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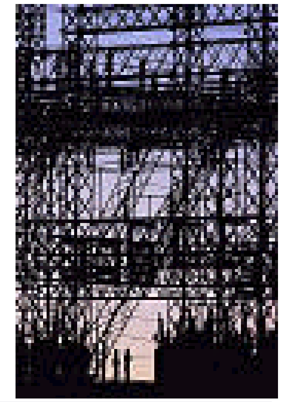

Integrated carbon capture, utilization and storage in the Louisiana chemical corridor.

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Introduction

Project motivations

On November 16, 2016, LSU announced that it was awarded a $1.3 million grant to examine the opportunities for carbon capture, utilization, and storage (“CCUS”) from the U.S. Department of Energy, Office of Fossil Energy.

The **goals of this project are consistent** with those articulated in the mission of the Office of Fossil Energy which is to help the United States meet is continual need for secure, affordable and environmentally-sound fossil energy supplies.

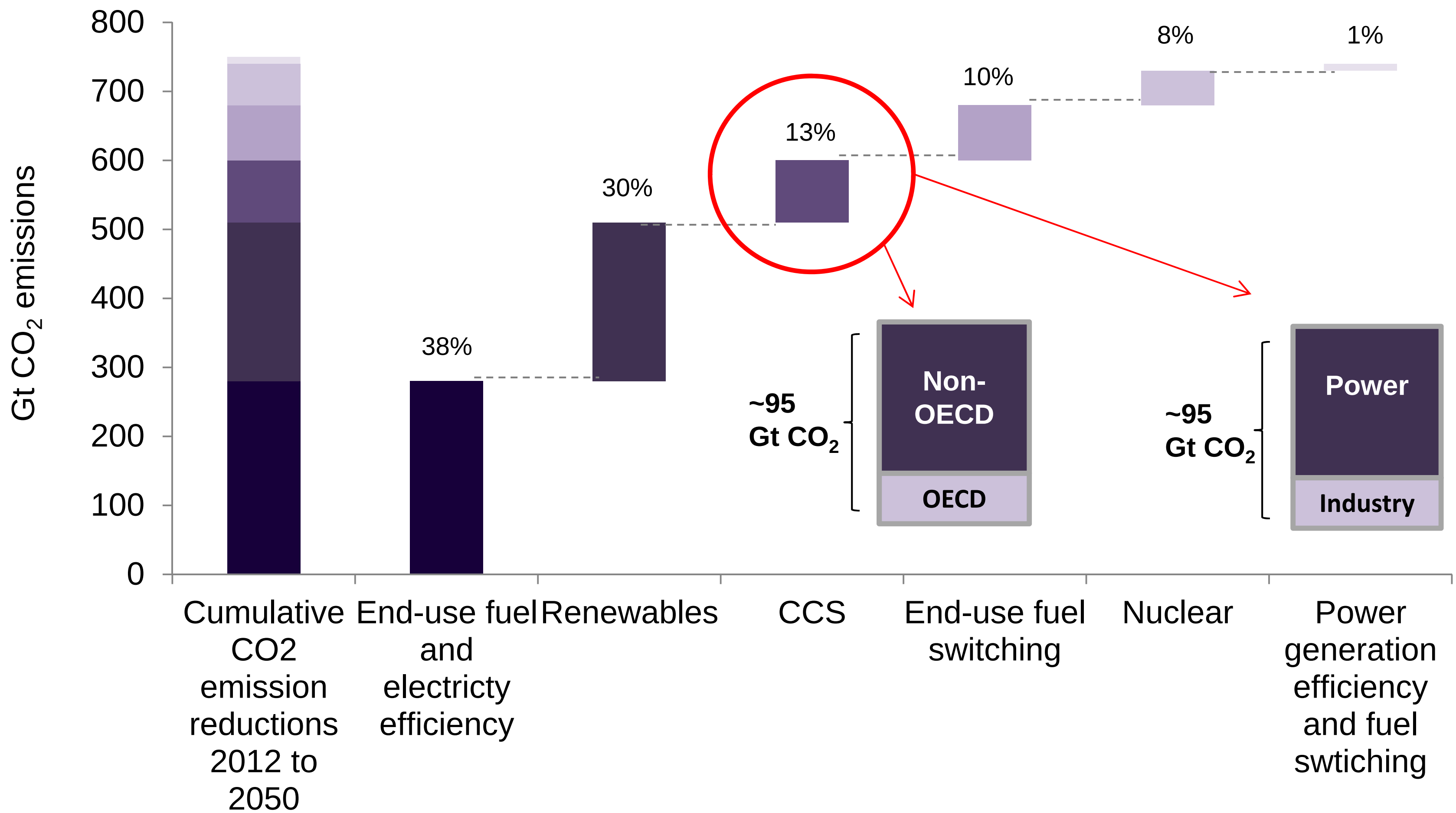
The motivation for funding this, and other similar research projects, is based upon the **recognition that several current and proposed federal and state regulations could severely limit the ability of current and future fossil energy sources to emit carbon to the atmosphere**.

