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North American Market Gas-trade (NAMGas) Model:
Preliminary Results

2019 Integrated Energy Policy Report

California Energy Commission

Presenter: Anthony Dixon
April 22, 2019
California Energy Commission

Purpose

- **Key elements of the natural gas model**
- **Integrated Energy Policy Report (IEPR) Common Cases**
- **Preliminary Results**
  - **Demand, supply, flows, and prices**
  - **Trends**

North American Market Gas-trade Model: Construction

- **Created in the MarketBuilder platform**
  - **General equilibrium modeling logic is well-vetted**
- **The 2019 NAMGas runs will incorporate:**
  - **Reset assumptions in the California portions to reflect the 2019 IEPR Common Cases**
  - **Updated changes to North American pipeline system capacity**
  - **Updated information on gas reserves and costs**
- **Vetting of staff assumptions and results by outside consultant and input from inputs and assumptions workshop held March 4, 2019**

Simplified View:
North American Market Gas-trade (NAMGas) Model

NAMGas components:

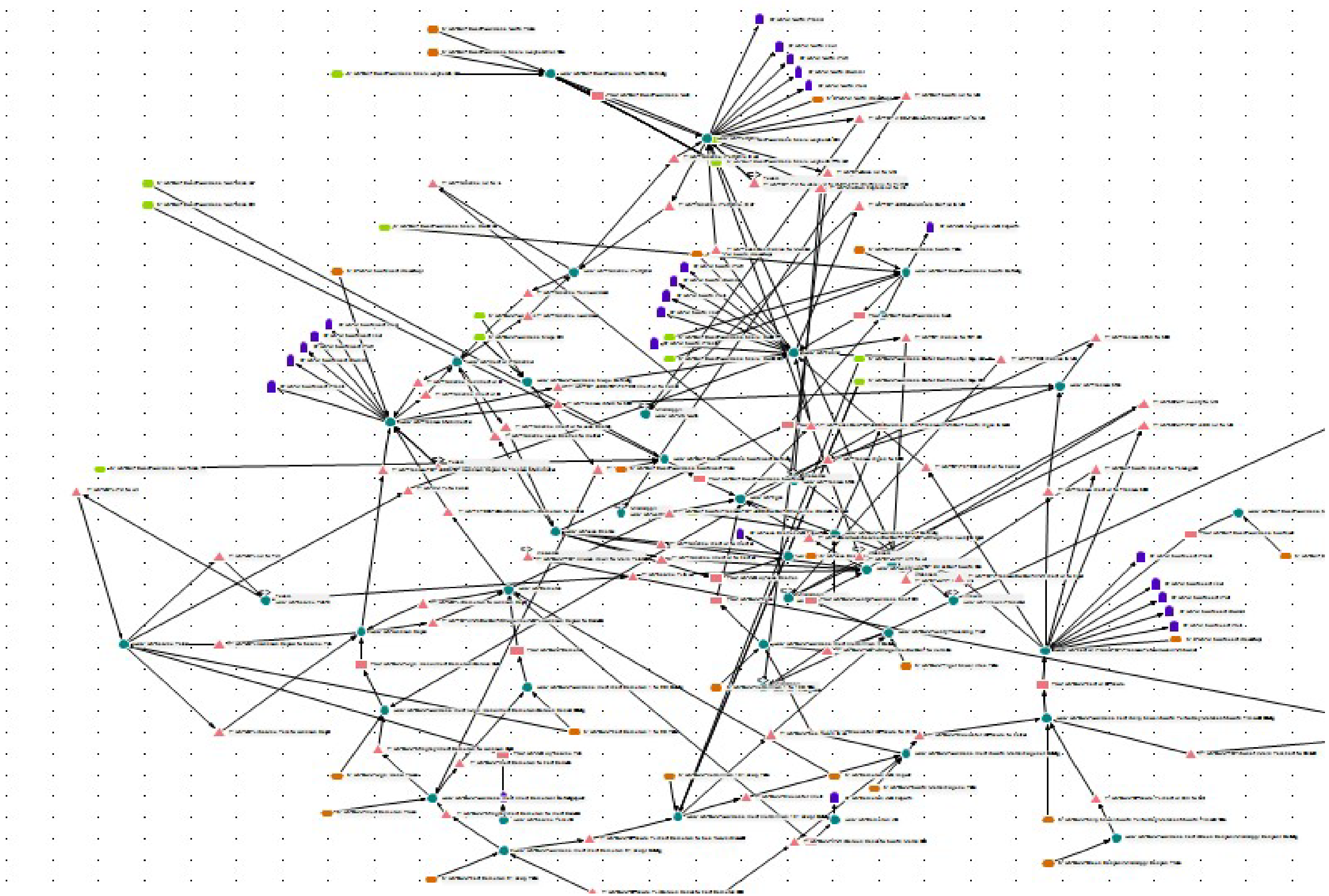
Natural gas supply basins
Connected to
Interstate and Intrastate pipelines
Connected to
Demand centers

➔

- Supply
- Transmission
- Demand

- **Model iterates between the three components to find economic equilibrium at all nodes at all time periods**
- **Results give prices, demand, and supply at equilibrium**

