Bureau of Economic Geology

Overview and Research Program Examples For JERA (Energy) Americas

Jan 2020

BUREAU OF ECONOMIC GEOLOGY

The University of Texas at Austin

Jackson School of Geosciences

Department of Geological Sciences

Bureau of Economic Geology

Institute for Geophysics

One of three components of Jackson School of Geoscience

- $300 million endowment
- Largest university-based geoscience program in US

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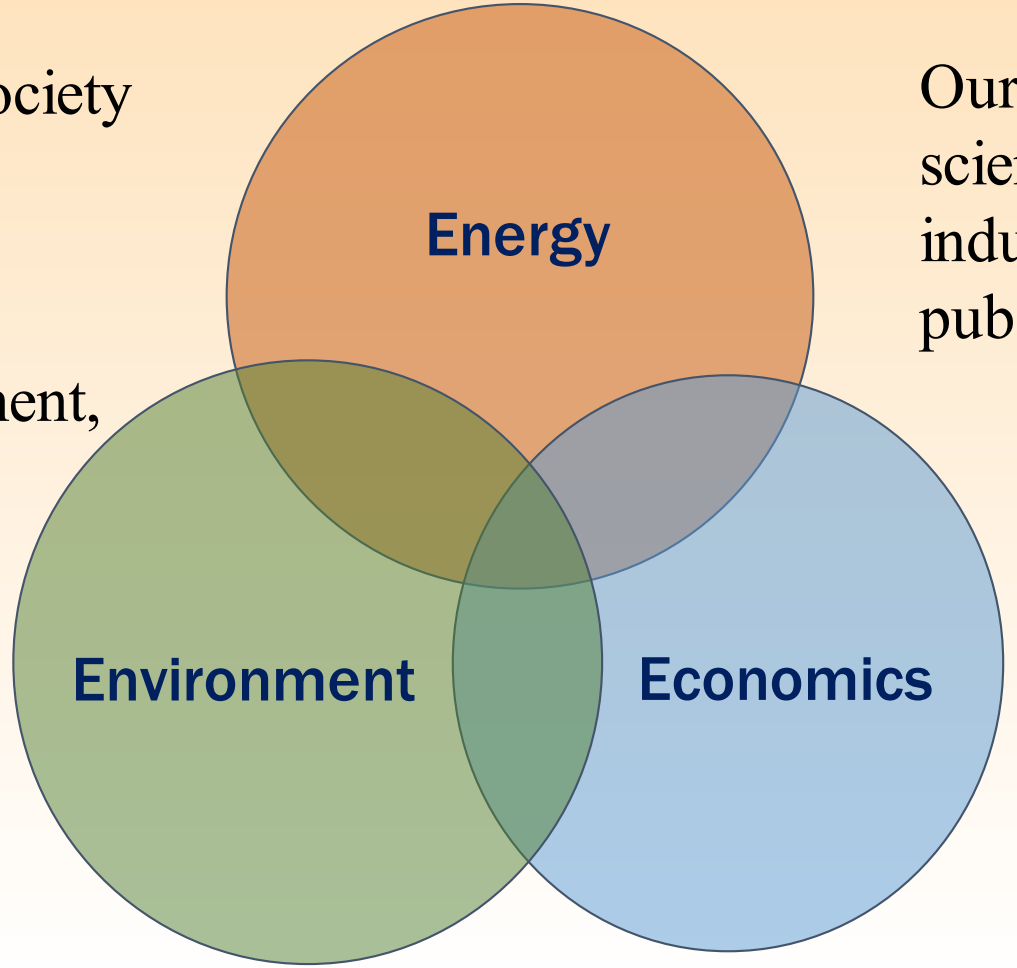
Our ***mission*** is to serve society by conducting objective, impactful, and integrated geoscience research on relevant energy, environment, and economic issues.



Our ***vision*** is to be a trusted scientific voice to academia, industry, government, and the public, whom we serve.

Our ***values:*** At the Bureau, we are Authentic, Respectful, Innovative, Impactful and Collaborative

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Bureau of Economic Geology

- Energy, Environment & Economic Research
  - Unit of the Jackson School of Geosciences
  - $30 - 35 million/year budget, 90% grants & contracts
  - Established in 1909
  - 2nd largest research unit at UT

- State Geological Survey of Texas

- Ca. 250 researchers, staff & students

- Assets include 3 core facilities, labs, Devine field test site, extensive IT infrastructure

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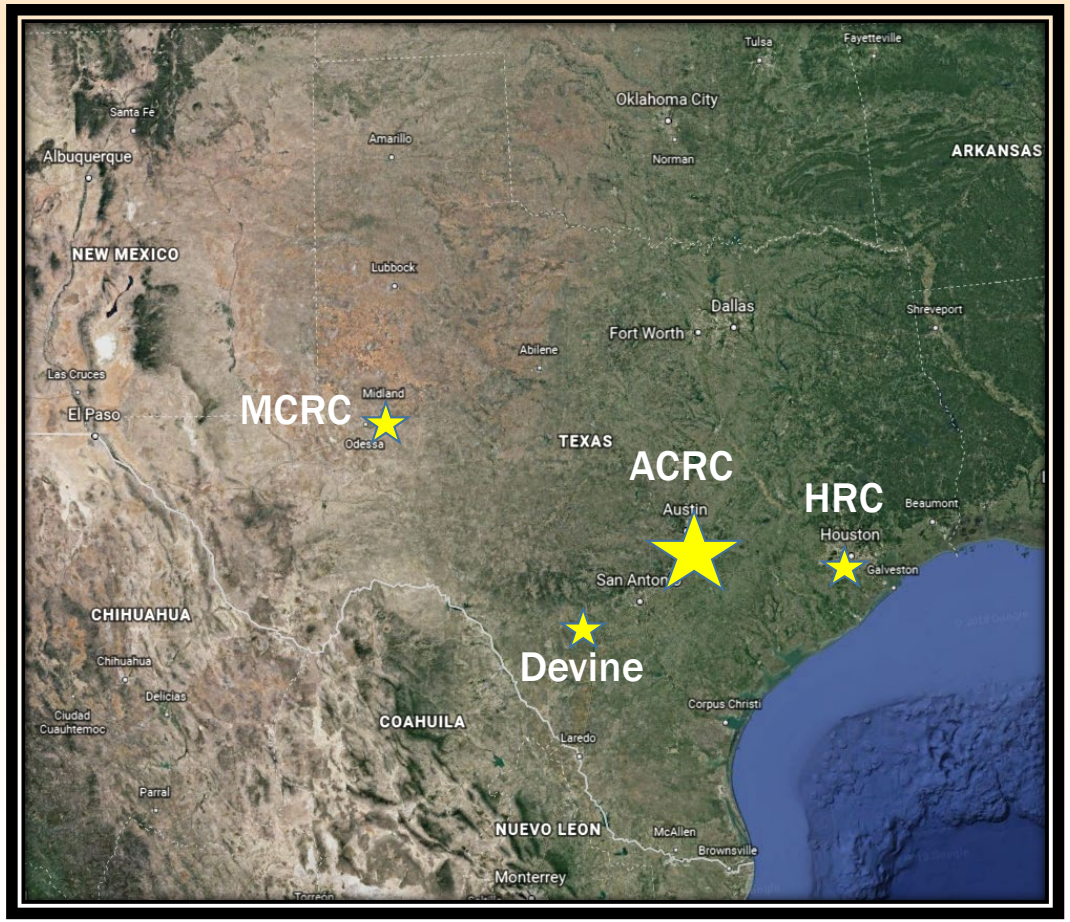
Assets

- Largest core collection in US (1500 miles of core)
- 3 core facilities: Austin (ACRC), Houston (HRC) & Midland (MCRC)
- Devine Geophysical Test Site (DGTS)
- > 1 million electric-logs (TRRC repository)
- Well-equipped laboratories and offices
- Strong IT support and infrastructure



