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Louisiana energy manufacturing development outlook and the energy transition

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

Introduction: Why industrial decarbonization?

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Increasing emphasis on net zero GHG emissions.

Over the past several years, several states have announced a goal of **reducing greenhouse gas ("GHG") emissions to "net zero" by a date certain**.

These state level initiatives also align with those of the **current Biden administration**.

This can be a **very ambitious goals for some states, particularly those that have large industrial sectors,** including those that have chemical manufacturing.

The challenges can be difficult for industrial states since: (a) they have **high relative GHG emissions levels** and (b) the **availability of substitutes and alternatives to traditional fossil fuels can often be limited.**

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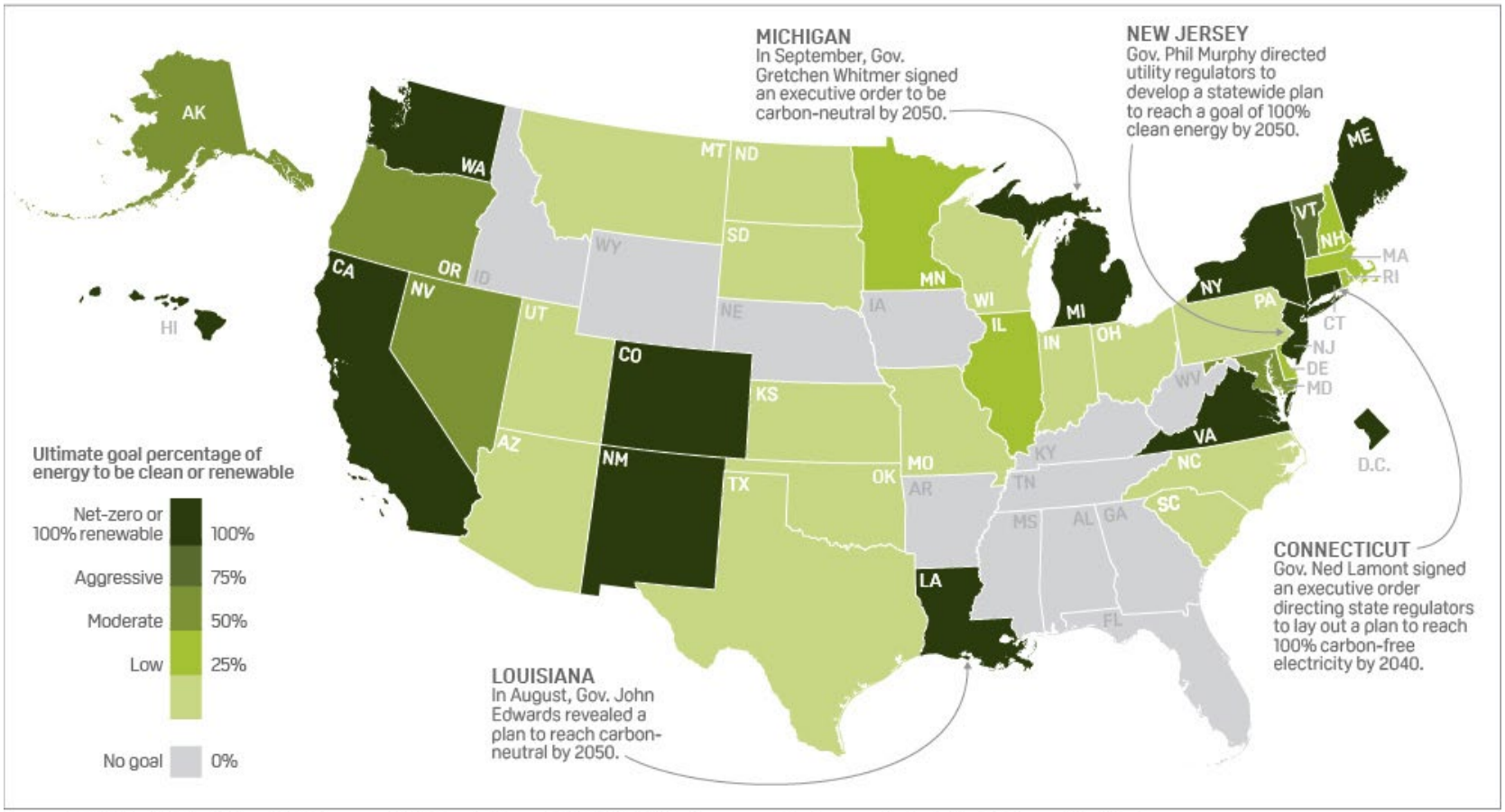
State climate goals and initiatives.

GROWING NUMBER OF US STATES RACE TO NET-ZERO EMISSIONS, 100% RENEWABLE POWER

There are now 12 states, plus Washington DC, with 100% renewable generation or net-zero carbon emission goals or aspirations in the coming decades. The latest to join the energy transition to clean power are Louisiana, Michigan, Connecticut and New Jersey where governors announced plans or signed executive orders. They follow Colorado, which made the move in late 2019, and Virginia, which announced the change earlier this year. While many Southeast states do not have official goals, many utilities have set their own net-zero emission targets.



Source: S&P Global Platts, National Conference of State Legislatures, ERCOT, Cal-ISO, other associated sources for individual states and territories

Source: S&P Global.

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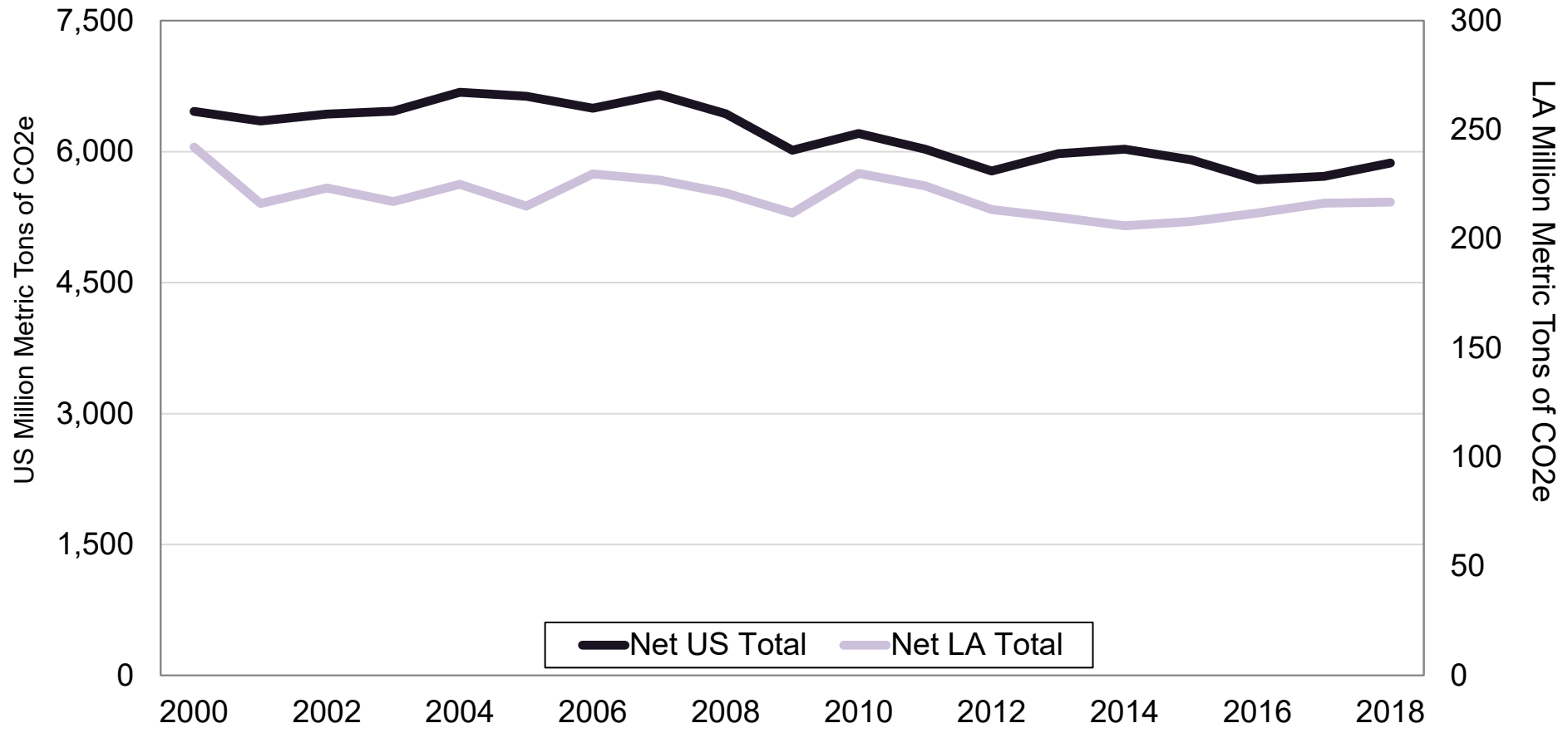
Total U.S. vs LA GHG emissions.

Total GHG emissions for the **U.S. and LA have trended down since 2000**. LA emissions are down relative to 2000, but flat since 2001.



Note: CO_2 emissions are net of sinks.
Source: U.S. Environmental Protection Agency, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2018; and State CO_2 Emissions from Fossil Fuel Combustion.

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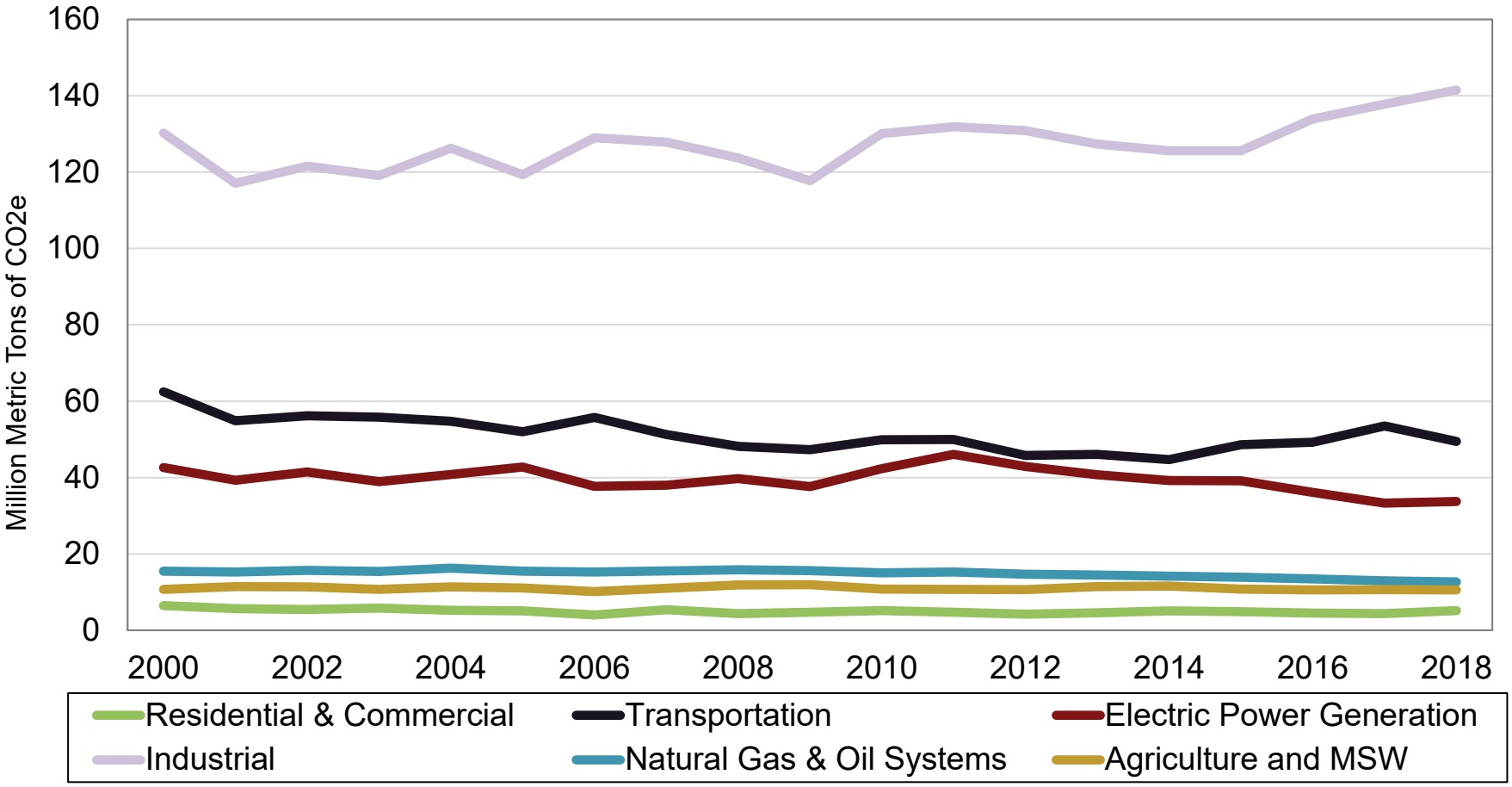
Louisiana GHG emissions per sector.

