JISEA Joint Institute for Strategic Energy Analysis

Summary and Follow-on Recommendations of:

Natural Gas and the Transformation of the U.S. Energy Sector: Electricity

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JISEA/PIE Natural Gas: Multi-Sector Opportunities and Impacts

10-11 December 2012

NREL/PR-6A20-57496

Outline

- Background: Study Goals and Team
- Key Questions Addressed
- Market Snapshot
- Methodology and Brief Findings by Topic
  - Life Cycle Greenhouse Gas Emissions of Shale Gas
  - Trends in Legal and Regulatory Frameworks
  - Water-related Practices
  - Electric Power Futures and Shale Gas
- Identified Follow-on Research

Background: Study Goals and Sponsors

- JISEA NG#1 study addressed four topics:
  - **Life cycle greenhouse gas (GHG) emissions** associated with shale gas compared to conventional natural gas and other fuels used to generate electricity
  - **Legal and regulatory frameworks** governing unconventional gas development at federal, state, and local levels, and how they are changing in response to industry growth and public concerns
  - **Water-related practices** of natural gas production companies
  - **Electric power futures** dealing with forecasts of demand for natural gas–and other generating options–in the electric sector under a variety of policy and technology developments over the next 20 to 40 years
- Study sponsors: Multi-client sponsor group composed of NG producers, utilities, transmission companies, investors, researchers, and environmental NGOs.

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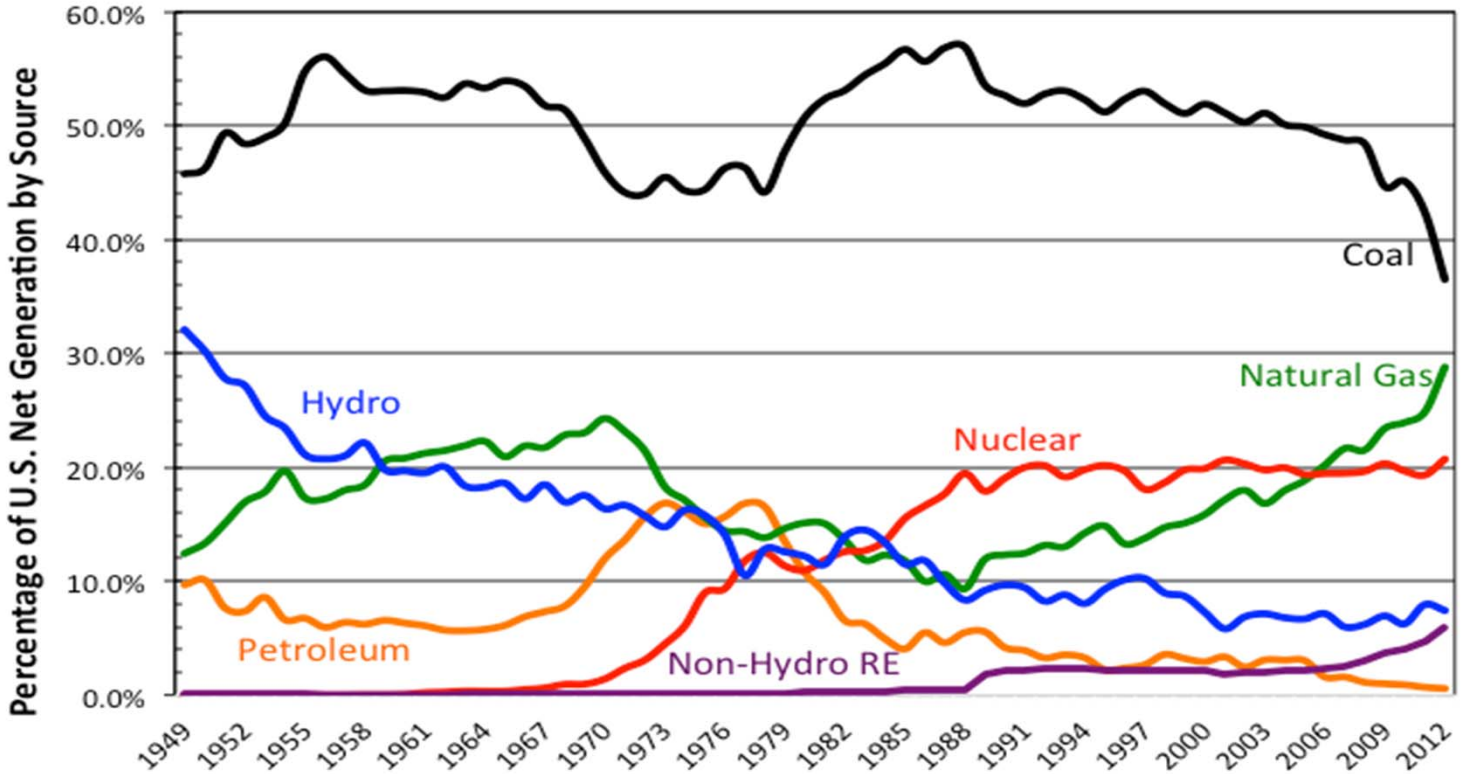
Market Snapshot: Early Impacts of Low-Cost Natural Gas



