



**California Energy Commission**

# **North American Market Gas-Trade (NAMGas) Model: Key Drivers, Structure, and Preliminary Cases**

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# North American Market Gas Trade Model: Construction

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- Started with the World Gas Trade Model (WGTM) and completed the following:
  - Reconfigured the California portion of the model to suit the Energy Commission needs
  - Removed all non-North American structure
  - Added functional nodes to account for Liquefied Natural Gas (LNG) imports and exports
  - Added nodes needed to represent natural gas demand in the transportation sector
- NAMGas Trade Model created in the MarketBuilder platform.



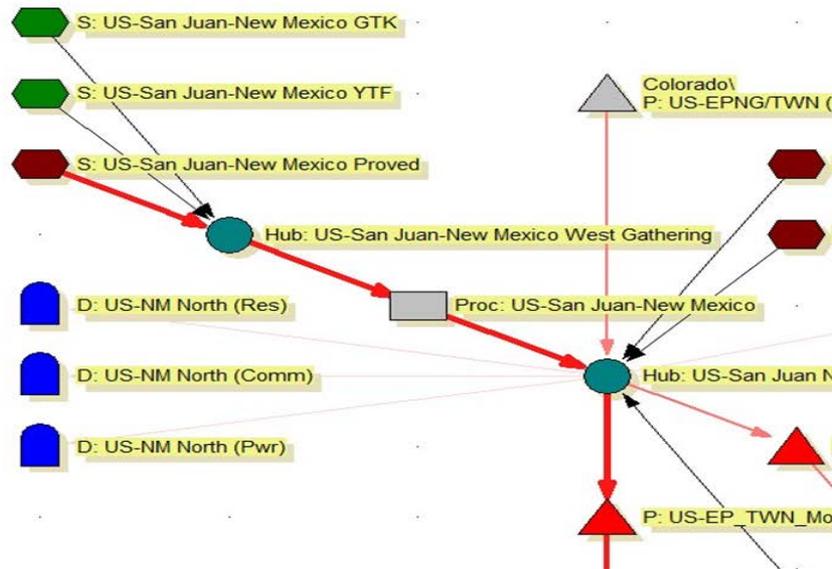
# North American Market Gas Trade Model: Key Drivers (Supply Side)

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- **Resource assessments:**
  - Assessments of technically recoverable resources
    - Most important factor affecting regional trade flows and price
  - In general, price path in any long-term model should be most affected by the quantity of resources that are technically available
- **Resource costs**
  - Costs of developing resources in various regions in North America define the subset of *technically* recoverable resources which is *economically* recoverable
    - Change as price increases
  - Regional trade flows reflect the fact
    - Production generally occurs from the lower-cost resources first
  - Technology innovations forces per-unit cost lower.



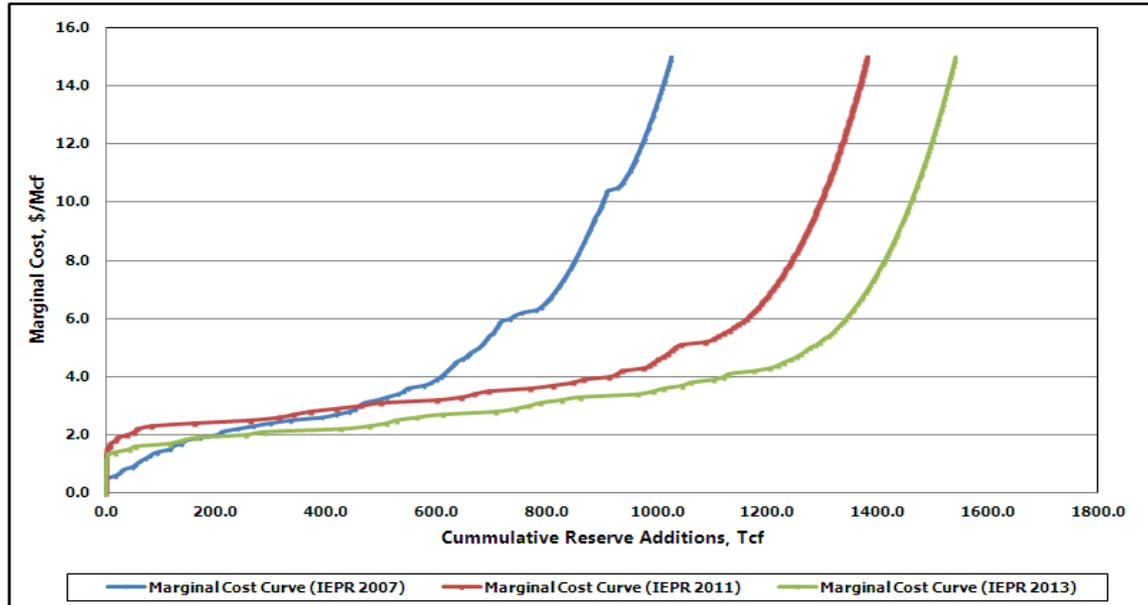
## North American Market Gas Trade Model: Key Drivers (Supply Side)



- **Model structure represents all production basins**
- **Green node is a depletable resource:**
  - Requires both capital cost and O&M cost for production
- **Brown node is a simple supply:**
  - Requires only O&M cost for production.



## North American Market Gas Trade Model: Key Drivers (Supply Side) ~ US Supply Cost Curve



- Marginal cost profile is a major input parameter for the natural gas model:
  - Technology is shifting the marginal cost profile
  - Overall, the shifting of the marginal cost supply profile results in more resources available at lower cost.

Sources: California Energy Commission; Altos Management Partners; Baker Institute; National Petroleum Council.



# North American Market Gas Trade Model: Key Drivers ~ (Demand Side)

- Development of initial (starting/reference) prices and quantities:
  - Excel-based econometric tool (Small 'm' model) uses historical data to calculate initial prices and quantities
- Initial prices and quantities uploaded to MarketBuilder-based general equilibrium model (NAMGas)
- Demand in Five Disaggregated Sectors:
  - Residential
    - Residential sector factors: recent historical demand for natural gas, population, natural gas price, income, heating oil price, and cold weather



# North American Market Gas Trade Model: Key Drivers ~ (Demand Side)

- **Demand in Five Disaggregated Sectors (cont'd):**
  - **Commercial:**
    - Commercial sector factors: recent historical demand for natural gas, income, natural gas price, population, heating oil price, and cold weather
  - **Industrial:**
    - Industrial sector factors: recent historical demand for natural gas, natural gas price, coal price, industrial production, and cold weather
  - **Power Generation:**
    - Power Generation sector factors: total electricity generation, weather, natural gas price, fuel oil price, renewable electricity generation, and coal price