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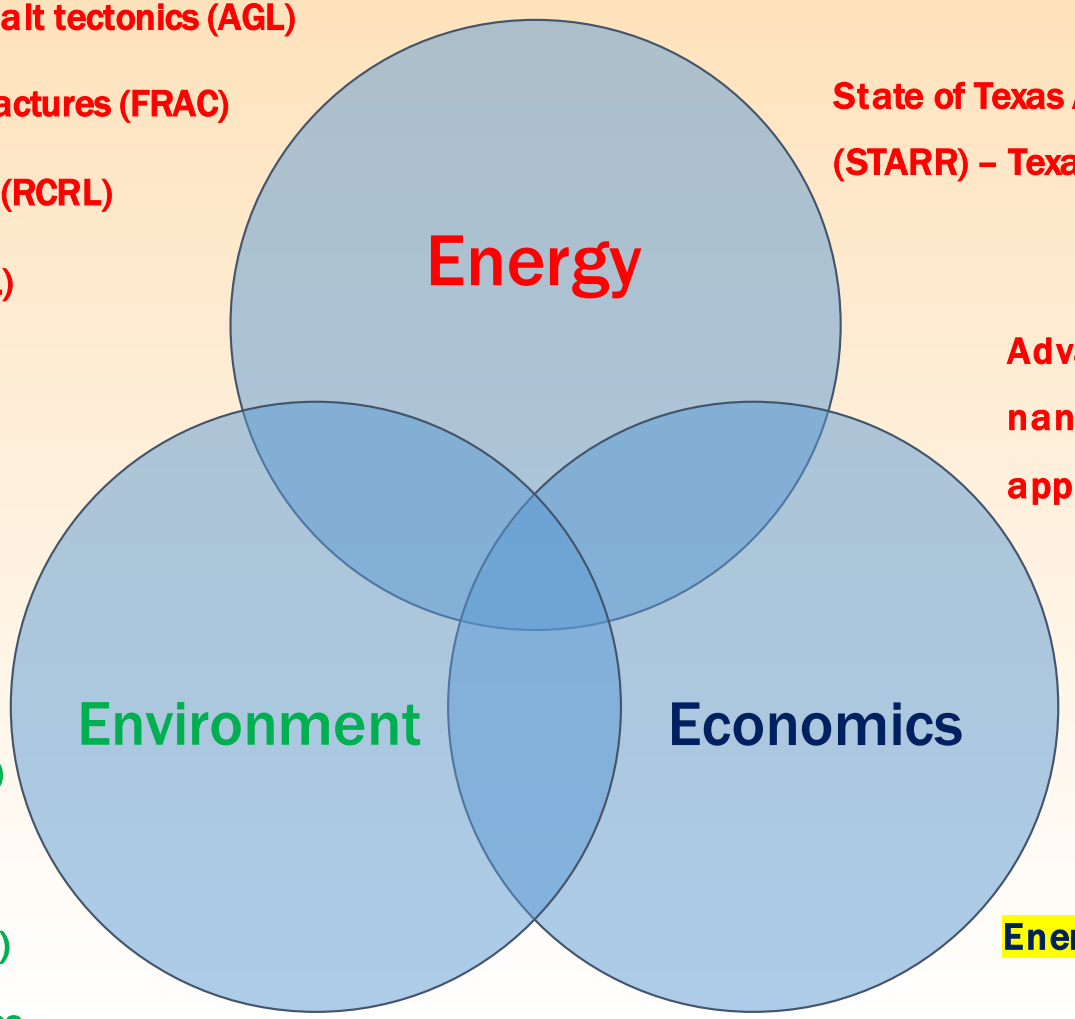
Bureau of Economic Geology Research Programs



Salt tectonics (AGL)

Natural fractures (FRAC)

Carbonate systems (RCRL)

Mudstone systems (MSRL)

Clastic systems (QCL/DRQ)

Computational geophysics (TCCS)

State of Texas Advanced Resource Recovery program (STARR) – Texas oil and gas field and regional studies

Advanced Energy Consortium – nanotechnology development and applications (AEC)

Gulf Coast Carbon Center (GCCC)

Texas Earthquake Monitoring and Center for Integrated Seismicity Research (TEXNET/CISR)

Near Surface Observatory

Water Resources (Water-Energy Nexus)

Economic Mineral Resources

State Geological Mapping

Tight oil resource assessment (TORA) – Permian Basin and other shale plays

Energy Economics (CEE)

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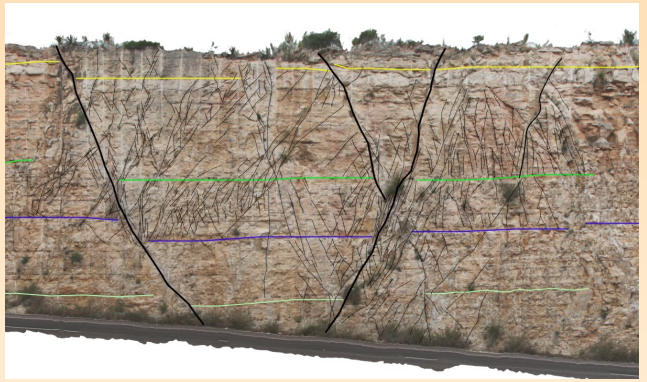
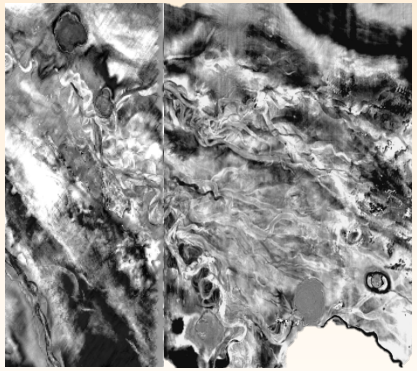
Bureau of Economic Geology Research

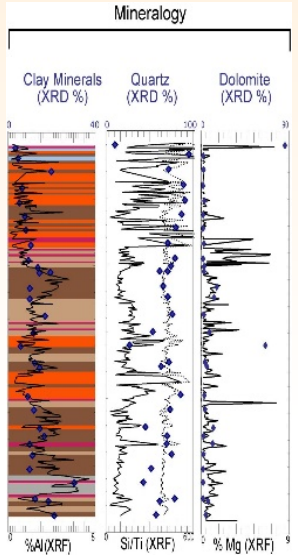


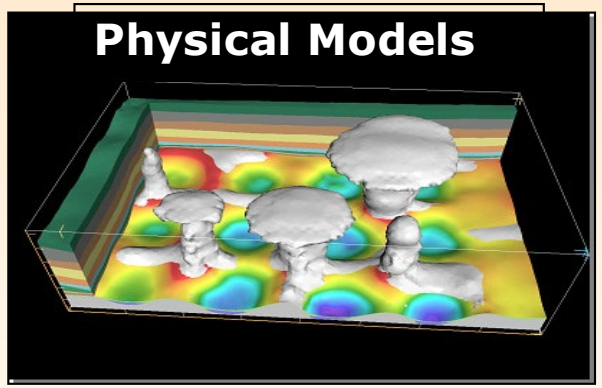
Field/Outcrop

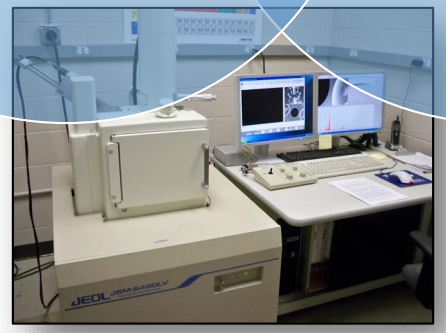
Subsurface (Core, log & seismic)

