Louisiana industrial decarbonization opportunities.


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Introduction: Why industrial decarbonization?
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, particularly those that include 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.
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.

**MICHIGAN**
In September, Gov. Gretchen Whitmer signed an executive order to be carbon-neutral by 2050.

**NEW JERSEY**
Gov. Phil Murphy directed utility regulators to develop a statewide plan to reach a goal of 100% clean energy by 2050.

**CONNECTICUT**
Gov. Ned Lamont signed an executive order directing state regulators to lay out a plan to reach 100% carbon-free electricity by 2040.

**LOUISIANA**

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

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Governor-appointed advisory board *unanimously approved the plan this past week* (Feb 1).

Defines a plan to reduce Louisiana’s GHG emission to “net zero” by 2050.

Plan calls for **industry to reduce GHG emissions** by using renewables, efficiency, and fuel switching to resources like hydrogen.

**Task force will meet in March to define an action plan.**

Source: Louisiana Climate Action Plan and Nola.com article (M. Schleifstein)
Carbon dioxide (CO₂) enters the atmosphere through the burning of fossil fuels (oil, natural gas, and coal), solid waste, trees and wood products, and also as a result of other chemical reactions (e.g., manufacture of cement).

Nitrous oxide (N₂O) is emitted during agricultural and industrial activities, as well as during combustion of fossil fuels and solid waste.

Methane (CH₄) is emitted during the production and transport of coal, natural gas, and oil. Methane emissions also result from livestock and other agricultural practices and by the decay of organic waste in municipal solid waste landfills.

Total U.S. Greenhouse Gas Emissions, 2016 (CO₂ eq.)

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<tr>
<th>Gas</th>
<th>Percentage</th>
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<tr>
<td>Carbon Dioxide</td>
<td>81.6%</td>
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<td>Methane</td>
<td>10.1%</td>
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<td>Nitrous Oxide</td>
<td>5.7%</td>
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<td>Fluorinated Gases</td>
<td>2.7%</td>
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Total GHG emissions for the US and LA have trended down since 2000. LA emissions are down relative to 2000, but flat since 2001.

Note: CO₂ emissions are net of sinks.
Louisiana’s share of total U.S. GHG emissions has been between three and four percent. Louisiana now accounts for just over four percent of all U.S. carbon emissions.

Louisiana CO$_2$ emissions per sector

Louisiana GHG emissions are dominated by the industrial sector.

Note: CO$_2$ emissions are from fossil fuel combustion only.
In Louisiana, power generation comprises about 17 percent of overall state emissions. Louisiana’s primary source of CO₂ emissions comes from industrial sources.

In the U.S., power generation comprises about 35 percent of overall national emissions.
Energy based industries pay considerably higher wages than other types of industrial activities.

Source: US BEA
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
Currently 37 states have RPS policies in place. Together these states account for over **75 percent of electricity sales** in the U.S.
Numerous corporations are now making large voluntary renewable energy purchases to meet their internal corporate climate goals.
Carbon capture, utilization and storage
Carbon capture, utilization, and sequestration ("CCUS") 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.
Carbon capture and sequestration ("CCS") involves the **capture of CO₂** from power plants and other large industrial sources, its **transportation to suitable locations**, and **injection into deep underground geological formations** for long-term sequestration.
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**.
Ten active projects in the U.S. with as much as **25 mtpa** in capture capabilities.

<table>
<thead>
<tr>
<th>Plant Name</th>
<th>Start up Year</th>
<th>State</th>
<th>Operator</th>
<th>Capacity (mtpa)</th>
<th>CO2 Source</th>
<th>Pipeline Connection (miles)</th>
<th>CO2 Sink</th>
<th>Federal Funding</th>
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<td>Terrell Gas Processing</td>
<td>1972</td>
<td>TX</td>
<td>Occidental Petroleum</td>
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<td>Natural gas processing</td>
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Large scale CCUS projects.

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Note: = 1 Mtpa CO₂ CIRCLE AREA = PROPORTIONATE TO CAPACITY

Source: Global Status of CCS 2020
Costs are an important challenge. High purity streams could be in a relatively economic range, particularly with 45(Q) or other enhanced tax incentives.

High purity streams with lower relative development costs.
Section 45Q credit and expanded credit

- **Section 45Q credit** first enacted in 2008 and significantly expanded in 2018.
- Expanded credit **encourages private investment in carbon capture equipment**.
- Expanded credit applies to carbon capture equipment placed in service on or after February 9, 2018. Credits accrue for 12 years after placed in service date.
- Higher credit, based on an “applicable dollar amount:”
  - For EOR – Per metric ton credit amount established by linear interpolation between $12.83 in 2017, **$35.00 in 2027**. Later increases based on inflation.
  - For non-EOR – Per metric ton credit amount established by linear interpolation between $22.66 in 2017, **$50.00 in 2027**. Later increases based on inflation.
- Taxpayer capturing CO₂ for credit **need not own industrial facility**:
  - Credit attributed to person that owns carbon capture equipment, and physically or contractually ensures capture, disposal, utilization, or EOR use of qualified CO₂
  - Can elect to have person that disposes of CO₂ in secure geological storage claim the credit.
- Taxpayers disposing of CO₂ directly, or using CO₂ in EOR, **must demonstrate secure geological storage**.