Louisiana GHG emissions are **dominated by the industrial sector**.



Note: CO_2 emissions are from fossil fuel combustion only.
Source: U.S. Environmental Protection Agency, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2018; and State CO_2 Emissions from Fossil Fuel Combustion.

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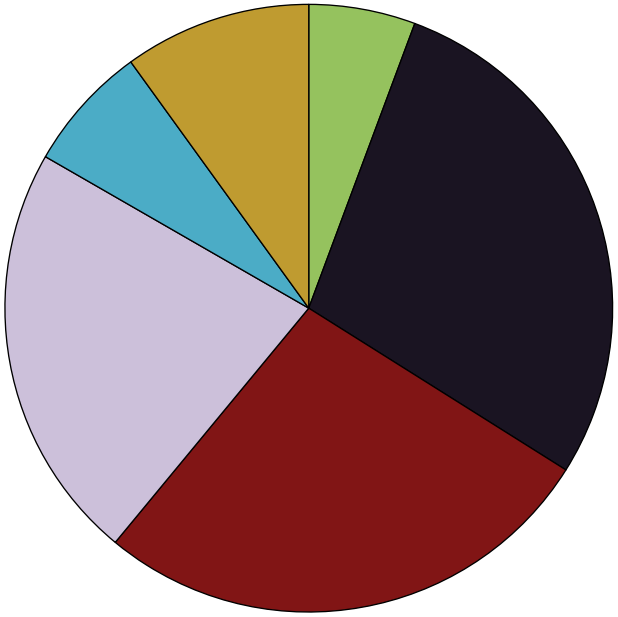
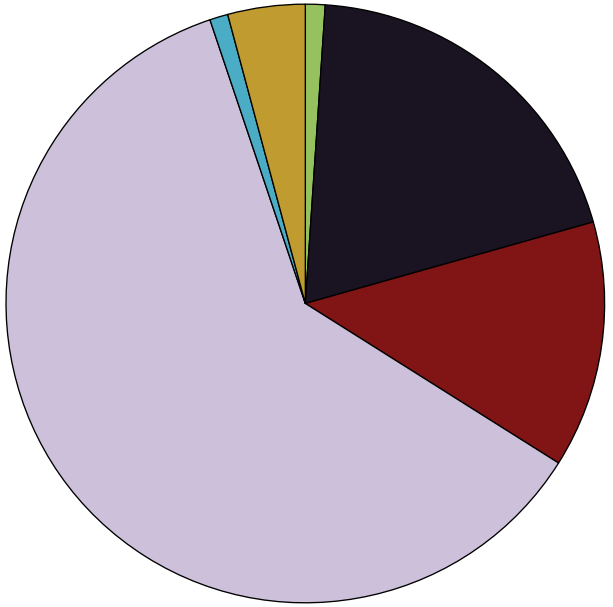
U.S. and Louisiana GHG emissions per sector, 2018

In the U.S., **power generation comprises about 27 percent** of overall national emissions.



In Louisiana, **power generation comprises about 13 percent of overall state emissions**. Louisiana's primary source of CO_2 emissions comes from **industrial sources**.



Note: CO2 emissions are from fossil fuel combustion only, adjusted for feedstock use.
Source: U.S. Environmental Protection Agency, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2018; and State CO_2 Emissions from Fossil Fuel Combustion.

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Industrial decarbonization.

Big picture, this is all about finding **pathways for industrial decarbonization**. There are a **variety of approaches** that include, and are not limited to:

- Renewables
- Carbon capture, utilization and storage (“CCUS”)
- Industrial fuel switching – electrification
- Industrial fuel switching – hydrogen

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Renewables

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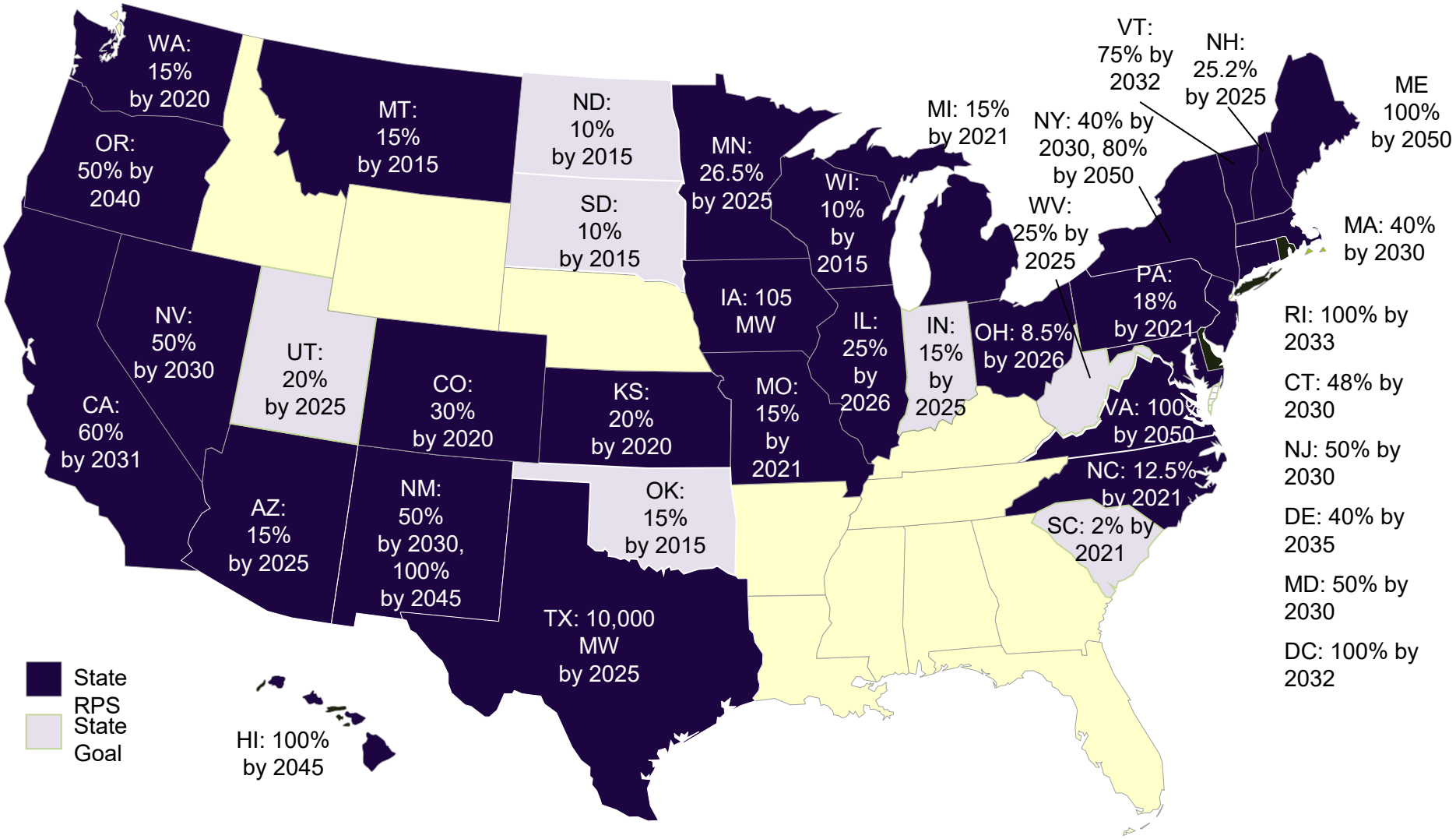
States with formal renewable portfolio standard



Source: Database of State Incentives for Renewable Standards.

