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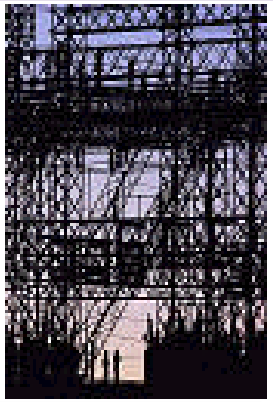


Critical energy infrastructure: the big picture on resiliency research.

National Academies of Science, Engineering, and Medicine. Committee on long-term coastal zone dynamics: interactions and feedbacks between natural and human processes along the U.S. Gulf Coast, September 18, 2017.

David E. Dismukes, Ph.D.
Center for Energy Studies
Louisiana State University

Infrastructure overview

Energy infrastructure supporting E&P activities.

Louisiana has a plethora of critical energy infrastructure. A large portion of which originated to support offshore exploration and production activities.

Natural Gas Processing

LNG

Ports/Supply Base

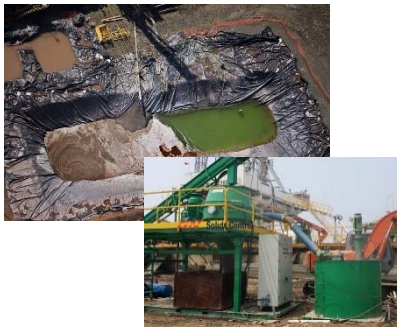
Pipes

Refineries

Platform Fabrication

Natural Gas/LPG/NGL Storage

Petrochemical

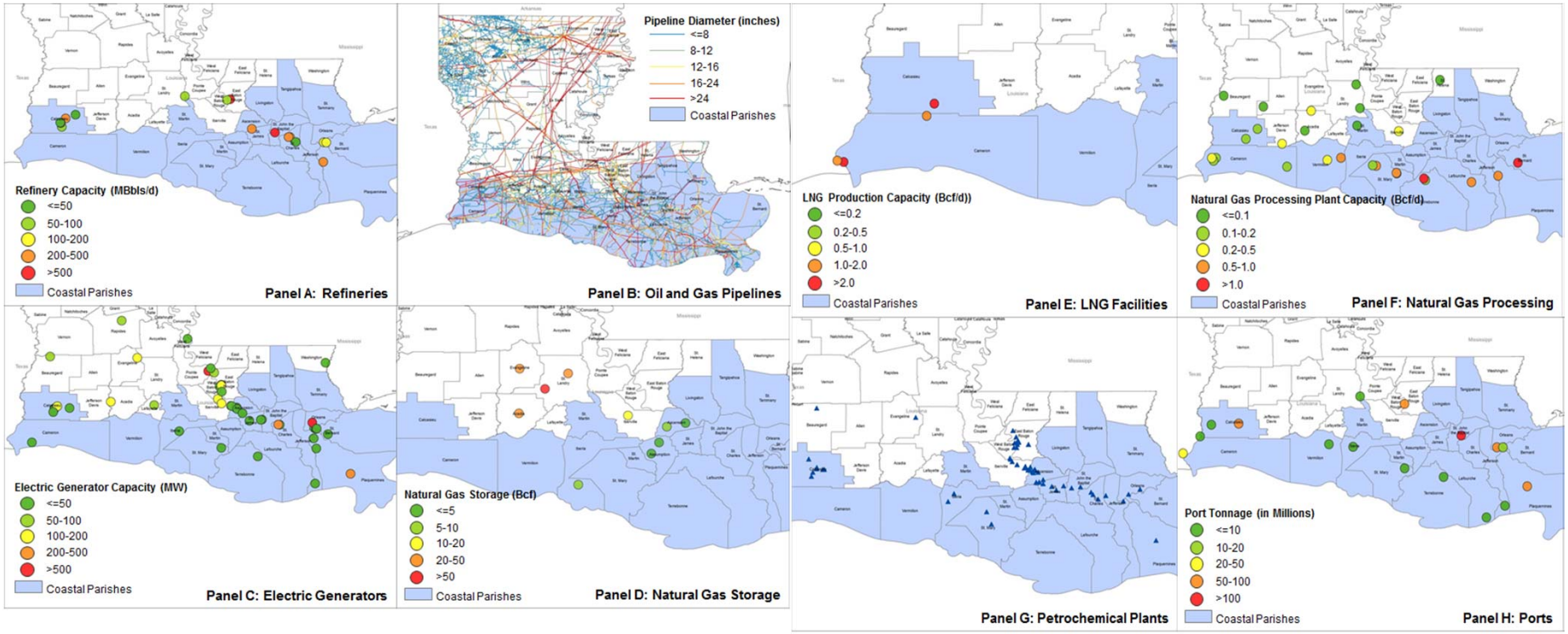


Waste Handling Facilities

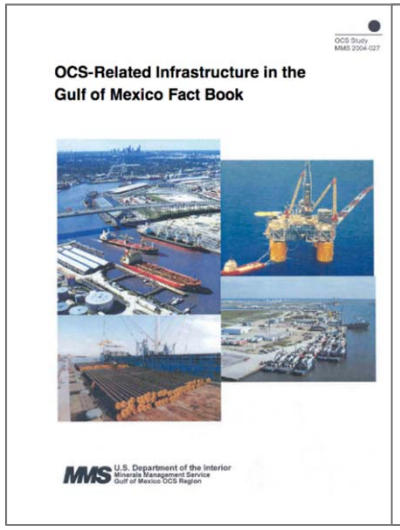
Electric Generation

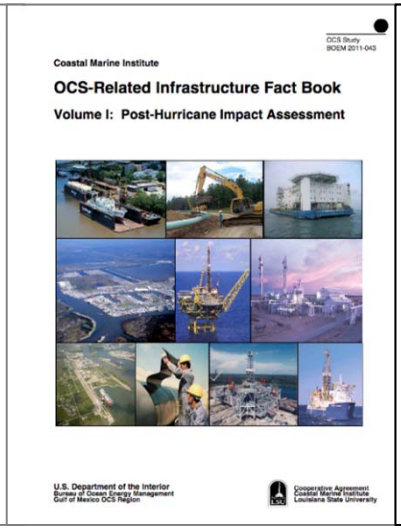
Louisiana's critical energy infrastructure.

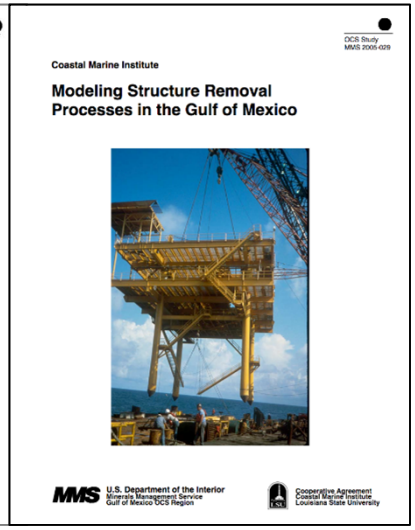
A large portion of this infrastructure, in fact, is located in the coastal zone, not only in Louisiana, but various places along the Texas Gulf coast as well.