Not So Simplified View:
North American Market Gas-trade (NAMGas) Model



IEPR Common Cases

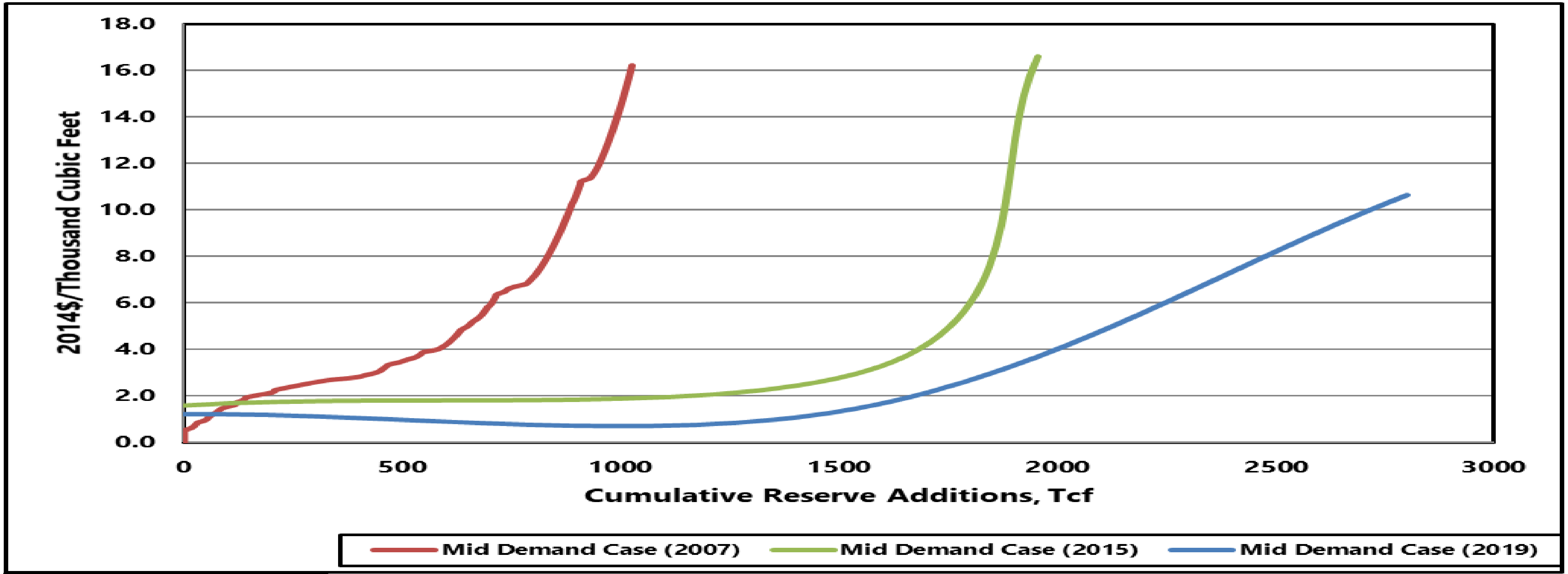
- **Staff scenarios/common cases:**
  - **High Demand/Low Price**
  - **Mid Demand**
  - **Low Demand/High Price**

❖ *All cases assume Senate Bill 100 - Zero carbon sources for power generation by 2045.*

Major Model Inputs:
Demand

- **Demand in Five Disaggregated Sectors:**
  - ➢ **Residential**
    - ✓ **Key factors: Recent historical demand for natural gas, population, natural gas price, income, heating oil price, and cold and hot weather**
  - ➢ **Commercial**
    - ✓ **Recent historical demand for natural gas, income, natural gas price, population, heating oil price, and cold and hot weather**
  - ➢ **Industrial**
    - ✓ **Key factors: Recent historical demand for natural gas, natural gas price, industrial production, and cold weather**
  - ➢ **Power Generation**
    - ✓ **Key factors: Natural gas, coal, and fuel oil cost; coal, nuclear, hydroelectric and renewable generation, and hot weather**
  - ➢ **Transportation**
    - ✓ **Key Factors: Recent historical demand for natural gas, income, natural gas price, and population**
    - ✓ **Applied outside California**
- **Estimated Elasticity**
  - ➢ **Residential, Commercial, Industrial, Power Gen, and Transportation**
  - ➢ **Range of elasticity ~ -0.57 to –0.20 (Hausman and Kellogg 2015)**
    - ➢ **Updated for this IEPR Cycle**

