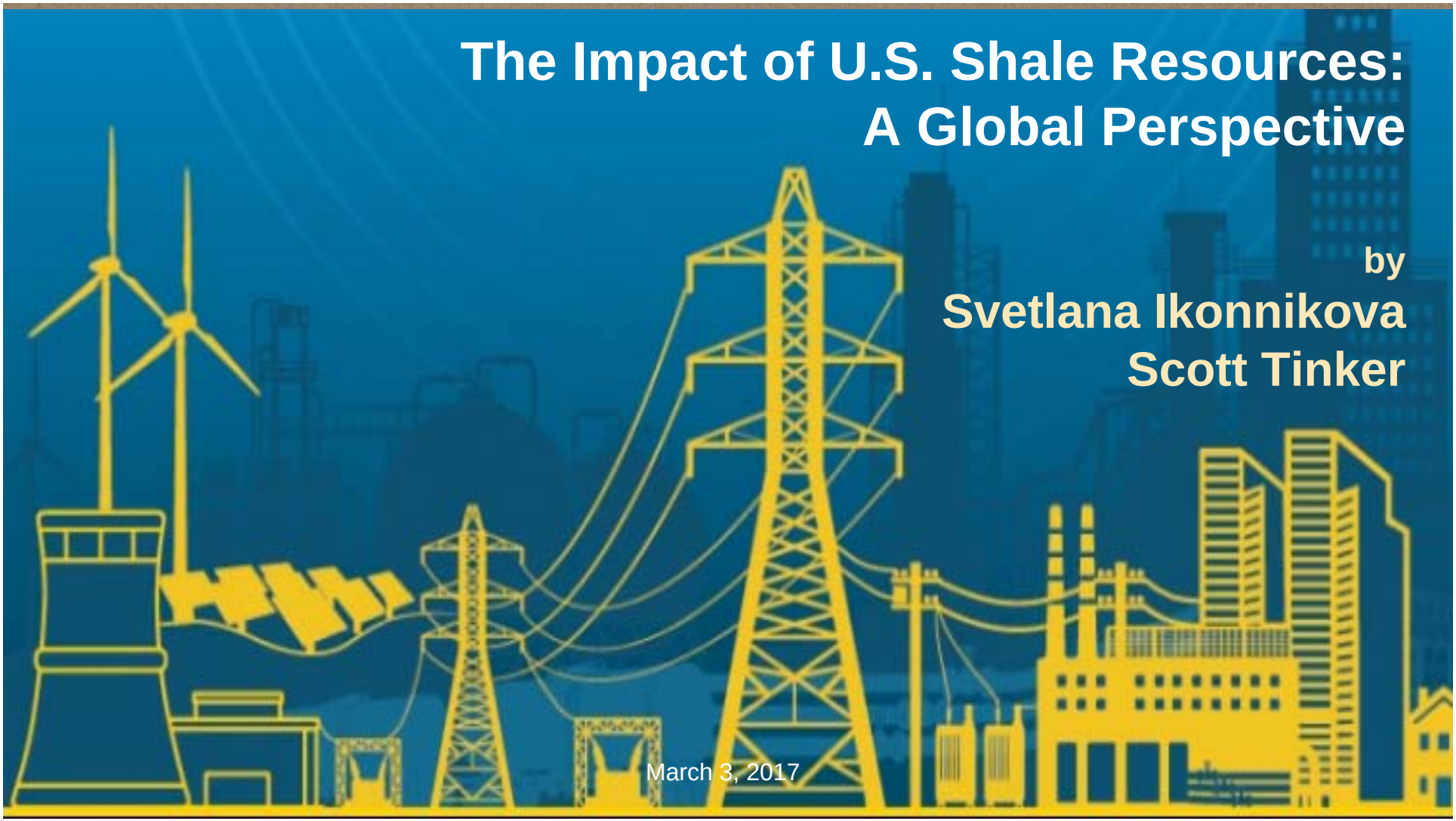
The Impact of U.S. Shale Resources: A Global Perspective



by
Svetlana Ikonnikova
Scott Tinker

March 3, 2017

Outline

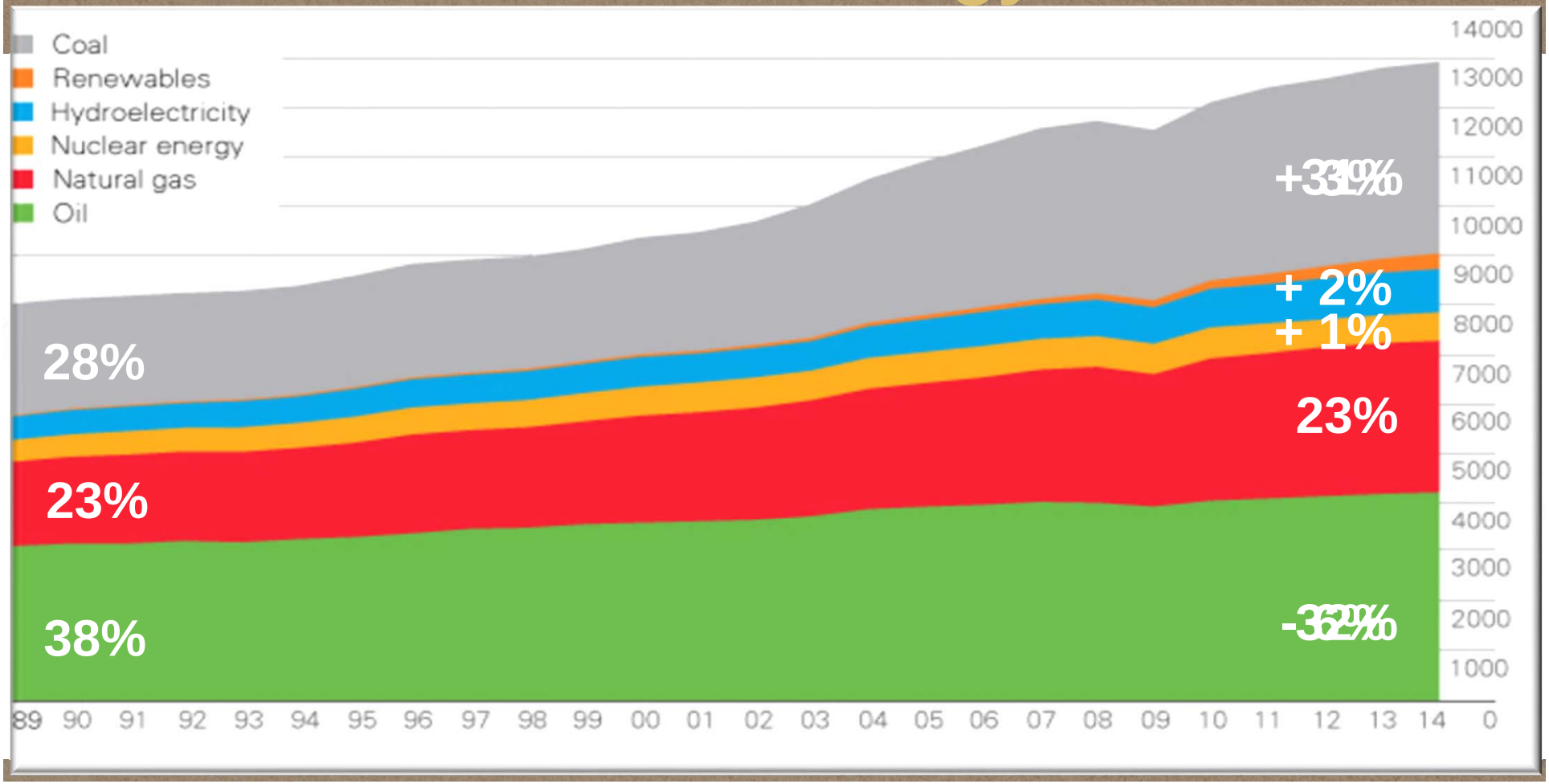
- Global Perspective
- U.S. Shale Resource Studies
- Implications