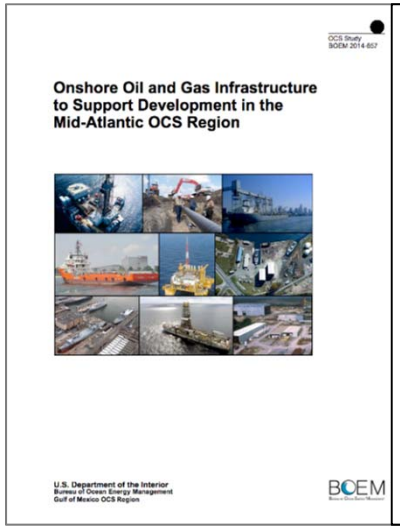


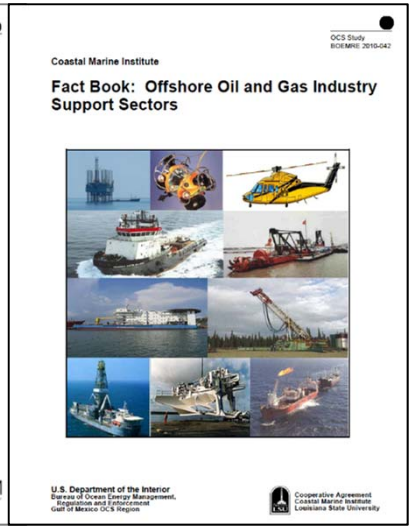
Prior CES research and analysis.











Prior CES related energy infrastructure and support services research focuses on:

(1) Describing and identifying relevant infrastructure and services in respective coastal areas (including development of GIS databases to support this description).

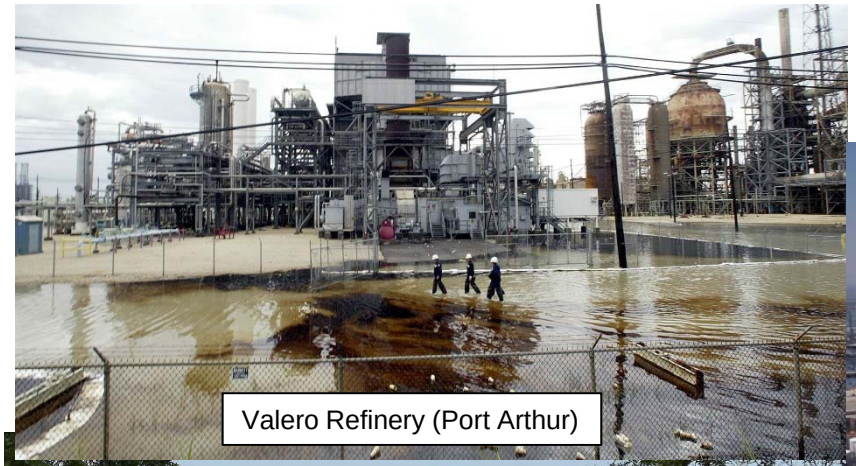
(2) Explaining onshore-offshore industry/infrastructure nexus.

(3) Examining and explaining infrastructure organization and structure (from industrial and labor market perspective).

(4) Examine recent changes and the outlook for infrastructure and support activity development.

Infrastructure vulnerability

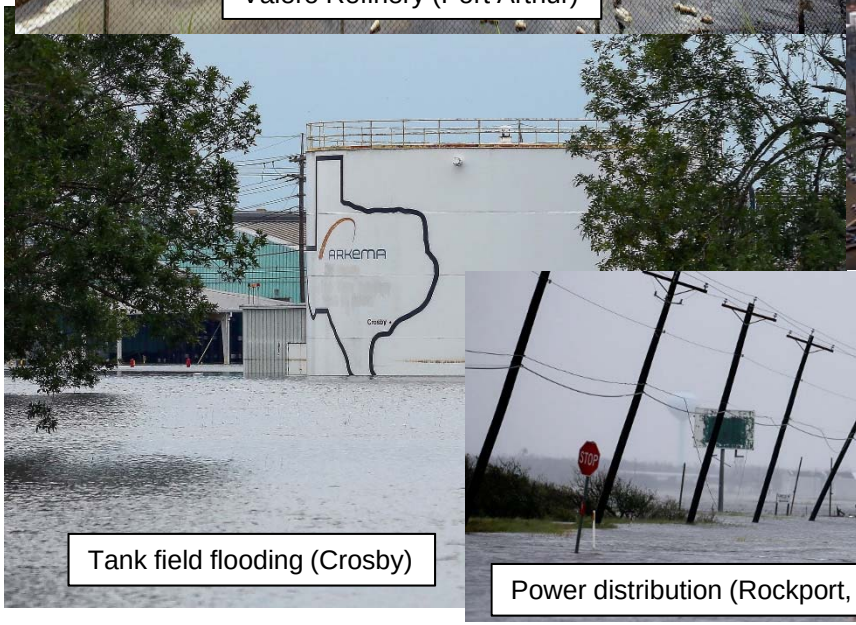
Hurricane Harvey, flooded energy infrastructure



Valero Refinery (Port Arthur)

Listing drilling rig (Port Aransas)

Motiva Refinery (Port Arthur)

