



California Energy Commission

Shale Production Uncertainty Cases: A Scenario Examination

Preliminary Results

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Shale Production Uncertainty Scenario Cases **Background**

- **NG production from shale formations has soared in the last ten years:**
 - Production in May 2013 exceeded 31 bcf/d
 - Accounts for over 40% of Lower 48 production
- **Accelerated technological innovation has transformed the NG industry**



Shale Production Uncertainty Scenario Cases

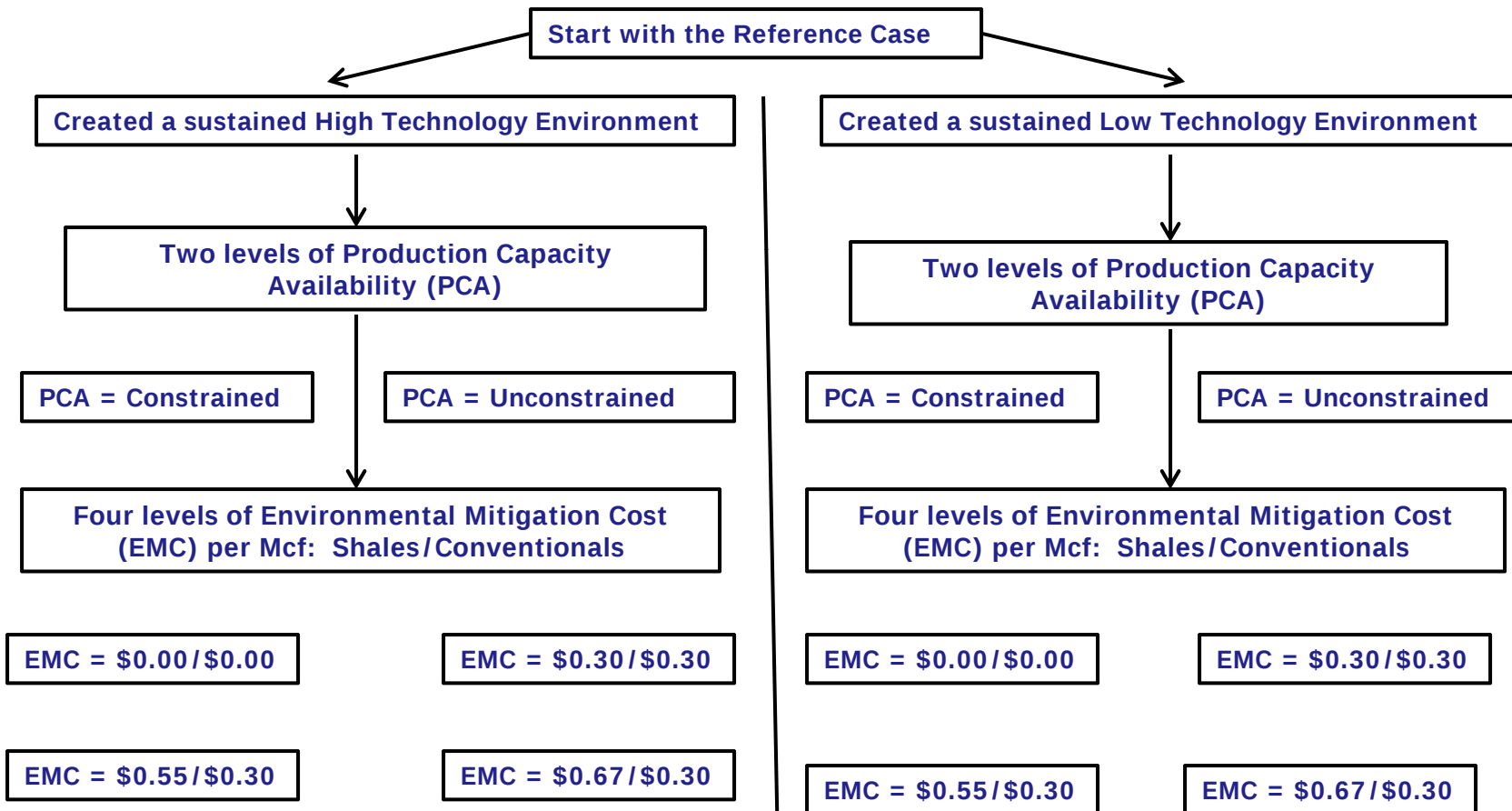
Background

- **Controversial Issues:**
 - Groundwater contamination
 - Increased seismic activity
 - Diversion of freshwater
 - Added methane emissions
- **Decision-makers re-examining policies**
 - Delayed development (e.g., New York)
 - Instituted environmental mitigation fees
 - Tightening regulation