Further, **public demand for energy from low-carbon sources** is growing and will continue to grow in the foreseeable future.

Concurrently, **many major energy-intensive industries**, that span various aspects of the energy value chain, **already recognize these constraints** and public pressures, particularly those energy companies that have an international footprint. Many are also looking at international solutions to this challenge, irrespective, in some instances, of domestic requirements.

Technical potentials for carbon emissions reductions (global).

CCUS is often recognized as an important and considerable means of addressing the carbon emissions problems from fossil fuels.



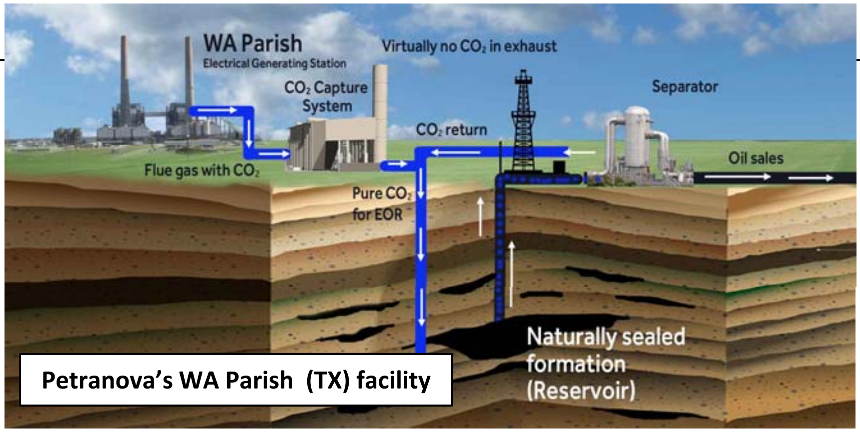
Source: IEA, Energy Technology Perspectives (2015).

Current challenges

One of the **key gaps** in the critical path towards the development of commercial-scale CCS applications in the U.S. has been in **identifying the commercial opportunities and challenges associated with a commercial application** (50 plus million metric ton of storage).

As a result, industrial/commercial applications will **bear a considerable amount of project development risk.**

While there have been some **limited investigations** associated with CCUS applications, they have been **restricted primarily to power applications and not completely with industrial applications** – this is particularly true along the GOM where the two leading applications are based upon the capture of carbon from solid fuel power generation.



Petranova's WA Parish (TX) facility

Southern Company's Kemper MS facility

CarbonSAFE goals

Phase 1 CarbonSAFE goals are to provide funding to research groups capable of (1) **formulating a team** to address the **technical and non-technical challenges** specific to commercial-scale deployment of the CO_2 industrial storage project; (2) development of a **plan encompassing technical requirements** as well as both **economic feasibility and public acceptance** of an eventual storage project; and (3) **high-level technical evaluations of the sub-basin and potential CO_2source(s)**.

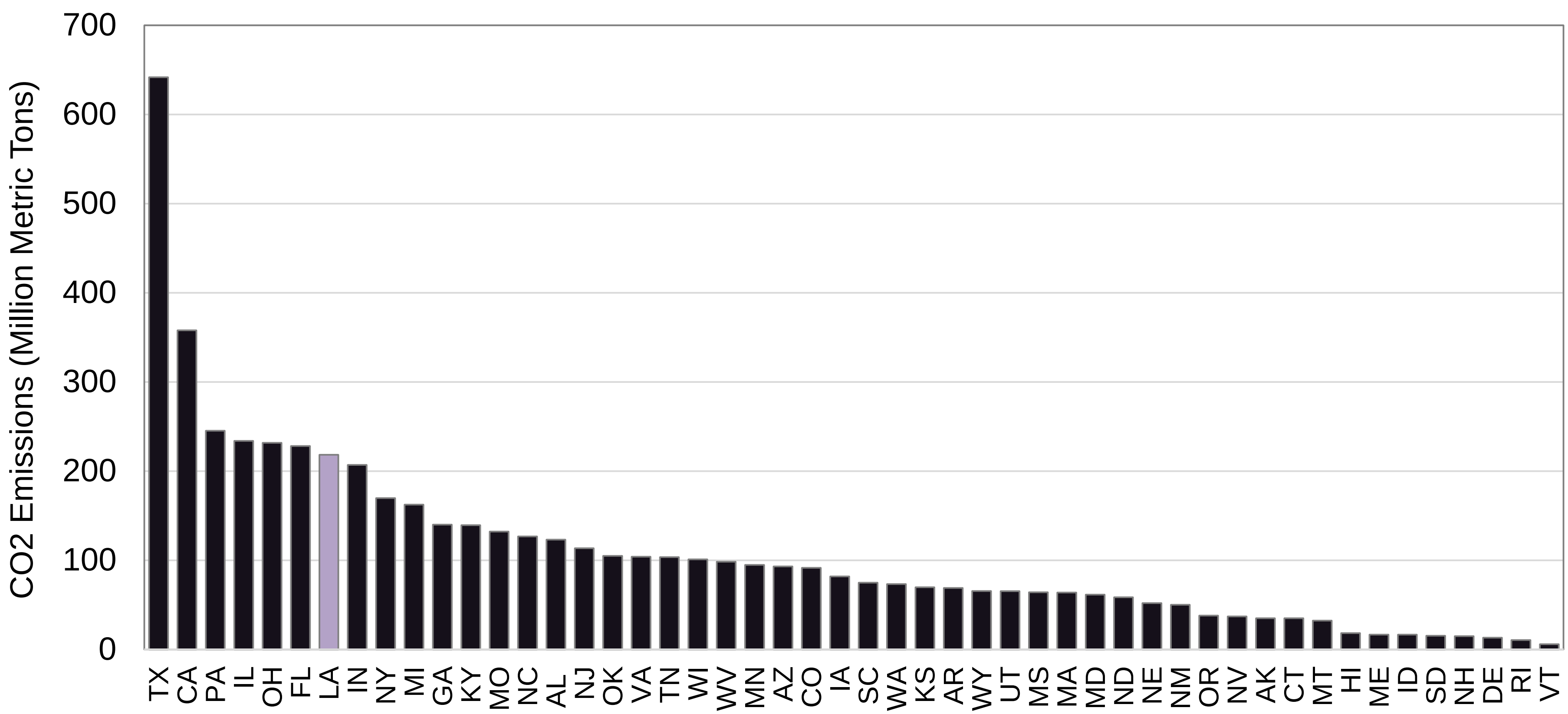
From a business development perspective, having a **geographically-concentrated** physical location with **diversified sources** will be critical in developing positive feasibility outcomes.

