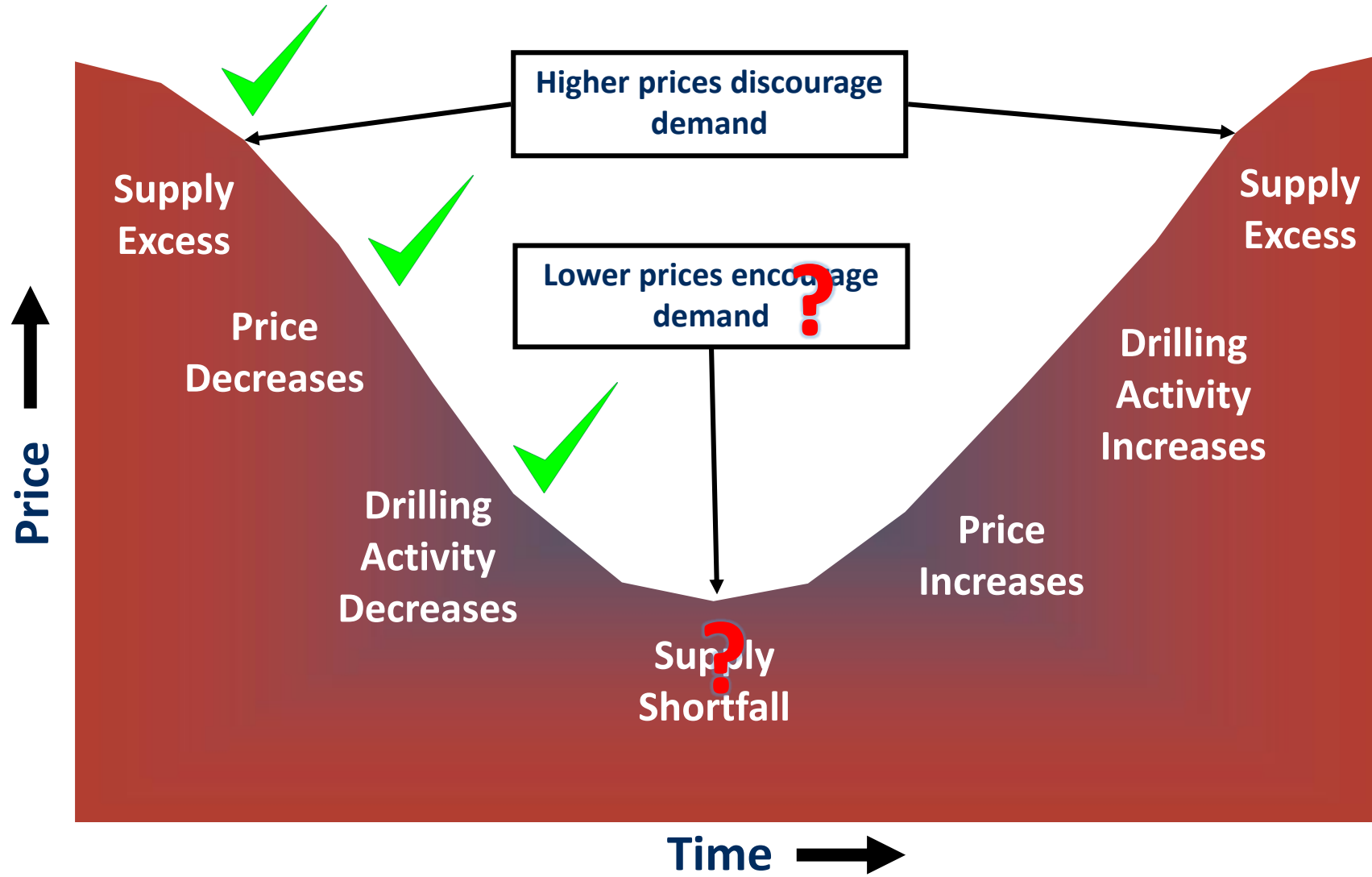


# Oil and Gas Development Scenarios in Texas

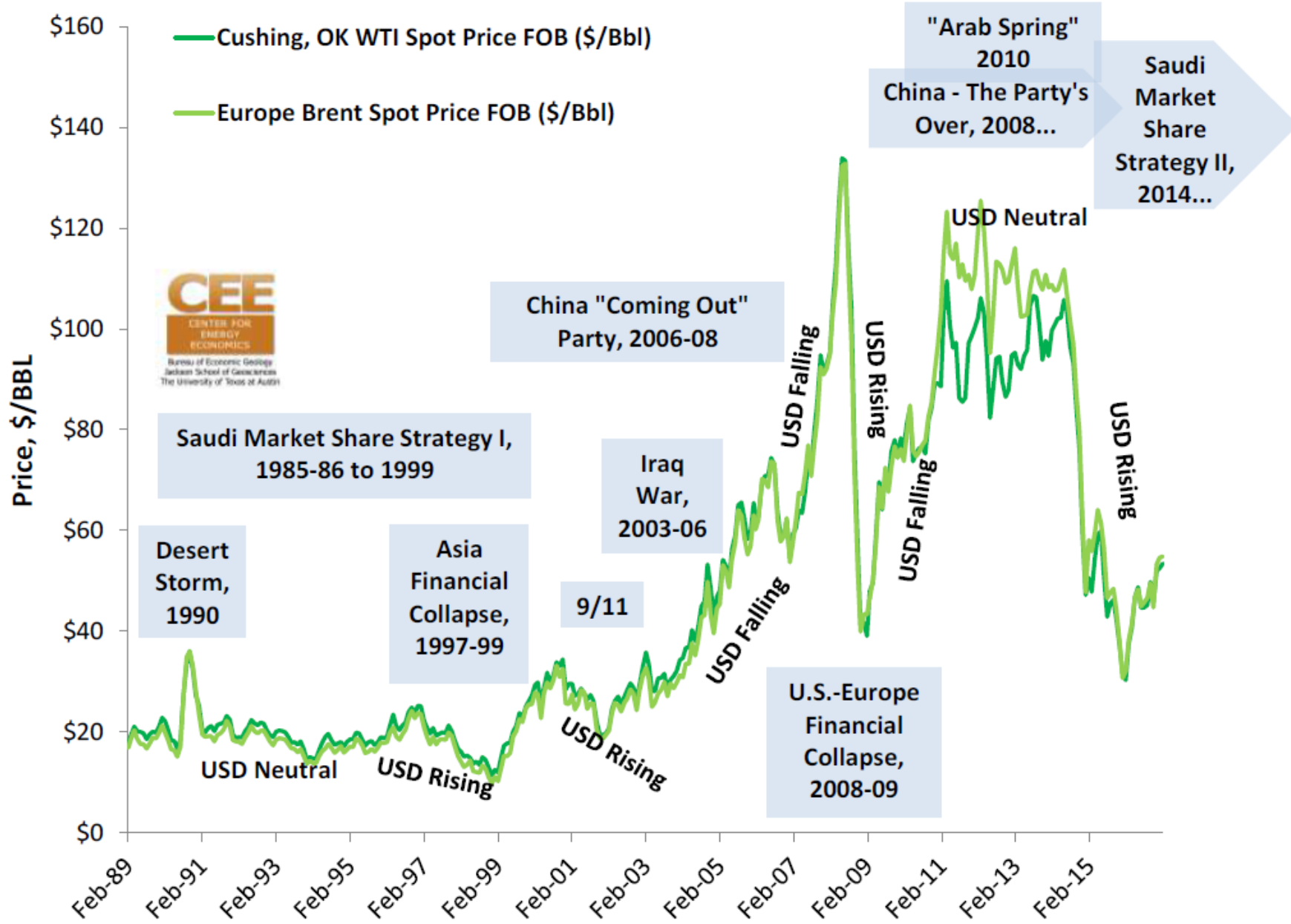
ERCOT LTSA Workshop

May 16, 2017

# Oil/Gas Market Fundamentals – Typical Cycles



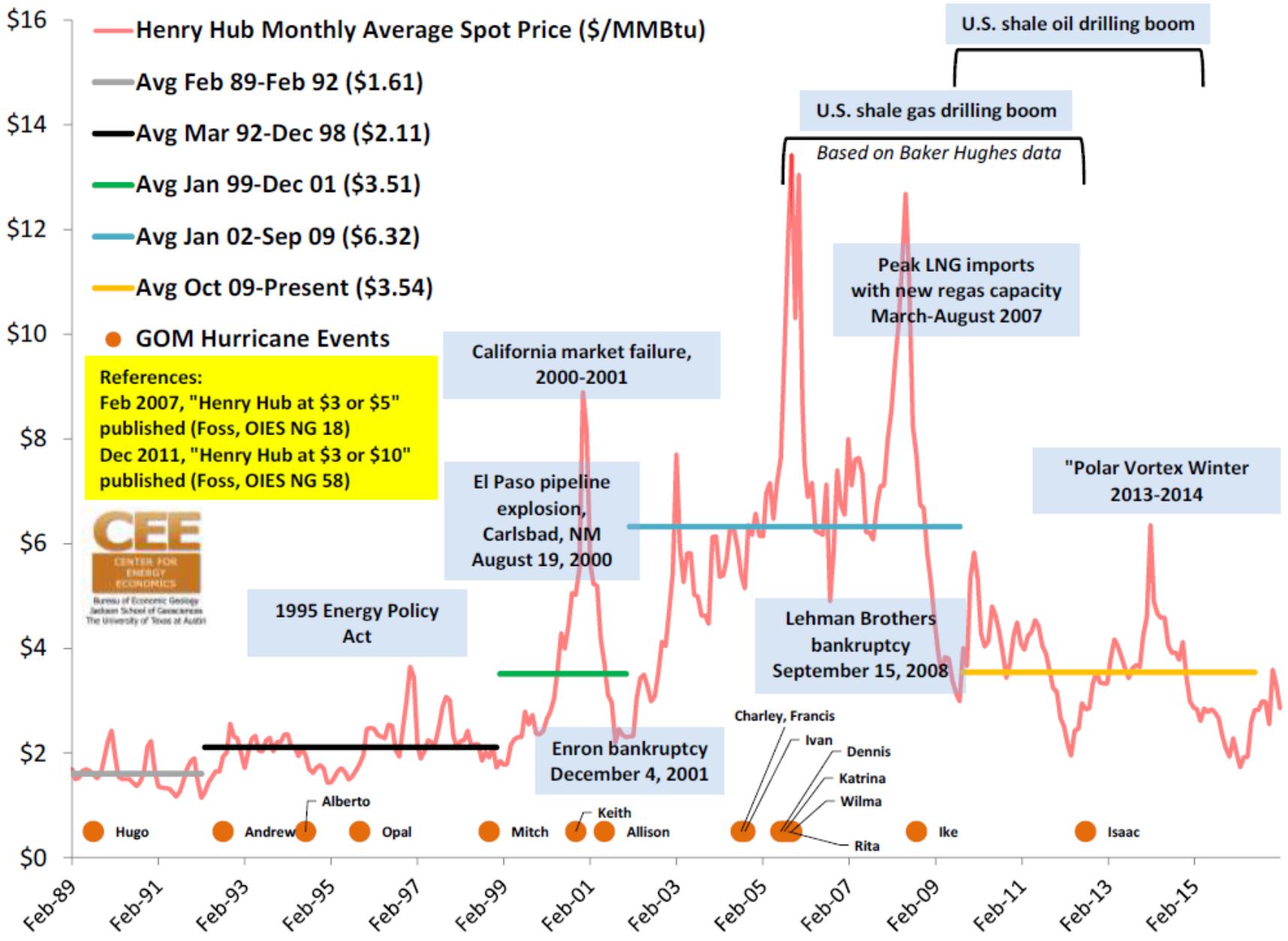
- Oil supply shortfall “fell short” because:
  - Iran, Iraq, Libya, ongoing projects
  - OPEC/Saudi policy
  - U.S. unconventional producers are nimble