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Shale Production Uncertainty Cases -16





Shale Production Uncertainty Scenario Cases Disaggregation of Cases

- Impact of technology
 - High Technology cases vs Low Technology cases
- Impact of policies on development and/or production
 - Unconstrained cases vs Constrained cases
 - Changes in the size of the resource base
 - Changes in the availability of productive capacity
- Impact of environmental mitigation fees
 - Group I cases vs Group II cases vs Group III cases vs Group IV cases
 - Group I: (Shale - \$0.00, Conventional - \$0.00)
 - Group II: (Shale - \$0.30, Conventional - \$0.30)
 - Group III: (Shale - \$0.55, Conventional - \$0.30)
 - Group IV: (Shale - \$0.67, Conventional - \$0.30)



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Shale Production Uncertainty Scenario Cases **Relation to Four Previous Cases**

- **Shale Abundance**
 - High Technology, EMC = \$0.30/\$0.30, unconstrained
- **Shale Reconsidered**
 - Low Technology, EMC = \$0.55/\$0.30, constrained
- **Shale Expensive**
 - Low Technology, EMC = \$0.67/\$0.30, constrained
- **Shale Deferred**
 - High Technology, EMC = \$0.55/\$0.30, constrained

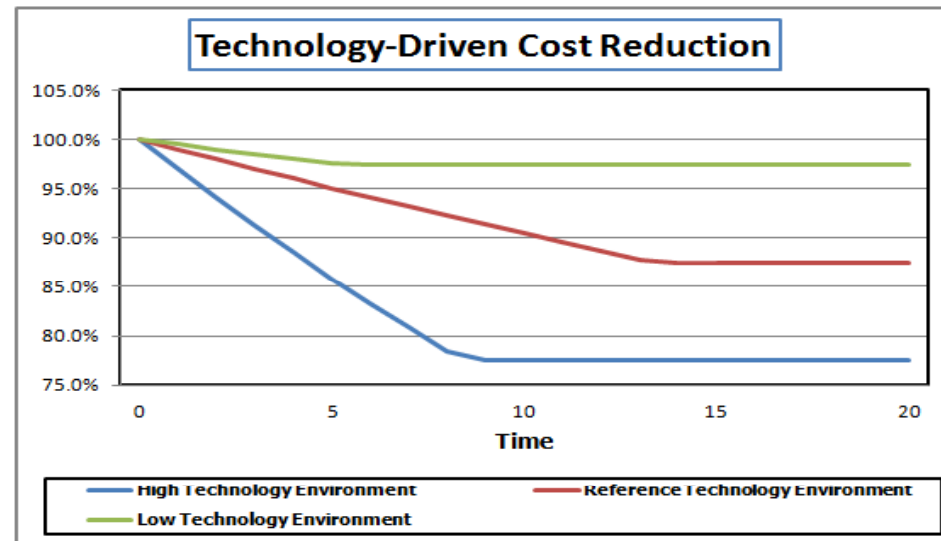


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Shale Production Uncertainty Scenario Cases Key Change Variables

- Changes in four key variables relative to the reference case
 - Changes in the supply cost curves
 - Resource size ranges from 15% increase to 15% decrease
 - Changes in the rate of growth of technological innovation

As the learning rate increases, cost reductions reach the learning limit at a faster rate.