2017

Energy Security

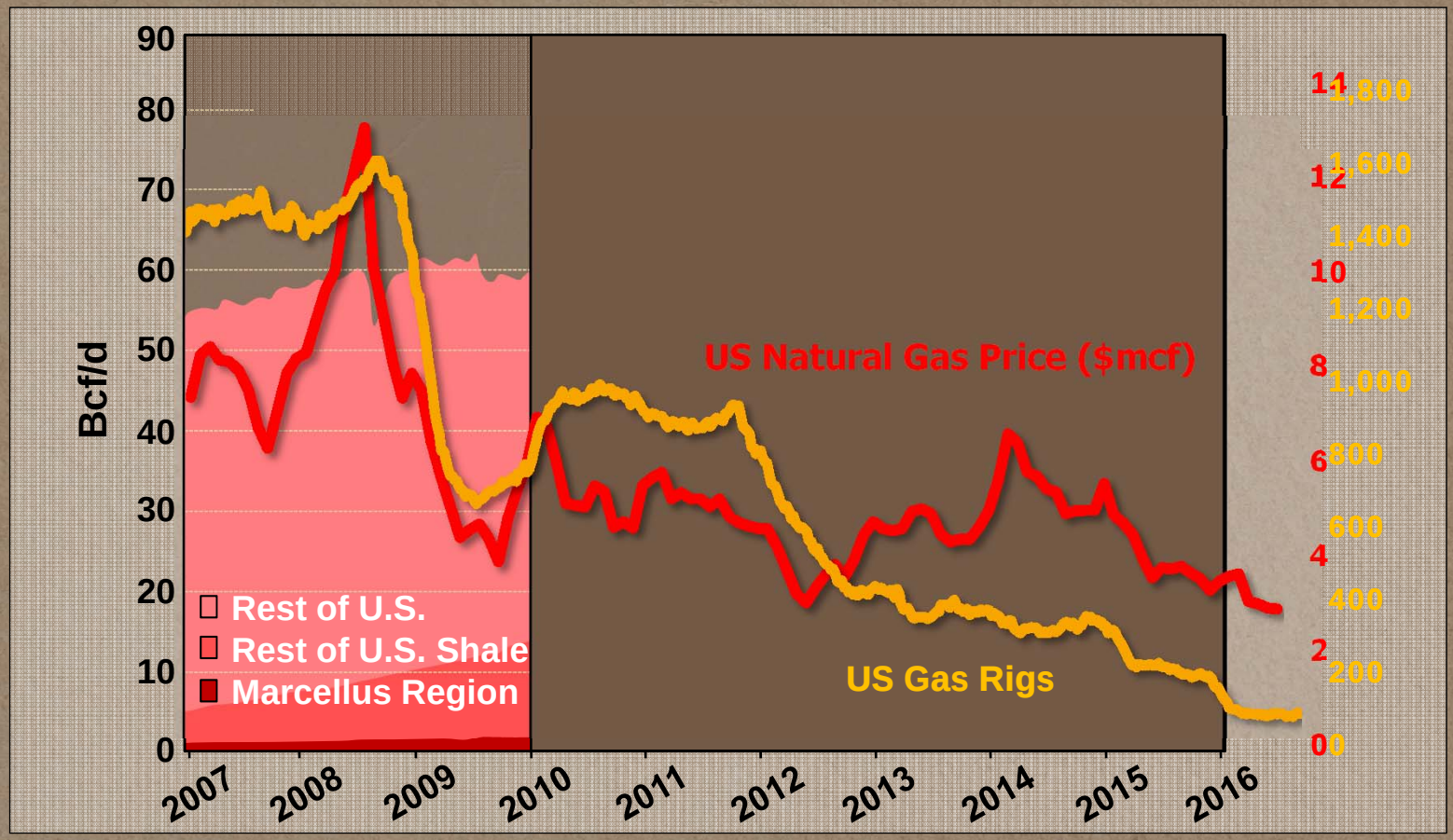
Affordable	**Cost: per unit of energy**
	Price Volatility: stable or fluctuating
	Infrastructure: cost to build the plant
Available	**Access: substantial resources**
Reliable	**Intermittent: source consistent or variable**
	Safe: natural/human causes
Sustainable	**Clean: air and atmospheric emissions**
	Dense: energy per area, weight and volume
	Dry: fresh water use/risk