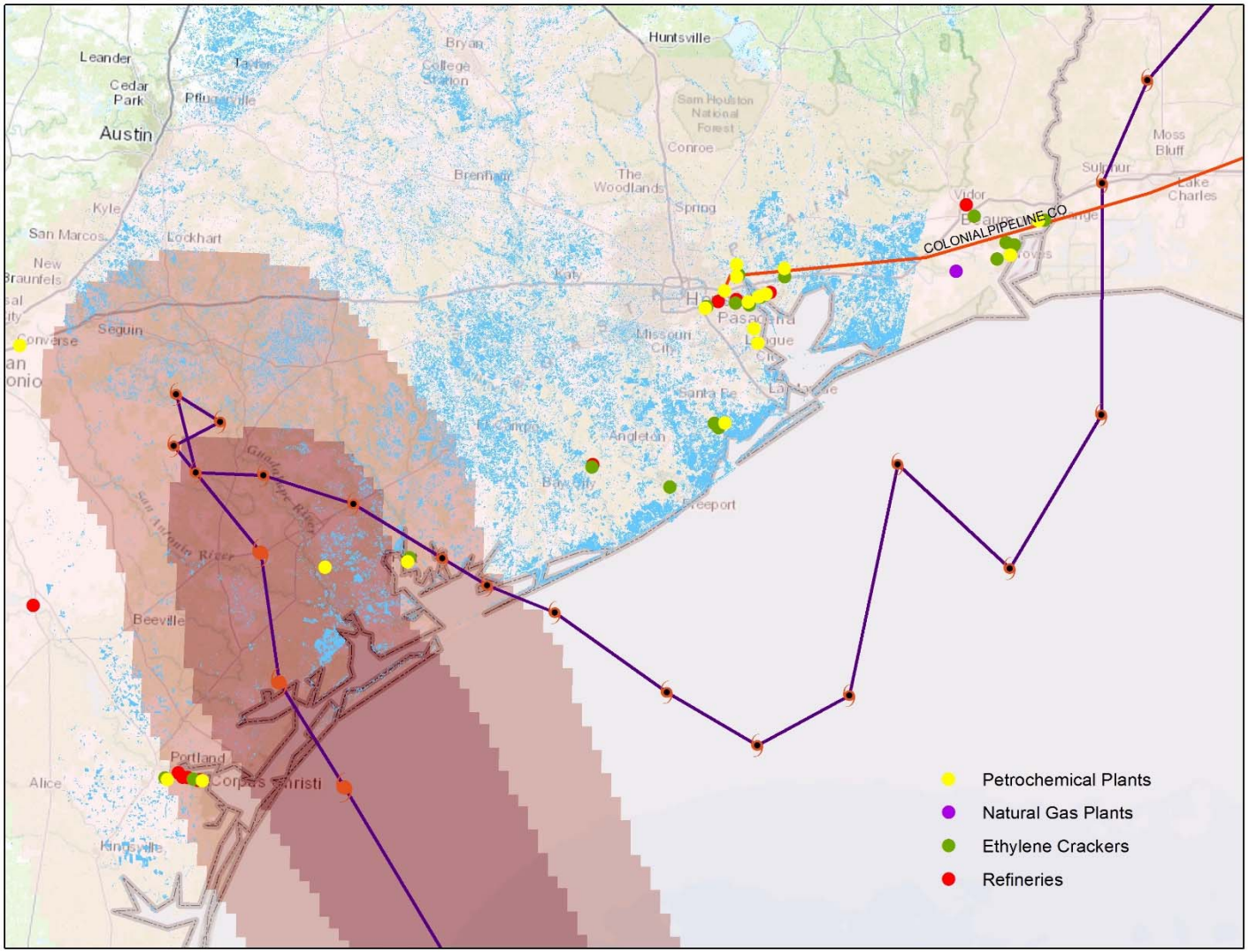


Tank field flooding (Crosby)

Power distribution (Rockport, coastal TX)

Arkema site fire/meltdown (Houston)

Hurricane Harvey, impacted infrastructure



Source: U.S. Energy Information Administration.

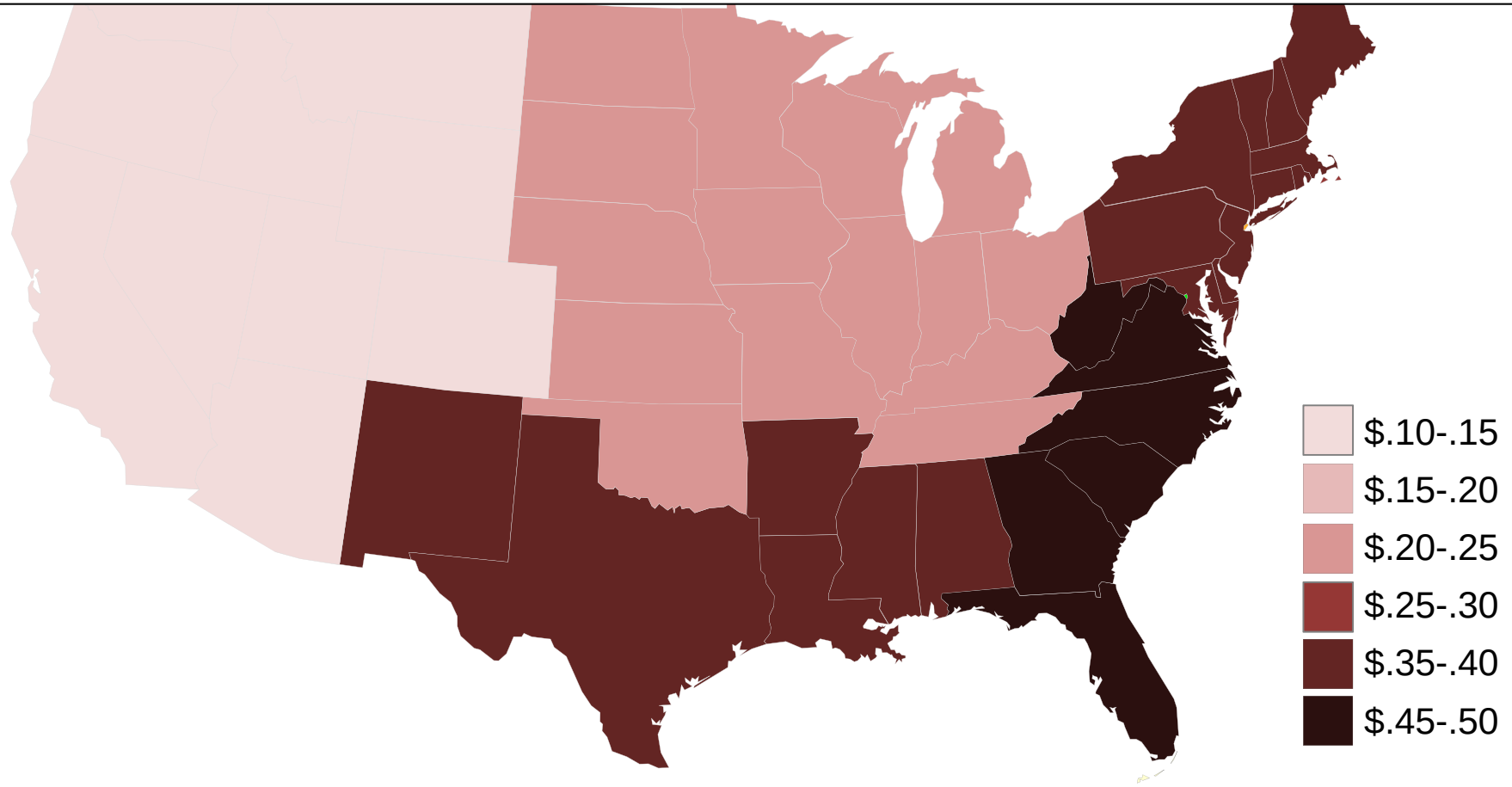
Hurricane Harvey, shut-in refinery capacity

Company	Site	Operable Capacity (bbl/day)	Percent of Total GOM Capacity (%)	Percent of Total U.S. Capacity (%)
ExxonMobil	Baytown	560,500	6.5%	3.0%
ExxonMobil	Beaumont	362,300	4.2%	1.9%
Flint Hills	Corpus Christi	296,470	3.4%	1.6%
Valero	Corpus Christi	293,000	3.4%	1.6%
Citgo	Corpus Christi	157,500	1.8%	0.8%
Buckeye Partners	Corpus Christi	46,250	0.5%	0.2%
Magellan	Corpus Christi	42,500	0.5%	0.2%
Shell	Deer Park	325,700	3.8%	1.7%
Marathon	Galveston Bay	459,000	5.3%	2.5%
Lyondell	Houston	263,776	3.1%	1.4%
Valero	Houston	191,000	2.2%	1.0%
Petromax	Houston	25,000	0.3%	0.1%
Petrobras	Pasadena	112,229	1.3%	0.6%
Motiva	Port Arthur	603,000	7.0%	3.2%
Valero	Port Arthur	335,000	3.9%	1.8%
Total	Port Arthur	225,500	2.6%	1.2%
Phillips 66	Sweeny	247,000	2.9%	1.3%
Valero	Texas City	225,000	2.6%	1.2%
Marathon	Texas City	86,000	1.0%	0.5%
Valero	Three Rivers	89,000	1.0%	0.5%
Total Shut-In Capacity		**4,945,725**	**57.3%**	**26.6%**
Total GOM Capacity		**8,637,186**	**100.0%**	**46.4%**
Total U.S. Capacity		**18,617,027**		**100.0%**

Source: U.S. Energy Information Administration; various trade press.

Change in U.S. regular gasoline prices

U.S. retail gasoline prices the week after Hurricane Harvey **were an average of $0.28 per gallon higher than prices the week before**. Supply disruptions and refinery outages caused will continue to affect **gasoline supply and prices**, particularly along the East Coast and Gulf Coast.