- Demand growth might remain lackluster:
  - slower economic growth in China+
  - energy efficiency & conservation
  - alternative fuels
  - environmental factors



Crude oil is a global commodity...

Certainly global, but is it a "commodity"?

Source: Michelle Foss

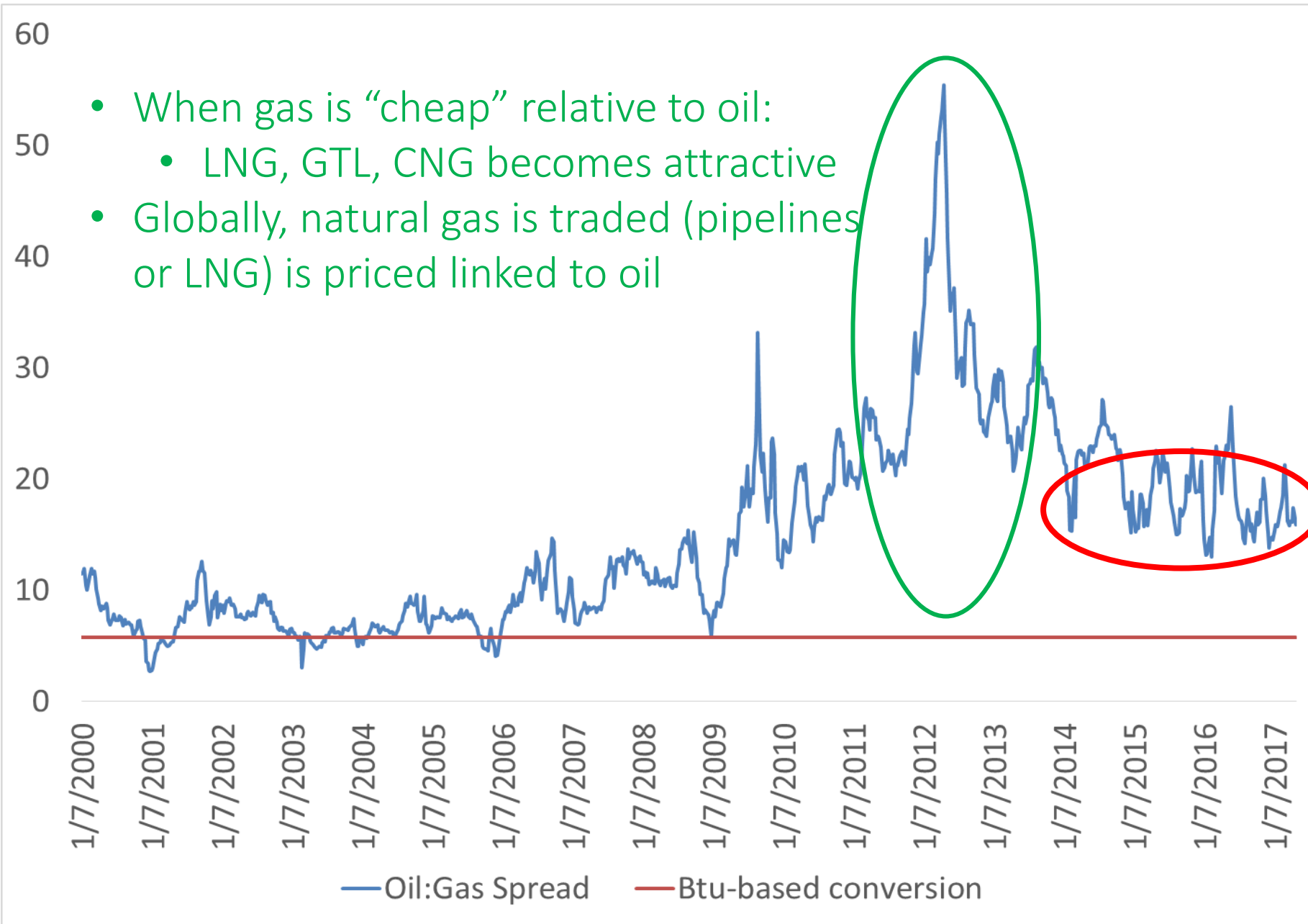


U.S. natural gas is not global but more of a commodity...