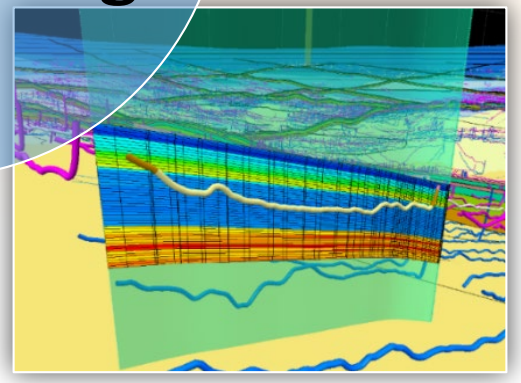
Laboratory, Analytics & Modelling

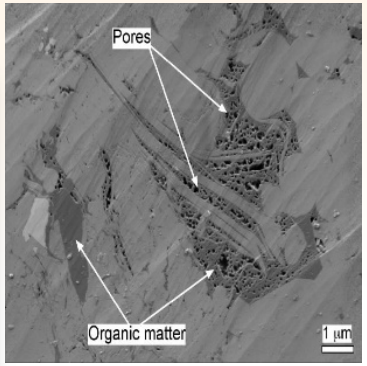












Industry Consortium Sponsors

$50,000/year per member contribution

Research Examples:
Center of Energy Economics

A Sharper Focus with A Wider Lens

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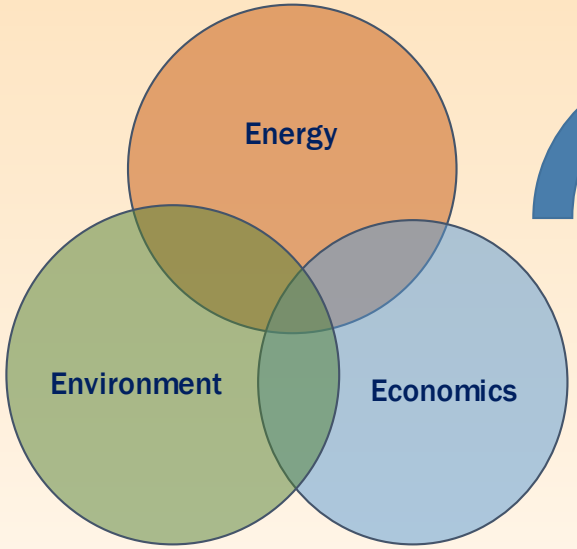
CEE - Strategies and Ongoing Work



Align and Bridge

- Opportunities and risks of unconventional resources
- Natural gas market and infrastructure simulator
- Analysis of impacts of Oil and Gas to power and midstream.

System Approach

- A pathfinder for sustainable energy transition in Texas
- Applied economic analysis on environmental and energy choices

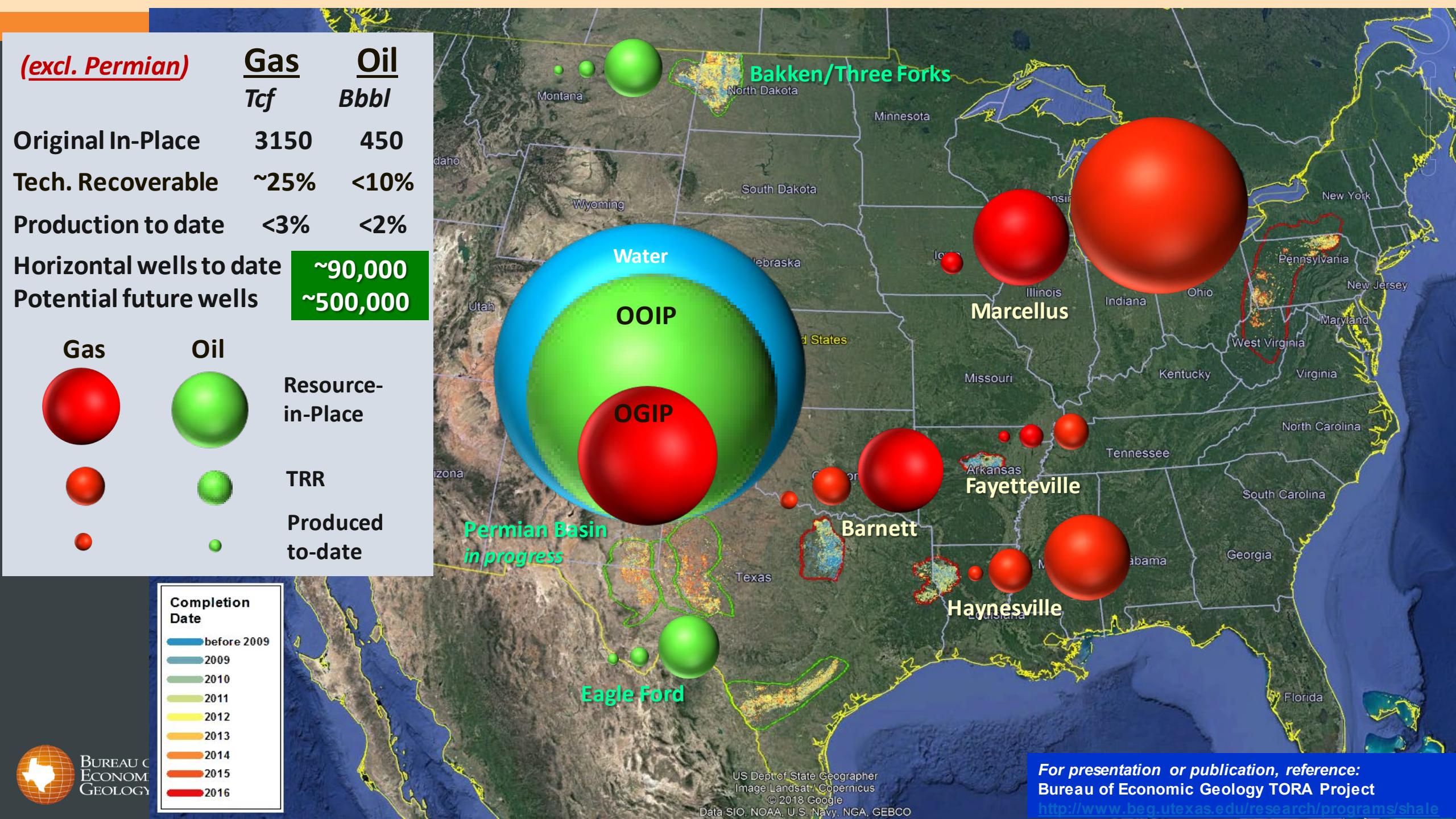
•Market research on energy and resource technology and options

- •Water resource management options in Permian
- •Economic impact of energy assets and infrastructure

TORA Mission and Research Questions

To provide all stakeholders with reliable and up-to-date estimates, projections, models, fundamental understanding and insights at the basin scale for the major US unconventional plays by conducting innovative, integrated research of in-place resource and recoverable volumes, play and well economics and production forecasts with environmental implications.