Supply Costs Continue Significant Decline – Major Input Parameter in NAMGAS

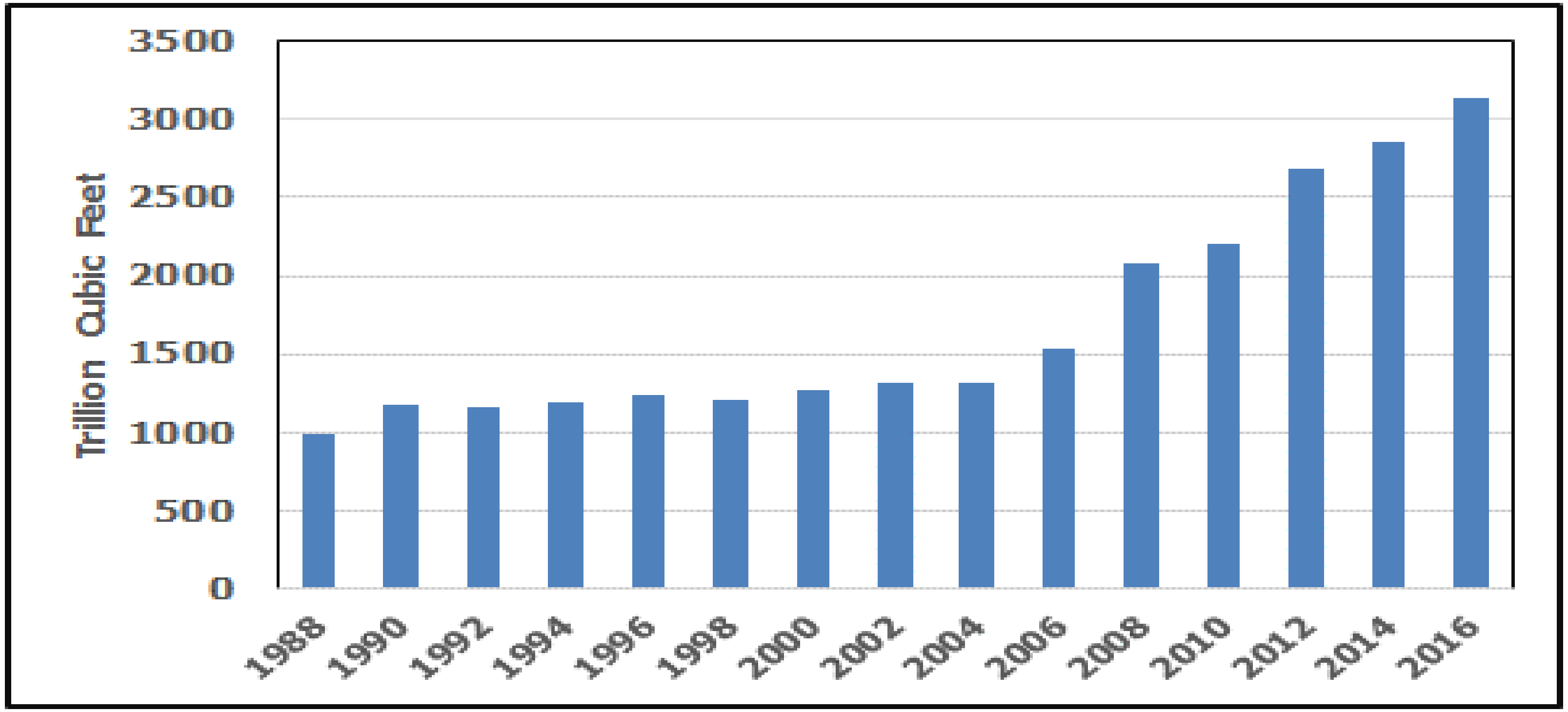


Sources: California Energy Commission

- **Technology improvements and efficiencies allow more production at lower costs.**
- **Shift in the marginal cost profile means more resources available at lower cost.**
- **Staff's updates show a significant change in supply cost for the long term.**

Natural Gas Reserves – Major Input Parameter in NAMGAS

Potential Gas Committee's Estimate of Future Supply (1988 – 2016)



- Technological innovations have extended the Zone of Abundance
- Coincides with the development of shale formations (reservoir pools)
- Future supply has reached 3141 Tcf in 2016

Natural Gas Reserves – Major Input Parameter in NAMGAS

- **Reserves:**
  - ✓ **Natural gas still in the subsurface in formations (reservoir pool)**
  - ✓ **Resources divided into two categories**
    - ➢ **Proven/Proved**
    - ➢ **Potential**

- **Proved/Proven reserves:**
  - ✓ **Reserves with a high certainty of production, usually higher than 90 percent**
    - ➢ **Producing**
    - ➢ **“Behind pipe” ~ Developed but not producing**
  - ✓ **Resources with sufficient geological and engineering information**
  - ✓ **Reasonable certainty of production using existing technology under existing economic and operating conditions**
  - ✓ **Production of these resources requires the expenditure of operating and maintenance funds and minimal capital dollars**

Natural Gas Reserves – Major Input Parameter in NAMGAS

- **Undeveloped resources with lesser certainty of production**
  - ✓ **Growth-To-Known (GTK) ~ Extensions of existing natural gas fields**
  - ✓ **Known Undeveloped Potential (KUP) ~ New fields in existing producing formations (reservoir pools)**
  - ✓ **Yet-To-Find (YTF) ~ New fields in formations not yet producing**
- **Undeveloped natural gas resources that are geologically known**
  - ✓ **Decreasing levels of certainty**
  - ✓ **Operating and maintenance costs and the full expenditures of capital dollars for the production of these resources**