1. Coal percentage down from 48% in 2008 to 36% in August 2012
2. 300 million tons of annual burner-tip carbon dioxide mitigation (13% of total power sector)
3. Trend could reverse itself depending on natural gas price relative to coal.

Source: EIA. (2012). "Annual Energy Review," *EIA Electric Power Monthly*. Data for 2012 includes generation through August only.

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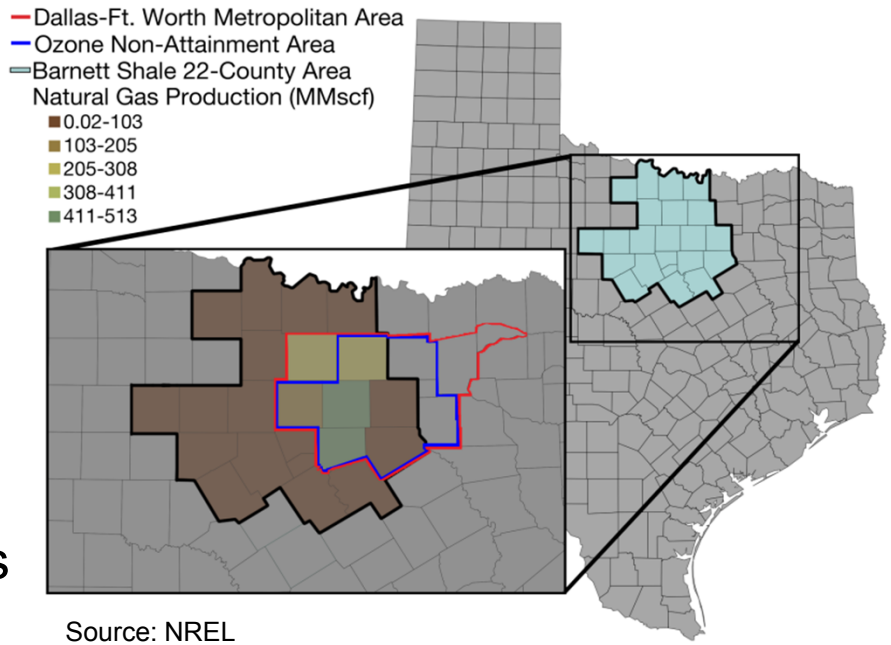
Lifecycle Greenhouse Gas Emissions

Data Sources for Barnett Shale Estimate

- Leveraged high-resolution inventories from Texas Commission on Environmental Quality of volatile organic compounds from NG production and processing stages
  - 16,000+ sources
  - Very high industry participation rates
  - Year 2009



Source: NREL

- Compiled a quality-screened data set of county-level, extended gas composition analyses of produced (raw) gas
  - Demonstrates wide variability of methane and VOC content within the Barnett Shale play.