Our group believes that the **Louisiana industrial corridor is a well-suited location** to focus these feasibility study efforts, and generate positive results, since:

1) There are a **large number of** geographically-concentrated and diversified **sources** of CO2.
2) There are a **large number of** geographically-concentrated and diverse **storage locations (or "sinks").**
3) There are sufficient number of opportunities to develop **transportation infrastructure linking supply to storage** in these areas.
4) This is a region with a **long history and commercial experience in moving and storing a number of different hydrocarbons**, as well as other hydrocarbon wastes, into underground geological formations.

Energy-Related Emissions by State, 2014

At just under 220 million metric tons of CO2 emissions, Louisiana ranks seventh in the U.S.

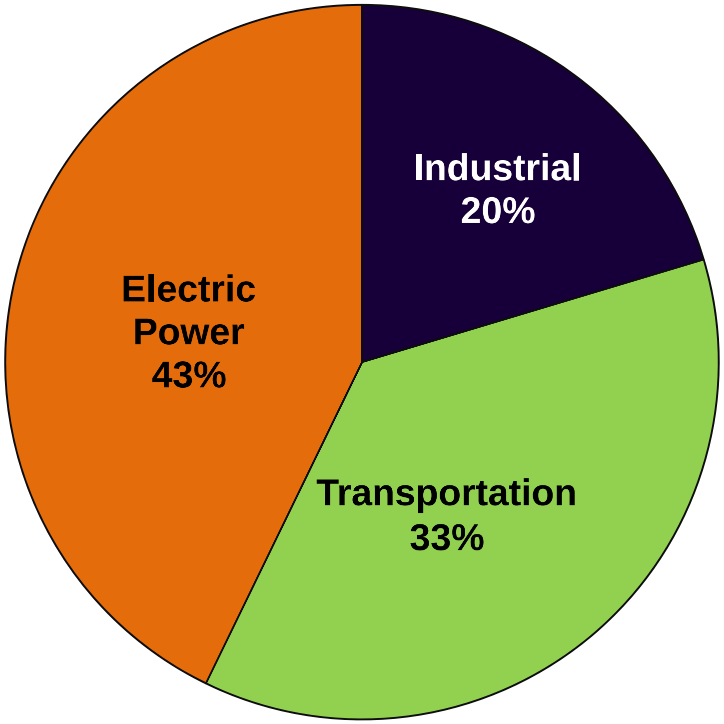


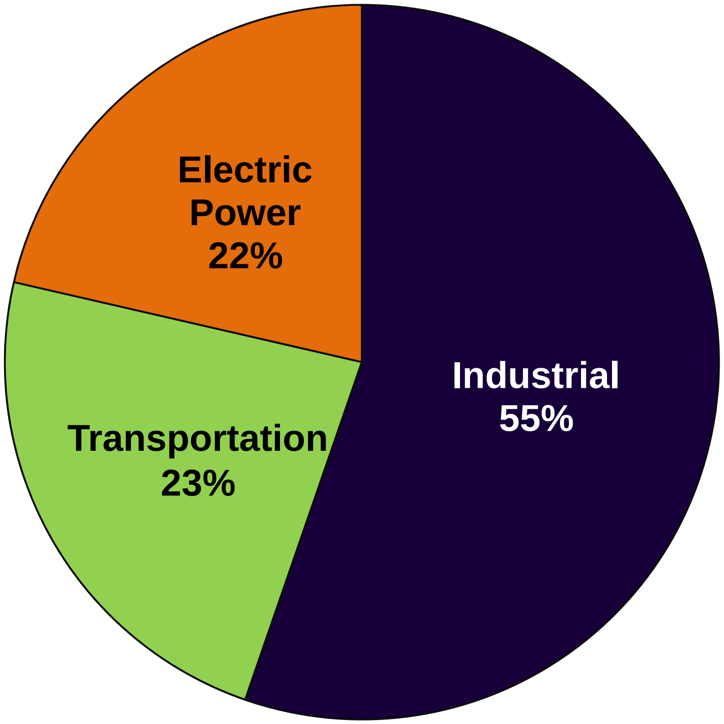
Source: Energy Information Administration, U.S. Department of Energy.

U.S. and Louisiana CO_2 Emissions per Sector, 2013

In the U.S., power generation comprises over 40 percent of overall national emissions.

In Louisiana, power generation comprises about 22 percent of overall state emissions. Louisiana's primary source of CO_2 emissions comes from industry.

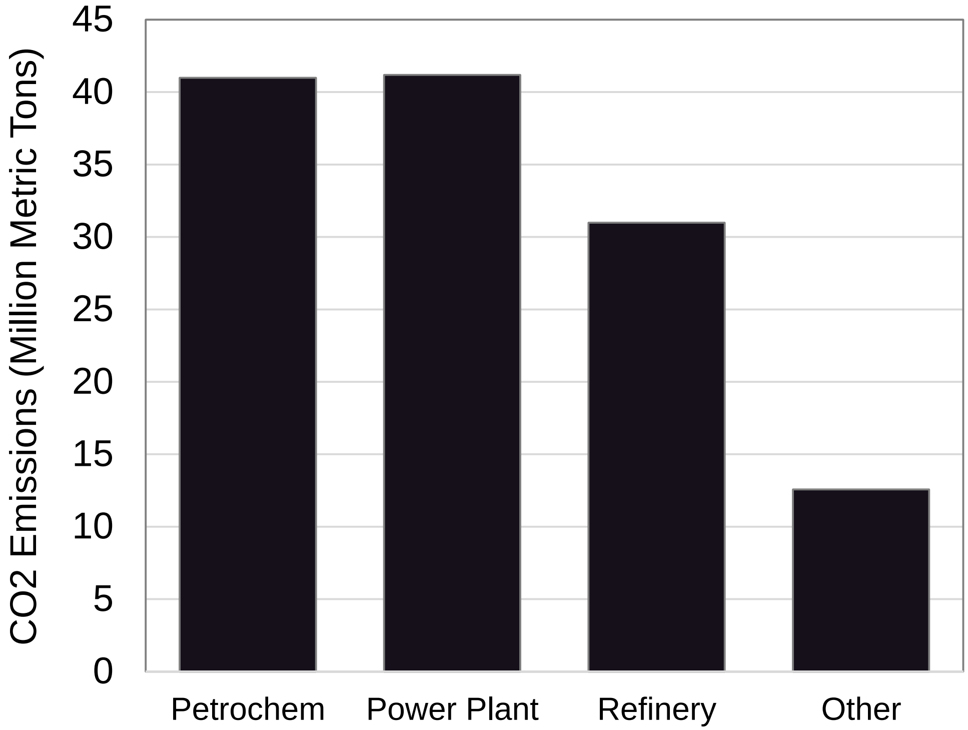


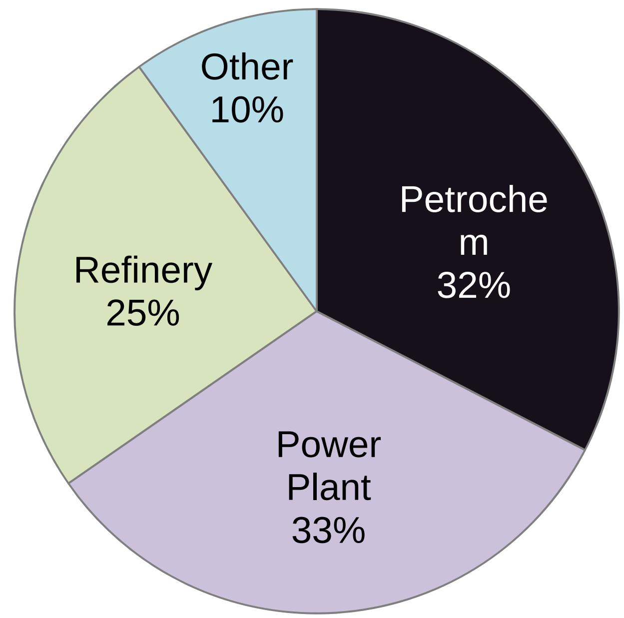


Source: Energy Information Administration, U.S. Department of Energy.