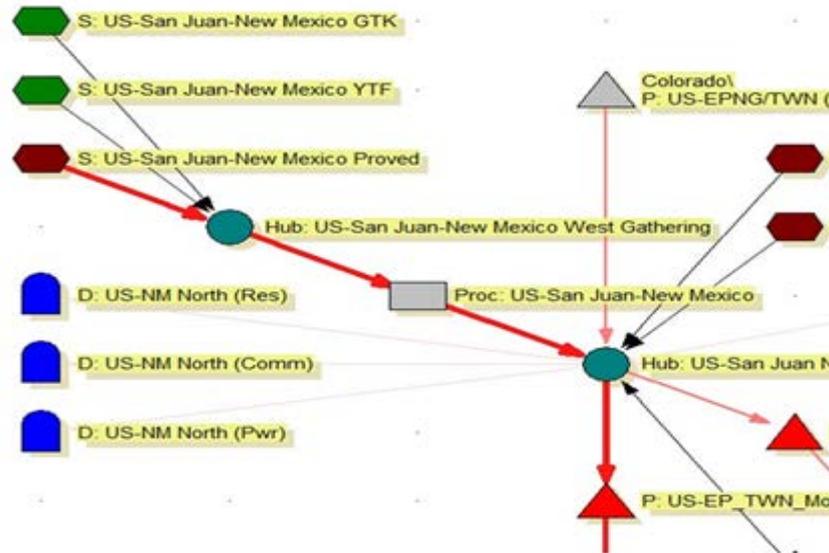


## North American Market Gas Trade Model: Key Drivers ~ (Demand Side)

- Demand in Five Disaggregated Sectors (cont'd):
  - Transportation:
    - Transportation Factors: recent historical demand for natural gas, income, natural gas price, population, heating oil price, and cold weather.
- General Demand-side Impacts:
  - High rates of demand growth tend to push the marginal source of production into higher-cost regions
  - This influences the flow of trade and the price.



## North American Market Gas Trade Model: Key Drivers ~ (Demand Side)



- Model structure with associated data represents all demand sectors:
  - Blue nodes (tombstones) are elastic demand nodes
    - Nodes are price-responsive.



# North American Market Gas Trade Model: Key Drivers (cont'd)

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- **Gas substitutes:**
  - Assumptions about the cost of “backstop” resources define the long run ceiling on gas price
  - As this price is approached, future investments in higher cost natural gas resources are disadvantaged
- **Policy parameters:**
  - Assumptions regarding various political and regulatory constraints can have profound impacts on model outcomes
  - Policy may limit access to resources, inflate demand, or lead to accelerated adoption of backstop technologies.



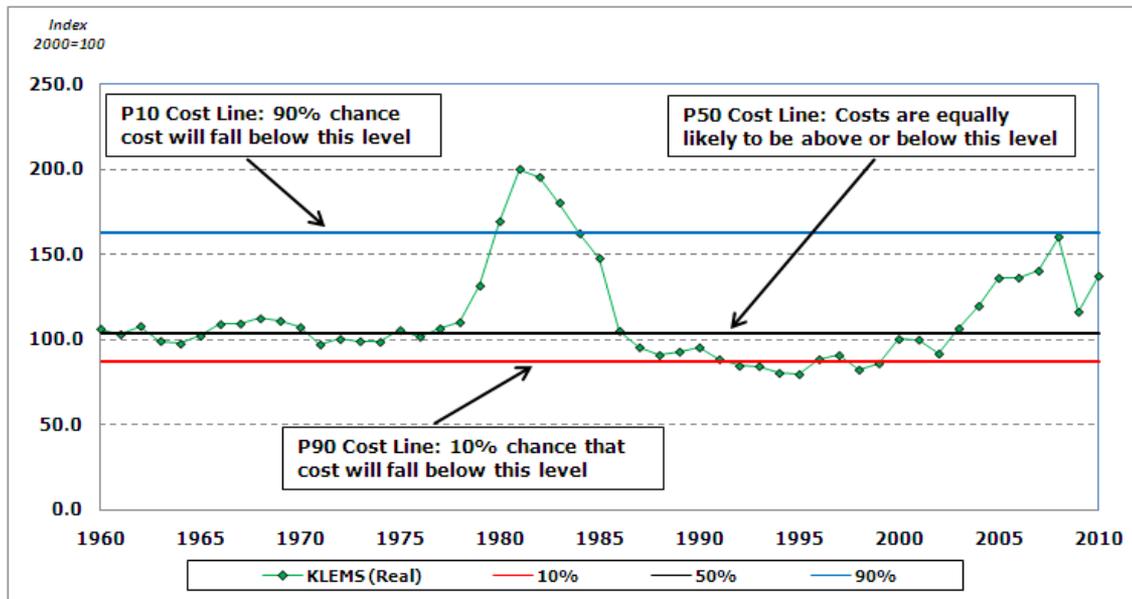
# North American Market Gas Trade Model: Key Drivers (cont'd)

- **Investment parameters:**
  - Fiscal terms under which resources and infrastructure can be developed influences economic viability
  - Factors such as high taxes/royalties and higher-than-normal required returns can inhibit production in those regions affected, thus shifting the flow of trade
- **Assumptions regarding timing and availability of resources and infrastructure:**
  - Constraints imposed on the availability of infrastructure (e.g., the start date and capacity of pipeline infrastructure) can have a large influence on regional pricing and flows.



## North American Market Gas Trade Model: Developing a Cost Environment

Typical Cost Environment (P50): 1975, 1986, and 2003



- Staff must simulate the cost environment for analysis:
  - Graph shows indexed cost between 1960 and 2010
  - High cost environment ~ 1979 – 1984
  - Low cost environment ~ 1992 – 2000.

Sources: Baker Institute.



# National Price and Supply Outlooks/Scenarios: Road Map

- Purpose of Preliminary Scenarios
- The Preliminary Scenarios
- Descriptions of the Scenarios
- General Impact of Price Changes
- Price Performance of Cases
- Supply Portfolio



# National Scenarios: Purpose of Scenarios

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- **To examine price and supply in the national natural gas market:**
  - Potential vulnerabilities to California
  - Potential opportunities for California
- **To investigate natural gas price and supply uncertainty:**
  - Plausible range of conditions developed
- **To develop plausible outlooks of prices and supply:**
  - The question: What if all plausible events associated with a particular outcome occurred simultaneously?



### **National Scenarios: Purpose of Cases (cont'd)**

- **To evaluate the impact of relevant policy drivers:**
  - **Implementation of Renewables Portfolio Standard (RPS)**
  - **Conversion of coal-fired generation**
  - **Environmental mitigation of shale development:**
    - **Water use and disposal**
  - **Licensing of liquefied natural gas (LNG) export capability.**



# National Scenarios: What are the National Scenarios?

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- **Staff constructed the following national outlooks:**
  - Reference Case
  - High Price (Low Consumption) Case
  - Low Price (High Consumption) Case.



