U.S. GULF PORTS HARBOR THE CHANGING ENERGY SUPPLY

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The Gulf of Mexico region has served for decades as the U.S. headquarters for energy production and exploration. Although petroleum dominates the region's energy sector, other industries include natural gas and coal, as well as renewable energy sources. Recent trends in the nation's energy sector are having an effect on the ports and private terminals along the Gulf of Mexico.

Petroleum Production

As the world's population has grown and as developing nations have become wealthier, global oil production has increased to meet demand. As shown in Figure 1 (below), global oil production grew from 64.0 million barrels per day in 1980 to 89.8 billion barrels in 2013—an increase of approximately 40 percent.

Despite claims of impending energy independence, U.S. oil production grew only by 1.6 million barrels per day between 1980 and 2013, to 12.4 million barrels per day; U.S. refineries process 15 million to 16 million barrels per day. In this period, the U.S. share of global oil production peaked in 1985, when it provided almost 20 percent of the world's oil supply, and fell to its lowest level in 2005, when it contributed slightly less than 10 percent. Since 2005, the U.S. share of global oil production has increased, reaching 13.7 percent in 2013.

Many U.S. ports, including ports and private industry terminals along the Gulf of Mexico, have benefited from the petroleum industry. In addition to handling crude oil and petroleum products, these facilities support an expansive and sophisticated oil and gas exploration and production industry.

Photo: Jennifer A. Dlouhy, Houston Chronicle

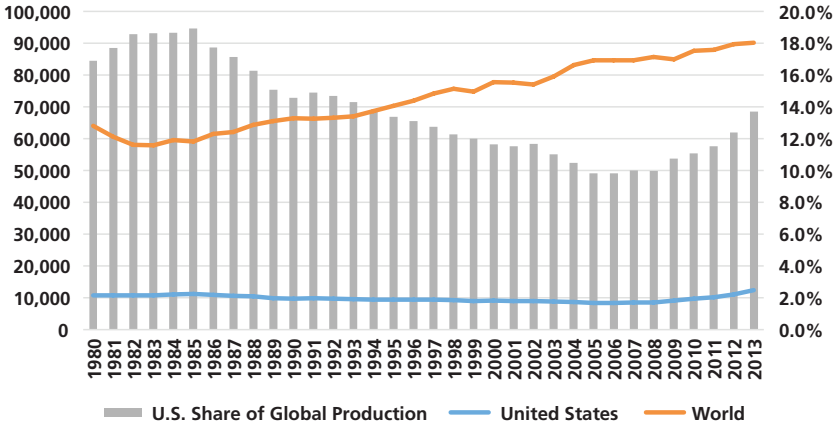
The *Maersk Developer* drills an exploratory well in the Gulf of Mexico. Gulf of Mexico ports and private terminals support both the exploration and the movement of crude oil and petroleum products.

Figure 2 (page 7) shows the production of crude oil in the Gulf of Mexico region between 1980 and 2013. Crude oil production in the Gulf region declined between 1980 and 2007, as field production in Texas fell. Increased production from offshore wells in the Gulf of Mexico, however, partly offset these losses during the 1990s and into the 2000s.

Pivotal Developments

After the *Deepwater Horizon* event in 2010, crude oil production in the Gulf of Mexico stalled. The rupture and explosion of the *Deepwater Horizon* well killed 11 workers and released more than 200 million gallons of crude oil into the Gulf of Mexico, the worst oil spill in U.S. history. Federal regulators applied a

FIGURE 1 Total oil production, thousands of barrels per day, 1980–2012. (Source: U.S. Energy Information Administration, 2014.)



higher level of scrutiny to offshore drilling and maintained a moratorium on deepwater drilling permits. These responses effectively capped Gulf oil production for several years.

Before the *Deepwater Horizon* disaster, offshore drilling in the U.S. Gulf accounted for 25 to 30 percent of total U.S. production. But while stricter oversight constrained offshore drilling, the shale plays in Texas were beginning to ramp up production—notably the Eagle Ford shale play in South Texas, the Permian Basin shale play in West Texas, and the Barnett shale play in the Dallas–Fort Worth region of North Texas.

The Eagle Ford wells, in particular, produce a large amount of crude oil and condensate, in addition to natural gas. By 2013, Texas's rapidly growing field production of crude oil reduced the Gulf of Mexico's offshore share to less than 17 percent of total U.S. oil production.