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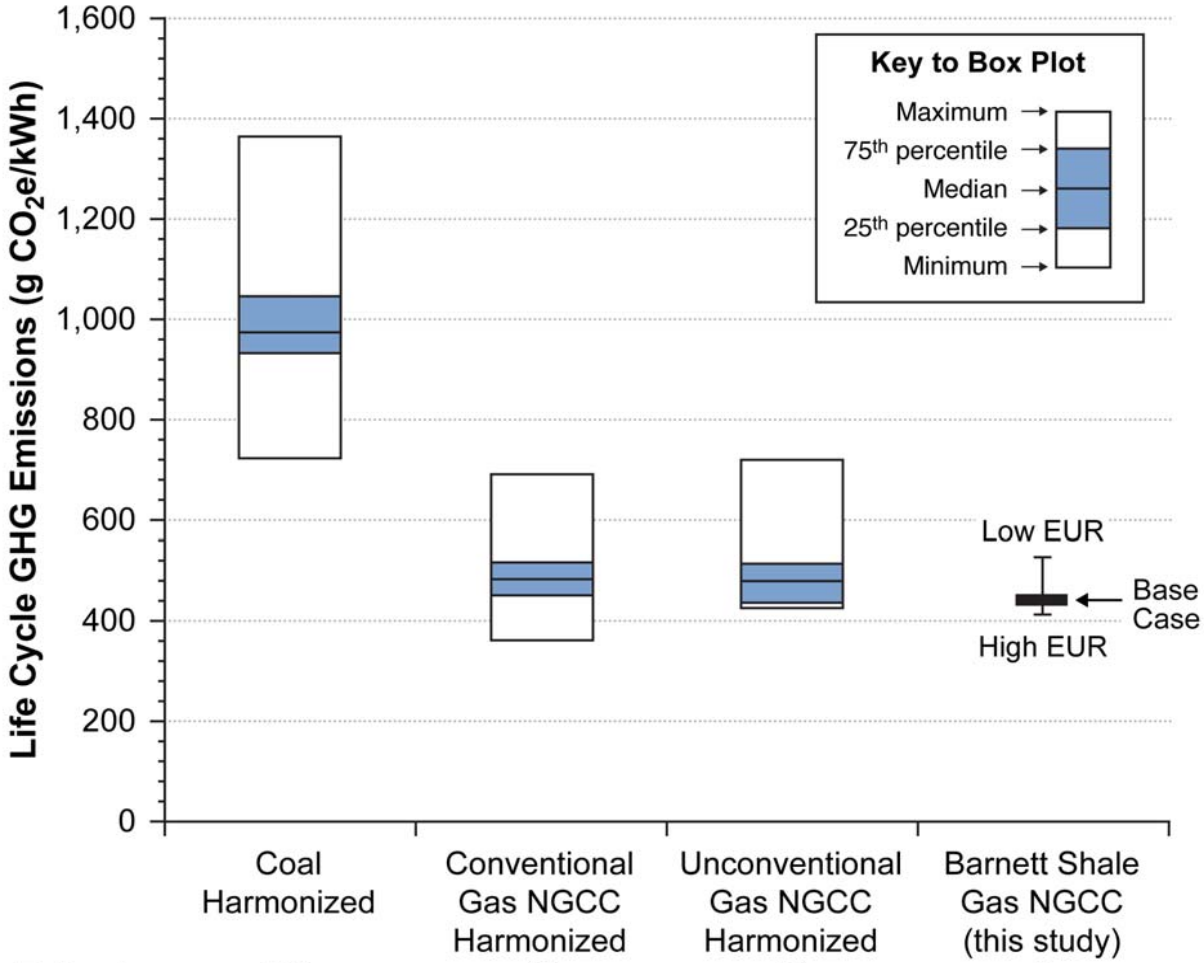
Barnett Shale Gas Estimate Compared to Harmonized Literature Estimates for Coal, Conventional, and Shale Gas



	Coal Harmonized	Conventional Gas NGCC Harmonized	Unconventional Gas NGCC Harmonized	Barnett Shale Gas NGCC (this study)
Estimates:	164	46	7	3
References:	53	41	6	1

EUR = estimated ultimate recovery
NGCC = natural gas combined cycle

Sources: **Conventional** – O'Donoughue, P.; Dolan, S.; Heath, G. (2012). "Life Cycle Greenhouse Gas Emissions from Natural Gas–Fired Electricity Generation: Systematic Review and Harmonization." *Journal of Industrial Ecology* (conditionally accepted). **Unconventional** – Heath. G.; Arent, D.; O'Donoughue, P. (forthcoming.) NREL Technical Report.

