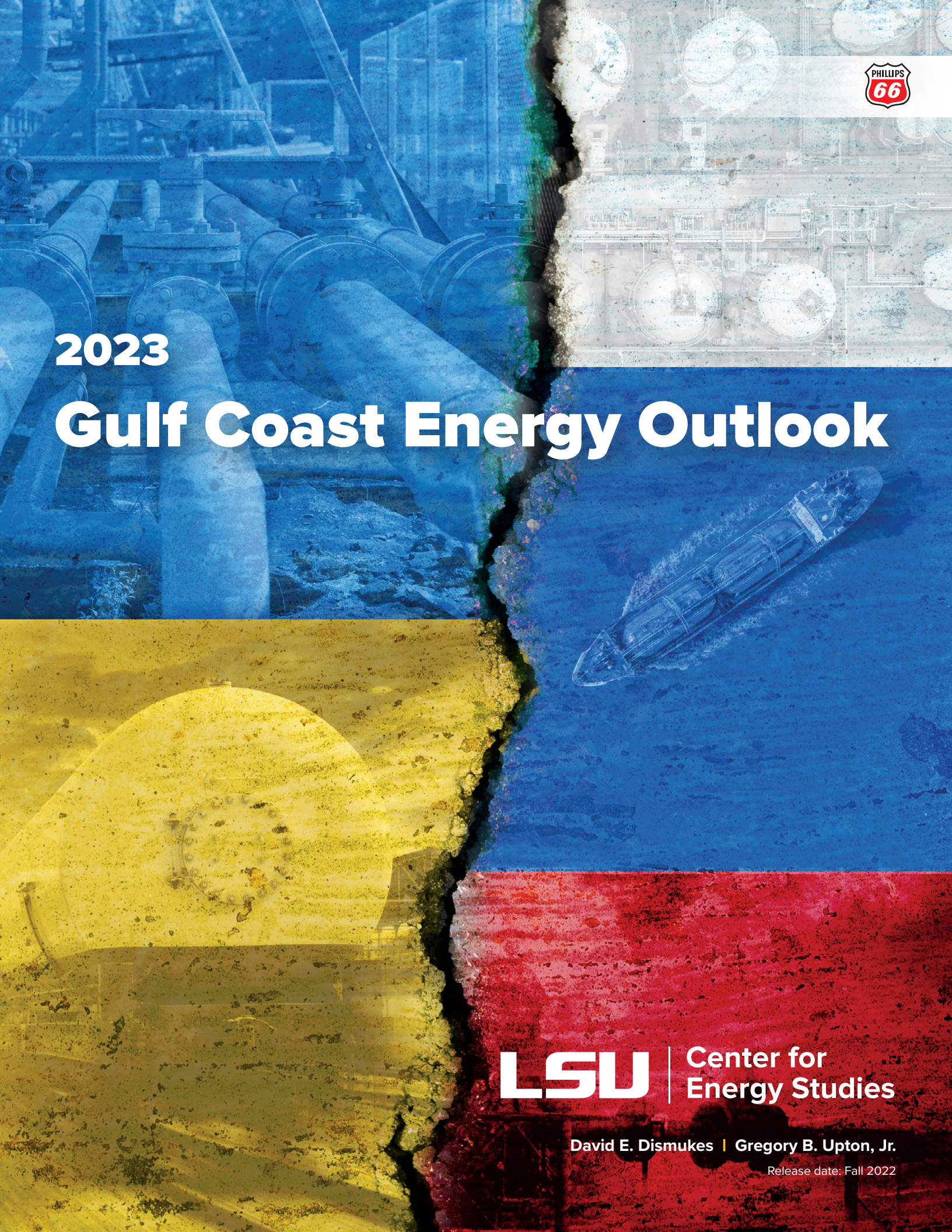

2023
Gulf Coast Energy Outlook

LSU | Center for Energy Studies

David E. Dismukes | Gregory B. Upton, Jr.

Release date: Fall 2022

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Acknowledgments

The 2023 *Gulf Coast Energy Outlook* (GCEO) would not be possible without the help of many who contributed both time and financial resources. First, the input from dozens of industrial, governmental, civic, and trade organizations that requested having the last year's GCEO presented to their organizations is much appreciated. The feedback that was provided during these conferences and individual meetings continues to be instrumental in preparing the current report. While "crunching the numbers" is an important aspect of any forecasting process, the input provided by stakeholders who have an "on-the-ground" view of what is occurring in real time is equally valuable.

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1. Introduction

The annual GCEO is designed to provide stakeholders with a "one-stop" overview of the current trends and outlook for the region's energy industry and its various sectors. The GCEO is a work product of Louisiana State University's Center for Energy Studies and has been sponsored by several companies and institutions looking to assist LSU in disseminating timely information and analysis impacting the region's economy, environment, and citizenry. The GCEO is also supported by the Center's general state appropriation, underscoring Louisiana's commitment to independent energy-related research. It would be difficult to produce the GCEO without both sources of support.

Unless otherwise stated, the "Gulf Coast" region specifically refers to the states of Texas, Louisiana, Mississippi, and Alabama. In some instances, the U.S. Department of Energy (DOE) reporting conventions will require references to data collected at the Petroleum Administration for Defense District 3 (PADD 3) level, which includes Arkansas and New Mexico in addition to the Gulf Coast states. Employment forecasts will focus on Louisiana and Texas. Where not specified, the forecast horizon extends to the end of 2025, or approximately three years.

The remainder of this introduction will highlight the big-picture considerations and assumptions made in subsequent analysis and forecasting.

1.1 Inflationary Pressures and Economic Performance

Beginning in late 2019, the global economy was fundamentally altered due to the advent of the COVID-19 virus that rapidly spread worldwide. The contagion spread to the U.S. as early as March 2020, and the following month, U.S. employment was a staggering 14 percent below the pre-pandemic peak. The April employment drop was the largest and swiftest in recorded U.S. history. Yet, as of today, the U.S. Bureau of Labor Statistics (BLS)[1] estimates that the U.S. economy surpassed its pre-pandemic peak employment for the first time in July of 2022—approximately two years after the trough of the pandemic-induced recession. At the time of this writing, estimated U.S. monthly employment continues to improve.

Although U.S. employment has recovered from the global pandemic, a new economic contagion looms: inflation. Over the past year, the U.S. Consumer Price Index (CPI) increased by approximately eight percent on an annualized basis (the highest in over 40 years), with the energy component of this index alone surging by as much as 24 percent between August of 2021 and August of 2022. This comes as no surprise to U.S. consumers, who experienced a retail gasoline prices increase from less than $2.00 per gallon to $5.00 per gallon in a single year.[2]

Price increases across all energy commodities (crude oil, natural gas, liquid and solid fuels), alongside global supply chain challenges, underscore a good part of this overall price inflation. Also, around the same time, the federal government began distributing the $1.2 trillion dollars from the Infrastructure Investment and Jobs Act (IIJA). Then in August of 2022 an additional $369 billion of

[1] Specifically, cited employment numbers are from the BLS's Current Employment Statistics (CES), commonly referred to as the "establishments survey."

[2] Comparison of average regular conventional gasoline prices per gallon in June of 2021 compared to peak gasoline prices observed in June of 2022.

stimulus was passed for the energy sector through the Inflation Reduction Act (IRA). Notably, the economy is approaching full employment at the time these stimulus payments are being injected into the economy

One might be tempted to compare economic performance during historical stimulus programs to model economic activity and energy demand today. But historically, stimulus programs, such as the American Recovery and Reinvestment Act (ARRA) after the Great Recession in 2008-2009, have been passed in response to national recessions. Following a recession, the aggregate labor market is slack and therefore stimulus programs are designed to put laid off workers to work.[3] But today, U.S. employment has reached pre-pandemic levels, and the unemployment rate nationally is well below four percent.

Thus, there has been a perfect storm of at least three factors driving inflation: (1) an economy already operating at full employment; (2) high energy prices facilitated by industry-related challenges and geopolitical tensions; and (3) considerable federal fiscal stimulus driven in part by two major spending programs that have injected, or will inject, copious levels of funding into an already "hot" economy. The Federal Reserve is raising interest rates in the hope that inflation will slow. But more worrying than inflation itself: U.S. wage growth has not kept up with inflation, and real hourly earnings have decreased by approximately three percent over the past year.

Economic theory suggests an adjustment is in order. Economic growth cannot continue indefinitely if inflation continues to outpace wage growth. If left to stand unchanged, the erosion of real wages will cause households to begin purchasing fewer goods and services. As these purchases slow, ripple effects through the economy will occur, leading to a business cycle contraction (i.e., a recession). However, another economic scenario could arise that sees inflation start to slow. A trend of stabilizing prices, which could lead to a return to real wage growth, could put the economy back on a path toward moderated expansion. In practice, some combination of the two is likely to occur, with each scenarios' weight determining the net outcome. The question is whether these factors result in a "soft landing" or result in a recession.

The good news is that, at the time of this writing, price increases are starting to slow down. BLS estimates an average monthly inflation rate of less than 0.2 percent inflation from the most recent three months of data available (July-September 2022), but September 2022 prices are still 8.2 percent higher than prices observed just one year prior. Major commodities such as hydrocarbons (oil and gas), precious metals, and wood products have already seen substantial reductions in prices over the past several months. These commodities are used as inputs into the creation and/or transportation of products worldwide.

Thus, reduced commodity prices alongside slowing CPI growth are indicators that inflation may be slowing. The other good news is that an important economic and political bellwether of economic activity, unemployment rates, have not yet shown signs of increasing, and the U.S. labor market is still strong. Thus, while a recession might certainly be on the horizon, this is not the GCEO base case.

[3] Hall, Robert, E. 2005. "Employment Fluctuations with Equilibrium Wage Stickiness." *American Economic Review*, 95 (1): 50-65.

This year's GCEO modeling will assume that inflation begins to slow, and regional economic activity will gradually expand over the forecast horizon. This year's GCEO, much like last year's, anticipates that long-run energy demand growth will lead to increased U.S. energy exports, especially to the growing developing world. If the global economy enters a recession, this will reduce demand for energy products making these forecasts too optimistic.

1.2 Russian Invasion of Ukraine

Assessing the outlook for energy markets goes hand in hand with the Russo-Ukrainian War. In this section, we briefly provide a timeline of events, putting into perspective the potential implications of this conflict on energy markets.

Rewind to early February of 2022. West Texas Intermediate (WTI) oil prices were trading at about $90 per barrel, and U.S. Gulf Coast natural gas was trading around $6 per million cubic feet (Mcf). Both oil and gas markets were in "backwardation," meaning futures contracts were trading below current prices. Thus, markets were anticipating that energy commodity prices would go down in coming months. But this is not what happened.

In February of 2022, the Russian military launched an invasion of Ukraine. Importantly, before the conflict began, Russia was the second-largest producer of oil and natural gas globally (with the United States as the largest producer of both oil and natural gas).[4] Also critical to note, the Nord Stream 2 pipeline, running through the Baltic Sea from Russia to Germany, was set to open in the coming weeks to greatly expand natural gas exports from Russia into European markets.

Global markets reacted immediately to Russia's invasion of Ukraine as markets experienced a sudden surge in energy commodity prices. West Texas Intermediate (WTI) oil prices peaked at over $120 per barrel, and the European-based Brent crude oil index peaked at over $130 per barrel. At the same time, the Dutch title transfer facility (TTF) natural gas price peaked at over $70 per MMbtu. While U.S. natural gas prices did not rise by as much, Henry Hub prices did surge to levels not seen in over a decade, causing concern for American consumers as summer utility bills began to spike.

The 2023 GCEO sees two energy-related outcomes from the Russo-Ukrainian conflict: First, it is not unlikely that commodity energy prices will remain higher in the future because of the conflict, which shows no sign of ending soon. Many military analysts believe that Russia will continue to be unsuccessful in achieving its overarching military objectives despite recent announcements to intensify its war efforts. Throughout this conflict, Western-based multinational companies have curtailed purchases of Russian products and/or withdrawn operations from Russian markets. This exodus of Western technical know-how will likely be particularly important for Russia's oilfield services sector, which relies on Western workers and equipment.

However, from a global energy commodity perspective, markets are trying to stabilize and adjust to this new reality of an ongoing conflict. Trade flows have and will likely continue to adjust by substituting Russian products away from some markets toward others. Further, the recently announced OPEC+ production curtailment of two million barrels per day seems to have not resulted, at least in the near

[4] Data from 2021. U.S. Energy Information Administration. International.

term, in any significant and sustained price spike, particularly one comparable to the early part of the conflict that saw prices in excess of $100 per barrel. Current futures prices underscore this new reality.

Russo-Ukrainian War Timeline

- Early February 2022: Brent Crude at ~$97/bbl and TTF natural gas at ~$37/mcf. Futures markets anticipating prices to go down over the next year.
- February 24, 2022: Russia launches a military invasion of Ukraine.
  - Germany suspends certification of Nord Stream 2 pipeline that was anticipated to begin shipping natural gas to Europe in coming months.
- March 2022: Brent crude surpasses $117/bbl and TTF natural gas surpasses $45/mcf.
- August 31, 2022: Russia suspends natural gas supplies to Germany via Nord Stream 1 for three days to perform repairs.
- September 3, 2022: Gazprom announces Nord Stream 1 will be shut down due to maintenance, citing Western sanctions.
- Worries mount over Europe's natural gas availability as winter looms.

This year's GCEO modeling will assume that the war in Ukraine continues, as does Western economic sanctions on Russia. The ongoing nature of the conflict will force global energy supply adjustments. Crude oil prices will gradually attenuate over the next several years, while Gulf Coast natural gas prices will likely remain elevated (relative to post-2008 historic trends) due to LNG export pressures.

1.3 Supply Chain Constraints

Discussions with industry have revealed that supply chain constraints continue to impact firms' abilities to conduct work. There are at least four plausible sources of these supply chain constraints: (1) structural post-pandemic dislocations and disruptions; (2) an economy that is already at full employment and being further stimulated by government fiscal stimulus; (3) the trade responses and sanctions adopted in response to the Russo-Ukrainian war; and (4) U.S. trade policies towards China.