# National Scenarios: Scenario Description (Reference Case)

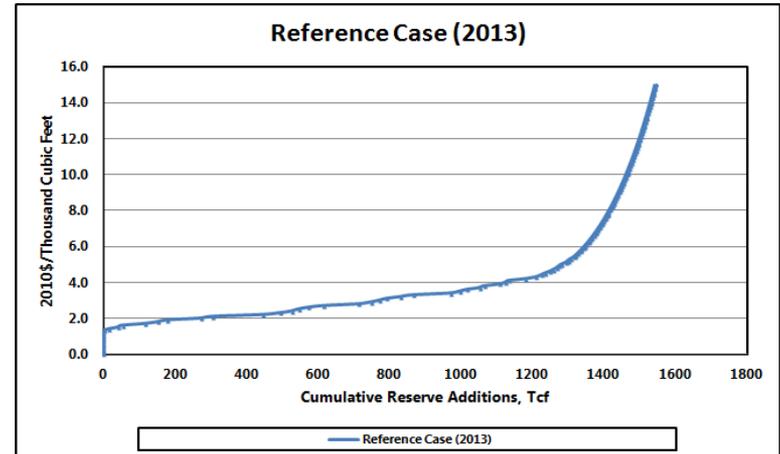
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- **Initial (starting) demand quantity (United States):**
  - 2011: Total ~ 22.1 Tcf; Power Gen ~ 7.5 Tcf
  - 2020: Total ~ 26.9 Tcf; Power Gen ~ 9.9 Tcf
  - 2030: Total ~ 26.2 Tcf; Power Gen ~ 10.6 Tcf
- **Estimated Elasticity:**
  - Residential, Commercial, Industrial, Power Gen, and Transportation;
  - Range of elasticity ~ 0.5298 – 1.2363
- **Coal Conversion: 30 Gigawatts starting in 2014**
- **Renewables Portfolio Standard:**
  - California meets on time
  - 5-year delay in other states.



## National Scenarios: Scenario Description (Reference Case) (cont'd)

- Proved Reserves: 325 Tcf
- Potential Reserves:
  - 1280.4 Tcf @ \$5.00/Mcf
  - 1462.4 Tcf @ \$10.00/Mcf
- Rate of Return:
  - Resources: 12.2% (real)
  - Pipeline Investment: 8.4% (real)
  - Income Tax Rate: 35%
  - Return on Equity: 8%
- Backstop Technology:
  - Unspecified at \$9.00/Mcf
- Technology Factor:
  - 1%/year.



**Aggregate Supply Cost Curve**



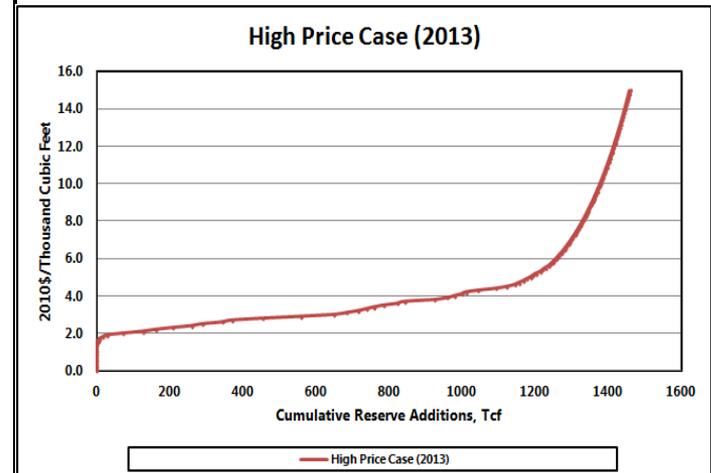
### **National Scenarios: Scenario Description (High Price Case)**

- **Converted 80 GW of coal-fired generation**
- **Assumed robust economic performance, with long-term annual economic growth capped at about 3.5%**
- **Delayed RPS implementation by 10 years as states grapple with budgetary concerns**
- **Starting in 2016, assumed robust LNG export capability developed and utilized at:**
  - **Kitimat (Canada, Apache)**
  - **Sabine Pass (Cheniere), Lake Charles (BG), and Freeport**
  - **Cove Point .**



## National Scenarios: Scenario Description (High Price Case) (cont'd)

- Assumed added environmental compliance costs in Canada and the United States:
  - \$0.40/Mcf to the O&M cost of developing shale formations
  - \$0.20/Mcf to conventional resources
- Removed from development potential shale resources in particular regions, such as New York and the Rocky Mountains (Colorado and Wyoming):
  - Altered the available gas resource and shrank resource base by about 5.5%
  - Re-established merit order of resource selection.