Source: U.S. Energy Information Administration.

Research questions

Committee-identified research questions

1. What are the coastal parameters/processes (e.g. storm surge, waves and currents, sediment transport etc.) that influence major/critical components of facility design, construction and operation for your organization and the industry?

2. What gaps do you perceive in these parameters/processes including technological maturity, physical understanding, data availability, data accuracy, conflicts, models' predictive abilities?

3. What time horizons (e.g. years, decades, century) are of interest to your organization and the industry with regard to each of these parameters/processes and where do you see gaps and uncertainties in how they may change over those time horizons?

4. How often do you typically utilize cutting-edge academic/research data/models from the coastal engineering/science community as opposed to benchmarked commercially available data and software, and what are the reasons behind these choices?

5. Who does your organization/industry consider a stakeholder when dealing with coastal issues?

6. What hurdles does your organization or the industry face when communicating with stakeholders (internal and external) about the science behind coastal processes/impacts and interactions with your facility and operations that are of mutual interest and concern?

7. What coastal parameters/processes do you address with regard to assessing any impacts from your facilities to the environment (natural, social) during construction and operations, and what are the perceived gaps in assessing these faithfully?

8. Are there are particular areas of research within coastal engineering and science that you would recommend be addressed that could fill in any gaps perceived by your organization and the industry?

9. How can this NASEM committee and its ultimate technical recommendations support the goals and objectives of your organization and the industry in sustaining the development of energy infrastructure along the Gulf coast?

10. How is facility planning, design, construction and operation in the coastal zone of the Gulf of Mexico similar/different from other environments your organizations works in, especially with regard to coastal issues? Are there lessons from other systems that could provide insights for the GOM and visa-versa?

11. How do you see the energy industry and associated infrastructure along the Gulf coast evolving in the next decades and century?

Question 1: Coastal design parameters.

1. What are the coastal parameters/processes (e.g. storm surge, waves and currents, sediment transport etc.) that influence major/critical components of facility design, construction and operation for your organization and the industry?

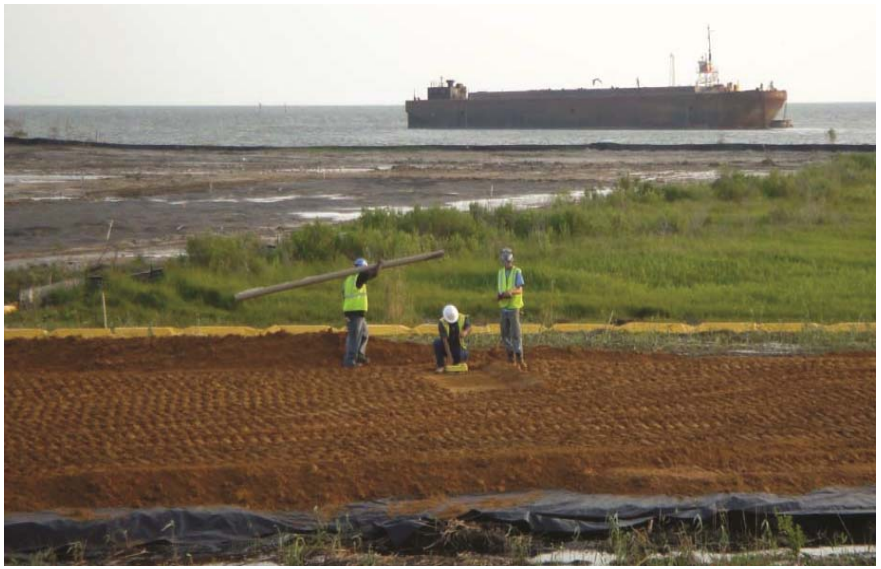
RESPONSE:

Energy infrastructure investments are changing, particularly in the coastal zone, to address increasing environmental stresses. This includes raising elevations of various new facilities to levels that can withstand storm surge and flooding events, as well as hardening assets, like power lines and natural gas transportation lines, for exposure.

Example – Cameron LNG site preparation.

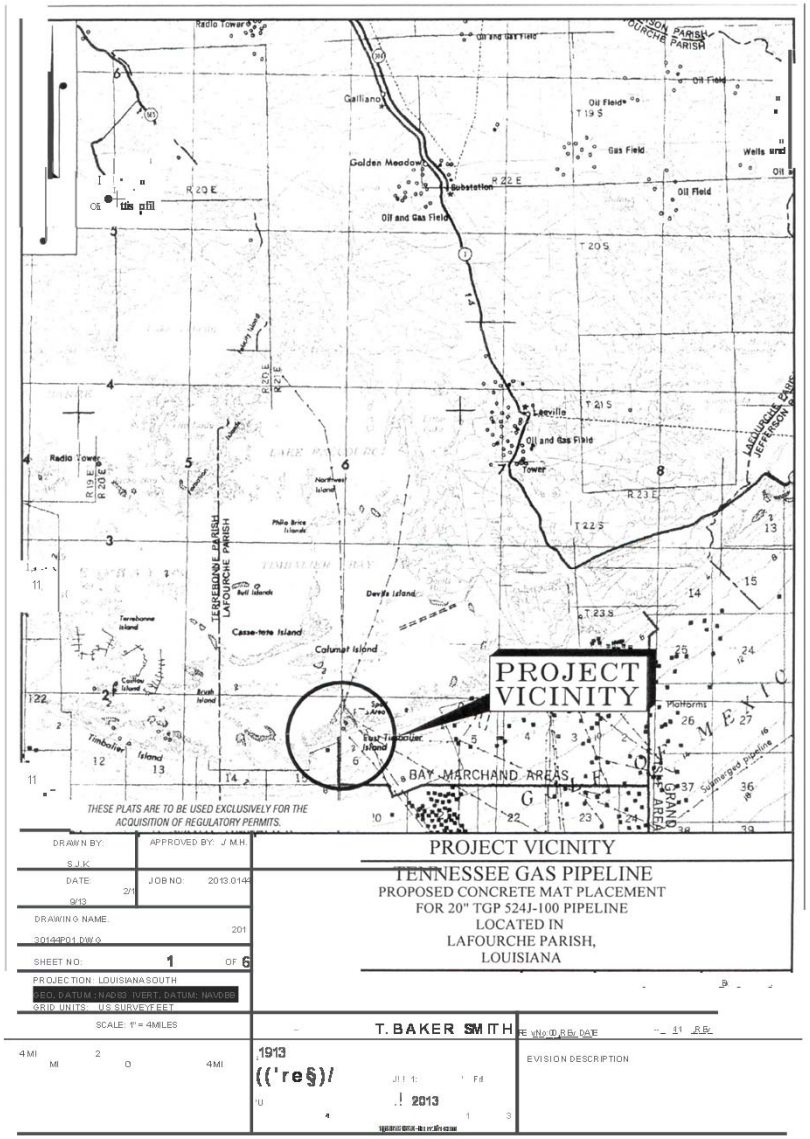
James Construction Group presentation, May 2017.

Example – Gulf LNG site preparation.