The Global Energy Mix



2016

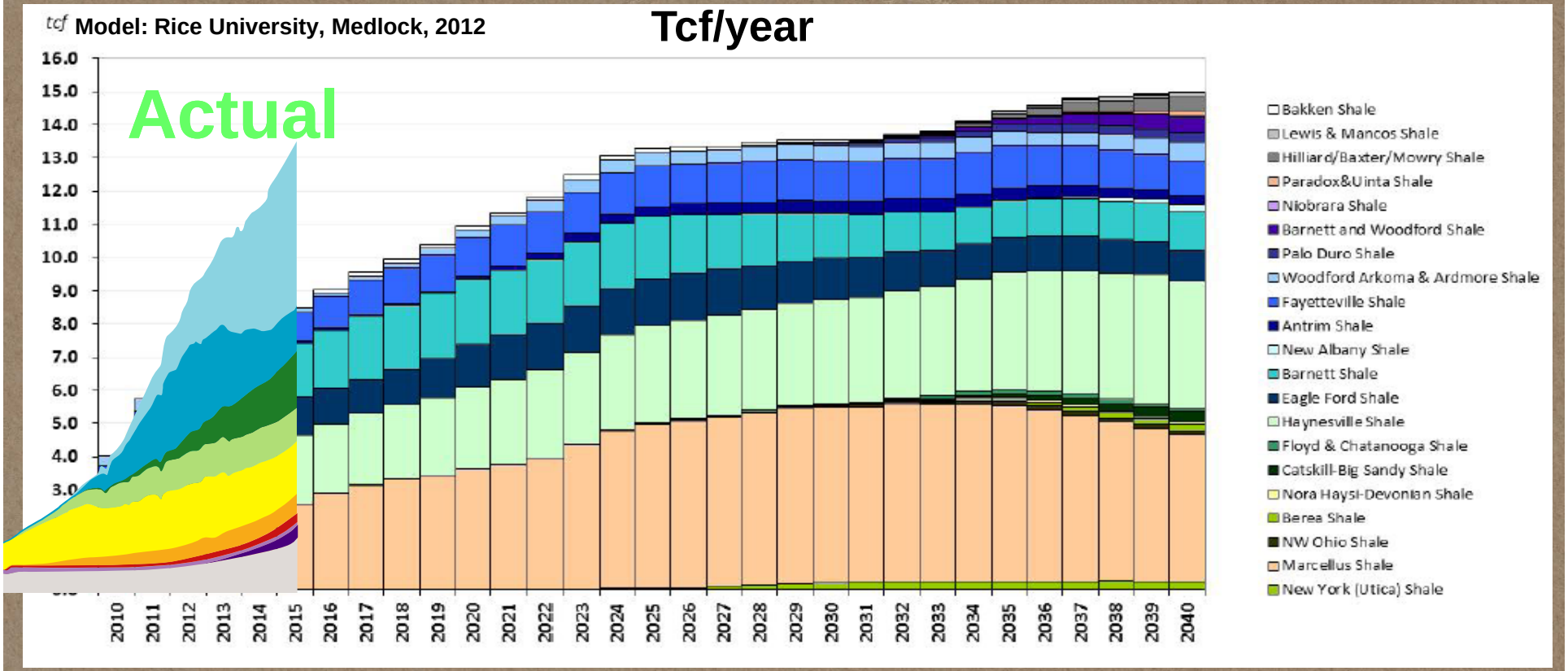
U.S. Marketed Natural Gas Production



Source:
U.S. Energy Information Administration
Drilling Productivity Report regions, *Petroleum Supply Monthly*, *Natural Gas Monthly*