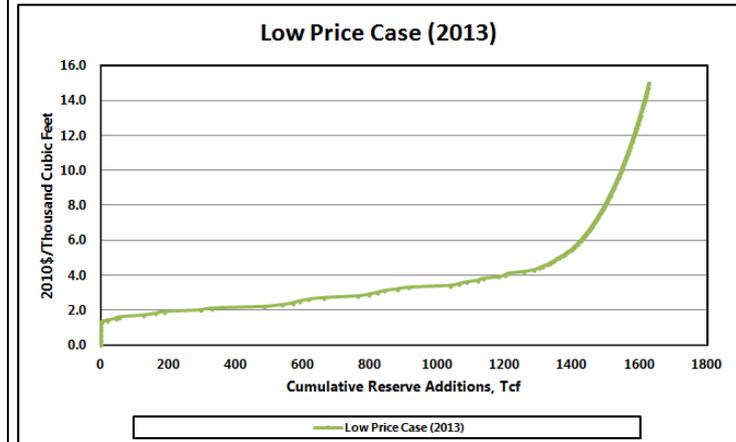


**Aggregate Supply Cost Curve**



## National Scenarios: Scenario Description (Low Price Case)

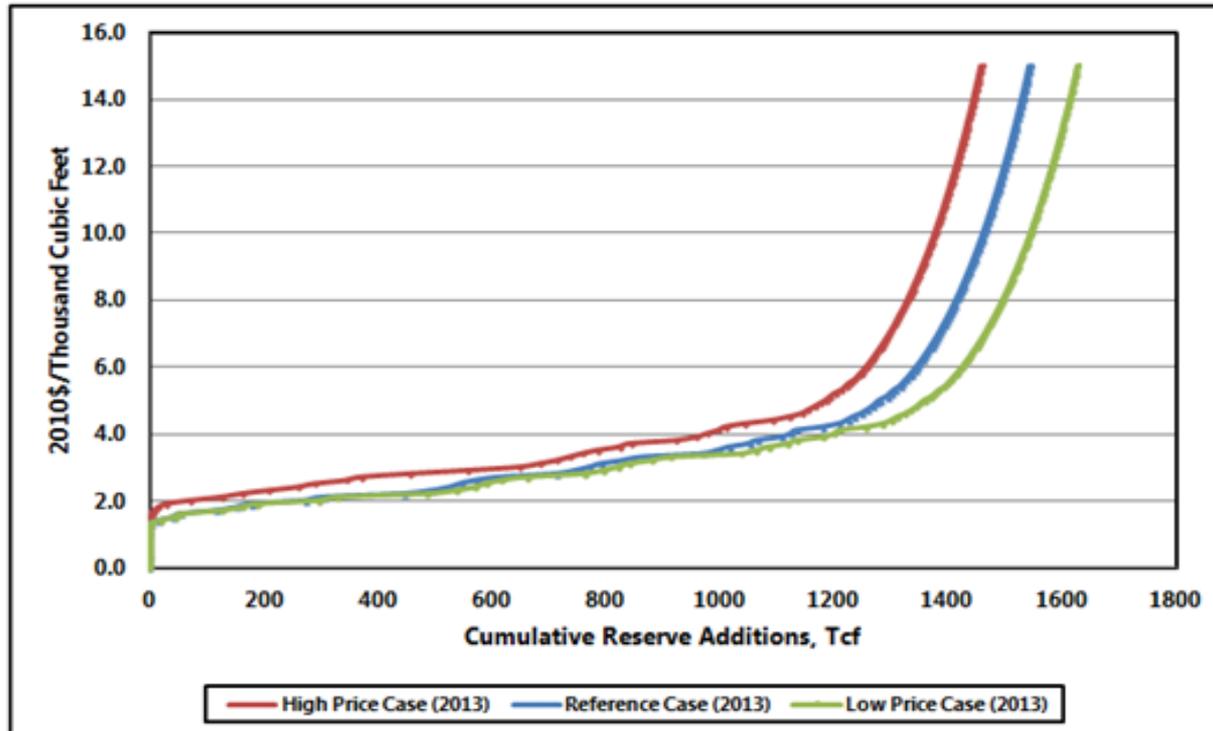
- Converted 1 Gigawatt of coal-fired generation
- Assumed all states meet RPS targets on time
- Capped long-term annual economic growth capped at about 2.1%, portending weak gross domestic product growth
- Disallowed LNG exports, thus keeping North America isolated



- Assumed technology develops at a rate of 2.5%
- Assumed larger resource base
  - Increased assessment size in the Marcellus, Haynesville, and western Canadian shale formations
  - Used upper range of published data
  - Resulted in additional 5.3% rightward shift of overall supply cost curve.



## National Scenarios: Scenario Description (Supply Cost Curve Comparison)



- Individual resources turned off or turned on
- Curves shift to the right or to the left.

Sources: California Energy Commission; Altos Management Partners; Baker Institute; National Petroleum Council.



# National Scenarios: General Impacts of Price Changes

- Price changes produce various responses:
  - Higher prices
    - Depress demand
    - Stimulate added supply
  - Lower prices
    - Stimulate demand
    - Suppress supply
- Usually, a combination of dual impact occurs
- Price *changes* also re-configure the order of economic selection and, thus, the supply portfolio:
  - In a dynamic market, this can affect the attractiveness of particular supply resources
- Question: What is the dominant effect?



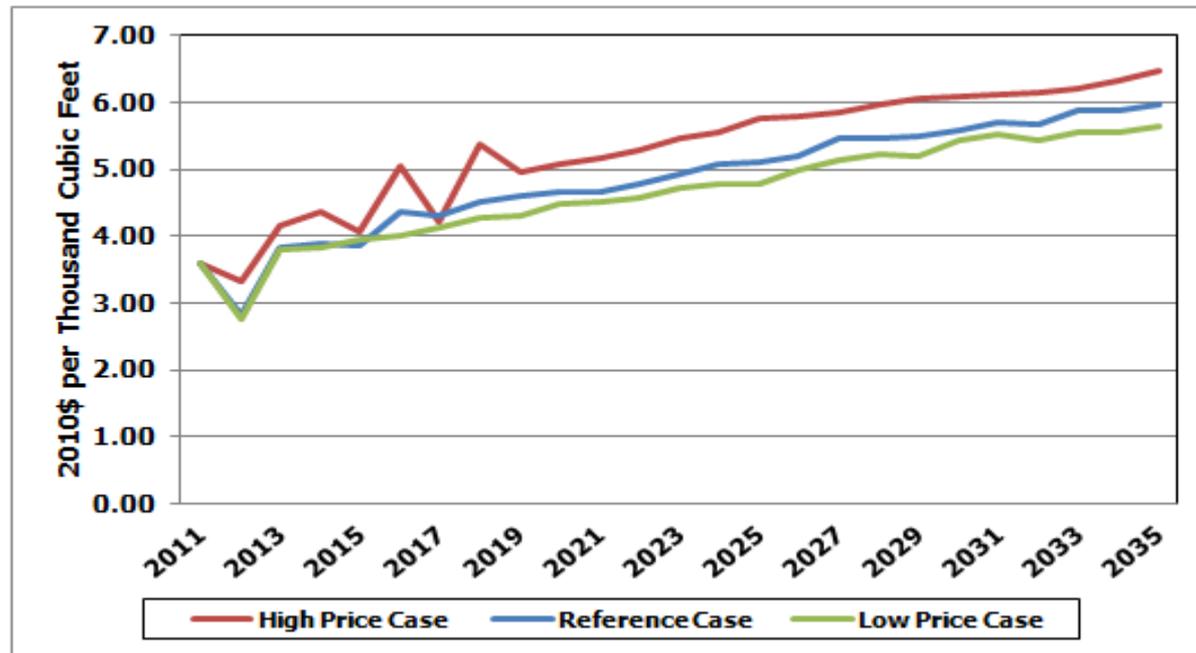
## **National Cases: Supply Balance**

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**Performance of Cases:  
Lower 48**



# National Cases: Price Performance of Cases (Henry Hub)



- In general, prices behave as expected:
  - High Price case produced highest prices
  - Low price case produced lowest prices
- Together, three cases produced the “zone of uncertainty.”