- **What is the original resource in place (OGIP, OOIP)?**
- **What portion of this resource is technically recoverable*?***
- **What are the long-term production outlook scenarios *(at various prices, costs, technology, regulations ?)***
- **What are the main subsurface controls that improve predictability?**


(excl. Permian)
Gas
Tcf
Oil
Bbbl
Original In-Place 3150 450
Tech. Recoverable ~25% <10%
Production to date <3% <2%
Horizontal wells to date ~90,000
Potential future wells ~500,000
Gas
Oil
Resource-in-Place
TRR
Produced to-date
Water
OOIP
OGIP
Bakken/Three Forks
Marcellus
Fayetteville
Barnett
Haynesville
Permian Basin
in progress
Eagle Ford
Completion Date
before 2009
2009
2010
2011
2012
2013
2014
2015
2016
Montana
North Dakota
Minnesota
South Dakota
Wyoming
Utah
Illinois
Indiana
Ohio
New York
Pennsylvania
New Jersey
Maryland
West Virginia
Virginia
Kentucky
Missouri
Arkansas
Tennessee
North Carolina
South Carolina
Georgia
Florida
Texas
US Dept of State Geographer
Image Landsat / Copernicus
© 2018 Google
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
For presentation or publication, reference:
Bureau of Economic Geology TORA Project
http://www.beg.utexas.edu/research/programs/shale

TORA is an Integrated, Multi-disciplinary Project

Geologic/Reservoir Analysis

- Basin Modeling and Reservoir Characterization
- Original-Resource-in-Place mapping

Well Production Analysis

- Individual Well Gas/Oil/Water Production over Well Lifetime

Recovery and Productivity Statistical Analysis

Expected production *as a function of*

- Well productivity drivers
- Location and Completion
- Inventory of future wells
- Technically Recoverable Resources

Well Economics

Expected well profitability

as a function of

- well production profile
- operational
- market and regulatory parameters

Production Outlook

- **Pace of drilling** *by year and area,*
- **Expected gas/oil/water production** *depending on* **economics, technology, regulation**

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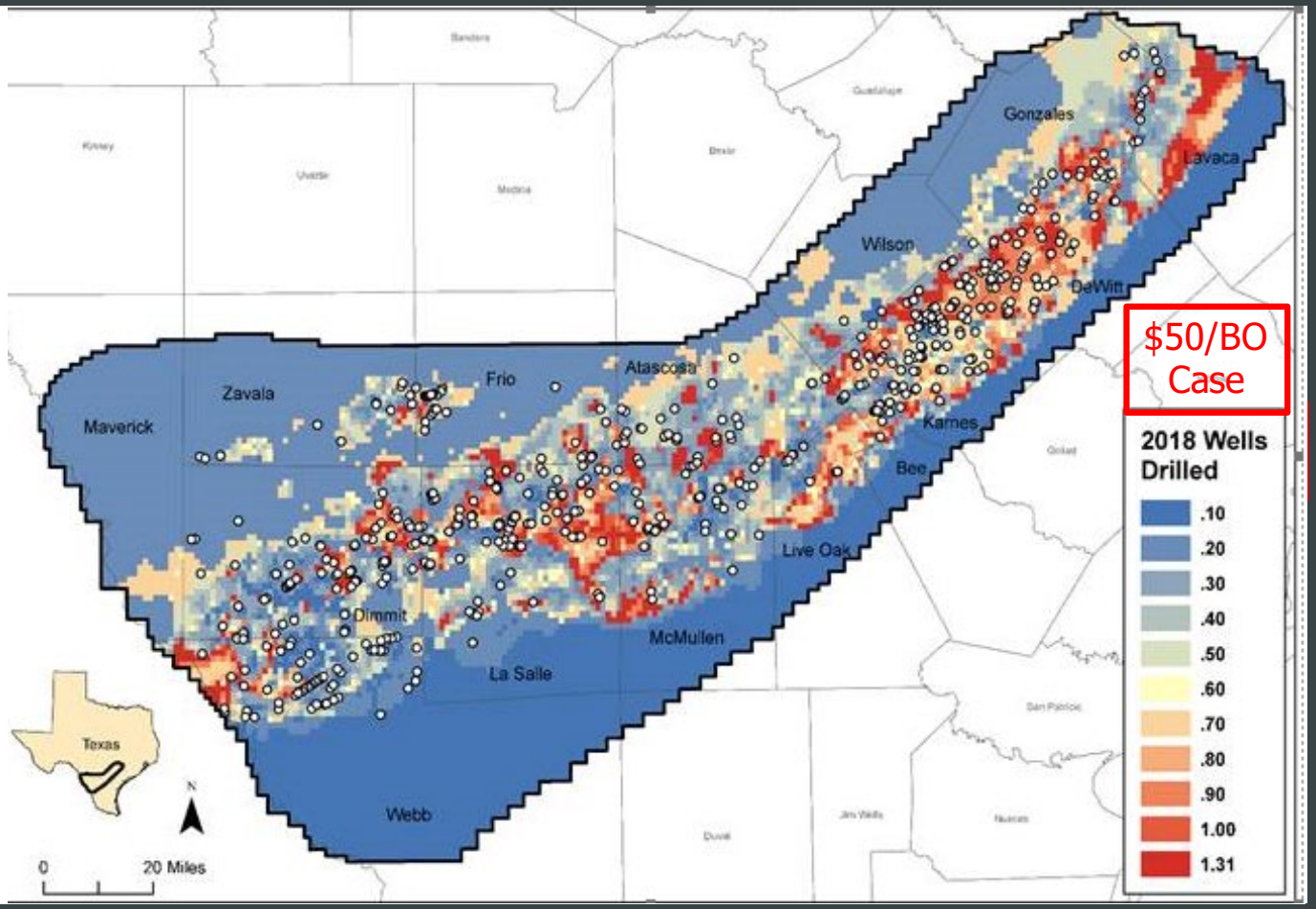
TEXAS Geosciences
Bureau of Economic Geology
Jackson School of Geosciences
The University of Texas at Austin

Expected Drilling



Profitability and well inventory maps are used to create expected drilling maps:

1. Depending on previous year's drilling and expected prices & costs we derive a **projection for the drilling portfolio**
2. Profitability map reveals which **locations are likely to be drilled**
3. **Probability of drilling** is assigned based on the inventory of wells available and drilling expected according to the portfolio.

Ikonnikova et. al., 2017

Challenges of Global Unconventional Oil and Gas

- **An eyes-wide-open feasibility assessment** for energy and environmental resources, technology, infrastructure, policy, scale, and financial implications, to set stage for identifying **actionable solutions** to support development decisions
- Provide **all-in analysis** on global unconventional resources as the foundation of long term exploration and production strategy.
- Currently providing private on-demand studies on top requested countries in Americas, Asia and Africa, for key global upstream players, as well as training and consultation for governments in emerging countries.

Global Shale Resource Scorecard

	U.S.	China	Argentina	Colombia
Resource potential	●	●	●	●
Indicative costs	●	◑	◔	◔
Service availability	●	◔	◑	◑
Midstream and infrastructure	◑	◔	◑	◑
Access to skill and talent	●	◑	◑	◔
Regulatory framework	◑	◔	◕	◕
Local business environment	◑	◕	◔	◔
Political and public support	◑	◕	◔	◔
Investment synergy	●	◕	◔	◔
Ease of trade flows	●	◑	◕	◕
Capital resource and financial channels	●	◕	◑	◑