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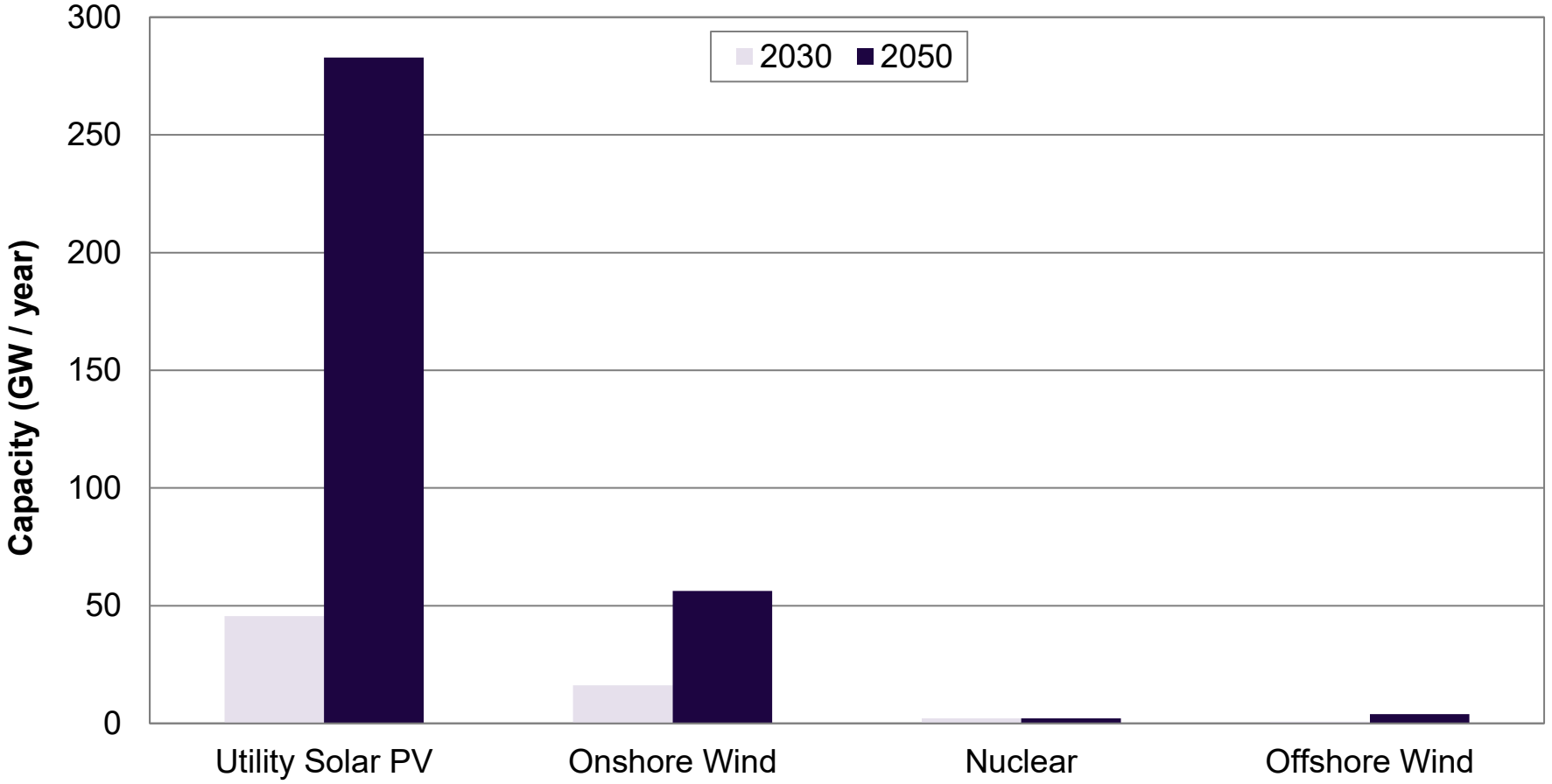
Louisiana electric capacity requirements (Governor's Climate Plan)

Over **350 GW of new generating resources** (mostly renewable) will be needed to meet the Governor's electrification goals.



Source: Louisiana Energy Policy Solutions tool.

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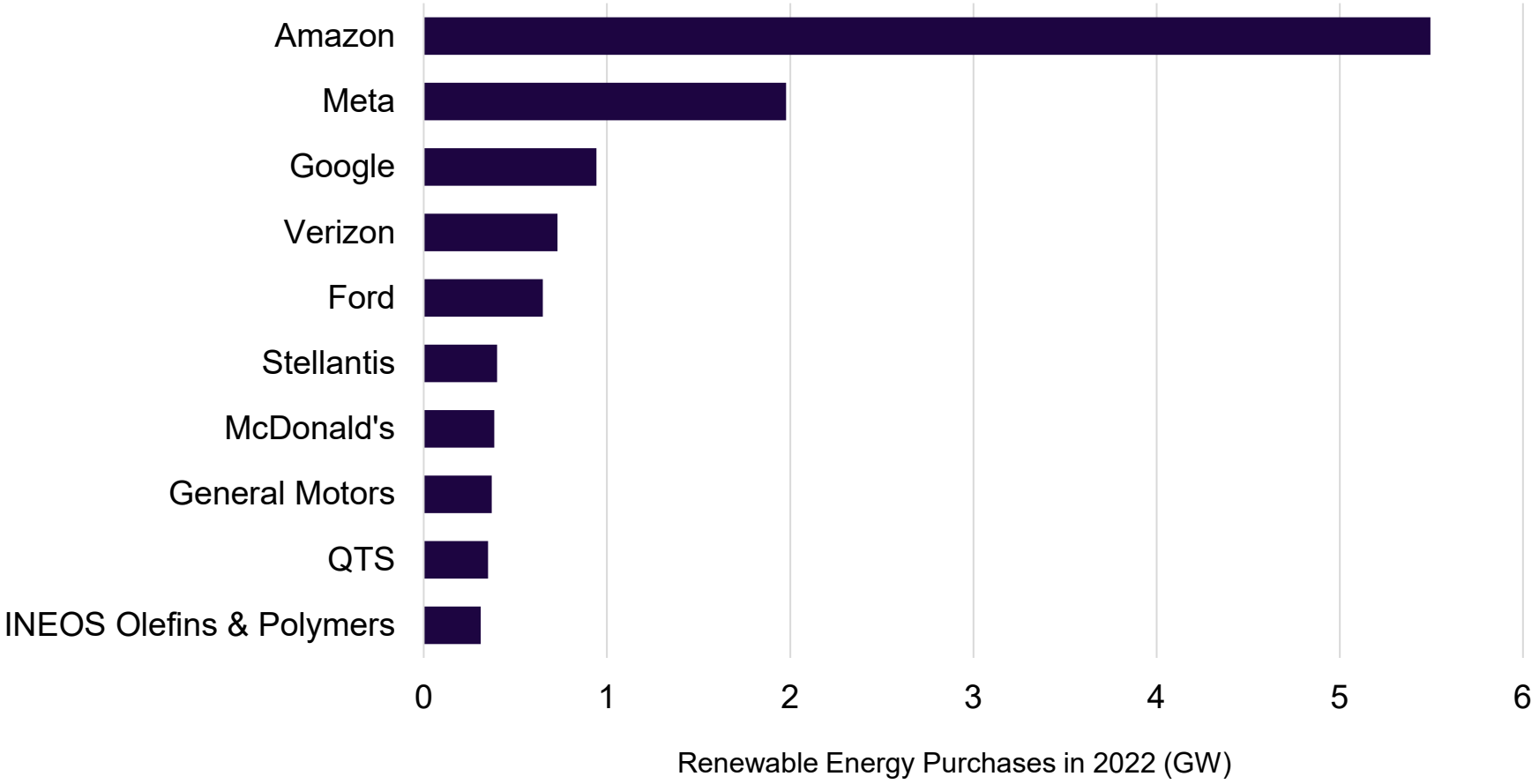
Top 10 U.S. corporate renewable energy buyers (2022)

Numerous corporations, across all industries, are now making **large voluntary renewable energy purchases** to meet their internal corporate climate goals.



Source: Clean Energy Buyers Association.

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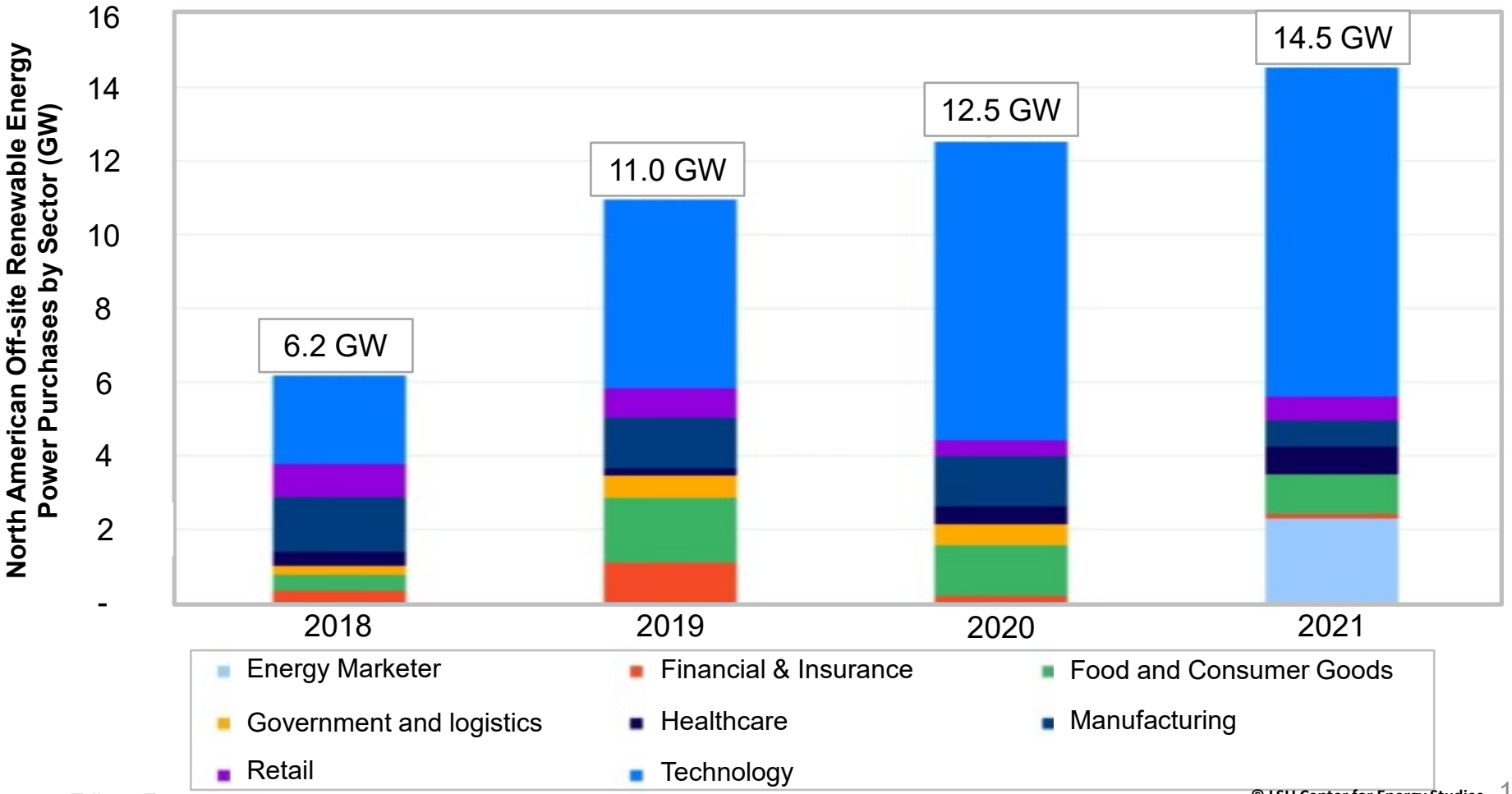
Corporate off-site renewable energy purchases (2018-2021).

Numerous corporations, across all industries, are now making **large voluntary renewable energy purchases** to meet their internal corporate climate goals.



Source: Edison Energy

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Carbon capture, utilization and storage

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CCS methods

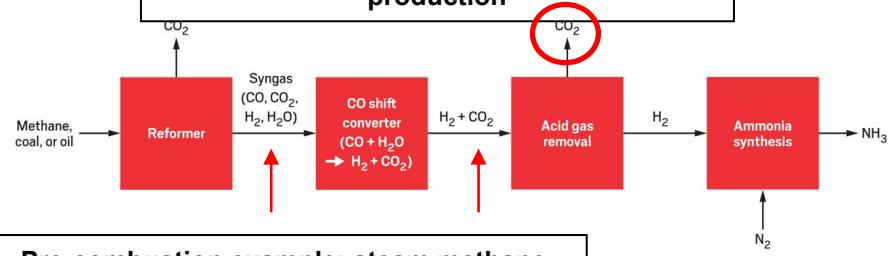
Pre-combustion capture

Precombustion separates CO_2 before combustion. This is usually done in the **reformation of various chemical processes** like steam methane reformation or ammonia production. **Can also include gasification** of solid fuels like petroleum coke or lignite.