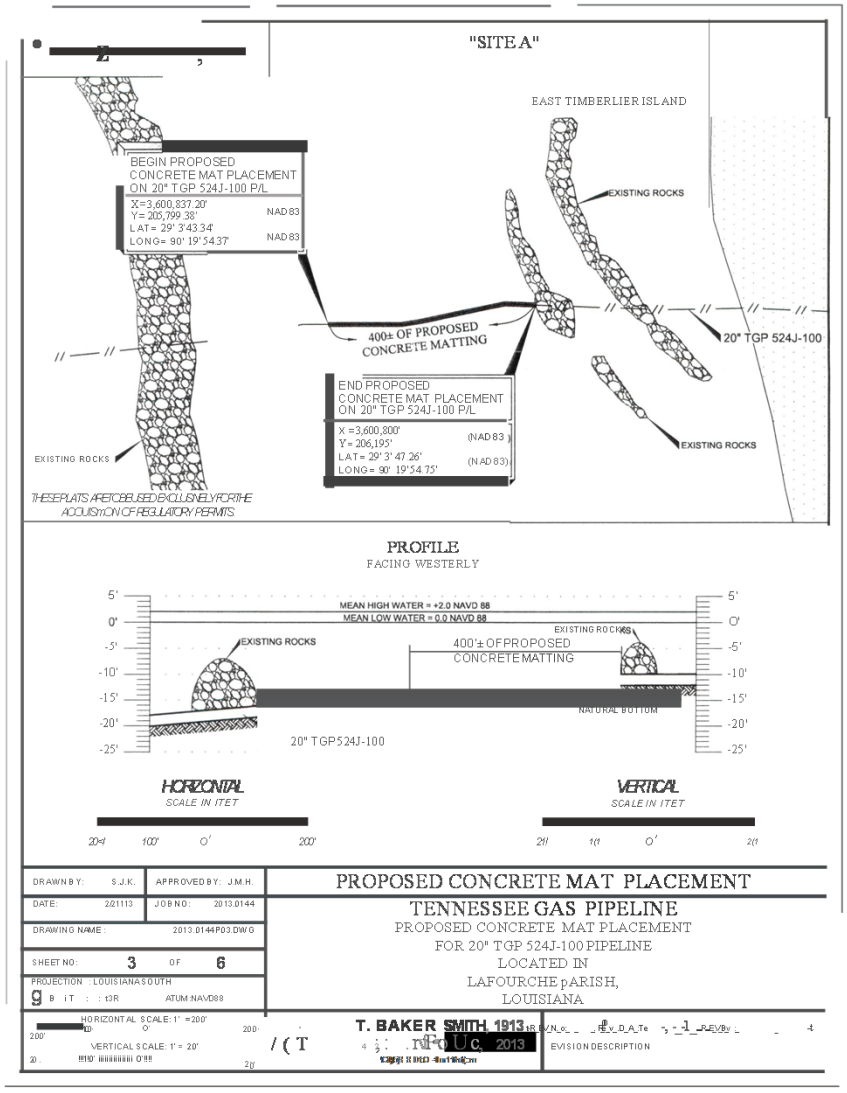


Example -- SASOL (ethane cracker) site preparation.

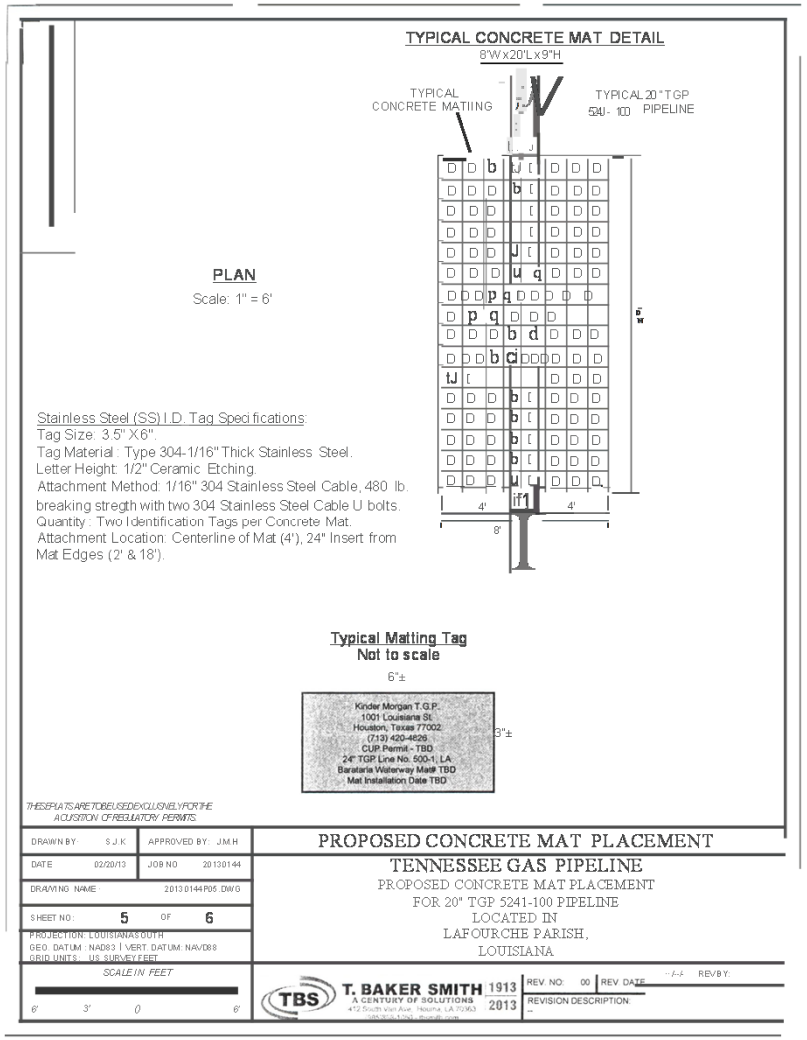
Example – pipeline exposure – former Tennessee pipeline system.



