Performance of the U.S. Petroleum Infrastructure under Future Oil Market Scenarios

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U.S. Oil Production and Market Impacts

- U.S. oil production has grown significantly since 2010 (+5 MMBD)
  - ...due to the shale oil & gas boom, with impacts on the entire petroleum market

- Crude Imports (-2 MMBD)
- Crude Exports (+0.6 MMBD)
- Net Product Exports (+2.5 MMBD)
- Crude Stocks (+5 MMBD)*
- Product Stocks (-4 MMBD)
- Positive (expected) changes for the U.S. economy

*Cumulative stock change since Dec. 1999 is divided by the number of days in the month. This converts the stock values to daily rates comparable to other variables.
U.S. Oil Flow Patterns were Disrupted

- Bakken oil location vs. refining locations
- Imported vs. domestic oil movements are different
- Heavy oil refineries on the Gulf Coast now close to abundant light oil
- Cost of oil transportation skyrocketed; Brent-WTI spread widened
  - Pipeline reversals, modification and new investments; rail movement of oil, etc.
- …disruptions to the petroleum infrastructure were not fully anticipated

U.S. Petroleum Administration for Deference Districts (PADD): with the petroleum infrastructure
Tight oil plays (brown), refineries (black dots), major crude oil (green) and product (red) pipelines (Based on available GIS data from the EIA)
TRIM*: Model of U.S. Petroleum System

- TRIM is a static, network LP model: Designed for integrated evaluation of the implications of future oil market scenarios on the petroleum supply system

- **Annual:** 2014, 2015, 2018, 2020, 2025, 2030

- **U.S. petroleum infrastructure**
  - 6 crude & 6 product categories
  - Oil production (19 regions)
  - Crude flow network (pipeline, rail and water)
  - Refining operations (35 regions)
  - Condensate processing on the Gulf Coast
  - Piece-wise linear oil supply curves
  - Piece-wise linear product demand curves

- **Linkages to global markets**
  - Transport links to crude suppliers
  - Refinery locations for Canada & Europe
  - Export links to Canada & Europe
  - Product trade based on transportation costs

- **Objective function:** Total surplus

*Transportation Refining and Infrastructure Model*
TRIM: Piece-wise linear oil supply curves

- Systematic oil production-price responses in TRIM
- Generated from simulations of the NEMS Oil & Gas Model (OGSM)
  - AEO2015 Scenarios
  - 15 steps (7 below/above AEO2015 equilibrium prices in $3 increments)
- Results aggregated to the TRIM regions
- Few backward bending curves (mostly low volume cases) were regularized

Example: Supply curves based on the AEO2015 Reference Case for the Permian Basin
TRIM: Network compared to GIS data

- Nodes in TRIM are primarily the oil production and refining regions.
- Additional nodes are used to capture key transportation routes/corridors.
- Industry data was used to specify capacities and rates.
Simulation scenarios

- Based on the AEO2015 scenarios
  - Reference, Low oil price, High resource

- Primary scenarios
  - Without crude exports

- Crude export scenario
  - With exports
  - Ex-post evaluation of policy change

- Prototype transport scenario
  - With exports
  - Excludes rail links in TRIM

Estimated equilibrium prices
U.S. Crude Balance: Reference (w/o Exports) - Level

- Refinery oil use steady at about 16 mmb/d
  - Small changes in composition over time
  - Imports at about 7.5 mmb/d
U.S. Crude Balance: High Resource vs. Reference (w/o Exports) - Difference

- Oil production jumps by about 5 mmb/d in 2030
- Displacing imports almost one for one

High Resource-Ban minus Reference-Ban

Preliminary Results

- Condensate
- Extra-Light-Sweet
- Light-Sweet
- Light-Sour
- Medium-Sour
- Heavy-Medium-Sweet
- Heavy-Sour
U.S. Crude Balance: High Resource (w/Exports vs. w/o Exports) - Difference