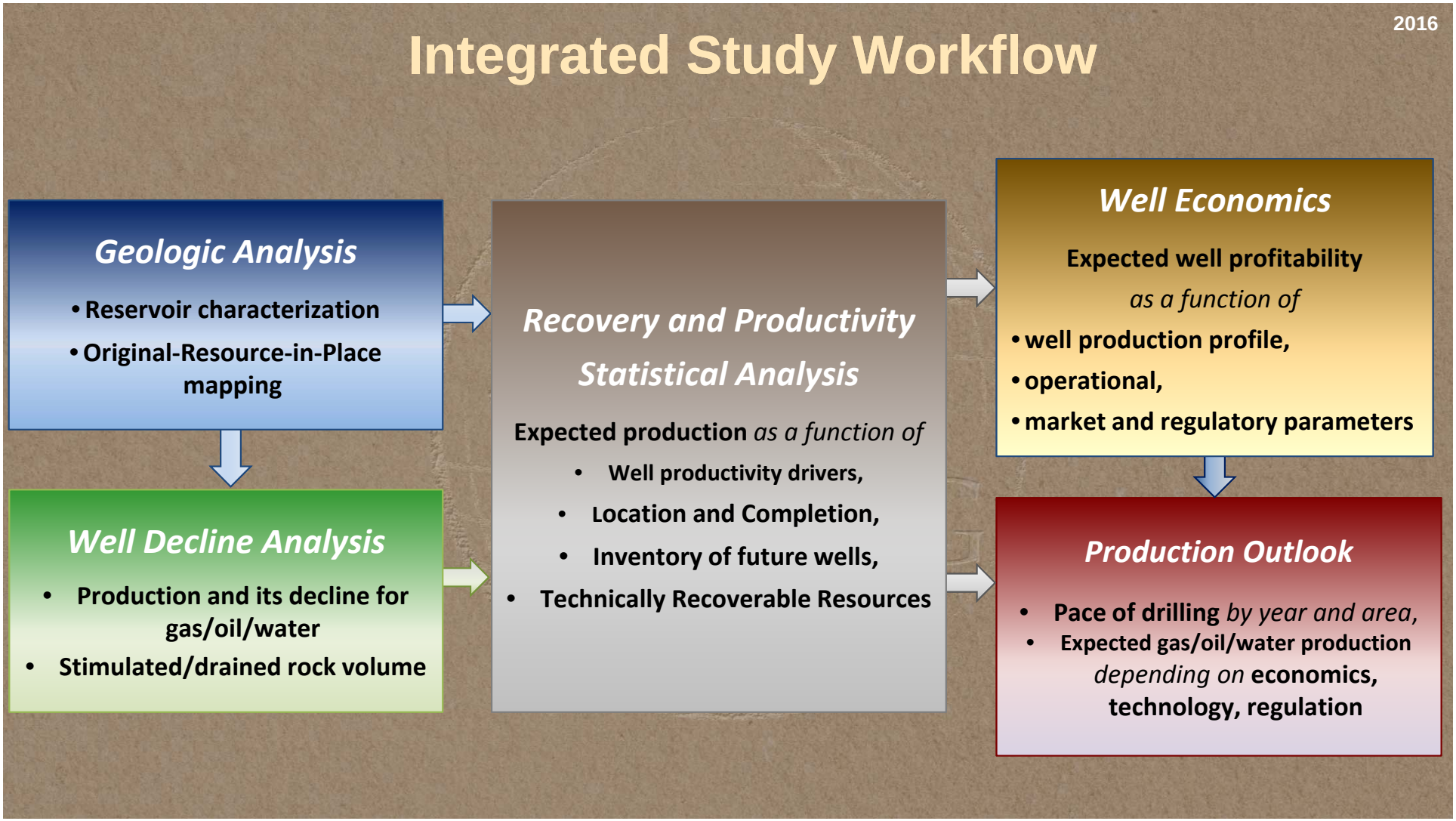
QAe4666

U.S. Natural Gas Forecast vs. Actual



2016

Integrated Study Workflow



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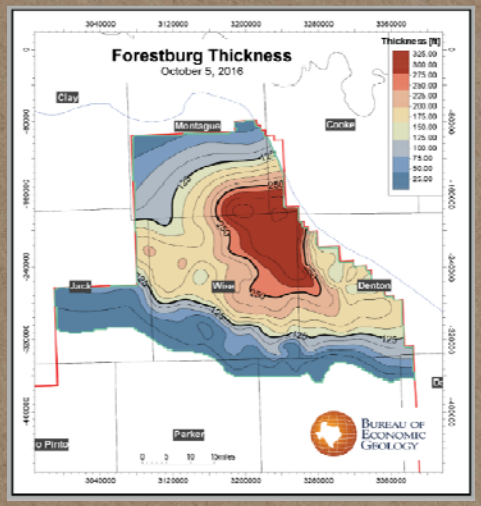
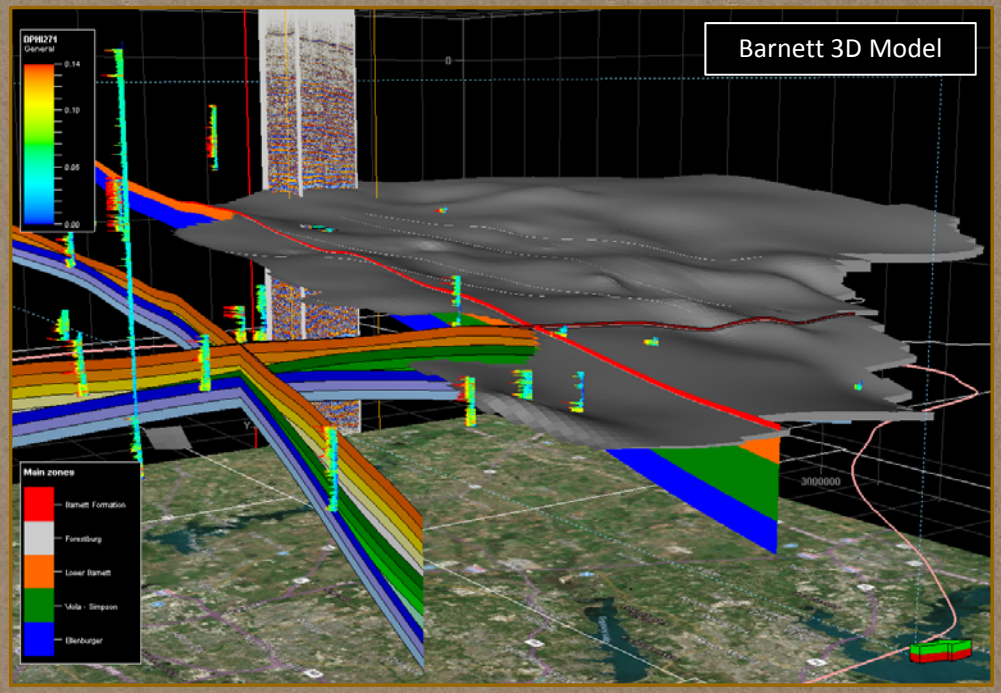
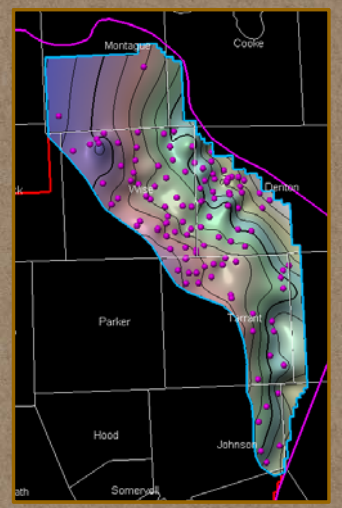
Frac Barrier Zones



Forestburg Isochore





Viola-Simpson Isochore

Phi H Interval

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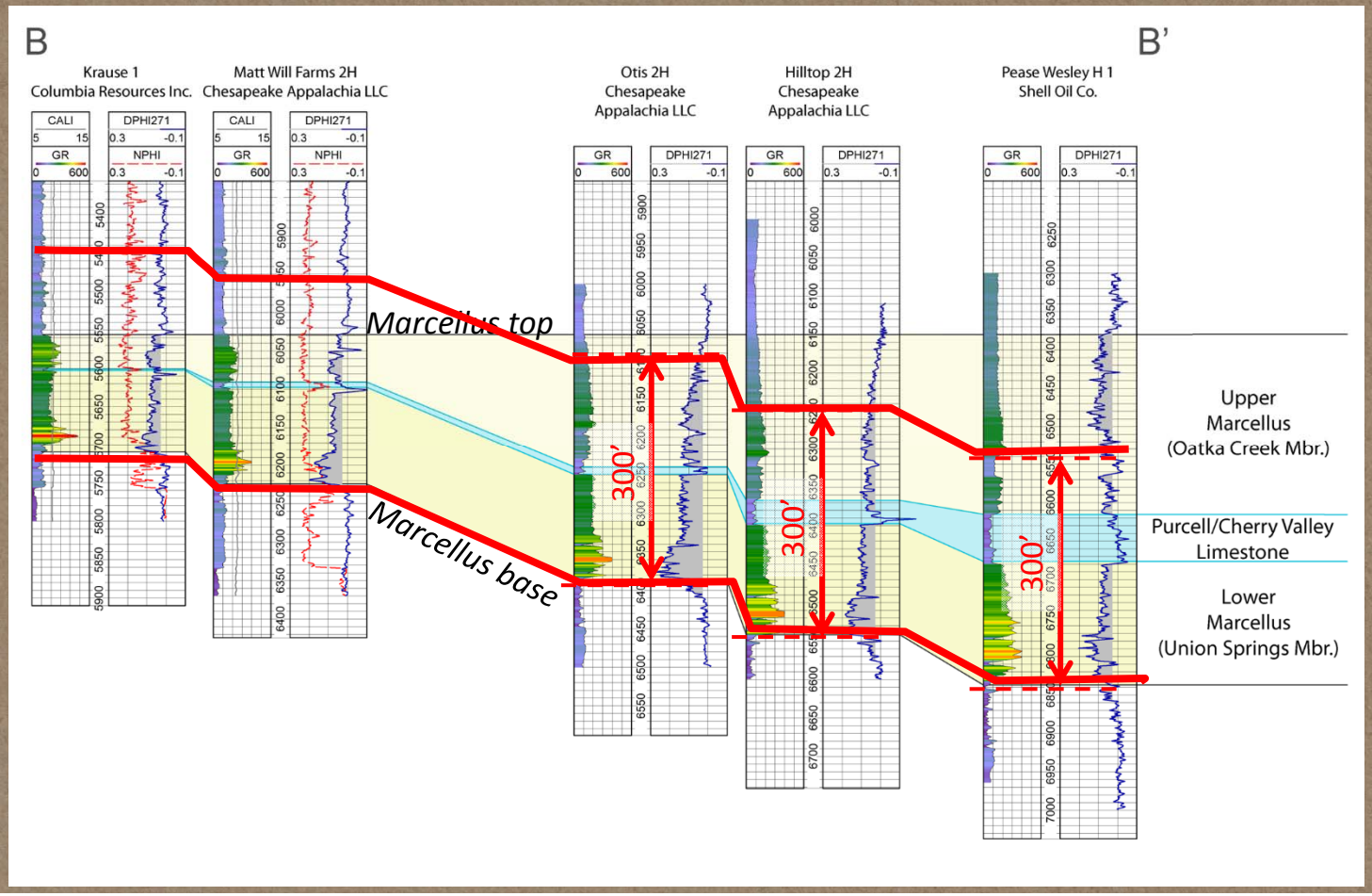