It is difficult to disentangle the relative importance of the four factors underscoring continued supply chain constraints. However, of the four factors, the continued pressures that strained Sino-American trade relationships have on the energy sector is one that often gets overlooked in current media reports. The importance of this strained trade relationship was something addressed as early as the 2020 GCEO. In fact, one important concern expressed in at least two pre-pandemic GCEOs was how increasingly strained trade relationships were impacting economic activity, energy trade flows, and energy commodity prices.

The Gulf Coast region is a net exporter of energy products to both China and the world. The region has increasingly become more intertwined in international energy trade as (a) crude oil and natural gas production exceeds domestic needs and uses, and (b) more and more commodity chemical

industries invest billions in the region's productive capacity to meet global, not domestic, commodity chemical demand. Thus, strained relationships with one of the fastest growing energy markets in the world is clearly impacting the Gulf Coast.

Last year's GCEO noted that in January 2020, the U.S. and China signed Phase 1 of a trade deal that went into effect on February 14, 2020.[5] The 91-page agreement includes six chapters covering topics such as intellectual property, technology transfer, trade in food and agriculture, financial services, and macroeconomic policies. The 2022 GCEO followed up on the progress of this agreement, noting that the Biden administration was in the process of re-entering trade negotiations with China.

In October 2021, the Biden administration began unveiling its China trade policy following a review of import tariffs and other measures originally imposed by the Trump administration.[6] But upon this review, tariffs have continued while the Biden administration began the process of launching new talks with Beijing.[7]

To date, there has been no meaningful policy pivot in the trade relationships between the two different administrations, much to the dismay of some free-trade-oriented groups.[8] Some fear we are entering into a new era of deglobalization. These ongoing trade conflicts threaten an important regional economic and energy growth engine for the Gulf Coast: continued energy manufacturing capital investment. While regional energy manufacturing investment continues to be robust, ongoing trade conflicts create uncertainties for capital formation in the outer years of the outlook period (i.e., post-2025).

The current GCEO modeling assumes that supply chain constraints continue to bind for the next year or so before beginning to attenuate gradually. These supply chain constraints likely come from a combination of four sources: (1) the economic recovery from COVID-19; (2) an economy that is currently at full employment alongside significant stimulus; (3) the war in Ukraine and the resulting sanctions, and (4) a continuation of Trump-era trade policies with China.

1.4 Decarbonization Policies

Decarbonization, particularly industrial decarbonization, continues to take on a new level of importance and urgency since last year's GCEO. The 2016 Paris Agreement addressing anthropogenic greenhouse gas (GHG) emissions was ratified by 190 countries, representing 97 percent of the global population. President Obama's administration participated in the negotiation of the Paris Agreement in 2015, and in 2016 the agreement was formally ratified. President Trump withdrew the United States from the agreement in June of 2017. Then, in January of 2021, one of President Biden's first actions upon assuming office was to re-enter the agreement. For perspective on the increased attention on this issue, the Kyoto Protocol signed in 1997 represented just 14 percent of global emissions, compared to 97 percent for the Paris Agreement.

These GHG policy initiatives and commitments are not restricted to international activities alone.

[5] Economic and trade agreement between the government of the United States of America and the government of the People's Republic of China.

[6] Josh Zumbrun. U.S. Poised to Unveil China Trade Policy. *Wall Street Journal*. October 1, 2021.

[7] Yuka Hayashi and Josh Zumbrun. Biden's China Tariff Plan Fails to Provide Enough Relief, Businesses Say. *Wall Street Journal*. October 11, 2021.

[8] E.g. "Biden and Trade at Year One: The Reign of Polite Protectionism." CATO Institute. April 26, 2022.

Louisiana Governor John Bel Edwards committed Louisiana to GHG emissions reduction targets of 25 to 28 percent by 2025 and complete carbon neutrality by 2050. This makes Louisiana the only Gulf Coast state with such ambitious GHG emissions reduction targets. In February 2022, the Louisiana Climate Action Plan was released, the result of the Climate Initiatives Task Force (CTF) that include non-governmental organizations (NGOs), environmental and social justice groups, industry, state executive agencies, and trade associations, among others.

Perhaps the most important piece of energy-related legislation passed over the last year has been the Inflation Reduction Act (IRA) which has three core components: (1) corporate tax increases; (2) health care; and (3) energy and climate. More importantly for the 2023 GCEO are the IRA's provisions allocating $386 billion in clean energy financial incentives (and expenditures) for renewables (primarily wind and solar), carbon capture and storage (CCS), biofuels, hydrogen, energy efficiency, electric vehicles (EVs), EV charging infrastructure, and manufacturing, among other priorities.

The IRA also imposes a fee on some methane emissions, which will likely increase oil and natural gas production costs as well the costs of other energy sectors (like transportation and storage) that can exhibit varying degrees of methane emissions. An important IRA provision impacting the Gulf Coast is the continuation of federal offshore oil and gas leasing, which was one of the major uncertainties in the 2022 GCEO. The IRA is also a major supplement to the Infrastructure Investment and Jobs Act (IIJA), passed earlier in the year, that also included subsidies for hydrogen hubs, electrical grid upgrades, EV charging, and Superfund and brownfields site clean-up (that includes funding for the oilfield site restoration).

Concurrent with these policy initiatives are the implementation by large international corporations of "environmental, social, and governance" (ESG) policies that include decarbonization commitments. For example, some of the largest vertically integrated oil and gas firms, many of which have large Gulf Coast footprints (ExxonMobil, BP, and Shell) have made specific decarbonization commitments. Two publicly traded utilities in Louisiana, Entergy and AEP-SWEPCO, have also made decarbonization commitments.

Increasingly, the refining and chemical manufacturing industries that process hydrocarbons are making moves to decarbonize through a variety of means that include continued end-use and process efficiencies, the use of alternative feedstocks, fuel substitution (electrification and hydrogen), and through the use of carbon capture, utilization, and storage (CCUS). The GCEO will discuss these decarbonization investments, and highlight recent project announcements and capital investment levels, in the section examining energy manufacturing investment trends.

> **Decarbonization will challenge existing Gulf Coast energy manufacturing, but it will also create an opportunity for regional leadership in the development of the production capacity for liquid fuels, chemicals, plastics, fertilizers, and other products historically derived from fossil fuels, with lower, or even net zero GHG emissions. Industrial decarbonization can also lead to competitive advantages for Gulf Coast industries, particularly if trade policies and global tariffs become tied to environmental attributes. The IRA is likely to speed the region's industrial decarbonization given the important financial incentives supporting hydrogen and CCS. Over the forecast horizon, the GCEO sees decarbonization creating considerable regional capital investment opportunities.**

1.5 The Future of Offshore Leasing Resolved?

Soon after taking office, President Biden issued an executive order (EO) suspending offshore leasing and outlining plans to reduce GHG gas emissions in light of concerns about global climate change.[9] The EO explicitly directed the Secretary of the Interior to "pause new oil and gas leases on public lands or in offshore waters pending completion of a comprehensive review and reconsideration of Federal oil and gas permitting and leasing practices."[10]

The industry's response to this EO was swift, as were the legal actions taken by several impacted states, including all of those in the GCEO region, challenging the basis of the EO and its consistency with prior congressional authorizations and legislation.[11] The Department of the Interior cancelled a Gulf of Mexico offshore lease sale scheduled for March 2021. By June, a federal court preliminary injunction was granted that allowed the Bureau of Land Management (BLM) and the Bureau of Ocean Energy Management (BOEM), the agencies responsible for conducting lease sales on federal lands and waters, to continue the leasing process while the review of federal oil and gas leasing practices was completed.

On November 17, 2021, Lease Sale 257 was conducted, with more than 80 million acres leased for $192 million dollars. Just days after the lease sale was conducted, the Department of the Interior released its review of leasing practices. In January of 2022, the U.S. District Court for the District of Columbia vacated the results of Lease Sale 257, and in June 2022, all remaining offshore lease sales in the current 2017-2022 five-year program were cancelled, with no indication that the administration would move forward with a new five-year program, which would be required by the OCS Lands Act. At this time, it was hard to envision that offshore leasing would continue in any meaningful way in the Gulf.

But the outlook for offshore oil and gas changed in August of 2022 when Congress passed the Inflation Reduction Act (IRA) and President Biden signed it into law. A sometimes overlooked component of the IRA was that Lease Sale 257, which had been previously vacated, was reinstated. And for the next decade oil and gas leasing on federal waters is to be continued. Although some have communicated skepticism of this progress, suggesting that the Biden Administration will continue to make attempts at discontinuing offshore activity, the current law of the land is that offshore leasing will continue. As with past GCEO's, our modeling assumptions are based on *current policies*, not predictions about future policy actions that could occur.

GCEO modeling will consider that offshore leasing has been reinstated and that the offshore industry is returning to a "business as usual" scenario, driven by the economics of offshore oil and gas activity.

[9] Executive Order on Tackling the Climate Crisis at Home and Abroad. January 27, 2021.

[10] Ibid. Sec. 208.

[11] E.g. Texas: Executive Order by the Governor of the State of Texas. Executive Order GA-33. January 28, 2021. Louisiana: House Committee on Natural Resources and Environment and Senate committee on Natural Resources. February 10, 2021. Louisiana State Legislature.

Offshore Leasing Timeline

- **2020 campaign trail:** Candidate Biden said he would ban “new oil and gas permitting” on public lands and waters.
- **January 2021 executive order:** “pauses new oil and gas leases” on public lands and waters during “comprehensive review and reconsideration” of leasing practices.
  - March Gulf of Mexico Lease Sale cancelled.
- **June 2021**: Preliminary injunction granted in Federal court that the Bureau of Land Management (BLM) and Bureau of Ocean Energy Management (BOEM) continue leasing while review is completed.
- **November 2021:** Gulf of Mexico Lease Sales 257 conducted.
  - ~81 million acres leased for ~$192 million
- **January 2022:** Washington, D.C. Court vacated results of Lease Sale 257.
- **June 2022:** Department of the Interior announces that all lease sales remaining in current five year program are cancelled.
  - Offshore leasing in the Gulf of Mexico effectively discontinued.
- **August 2022:** Inflation Reduction Act signed into law.
  - Lease Sale 257 reinstated.
  - Offshore leasing resumed and tied to offshore wind developments.

2. Crude Oil and Natural Gas Production and Prices

2.1 Crude Oil and Natural Gas Production

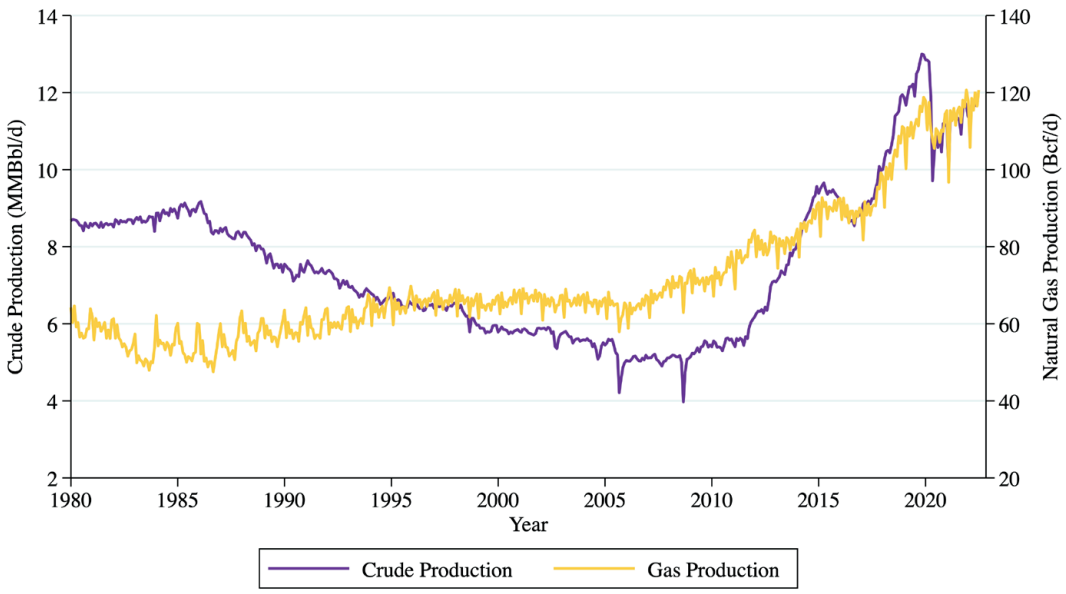
The impact of the pandemic on U.S. and Gulf Coast crude oil and natural gas production is still visible and has dramatically changed the fortunes of U.S. energy across almost every sector. U.S. and Gulf Coast oil and natural gas production were both at historical levels prior to the pandemic, and GCEO anticipated production of both crude oil and natural gas to continue to grow at relatively robust rates for the coming decade.

Consider that U.S. oil and natural gas production peaked at the end of 2019 at 12.97 million barrels per day (MMBbl/d) of crude oil and 119 billion cubic feet per day (Bcf/d) of natural gas (see Figure 1).[12]

However, by spring 2020, U.S. crude oil production dropped to less than 10 MMBbl/d—a drop of over 25 percent. Natural gas production was also negatively impacted, but to a lesser extent, bottoming out at less than 100 Bcf/d in June of 2020—a drop of 12 percent. Although both oil and natural gas production have rebounded, at the time of this writing, natural gas production is approximately back to pre-pandemic levels, while crude oil production is still about nine percent below pre-pandemic levels. Thus, U.S. oil production has still not yet recovered from the pandemic, while natural gas production has.

Although not shown here, regional (PADD 3) crude oil and natural gas production follows U.S. trends. Like the U.S., regional natural gas production is approximately back to pre-pandemic levels, while regional oil production is still approximately nine percent below its pre-pandemic peak.