Section 45Q credit: “Build Back Better” proposals

- **6-year extension** – extended to projects beginning construction before January 1, 2032. Currently, the 45Q credit only applies to projects beginning construction by December 31, 2025.

- **Lower capture requirements** – capture at least 12,500 metric tons of qualified carbon oxide during the taxable year. Electric generating facilities 18,750 metric tons. A direct air capture facility at least 1,000 metric tons of qualified carbon oxide during the taxable year.

- **Increased credit amounts** – increased to $85/metric ton (prevailing wage requirement) and $60/metric ton for tertiary project. Credit is $17/metric ton for secure geological storage and $12/metric ton for use as a tertiary injectant for non-prevailing wage projects. **Direct air capture facilities at $180/metric ton** (wage requirement) and $36/metric ton (non-wage). Tertiary $130/metric ton (wage) and $26/metric ton (non-wage).

- **Direct pay** – Taxpayers otherwise eligible for the 45Q Credit would be entitled to elect for direct payment of the credit amount.

- **Effective Date** – These amendments to Section 45Q would only apply to facilities or equipment the construction of which begins after December 31, 2021.

Federal Safety Regulations for CO₂ Storage

EPA’s Underground Injection Control (UIC) Program & Class VI
- Regulatory framework to ensure that large volumes of CO₂ captured from industrial facilities, power plants, and ambient air can be safely, securely, and permanently stored underground.
- Requirements for well siting, permitting, operation, testing and monitoring, post-injection site care and site closure.

Federal and State Capacity in High Demand
- EPA reports more than 50 Class VI permitting inquiries
- EPA has only recently increased staff capacity to respond to Class VI permitting needs
- Interested states may be able to act faster with primacy while following the UIC regulatory framework
- 8 states have convened an MOU around Class VI Primacy issues
- Bipartisan Scale Act (H.R. 1992, S. 799) would increase EPA funds for Class VI permitting and provide grants for state programs
  - **North Dakota** and **Wyoming** have been granted primacy to regulate Class VI through state departments
  - **Louisiana** has applied for Class VI Primacy, with approval expected in 2022.

Source: CTF October Special Meeting on Industrial Decarbonization Part 2; Great Plains Institute; Dane McFarlane
Fuel substitution: electricity
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.
Industrial GHG emissions are concentrated in five sectors.

U.S. Energy-related CO₂ Emissions in 2015

Five sectors - 70% of CO₂
- Refining
- Chemicals
- Iron & Steel
- Food
- Cement

Source: CTF October Special Meeting on Industrial Decarbonization Part 1; Ed Rightor, AEO2020
Industries are heterogeneous in their GHG with some having far more percentages dedicated to just stationary combustion than process GHG emissions.

**Industrial Process Emissions**
- Process emissions result from the manufacture of products
- Not strictly related to energy use
- Often the result of chemical processes that release CO2
- Hard to decarbonize without carbon capture or new techniques

**Emissions**
- On-site combustion: Electrification & Fuel Switching
- Process Emissions: Carbon Capture; R&D and New Technology
- Indirect Emissions: Decarbonizing Electric Grid

**Reduction Strategy**
- Stationary Combustion
- Process Emissions
- Electricity Generation
- Fermentation Emissions

Source: CTF October Special Meeting on Industrial Decarbonization Part 2; Great Plains Institute; Dane Mcfarlane
Heat, steam and electric motors are largest industrial end uses. Steam and heat are difficult to replace with electricity.
Over **40 percent** of chemical industry energy use is for **non-feedstock purposes**.

<table>
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<tr>
<th>Energy Source</th>
<th>Global Chemicals Non-Feedstock Energy Use (%)</th>
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<tbody>
<tr>
<td>Natural gas</td>
<td>29%</td>
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<tr>
<td>Purchased electricity</td>
<td>23%</td>
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<tr>
<td>Coal</td>
<td>23%</td>
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<td>Petroleum</td>
<td>13%</td>
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<tr>
<td>Purchased heat/steam</td>
<td>12%</td>
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<td>Bioenergy</td>
<td>&lt;1%</td>
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Electrified Steam Cracking

- A steam cracker breaks large hydrocarbon molecules into small ones in the presence of steam
  - Operates at over 800 °C
  - $2 billion to construct

- A consortium of six chemical companies is working to develop electrified steam crackers, aiming to have a pilot operating by 2030
  - BASF, Borealis, BP, LyondellBasell, Sabic, and Total

Source: Jeff Rissman. “Decarbonizing Chemicals and other Industries in Louisiana. CTF Presentation. October 8, 2021.”
Most industrial sectors will see movements towards electrification.
Fuel substitution: hydrogen
Hydrogen

Simplest and most abundant element with an estimated 90% of the visible universe being composed of hydrogen.

