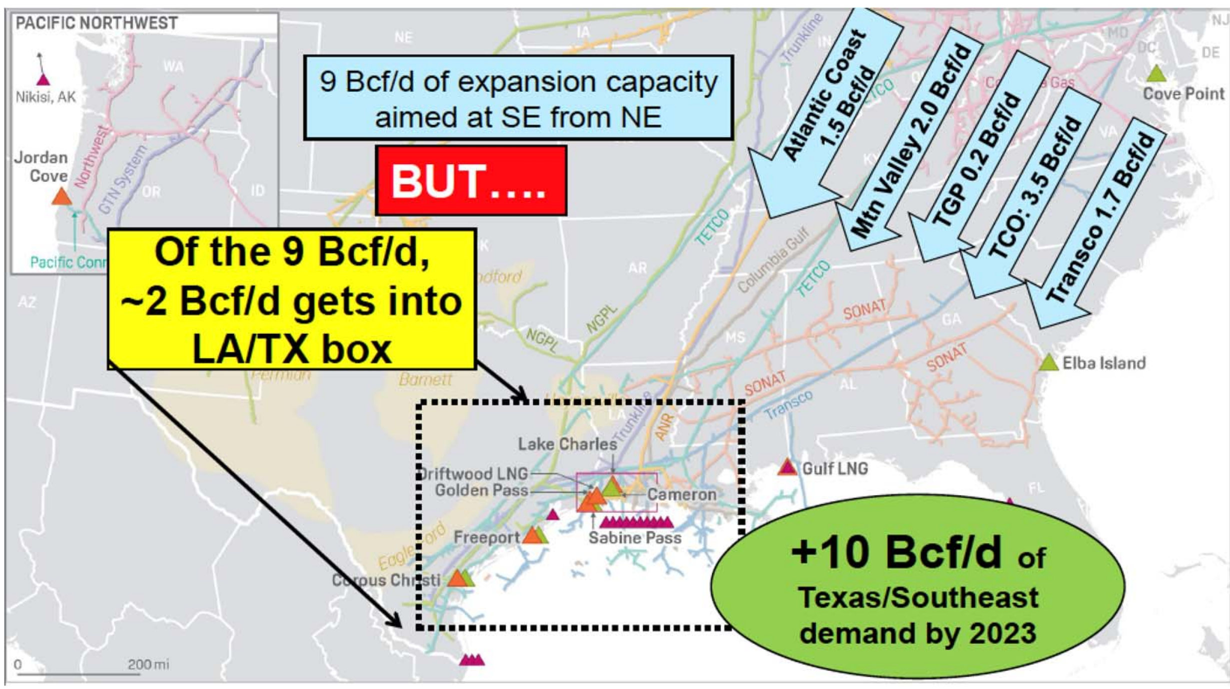
Debate Has Focused on Wrong Issues

- Severe indictment of FERC's oversight of electricity and natural gas market
- Similar problem has persisted in New England for more than 13 years without FERC seriously addressing
- Could be just as severe in PJM and throughout the Northeast within the next few years

Henry Hub Basis Differential Just as Significant an Issue

- Basis differential vs. Chicago and many other regional highs already at record levels
- As regional demand continues to increase, likely to get much worse
  - May lead to serious challenges in hedging prices for electricity and gas
- No quick fix

The Last Mile Problem: New Northeast Capacity Falls Short of Southeast Markets



Source Platts

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