Figure 1: U.S. crude oil and natural gas production



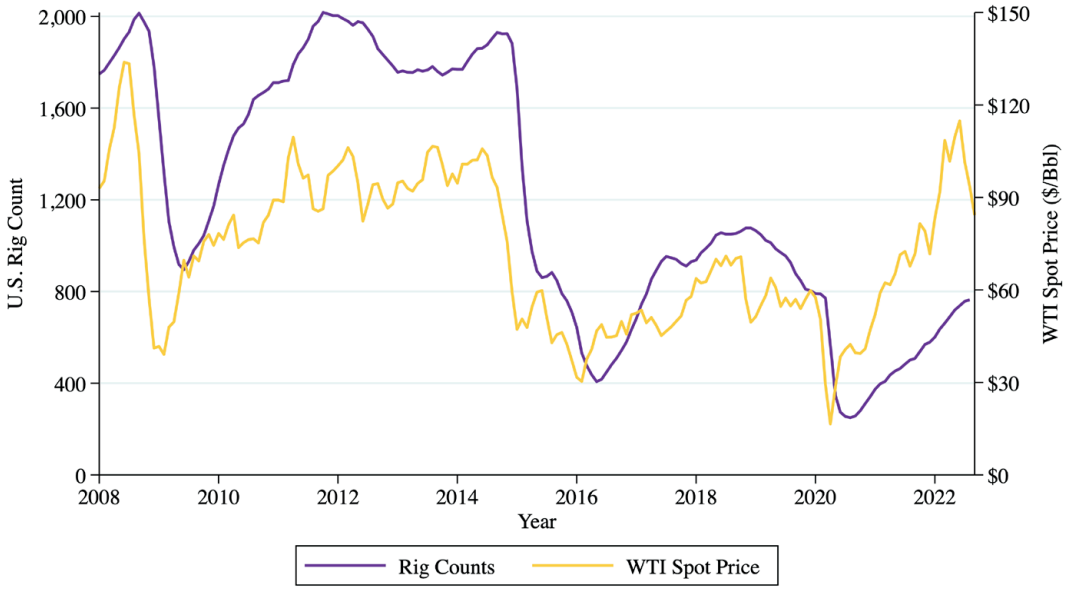
Source: U.S. Energy Information Administration. Petroleum & Other Liquids. Crude Oil Production. Natural Gas Gross Withdrawals.

[12] Annual averages provided by EIA listed in text. Monthly data shown in Figure.

Figure 2 highlights the pandemic's impact on U.S. drilling activity and the subsequent rebound. Baker Hughes reported 250 active rigs in August 2020, the lowest active recorded rig count that was 73 percent lower than the prior August (2019). Unsurprisingly, this rig count drop mirrored the drop in the West Texas Intermediate spot price that bottomed out at less than $17 per barrel in March of 2020.

Rig counts have rebounded, but not back to pre-pandemic levels. In the most recent full month of data available (August 2022) the Baker Hughes rig count is 764 rigs. Although this has more than tripled since the trough, rig counts are still significantly below the levels experienced in 2018 and 2019. As will be discussed in Section 7, the GCEO anticipates that drilling activity will continue to increase but is unlikely to return to pre-pandemic levels. Although, as will be discussed further in the production forecast modeling, oil *production* is expected to reach pre-pandemic levels over the forecast horizon. Thus, the industry is expected to continue producing more with fewer inputs, a sign of continued efficiency improvements.

Figure 2: U.S. crude oil prices and rig count

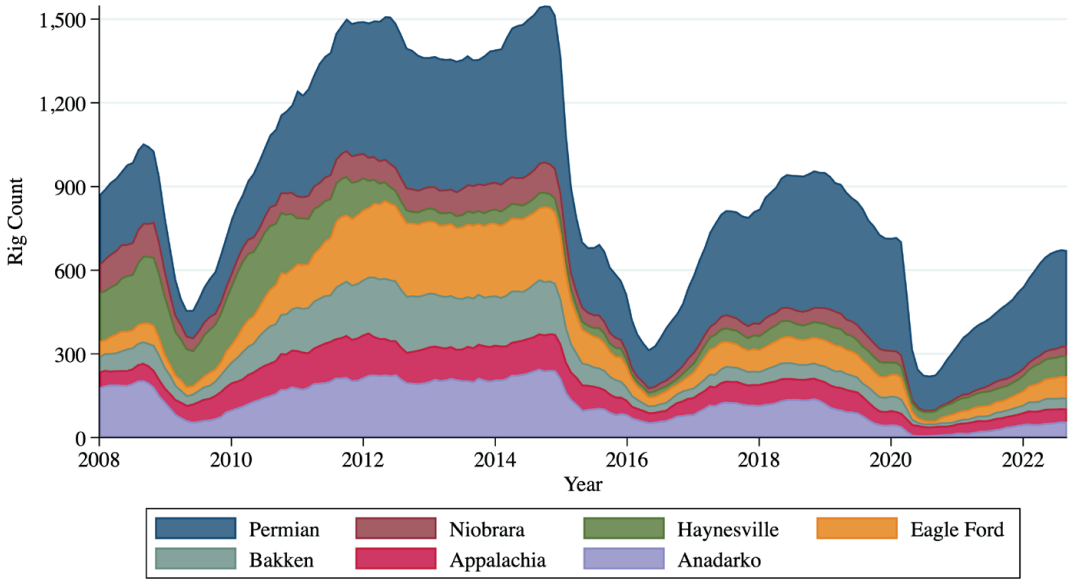


Source: U.S. Energy Information Administration. West Texas Intermediate Spot Price. Baker Hughes Rotary Rig Counts.

Figure 3 displays rig activity levels in seven major U.S. shale plays, as defined by EIA's *Drilling Productivity Report*. Last year's GCEO noted that the Permian basin had been the predominant U.S. shale play, accounting for approximately 46 percent of all active 2019 rigs. While the Permian is the premier basin, it is also the one that experienced the largest rig count reduction, losing more than 700 rigs between the beginning of 2019 and the August 2020 post-pandemic trough.

All seven of the basins shown in Figure 3 have experienced rig count increases since the trough in September 2020, but not a single one of these basins has reached rig counts experienced in the prior peak, in 2018 and 2019. More focus on Gulf Coast oil and gas production specifically will be provided in Section 2.3 on page 16.

Figure 3: Rig counts in major shale basins



Source: U.S. Energy Information Administration. Drilling Productivity Reports.

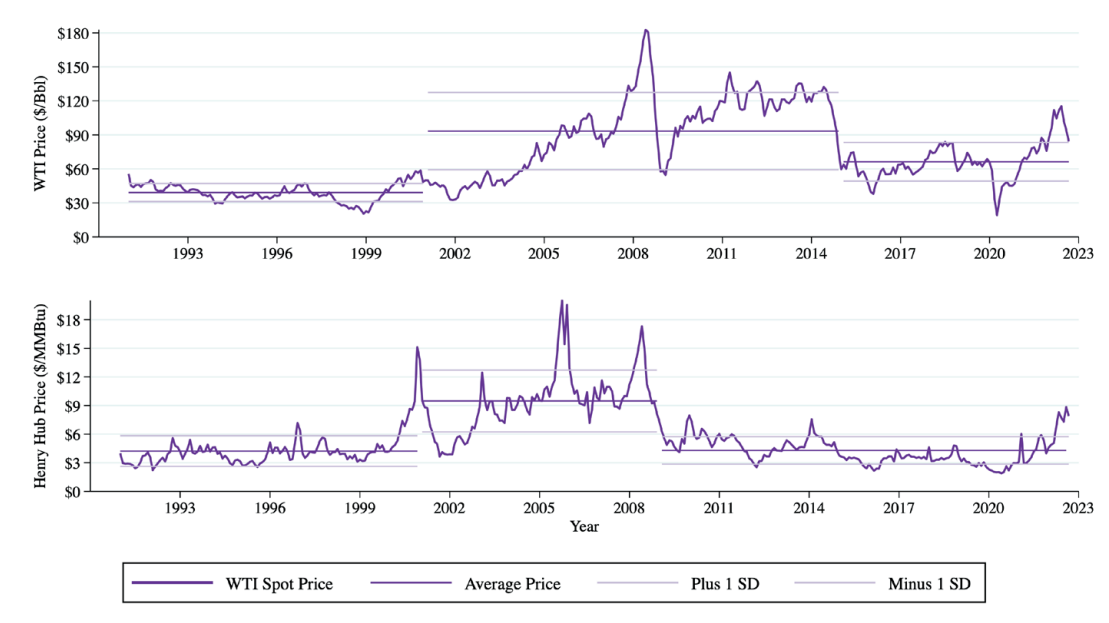
2.2 Commodity Pricing

Figure 4 shows recent trends in both crude oil and natural gas commodity pricing. The top panel shows historic trends, and pricing "epochs for oil," whereas the bottom panel presents historic trends for natural gas pricing.

Historic natural gas pricing shows three separate epochs: (1) the period spanning the 1990s; (2) the period starting with the natural gas supply/pricing crisis of the 2000s; and (3) the post-recession period to current. These epochs differ in both their levels and variability.[13] The relevant question today is whether natural gas prices have entered into a new epoch that reflects a greater integration of U.S. natural gas markets to global markets. Prior to the advent of LNG, U.S. markets faced limited pricing exposure to changes in global markets. The Russo-Ukrainian war, the resulting sanctions on Russian natural gas, as well as what appears to be the near-term halt of Nord Stream 1 gas flows, and the fact that the U.S. is now the largest producer and exporter of natural gas will likely result in substantially more, but still not total, integration.

[13] Variability is shown as the standard deviation in the change in average monthly prices.

Figure 4: Historical inflation-adjusted oil and natural gas price



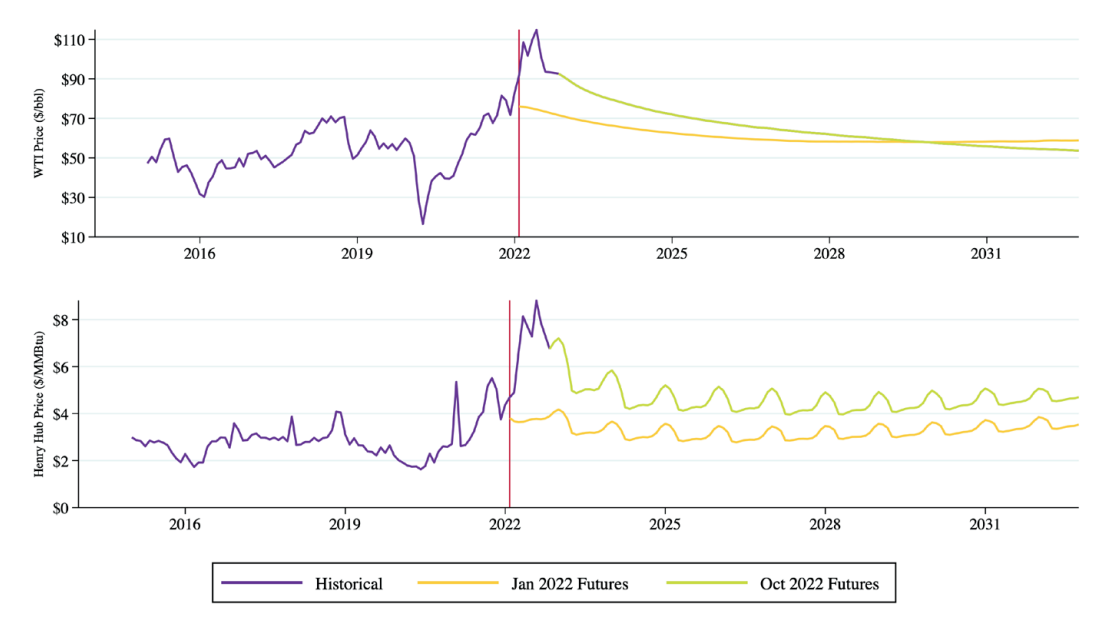
Source: U.S. Energy Information Administration. Henry Hub Natural Gas Spot Price (top) and West Texas Intermediate Spot Price (bottom). Inflation adjustment based on U.S. Consumer Price Index sources from the Bureau of Labor Statistics.

The trends in inflation-adjusted crude oil pricing underscore how the unconventional revolution has led to dramatically reduced volatility relative to past pricing epochs. Pre-pandemic crude oil prices are shown in the middle range of the third epoch. The pandemic, quite simply, crashed crude oil prices in ways never experienced in the past. Crude oil prices bottomed out at a monthly average of less than $17 per barrel in April 2020, but quickly rebounded. But like natural gas, the global economic recovery alongside the war in Ukraine has put significant upward pressure on oil prices. Although notably, oil prices are still below levels experienced in the 2000s.

Figure 5 compares historical prices and futures for both the West Texas Intermediate (WTI) crude oil price (top panel) and Henry Hub natural gas price (bottom panel). Unlike Figure 4, both energy commodity prices are shown in nominal dollars (i.e., no inflation adjustment). Futures prices are shown in January of 2022, the month before Russia began its military invasion of Ukraine. The vertical red line represents February of 2022, the month of the invasion. Second, futures markets are shown for October—the most recent month available at the time of this writing.

There are several notable observations based on Figure 5. First, before the Russian invasion of Ukraine, oil and natural gas prices were in "backwardation," meaning prices were anticipated to fall in the coming years. More specifically, future oil prices were trading at around $83 per barrel in January and were anticipated to fall by about $13 per barrel by the following January. Natural gas prices traded at approximately $4.40 per MMBtu and were anticipated to fall by about 20 cents by the following January.

Figure 5: Oil and natural gas price outlook



Source: New York Mercantile Exchange Henry Hub Futures Price. Sources from S&P Global Market Intelligence. Red vertical line represents February of 2022. Most recent future price as of October 7, 2022.

But clearly, prices did not fall in the coming months. In fact, prices of both oil and natural gas rose precipitously in response to the Russian invasion of Ukraine. Oil prices increased to over $114 per barrel, and natural gas prices spiked to over $8 per MMBtu in the months after the invasion. Although not shown here, international benchmarks of both oil and natural gas were impacted even more than prices in the Gulf Coast region of the U.S.