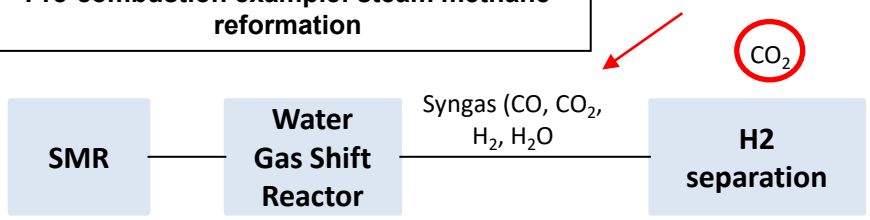
Post-combustion capture

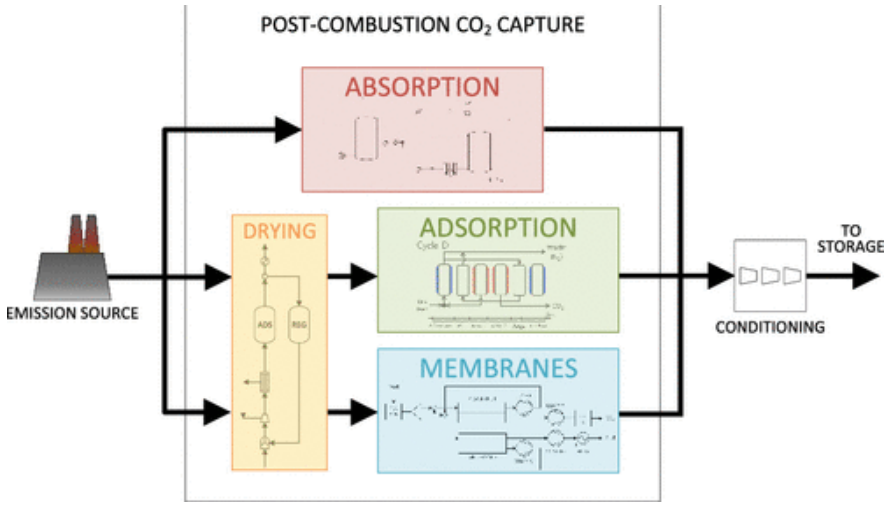
Usually involves cleaning flue gases after the combustion process. CO_2 is removed by scrubbing the flue gas with chemical solvent like amine. **Common in power generation** applications.

Pre-combustion example: ammonia production



Pre-combustion example: steam methane reformation





Source: Chemical and engineering news, EIA, Concawe Report 18/20, Linde Engineering.

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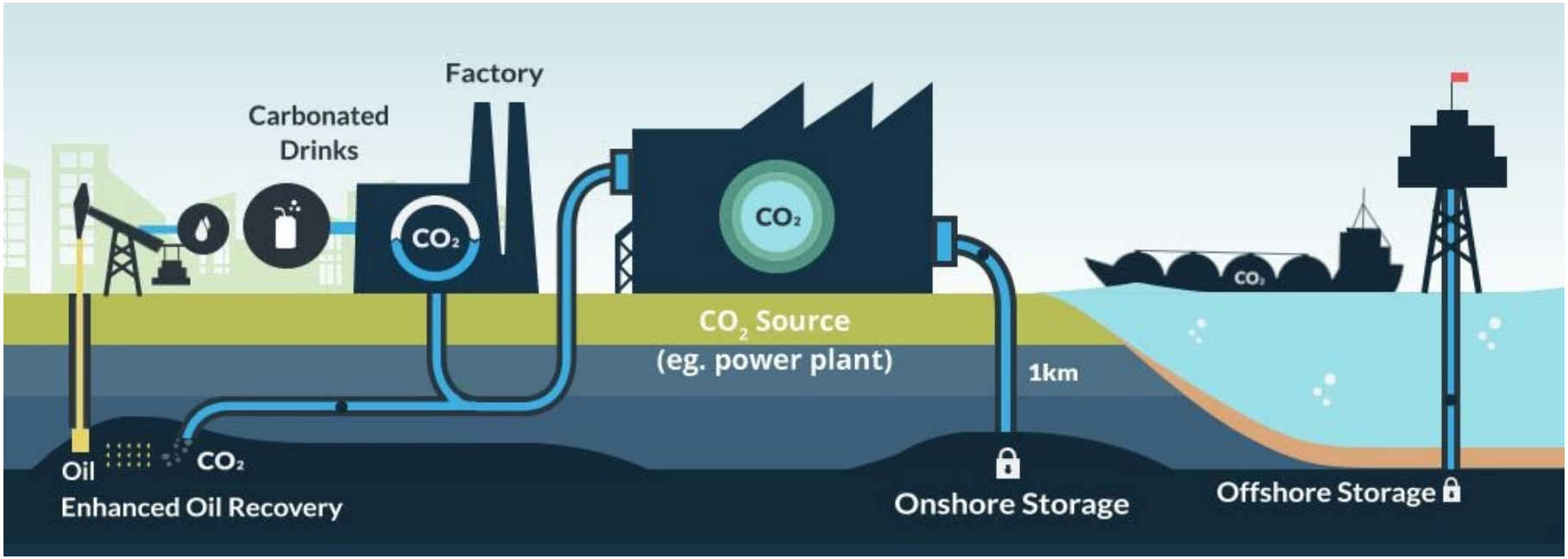
CCUS application (industry/power).

Carbon capture and sequestration ("CCS") involves the **capture of CO_2** from power plants and other large industrial sources, its **transportation to suitable locations**, **and injection into deep underground geological formations** for long-term sequestration.



Source: Global CCS Institute, CCS features at European Sustainable Energy Week, June 15, 2015.

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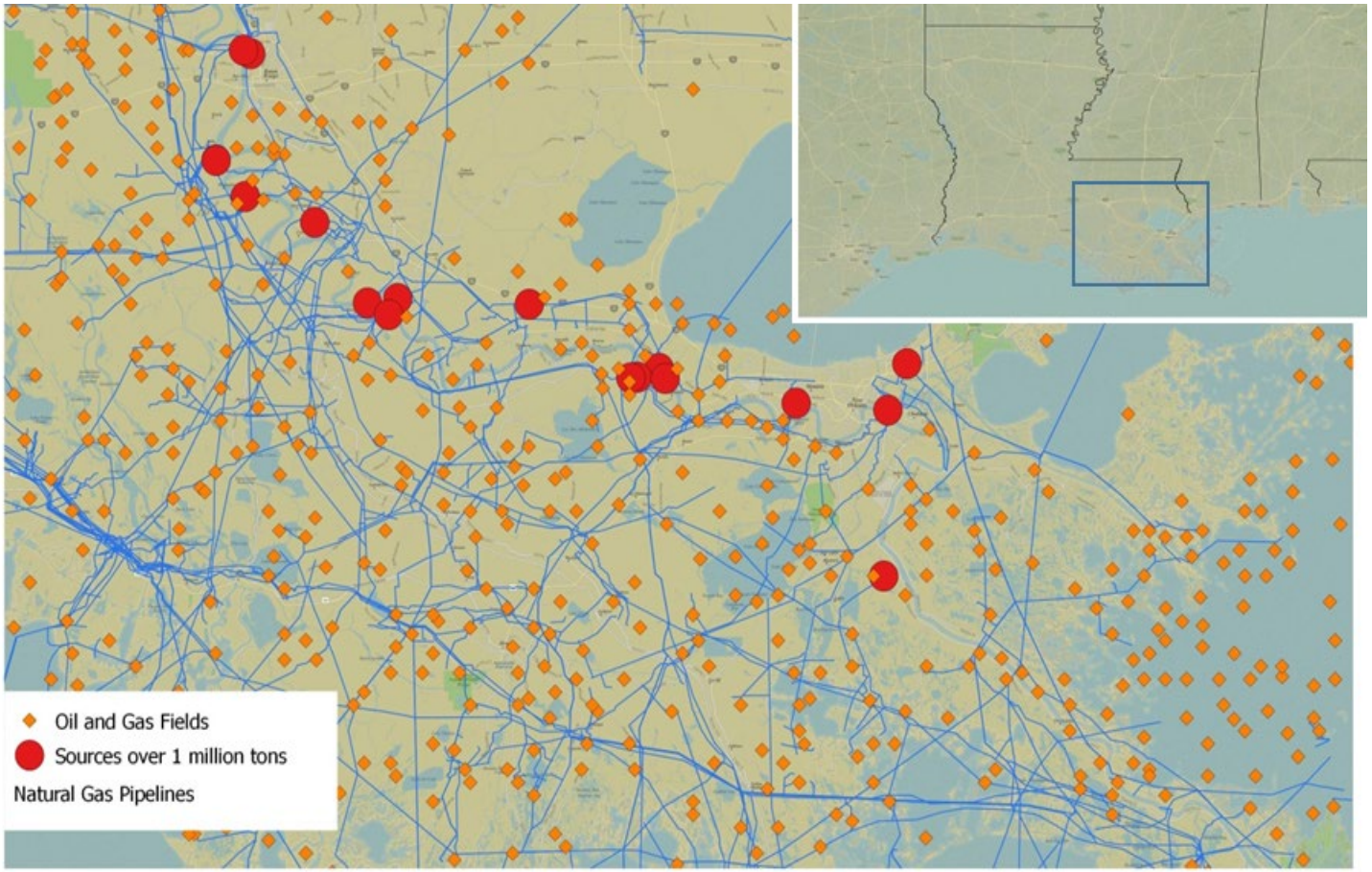
Potential sinks and transportation alternatives.

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



Source: Author's construct.