Louisiana Stationary CO2 Emissions, 2014

Petrochem facilities are the larger Louisiana carbon emission sources, followed by power plants and then refineries.

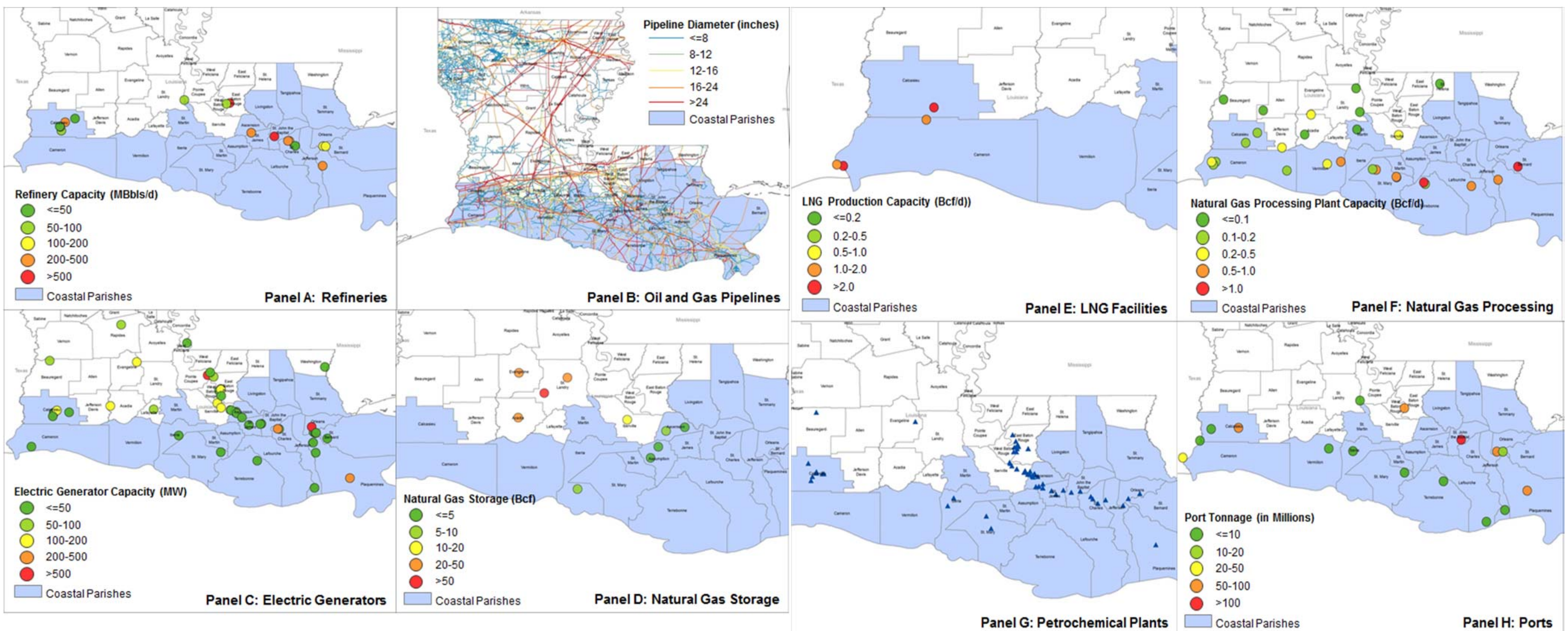




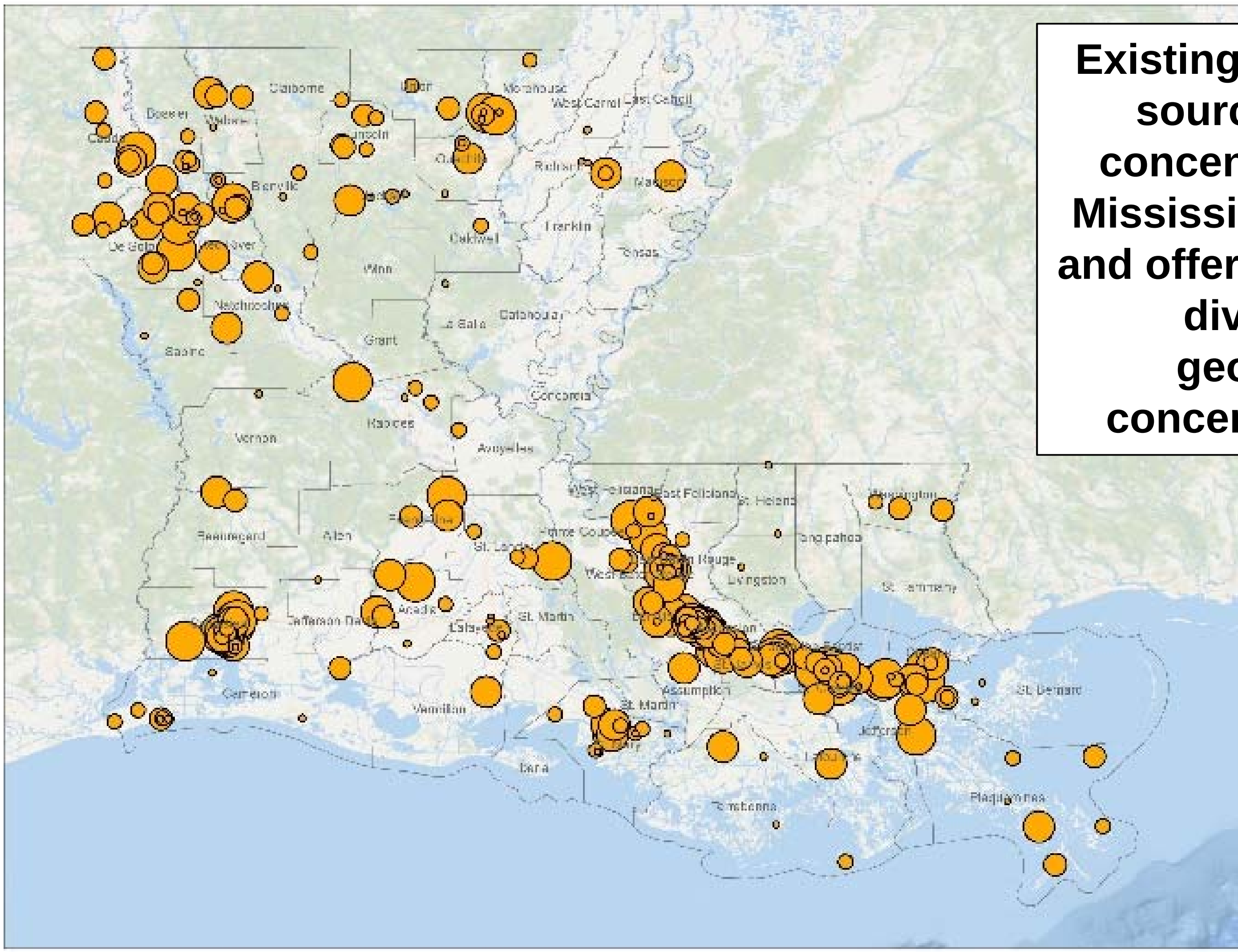
Source: Energy Information Administration, U.S. Department of Energy.

Louisiana's critical energy infrastructure.

Louisiana has a plethora of critical energy infrastructure. Refineries, certain petrochemical facilities, and gas processing facilities can serve as important carbon sources. The existing pipeline and storage infrastructure underscores opportunities for linking potential sources and sinks.



Louisiana industrial emission sources.