Figure 5 also offers insights into the plausible longer-term effects of the war in Ukraine on oil and gas prices regionally. Oil prices that are currently trading at over $90 per barrel (spot market) are anticipated to decline by the end of 2023, when oil price futures fall to about $80 per barrel. In the long run, oil futures converge to prewar levels and even fall *below* prewar futures prices by 2030. Natural gas prices, however, while falling from $5.50/MMBtu in 2023 to $4.70/MMBtu in 2024, are expected to remain about $1.40/MMBtu higher than what was anticipated before the war.

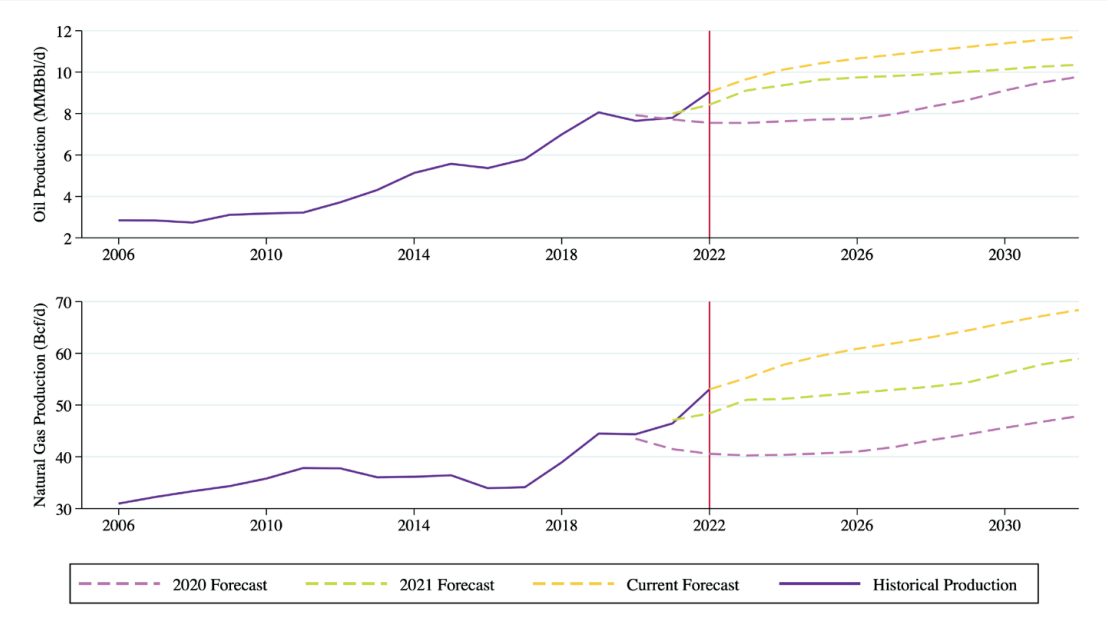
In sum, Figure 5 suggests the following: First, both oil and natural gas prices today are *higher* than over the past several years. Second, both oil and natural gas prices are anticipated to fall over the coming year. Lastly, while long-run oil prices are anticipated to converge back to pre-war levels, natural gas prices will likely settle at average levels higher than those seen over the past decade.

2.3 Outlook: Crude Oil and Natural Gas Production

Figure 6 provides the 2022 GCEO crude oil and natural gas production forecasts for the Gulf Coast based on the Enverus ProdCast model. Following tradition, both figures show the current forecast as well as those in the past two years' GCEOs.

Gulf Coast crude oil production forecast is anticipated to increase over the forecast horizon.[14] For perspective, in 2020 regional crude oil production averaged 7.7 MMBBl/d, and although monthly oil production was negatively impacted by the pandemic, the 2021 calendar year experienced about a two percent increase in Gulf Coast oil production, to about 7.8 MMBBl/d. In calendar year 2022, which at the time of this writing is partially completed, ProdCast estimates Gulf Coast oil production to average 9.0 MMBBl/d, or an increase of approximately 16 percent and to a level surpassing pre-COVID levels. By 2032, Gulf Coast oil production is forecasted to reach 11.7 MMBBl/d. This oil production forecast has been upgraded since the last two GCEOs, as is perhaps unsurprising given the current high-price environment. As with prior years, there is plenty of oil in the ground to sustain a decade of production growth. Notably, the ProdCast model does not explicitly take into account the supply chain constraints discussed previously; thus the short-term outlook for oil production is likely to be optimistic given the current monthly production numbers.

Figure 6: Gulf Coast oil and natural gas production forecast



Source: Enverus ProdCast.

Figure 6 also shows that Gulf Coast natural gas production is also anticipated to continue to grow over the next decade.[15] In 2020, Gulf Coast natural gas production was about 44.4 Bcf/d and increased to 46.5 Bcf/d in 2021. Prodcast is estimating natural gas production to increase to 53.0 Bcf/d in 2022, or a 14 percent increase. By 2032, ProdCast estimates Gulf Coast natural gas production to reach over 68 Bcf/d. Thus, both oil and natural gas production in the region are anticipated to experience a decade of growth despite the fact that oil and natural gas prices are both in backwardation.

[14] Note that the definition of the Gulf Coast region in the Enverus Prodcast model differs slightly from political boundaries, due to the inherent geological nature of the model.
[15] Ibid.

3. Midstream Constraints and Pipeline Activity

Geographic differences in crude oil and natural gas prices often drive pipeline development. If prices at "Point A" are higher than "Point B" at a given time, firms have the incentive to develop transportation resources to capture this price differential (or "basis").

As in prior year GCEOs, Figure 7 compares differences in prices of West Texas Intermediate (WTI) and Louisiana Light Sweet (LLS). Three vertical lines are drawn. The first vertical line marks pricing levels as of January 2007, the date at which the EIA began tracking crude oil and natural gas unconventional production in its *Drilling Productivity Report*. The second line marks pricing levels as of May 2012, when the Seaway pipeline was reversed. Seaway initially moved crude from Freeport, Texas, on the Gulf Coast, to Cushing, Oklahoma, where WTI is priced. After Seaway was reversed, the pipeline carried crude produced in the Mid-Continent to Gulf Coast refineries. This line divides a regime of increasing internal shipping constraints from a regime where those constraints were relieved. The third line marks pricing levels as of December 2015, when the U.S. government lifted the crude oil export ban.

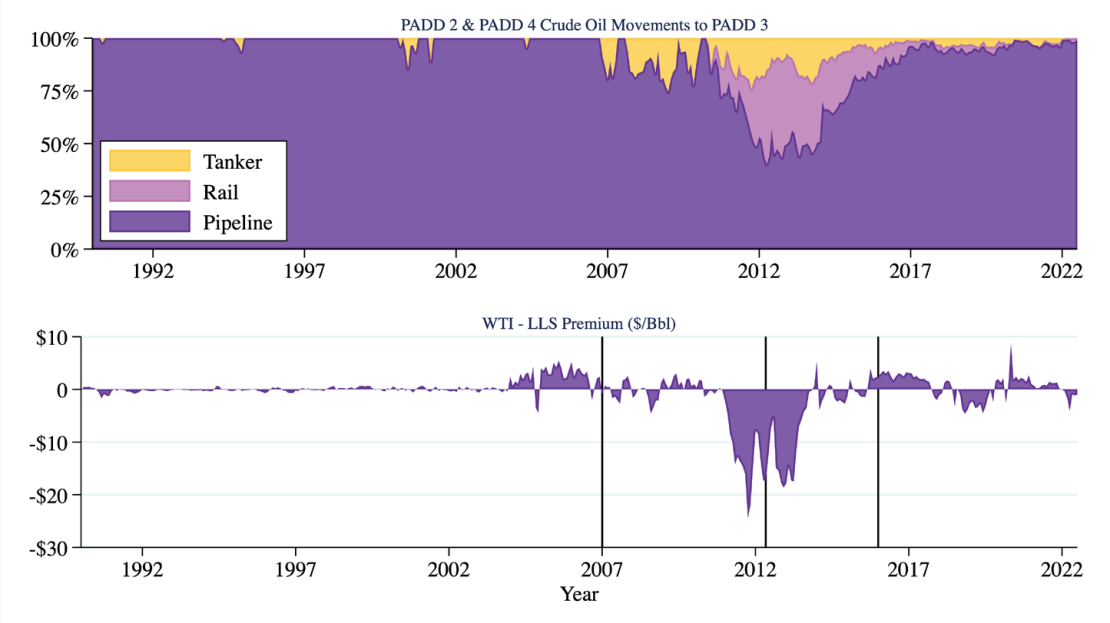
The top panel of Figure 7 shows the share of crude oil transported from PADD 2 to PADD 4 in the Mid-Continent (states in the Rocky Mountain and Midwestern regions) to PADD 3 on the Gulf Coast. From 1990 to 2007, almost all crude was transported from the mid-continent to the Gulf Coast via pipeline. Shippers used pipelines because rail and tankers were more expensive on the margin. During this time WTI and LLS moved in lockstep. In fact, by April 2012, more than half of the crude shipped from the mid-continent to the Gulf Coast went via high-cost barge and rail, as pipelines were at full capacity. Almost immediately after the reversal of the Seaway pipeline, this trend stopped, and the share of crude shipped via pipeline began to recover.

The LLS-WTI premium closely mirrors changes in the mode of transport over the 2007-to-2015 time period. This close correlation between shipping and prices can explain between one-half to three-quarters of relative price movements. Prior empirical research has investigated the degree to which refinery composition, captured by API crude oil gravity, can explain these differentials.[16] Evidence of shipping constraints, but not refining constraints, is observed.

This analysis provides strong evidence that shipping constraints between the Mid-Continent and Gulf Coast were the culprit for the price discount. The good news is that at the time of this writing, crude markets are approximately in balance, with a slight premium for LLS. The GCEO anticipates a small premium will persist over the forecast horizon and that more than 95 percent of crude shipped from the Mid-Continent to the Gulf Coast will continue to come from pipelines. Although oil production is anticipated to increase, due to the investment in pipeline infrastructure over the past decade, the need for increased barge and rail shipments is unlikely at this time. Thus, significant investment in crude oil pipelines is likely not needed at this time to continue moving crude from the Mid-Continent to the Gulf Coast region for refining and/or export. This is especially true given the fact that oil production has yet to reach pre-pandemic levels.

[16] Agerton and Upton, 2019. Decomposing Crude Price Differentials: Domestic Shipping Constraints or the Crude Oil Export Ban? *The Energy Journal*, Vol. 40, No. 3.

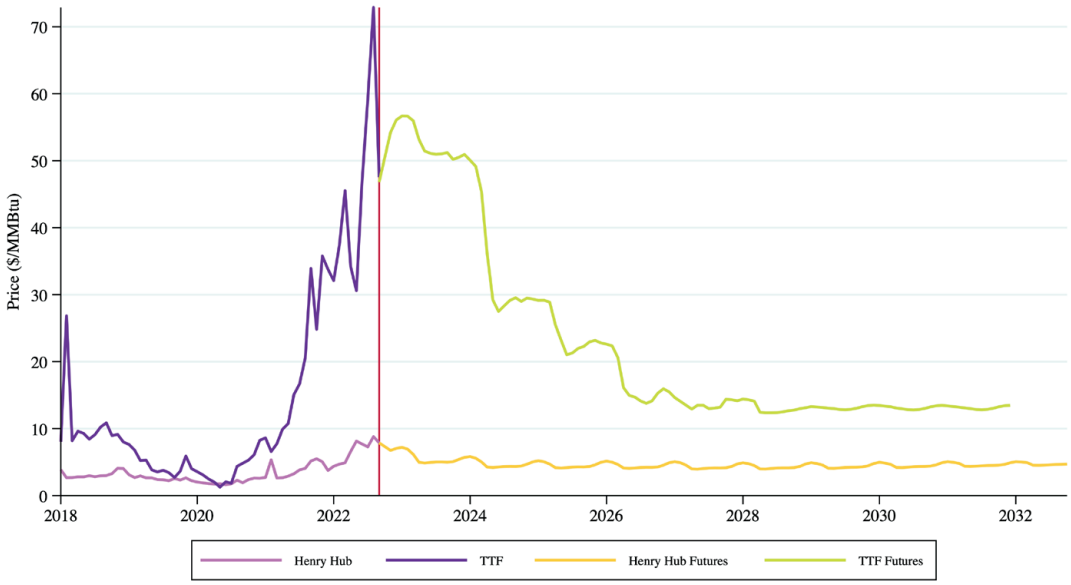
Figure 7: PADD 3 crude oil movements by transportation type



Source: U.S. Energy Information Administration, West Texas Intermediate Spot Price and Light Louisiana Sweet First Purchase Price. Movements between PADD Districts, by pipeline, tanker and barge, and rail.

Figure 8 illustrates the major price difference for natural gas markets over this past year, namely comparison of Henry Hub natural gas prices here in the Gulf Coast region of the United States and the Dutch TTF prices, which is the notable natural gas price in European markets. This is the incentive for continued investment in LNG exports that will be discussed further in Section 5.