Petroleum Exploration

Gulf ports are the nexus of U.S. landside and offshore petroleum exploration and production activities, which require the movement of heavy equipment, consumables, work crews, and extracted product. For offshore drilling, all of these activities go through ports or private terminals. West of Florida, the construction, maintenance, and mooring of offshore drilling platforms, as well as offshore servicing vessels, are common sights at ports and private terminals.

Offshore platforms usually transport cargoes to shore via pipelines, although some facilities, like the Cayo Arcas terminal in Mexico, load the crude oil directly into tankers. With the lifting of the moratorium on new drilling in the Gulf of Mexico, several major deepwater projects are moving forward, providing continuing opportunities for Gulf ports.

Landside oil and gas exploration and production in the shale plays has generated significant volumes of new cargoes for Gulf ports, especially for consumables like sand and pipe. Hydraulic fracturing requires a special type of sand, which is mixed with water and chemicals and forced underground at high pressures to extract the gas and oil. The grains of sand must have the right dimensions; as a result, the sand often is transported considerable distances to the drilling sites.

All oil wells require pipe casing to line the bore hole, but hydraulic fracturing wells run deep in the ground and extend horizontally for significant distances, requiring a lot of pipe. Pipelines are the preferred mode for transporting the crude oil from the wells to the refineries, but when pipelines are not close by or may not have sufficient capacity, the crude may travel by railway tank car or by tanker truck to the pipeline network—or by barge directly to the refineries. The Eagle Ford shale play, for example, has increased barge traffic on the Gulf Intracoastal Waterway.

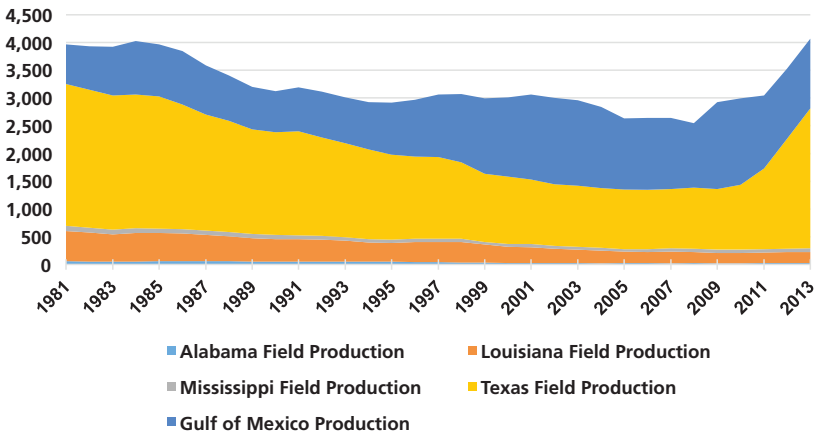


FIGURE 2 Crude oil production in the Gulf of Mexico region. (Source: U.S. Energy Information Administration, 2014.)

Crude Oil

Approximately half of the nation's annual total of foreign waterborne commerce is handled at ports and private marine terminals in the Gulf of Mexico, and a large share of that cargo is crude oil. During 2012, ports and private terminals along the Gulf of Mexico handled almost 208 million tons of crude oil, with almost 93 percent at locations west of the Mississippi River (see Figure 3, page 8).

Between 2008 and 2012, the volume of crude oil handled in the Gulf declined by 21 million tons or 9.2 percent. Three factors influenced this trend. First, personal vehicles continued to gain fuel efficiency. Second, total vehicle miles traveled in the United States have declined. Third, domestic oil production from shale plays is replacing imported crude oil.

Photo: U.S. Coast Guard

Crude oil–filled barges travel the Gulf Intracoastal Waterway, which has experienced increased traffic from hydraulic fracturing activity in Texas shale plays.