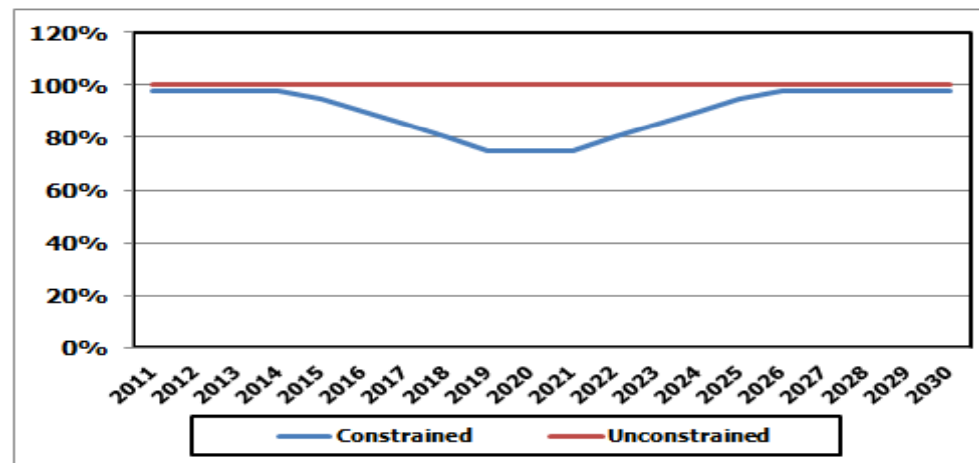




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Shale Production Uncertainty Scenario Cases Key Variable Changes (cont'd)

- Changes in the time of availability of some resources



- Changes in environmental mitigation cost
 - Ranged from \$0.0 to \$0.67 per Mcf



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Shale Production Uncertainty Scenario Cases

High Technology vs Low Technology

Sustained High Technology Environment:

Learning Rate: 3 %

Cost Reduction Limit: 77.5 %

Underestimation of Shale Resources: 15 %

Sustained Low Technology Environment:

Learning Rate: 0.5 %

Cost Reduction Limit: 97.5 %

Overestimation of Shale Resources: 15 %



Shale Production Uncertainty Scenario Cases

Performance of Cases: 2020 Results



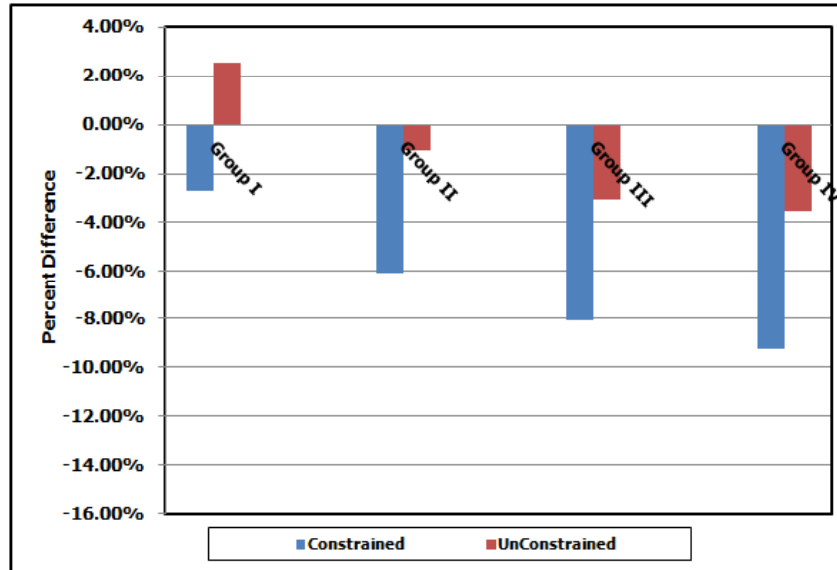
Shale Production Uncertainty Scenario Cases: Understanding the Results

- Three effects in following schematics:
 - **Effect of Technology**
 - Compare side by side schematics
 - **Effect of Environmental Mitigation Cost**
 - Discern trend by moving left to right within each schematic
 - **Effect of production constraint**
 - Compare blue bars to red bars (sitting next to each other)
- All schematics show changes relative to Reference Case (0.00%)