Will U.S. LNG exports "integrate" U.S. and world gas markets?

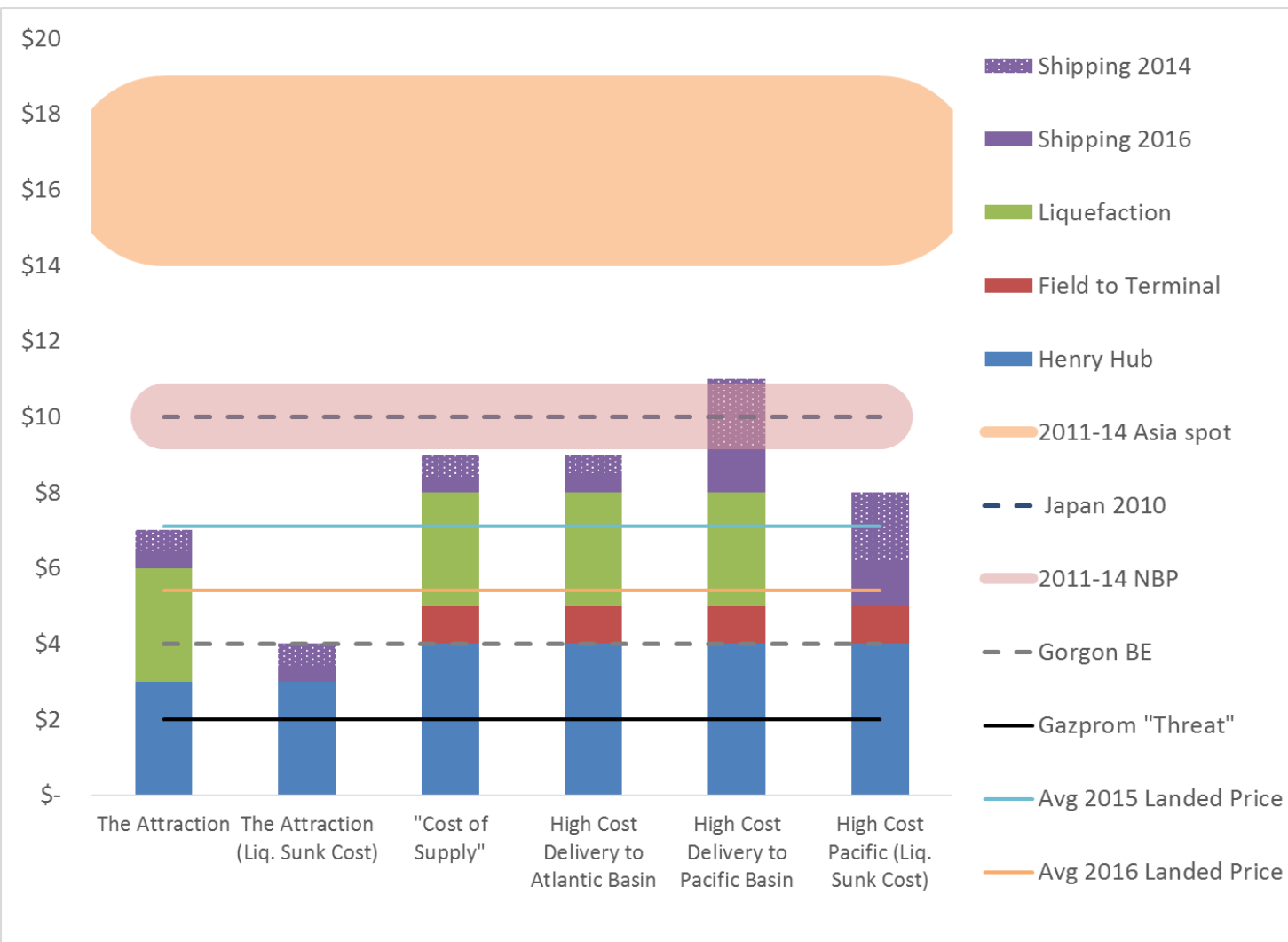
Source: Michelle Foss

- When gas is “cheap” relative to oil:
  - LNG, GTL, CNG becomes attractive
- Globally, natural gas is traded (pipelines or LNG) is priced linked to oil



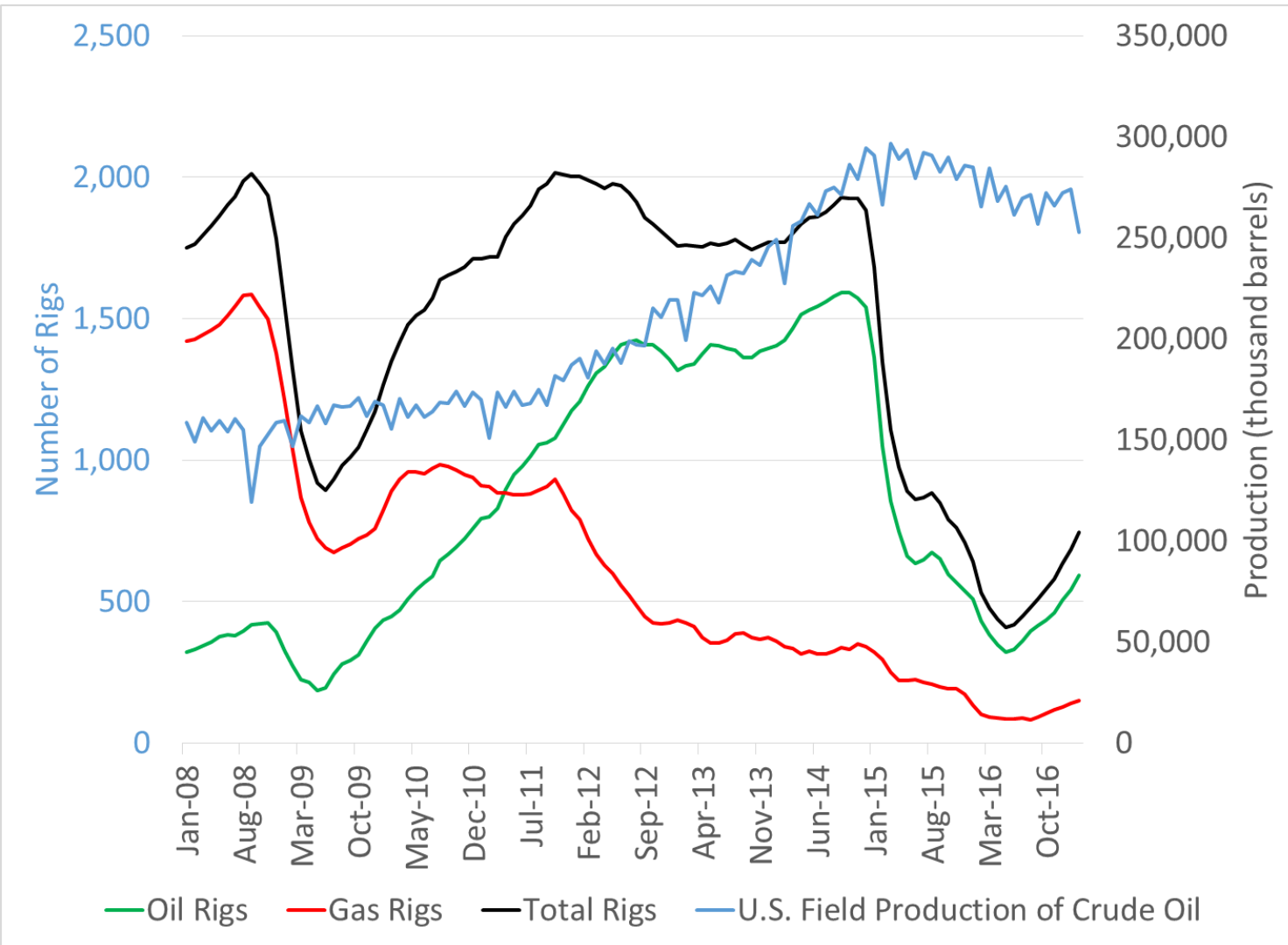
- 2 large GTL facilities planned for LA cancelled
- Limited switching from diesel to LNG/CNG in transportation
- LNG exports “less” attractive...