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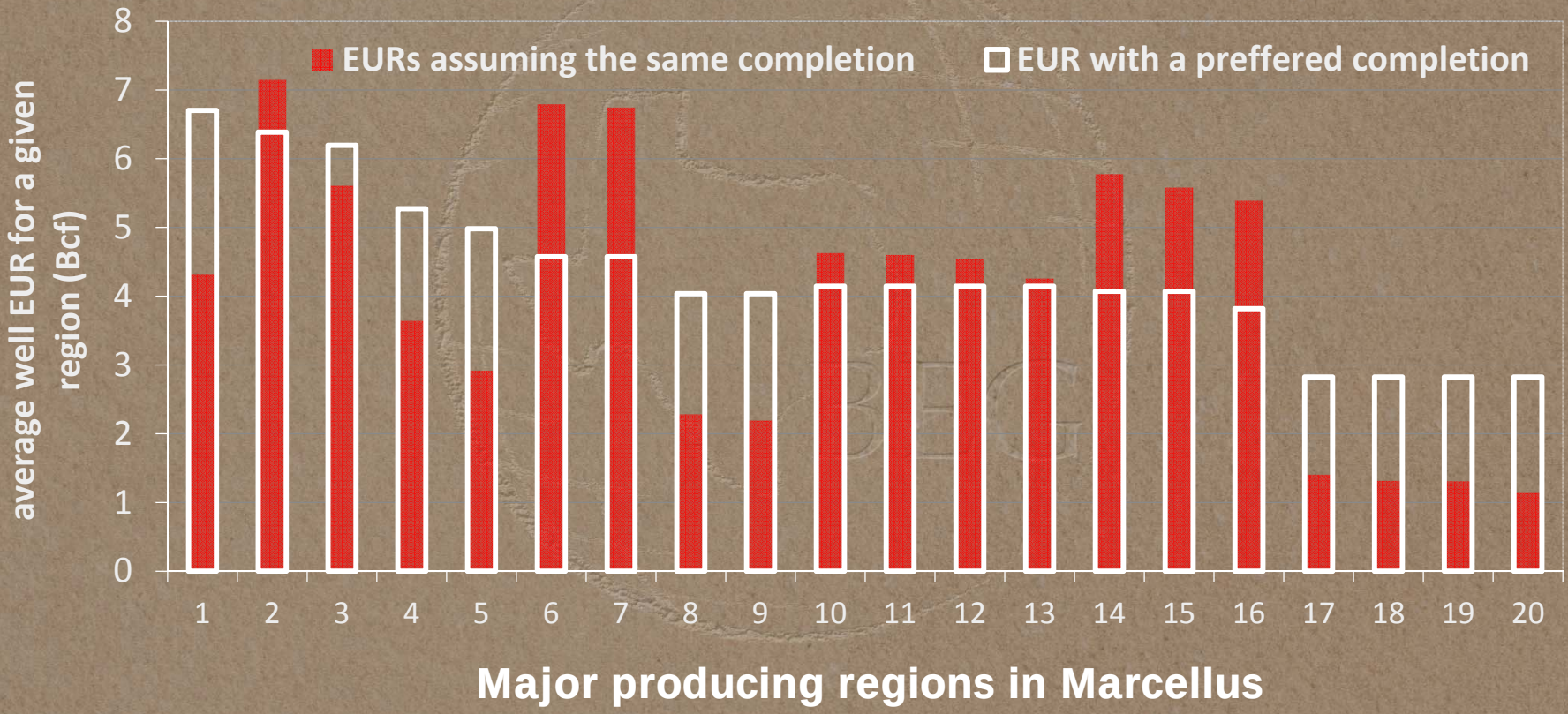
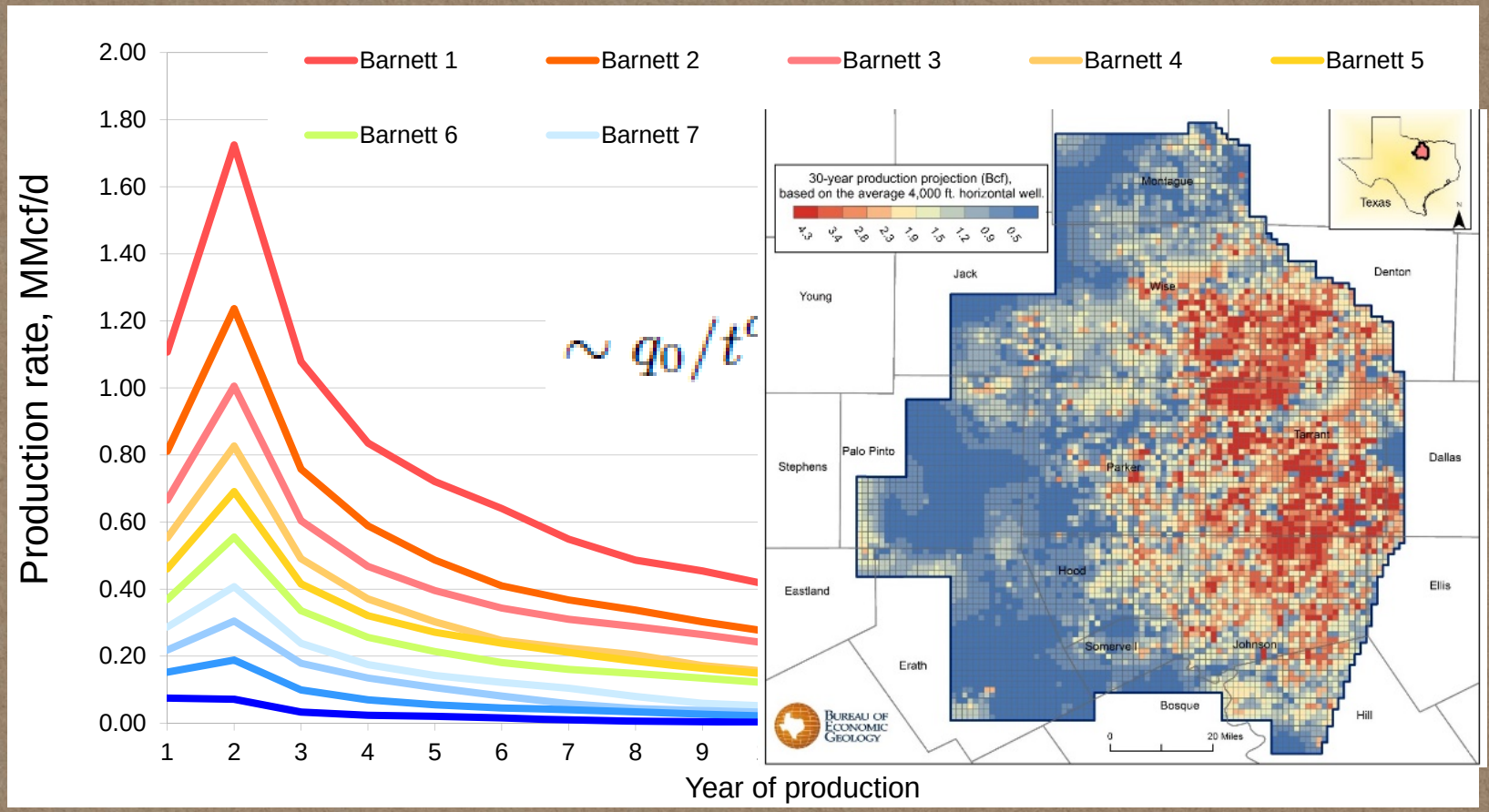
Effect of Completions of Expected Recovery