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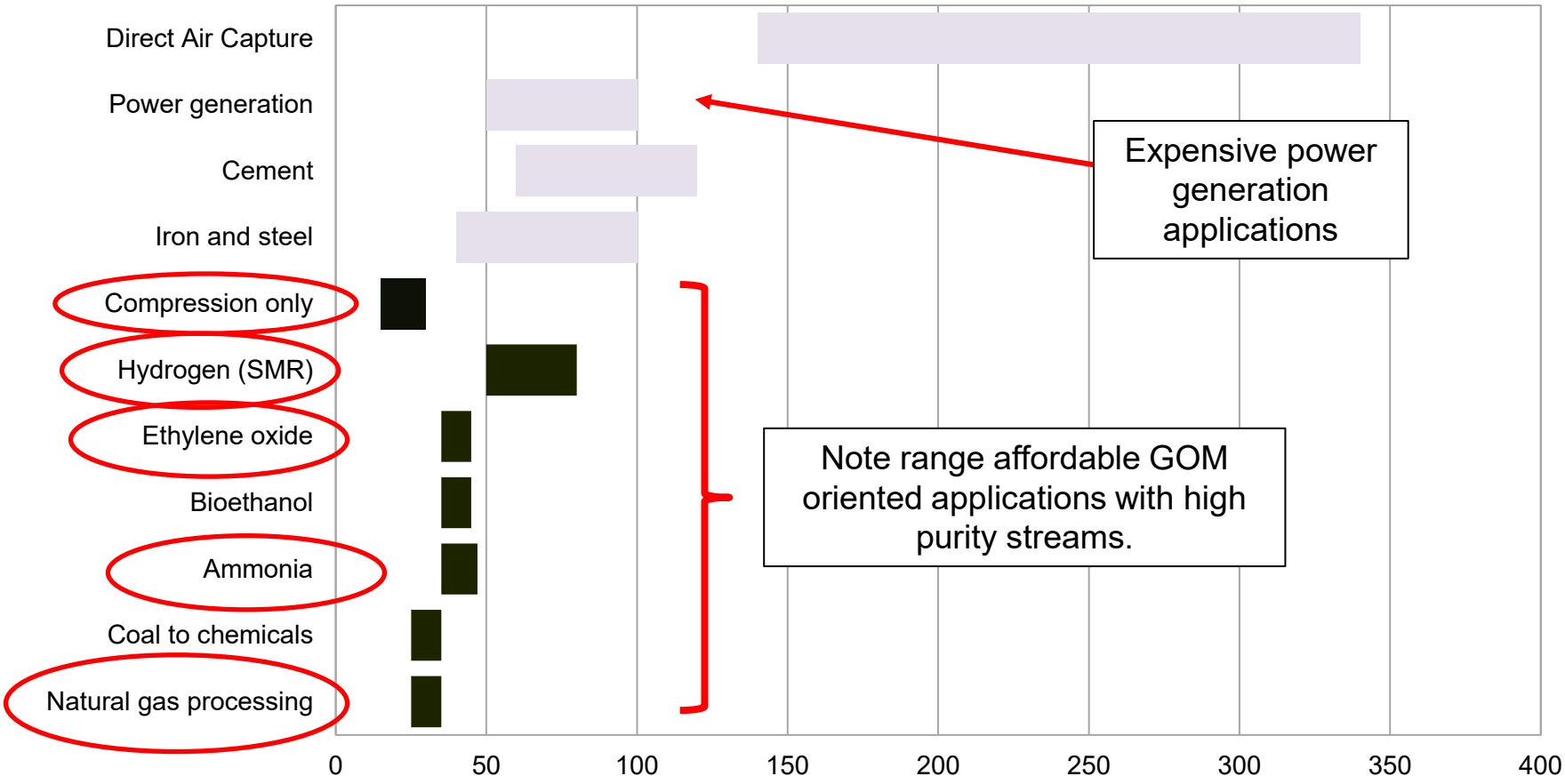
Levelized cost per ton of CO2 capture by application

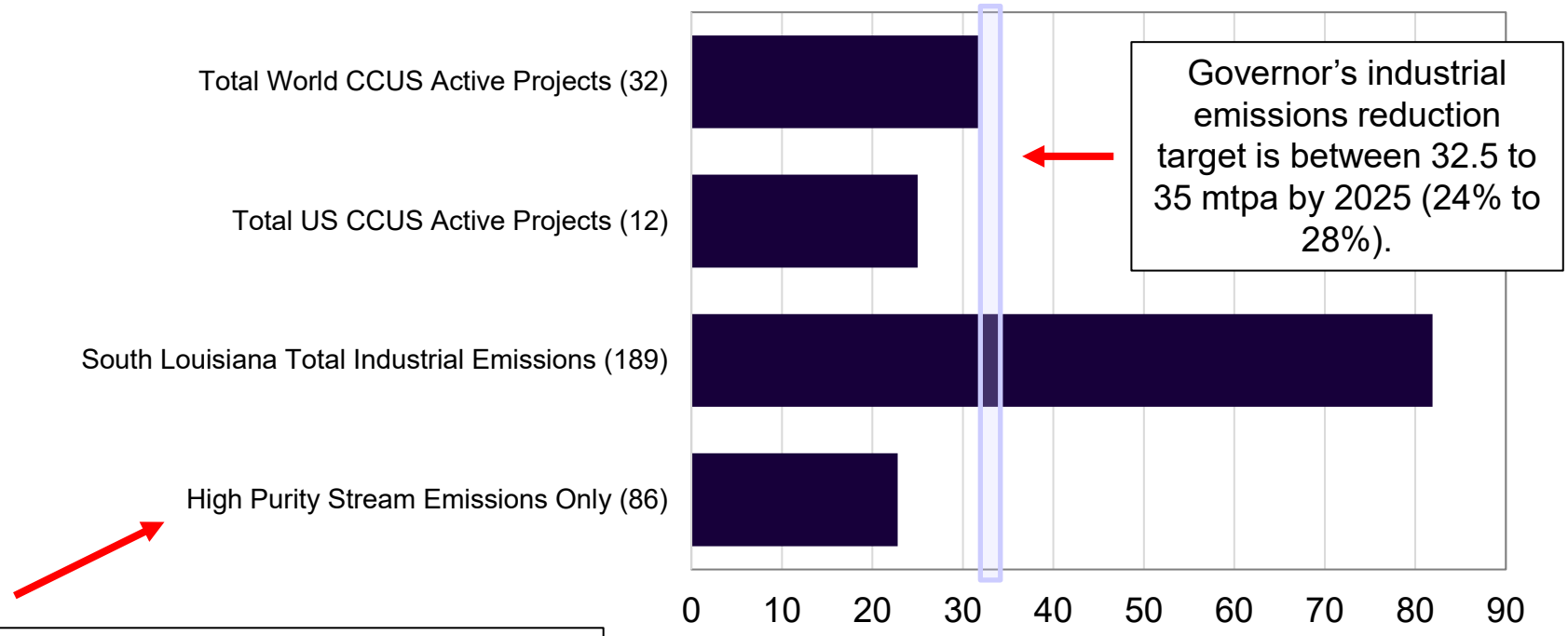
Power generation is one of the more expensive applications – however, one that has the most experience at large scales – reflected by high capture costs, complex processes, low CO_2 recovery rates, low CO_2 purity.



Source: IEA "Levelized cost of CO2 capture by sector and initial CO2 concentration, 2019"

Louisiana high purity streams of CO_2

The opportunities for development in Louisiana are rich. There is **in excess of 20 mpta in high quality (90 percent plus) streams** in Louisiana alone: a level comparable to all the active U.S. CCUS facilities.



Close to 6,000 MW of load associated with the high purity streams alone.

Source: Author's construct and Global CCS Institute.

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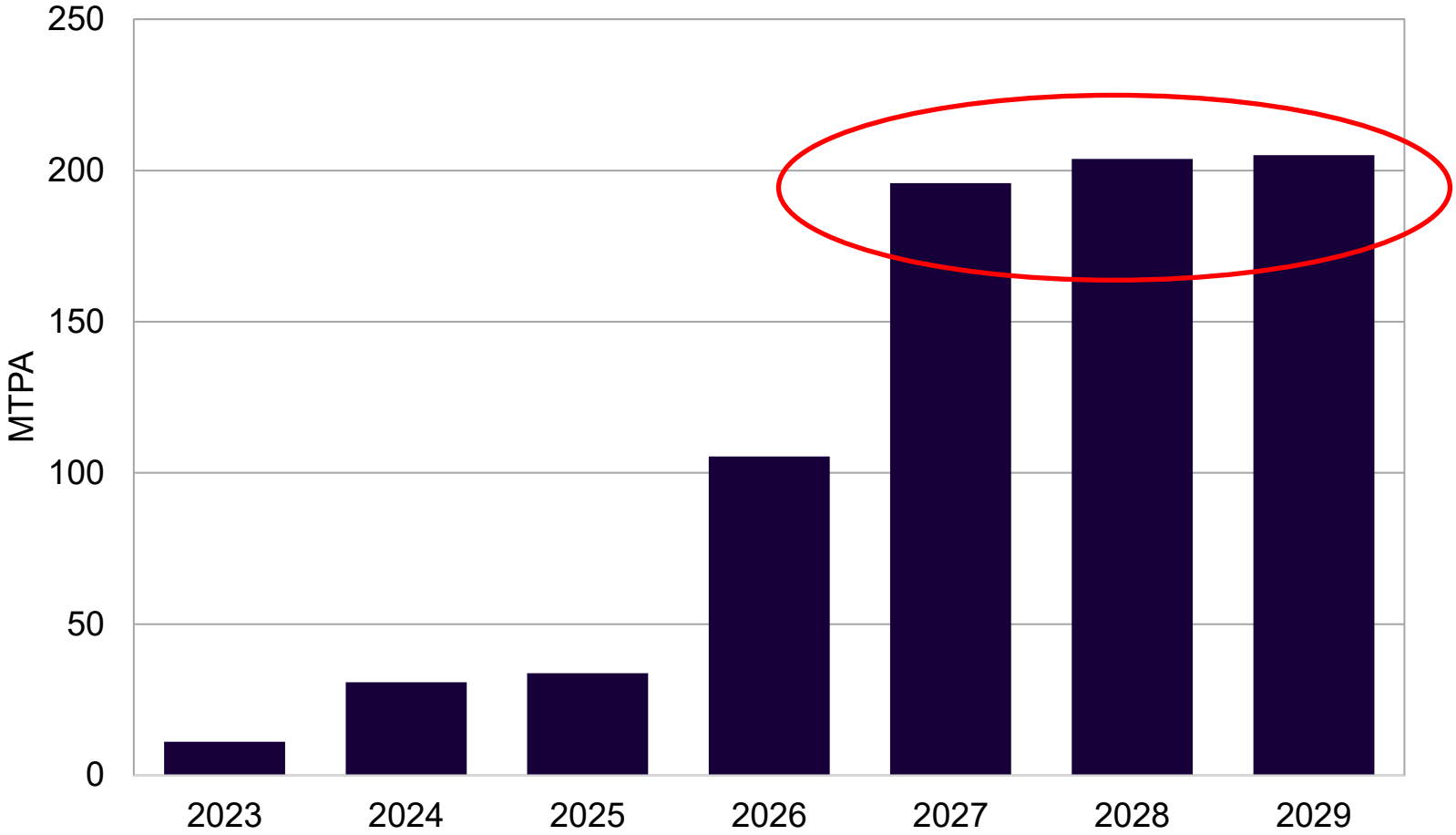
Cumulative GOM carbon sequestration (by mtpa injection capacity).

GOM looking at close to **200 mtpa of carbon sequestration capacity** in the development pipeline.