# Challenges Facing U.S. LNG Exports



- “Low” demand growth (China, India, Japan, and others):
  - Coal, nuclear, renewables have priority - energy security
  - Not enough gas infrastructure (especially storage)
  - Low gas market readiness
  - Sluggish economic growth
  - Japanese energy policy: nuclear, renewables, efficiency
- “Surging” global LNG supply → excess supply until the early 2020s
  - Unsubscribed U.S. liquefaction capacity
  - Parts of contracted volumes not tied to specific destinations

# U.S. Oil and Gas Production Proved Resilient



The rig count does not mean the same as before:

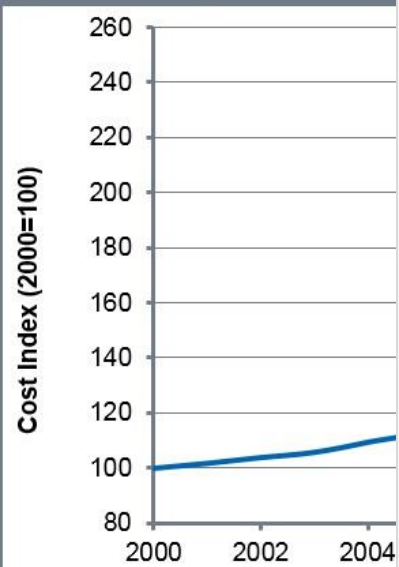
- Cluster drilling: more wells per rig
- Infill drilling:
  - less production per well but also lower cost
  - in areas with proven high productivity
- Focusing on best acreage

D&C and operating costs decreased significantly since 2014

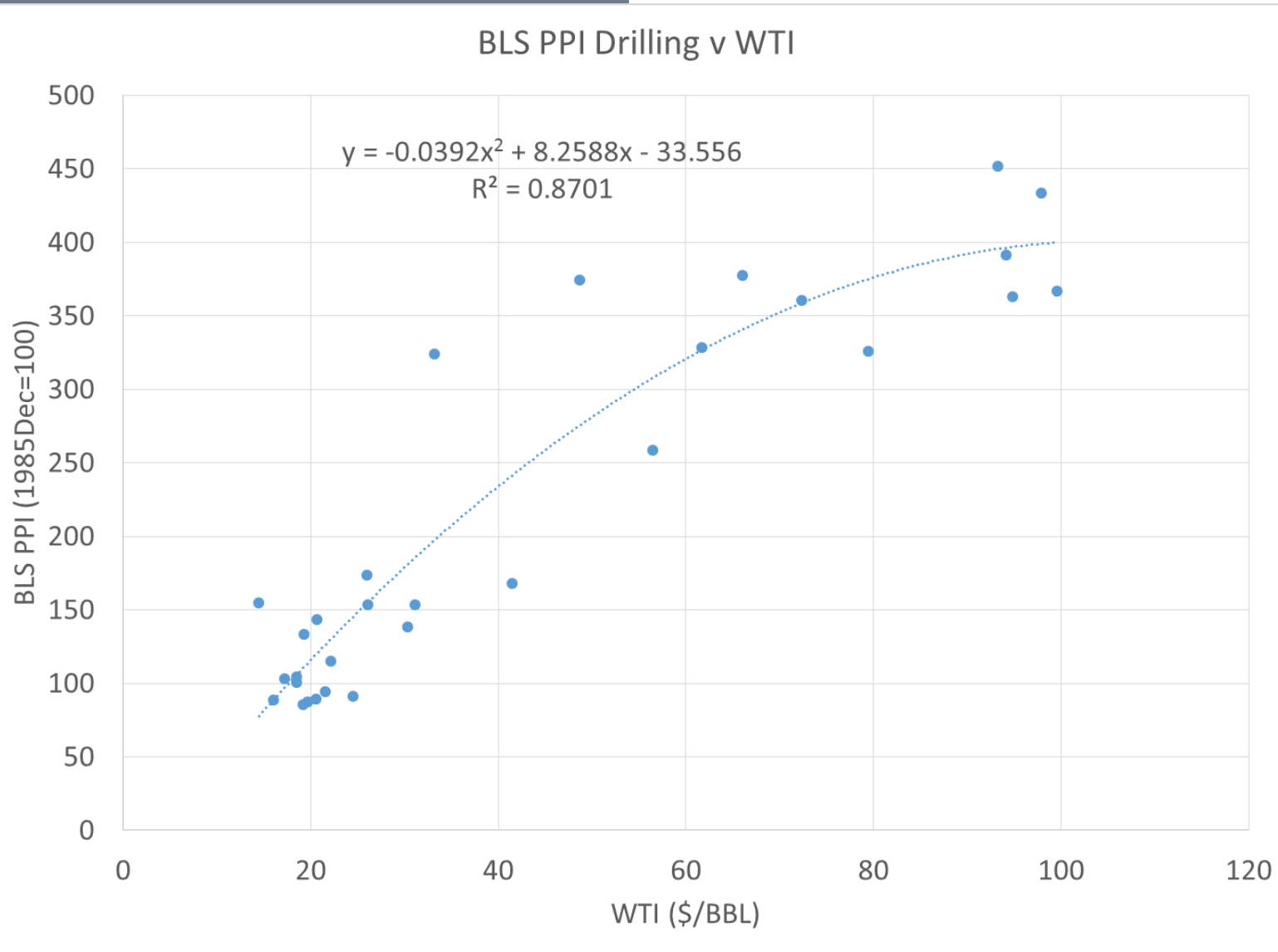
- Sustainable?