Production Profiles by Tier

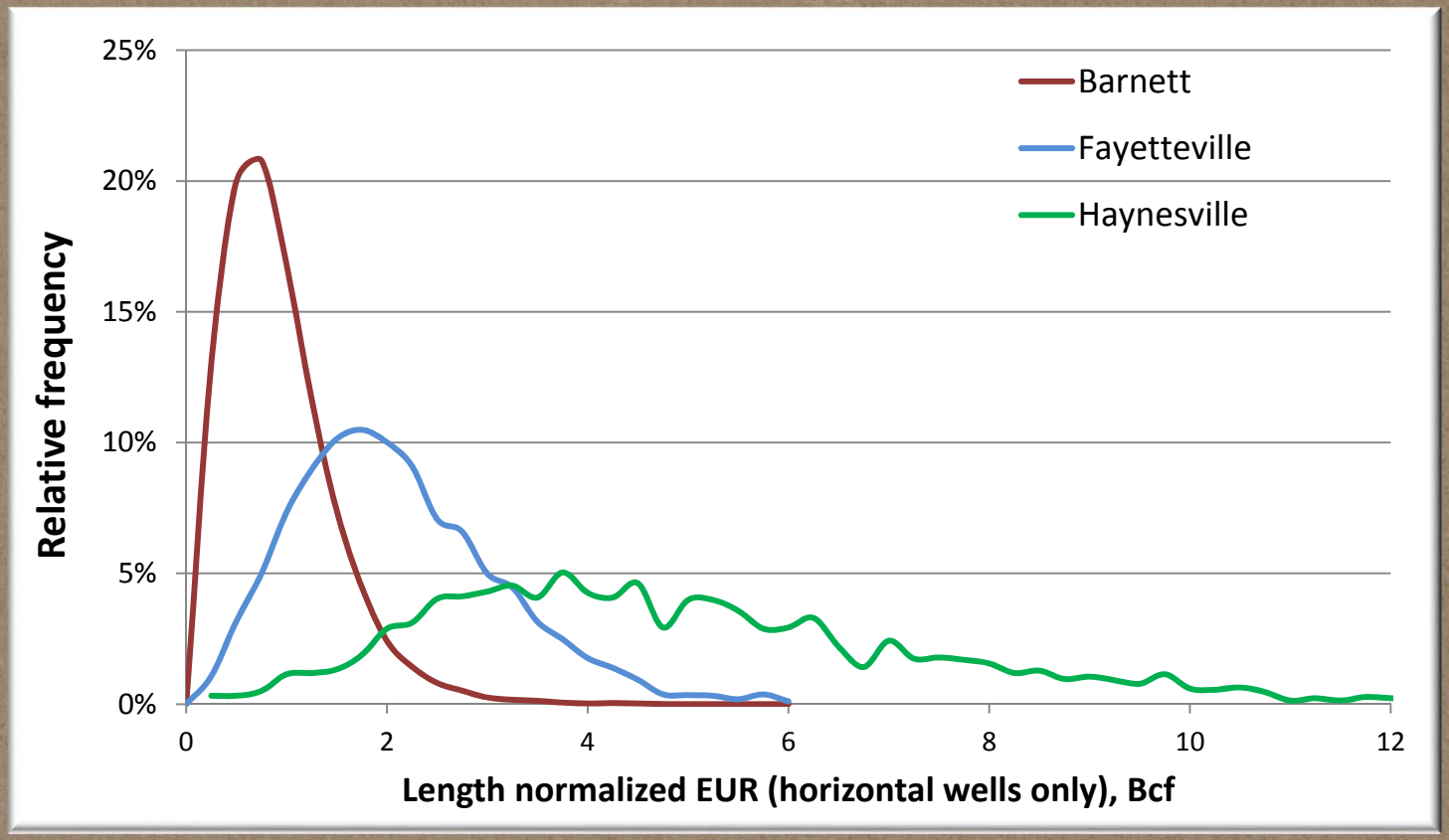
Ikonnikova 2016



BEG Shale Reserves and Production Team

Ikonnikova 2016

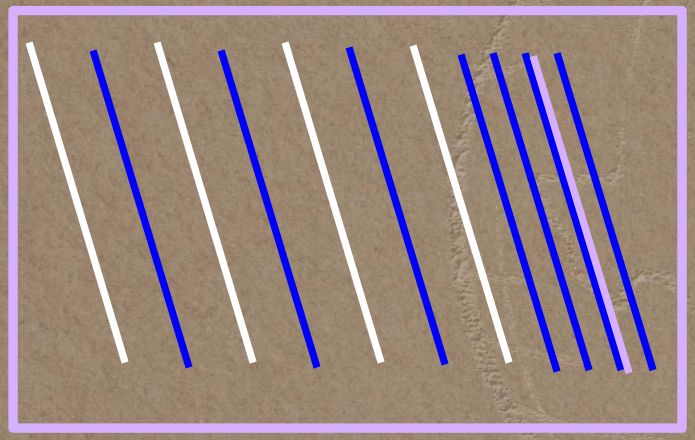
Distributions of Individual Well Recovery



Ikonnikova et al., 2015

New Completion Strategies

Ikonnikova et al., 2016



- Established drilling patterns rapidly change owing to resource exhaustion, technological advances and new economic realm
- New drilling and completion techniques also affect the use of other resources, i.e. water, land, proppants

Practices like infill drilling and cluster drilling already change our views on the future play recovery and aggregate production possibilities.

New Features

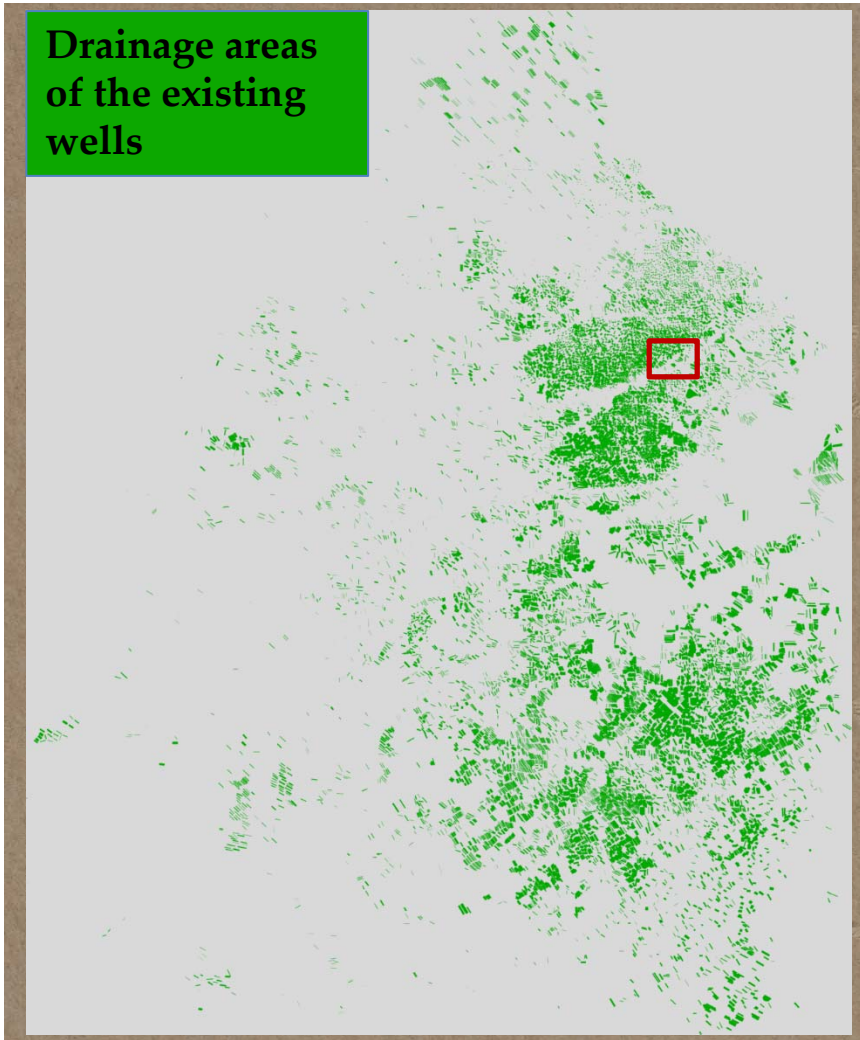
Well economics in the past was very sensitive to D&C costs in particular, so operators get smarter about