Figure 8: Henry Hub (HH) and Title Transfer Facility (TTF) natural gas prices



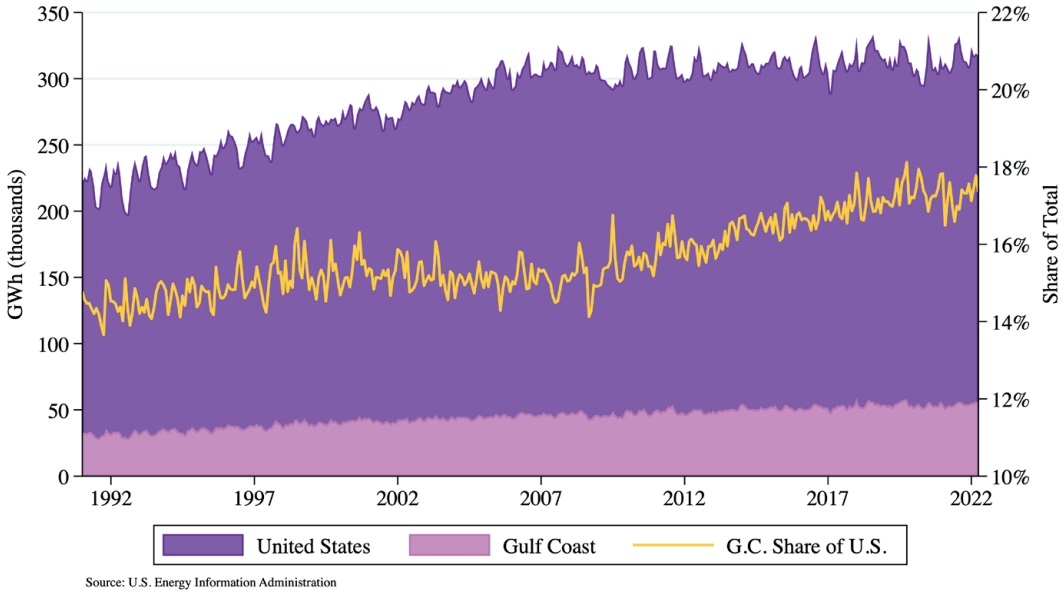
Source: Bloomberg Terminal.

4. Power Sector

4.1 Load Growth

Figure 9 shows trends in both U.S. and regional electricity sales. First, U.S. electricity sales growth has been relatively flat over the past decade. For instance, compare total sales in MWhs to all customers in the United States in 2007 (the highest load year before the Great Recession) to the most recent full year available (2021). Current (2021) electricity sales are within one percent of those reported in 2007 (the last highest annual sales level). The Gulf Coast, however, has seen differing trends with electricity sales increasing by 15 percent over this same time period. Gulf Coast retail electricity sales, as a share of total U.S. electricity sales, has increased from 15 percent to over 17 percent over this time period. Although not shown here, the Gulf Coast's growing share of electricity sales is driven by industrial sales. The Gulf Coast region accounted for over 18 percent of U.S. industrial sales in 2007, and at the time of this writing accounts for over 21 percent of nationwide industrial sales. This growth in industrial sales has been spurred by energy manufacturing activity, which will be discussed further in Section 5.

Figure 9: U.S. and Gulf Coast electricity sales



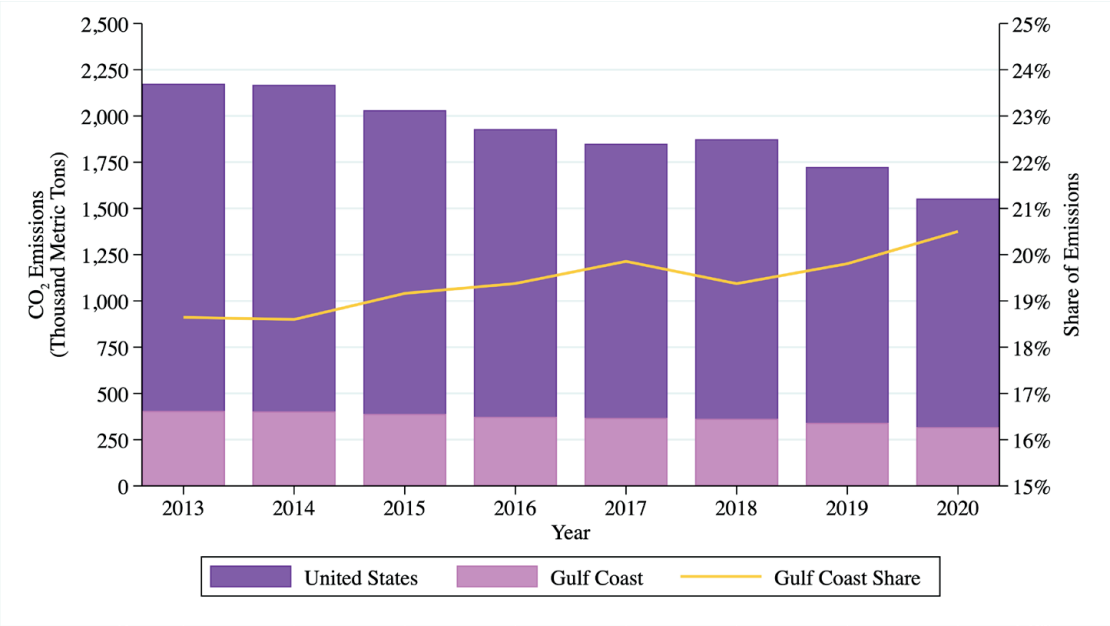
Source: U.S. Energy Information Administration. Retail sales of electricity to ultimate consumers.

4.2 Carbon Emissions

GHG emissions associated with power generation are provided in Figure 10. Note that this data is available with a lag, and thus is only available until the calendar year 2020, which of course coincided with the pandemic. Between 2013 and 2020, U.S. and Gulf Coast power-generation-related GHG emissions are down 28.5 percent and 21.5 percent, respectively. These decreases are attributable

to (1) the development of a greater level of renewable energy and (2) considerable thermal efficiency gains by the region's utilities and (3) the reduction in electricity production during the pandemic. These power generation related GHG emission trends are addressed in greater detail in CES' recent GHG inventory report.[17]

Figure 10: U.S. and Gulf Coast carbon dioxide emissions from electricity generation



Source: U.S. Energy Information Administration. Electricity. Emissions by plant and by region.

4.3 Capacity Investment

Figure 11 shows historic and projected power generation capacity by fuel source for the Gulf Coast region. Projections are developed by S&P Global Market Intelligence.[18] Interestingly, approximately 65,000 MW of solar generating capacity is currently in the planning phase or under construction in the Gulf Coast region according to S&P. While not shown in this figure, in MISO alone, Louisiana currently has approximately 11,500 MW of solar capacity in the interconnection queue. This number is almost double the approximately 6,000 MWs reported in last year's GCEO. For perspective, solar capacity was less than 100 MW in the Gulf Coast region as recently as 2011.

Figure 11, also shows over 14,000 MW of wind capacity in the planning phase. In third place, natural gas has approximately 10,000 MW of capacity currently being planned in the region.

Note that while solar capacity will likely experience significant growth, in 2020 solar PV nationally had a capacity factor of approximately 25 percent, compared to 35 percent for wind and 57 percent for combined-cycle natural gas.[19] Thus, although solar capacity might very well grow over the next

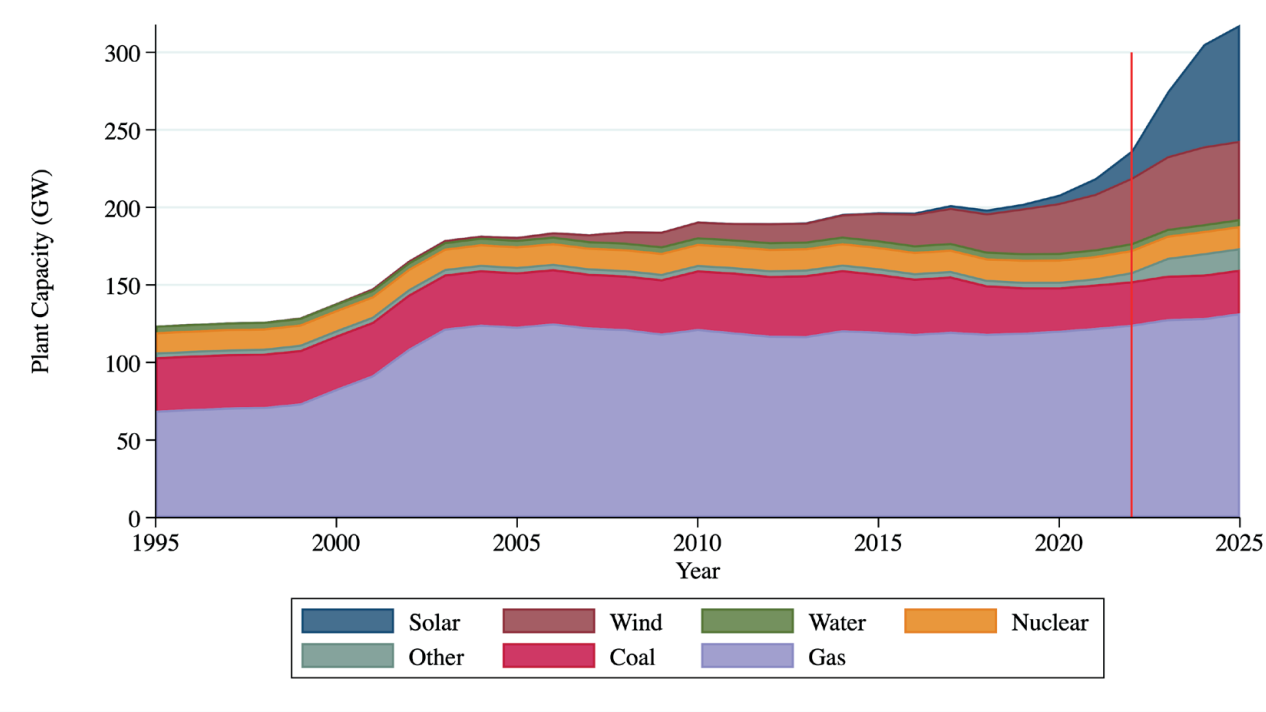
[17] Dismukes, DE. Louisiana 2021 Greenhouse Gas inventory. Prepared on behalf of the Governor's Office of Coastal Activities. October 2021. LSU Center for Energy Studies.

[18] Future capacity is based on actual planned and under-construction projects, and not based on any projections of unreported new developments or retirements.

[19] U.S. Energy Information Administration. Electric Power Monthly. Table 6.07.B. Capacity Actors for Utility Scale Generators Primarily Using Non-Fossil Fuels. Table 4.08.A. Capacity Factors for Utility Scale Generators Primarily Using Fossil Fuels.

five years or so, this is still anticipated to be a small share of total electricity generated for the foreseeable future.

Figure 11: Gulf Coast power generation capacity and outlook



Source: S&P Global Market Intelligence, Historical and Future Power Plant Capacity.

5. Energy Manufacturing Activity

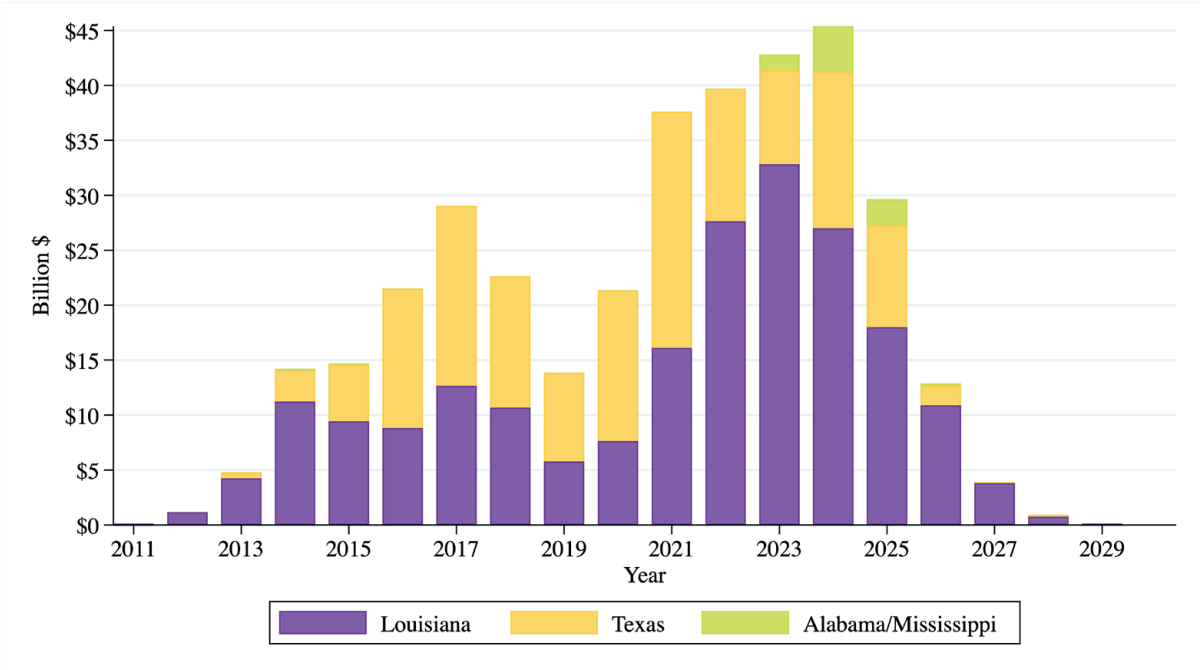
5.1 Energy Manufacturing

The energy manufacturing recovery from the recent pandemic has continued to prove that the Gulf Coast region continues to be a very attractive location for capital investment. Over the past decade (2011-2021), the Gulf coast has supported more than $180 billion in energy manufacturing investment; as much as $5.5 billion on an annual average basis. This investment has resulted in the upgrade of decades of legacy energy manufacturing assets and propelled the region into a new capacity growth period focusing on international energy commodity, refined product, and commodity chemical trade.

The surge in energy manufacturing investment has slowed over the past several years, in part as a "catch up" reaction to consistently strong activity and, in very large part, due to the challenges faced by the global economy, particularly the global economic contraction precipitated by the pandemic. Figure 12, for instance, shows the slowdown in investment activity arising during the 2017 to 2020 time period as trade woes, early signs of supply chain fatigue, and labor market challenges all dampened regional energy manufacturing investment to levels below $20 billion per year.

Recovery began soon after many of the uncertainties of the pandemic subsided, and in 2021, the Gulf Coast saw a boom of pent-up investment activity surpassing the prior $15 to $20 billion per year annual average investment level seen immediately before the pandemic. Regional energy manufacturing investment growth has continued into 2022 at levels anticipated to be around $40 billion per year.