## National Cases: Price Performance of Cases (Differentials)

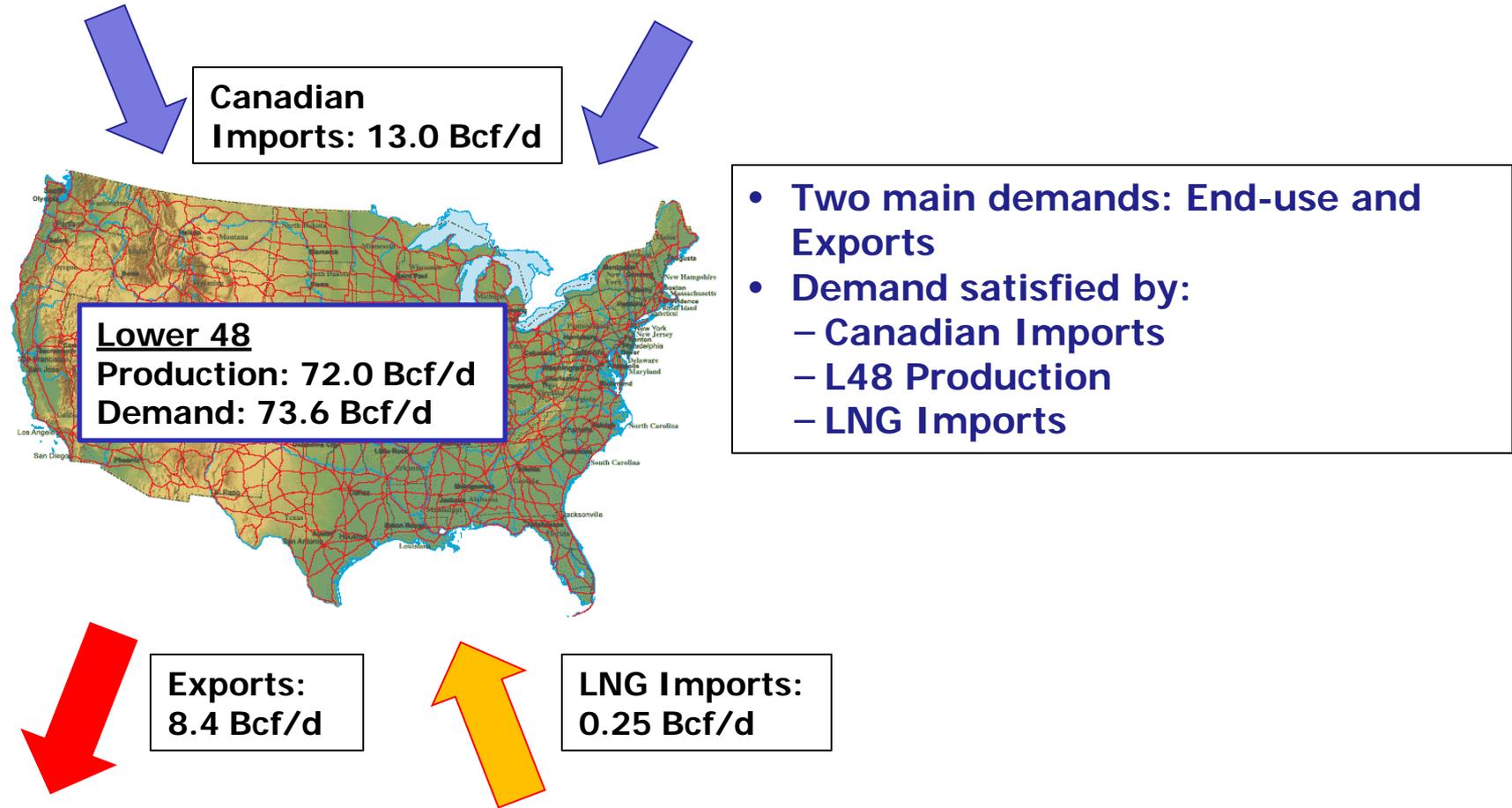
Topock - Henry Hub



- In general, differentials turn positive after 2013:
  - Resource abundance more evident in the eastern US
  - Access to shale and 'tight' gas resources is re-ordering the supply portfolio, impacting eastern prices more than western.