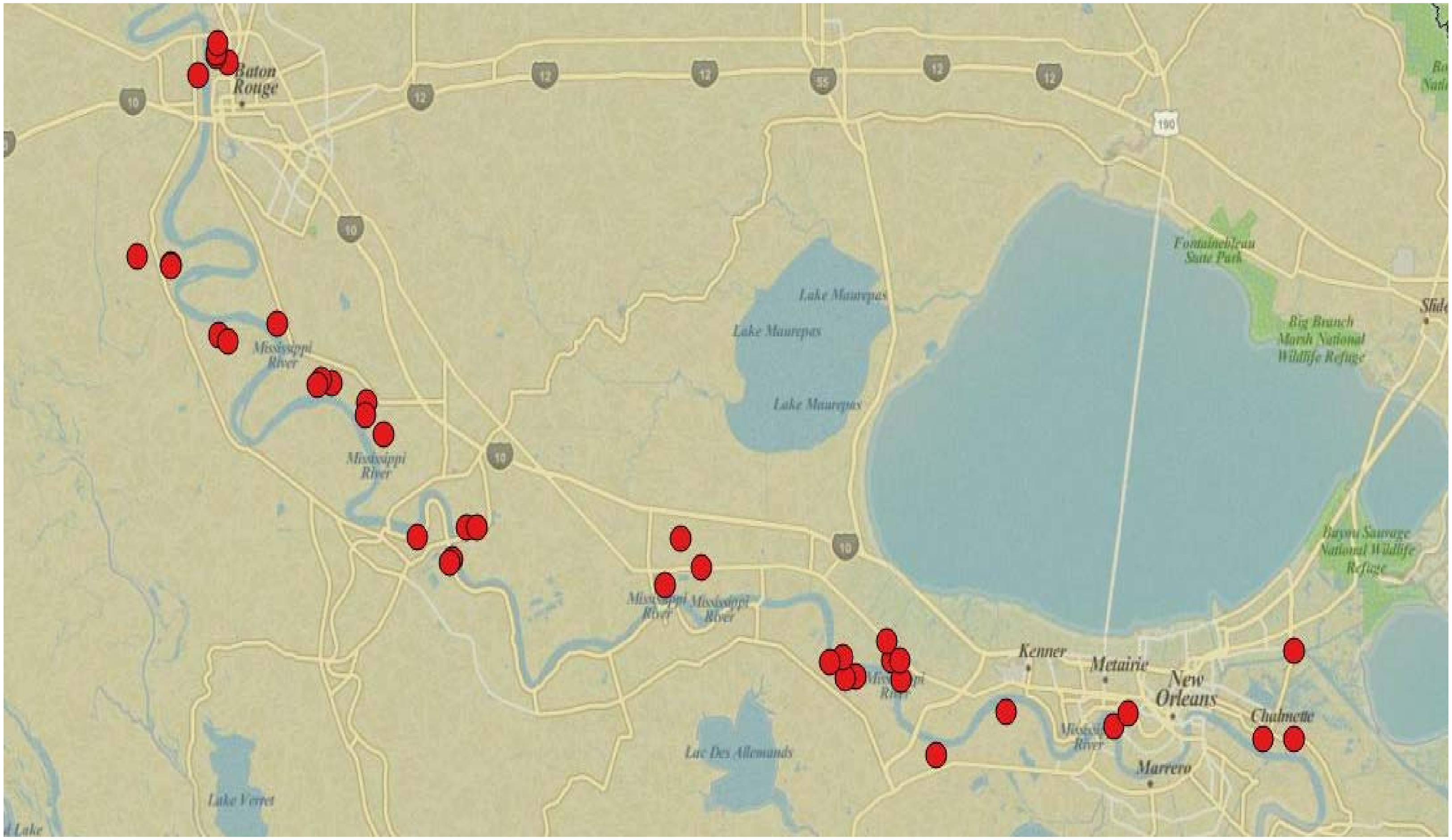


Existing carbon emission sources are heavily concentrated along the Mississippi River corridor and offer a large number of diversified and geographically-concentrated sources.

Proposed Project

Part 1: Identifying carbon sources and emissions levels

Preliminary analysis shows there are considerable potential industrial sources (250,000 metric tons or greater) in a geographically-concentrated area.