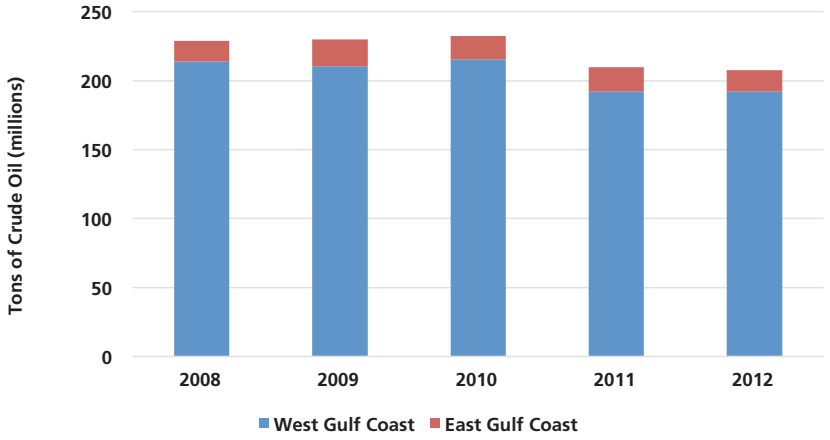


FIGURE 3 Tonnage of crude oil offloaded at U.S. Gulf ports and private terminals, 2008–2012. (SOURCE: U.S. Army Corps of Engineers, 2014.)

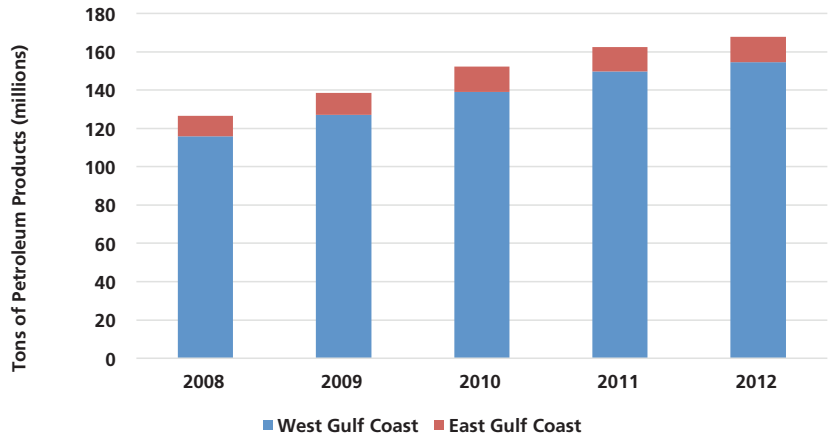
This last trend is evident in the share of domestic oil handled at Gulf ports (Figure 4, below). During 2008, less than 4.0 percent of crude oil handled at Gulf ports originated from a domestic port, but by 2012, that figure had risen to 10 percent and will likely increase for 2013 and 2014.

When the crude oil arrives onshore, refineries render it into gasoline, diesel, and other petroleum products or into feedstocks for the petrochemical industry. Table 1 (right) shows that the United States has the capacity to refine almost 18 million barrels of crude oil per day.

The states along the Gulf of Mexico provide almost half—49.8 percent—of that capacity. Texas provides almost 29 percent of the nation's oil refinery capacity, followed by Louisiana at 18.3 percent; the remaining U.S. Gulf states provide less than 3 percent: Mississippi, 2.0 percent; Alabama 0.7 percent; and Florida, less than one-tenth of 1 percent. The various fuels produced are transported to local distribution centers through pipelines or by tanker or barge.

Although the volume of crude oil imported by Gulf ports and private terminals between 2008 and 2012 fell by 9.2 percent—the decline nationwide was more than 25.5 percent—Gulf maritime facilities are handling larger and larger volumes of outbound petroleum products, mostly at ports and private terminals in the Western Gulf. Between 2008 and 2012, this volume grew by 41.3 million tons or 32.6 percent. The trend suggests that pipelines increasingly are feeding these refineries with domestically produced crude oil.

FIGURE 4 Tonnage of petroleum products originating from U.S. Gulf ports and private terminals, 2008–2012. (SOURCE: U.S. Army Corps of Engineers, 2014.)



Natural Gas

Hydraulic fracturing also has increased the production of natural gas in the United States. Between 2006 and 2013, U.S. production of natural gas increased by 27.5 percent or almost 6.5 million cubic feet (MMcf or 1,027,000,000 Btu; see Figure 5, page 9). Consumption also has grown, as natural gas replaces coal for generating electric power and as the petrochemical industry takes advantage of the cheap feedstock.

The export of natural gas has increased, although modestly. In 2013, approximately 5 percent of U.S.-produced natural gas was exported, almost entirely to Mexico and Canada. Most of the nation's supply of natural gas remains in the domestic market, keeping natural gas prices in the United States low.