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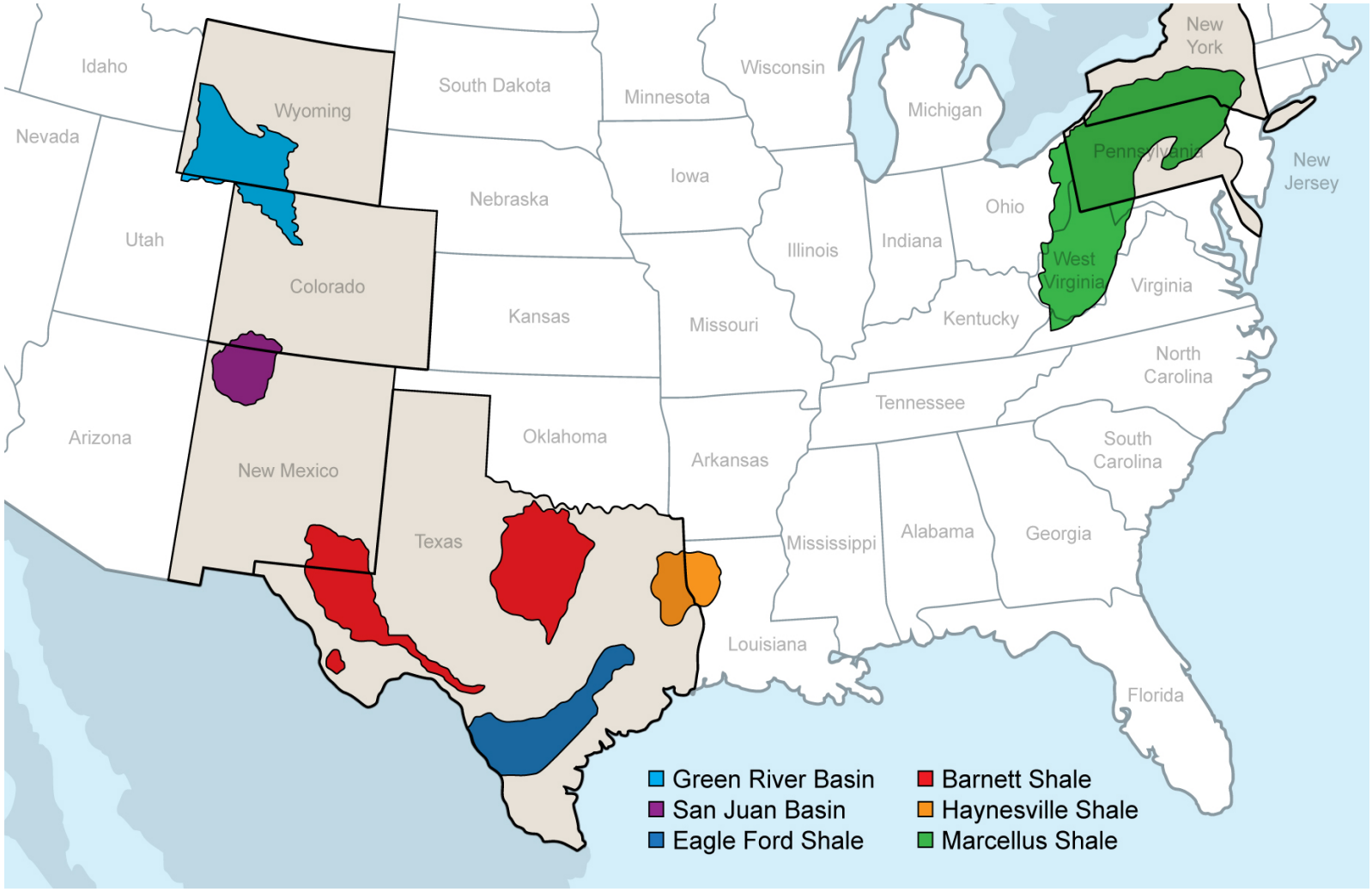
Trends in Legal and Regulatory Frameworks

Focus: Six Basins/Plays + Federal and Local



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Main Regulatory Topics

- Requirements related to **water withdrawals** for fracking
- **Disclosure** of chemicals used in fracking
- **Setbacks** for wells
- **Baseline water monitoring** of surface water resources or water wells
- **Well construction standards**
- "**Green**" or "reduced emission" **completions**
- Storage of waste in **closed-loop systems**
- **Disposal of produced water**
- **State compliance monitoring and enforcement** capabilities, and the efforts by some local governments in key gas-producing states to limit or ban unconventional gas development.

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Key Finding: Regulatory Frameworks

- The legal and regulatory frameworks governing shale gas development are changing in response to public concerns and rapid industry changes, particularly in areas that have limited experience with oil and gas development.
- All states examined in this study have updated their regulatory frameworks to address the opportunities and challenges associated with increasing unconventional natural gas production.
- Approximately 6 other specific findings