Note: Author's construct

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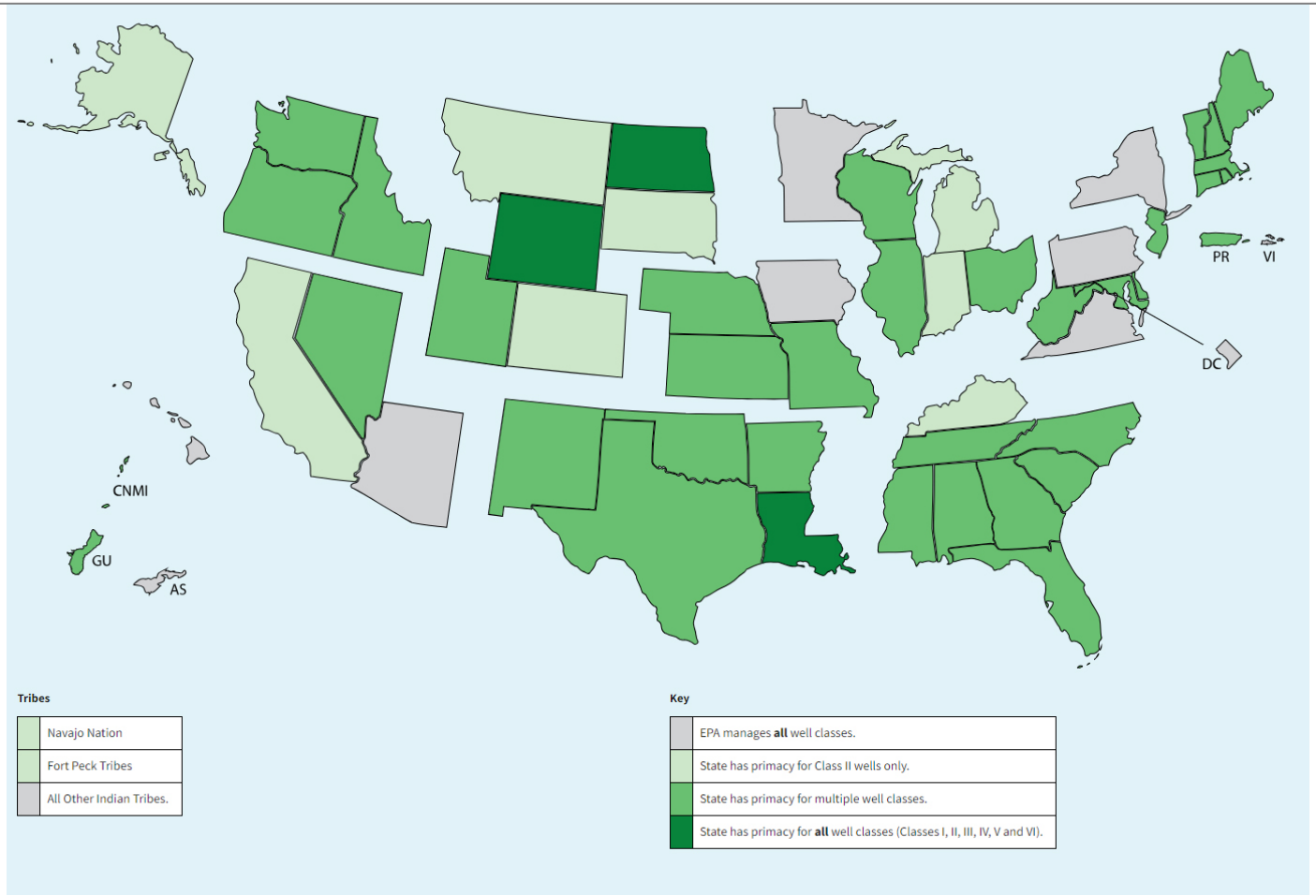
Class VI wells: states with primacy

Currently **Wyoming, North Dakota, and Louisiana** have state primacy for all well classes



Source: US EPA

Fuel substitution: electricity

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Changing end uses.

Industry has been **moving more and more towards electrical end-uses** over several decades, arguably dating back to the CAAA of 1990.

Examples in the natural gas midstream industry include **moving compression fuel from pipeline gas to electricity** – which had considerable implications in during **Winter Storm Uri in 2021.**

Other examples include moving other forms of **compression, motors, pumps, and other forms of mechanical energy** and using electricity rather than **natural gas, waste fuels, and other fossil-based options.**

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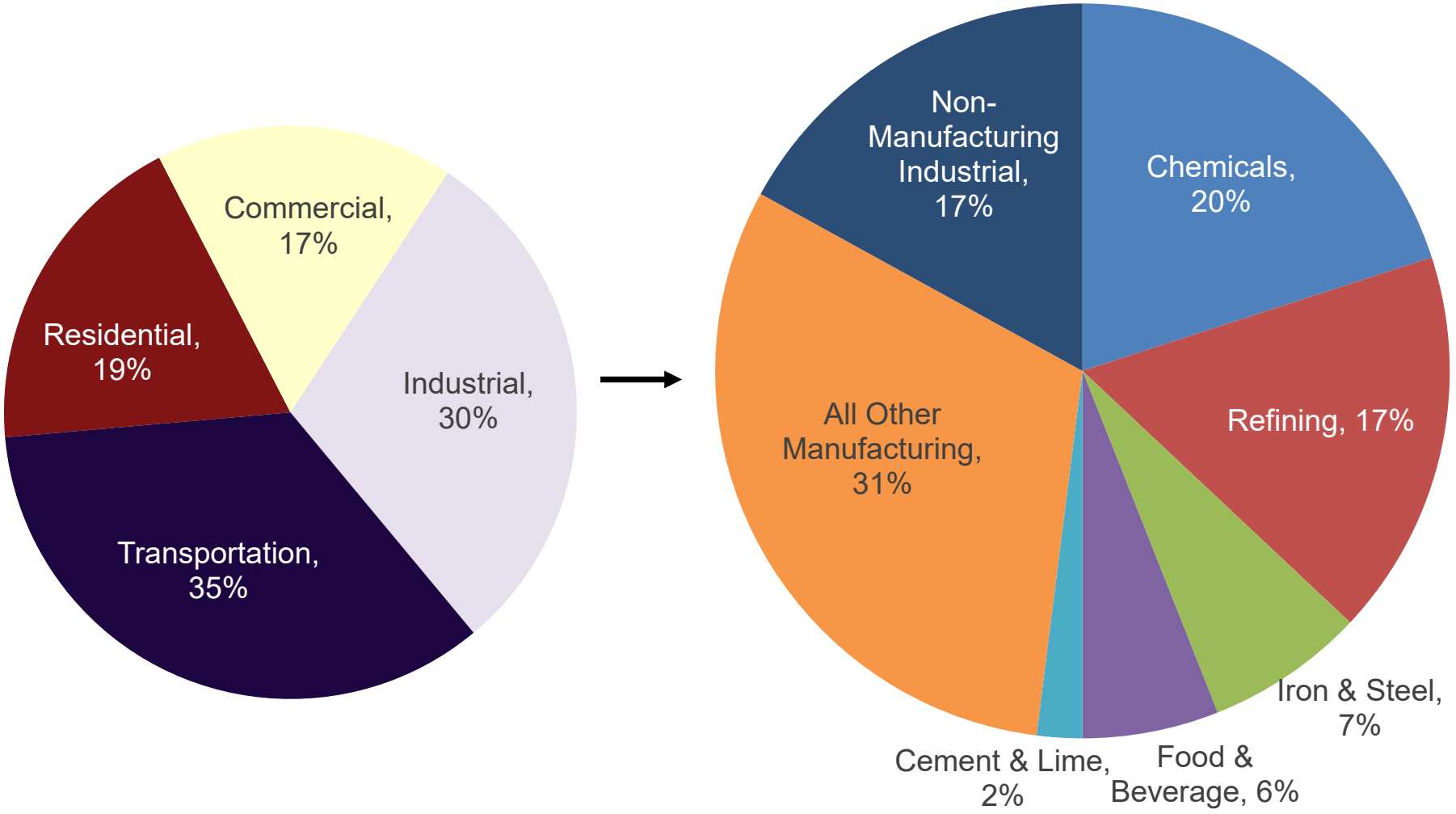
U.S. industrial energy use & GHG emissions.

Industrial GHG emissions are **concentrated in a six sectors.**



Source: Energy Central; EIA.

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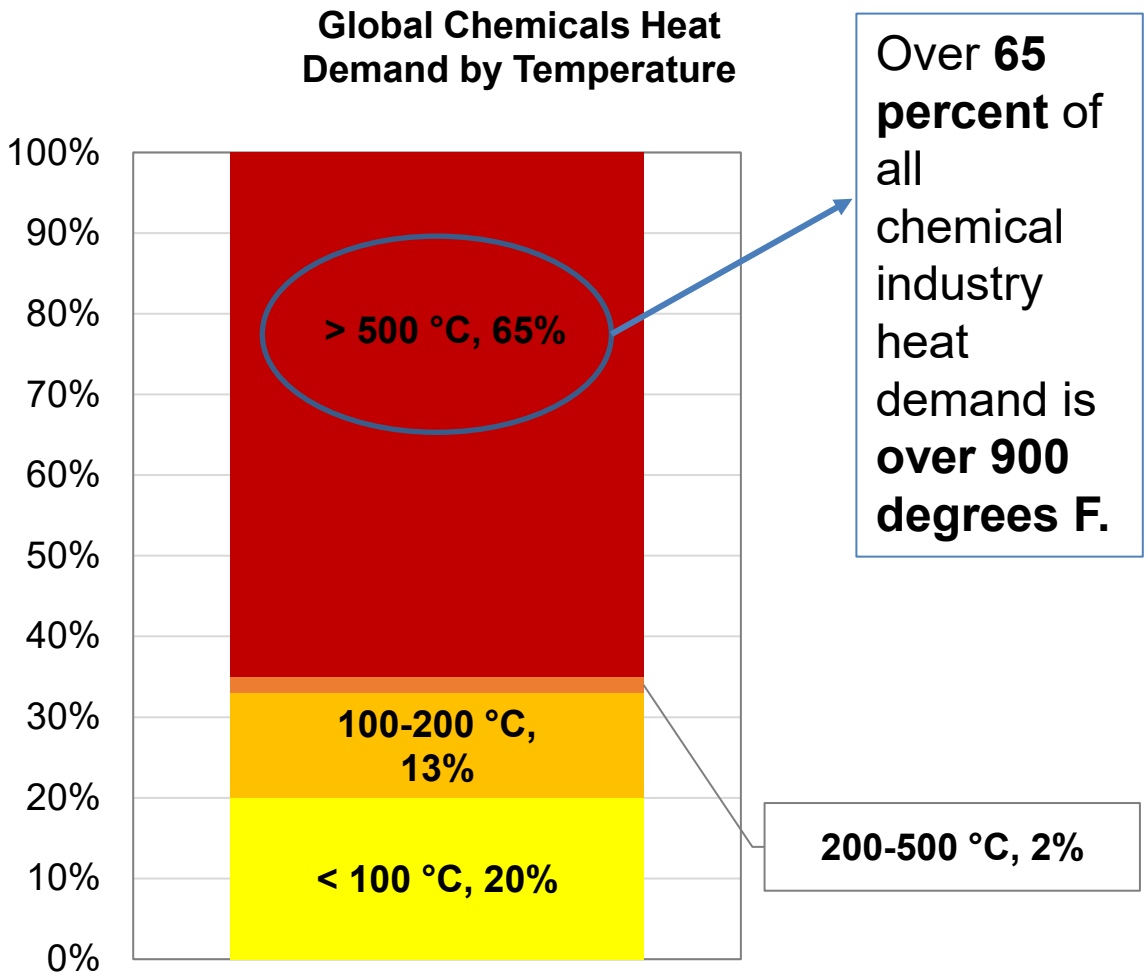
Chemical industry use.

Over **40 percent** of chemical industry energy use is for **non-feedstock purposes**.

Energy Source	Global Chemical Non-Feedstock Energy Use (%)
Natural Gas	29%
Purchased Electricity	23%
Coal	23%
Petroleum	13%
Purchased Heat / Steam	12%
Bioenergy	>1%



Source: Jeff Rissman. "Decarbonizing Chemicals and other Industries in Louisiana." CTI Presentation. October 8. 2021.