Logically, producers would want to export natural gas to countries with higher prices. Table 2 (page 9) shows the price for liquefied natural gas (LNG) in Lake Charles, Louisiana, compared with the prices in locations around the world. Although the price of LNG has declined in the past year, the global price dif-

TABLE 1 U.S. Refinery Capacity for Selected States, as of January 1, 2014

Rank	Location	Barrels per Calendar Day	Production (%)
1	Texas	5,174,209	28.9
2	Louisiana	3,274,520	18.3
3	California	1,960,671	10.9
4	Illinois	958,645	5.3
5	Washington	631,700	3.5
6	Pennsylvania	596,000	3.3
7	Ohio	530,000	3.0
8	Oklahoma	523,300	2.9
9	New Jersey	468,000	2.6
10	Indiana	440,600	2.5
11	Mississippi	364,000	2.0
12	Minnesota	359,500	2.0
	Remainder of the United States	2,643,485	14.7
	Total United States	17,924,630	100.0
	Total U.S. Gulf Coast Capacity[a]	8,108,826	45.2

[a] *Only includes refineries located directly on the Gulf Coast.*
SOURCE: U.S. Energy Information Administration, 2014.

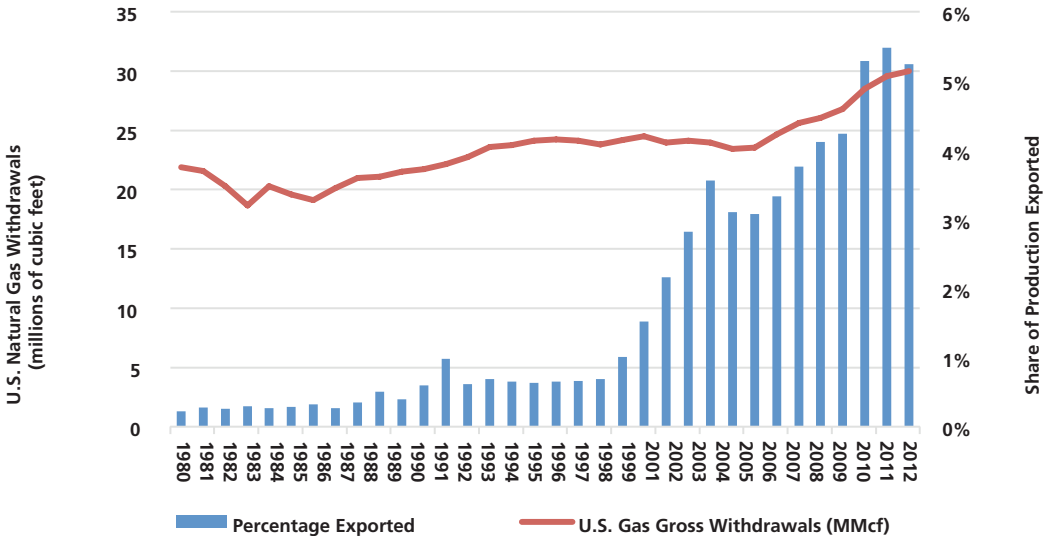


FIGURE 5 U.S. withdrawals and production of natural gas (MMcf), 1980–2013. (SOURCE: U.S. Energy Information Administration, 2014.)

ferential with the Lake Charles price ranged from $4.54 to $13.06 per million Btu as of December 2014.

The difficulty of exporting natural gas relates primarily to its transportation. Pipeline is the optimal mode, but the natural gas pipelines between the United States and Mexico or Canada are limited. Selling in more distant markets requires that the gas be liquefied by chilling to −162°C (−260°F). Liquefaction allows further compression, so that the gas can be loaded onto LNG tankers for export. This process requires a special facility; the United States currently has none.

As of December 2014, however, four LNG export terminals have received approval—three are in the Gulf of Mexico: in Sabine and Hackberry, Louisiana, and Freeport, Texas—and 10 others are planned along the Gulf Coast. Export terminals for LNG cost several billion dollars to construct, and the federal permitting process is rigorous.

Another difficulty is that the draft of most LNG tanker vessels is deep; more than 90 percent cannot fit into the locks of the Panama Canal. With the Panama Canal's expansion, however, approximately 90 percent of the world's fleet will be able to fit. Many in the shipping and petroleum industry anticipate that the liquefaction plants and the expanded Panama Canal will make LNG a significant export commodity from the Gulf of Mexico.