# Upstream Costs: Efficiency? Technology? Oil Price?

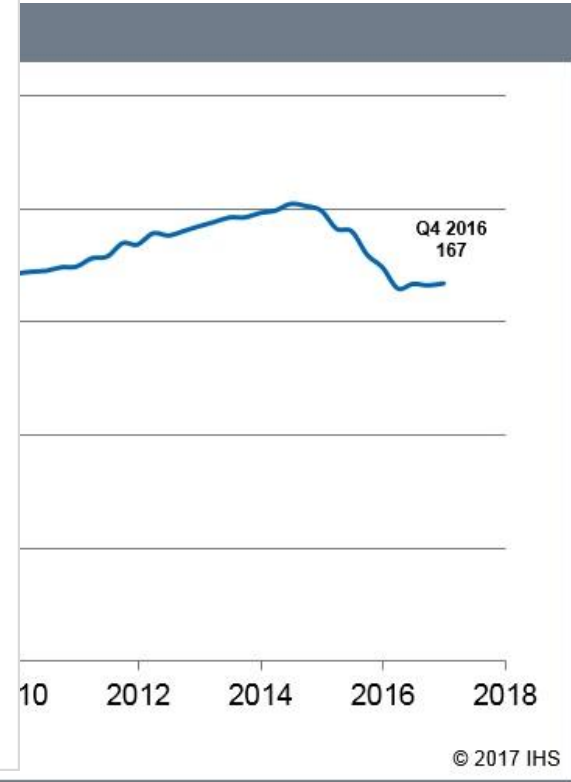
Upstream Capital Cost Index



Source: IHS



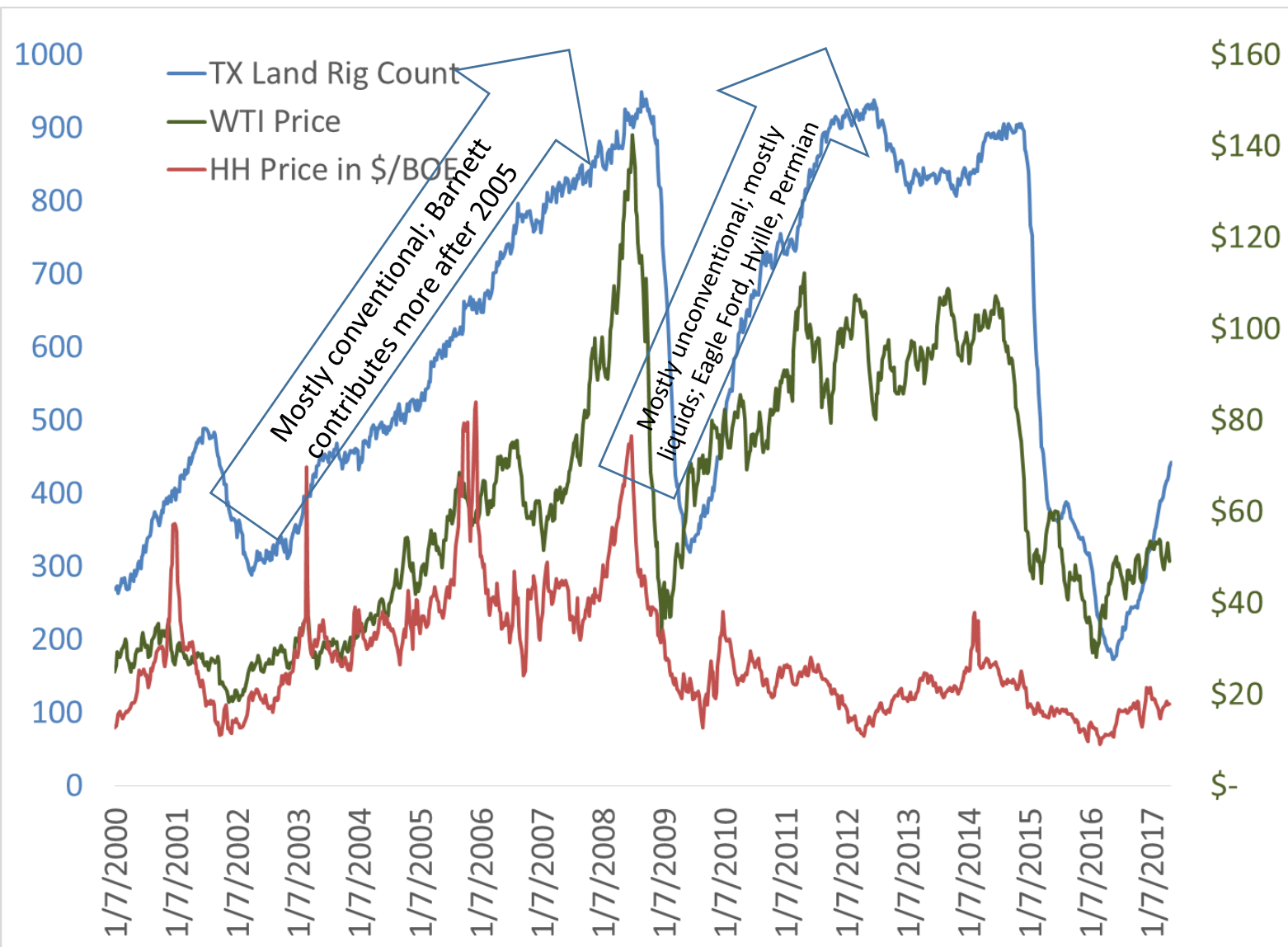
these reductions  
ordinary?



© 2017 IHS



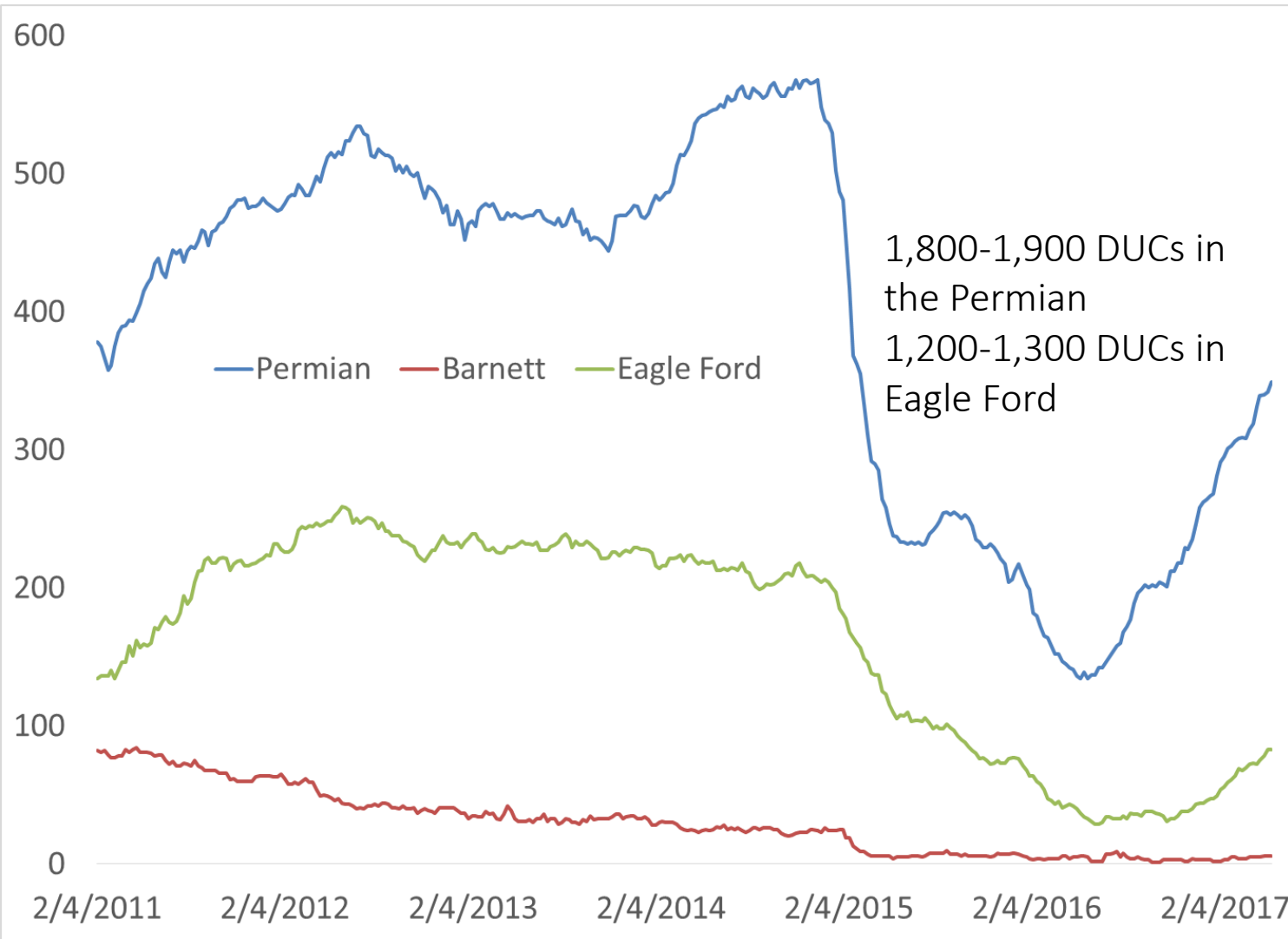
# TX: Rig Count (hence, production) Rebounding Fast