● Favorable ○ Unfavorable

Not an exclusive list of countries included in the project

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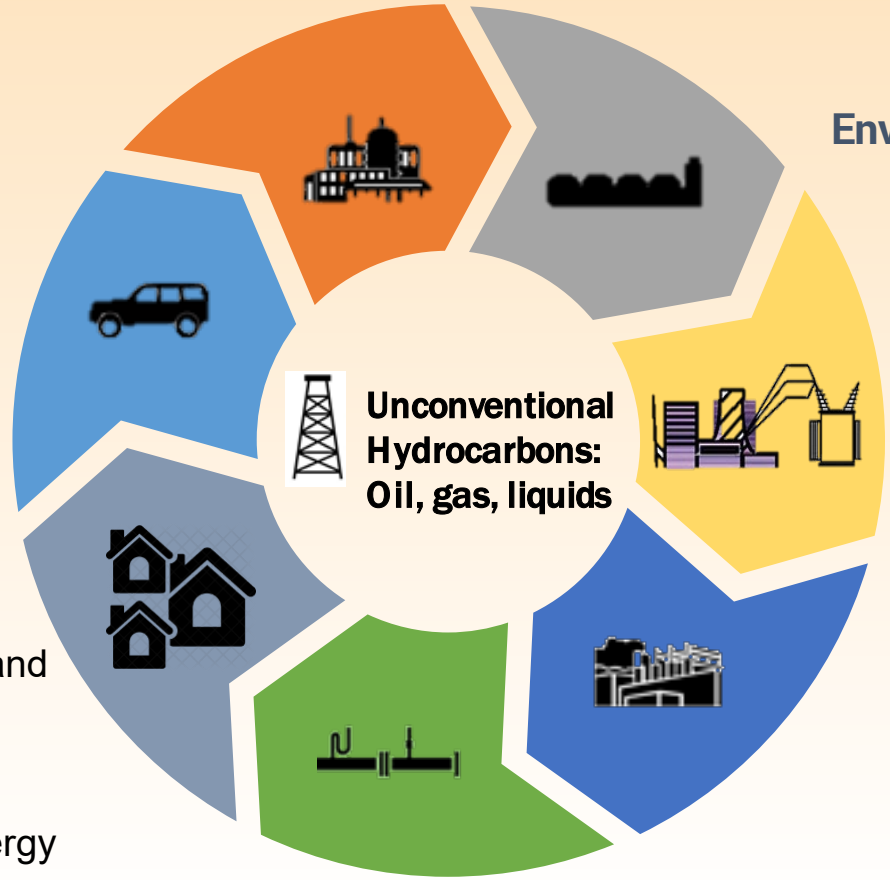
An ecosystem for value creation of unconventional resources

1 Economic Value

- Interconnected energy product flows across and along value chains, **Impact and oppty of gas pipeline and LNG**
- Multiplier effect for communities, states, and countries



2 Environment and Resources

- Minimize and manage **environmental impacts**
- **Collaborative environmental resource** planning aligned with local needs

3 Efficiency and Synergy

- Minimize waste footprint and optimize infrastructure buildout, **like power grid integration**
- Promote operational synergy across product flows and processes from OG to **renewables and alternative fuels**

4 Innovation and Services

- Create a full life cycle support and service network that shares assets, talents, and supply chains, etc.
- Encourage innovation across all segments
- **Hydrogen, CCUS, Nano Tech**

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Shale Development Impacts on Energy Markets and Infrastructure

- Leverage upstream research and focus on economic impacts and market dynamics through the whole value chain
  - Natural gas midstream and downstream
  - Electricity grid and load forecast

Workflow of Natural Gas Market (North America) Simulator

Model Inputs

(TORA) Bottom-up resource evaluation

Customized assumptions to focus on specific projects or markets

Supply Builder

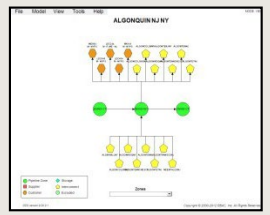
- Pipeline Flows (+245 Pipelines across CA, USA, and MEXICO)
- Storage Levels and Values (+440 Storage areas)

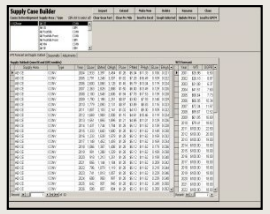
Infrastructure Builder

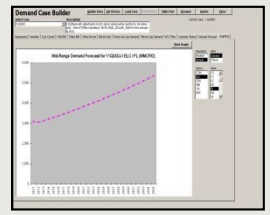
- LNG Exports / Imports (+20 Terminals)
- Market Prices (+100 Market Points)
- Storage Injections / Withdrawals

Demand Builder

- Field Prices
- Pipeline Values
- Import/Export Volumes

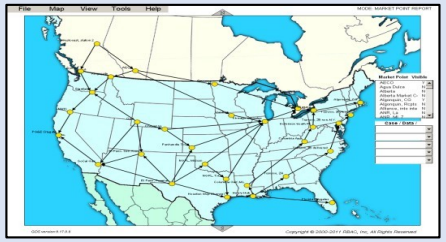




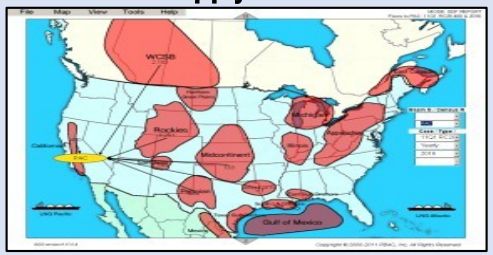


Sample Output

Price outputs by Market Point



Supply Flows



Demand Outlook By Sector

courtesy of RBAC, Inc. using GPCM Gas Pipeline Competition Modeling System

G2M2® Global Gas Market Modeling System

Time period

- Monthly forecast required to capture seasonality
- Can back-cast to 2011
- Currently forecasts to 2050

Pipelines and Storages

- 400+ pipelines and 600+ underground storages
  - Existing
  - Under Construction
  - Proposed and user defined

100+ Countries

- All natural gas producers / consumers
- Supply curves based on field level projections with price elasticities
- Five (5) segments of demand (RES, COM, IND, ELC, TRN) with customized elasticities.

Multi-Tanker Classes

- Q-Max / Q-Flex
- ARC 7 (Arctic class)
- Conventional (5 size groups)

LNG Contract and infrastructures

- Contract parameters; take-or-pay volume assumed to flow
- Above take-or-pay competes against spot market
- Portfolio asset contracts included

Customizable and calibrated

- Customize assumptions (supply, demand and infrastructure) to create scenarios
- Calibrated model based on regular database updates.

G2M2® unlocks potential for global gas opportunities

(supply-demand balancing network including pipeline systems & LNG infrastructure)

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Courtesy of RBAC

One-of-Kind Market Simulator

Short term operation strategy

- Extreme weather scenarios based on pre-set demand elasticities;
- Monthly Regional or locational basis value,
- Projected utilization rate for pipelines, storage and regasification terminals;
- Customized assumptions on demand to align with government policies on coal and renewables;

A long term global gas outlook

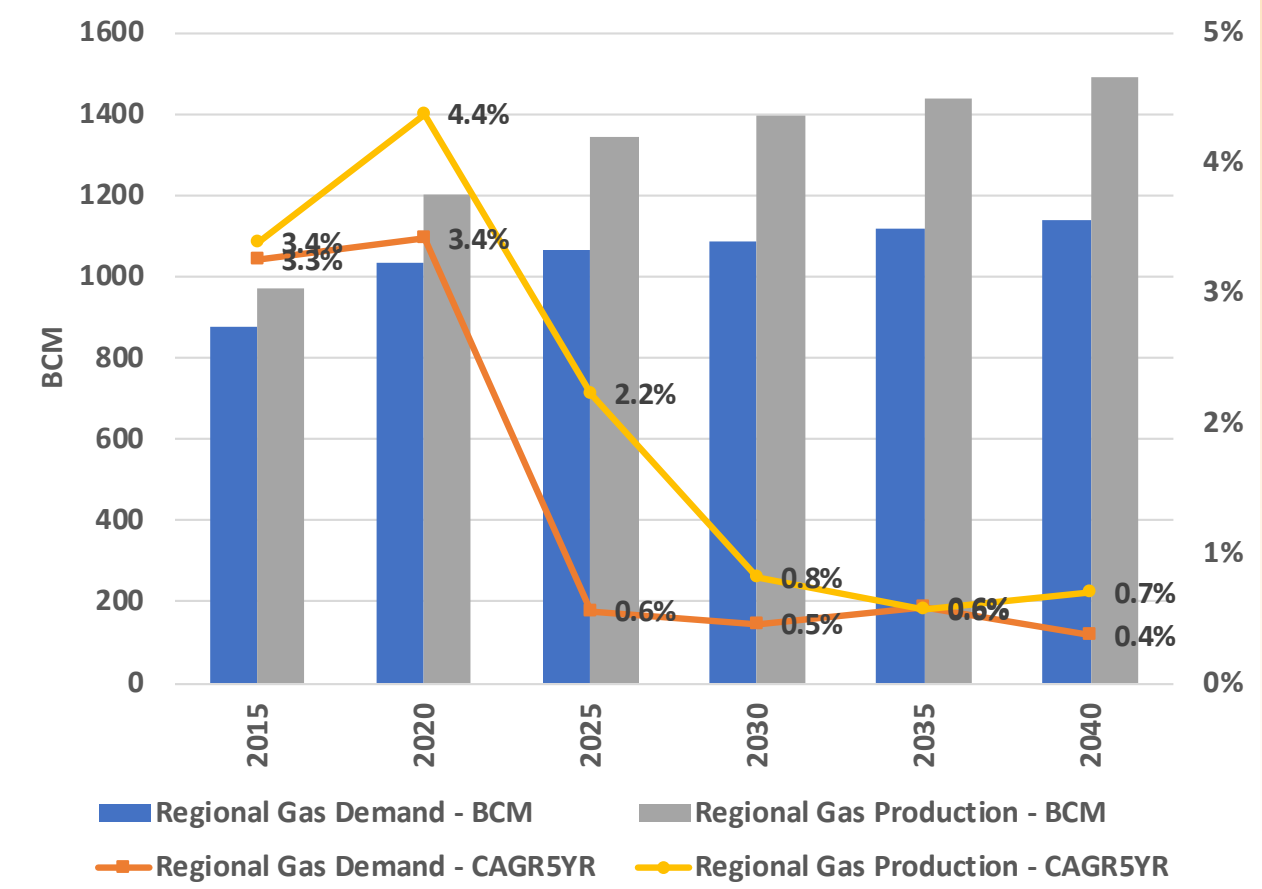
- Cost stacks of all suppliers year-by-year – who and when?
- Long-term projection of pipeline and trade flows based on existing contracts, with ability to add hypothetical contracts and related infrastructures.