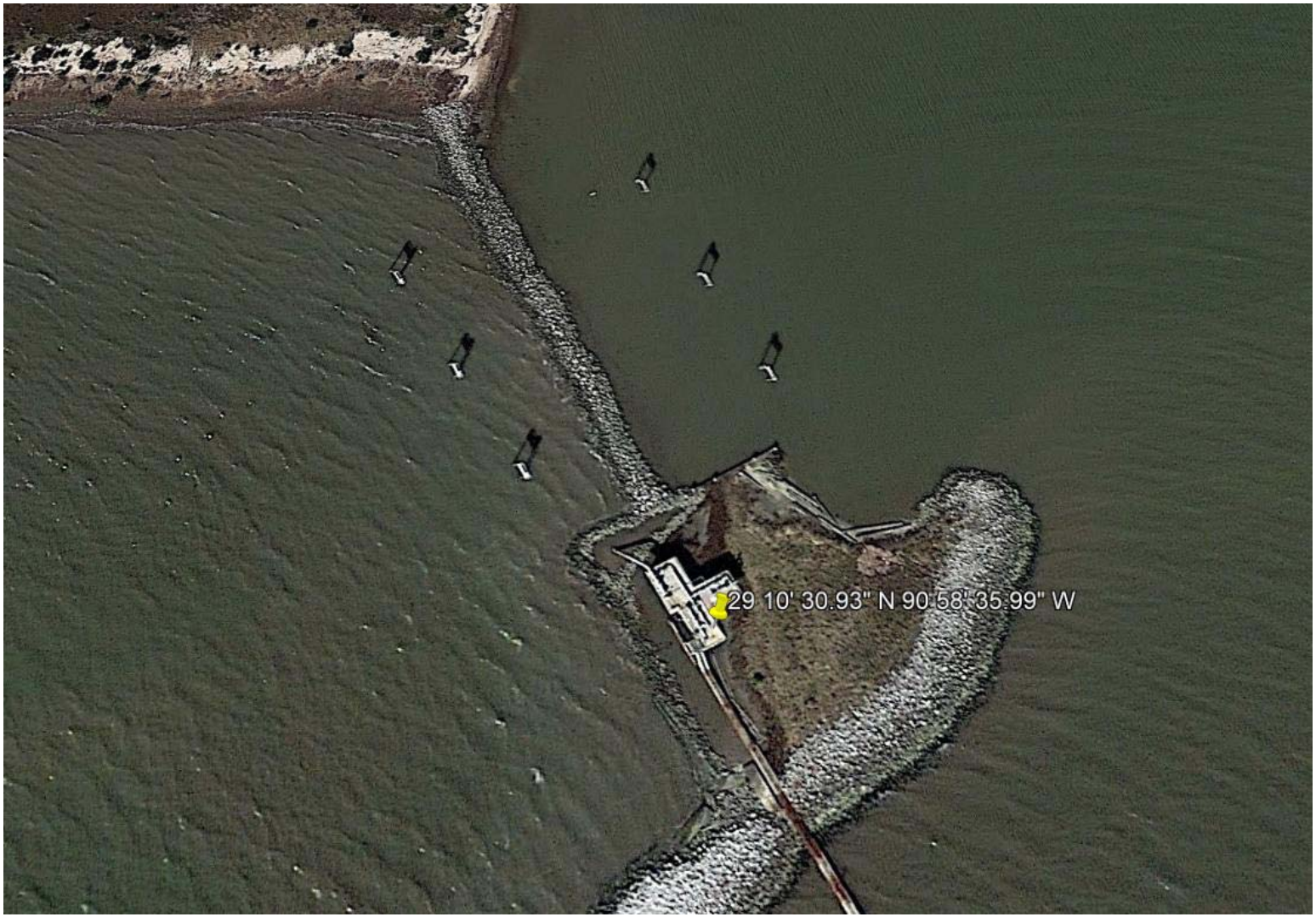
Example – pipeline exposure – former Tennessee pipeline system: layout schematic.



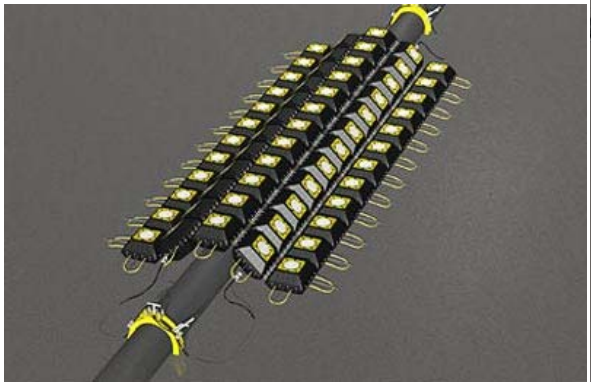
Example – pipeline exposure – former Tennessee pipeline system: matting schematic.

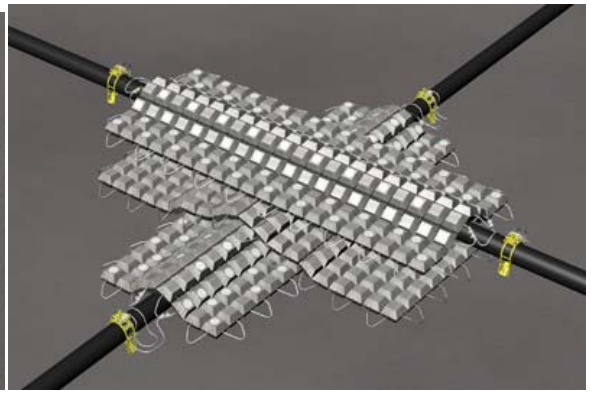


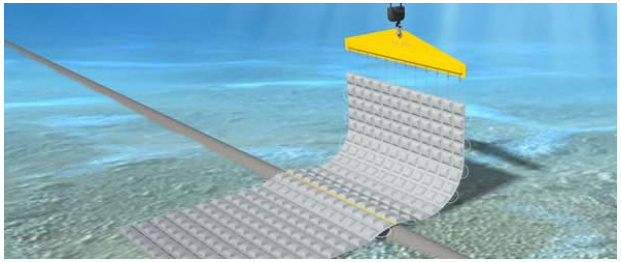
Example – pipeline exposure – former Tennessee pipeline system: photo.



Other pipeline matting configurations.







Question 2: Design parameter gaps.

2. What gaps do you perceive in these parameters/processes including technological maturity, physical understanding, data availability, data accuracy, conflicts, models' predictive abilities?

RESPONSE:

Current gaps include (but are not limited to) understanding, on a consistent basis, how existing infrastructure, and new infrastructure, are being modified to adapt to new environmental conditions and quantifying the impact these new reliability/resiliency measures are having on infrastructure development (as well as understanding their effectiveness).

Question 3: Time horizons.

3. What time horizons (e.g. years, decades, century) are of interest to your organization and the industry with regard to each of these parameters/processes and where do you see gaps and uncertainties in how they may change over those time horizons?

RESPONSE:

Short term decisions and longer-term impacts are important given the long-lived nature of these types of assets.

Question 4: Academic vs. industry data and methods.

4. How often do you typically utilize cutting-edge academic/research data/models from the coastal engineering/science community as opposed to benchmarked commercially available data and software, and what are the reasons behind these choices?

RESPONSE:

- Academic modeling can be used in certain cases, particularly with simulation modeling, but most of this is contingent on the scope of the available information. It is difficult to model energy infrastructure development when there are often a limited number of "data points."
- Commercially-available data is often relied upon.

Question 5: Stakeholder definitions.

5. Who does your organization/industry consider a stakeholder when dealing with coastal issues?

RESPONSE:

Any party with a vested interest that usually is organized into a bona fide group. CES tends to have a relatively heavier focus on industry-related relationships as well as relationships with regulators.

Question 6: Stakeholder communications.

6. What hurdles does your organization or the industry face when communicating with stakeholders (internal and external) about the science behind coastal processes/impacts and interactions with your facility and operations that are of mutual interest and concern?

RESPONSE:

Energy infrastructure development, even along the central Gulf Coast, is becoming more adversarial – more national advocacy groups are participating in the permitting process, particularly on pipelines.

Question 7: Perceived gaps in coastal parameters/processes

7. What coastal parameters/processes do you address with regard to assessing any impacts from your facilities to the environment (natural, social) during construction and operations, and what are the perceived gaps in assessing these faithfully?

RESPONSE:

CES' research focusses more heavily on the economic and regulatory issues associated with infrastructure development and how that development changes, particularly with regard to offshore activities.

Question 8: Research priorities

8. Are there are particular areas of research within coastal engineering and science that you would recommend be addressed that could fill in any gaps perceived by your organization and the industry?

RESPONSE:

- Continued changing nature of infrastructure to meet resiliency challenges.
- The role of infrastructure in perhaps supporting (or undermining) local resiliency – understanding the relationship of the infrastructure and its impact on the human/social environment.

Question 9: NASEM support actions.

9. How can this NASEM committee and its ultimate technical recommendations support the goals and objectives of your organization and the industry in sustaining the development of energy infrastructure along the Gulf coast?

RESPONSE:

- Continued research interest and funding in these important issues.
- Facilitating dialogues, particularly with industry, on understanding these issues.