- Drilling is much more responsive to the oil price rather than the natural gas price
- 442 rigs in TX in early May 2017 versus 173 in May 2016 and 949 in August 2008

Source: Baker Hughes rig and EIA price data.

# An oil (primarily, Permian) story!



- Oil and natural gas prices decoupled since the late 2000s
- Oil price recovered some after OPEC announcement in late 2016
- Gas price is still low → gas-directed drilling remains anemic
- NGL prices traditionally linked to oil price; but today they are discounted, especially ethane → “industrial renaissance”

Source: Baker Hughes rig data.

# Summary of TX

Permian: 4-5K per year 2011-14; peak of 560+ rigs in Oct14; hit low of 130 May 2016; today ~350; largest (~60,000 mi<sup>2</sup> in TX) most complex (multiple formations); conventional and unconventional mixed; oil, gas & liquids; long history of drilling; activity to remain strong for years (as long as oil price remains "attractive")

Barnett: >20K wells 1995-now; peak drilling of 2,900+ in 2008 (100+ rigs); today only 5-6 rigs; gas core in Tarrant, Wise, Denton & Johnson; oil/liquids drilling in Montague, Cooke & Wise after 2010; ~8,000 mi<sup>2</sup>; BEG scenarios of 10K to 20K more wells through ~2040

Haynesville (TX): >1,000 wells 2008-now (including Bossier); peak of ~190 in 2011 (~30 rigs); today 37-38 (mostly in LA); San Augustine, Shelby, Nacogdoches, Harrison, Panola, Rusk (~2,000 mi<sup>2</sup> in TX); BEG scenarios for all Haynesville of 5K to 10K more wells through ~2045

Midstream: pipelines for crude, liquids and natural gas; processing; fractionation. Long-distance pipelines to Gulf Coast from Permian, Marcellus and Cushing; gas export pipelines to Mexico.

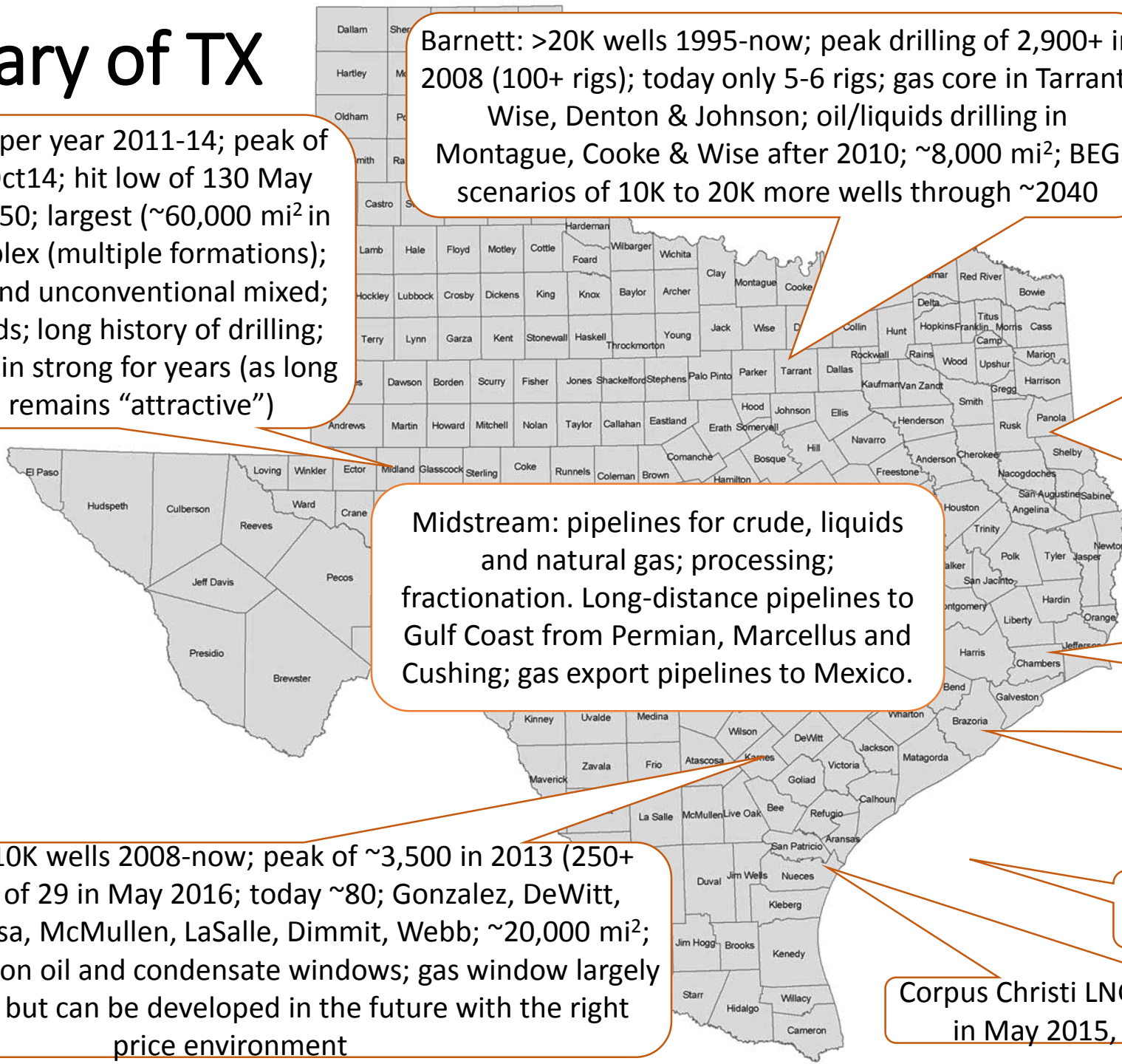
Downstream: 22 projects 2017-22, \$29 billion; possibly 4 more, additional \$7 billion

Freeport LNG (3 trains, 13.2 MTPA): construction started Nov14; first shipment from the first train in late 2018; trains 2 and 3 estimated in 2019

Several LPG, condensate and ethane export projects along the coast

Corpus Christi LNG: FID on 2 trains (4.5 MTPA each) in May 2015, production expected in 2018.