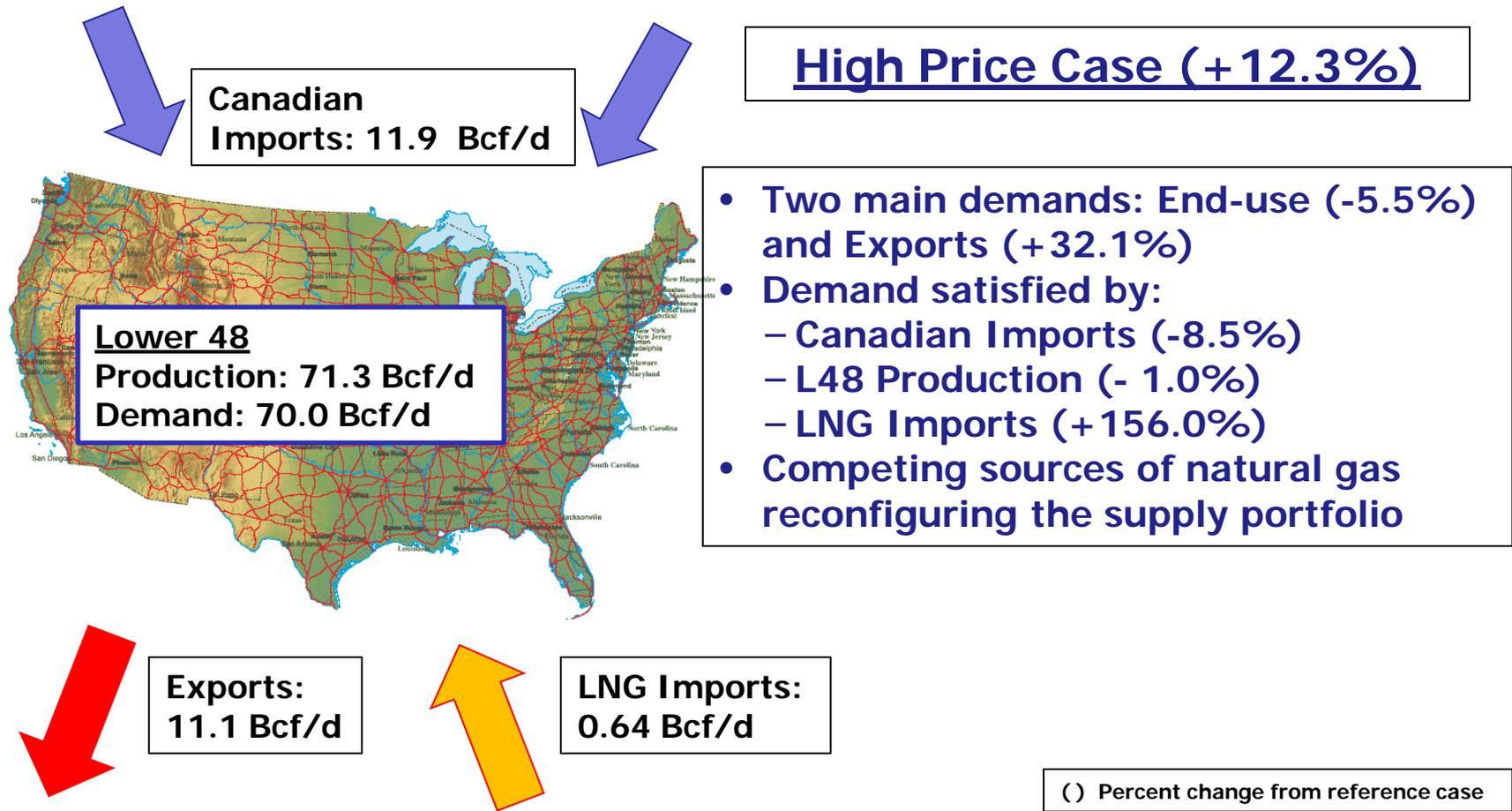


# National Scenarios Cases: Supply Portfolio of Reference Case (2025)



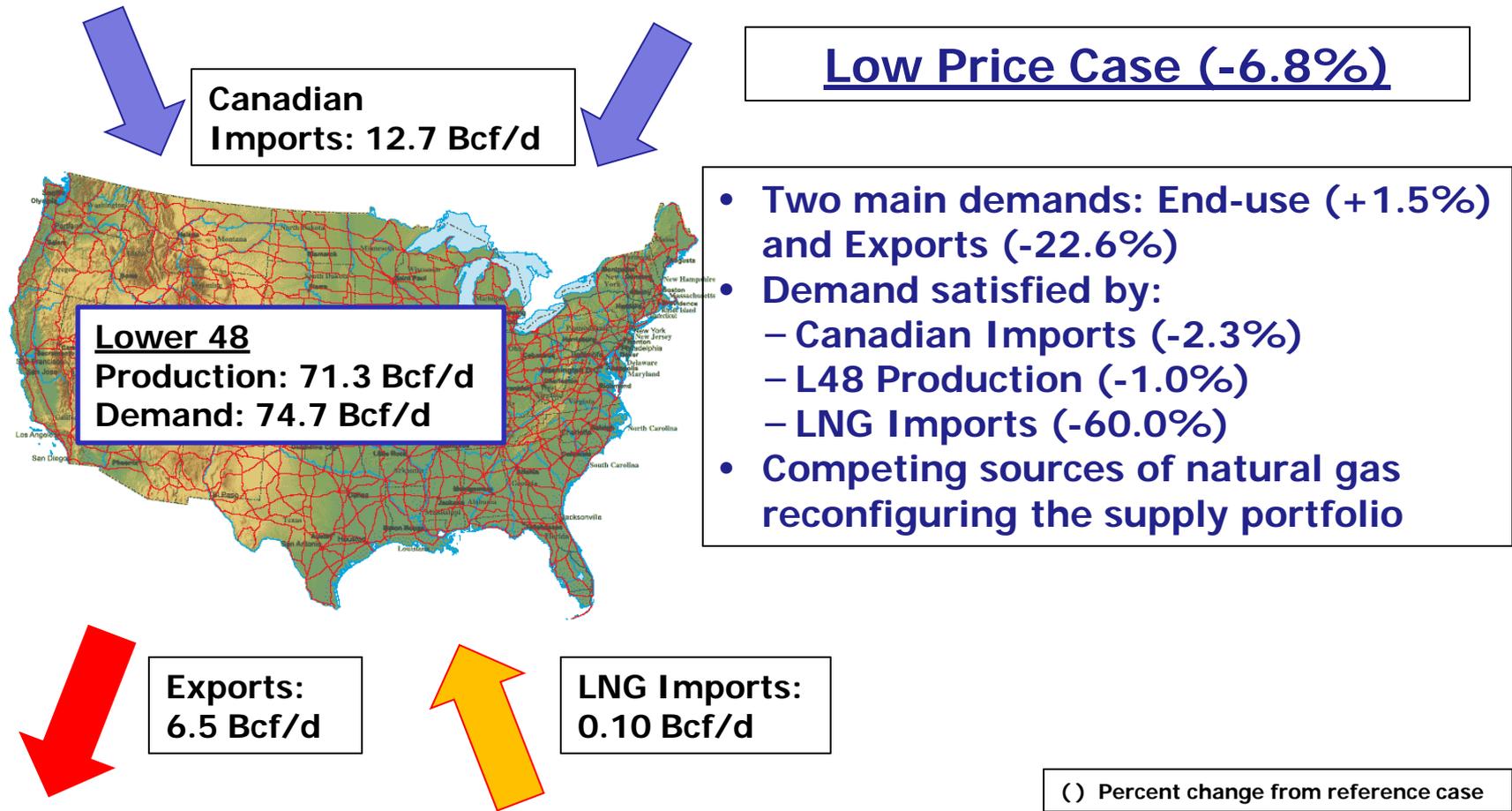


# National Scenarios: Reconfiguration of Supply Portfolio (2025)





# National Cases: Reconfiguration of Supply Portfolio (2025)





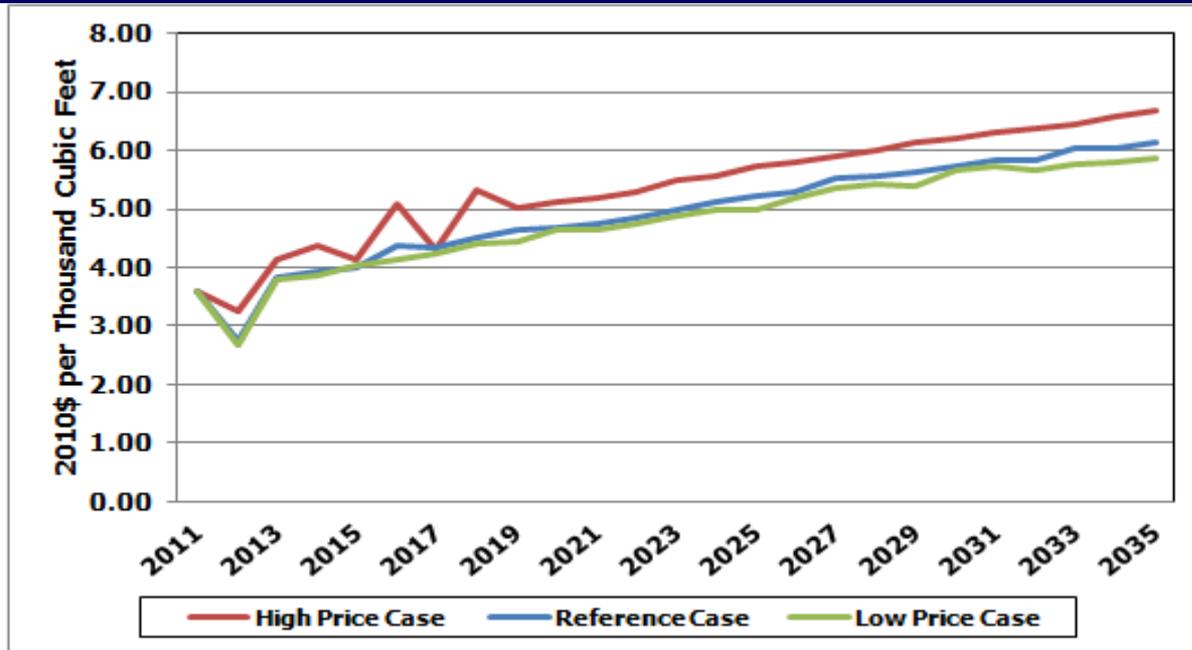
## **National Cases: Supply Balance**

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## **Performance of Cases: California**