Natural Gas Reserves – Major Input Parameter in NAMGAS

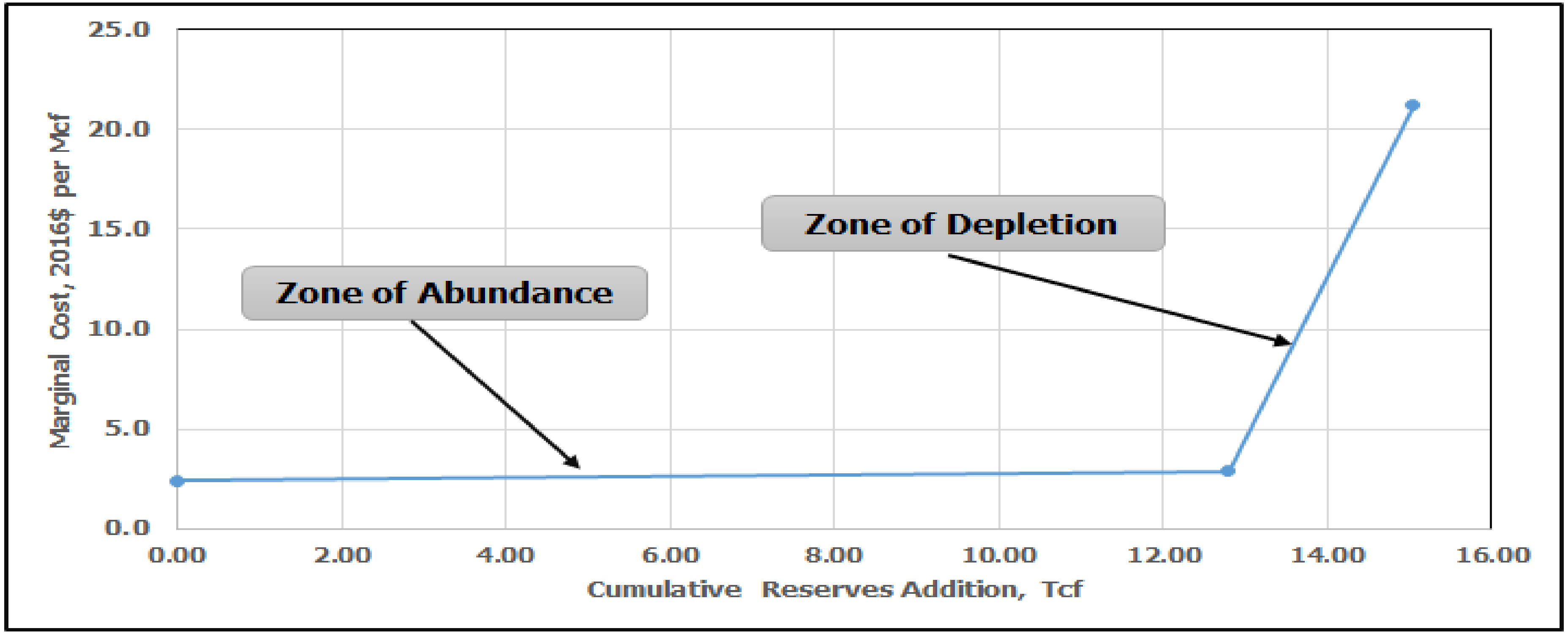
- **Supply Cost Curves**
  - ✓ **Used in NAMGas model stimulations**
  - ✓ **Link marginal cost to reserves addition**
  - ✓ **Provide information about the amount reserves available and at what marginal cost**
  - ✓ **Main driver of prices in the model**

- **Data requirements**
  - ✓ **Natural gas reserves information provided by the Potential Gas Committee and the Energy Information Administration**
  - ✓ **Capital expenditures in the Oil and Gas industry provided by the Oil and Gas Journal**
  - ✓ **Rig count information provided by Baker Hughes**
    - ➢ **Rig count serves as a proxy for investment**
    - ➢ **Used to determine capital expenditures in individual natural gas basins**

Natural Gas Reserves – Major Input Parameter in NAMGAS

- **Two main variables in the development of the supply cost curves**
  - ✓ **Average footage drilled per well in the individual basin**
    - ➢ **Vertical footage plus horizontal footage**
    - ➢ **Higher footage leads to higher cost per Mcf of natural gas recovered**
  - ✓ **Producing liquid-gas ratio**
    - ➢ **Higher liquid-gas ratio leads to lower cost per Mcf of natural gas recovered**
    - ➢ **Growing production of associated natural gas pushing prices lower**

Natural Gas Reserves – Major Input Parameter in NAMGAS



- Relatively flat segment of curve: Zone of Abundance
- Relatively steep portion of curve: Zone of Depletion
- Technology is extending the Zone of Abundance
- NAMGas utilizes over 180 supply cost curves

IEPR Common Cases:
Mid Demand Case

- **Initial U.S. demand quantity (Mid Demand Case):**
  - **2018: Total ~ 27.51 Trillion cubic feet (Tcf); Power Gen ~ 9.28 Tcf**
    - **EIA actual natural gas demand 27.51 Tcf**
    - **EIA actual power generation demand 10.65 Tcf**
  - **2020: Total ~ 33.54 Tcf; Power Gen ~ 11.34 Tcf**
  - **2030: Total ~ 35.87 Tcf; Power Gen ~ 11.92 Tcf**
- **Proved Reserves: approx. 438 Tcf (EIA estimate, Dec. 2018)**
  - **324 Tcf reserves assumed in 2017 IEPR**
  - **Record Production in 2018, approximately 32 Tcf**
  - **Proved Resources increased 114 Tcf, 35%**
- **Coal Conversion: 65 Gigawatts (beginning in 2019)**
  - **Analysis of EIA data of forecasted fuel use**