Question 10: Similarity of GOM to other coastal areas.

10. How is facility planning, design, construction and operation in the coastal zone of the Gulf of Mexico similar/different from other environments your organizations works in, especially with regard to coastal issues? Are there lessons from other systems that could provide insights for the GOM and visa-versa?

RESPONSE:

The Gulf Coast is one of the most unique working coasts in the world. Not clear that there are considerable lessons learned that could be brought to the GOM – perhaps many that could be extended to other emerging frontier areas.

Question 11: GOM industry evolution.

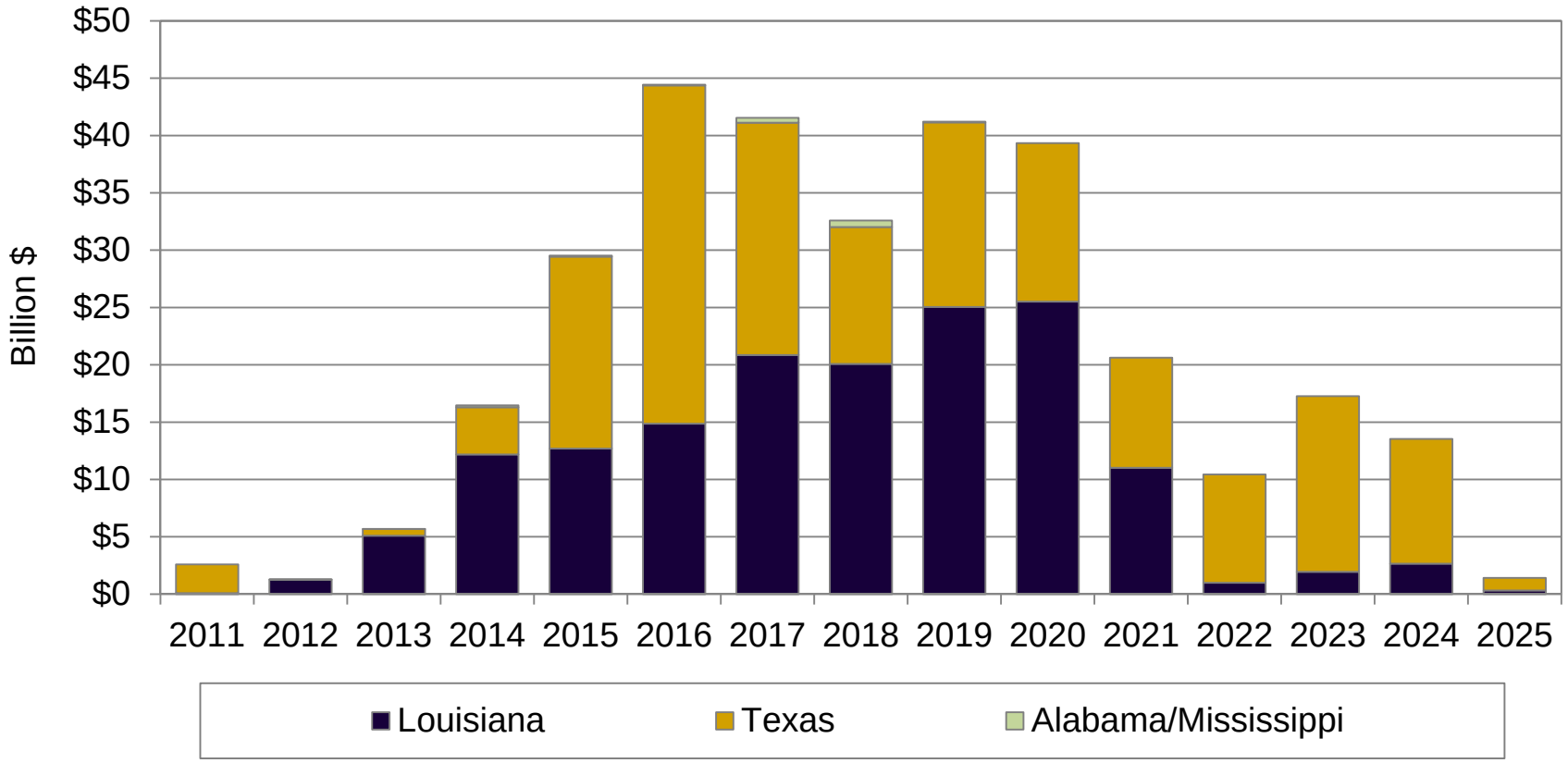
11. How do you see the energy industry and associated infrastructure along the Gulf coast evolving in the next decades and century?

RESPONSE:

- GOM critical energy infrastructure is getting a "second wind" due to unconventional oil and gas activity.
- Infrastructure is being modified to meet new markets/requirements (i.e., growing U.S. energy export market).

Gulf of Mexico region – state-specific total capital expenditures

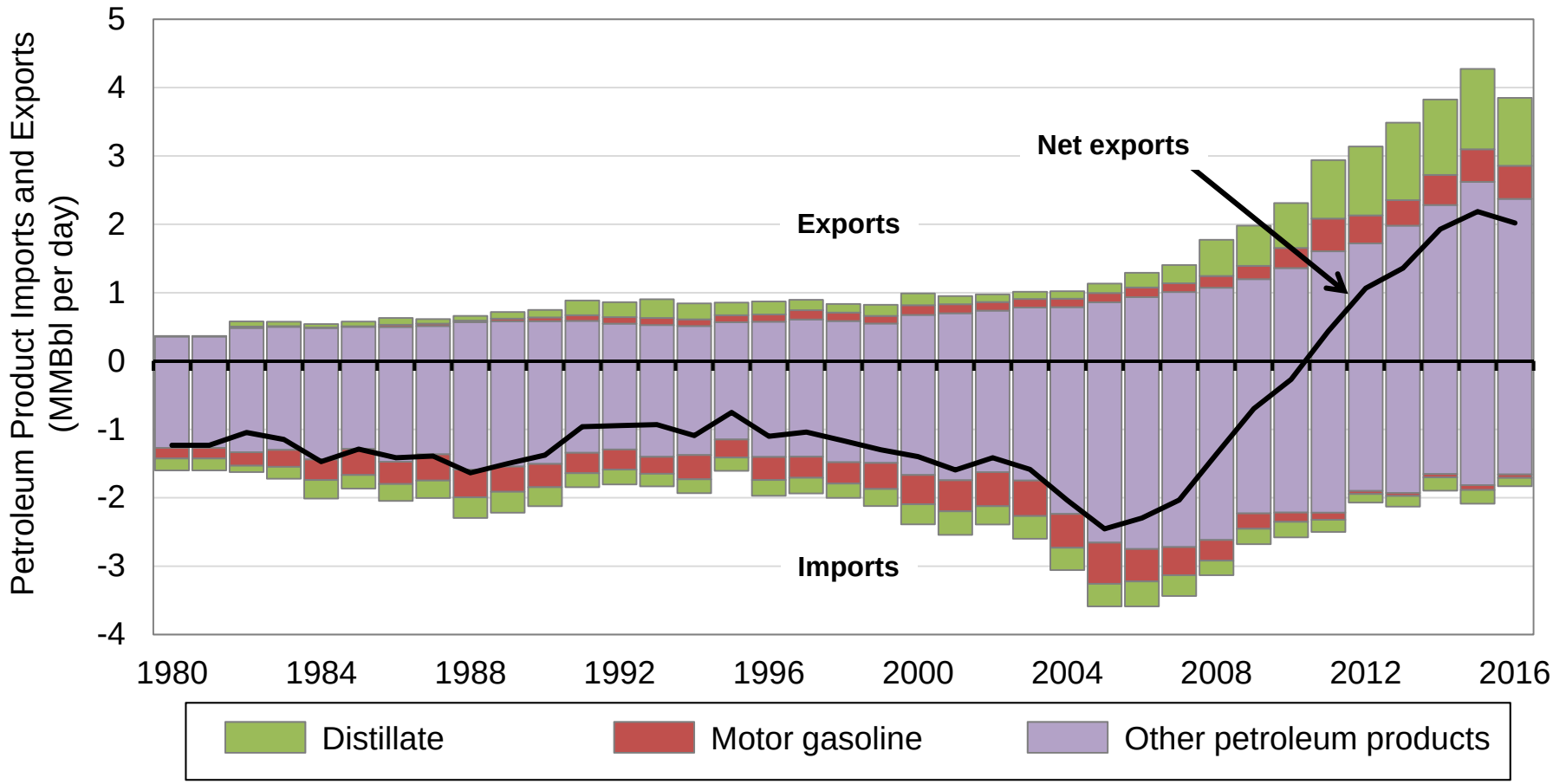
The continued low natural gas price outlook has facilitated considerable development of over $318 billion: $100 billion already completed, $218 billion remaining.