Fuel substitution: hydrogen

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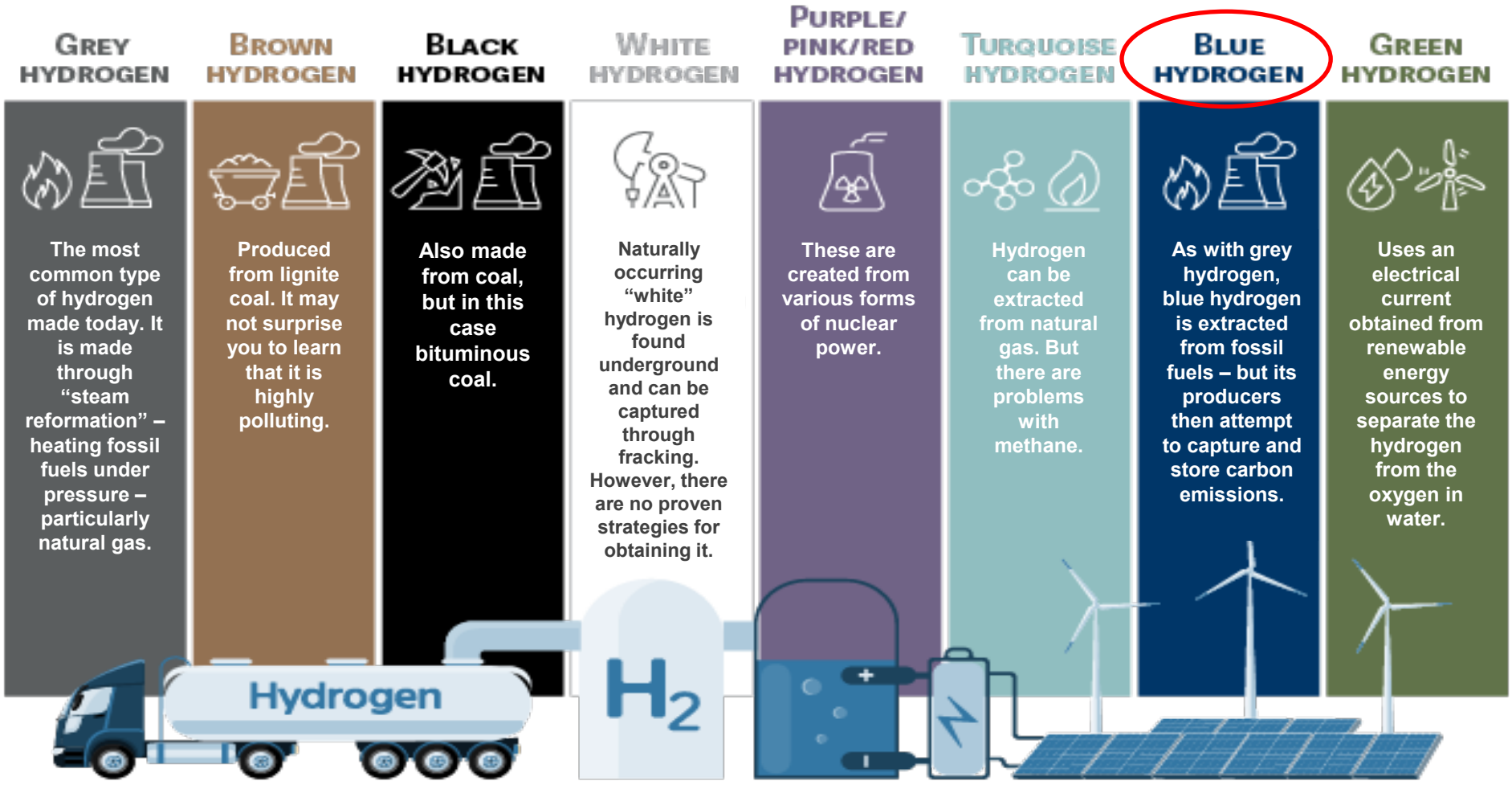
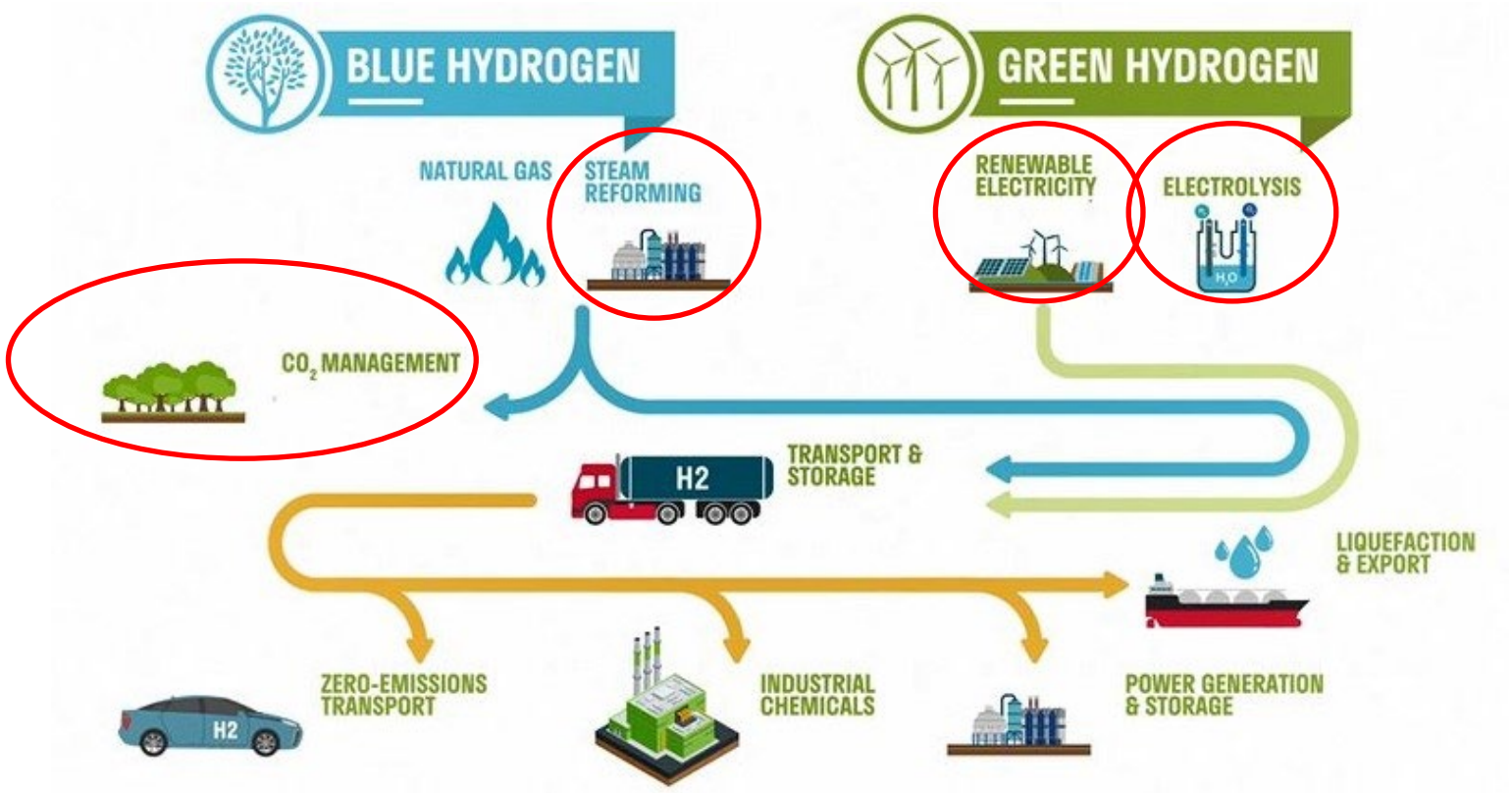
The hydrogen rainbow.



Source: Goddin, Neal. Artemis Investments. January 12, 2022

Blue v. green hydrogen.

How the hydrogen is made, matters.
Blue uses SMR and CCS;
Green uses RE and electrolysis



Source: Energy Tracker Asia.https://energytracker.asia/hydrogen-oil-green-vs-blue-whats-the-difference

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Louisiana importance

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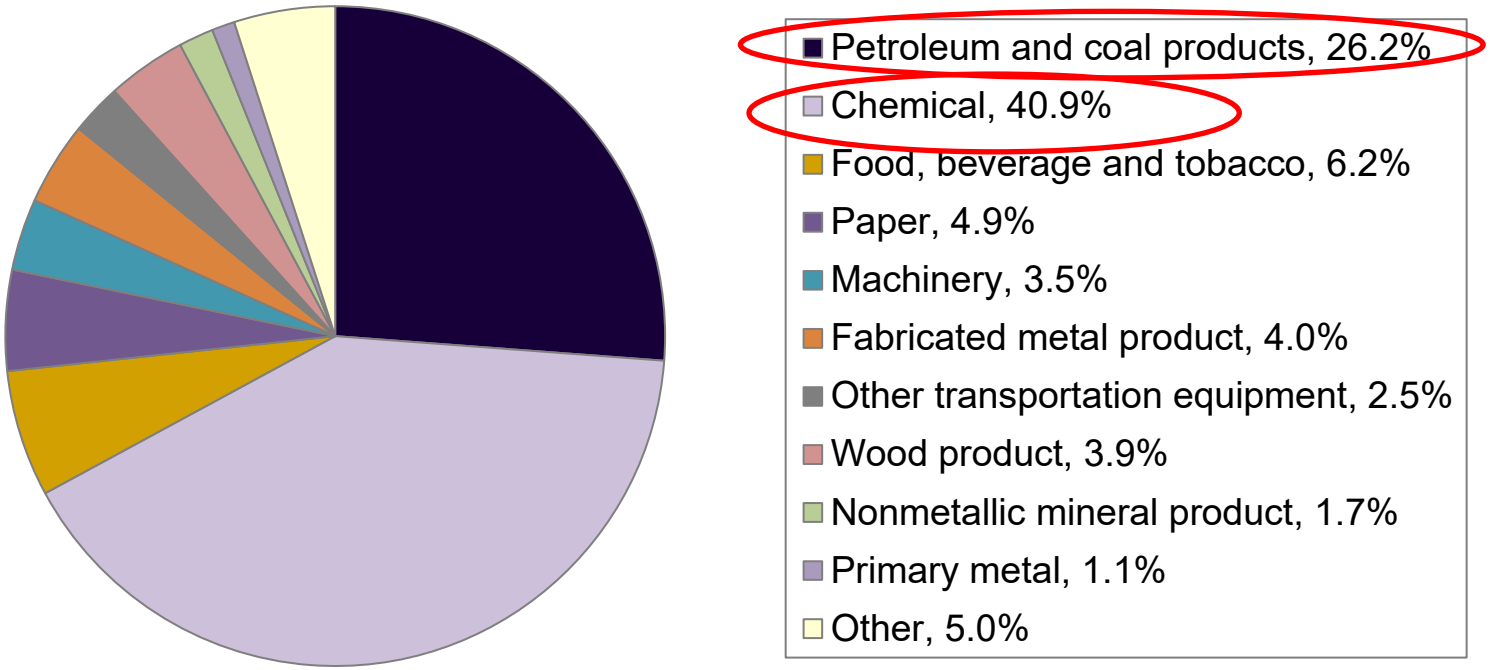
GDP by sector and share of Louisiana manufacturing total (2021).