Market price of natural gas

- Given a new contracts term for either LNG or gas purchase agreement, what is the fair price of the gas?
- With an investment of pipeline delivering gas to a demand region, what is the value of the project by providing the incremental gas to the market?
- Can the current tariff structure justify the cost of delivery?

Courtesy of RBAC

North America – LNG as an outlet not a driver



- Potential impacts of trade constraints with China on LNG exports from US
- Project focus: Ongoing additions of LNG projects
- Less a market driver: impact of Henry Hub price from global dynamics is generally minor.

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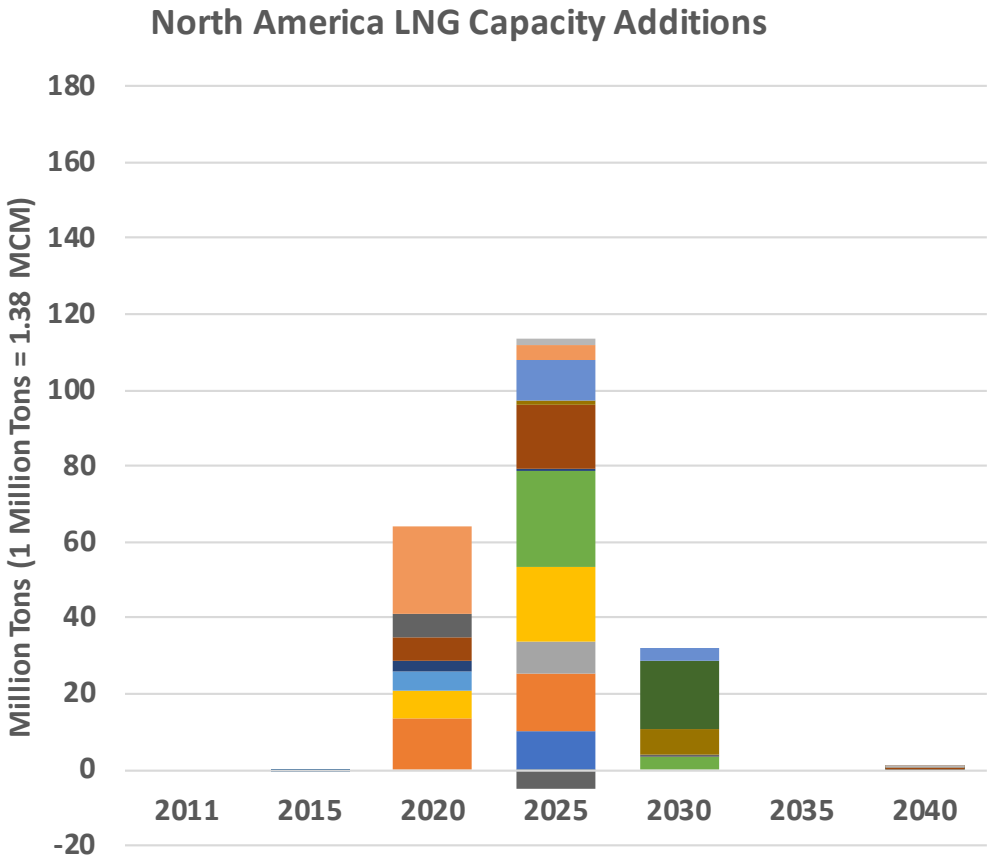
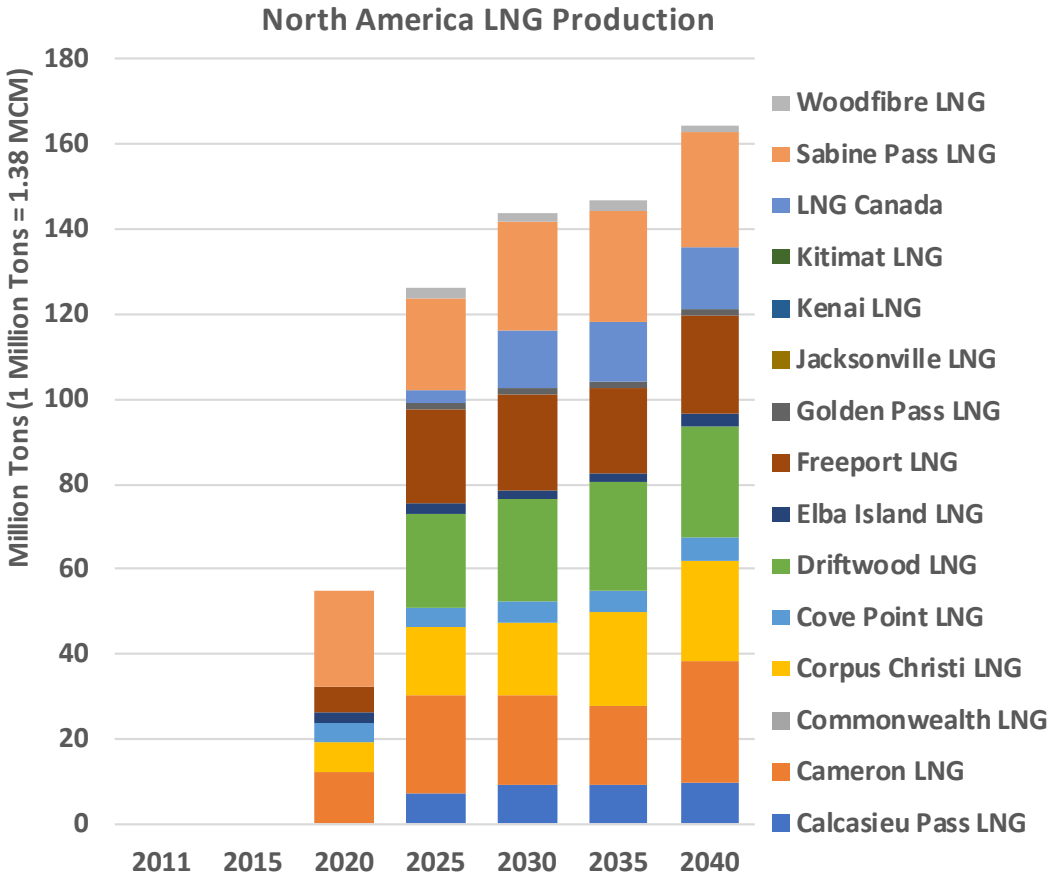
Courtesy of RBAC