Eagle Ford: >10K wells 2008-now; peak of ~3,500 in 2013 (250+ rigs); hit low of 29 in May 2016; today ~80; Gonzalez, DeWitt, Karnes, Atascosa, McMullen, LaSalle, Dimmit, Webb; ~20,000 mi<sup>2</sup>; mostly focused on oil and condensate windows; gas window largely undeveloped but can be developed in the future with the right price environment



# Oil & Gas Price Scenarios through 2030\*

Low oil (\$50-60), low gas (\$3-4)	Low oil (\$50-60), high gas (\$4-\$5)	High oil (\$60-90), high gas (\$4-6)
<ul style="list-style-type: none"> <li>• OPEC/others fail to maintain production cuts</li> <li>• U.S. unconventional D&amp;C costs remain low               <ul style="list-style-type: none"> <li>• Technological improvements</li> <li>• Operational improvements</li> <li>• Low oil price</li> </ul> </li> <li>• Global oil demand slow to grow               <ul style="list-style-type: none"> <li>• Weak macroeconomics (China+)</li> <li>• Alternatives</li> <li>• Efficiency gains</li> </ul> </li> <li>• Gas demand slow to grow in the U.S.               <ul style="list-style-type: none"> <li>• Renewables, efficiency</li> <li>• Saving nuclear, coal units</li> <li>• Stagnant load growth</li> <li>• Limits to industrial renaissance</li> </ul> </li> <li>• LNG exports slow to grow               <ul style="list-style-type: none"> <li>• Too much liquefaction capacity globally</li> <li>• Global gas demand slow to grow</li> </ul> </li> <li>• Pipeline exports to MX grow as expected</li> </ul>	<ul style="list-style-type: none"> <li>• OPEC/others fail to maintain production cuts</li> <li>• U.S. unconventional D&amp;C costs recover some               <ul style="list-style-type: none"> <li>• Increasing cost of frac sand, rig rates</li> </ul> </li> <li>• Global oil demand slow to grow               <ul style="list-style-type: none"> <li>• Weak macroeconomics (China+)</li> <li>• Alternatives</li> <li>• Efficiency gains</li> </ul> </li> <li>• Strong gas demand growth in the U.S.               <ul style="list-style-type: none"> <li>• Slowing penetration of renewables</li> <li>• Coal &amp; nuclear retirements</li> <li>• Second wave of industrial renaissance</li> </ul> </li> <li>• LNG exports grow stronger               <ul style="list-style-type: none"> <li>• Global gas demand grows faster</li> </ul> </li> <li>• Pipeline exports to MX grow stronger</li> <li>• Low oil price &amp; cost increase → less associated gas → need higher gas price to drill for dry gas</li> </ul>	<ul style="list-style-type: none"> <li>• OPEC/others maintain production cuts</li> <li>• “Lasting” crises in Nigeria, Venezuela, Libya, Iraq, and/or Iran (not an exclusive list)</li> <li>• U.S. unconventional D&amp;C costs recover strongly               <ul style="list-style-type: none"> <li>• Increasing cost of frac sand, rig rates</li> <li>• High oil price</li> <li>• Depleting best geology</li> </ul> </li> <li>• Global oil demand grows stronger               <ul style="list-style-type: none"> <li>• China and others recover</li> <li>• Limited penetration by alternatives</li> <li>• Limited efficiency gains</li> </ul> </li> <li>• Strong gas demand growth in the U.S.               <ul style="list-style-type: none"> <li>• Slowing penetration of renewables</li> <li>• Coal &amp; nuclear retirements</li> <li>• Second wave of industrial renaissance</li> </ul> </li> <li>• LNG exports grow stronger               <ul style="list-style-type: none"> <li>• Global gas demand grows fast</li> </ul> </li> <li>• Pipeline exports to MX grow stronger</li> <li>• Higher cost, higher gas demand → higher gas price</li> </ul>

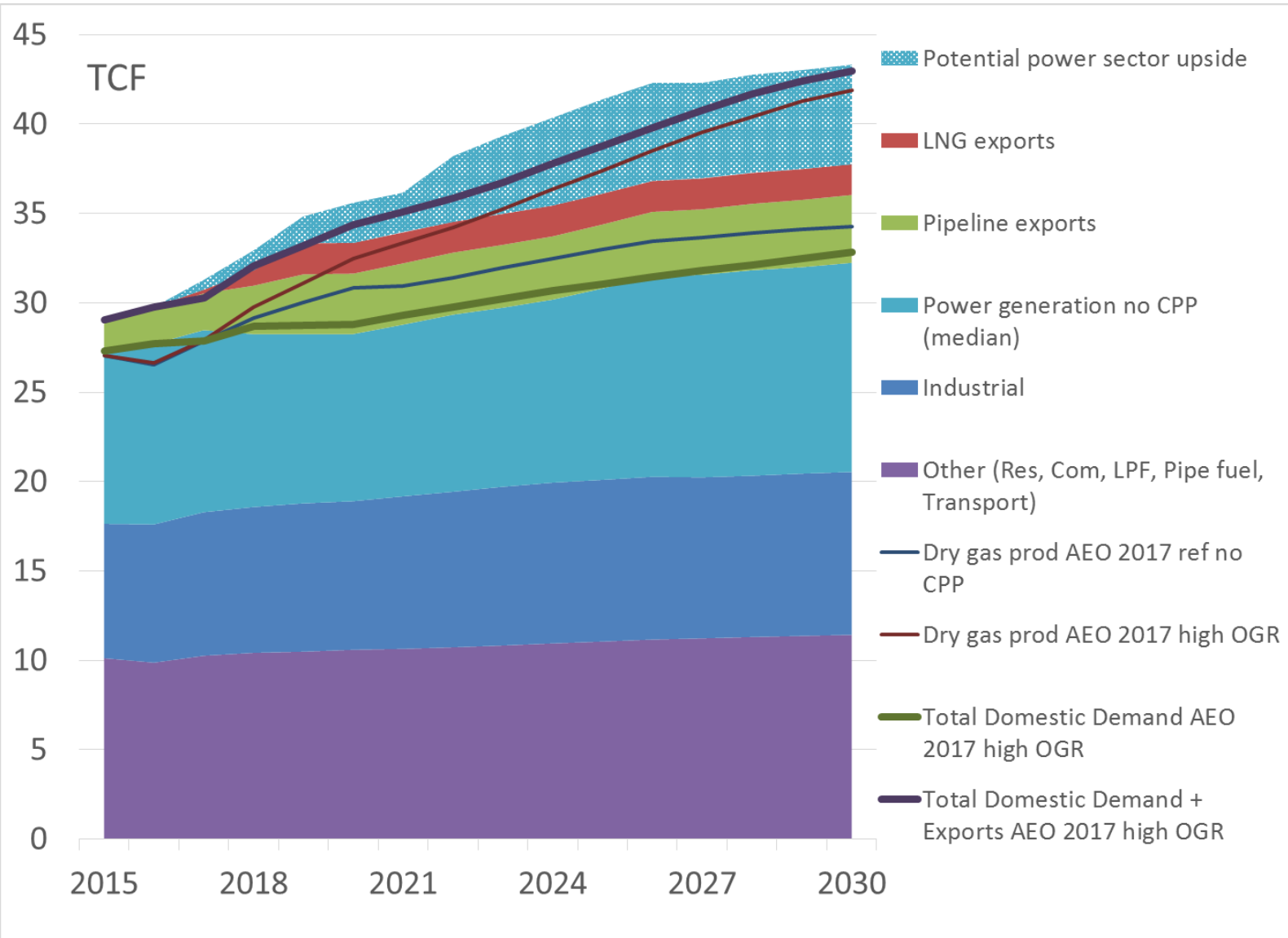
\*Assume cyclicity; price movements above and below these ranges are likely. For example, 2020-25 may see oil price collapse if oil price recovers soon.