- Exports increase by about 1 mmb/d in 2030 under High Resource scenario
  - With a small change in production, imports increase to re-balance the domestic market

- Exports changed little under the Low Price and Reference scenarios

Preliminary Results
U.S. Crude Balance: High Resource w/Exports (w/o Rail vs. w/Rail) - Difference

- Significant impacts on the crude balance
- Rail or additional pipeline capacities would be necessary under this scenario

### Preliminary Results

**High Resource-Lift-BanNR minus High Resource-Lift-Ban**

- **2018**
  - Condensate: 
  - Extra-Light-Sweet: 
  - Light-Sweet: 
  - Light-Sour: 
  - Medium-Sour: 
  - Heavy-Medium-Sweet: 
  - Heavy-Sour: 

- **2020**
  - Condensate: 
  - Extra-Light-Sweet: 
  - Light-Sweet: 
  - Light-Sour: 
  - Medium-Sour: 
  - Heavy-Medium-Sweet: 
  - Heavy-Sour: 

- **2025**
  - Condensate: 
  - Extra-Light-Sweet: 
  - Light-Sweet: 
  - Light-Sour: 
  - Medium-Sour: 
  - Heavy-Medium-Sweet: 
  - Heavy-Sour: 

- **2030**
  - Condensate: 
  - Extra-Light-Sweet: 
  - Light-Sweet: 
  - Light-Sour: 
  - Medium-Sour: 
  - Heavy-Medium-Sweet: 
  - Heavy-Sour: 

### Components

- U.S. Production
- U.S. Shut-in
- Net Imports Canada
- Imports Other
- Exports of Processed Condensates
- Exports Others
- Total crude to US refineries
Shadow Prices on Flow Capacity: Reference scenario (w/Exports) - Level

- Shadow prices are generally below $5/bbl
  - Values near $10/bbl for a few links in the early years
  - Declines over time reflect the impacts of transportation capacity build-up

Reference-Lift-Ban

Preliminary Results
Shadow Prices on Flow Capacity: High Resource vs. Reference (w/Exports) – Diff.

- Shadow prices are significantly higher overall
- Additional transportation capacity would be necessary under this scenario

Preliminary Results
Changes in shadow prices are widespread

- Largest changes are on links to the Bakken region

Effects in the Reference are also significant, but less widespread

Preliminary Results
Conclusions: summary

- TRIM addresses a critical analytical need in the resurgent U.S. oil market:
  - evaluating the impacts of future oil market and economic scenarios on petroleum infrastructure requirements and the system costs/benefits of different options

- Preliminary simulation results suggest that:
  - Crude exports would depend on the future combinations of world oil prices & resources
  - Current and planned transportation capacity may be adequate under the Reference and Low Price AEO2015 scenarios
  - Higher shadow prices on flow capacity mean that additional transportation investments (beyond current industry plans) may be needed under the High Resource scenario
  - Higher shadow prices when excluding rail demonstrates its value in reducing crude flow capacity constraints, especially in the Reference and High Resource scenarios

- Ongoing and future changes would enhance the ability of TRIM to meet its objectives (see next slide)
Conclusions: ongoing and next steps

- Many ongoing updates not reflected in the results discussed here:
  - More flexible refinery sub-model incorporating:
    - 7 potential refinery configurations for each refinery region, instead of 1.
    - Yield vectors for 7 crude types (including condensates) for each refinery configuration
    - Refinery units capacity constraints in each region
    - Refinery units utilization requirements for each yield vector
    - Account for coke production in coking refineries
  - More detailed comparison to data for historical years
  - Updated simulations of existing and additional scenarios
  - PADD-level product elasticities as basis for piece-wise linear demand curves

- Down the line:
  - Update data to match 2016/2017 Annual Energy Outlook
  - Update mid-stream infrastructure buildout forecasts
  - Globalize the model
    - More detailed global regions
    - Incorporate refinery operations in other regions
    - Incorporate product demand for other regions of the world
    - Incorporate transport linkages among all regions
Thank you for listening

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