North America LNG





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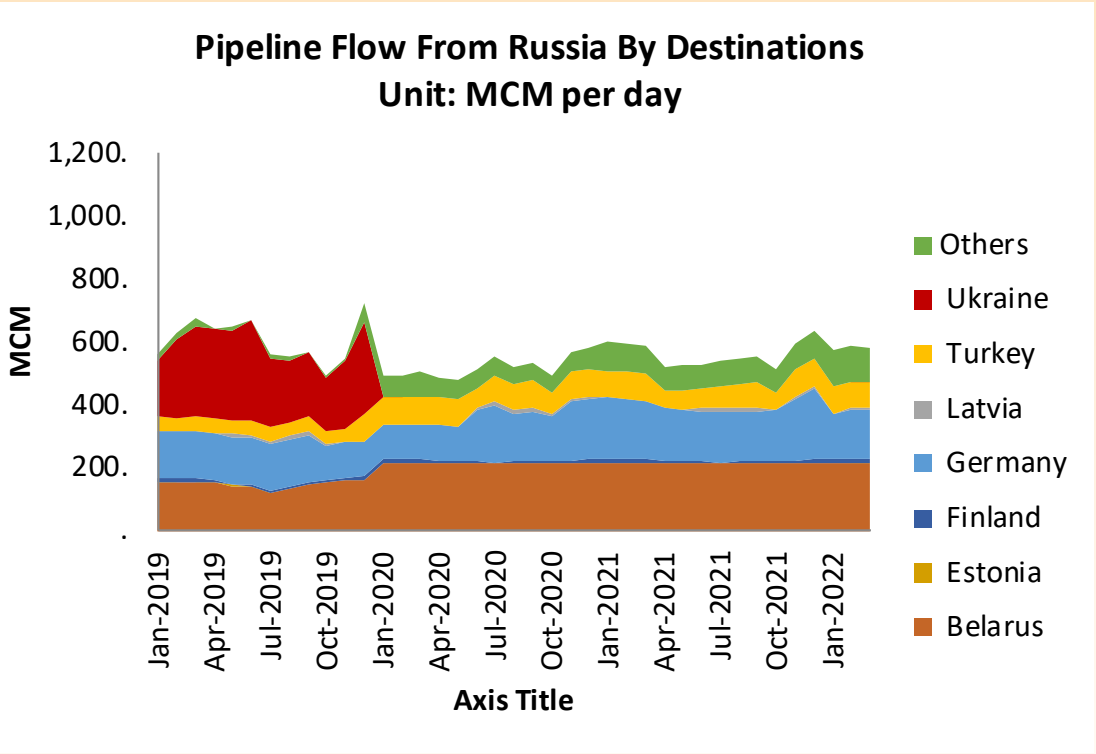
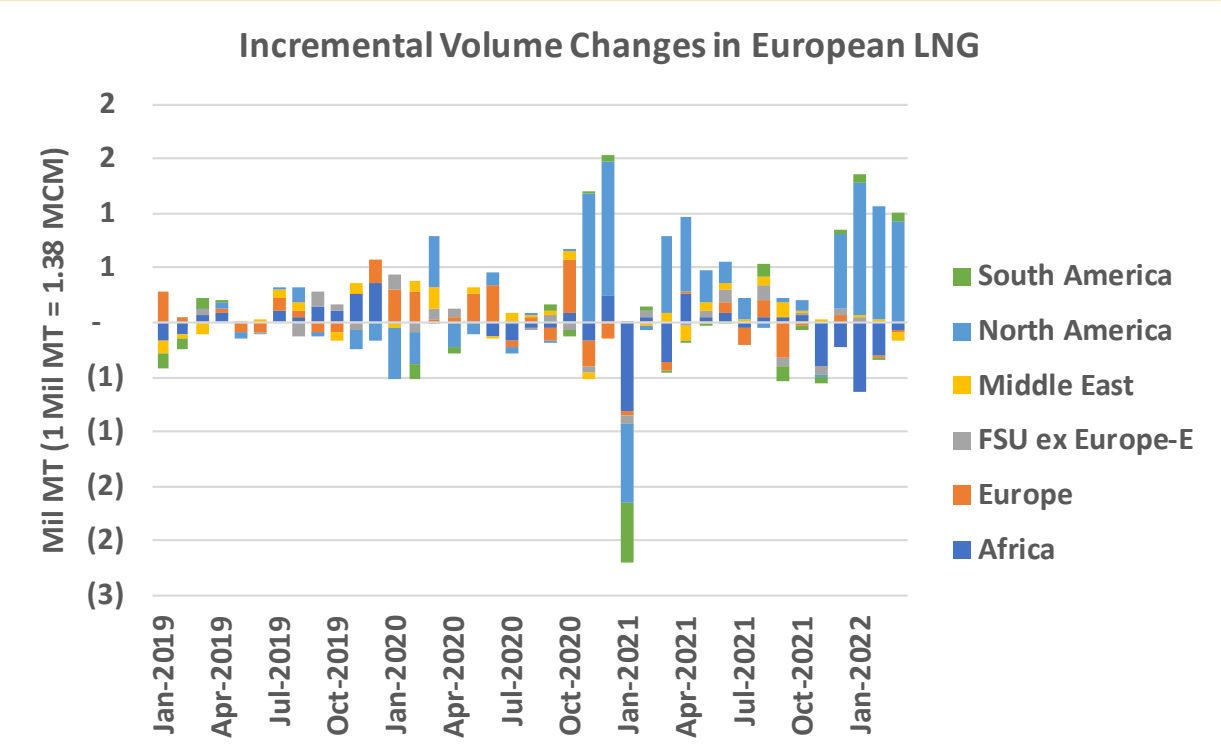
Courtesy of RBAC

Sensitivity Analysis: Colder Winter plus infrastructure constraints





- A colder winter in Europe: +5 BCM increase in demand from winter of 2019 (ending Mar-2020)
- Nuke phasing out adds +5 BCM increase in demand
- Cut-off of Russia gas via Ukraine starting Jan 2020: 6 BCM loss