Coal

Coal is another source of fossil energy handled at ports and private terminals in the Gulf region. Figure

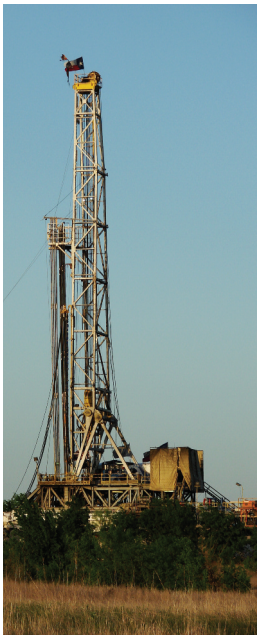


PHOTO: DAVID R. TRIBBLE

Oil drilling rig on the Barnett Shale near Alvarado, Texas. Most domestically produced crude oil stays in the United States.

TABLE 2 Estimated World LNG Landed Prices: November 2013 and December 2014 (US$/MMBtu)

Location	November 2013	December 2014	Differential with Lake Charles	2013–2014 Difference
Canaport, Canada	NA	$16.78	$13.06	NA
Altamira, Mexico	$16.40	$11.54	$7.82	-$4.86
Rio de Janeiro, Brazil	$14.65	$11.35	$7.63	-$3.30
Bahia Blanca, Argentina	$15.65	$11.78	$8.06	-$3.87
United Kingdom	$10.66	$8.56	$4.84	-$2.10
Belgium	$10.40	$8.26	$4.54	-$2.14
Spain	$10.90	$9.76	$6.04	-$1.14
Korea	$15.65	$12.00	$8.28	-$3.65
India	$13.75	$11.45	$7.73	-$2.30
Japan	$15.65	$12.00	$8.28	-$3.65
China	$15.25	$11.60	$7.88	-$3.65
Lake Charles, La.	**$3.15**	**$3.72**	**—**	**$0.57**

NOTE: NA = not available. SOURCE: Waterborne Energy, Inc., 2013 and 2014.

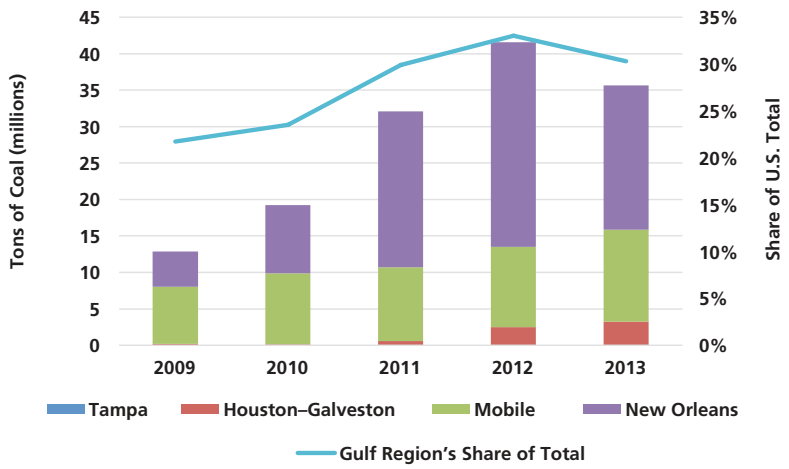


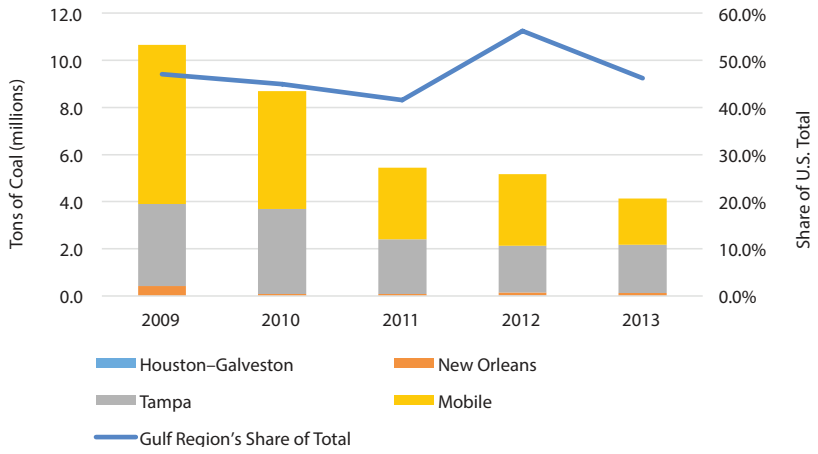
FIGURE 6 U.S. coal exports by U.S. Customs districts along the Gulf of Mexico. (SOURCE: U.S. Energy Information Administration, 2014.)

