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<tr>
<td><strong>Docket Number:</strong></td>
<td>19-IEPR-08</td>
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<tr>
<td><strong>Project Title:</strong></td>
<td>Natural Gas Assessment</td>
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<tr>
<td><strong>TN #:</strong></td>
<td>227782</td>
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<tr>
<td><strong>Document Title:</strong></td>
<td>North American Market Gas-trade (NAMGas) Model - Preliminary Results</td>
</tr>
<tr>
<td><strong>Description:</strong></td>
<td>Presentation for April 22, 2019, IEPR workshop on Preliminary Natural Gas Price Forecast and Outlook</td>
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<tr>
<td><strong>Filer:</strong></td>
<td>Stephanie Bailey</td>
</tr>
<tr>
<td><strong>Organization:</strong></td>
<td>California Energy Commission</td>
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<tr>
<td><strong>Submitter Role:</strong></td>
<td>Commission Staff</td>
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<td><strong>Submission Date:</strong></td>
<td>4/19/2019 11:37:36 AM</td>
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<td><strong>Docketed Date:</strong></td>
<td>4/19/2019</td>
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North American Market Gas-trade (NAMGas) Model:
Preliminary Results

California Energy Commission

Presenter: Anthony Dixon
April 22, 2019
California Energy Commission
Purpose

• Key elements of the natural gas model


• 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
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

- 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.

Sources: California Energy Commission
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
**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:
Mid Demand Case
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.
<table>
<thead>
<tr>
<th>Input Category</th>
<th>High Demand</th>
<th>Mid Demand</th>
<th>Low Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP/GSP</td>
<td>High Case in EIA's 2018 Energy Outlook: 2.4% Annual GDP Growth</td>
<td>Reference Case in EIA's 2018 Energy Outlook: 1.9% GDP Growth</td>
<td>Low Case in EIA's 2018 Energy Outlook: 1.4% Annual GDP Growth</td>
</tr>
<tr>
<td>Renewables</td>
<td>60% by 2030 for CA Other US States Meeting RPS Targets</td>
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<tr>
<td>Coal Retirement</td>
<td>75 GW</td>
<td>65 GW</td>
<td>65 GW</td>
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<tr>
<td>Through 2050</td>
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### IEPRA Common Cases: Key Case Assumptions

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<thead>
<tr>
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<th>High Demand</th>
<th>Mid Demand</th>
<th>Low Demand</th>
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</thead>
<tbody>
<tr>
<td>Resource Capital Costs</td>
<td>30% Lower Than 2019 Inputs</td>
<td>2019 Inputs</td>
<td>30% Higher Than 2019 Inputs</td>
</tr>
<tr>
<td>Resource O&amp;M Costs</td>
<td>30% Lower Than 2019 Inputs</td>
<td>2019 Inputs</td>
<td>30% Higher Than 2019 Inputs</td>
</tr>
<tr>
<td>Proved Supply Forward Costs</td>
<td>10% Lower Than Mid Case in 2019 20% Lower Than Mid Case in 2020 30% Lower Than Mid Case in 2021 and after</td>
<td>Estimate Based on Hub Prices</td>
<td>10% Higher Than Mid Case in 2019 20% Higher Than Mid Case in 2020 30% Higher Than Mid Case in 2021 and after</td>
</tr>
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### 2018 EIA Actuals for Comparison

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<tr>
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<tbody>
<tr>
<td>2018 US Demand (EIA)</td>
<td></td>
<td>27.51 Tcf</td>
<td></td>
</tr>
<tr>
<td>2018 US Demand for Power Generation (EIA)</td>
<td></td>
<td>10.65 Tcf</td>
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</table>

### Input Category

<table>
<thead>
<tr>
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<th>High Demand</th>
<th>Mid Demand</th>
<th>Low Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020 US Initial Demand</td>
<td>27.27 Tcf</td>
<td>25.41 Tcf</td>
<td>23.63 Tcf</td>
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<tr>
<td>2025 US Initial Demand</td>
<td>28.08 Tcf</td>
<td>26.17 Tcf</td>
<td>24.37 Tcf</td>
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<tr>
<td>2030 US Initial Demand</td>
<td>29.72 Tcf</td>
<td>26.86 Tcf</td>
<td>24.98 Tcf</td>
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<tr>
<td>2020 US Initial Demand (Power Gen)</td>
<td>14.00 Tcf</td>
<td>12.24 Tcf</td>
<td>10.82 Tcf</td>
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<tr>
<td>2025 US Initial Demand (Power Gen)</td>
<td>15.38 Tcf</td>
<td>12.55 Tcf</td>
<td>11.15 Tcf</td>
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<tr>
<td>2030 US Initial Demand (Power Gen)</td>
<td>16.57 Tcf</td>
<td>12.78 Tcf</td>
<td>11.33 Tcf</td>
</tr>
</tbody>
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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).

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.

- 2019 IEPR Preliminary US Production
Preliminary Results

Performance of Cases:
California’s Prices and Supply Portfolio
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.
• 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
Questions and Comments