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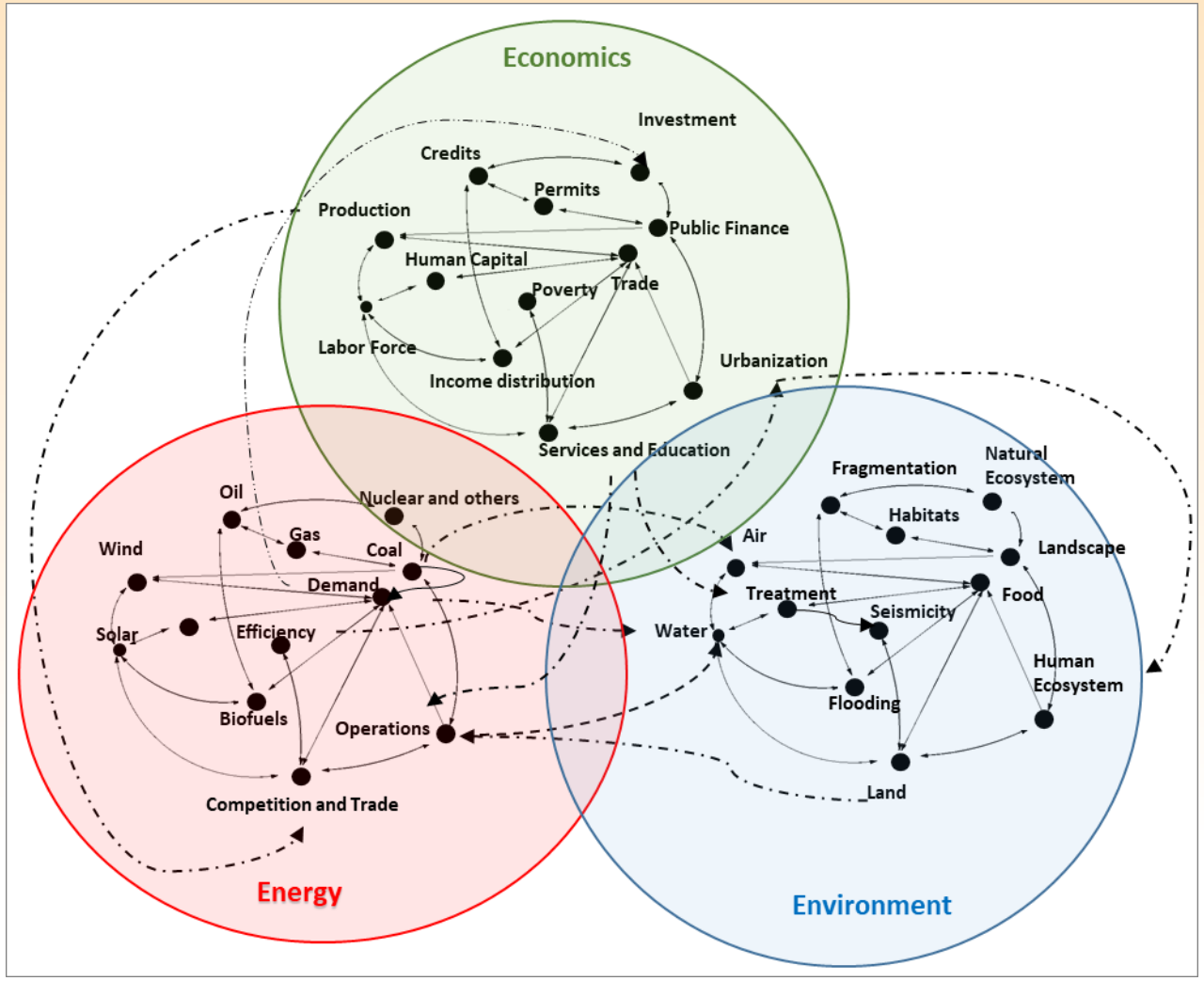
A Pathfinder for Sustainable Energy Transition in Texas

An economic framework to assess "what-if" scenarios and facilitate effective decision making for energy technology and policy choices.

*… captures the relationships among the energy mix—driven by **resources, technology and legacy infrastructure, policy, scale, and financial implications**—and*

*… link decision to repercussions of that mix for **economic development and environmental** quality for the Texas*



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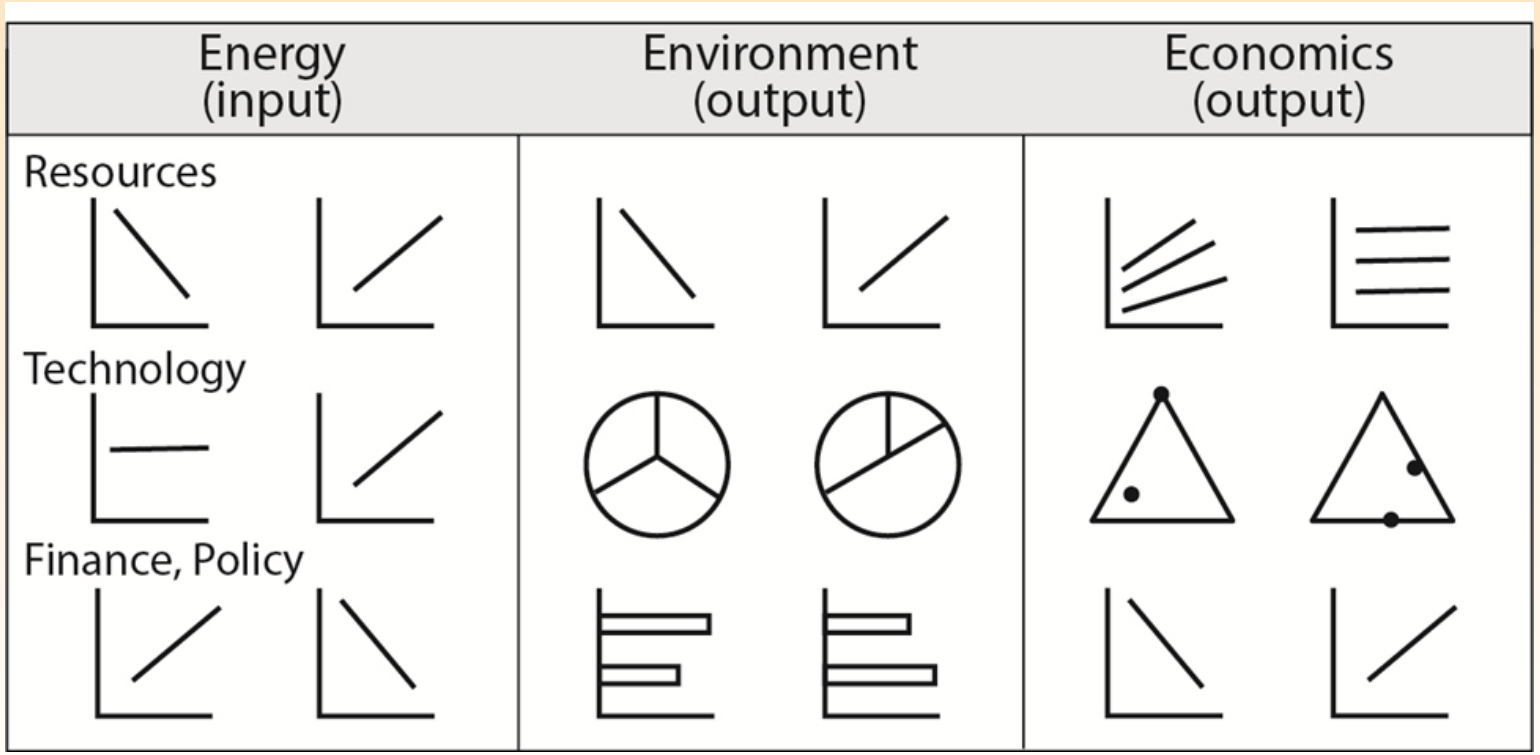
Input Matrix and Output Visualization

Model inputs will include:

- Energy input matrix – a set of choices of energy resources, technologies, policies, and financial realities
- Assumptions
  - Existing energy mix options
  - Legacy infrastructure
  - Implementation requirements
  - Fundamental trends in key subsystems based on industry and subject specific knowledge
- Customized input and output measures to be presented on the interactive user defined interface



Economic Analysis on Environmental and Energy Related Choices

- Economic analysis on produced water options in Permian.
  - Capture the variations of value and risks over time for intangible benefits of natural resource
  - Customize optimization problem and define options to reflect long term strategic value for resource management standpoint versus private operator
- Economic evaluation on new conversion technology of wasted gas (methane) into ammonia
  - Techno-economic analysis (Cost of conversion, CAPEX, OPEX, ROI) to highlight competitive advantage
  - Assessment of necessary market and policy framework for commercialization

Vision of Center of Energy Economics

- Provide **impactful and data driven** analyses on environmental, economic, and energy issues, with a sharper focus and wider perspective
- Facilitate government, industry, and independent stakeholders to seek **actionable and innovative solutions** leveraging cross-discipline expertise
- Build solid knowledge system of U.S. and global energy fundamentals serving as a necessary foundation for collaborations