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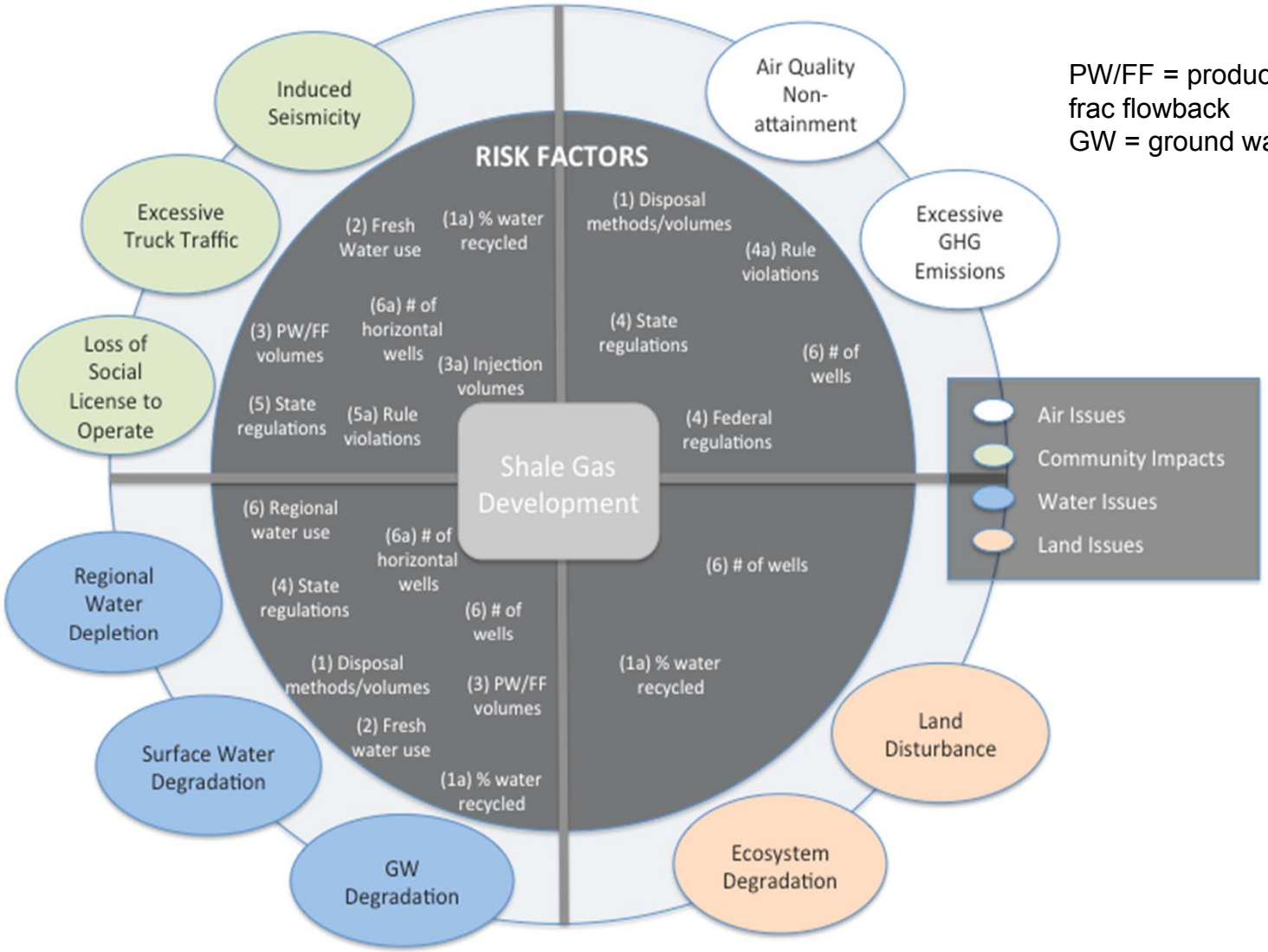
Water-related Practices and Shale Gas Production