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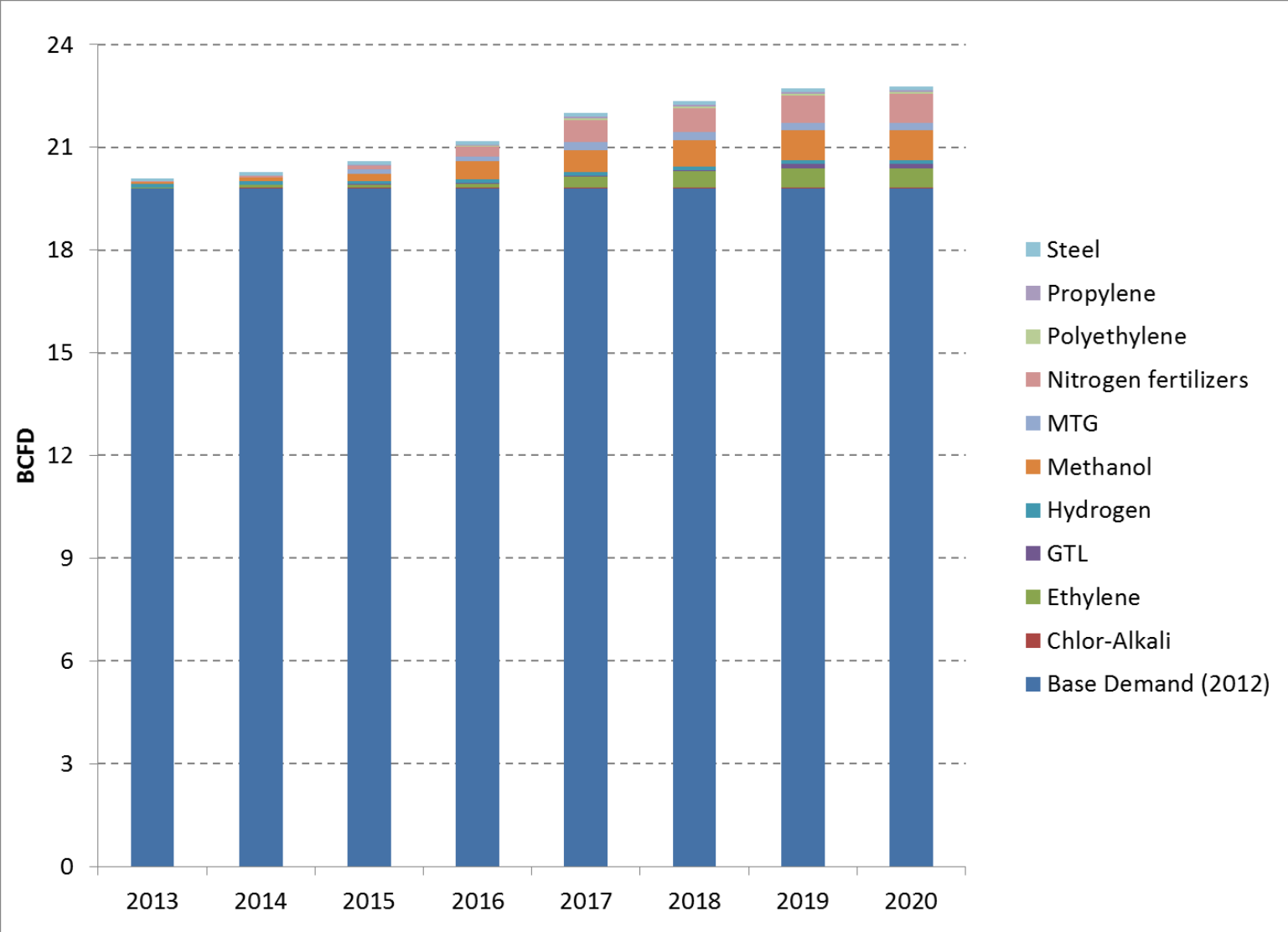
[gurcan.gulen@beg.utexas.edu](mailto:gurcan.gulen@beg.utexas.edu)  
[www.beg.utexas.edu/energyecon](http://www.beg.utexas.edu/energyecon)

# A Strong “Gas Demand Stack” Scenario v EIA AEO 2017

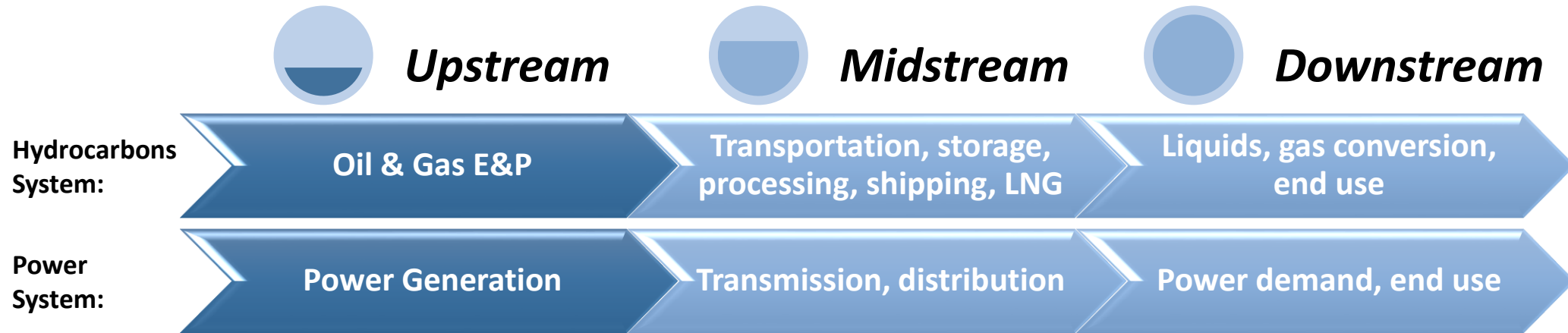


- Two largest uncertainties: Power generation and LNG exports
- Potential drivers:
  - Price of natural gas
  - Renewables generation
    - Declining costs
    - Federal subsidies?
  - Coal retirements
    - Env’l regulations?
  - Nuclear retirements
    - Aging fleet, rising costs, state subsidies
  - CO<sub>2</sub> prices
  - Load growth
    - EE, DER, DR

# CEE Industrial Projects Database - About 100 Projects; Incremental NG demand of ~3 BCFD



# Our Portfolio and Examples



- U.S. producer cost benchmarking
- CEE/World Bank NOCs
- BEG Sloan Foundation shale resource assessments
- Upstream regimes, HC sector governance (Shell; USAID; DOS-ENR)
- CO<sub>2</sub>-EOR, carbon capture (BEG/GCCC, Texas FutureGen)
- Oil price drivers (USEIA)

- Natural gas studies (OIES)
- LNG public knowledge base and economic, community benefits (Industry Donors)
- Midstream, MLP review (BEG STARR)
- ERCOT/US power dispatch scenarios (BEG STARR, Industry Donors)

- Natural gas market for petrochemicals (MHTL)
- Industrial gas demand project inventory (BEG STARR)
- Texas renewables (State Energy Conservation Office)
- CEE gas demand stack (BEG STARR)

*NOC=national oil company; GCCC=Gulf Coast Carbon Center; OIES=Oxford Institute for Energy Studies; STARR=State of Texas Advanced Resource Recovery Program; MLP=master limited partnership; MHTL=Methanol Holdings of Trinidad and Tobago Ltd.*