IEPR Common Cases Assumptions:
Mid Demand Case

- **Potential Reserves:**
  - **2,112 Tcf @ $5.00 / Million cubic feet (Mcf)**
  - **2,816 Tcf @ $10.00 / Mcf**
- **Rate of Return (Same as 2017 IEPR):**
  - **Resources: 12.2% (real after tax)**
  - **Pipeline Investment: 8.4% (real after tax)**
  - **Income Tax Rate: 35%**
  - **Return on Equity: 10%**
- **Backstop Technology (Updated assumptions for 2019 IEPR):**
  - **Unspecified at $15.00 / Mcf**
- **Technology Factor (Same as 2017 IEPR):**
  - **1% / year.**

IEPR Common Cases: Key Case Assumptions

Input Category	High Demand	Mid Demand	Low Demand
GDP/GSP	High Case in EIA's 2018 Energy Outlook: 2.4% Annual GDP Growth	Reference Case in EIA's 2018 Energy Outlook: 1.9% GDP Growth	Low Case in EIA's 2018 Energy Outlook: 1.4% Annual GDP Growth
Renewables	60% by 2030 for CA Other US States Meeting RPS Targets	60% by 2030 for CA Other US States Meeting RPS Targets	60% by 2030 for CA Other US States Meeting RPS Targets
Coal Retirement Through 2050	75 GW	65 GW	65 GW

IEPR Common Cases: Key Case Assumptions

Input Category	High Demand	Mid Demand	Low Demand
Resource Capital Costs	30% Lower Than 2019 Inputs	2019 Inputs	30% Higher Than 2019 Inputs
Resource O&M Costs	30% Lower Than 2019 Inputs	2019 Inputs	30% Higher Than 2019 Inputs
Proved Supply Forward Costs	10% Lower Than Mid Case in 2019 20% Lower Than Mid Case in 2020 30% Lower Than Mid Case in 2021 and after	Estimate Based on Hub Prices	10% Higher Than Mid Case in 2019 20% Higher Than Mid Case in 2020 30% Higher Than Mid Case in 2021 and after

Natural Gas Common Cases:

2019 Key Assumptions for US Initial Demand

(Trillion Cubic Feet [Tcf])

2018 EIA Actuals for Comparison	
2018 US Demand (EIA)	27.51 Tcf
2018 US Demand for Power Generation (EIA)	10.65 Tcf

Input Category	High Demand	Mid Demand	Low Demand
2020 US Initial Demand	27.27 Tcf	25.41 Tcf	23.63 Tcf
2025 US Initial Demand	28.08 Tcf	26.17 Tcf	24.37 Tcf
2030 US Initial Demand	29.72 Tcf	26.86Tcf	24.98 Tcf
2020 US Initial Demand (Power Gen)	14.00 Tcf	12.24Tcf	10.82 Tcf
2025 US Initial Demand (Power Gen)	15.38 Tcf	12.55 Tcf	11.15 Tcf
2030 US Initial Demand (Power Gen)	16.57 Tcf	12.78 Tcf	11.33 Tcf

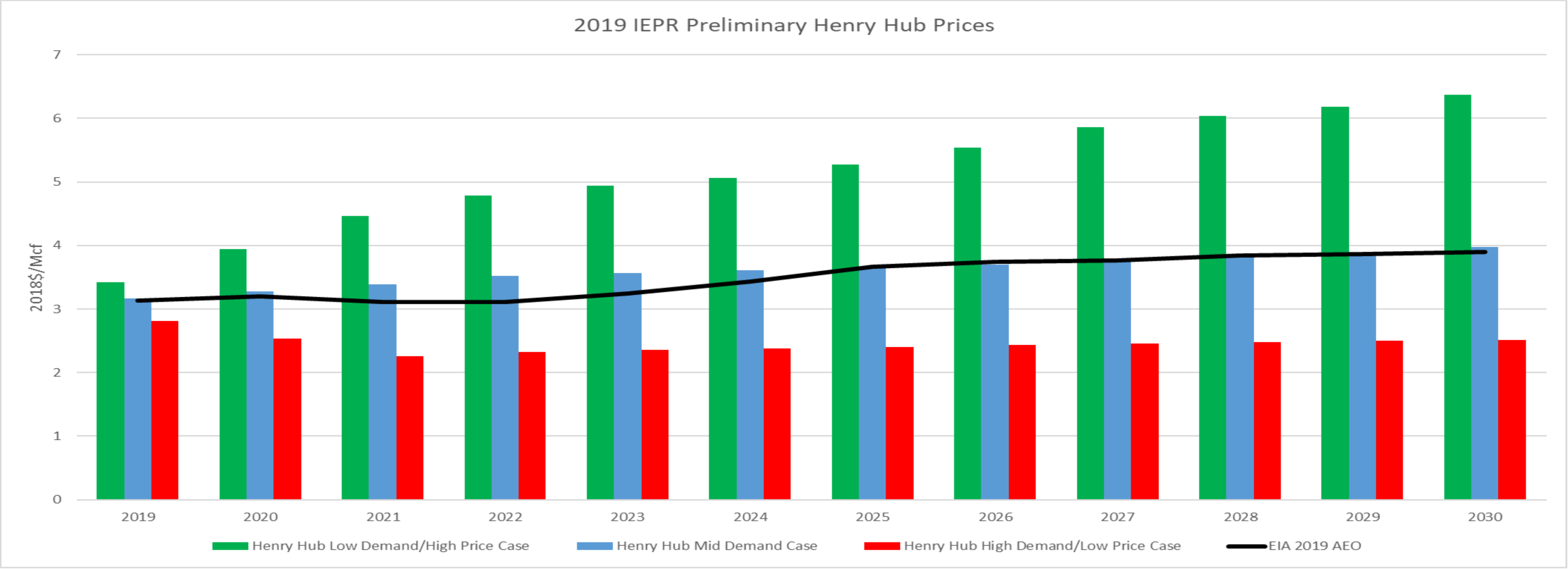
Performance of Cases:

United States

Preliminary Results:

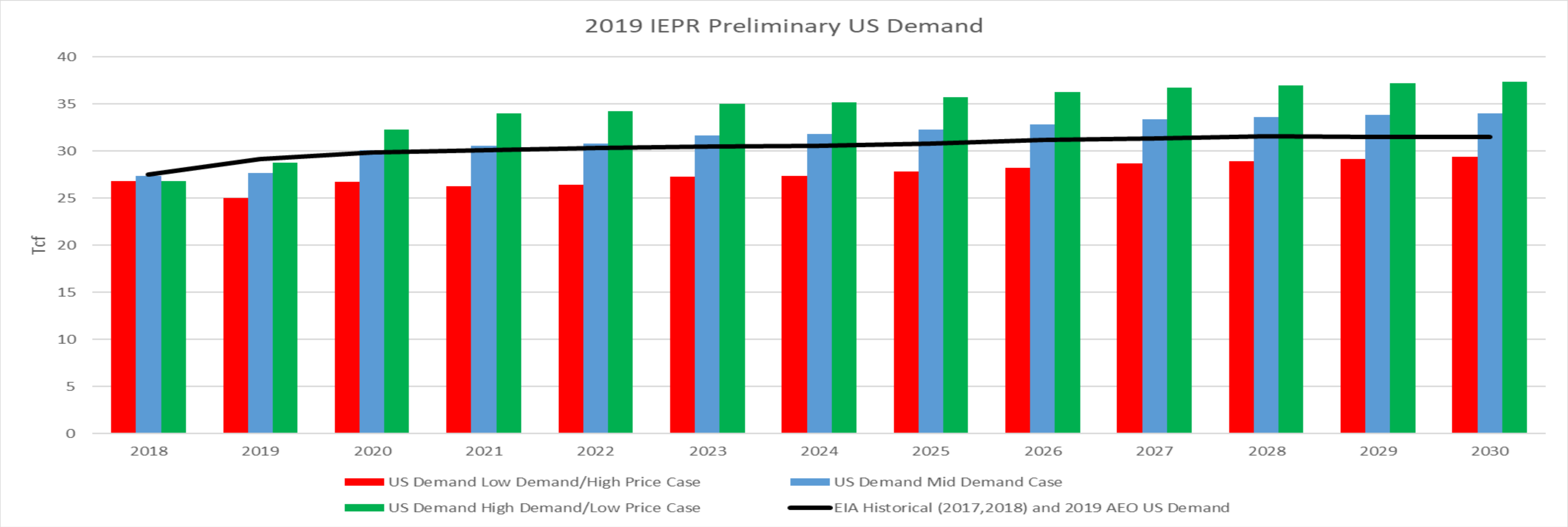
IEPR Common Cases for Henry Hub Pricing Point

(2018$/MCF)



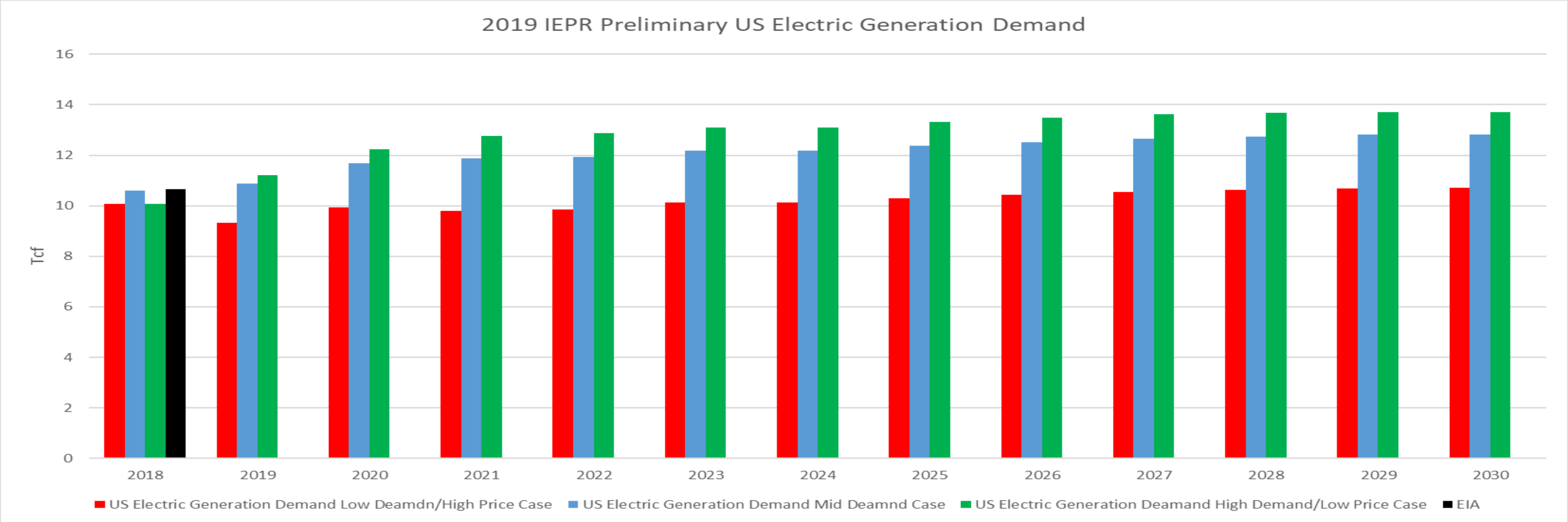
- In 2030, prices vary between $2.52 (High Demand Case) and $6.38 (Low Demand Case).