Despite the massive abundance, pure hydrogen is rarely found on earth, instead it is combined with other elements such as hydrocarbons, acids, and hydroxides.

Today use is dominated by the industry sector, with growing potential in the energy sector.

Characteristics:
- Non-toxic, Colorless,
- Odorless, Tasteless,
- Flammable, Gaseous Substance.

Hydrogen cycle
Why hydrogen?

Fuel of the Future?
Potential to be the key player in achieving a greenhouse gas-neutral economy by 2050

- Abundance & variety of domestic sources
- Energy carrier with 3x energy density as conventional fuels
- Can be stored and transported for use as fuel or converted into electrical energy
- Low to zero-emissions of CO2
- Clean energy is a growing priority
- Must be separated from other compounds
- Production is more energy exhaustive than what is produced
- Low density poses challenges
- Some process are dependent on fossil fuels
- Higher cost compared to fossil fuels

The Colors of Hydrogen

GREEN Source: Renewables
PINK Source: Nuclear Power
YELLOW Source: Solar Power
BLUE Source: Natural Gas

BROWN Source: Coal
GREY Source: Natural Gas

The hydrogen rainbow

Natural gas-based production methods with CCUS are the more likely cost-effective transition methods.
### Salt Cavern Storage Constraints

#### US Hydrogen Storage

<table>
<thead>
<tr>
<th>Energy Equivalent Consumption (BCF)(^{1,2})</th>
<th>5%</th>
<th>10%</th>
<th>20%</th>
<th>50%</th>
</tr>
</thead>
<tbody>
<tr>
<td>31,533</td>
<td>32,659</td>
<td>35,172</td>
<td>45,723</td>
<td></td>
</tr>
</tbody>
</table>

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<tr>
<th>Volume Hydrogen Req'd (BCF)</th>
<th>1,577</th>
<th>3,266</th>
<th>7,034</th>
<th>22,862</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen Working Gas Capacity (BCF)(^3)</td>
<td>249</td>
<td>517</td>
<td>1,113</td>
<td>3,617</td>
</tr>
<tr>
<td>Approximate Salt Cavern Facilities(^4)</td>
<td>19</td>
<td>40</td>
<td>85</td>
<td>277</td>
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<td>Salt Caverns(^5)</td>
<td>62</td>
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<td>904</td>
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#### Hydrogen Blend

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### Existing Natural Gas Storage Facilities (US, 2019)

<table>
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<tr>
<th>Storage Type</th>
<th>Facilities</th>
<th>Working Gas (BCF)</th>
<th>Avg Working Gas (BCF)</th>
<th>% of Annual Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aquifer</td>
<td>47</td>
<td>403.81</td>
<td>8.59</td>
<td>1%</td>
</tr>
<tr>
<td>Depleted Field</td>
<td>328</td>
<td>3,935.13</td>
<td>12.00</td>
<td>13%</td>
</tr>
<tr>
<td>Salt Dome</td>
<td>37</td>
<td>483.17</td>
<td>13.06</td>
<td>2%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>412</td>
<td>4,822.11</td>
<td>11.70</td>
<td>16%</td>
</tr>
</tbody>
</table>

NOTES
1. Consumption based on 2020 natural gas consumption of 30,482 BCF per EIA
2. Energy Equivalency assumes H2 energy density is 33% of natural gas
3. Hydrogen Storage Capacity based on ratio of total storage to total consumption for natural gas per EIA (2019)
4. Cavern Facilities based on average work gas per Salt Cavern facility per EIA
5. Salt Caverns assumes average 4 BCF working gas per cavern

Source: Frank Frey, GHD; "Hydrogen and CCUS"
New Section 45X credit for hydrogen

- **New credit** – A ten-year PTC clean hydrogen produced after December 31, 2021 by a taxpayer at a qualified facility beginning construction by December 31, 2028.

- **ITC-in-lieu-of-PTC election** – Taxpayers would have the option to elect the ITC in lieu of the PTC with respect to a clean hydrogen production facility.

- **Amount** – Credit rate is $3.00/kg, adjusted for inflation, multiplied by an applicable percentage, which is 100% if the lifecycle greenhouse gas emissions rate is less than 0.45 kilograms of CO2e (carbon dioxide equivalent) per kilogram of hydrogen (adjusted downward based on the lifecycle greenhouse gas emissions rate). If the prevailing wage and apprenticeship requirements are not met, the credit rate is reduced to $0.60/kilogram.

- **Exclusivity** – A taxpayer cannot benefit from both the clean hydrogen PTC and the 45Q credit but appears to be able to take both the PTC or ITC and the clean hydrogen PTC.

- **Direct pay** – Taxpayers otherwise eligible for the clean hydrogen PTC would be entitled to elect for direct payment of the credit amount. The 45X Credit direct payment option does not require domestic content requirements to be met.

Conclusions
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• **Industrial carbon emissions are high** in energy producing states, particularly those along the Gulf Coast.

• These industries, however, are **important components of many regional economies**. Their loss could be devastating.

• **Industrial decarbonization will be important** over the next several years in order 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.
Questions, comments and discussion.

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