6 (above) shows the volume of U.S. coal exports handled within U.S. customs districts, large regions that include multiple ports and terminals. These figures show that coal exports from the Gulf region rose sharply between 2009 and 2012, from 12.8 million to 41.6 million tons, but dropped 14.2 percent to 35.7 million tons between 2012 and 2013.

Coal exports from the Gulf region comprised 30.1 percent of the U.S. total in 2013. The majority of the coal, however, did not go to Asia, despite China's heavy use of coal for energy production. The customers for 51.3 percent of U.S. export coal were the nations of Europe; China received only 7.0 percent; moreover, the Chinese government recently committed to cap coal use by 2020.

Major coal exporting facilities in the Gulf of Mexico are located within or near the Ports of Houston, Texas; New Orleans, Louisiana; and Mobile, Alabama. As in the Pacific Northwest, environmental groups have worked to prevent the construction of new coal export terminals. Although opponents emphasize the local effects of the terminals, climate change is usually the main concern.

FIGURE 7 U.S. coal imports by U.S. Customs districts along the Gulf of Mexico. (SOURCE: U.S. Energy Information Administration, 2014.)



Three terminals proposed in Corpus Christi, Texas, were canceled because of market uncertainties but also came under scrutiny from environmental groups. The Port of Mobile, which receives approximately two-thirds of its revenue from coal exports, is considering a $140 million expansion near a coal terminal.

Coal imports, in contrast, fell from 10.7 million tons in 2009 to 4.1 million tons in 2013 (Figure 7, below left). The Mobile customs district lost a large volume of cargo; the Tampa, Florida, customs district also experienced losses. The drop in coal imports from the Gulf region reflects a national trend.

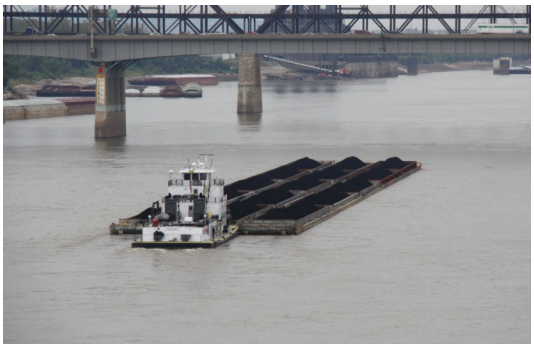


PHOTO: LANCE AND ERIN, FLICKR

Coal exports from the Gulf more than tripled between 2009 and 2012, topping 41 million tons, but by 2013 decreased to 35.7 million tons.

Wind

Renewable energy—namely wind—has played an important role in the cargo mix for some Gulf ports for a decade or more. The United States has only a few wind turbine manufacturing facilities—many of the nation's wind turbines are manufactured overseas. Imported wind turbines must travel a portion of their trip by water, moving in parts from the manufacturer to final assembly.

Typically, a disassembled windmill arrives as seven or more major components: three blades, three or more tower sections, and the nacelle, which contains the generator mounted at the top of the wind turbine. The blades typically range in length from 105 to 160 feet, and the assembled tower sections range from 100 to 150 feet in height. The nacelle is roughly the size of a city bus. After these components are offloaded from ships, they travel by truck and sometimes by rail as oversize movements to the places of installation.

Texas ports handle most of the wind turbine cargoes in the Gulf of Mexico. Texas and some areas of western, coastal Louisiana are the only locations in the Gulf region with wind conditions to support energy production. According to the U.S. Depart-

ment of Energy, Texas is the only U.S. Gulf state that produces wind power and ranks first among all states in wind power capacity, with 12,354 megawatts (MW) at the end of 2013; California ranks second, with 5,829 MW.