Risk Landscape in Hydraulic Fracturing



PW/FF = produced water, frac flowback
GW = ground water

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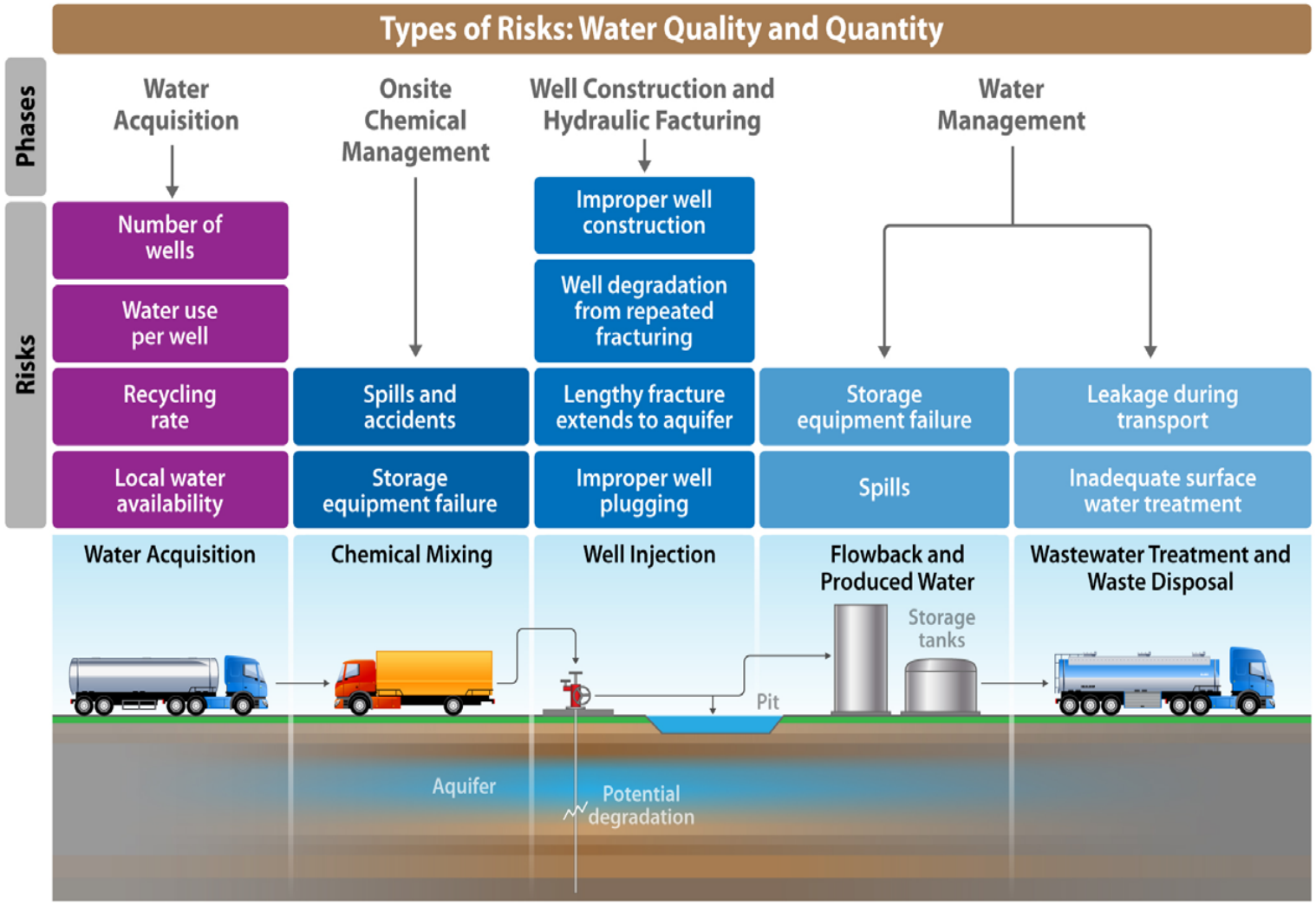
Water Practices: Types of Risks



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Key Finding: Water Practices

- Many regions evaluated in this study are making greater use of innovative water management practices to limit real and perceived risks.

- Lack of reliable water usage and management data—such as total water withdrawals, total wells drilled, water-recycling techniques, and wastewater management practices—hinders efforts to develop appropriately flexible and adaptive best management practices.

- Recent studies document management practices related to the chemical makeup of fracking fluids, impacts on local freshwater, and on-site wastewater management that may be appropriate in many locations.

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Electric Power Scenarios and Shale Gas

Scenario Framework

Coal Scenarios

Coal Retire (80 GW by 2025)
No New Coal (NSPS)

Clean Electricity Standard Scenarios

CES – Low EUR
CES – High EUR
CES – High EUR, No CCS

Reference Scenarios

Baseline
Baseline – Low-EUR
Baseline – Low-Demand

Technology Improvement Scenarios

Advanced RE
Advanced Nuclear

Natural Gas Supply-Demand Scenarios

1) Dash to Gas
2) Social License to Operate - Higher NG Production Cost

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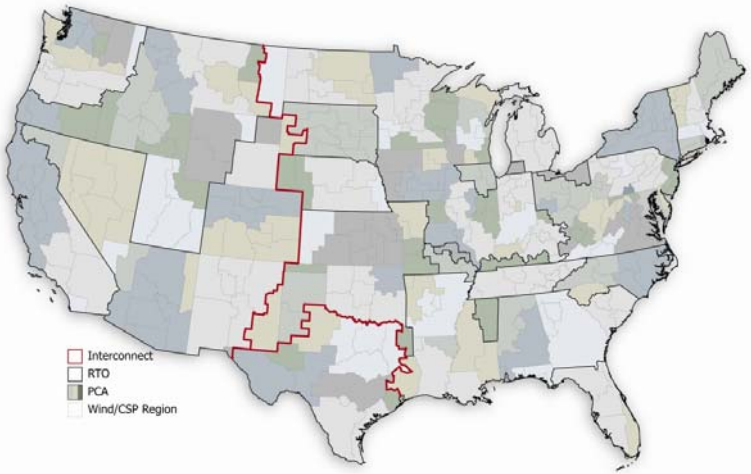
Regional Energy Deployment Systems

- **Capacity expansion and dispatch** for the contiguous U.S. electricity sector, including transmission and all major generator types

- **Minimize total system cost** (20-year net present value)
  - All constraints (e.g., balance load, planning and operating reserves, etc.) must be satisfied
  - Linear program (with non-linear statistical calculations for variability)
  - Sequential optimization (2-year investment period 2010-2050)

- **Multi-regional** (356 wind/solar resource regions, 134 BAs)
  - Regional resource characterization
  - Variability of wind/solar
  - Transmission capacity expansion

- **Temporal resolution**
  - 17 timeslices in each year
  - Each season = 1 typical day = 4 timeslices
  - 1 summer peak timeslice.