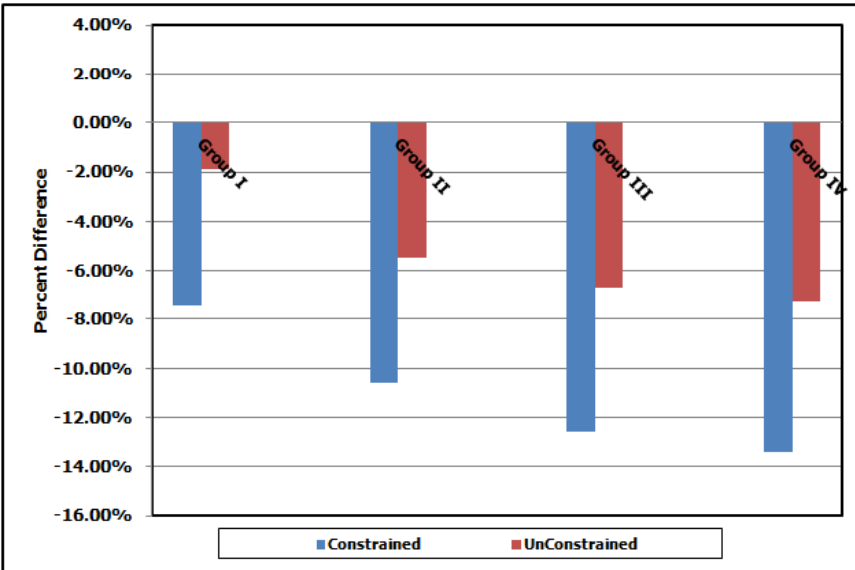


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L48 Total Production (Change relative to Reference Case)



Sustained High Technology: L48 Total Production



Sustained Low Technology: L48 Total Production

Sustained Low Technology environment impacts NG supply more a Sustained High Technology environment

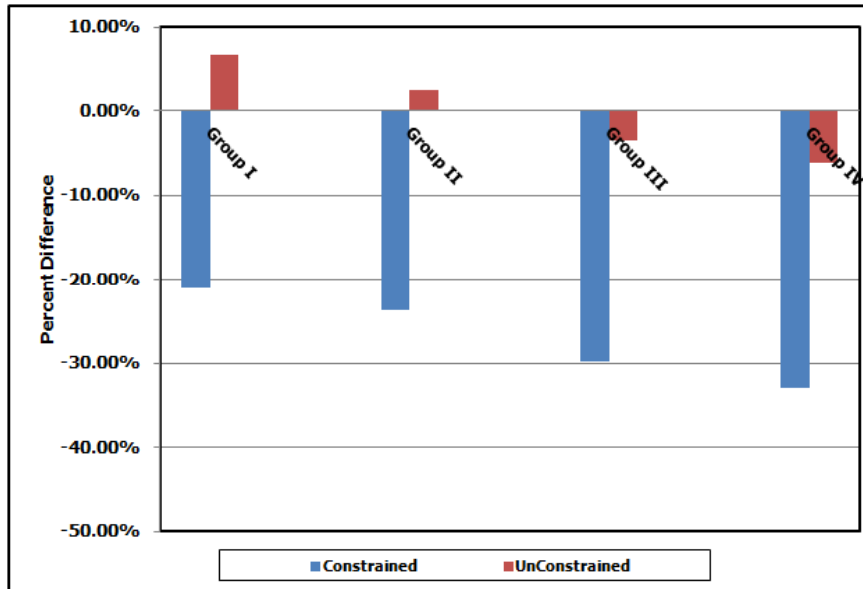
EMC

Group I: (Shale - \$0.00, Conventional - \$0.00); Group II: (Shale - \$0.30, Conventional - \$0.30);
Group III: (Shale - \$0.55, Conventional - \$0.30); Group IV: (Shale - \$0.67, Conventional - \$0.30)

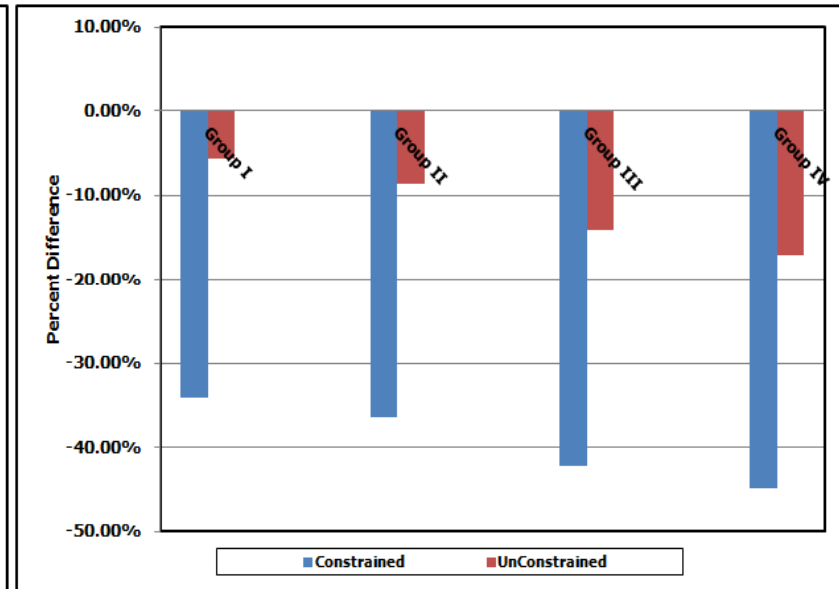


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L48 Shale Production (Change relative to Reference Case)