Preliminary Results:
US Natural Gas Demand (Tcf/Year)



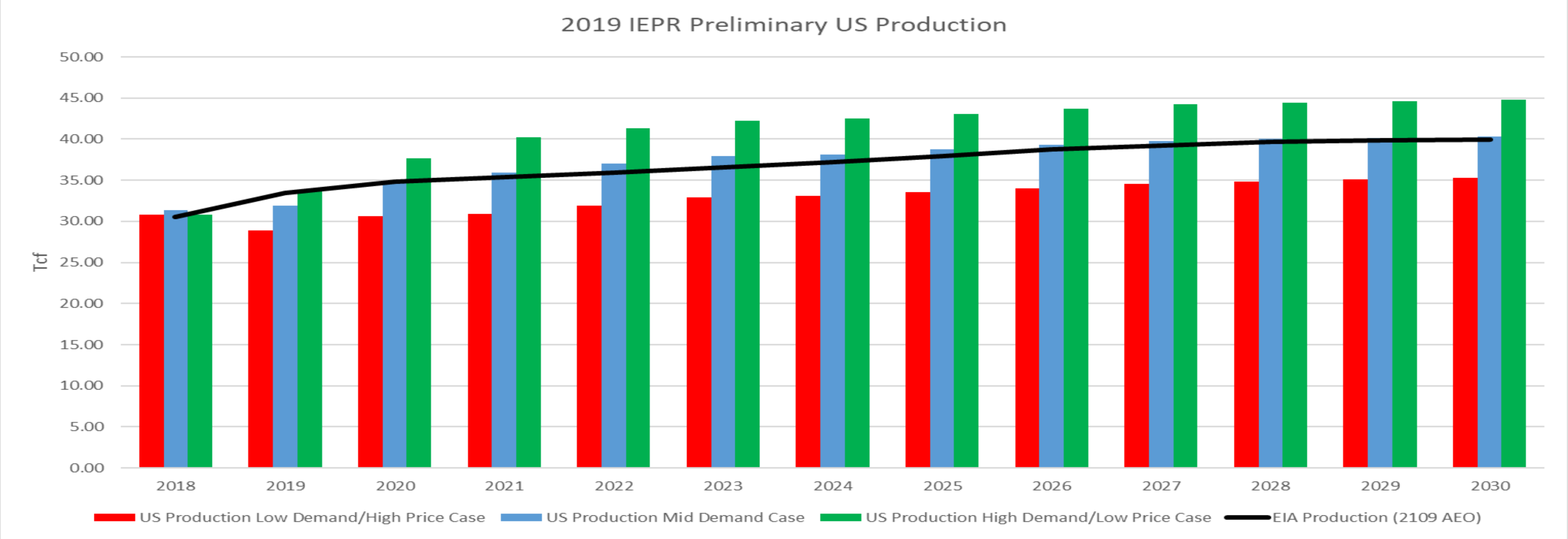
- US natural gas demand growing steadily
  - Annual growth rate in mid demand case about 1.03%, mainly driven by Industrial and Power Generation use.
  - Demand forecasted to grow from 27.51 Tcf (2018 EIA estimate) to 34.00 Tcf in 2030.

Preliminary Results:
US Power Generation Demand for Natural Gas (Tcf/Year)



- Annual Natural Gas Demand for Power Generation Growth Rates (approx.)
  - High Demand Case: 1.12%
  - Mid Demand Case: 0.99%
  - Low Demand Case: 0.48%

Preliminary Results:
US Natural Gas Production (Tcf/Year)



- ➢ Highest natural gas production is in high demand case
  - ✓ Driven by lower production costs and increased demand.

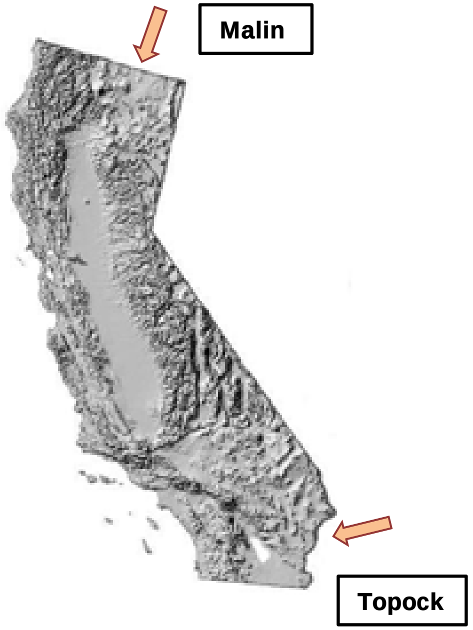
Performance of Cases:

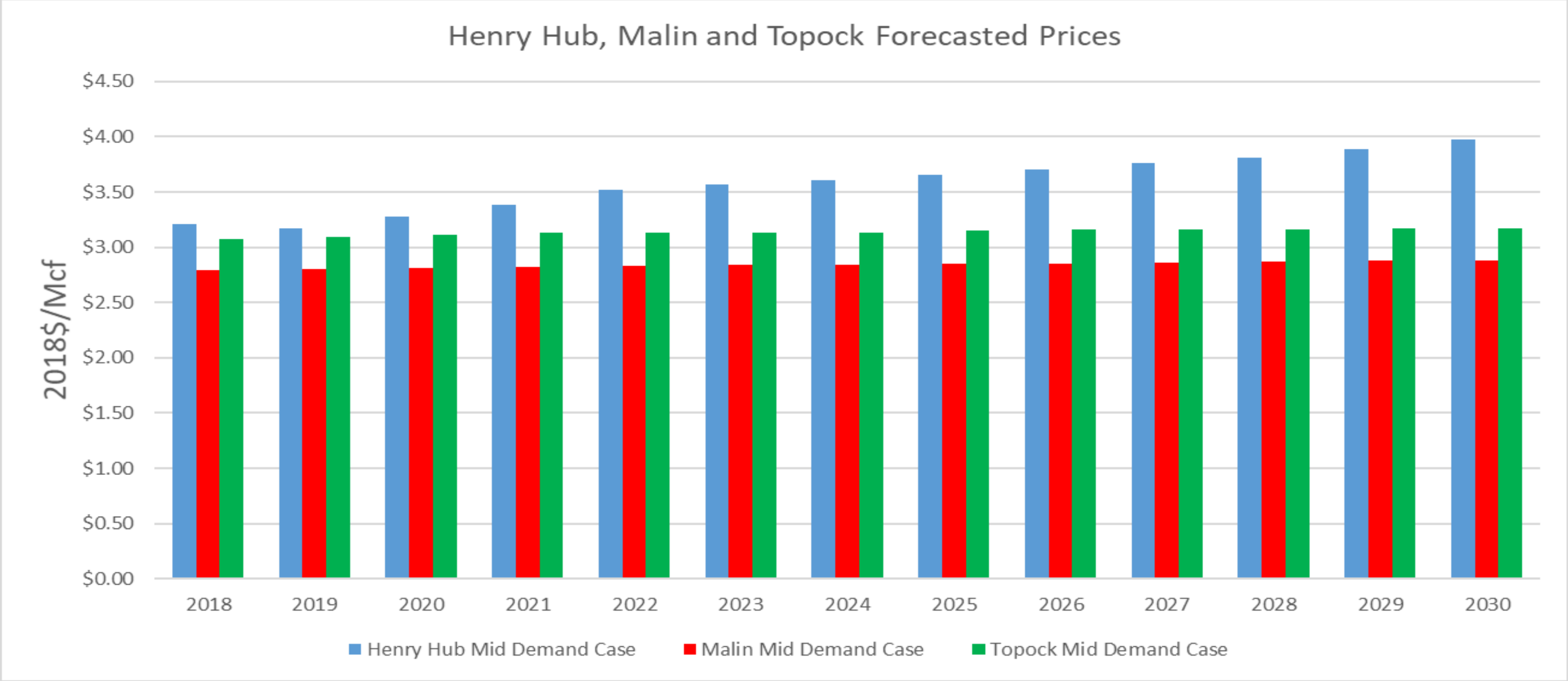
California’s Prices and Supply Portfolio

Price Performance

Reference Case Prices for Henry, Topock, and Malin Hubs

(2018$/MCF)





- Topock and Malin prices continue to trade at a discount to Henry Hub
- Discount widens over time due to low cost Permian and Canadian natural gas
- Basis between Malin and Topock remains constant over time, approximately 25 cents.

Preliminary Results
Conclusions

- **US natural gas demand grows at an approx. annual rate of 1.03% between 2018 and 2030, reaching 34.00 Tcf/Year in the Mid Demand case**
- **Henry Hub prices reach $3.97 (2018$)/Mcf by 2030, representing an approx. average growth rate of 2.0% per year between 2018 and 2030**
- **Average US natural gas production grows at rate of 3.0% per year between 2018 and 2030**
- **Prices to remain low due to:***
  - **High Production of Associated Gas**
  - **High Proved Reserves**
  - **High Potential Reserves**
  - **Higher Efficiency in Production Techniques**

Barring new technology to replace natural gas or new policies

Preliminary Results
Next Steps

- Continue to monitor and better include in model the effects from the Southern California price spikes
- Better incorporate international market developments
  - International LNG market
  - The changing Mexico market
- Improve the small “m” model used to estimate natural gas demand
  - Revisit model regressions
  - Update model initial prices
- Incorporate Preliminary CED forecasts of natural gas end-use demand
- Incorporate Production Cost Modeling Revised Results (WECC Power Demand)
- Continue to develop monthly model
- Continue to update and revise the assumptions
- Revised Results Workshop in Fall 2019

NAMGas Preliminary Results
IEPR Common Cases

Questions and Comments