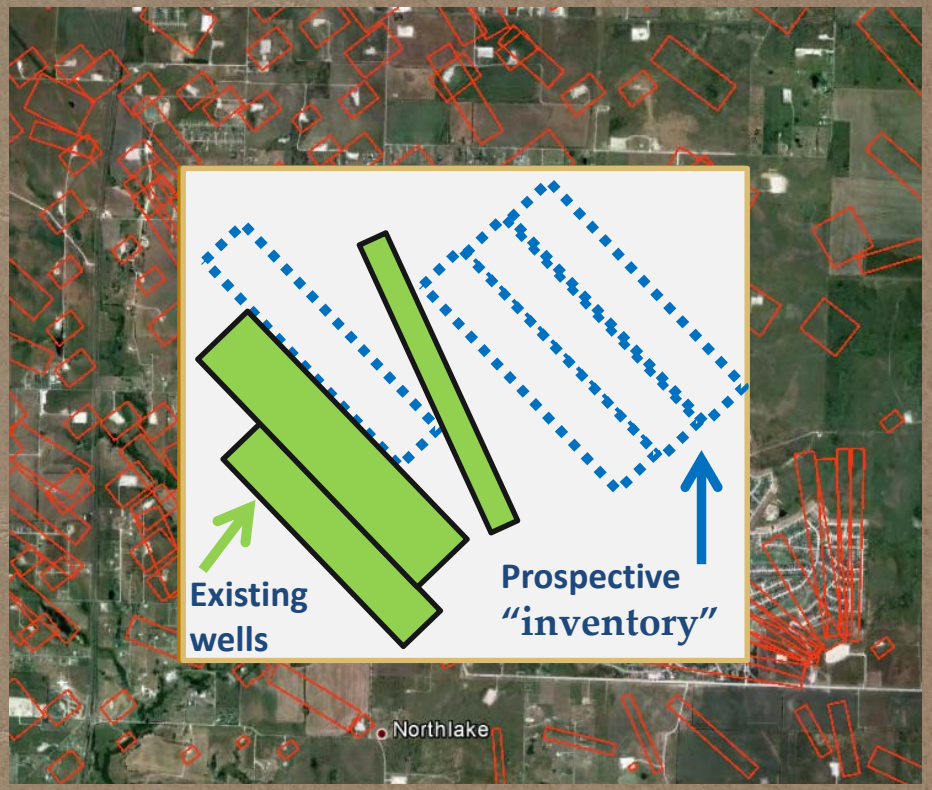
- **Energy prices: Futures Strips / Hedging,**
- **Economies of scale with a multi-well pads and joint leases,**
- **Gathering & transportation costs: develop more efficient solutions,**
- **Water demand and processing of produced water**

2016

Inventory of Future Wells

Drainage areas of the existing wells





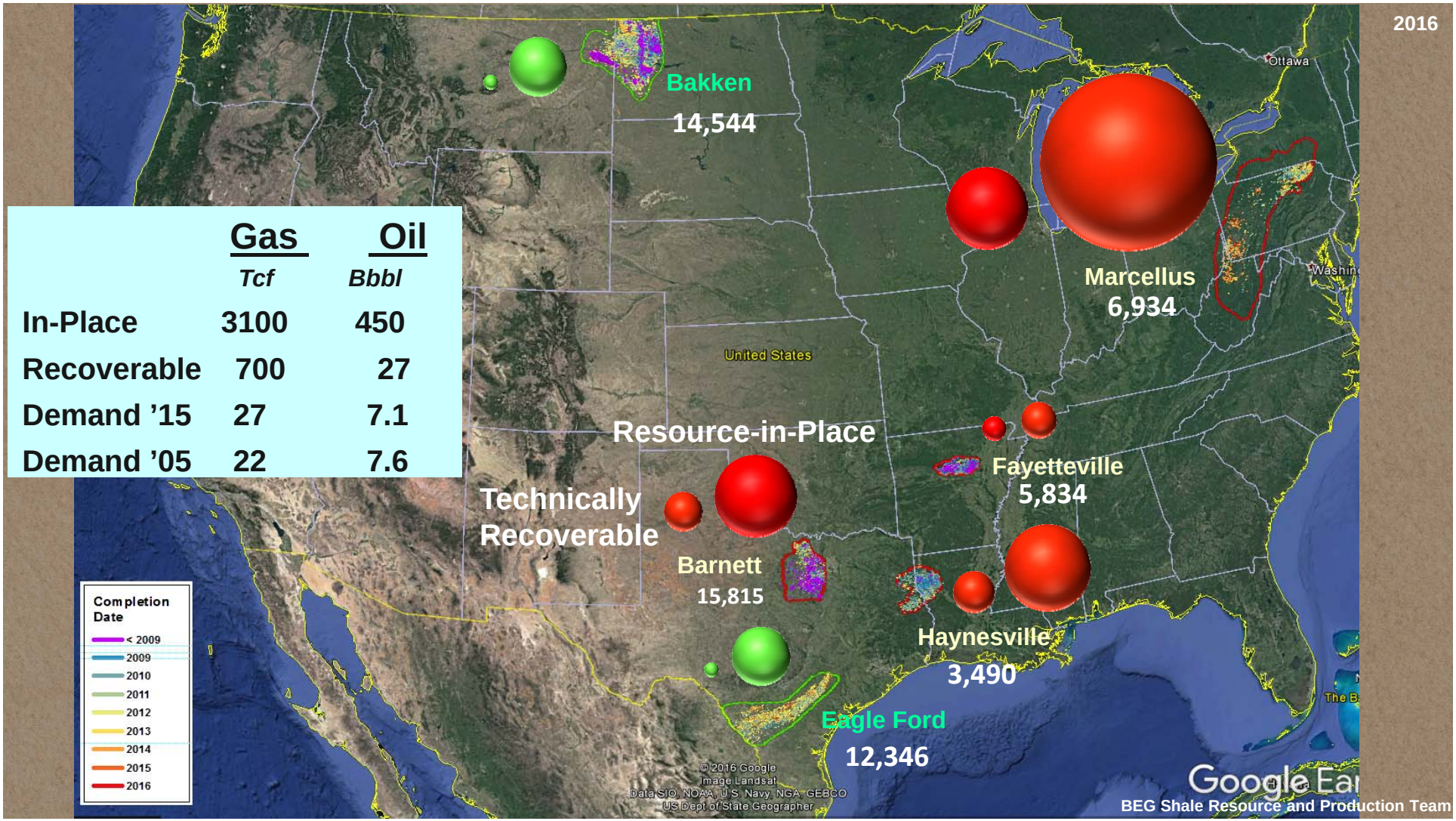

2016
Bakken
14,544
Marcellus
6,934
Resource-in-Place
Technically Recoverable
Barnett
15,815
Fayetteville
5,834
Haynesville
3,490
Eagle Ford
12,346
Gas Tcf
Oil Bbbl
In-Place 3100 450
Recoverable 700 27
Demand '15 27 7.1
Demand '05 22 7.6
Completion Date
< 2009
2009
2010
2011
2012
2013
2014
2015
2016
Ottawa
United States
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Image Landsat
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
US Dept of State Geographer
Google Ear
BEG Shale Resource and Production Team