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Clean Electricity Standard Scenarios

- Clean Electricity Standard
  - 80% clean electricity by 2035, 95% by 2050
  - Crediting: 100% for nuclear/RE, 50% for NG-CC, 95% for NG-CCS, 90% for coal-CCS, 0% all others

- Three CES scenarios:
  - High EUR
  - High EUR, No CCS
  - Low EUR

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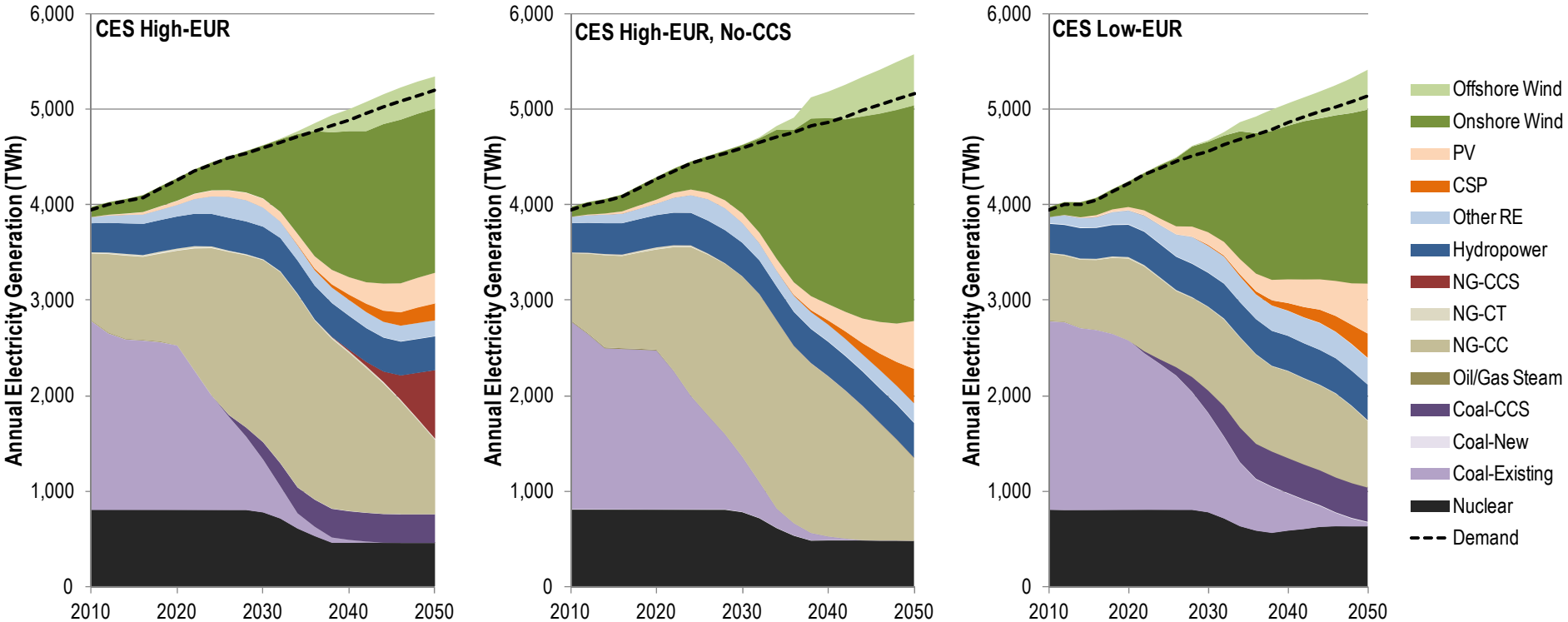
Clean Electricity Standard Scenarios



- A CES generally leads to greater NG power generation in the near term, followed by reliance on RE (and to a lesser degree, CCS and nuclear) in the long term
- Under a CES, 2050 RE power generation is significant even with high EUR and CCS deployment: 38% wind, 9% solar, 7% hydro, 3% other RE
- New nuclear capacity expansion is more limited under cost assumptions used.