Figure 12: GOM energy manufacturing investments by state



Source: Center for Energy Studies, authors' construct from publicly reported data.

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

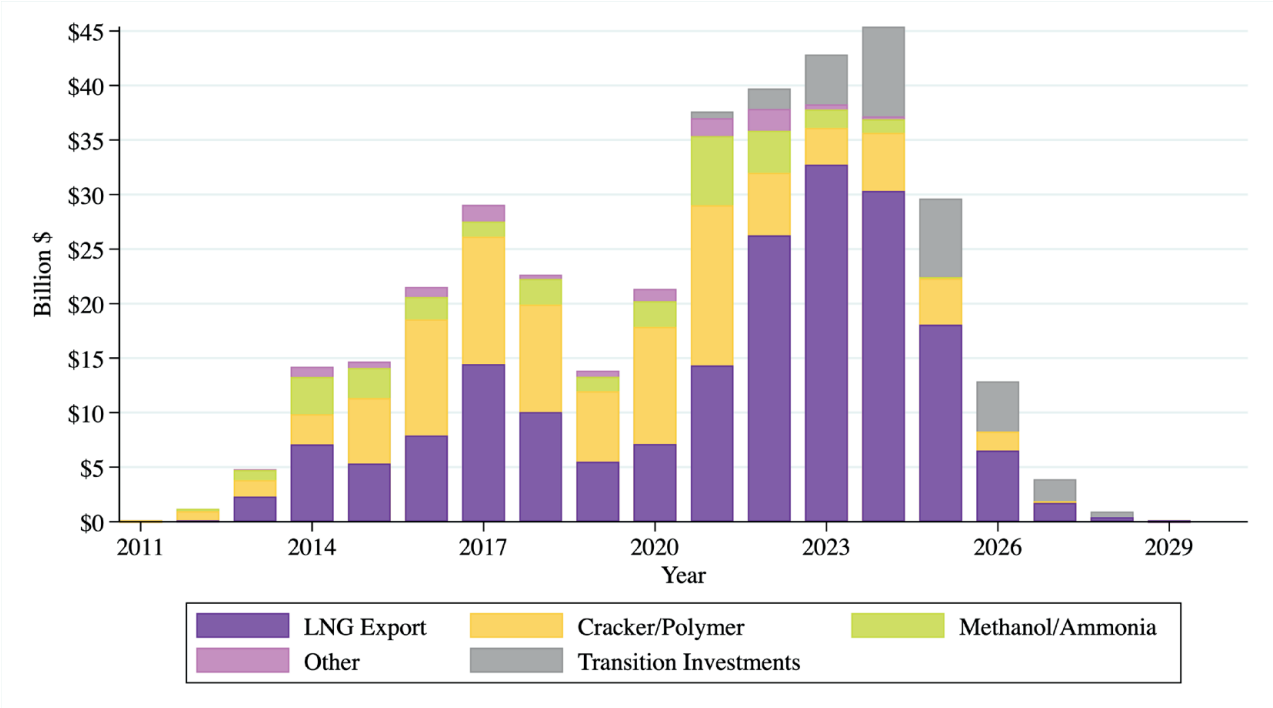
Over the past decade, energy manufacturing investment dollars have been approximately equally distributed between Louisiana and Texas. The same can be said of the sectoral allocation of energy manufacturing investments, as show in Figure 13, having been equally allocated across LNG investments and non-LNG investments (chemical industry, refinery, and other).

Last year's GCEO noted $38.2 billion in new 2021 capital investment based on publicly available project announcements. The 2021 GCEO handicapped this publicly announced level down to $21.7 billion due to the uncertainty about the pandemic – about $16.5 billion below the publicly announced 2021 level. Actual 2021 energy manufacturing investments, however, were considerably more resilient than anticipated in last year's GCEO and reported in at over $35 billion, setting a record annual high over the past decade.

Gulf Coast Manufacturing

- Between 2011 and 2021, there were approximately $180 billion of investment in refining, chemicals, and hydrocarbon export across the Gulf Coast region.
- Approximately $87 billion, or 48 percent is within Louisiana.
- Currently, there are an additional $175 billion in announcements, with approximately 70 percent of these announcements in Louisiana.

Figure 13: GOM energy manufacturing investments by sector



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

5.2 Energy Manufacturing Outlook

The 2023 GCEO anticipates as much as $175.4 billion in new energy manufacturing investment activity from 2022 through 2030. This represents a $15 billion, or 7.9 percent reduction in total regional capital investment relative to last year's GCEO over a comparable period of time. While overall investment dollars are down, what differs in this outlook relative to prior years is the surge in new "energy transition" investments. Table 1, for instance, breaks out investments across four primary categories: (a) LNG investments; (b) non-LNG/chemical industry investments; (c) energy transition investments; and (d) "other" investments. These energy transition investments collectively, account for over $29 billion and include a wide range of new and innovative plans and processes to avoid GHG emissions, including carbon capture and storage (CCS), "green" hydrogen, "green" ammonia, and various "blue" hydrogen/ammonia processes. Note that utility-scale renewable energy generation is not included in this category and has been discussed earlier in the electric capacity outlook. While not readily apparent from Table 1, the 2023 GCEO envisions energy transition-related investments to continue to grow in outlying years and ultimately catch up with, or even rival, more traditional LNG and non-LNG investment levels.

Table 1: Total GOM investments

	Texas					Louisiana					Other GOM					Total GOM				
Year	LNG	Non-LNG	Transition	Other	Total	LNG	Non-LNG	Transition	Other	Total	LNG	Non-LNG	Transition	Other	Total	LNG	Non-LNG	Transition	Other	Total
	(million $)																			
2022	5,529	4,699	54	1,762	12,044	20,687	4,916	1,815	225	27,642	33	-	-	-	33	26,249	9,615	1,869	1,987	39,720
2023	5,241	2,376	743	228	8,588	26,171	2,685	3,834	136	32,826	1,321	-	-	101	1,422	32,734	5,061	4,576	466	42,837
2024	7,142	4,335	2,720	-	14,197	19,155	2,227	5,507	117	27,005	4,038	-	-	149	4,187	30,335	6,562	8,226	265	45,389
2025	3,825	3,491	1,930	-	9,246	11,836	894	5,251	15	17,996	2,394	-	-	-	2,394	18,055	4,385	7,181	15	29,636
2026	336	1,005	424	-	1,765	5,963	745	4,180	-	10,889	213	-	-	-	213	6,513	1,750	4,604	-	12,867
2027	-	68	44	-	112	1,716	88	1,995	-	3,800	-	-	-	-	-	1,716	156	2,039	-	3,912
2028	-	-	187	-	187	412	-	336	-	748	-	-	-	-	-	412	-	523	-	936
2029	-	-	45	-	45	29	-	15	-	44	-	-	-	-	-	29	-	60	-	89
2030	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	$ 22,073	$ 15,974	$ 6,146	$ 1,990	$ 46,184	$ 85,970	$ 11,556	$ 22,934	$ 493	$ 120,951	$ 8,000	$ -	$ -	$ 250	$ 8,250	$ 116,043	$ 27,530	$ 29,080	$ 2,733	$ 175,385

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

Louisiana leads the Gulf Coast region in total energy manufacturing investments with as much as $120.9 billion by 2030 (68.9 percent of total). Much like last year's GCEO, LNG investments dominate the energy manufacturing investment outlook with as much as $116 billion in total investment in the outlying years of the outlook period, most of which are earmarked for Louisiana. Non-LNG investments ($27.6 billion), mostly associated with chemical and refinery upgrade investments, are estimated to be around 15.6 percent of total regional investment and are more evenly balanced between Texas and Louisiana.

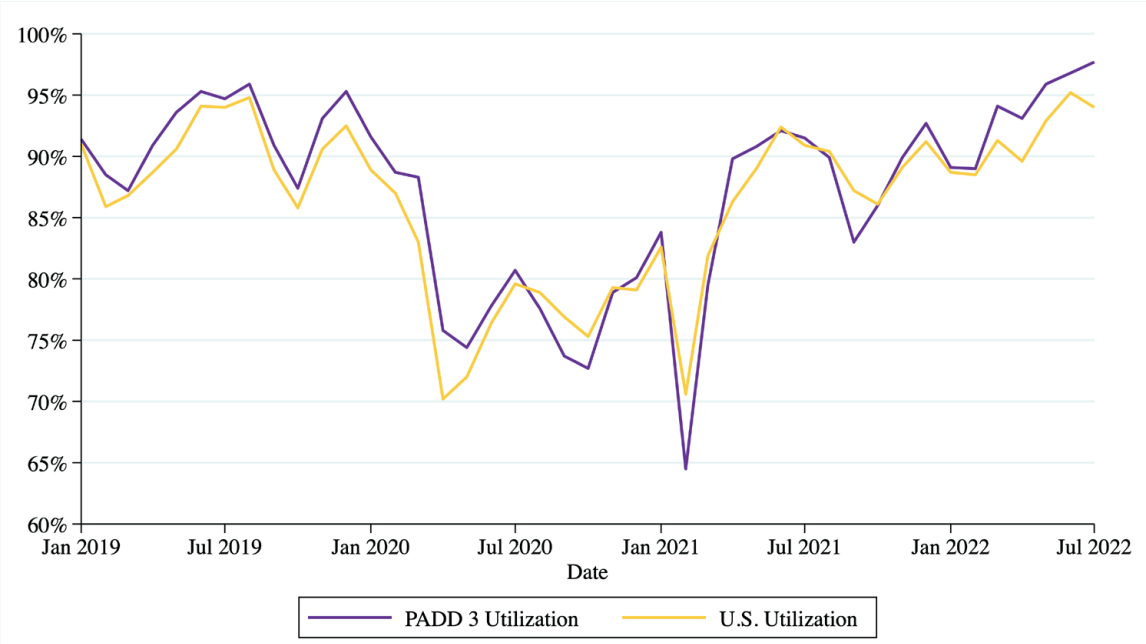
6. Energy Exports

6.1 Refined Products

The Gulf Coast region has the largest refinery capacity in the U.S. As of the beginning of 2022, the region accounts for 54 percent of all refining capacity nationwide[20] and is interconnected into a variety of input and refined product pipelines. In addition, these refineries are integrated either directly or indirectly with various hydrocarbon pipelines, such as liquefied petroleum gas (LPG) or natural gas liquids (NGL), that move these commodities to chemical plants, where they are converted into a number of intermediate commodity chemicals that, in turn, are shipped around the world. Hence, the refineries in the Gulf Coast region are some of the most efficient and profitable in the U.S. and in some instances around the world, given these forward and backward linkages.

The pandemic was particularly hard on U.S. refineries, including those located along the Gulf Coast. Figure 14 provides the monthly refinery capacity and utilization trends that underscore the impact of the pandemic on the region's refineries and subsequent rebound. In 2019, the year before the pandemic, refinery utilization in both the U.S. and Gulf Coast oscillated between about 85 percent and 95 percent. But during the pandemic, overall utilization plummeted to below 70 percent in some months. Over the past year, refinery utilizations have rebounded to more recently reported levels of approximately 95 percent. The 2023 GCEO anticipates that these levels will continue into the future, although some downward revisions may be needed if a more serious global economic contraction arises in the upcoming year.

Figure 14: U.S. and PADD 3 monthly refining utilization



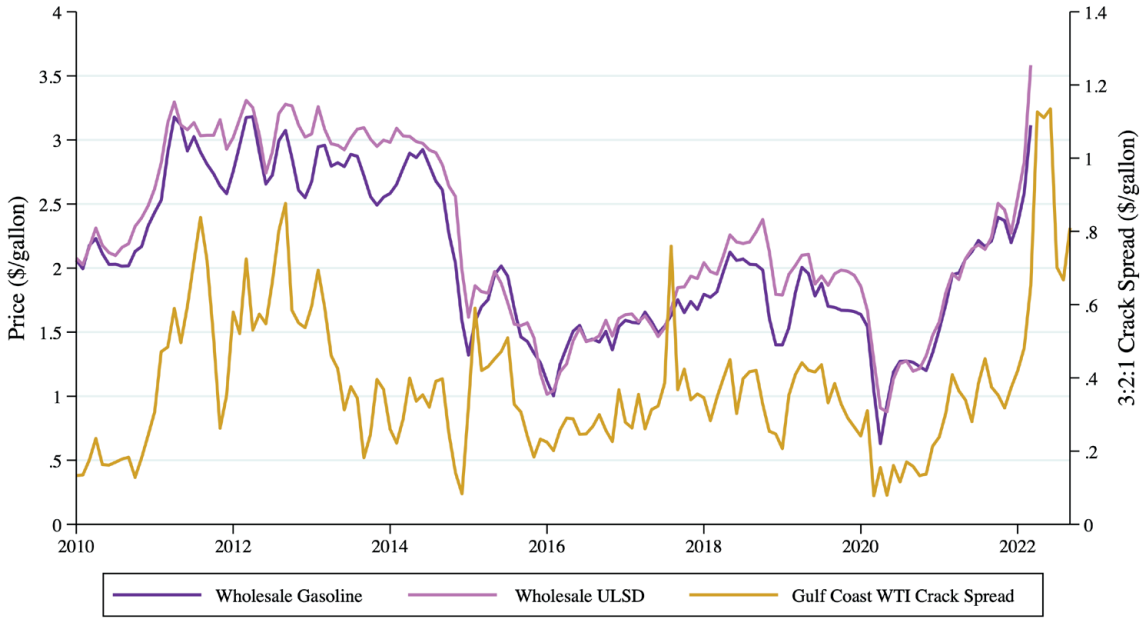
Source: U.S. Energy Information Administration. Petroleum & Other Liquids. Refinery Utilization and Capacity.

[20] U.S. Energy Information Administration. Authors' calculations from Form EIA-820.