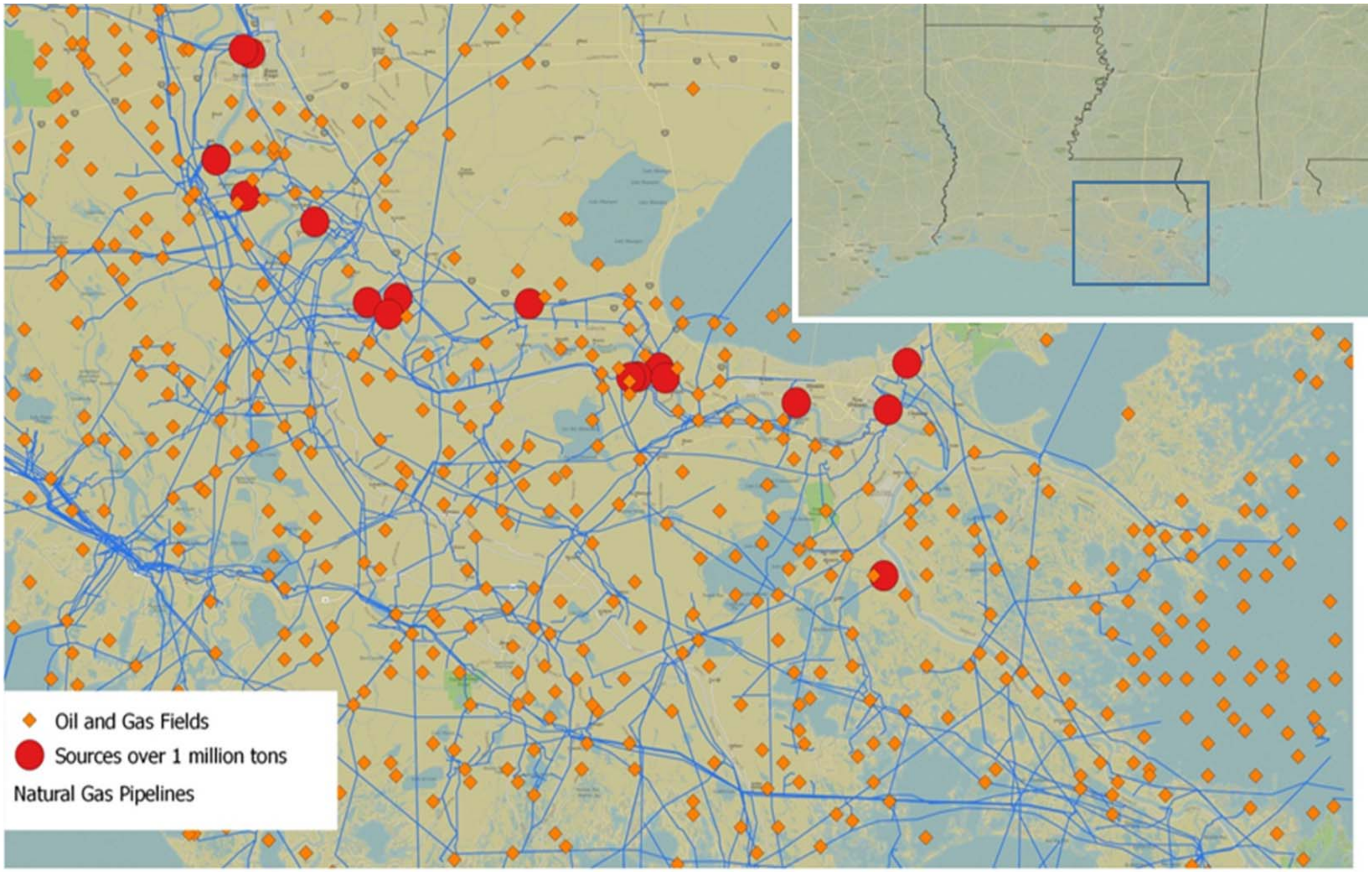
Part 2: Sink Site Selection

- **Site selection criteria**:
  - Proximity to CO_2 sources
  - Potential for CO_2 containment
  - Potential for large storage capacity
- **Initial site screening by LGS (Louisiana Geological Survey)***
- **Site specific data collection from public source (SONRIS)**
  - Field production history (initial site potential)
  - Well data (active and abandoned)
  - Well logs (to estimate pore space)
  - Well history data:- cement tops, plugged data etc (to estimate leakage risk)

Source: *Chacko John, Warren Schulingkamp, Bobby Jones, Brian Harder & Reed Bourgeois, (2011). "Potential for Carbon Dioxide Sequestration in Five Fields along the Mississippi River Industrial Corridor in Louisiana", LGS, LSU.

Part 2: Potential sinks and transportation alternatives

There are a number of oil and gas production reservoirs, some of which are depleted, that could be used as sources with considerable co-located transport infrastructure.



Part 3: Storage Capacity Estimation – Two Approaches

Static Estimation Approach

- Pore volume estimates (mainly based on well log data)
- Initial temperature and pressure Supercritical CO_2 volume estimates as discounted pore volume (using storage efficiency factor)
- Capacity estimation for multiple geological model realizations

Dynamic Estimation Approach

- Reservoir numerical simulations
- Boundary conditions sensitivity
- Injection scheme sensitivity
- Monitorability of injected CO_2
- NRAP tools will be used wherever they could provide additional information

Part 4: Baseline seismicity monitoring

In the US, **recent increases in the numbers of induced seismic events** accompanying the subsurface storage of fluid waste **has created public concern** and cast a shadow over the use of CO_2 storage technology. **We propose to apply a key lesson learned from public perceptions to hydraulic fracturing**, to provide open information on the potential seismic risk and occurrence of natural seismic activity.

Our proposed CO_2 sequestration site(s) in **Louisiana have a great natural advantage because of their low chance of natural earthquake damage and activity.** Reviews of natural and induced seismicity across Louisiana for the period April 2010 and July 2012 confirm **the low level of natural seismicity** but also highlight nearby sources of induced seismic activity possibly associated with wastewater injection.

Without baseline monitoring, if seismic events become more noticeable during the sequestration phase, the exact cause of these seismic events is harder to evaluate. A baseline evaluation of natural seismicity is required to facilitate later analysis of potentially induced events during sequestration phase.

Part 5 & 6: Legal analysis and stakeholder interest/concerns/comments

Legal Issues

The use of the subsurface to permanently store captured carbon emissions is replete with a **number of legal and public policy issues**. **Liability** is one issue that often comes to mind. This phase of the project will examine **a wide range of issues associated with underground carbon storage as well as transport (eminent domain)** that will have to be addressed clearly before any commercial application can be determined as being feasible.

Public Acceptance Issues

Project team members will work with **federal, state and local community groups to ascertain issues** associated with the public acceptance of carbon capture and storage in the Louisiana industrial corridor. We will also **work at disseminating the results of this research, and its importance, on an ongoing basis**.

Conclusions

Conclusions

Louisiana has a **confluence of factors** that should lead to a **successful development of a CCS feasibility analysis**.

The state has several **large emission sources and sinks and is a great test location**.

These sources and sinks are **geographically concentrated**, yet **diversified** across a number of different industrial facilities.

The feasibility study arises from this work, therefore, will likely have **broad applicability in the industrial corridor** between **Baton Rouge and New Orleans** as well as from **Lake Charles to Cameron Parish.**

The **project team is already making progress** on our initial tasks and see **no near term barriers to successfully completing this project.**

Questions, comments and discussion

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