Energy production from wind power relies on a federal tax credit to make many projects financially viable. A federal tax credit of $0.023 per kilowatt-hour produced in the first 10 years of a wind project expired in 2014. The loss of this tax credit could reduce—if not eliminate—the installation of wind turbines in the United States.

In addition, offshore wind farms in the Gulf of Mexico are under proposal, with a total capacity of 4,371 MW; none of the facilities listed in Table 3, however, has been built. Except for one in Louisiana, all of the proposed offshore wind farms are in Texas.

The Port of Corpus Christi has become a renewable energy producer. The port took advantage of its location along the Gulf Coast, its abundant land holdings, and the almost constant winds in the area to install six 1.5-MW wind turbines.

Wood Pellets

Wood pellets are another sustainable energy source moving through Gulf ports. The vitamin-sized wood waste products are burned to generate electricity. Burning coal or natural gas releases carbon dioxide (CO_2) that was sequestered underground; in contrast, the CO_2 in wood pellets, like that from other biomass sources, is released by natural decomposition; therefore the net effect of the emissions is considered close to zero.

Wood pellets are in demand in Europe, where the European Union has mandated production of 20 percent of electricity from renewable energy sources. Because the pellets can be mixed with coal, utility operators do not need to retrofit power plants. Environmental advocacy groups, however, are concerned that the demand for wood pellets may encourage deforestation.

Many ports along the Gulf of Mexico already handle wood products from the timber industry of the Southeastern United States; wood pellets have become one more commodity in the mix, particularly at ports from the Florida Panhandle to Port Arthur, Texas. As many states or utilities seek to substitute biomass fuels for coal, the wood pellet industry is expected to continue growing.

Future Trends

A variety of factors, including channel deepening and navigational improvements, fluctuating oil prices, climate change, and the opening of the Mexican petroleum industry to private investment, will influence the near- and long-term future of ports and private terminals in the Gulf of Mexico and their role in the energy sector.

PHOTO: J. BREW, FLICKR

Many wind turbine parts are manufactured overseas, delivered to Gulf ports, and shipped by truck or rail—often as oversize loads—for assembly onsite.

Channel Projects

The Water Resources Reform and Development Act of 2014 (WRRDA) has moved several significant channel projects important to the energy industry closer to construction. The projects in Texas include the $1.1 billion Sabine-Neches Waterway project, the $239 million Freeport Harbor Channel project, and the $353 million Corpus Christi Channel project, each serving a major activity center for the oil and gas industry.

WRRDA also sets aside $50 million dollars of discretionary funding for "energy transfer ports." These U.S. Customs ports must have handled at least 40 million tons of cargo during FY 2012, and energy commodities must have comprised at least 25 percent of the tonnage. Although the need for port and naviga-

TABLE 3 Proposed Offshore Wind Farms in the Gulf of Mexico

State	Project Name	Generating Capacity (MW)
Louisiana	Vermillion Bay	36
Texas	Jefferson Offshore	300
Texas	Galveston Offshore Wind Farm	150
Texas	Galveston Offshore Wind Farm 2	150
Texas	Galveston Test	3
Texas	Brazoria Offshore	500
Texas	Titan Platform	7
Texas	Mustang Island Offshore Wind Farm	1,200
Texas	Rio Grande North	1,000
Texas	Rio Grande South	1,000
Texas	Texas Offshore Pilot Research Project	25
	TOTAL	**4,371**

NOTE: MW = megawatts = 1,000,000 watts.
SOURCE: OpenEI, 2014.

In 2012 the Port of Corpus Christi constructed six wind turbines along Nueces Bay in Texas—the first wind farm located on industrial port property in the country.

Photo: Jesse Saxu, Port Corpus Christi Authority

tion improvements outstrips the supply of public funding, the WRRDA will address some of the nation's most urgently needed improvements for the energy sector.

Oil Prices

The refining side of the petroleum industry is relatively stable, but the exploration and production side faces intrinsic instability and risk. These instabilities lead to price fluctuations and production booms and busts. Petroleum prices often produce countervailing impacts on the economy—higher prices can encourage oil exploration and drilling but also discourage driving, reduce household incomes, and raise business costs. Lower gasoline prices, usually seen as positive for the economy, can diminish economic activity related to exploration and drilling.