As noted in last year's GCEO, 2019 was a "down" year in utilization given a slowdown in Asian economies and the Sino-American trade imbroglio. The onset of the 2020 pandemic also impacted the refining industry. By mid-year (July 2020) a relative recovery was underway, as refinery utilization bottomed out and actually started to rise. Then in 2020 and 2021, the Gulf Coast was inundated with weather events. Hurricane Laura impacted East Texas and the Lake Charles Region of Louisiana. Then in February of 2021, Winter Storm Uri also operationally impacted refineries across the region. Refinery activity rebounded until the summer of 2021, when Hurricane Ida delivered a second regional blow. However, a new recovery in the refinery sector is underway, and it seems likely that utilizations will hover around levels comparable to those experienced before the pandemic.

With the recent run-up in gasoline prices associated with the war in Ukraine, refinery margins have improved significantly, as illustrated in Figure 15. However, those margins continue to show volatility, falling from the rapid peaks seen over the summer 2022. The GCEO anticipates continued volatility in these crack spreads as the market tries to process the offsetting pressures of geo-politics (upward pressure) and the increasing likelihood of a global economic contraction (downward pressure).

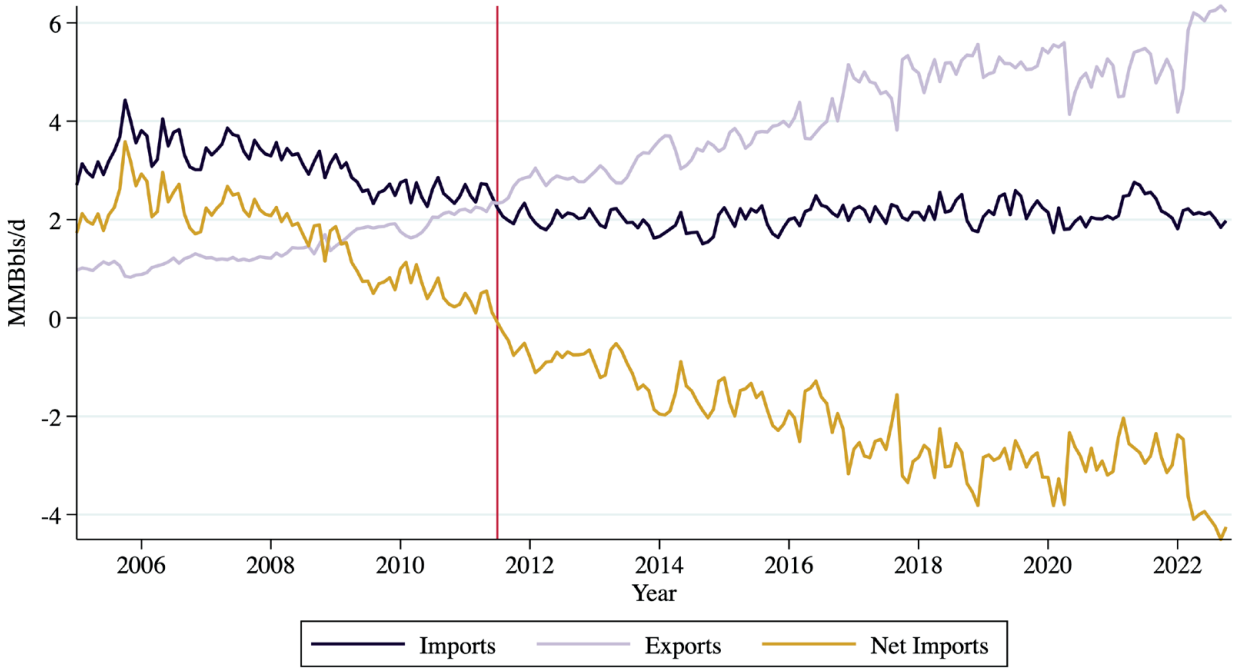
Figure 15: Wholesale gasoline, diesel prices, and refinery crack spread



Source: EIA, Bloomberg Terminal, and authors' calculations. Wholesale prices based on total U.S. gasoline and U.S. No. 2 ultra-low sulfur diesel wholesale price by refiners.

An important aspect of the unconventional revolution has been the transformation of the U.S. energy economy from one that is based upon net imports to one that is now a strong and important global net exporter. Figure 16 clearly shows that in 2011, the U.S. became a net exporter of refined products, and that position has continued to date. While overall refined product exports fell during the pandemic, resulting in a moderation of the continued march toward higher levels (in absolute terms) of net exports, that trend has already reversed itself in 2022. The GCEO anticipates this trend will continue into 2024.

Figure 16: U.S. refined products trade

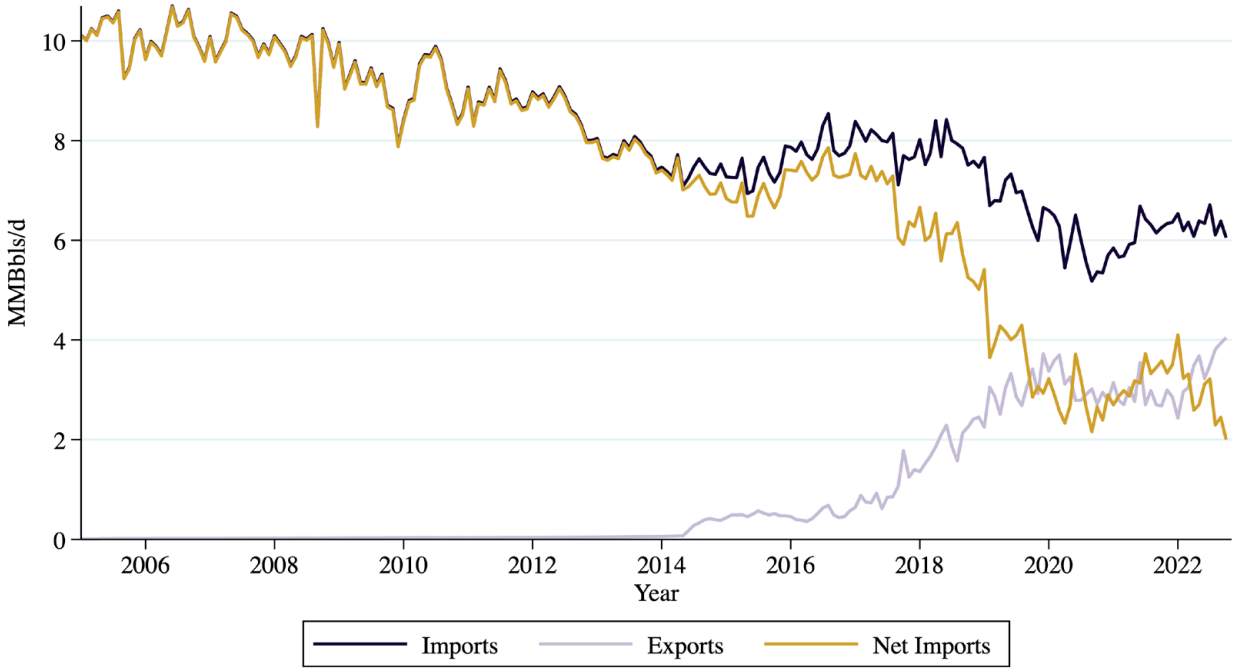


Source: U.S. Energy Information Administration

6.2 Crude Oil

As shown in Figure 17, unlike refined products, the U.S. is still a net importer of crude oil, currently importing over six million barrels per day, while exporting three million barrels per day, resulting in net imports of above three million barrels per day. Comparing this to refined products trade yields a few observations: First, imports and exports of crude oil move in ways that balance the necessary crude oil supplies (by quality) to the appropriate refining capacity (by quality). Such swaps were more costly before the crude oil export ban was lifted in 2014, which facilitated greater market efficiencies, as higher quality unconventional crude oils produced in the U.S. could then find the best home for refining purposes (regardless of whether that home is in the U.S. or elsewhere). Second, that the U.S. is a net exporter of refined products, but a net importer of crude oil, suggests that the U.S. is importing oil from other parts of the world, and then exporting those refined products. Again, this is efficiency-improving for the market overall because it allows U.S. refineries to choose the most advantageous and profitable feedstocks. This also underscores the importance of international energy trade to Gulf Coast refining activity. The recent crack spreads seen in Figure 15 highlight the profitability of such options for Gulf Coast refineries.

Figure 17: U.S. crude oil exports and imports

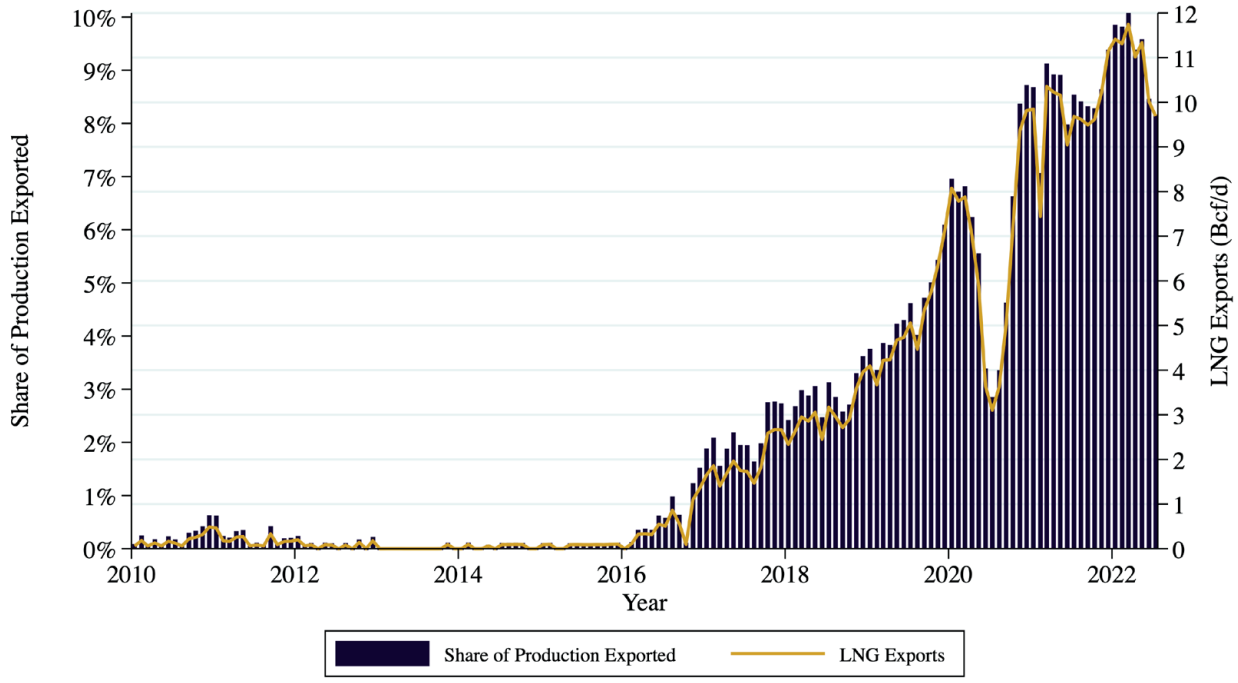


Source: U.S. Energy Information Administration. Petroleum & Other Liquids. U.S. Imports and Exports of Crude Oil.

6.3 Liquified Natural Gas Exports

The Russian invasion of Ukraine has created considerable interest in the global trade of liquified natural gas (LNG). The U.S. has exhibited some of the fastest LNG export growth (capacity and throughput) of any country over the past decade. Pre-2016, as seen in Figure 18, essentially zero LNG was exported from the U.S. In 2016, Cheniere Energy's Sabine Pass facility in Cameron Parish Louisiana began exporting LNG. Today, the U.S. has seven LNG export terminals operating—all of which are located in Texas and Louisiana. An additional three facilities are currently under construction. Discussions with those in the LNG industry suggest that international buyers are eager to sign long-term take or pay contracts due to the recent events in Ukraine, and the resulting effects on natural gas supplies.

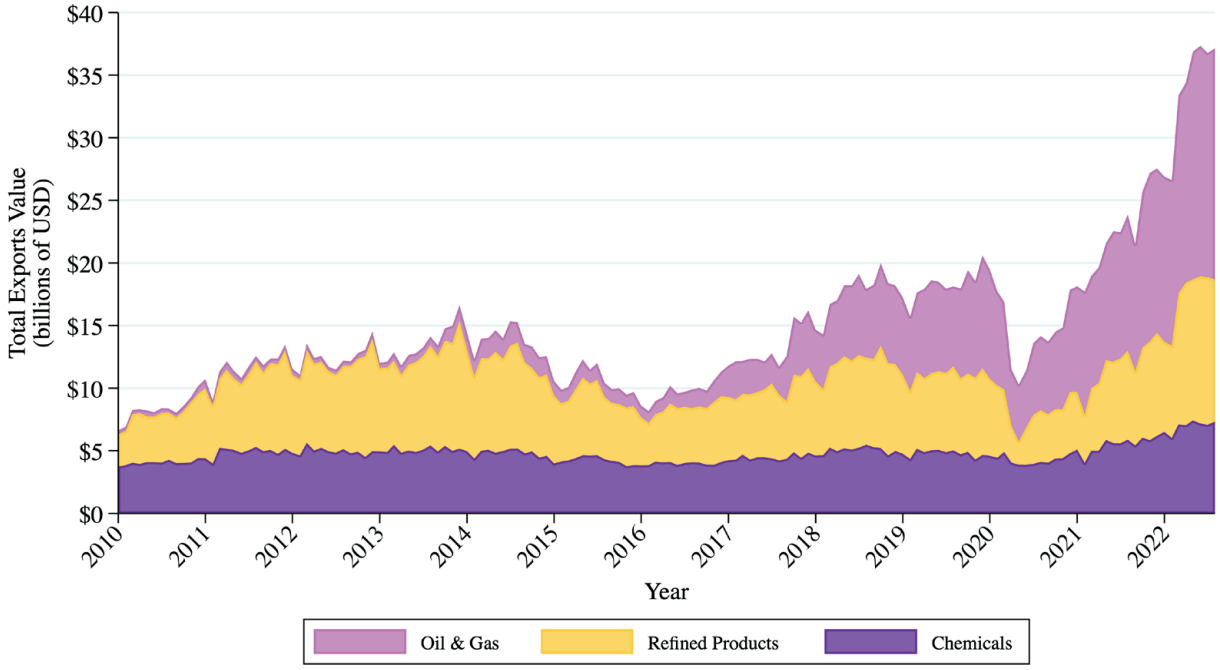
Figure 18: U.S. liquified natural gas exports



Source: U.S. Energy Information Administration.