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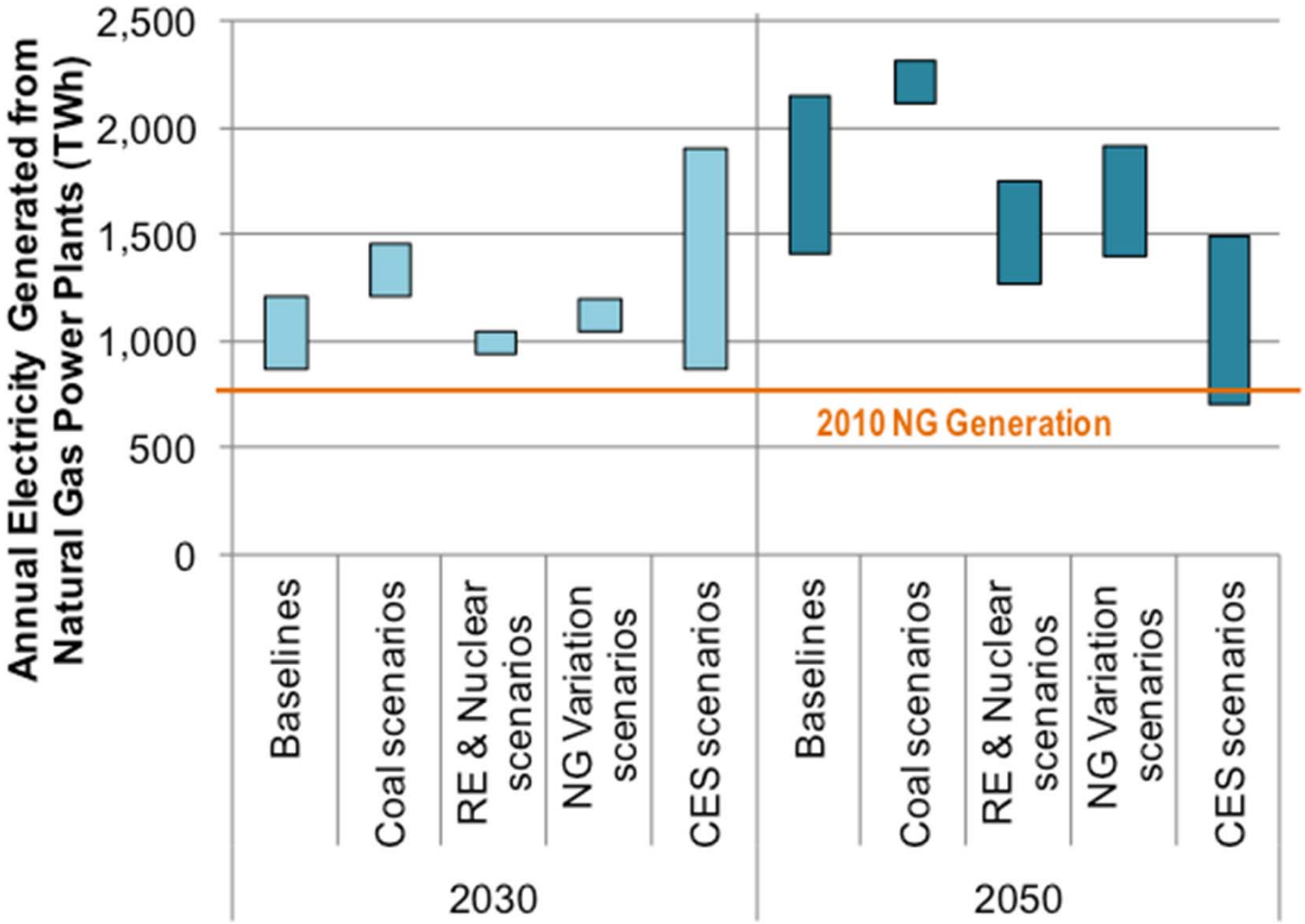
Range of Electricity Generated from NG in the Scenarios



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Selected Follow-on Research Priorities

- **GHG LCAs:** Replicate analysis for other plays (data available for Wyoming/Colorado and Louisiana) to generalize findings; add other refinements (gathering lines, EUR)
- **Regulatory:** Update trends; estimate the range of potential costs associated with more uniform and robust practices in the field based on industry-provided data ($/MMBtu) and explore implications
- **Water:** Address risk profile holistically and consider applicability of appropriate best management practices
- **Scenarios**: Consider alternative futures and add additional sensitivities; modify ReEDS to improve accuracy and expand functionality.

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Selected New Topics in NG-Electricity

- Estimated Ultimate Recovery: Refinements and Impacts
- LNG Exports: Domestic and international impacts
- Carbon Constraint Options & NG: C&T vs. tax vs. CES
- NG Price and Volatility Forecasts: Where to Next?
- R&D Portfolio: Climate and Energy Security
- International NG Developments and Impacts.

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Learn More

Download the full report at

www.nrel.gov/docs/fy13osti/55538.pdf.

Learn more about JISEA's natural gas work at

http://www.jisea.org/natural_gas.cfm

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