Historically, Gulf ports serving the energy industry have benefited from higher prices, which encourage more offshore exploration and production. More recently, the growth in hydraulic fracturing has led to the handling of more fracking sand, pipes, heavy equipment, and crude oil. In contrast, prices that are too high can reduce the volume of crude oil imported for refinement into gasoline, distillates, and other products.

Even with higher prices, the demand for gasoline is fairly inelastic, and the number of refineries is relatively fixed—reduced production therefore has relatively small impacts on employment. The demand for exploration and drilling activities, however, is highly elastic and responds strongly to prices, generating or contracting significant ancillary employment.

Offshore drilling and hydraulic fracturing are expensive methods of extracting oil, and the viability correlates strongly with the price of oil. In December 2014, for example, oil was approximately $60 per barrel, down from more than $100 dollars a barrel at midyear and with predictions of prices in the range of $40 to $45. The high cost of extracting oil by hydraulic fracturing and from the Canadian tar sands can make some sources of oil and gas no longer financially viable.

Industry experts have estimated that the Eagle Ford shale wells can operate profitably in the range of $40 to $60 per barrel, but the Permian Basin shale play requires between $59 and $82 per barrel to break even. Canadian tar sands need prices at $90 per barrel or more to cover operating costs. As prices drop, exploration and production will diminish, and the volume of related crude oil, equipment, and consumables handled at Texas ports will drop.

An exploratory drillship on the Gulf of Mexico. In general, demand for oil exploration rises and falls with oil prices.

Photo: KM&G-Morris, Flickr

Climate Change

Although the global response to climate change has been lackluster, the long-term effects and consequences are yet to come. Fossil fuels play a significant role in climate change; the world may be forced to rely less on fossil fuels and more on renewable energy sources. These changes may be decades away but

likely will curtail or end many of the activities related to fossil fuels in the Gulf of Mexico. Current and potentially new sources of renewable energy will become more prominent in port activities, but their economic footprint is unlikely to be as large as that of the fossil fuel industries today.

Mexico's Oil Industry

In December 2013, Mexico's Congress and Executive Branch approved a constitutional amendment that would allow private-sector investment in the exploration and production of the nation's oil and gas reserves. The amendment can induce significant investment of foreign capital into Mexico's petroleum industry. Petróleos Mexicanos, or PEMEX, the national oil corporation, needs foreign investment, technical expertise, and technologically advanced drilling equipment to maximize the exploitation of current fields and to drill in new oil fields and gas plays.

Northern Mexico—notably the Burgos shale basin near the Texas border—may contain large shale gas formations comparable in scale to the Eagle Ford shale play. U.S. firms looking to expand operations or to redeploy underutilized or idle drilling equipment will likely consider sending their equipment into Mexico.

Other potential impacts to the Texas transportation system include servicing the expanded drilling in Mexico's territorial waters in the Gulf—such as the 200-mile Exclusive Economic Zone—and shipping oil and gas from Mexico to Texas for additional processing. These movements could generate substantial freight volumes, consisting of heavy oil field equipment and other materials, such as pipes, from Texas into Mexico, as well as petroleum products from Northern Mexico into Texas. U.S. Gulf ports and private terminals—particularly those west of the Mississippi River—are likely to see increased freight volumes related to activities in Mexico.

Critical Role and Challenges

The critical role of Gulf ports in the nation's energy sector is expected to continue. A return to deepwater offshore drilling in the Gulf of Mexico, the continuation of hydraulic fracturing in shale plays around the country, and the opening of the Mexican petroleum industry to foreign investment will drive demand for the services provided by Gulf ports and private terminals. In addition, navigation improvements through WRRDA and the completed expansion of the Panama Canal will make LNG a feasible U.S. export commodity.

Fluctuations in the price of oil, however, will challenge growth in the petroleum industry. The production of energy by renewable sources also will continue to have an important role at Gulf ports, although not likely to replace fossil fuels in the short to medium term. Renewable sources typically are more expensive and are not able to provide energy on the scale necessary to maintain current levels of consumption.

Over the longer term, the consequences of climate change may become too great to ignore, and the reliance on fossil fuels will have to be scaled back. The economic consequences of this shift likely will mean a contraction of the fossil fuel sector, affecting economic activity in the Gulf region.

Photo: Bob Laura, U.S. Coast Guard

The *Discoverer Enterprise* and other vessels continued to recover oil from the site for months after the *Deepwater Horizon* explosion in 2010.

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