Figure 19 underscores the growth opportunity that LNG represents for the Gulf Coast. The value of exports of oil and gas, refined products, and chemicals have expanded over the past two years, and have all reached levels exceeding pre-COVID levels. Thus, just as in years prior, the GCEO continues to take the view that long-run energy demand growth will lead to increased U.S. energy exports, especially to the growing developing world. Without this international demand growth alongside the growth of domestic oil and gas production due to the advent of shale production, the industrial expansion we have seen in the Gulf Coast region would not have been possible.

Figure 19: Gulf Coast international energy exports



Source: U.S. Census Bureau. Economic Indicators Division. USA Trade Online.

7. Employment Outlook

7.1 Employment Forecasts

In this final section of the GCEO, all prior sections are synthesized into employment forecasts for the regional energy industry. Employment is forecast within two broad sectors: (1) upstream oil and gas extraction and services and (2) refining and chemical manufacturing. Sectors are identified based on the North American Industry Classification System (NAICS). Upstream oil and gas is defined as including oil and gas extraction (NAICS sector 211) and support activities for mining (NAICS sector 213). Refining and chemical manufacturing employment includes petroleum and coal products manufacturing (NAICS sector 324) and chemical manufacturing (NAICS sector 325).[21] Employment forecasts are produced for each of these aggregated sectors for Texas and Louisiana. Note that recent historical data is subject to future revisions by the U.S. Bureau of Labor Statistics (BLS).

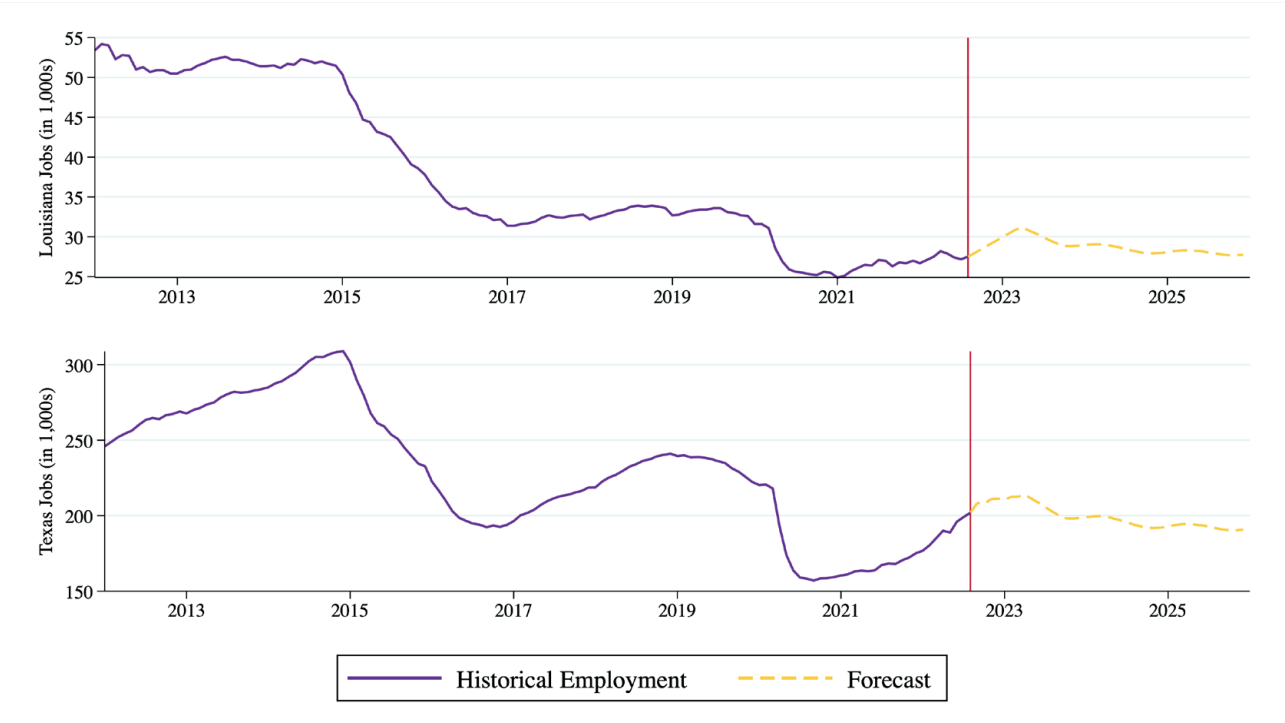
Upstream oil and gas employment for both Louisiana and Texas exhibit three key patterns in historical data shown in Figure 20. The first key pattern is that Louisiana employment growth, pre-2015, was modest relative to the rapid growth in Texas employment. Both states, however, saw a collapse in upstream employment in 2015, when crude oil prices also collapsed, as did rig counts (see Figure 2 in Section 2.1). During the 2015 crash, Texas lost more than 100,000 upstream jobs from peak to trough. Louisiana lost about 18,000 over the same time period. After the 2015 crash, Texas employment climbed back slowly through approximately the end of 2018 before beginning a modest decline. Louisiana upstream employment was approximately flat over this period.

The third shock began in early 2020 in response to the COVID-induced economic downturn. Comparing the peak employment experienced in 2019 relative to the post COVID-trough, Louisiana lost ~8,700 jobs in total while Texas lost ~83,000 jobs. On a percentage basis, Louisiana and Texas lost 26 percent and 35 percent, respectively. Thus, not only did Texas lose more jobs, but it also experienced a larger percentage drop relative to Louisiana. Based on the most recent monthly estimate (August of 2022), Louisiana and Texas have gained back ~2,500 jobs and ~44,700 respectively. Thus, Louisiana has gained back 29 percent of the jobs lost, while Texas has gained back 54 percent.

Figure 20 also shows the forecasted employment in the upstream oil and gas sectors for Louisiana and Texas, respectively. Econometric forecasts are based on a combination of both the futures markets for oil and natural gas shown in Figure 5, alongside the Enverus ProdCast model outputs shown in Figure 6.

[21] Chemical manufacturing includes many product types, including resins, pesticides, pharmaceuticals, paints, soaps, and others.

Figure 20. Upstream employment forecast

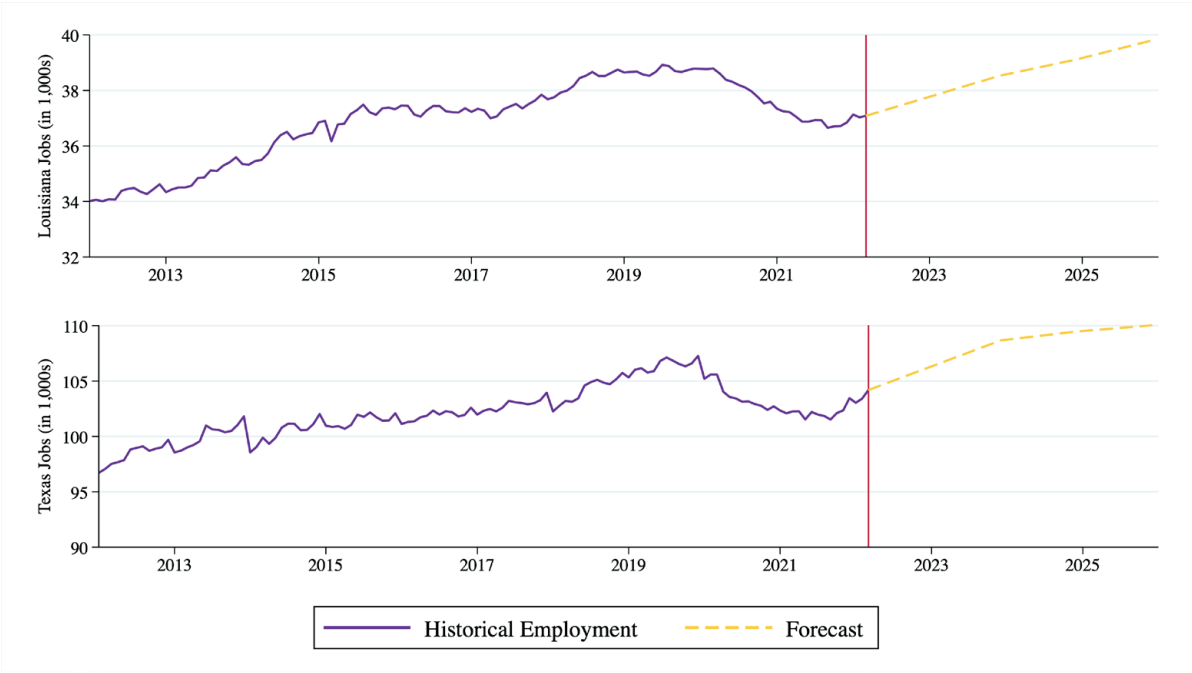


Source: U.S. Bureau of Labor Statistics, Current Employment Statistics. Authors' forecast.

Over the next year, the GCEO anticipates both states to continue to gain back some of these COVID-induced job losses. By the second quarter of 2023, Louisiana is expected to gain about 3,500 jobs. Texas is forecasted to gain about 12,200 upstream jobs between August 2022 and the second quarter of 2023. It is important to note that although employment is expected to increase over the forecast horizon, these model results are not anticipating employment in either state to reach pre-COVID levels over the forecast horizon. After the peak in the second quarter of 2023, models suggest that upstream employment is forecasted to actually decline steadily in both states. This is driven by a combination of projected increases in oil and gas production alongside futures market prices that are currently in backwardation (i.e. expected to decline over the forecast horizon). Although, we note that given the margin of forecasting error, upstream employment post the peak forecasted in 2023 should be considered a random walk, for all intents and purposes. Nonetheless, forecasts do not suggest that employment will reach levels seen pre-pandemic in either state. Discussions with those in the upstream oil and gas industry almost unanimously corroborated this view that although the trough is behind us, employment is unlikely to reach pre-COVID levels in coming years.

Historical data on refining and chemical manufacturing employment are shown in Figure 21. Both states exhibit two notable trends. First, pre-COVID, both states experienced approximately a decade of growth in these sectors. The GCEO attributes this employment growth to the investment in these sectors that has facilitated the exporting of products around the globe. But second, both states experienced reductions in refining and chemical manufacturing employment due to the COVID-induced recession, but these employment losses were not as large, both in terms of total numbers and as a

Figure 21: Refining and chemical manufacturing employment forecast



Source: U.S. Bureau of Labor Statistics, Quarter Census of Employment and Wages. Authors' forecast.

share of employment, as experienced in the upstream sector. From peak to trough, Louisiana and Texas lost approximately 2,200 and 5,700 jobs. This is about a 5 to 6 percent reduction in both states (compared to more than 25 percent job losses in upstream employment in each state).

Figure 21 also show the forecasted employment in the refining and chemical manufacturing sectors. For both Louisiana and Texas, the GCEO forecast is based on the historical relationship between capital expenditures and employment growth alongside our baseline capital expenditures presented in Section 5.[22]

For Louisiana, the GCEO anticipates employment to first recover from the recession and then modestly increase over the rest of the forecast horizon. Specifically, the GCEO envisions employment to increase by about 1,450 jobs by the end of 2023, or about a 3.9 percent increase. Employment growth is expected to slow thereafter, gaining approximately 600 jobs in 2024 and 700 jobs in 2025. This employment growth is due to the anticipated continuation of capital expenditures in these sectors.

Texas refining and chemical manufacturing employment exhibits a similar pattern to Louisiana. It is expected to increase by approximately 4,500 jobs by the end of 2023, or about 4.3 percent. In 2024 and 2025, we anticipate the Texas refining and chemicals sectors to gain approximately 800 jobs and 600 jobs, respectively.

Both Louisiana and Texas are anticipated to reach new highs in refining and chemical manufacturing employment over the forecast time horizon, which extends through the end of 2025.

[22] Novel to this year's forecast, we also adjusted for growth in national refining and chemical manufacturing employment estimates that is available with a shorter lag. Thus, some of this growth comes from the COVID recovery, with additional growth due to continued investment.

8. Conclusions

This past year will be remembered for Russian's invasion of Ukraine and its implications for energy markets globally. Just one year ago, discussions around energy markets were centered around decarbonization goals over multi-decade time horizons. But the focus has shifted swiftly toward energy security in the short term as consumers have seen higher prices and Europe in particular is at risk for not having sufficient natural gas to get through the upcoming winter.

Given the Gulf Coast's position as a net exporter of energy, we are well positioned to experience economic growth through this time of turbulence. Upstream oil and gas employment is forecasted to increase until mid-2023, at which time it is expected to level off. Refining and chemical manufacturing employment are anticipated to increase in both Texas and Louisiana through the forecast horizon that concludes in 2025.

But decarbonization is at the forefront of corporate strategies, and some have suggested that the Russian invasion of Ukraine might even *accelerate* the global movement to wean off fossil fuels.[23] Also significant, the U.S. has passed its most ambitious legislation to date addressing the energy transition in the ironically titled Inflation Reduction Act (IRA). Supply chain constraints are likely to reduce the effectiveness of the IRA in the coming year, but nonetheless the IRA is anticipated to accelerate investment in lower-carbon energy. GCEO sees that the key to the region's continued energy expansion is to balance shorter-term goals of energy security induced by the Russian invasion of Ukraine while continuing the longer-term goals of decarbonizing the energy sector in cost competitive ways to ensure global competitiveness in decades to come.

[23] E.g., World Energy Outlook 2022. International Energy Agency.

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