2016

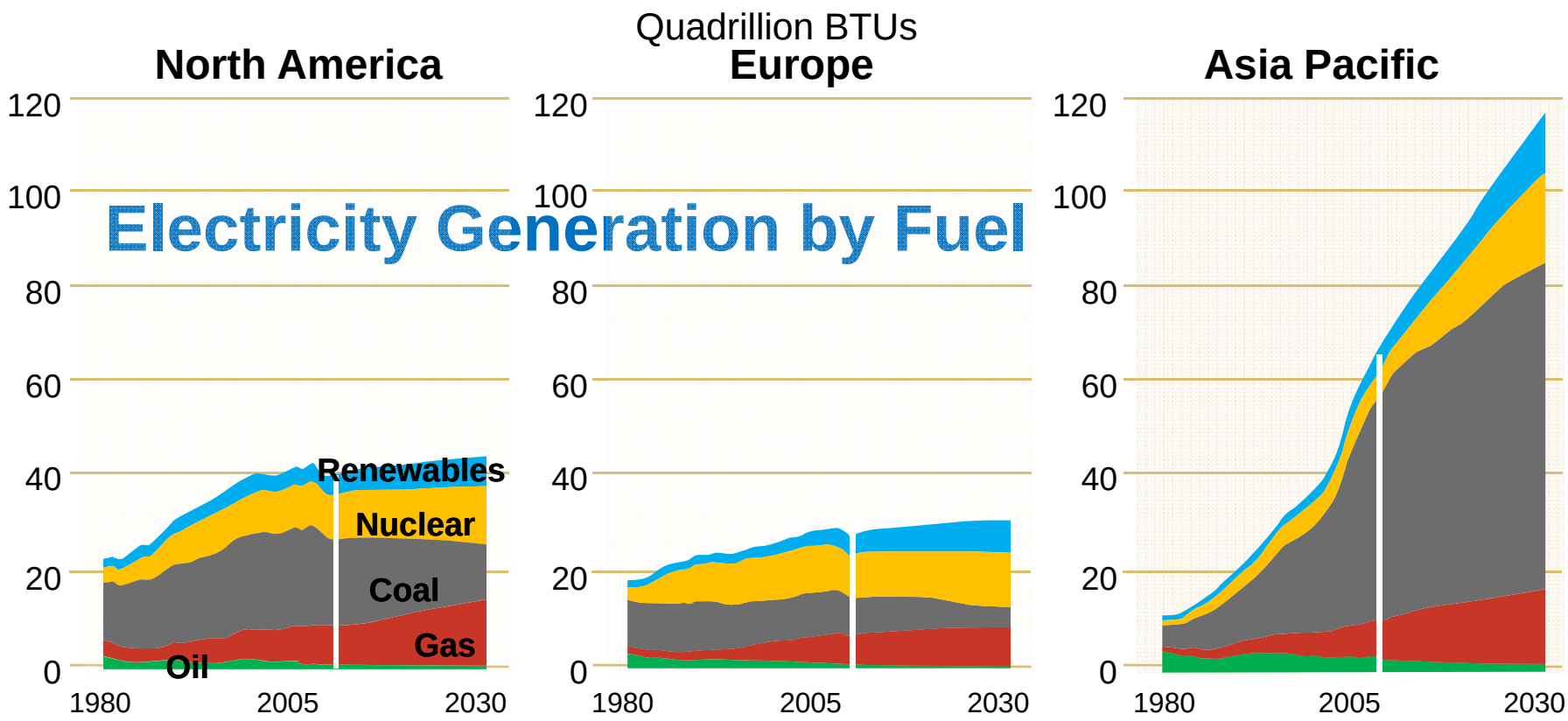
From the Past into the Future
New Advances

- **Improved geologic resource characterization and assessment:**
  - ⇒ **Higher fracturing efficiency: greater energy return on water and proppant used**
  - ⇒ **Increased resource recovery: drilling into several sub-horizons**
- **Advances in well engineering and drilling:**
  - ⇒ **Greater subsurface area developed from one pad with longer laterals and wells placed closer vertically and spatially**
  - ⇒ **“Surface” use is more condensed in time and spatially**

Uncertainty in parts may decrease, but in total is still high

The Future Electricity Mix

2017



ExxonMobil Corporation, 2010, The outlook for energy: a view to 2030: ExxonMobil report, 53 p.

Economic and Environmental Implications

- **Economics**
  - High prices stimulated resource exploration and development
  - Low prices pushed technology and cost efficiency through scale / intensity
  - With large scale operational risks, e.g. spills or gas, are more costly
  - Higher risks lead to investments in safety and infrastructure
- **Environment**
  - Low prices and weak economics makes producers vulnerable to regulatory risks
  - Operators “preempt” regulations with acceptable solutions in advance

World Learns from Us: Will We leave Positive Legacy

- **Environmental concerns, particularly about land use and water resources, motived operators to improve**
  - **Subsurface-to-surface ratio**
  - **Water handling**
  - **Spill and leakage protection**
  - **Local communities involvement**

Key Insights

- **Economy-wide implications:**
  - Emissions reduction supported by increasing natural gas supply and low prices
  - Job creation in upstream, midstream, services and more
  - U.S. manufacturing growth owing to affordable and reliable natural gas
- **Unconventional resources are very heterogeneous**
  - Each play is different and there are no “best” recipe
- **Industry is very dynamic**
  - Technology, players, and concerns continuously change
- **We will continue our path forward into the bright future and shale resource will support it!**

Shaping Further Conversation

- **Discussion about future development must include major stakeholders, land owners/communities, regulators and producers, supported by:**
  - **Comprehensive information and data collection/interpretation**
  - **Understanding of each party interests and responsibilities**
  - **Longer planning horizon to motivate investments with efficiency**
- **Lessons about Integration**
  - **Consistency**
  - **Integrity**
  - **Transparency**
  - **Communication**

Wrapping Up

- **Energy security dictates the energy mix.**
  - ✓ **Oil and coal are secure and difficult to replace.**
  - ✓ **Natural gas and nuclear are scalable, and cleaner.**
  - ✓ **Renewables are growing regional supplements.**
  - ✓ **Energy efficiency has major benefits.**
- **Take the long-term view and keep the perspective.**

❖Thanks!