Source: Louisiana State University, Center for Energy Studies.

U.S. petroleum product imports and exports

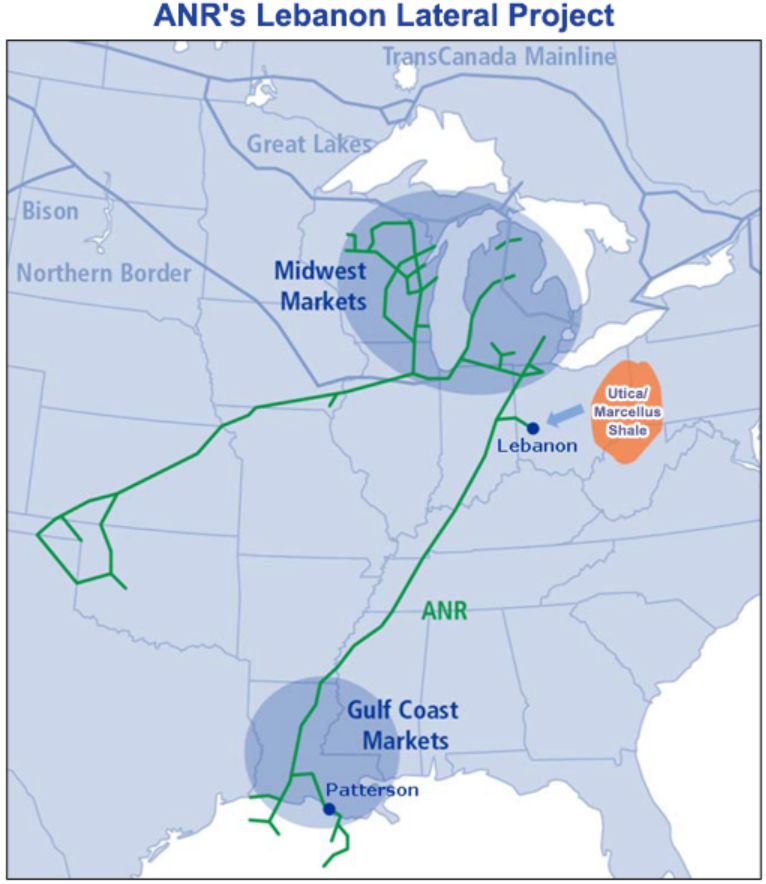
In 2011, the U.S. became a net exporter of petroleum products. Net exports have increased 360 percent since then.



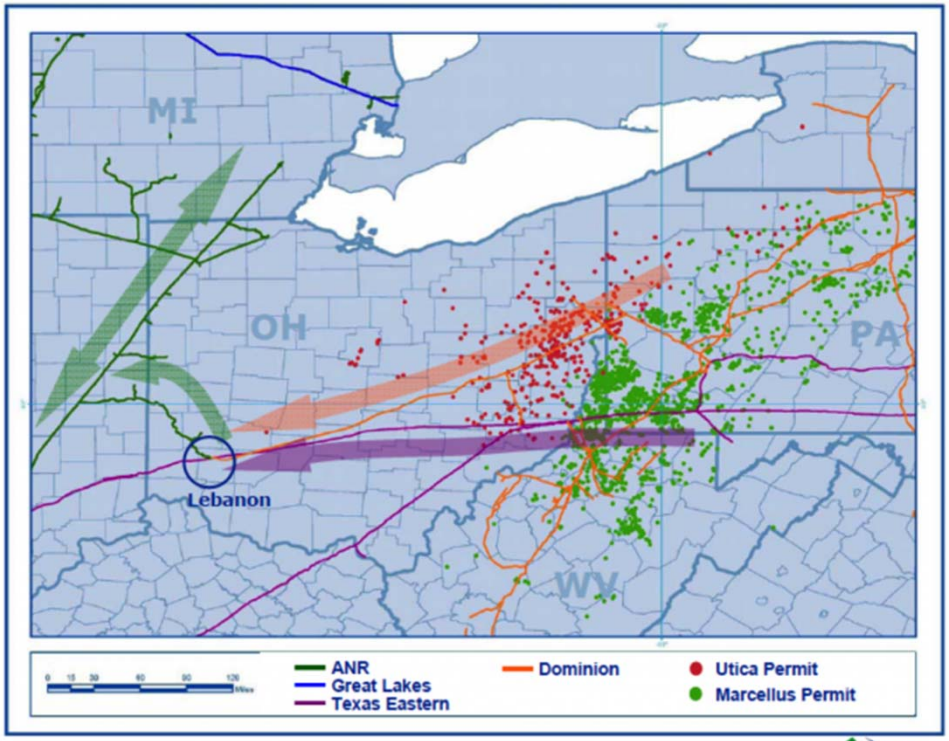
Source: Energy Information Administration, U.S. Department of Energy.

Natural gas pipeline reversal

ANR Pipeline's Southeast line was constructed to transport gas from south Louisiana, north to Michigan. The Lebanon Lateral was built as a joint venture between ANR and Texas Eastern to bring additional supplies into northeast markets by delivering gas into Texas Eastern and Dominion systems. Today, those supplies are not longer needed as Appalachian production is displacing those long haul supplies. Flows have been reversed on the Lebanon Lateral, as well as the Southeast line, moving gas north and south.



Source: TransCanada



TransCanada

Examples of other selective industry changes

Infrastructure Category	GOM Outlook	Influencing Factors
Petrochemicals	↑	low natural gas prices; diverse sources; low volatility.
Refineries	↑	low crude oil prices, diverse crude quality, diverse sources.
Power Generation	↔	flat intrinsic growth because of efficiency measures; new end uses.
Pipelines	↑	diverse resource mix; northeast constraints; re-purposing, re-orientation opportunities.
Storage	↓	No supply volatility; ample storage of intrinsic growth.
Gas Processing	↑	Growing liquids market
Shipyards, bases, and marine terminals	↓	Decreasing offshore activity.
LNG	↑	Increasing export oppportunites; abundant, diverse supplies.

Questions, Comments and Discussion

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