Sustained High Technology: L48 Shale Production



Sustained Low Technology: L48 Shale Production

Increasing Environmental Mitigation Cost can result in larger reductions in shale production

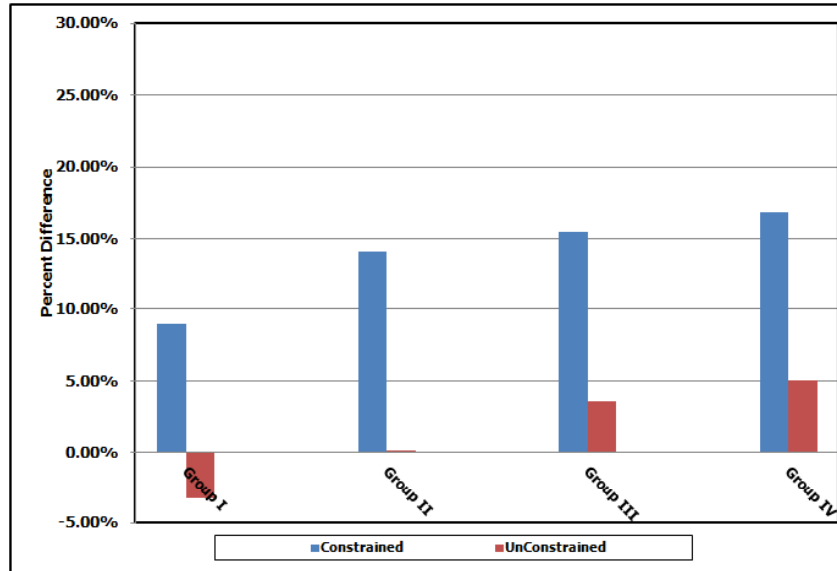
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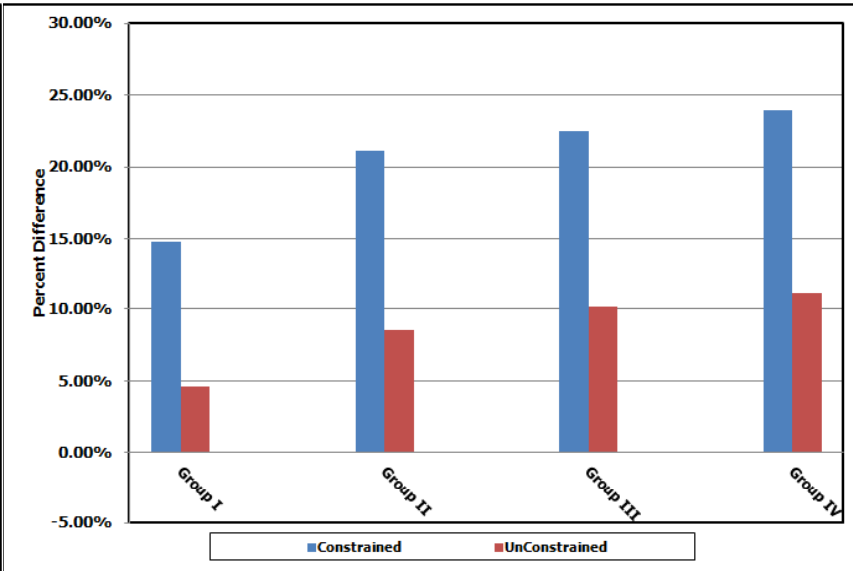


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Henry Hub Prices (Change relative to Reference Case)



Sustained High Technology: Henry Hub Prices



Sustained Low Technology: Henry Hub Prices

Constraints on production can result in larger price impacts

EMC

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Shale Production Uncertainty Scenario Cases: Conclusions and Insights

- **Constraining NG from shale formations significantly impacts prices and supply**
- **Proliferation of technological innovation reduces impacts:**
 - Cost reduction
 - Water handling
- **Environmental policies alter development and production outcomes**
- **Environmental impact fees alter the structure of the natural gas supply portfolio**



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Shale Production Uncertainty Scenario Cases

Questions & Comments