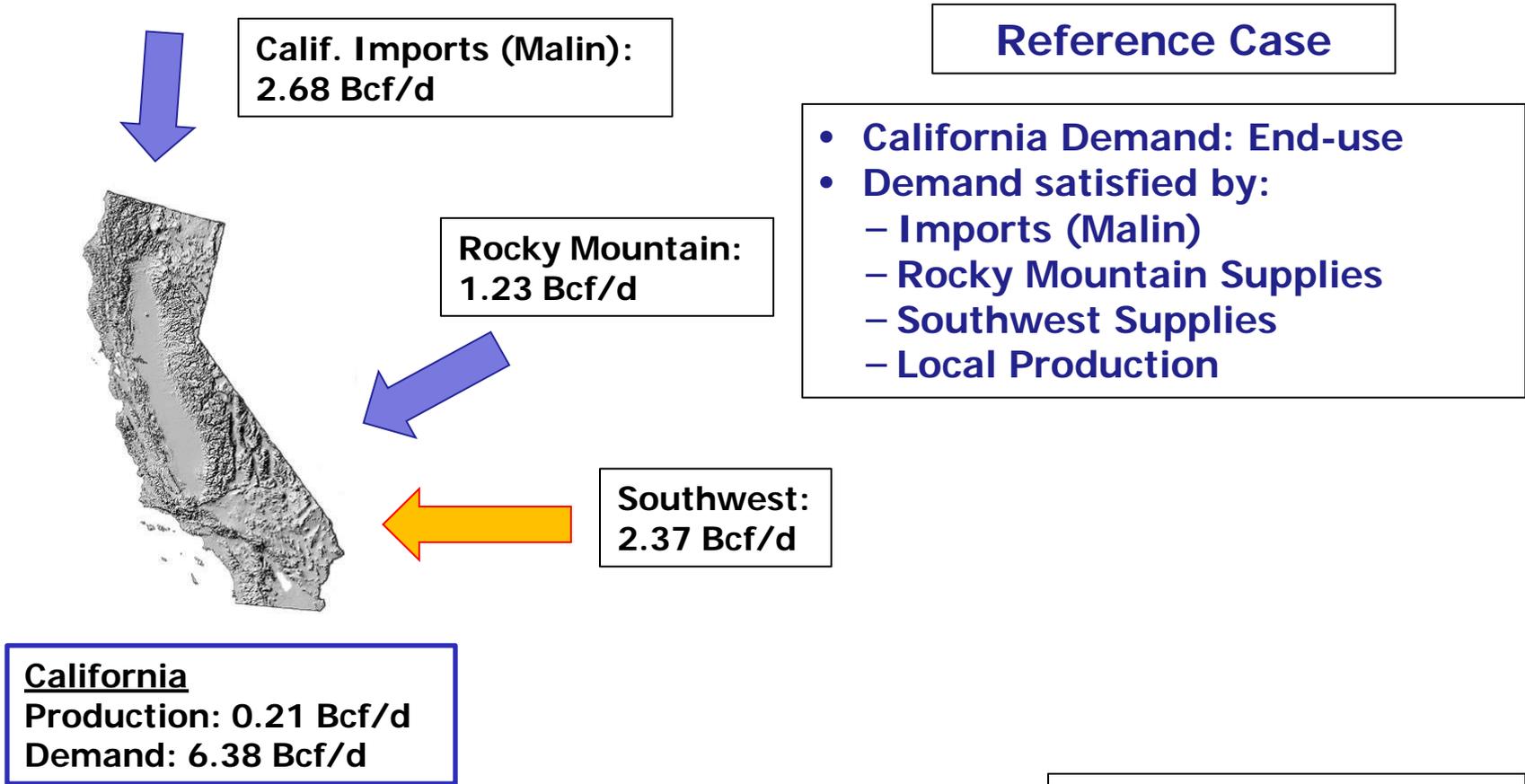
## National Cases: Price Performance of Cases (Topock Hub)



- In general, prices behave as expected:
  - High Price case produced highest prices
  - Low price case produced lowest prices
- Together, three cases produce “zone of uncertainty” for California.



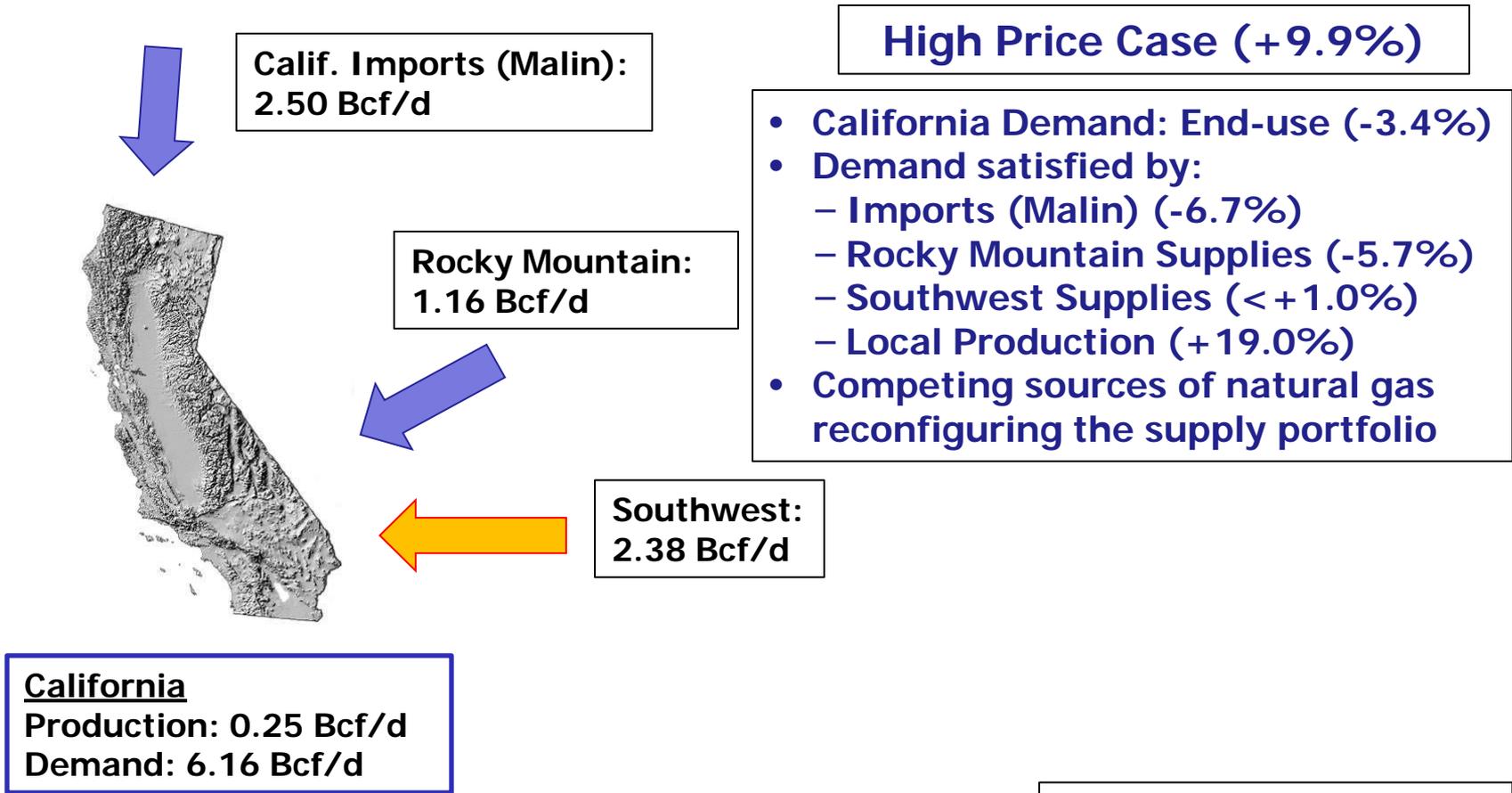
## National Cases: California Supply Portfolio (2025)