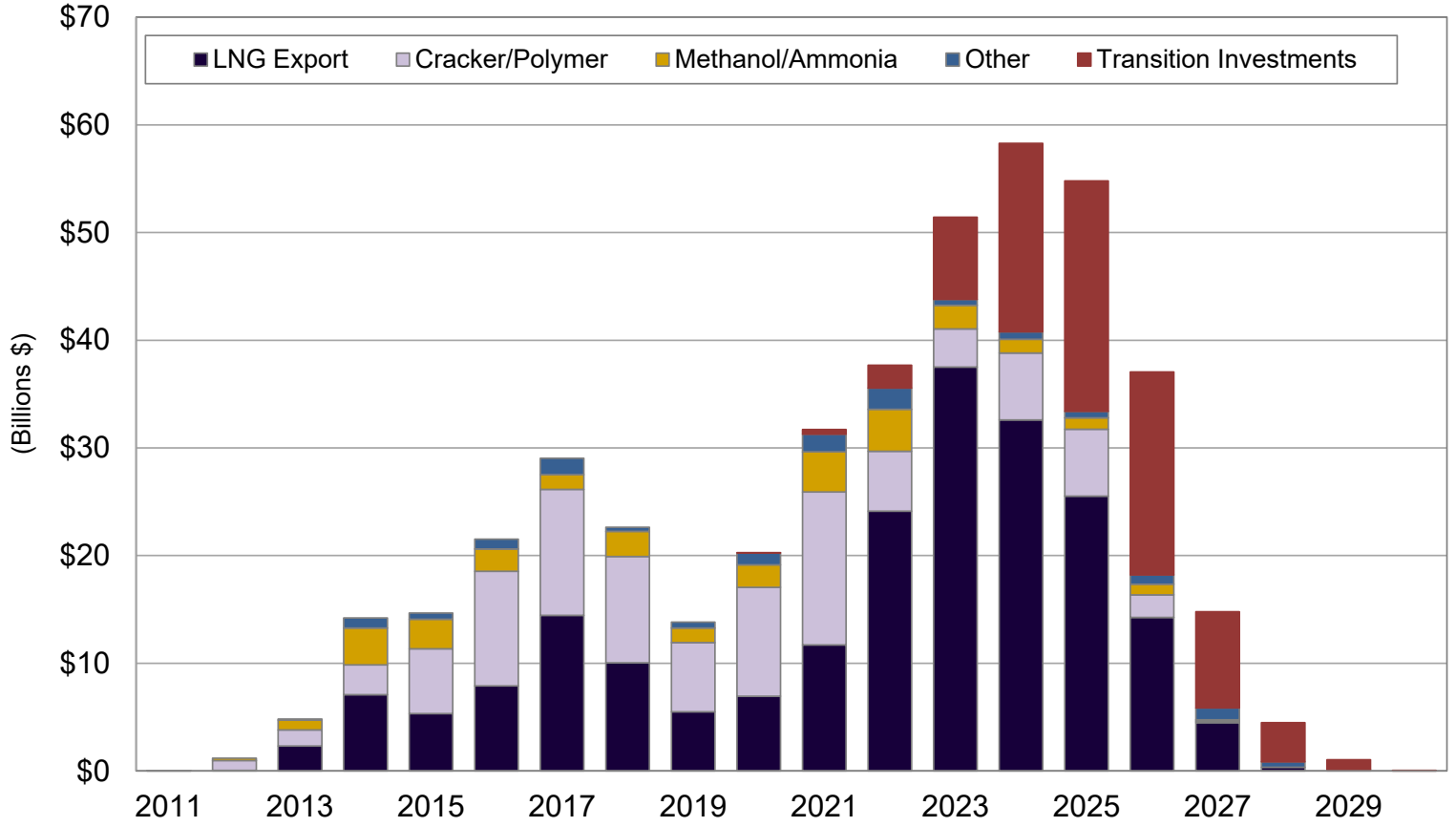
In terms of total economic contributions, **manufacturing accounts for 16 percent of Louisiana's state GDP. Energy-related industries account for 67 percent of total state manufacturing GDP ($40.3 billion), or 11 percent of total state GDP ($258.6 billion)**.



Note: Energy-based manufacturing includes: petroleum and coal products; chemical; and plastics and rubber products manufacturing.
Source: Bureau of Economic Analysis, U.S. Department of Commerce.

GOM energy manufacturing investments by sector.

Large number of future investments tied to energy transition. Note the Inflation Reduction Act has **$3.2 billion in additional CCS tax credits** and **$7.8 billion in clean hydrogen**.



Source: Authors Construct; capex for announced projects with missing information were estimated using available data from average/typical facility type/cost.

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Total GOM energy manufacturing investment, all project announcements.

GOM looking at **$79 billion in total energy transition investments (36 percent of $222 billion total)**, most of which are announced to be in Louisiana (**~$47 billion, 60 percent**).

Year	Texas				Louisiana				Other GOM				Total GOM			
	LNG	Non-LNG	Transition	Total	LNG	Non-LNG	Transition	Total	LNG	Non-LNG	Transition	Total	LNG	Non-LNG	Transition	Total
	(million $)															
2023	5,274	2,986	3,133	11,393	30,910	3,190	4,513	38,613	1,321	-	1	1,322	37,506	6,277	7,646	51,429
2024	8,517	5,413	6,066	19,997	20,049	2,609	11,426	34,085	4,038	-	21	4,060	32,604	8,171	17,514	58,290
2025	10,010	4,941	8,851	23,803	13,113	2,946	12,507	28,566	2,394	-	29	2,423	25,517	7,887	21,387	54,791
2026	9,292	1,742	8,116	19,151	4,750	2,200	10,735	17,684	213	-	3	217	14,255	3,942	18,854	37,052
2027	4,103	1,139	3,387	8,629	373	232	5,558	6,163	-	-	-	-	4,477	1,371	8,945	14,792
2028	347	505	1,698	2,550	-	-	1,935	1,935	-	-	-	-	347	505	3,633	4,484
2029	-	118	473	591	-	-	457	457	-	-	-	-	-	118	930	1,048
2030	-	8	30	38	-	-	31	31	-	-	-	-	-	8	61	69
Total	**$ 37,544**	**$ 16,852**	**$ 31,754**	**$ 86,151**	**$ 69,195**	**$ 11,177**	**$ 47,161**	**$ 127,533**	**$ 7,967**	**$ -**	**$ 55**	**$ 8,022**	**$ 114,706**	**$ 28,279**	**$ 78,970**	**$ 221,955**

Source: Authors Construct; capex for announced projects with missing information were estimated using available data from average/typical facility type/cost.

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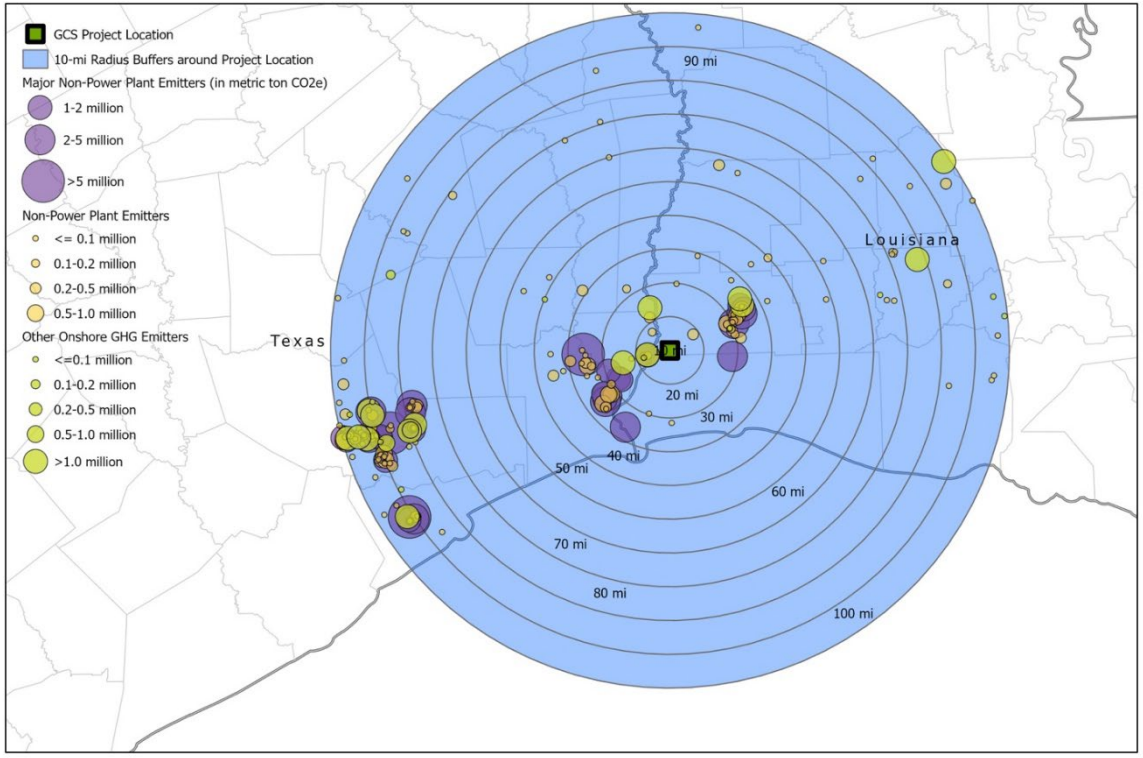
Regional CO_2 industrial emissions (LSU-CCUS Economic Impact Study).

The LSU Center for Energy Studies estimates that **the Lake Charles region has between 51,000 to 95,000 jobs at risk** in the refining and chemical sector without some form of carbon mitigation. **These jobs support between $7.4 billion to $13.7 billion in average annual wages**.



Source: David E. Dismukes, Ronald E. Minsk, Brian J. Snyder and Gregory B. Upton, Jr. (2022). *The Economic Implications of Carbon Capture and Sequestration for the Gulf Coast Economy.* Baton Rouge (LA): LSU Center for Energy Studies. Pp. 51. Note, jobs at risk within 100 miles and 200 miles of a location close in proximity to LCM2.

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Conclusions

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Conclusions.

- **Industrial carbon emissions are high** in energy producing states, particularly those along the Gulf Coast.
- These industries, however, are **important components of our economy**. Their loss could be devastating.
- **Industrial decarbonization will be important** over the next several years to meet many state's clean energy and climate goals.
- Further, **industrial decarbonization** will be important for future industrial development since, at the margin, a good share of this development is **tied to international trade**.
- **CCUS is a critical component of industrial decarbonization** and is also a critical component of managing the negative impacts of the clean energy/climate transition.

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Questions, comments, and discussion.

David E. Dismukes, Ph.D.

Professor Emeritus
Center for Energy Studies
Louisiana State University

Email: dismukes@lsu.edu

Phone: 225-578-4343

URL: www.enrg.lsu.edu

David E. Dismukes, Ph.D.

Consulting Economist/Managing Partner
Acadian Consulting Group, LLC
5800 One Perkins Place Drive, Suite 5-F
Baton Rouge, LA 70808
Ph: 225.769.2603

daviddismukes@acadianconsulting.com

URL: www.acadianconsulting.com

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