( ) Percent change from reference case



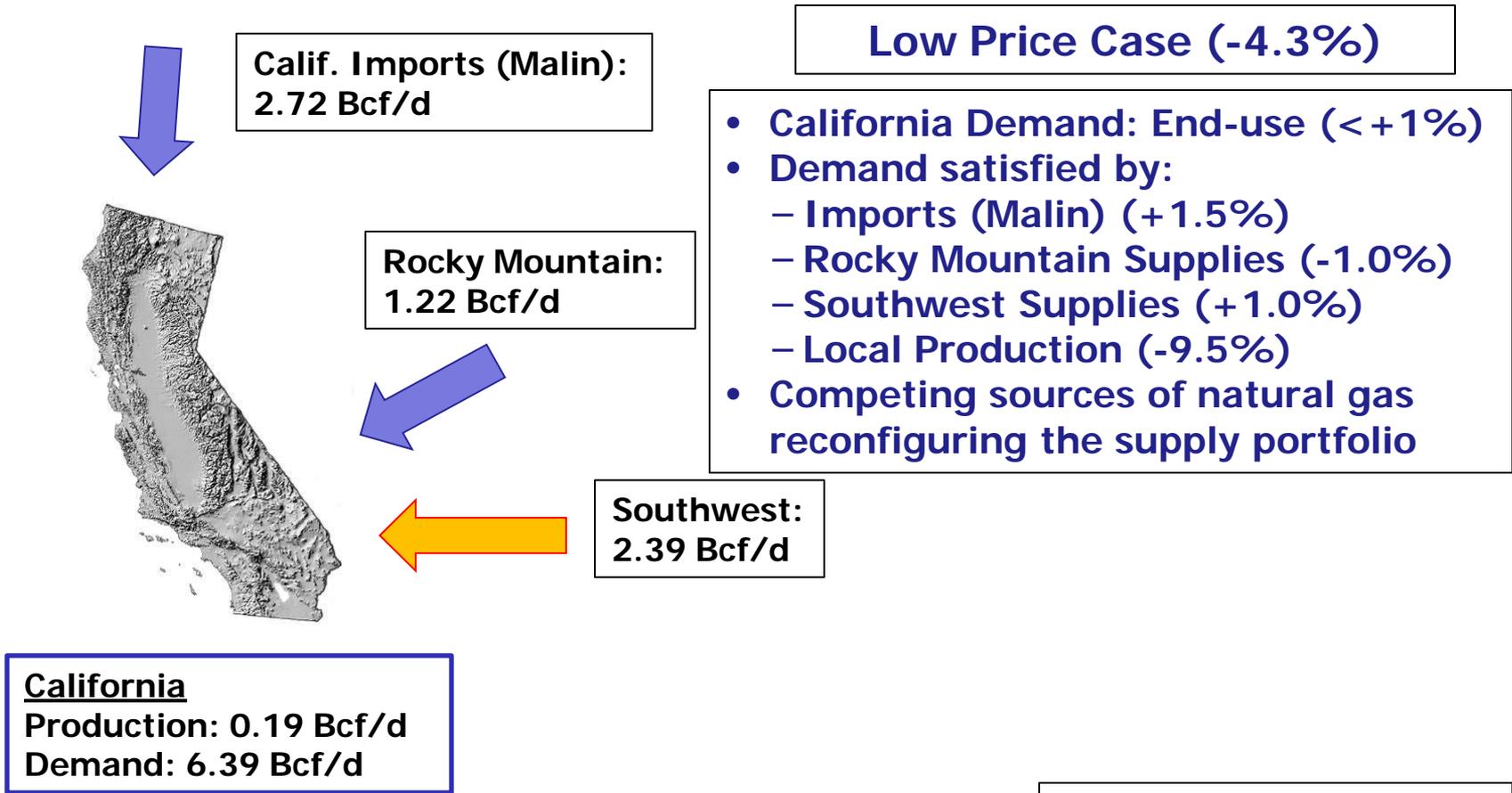
## National Cases: California Supply Portfolio (2025)



( ) Percent change from reference case



# National Cases: California Supply Portfolio (2025)



( ) Percent change from reference case



## Additional Scenarios: Merging of Reserves Estimates and Cost Environment

		Reserve Estimates (RE)		
		<b>P10: 10% chance costs reach value or higher</b>	<b>P50: Actual cost value equally likely to be higher or lower than estimate</b>	<b>P90: 90% chance costs reach value or higher</b>
Cost Environment (CE)	<b>P10: 10% chance costs reach value or higher</b>	Reserve Estimates: Proven: 325 Tcf Potential: 1970 - 2460 Tcf** <u>Cost Environment:</u> Cost going forward approximates real costs in 1984 and 2008	Reserve Estimates: Proven: 325 Tcf Potential: 1543 Tcf <u>Cost Environment:</u> Cost going forward approximates real costs in 1984 and 2008	Reserve Estimates: Proven: 325 Tcf <u>Cost Environment:</u> Cost going forward approximates real costs in 1984 and 2008
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	<b>P90: 90% chance costs reach value or higher</b>	Reserve Estimates: Proven: 325 Tcf Potential: 1970 - 2460 Tcf** <u>Cost Environment:</u> Cost going forward approximates real costs between 1991 and 1999	Reserve Estimates: Proven: 325 Tcf Potential: 1543 Tcf <u>Cost Environment:</u> Cost going forward approximates real costs between 1991 and 1999	Reserve Estimates: Proven: 325 Tcf <u>Cost Environment:</u> Cost going forward approximates real costs between 1991 and 1999

\*\*Gross approximation assuming a log-normal distribution

- Additional scenarios result from the combination of the cost environment and the reserve estimates
- Extreme high-price will pull toward the upper right cell; Extreme low-price will pull toward lower left cell.

Sources: California Energy Commission, EIA, and Baker Institute



# National Scenarios: Conclusions

- Plausible national scenarios produce a range of price and supply outcomes
- Price changes can reconfigure the supply portfolio
- To integrate renewables into the generation supply portfolio, California needs a robust natural gas supply base
- The switch from coal-fired generation may lead to higher natural gas demand
- Plausible national scenarios produce a “Zone of Uncertainty”
- The abundance of shale resources keeps the “Zone of Uncertainty” relatively narrow.