

Moving Crude Oil by Rail

ASSOCIATION OF AMERICAN RAILROADS

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Summary

Technological advances, along with relatively high crude oil prices, have led to sharply higher U.S. crude oil production. Historically, most crude oil has moved from production areas to refineries by pipeline. However, much of the recent increases in crude oil output has moved by rail. In 2008, U.S. Class I railroads originated just 9,500 carloads of crude oil. In 2012, they originated nearly 234,000 carloads and will likely originate around 400,000 carloads in 2013.

Railroads have an excellent safety record regarding crude oil transportation — better, in fact, than pipelines in recent years. Based on U.S. DOT data, the crude oil “spill rate” for railroads from 2002-2012 was an estimated 2.2 gallons per million ton-miles, compared with an estimated 6.3 for pipelines. Railroads are continuously striving to further improve the safety of moving crude oil by rail. For example, the rail industry recently urged federal regulators to toughen existing standards for new tank cars and require that the approximately 92,000 existing tank cars used to transport flammable liquids, including crude oil, be retrofitted with advanced safety-enhancing technologies or, if not upgraded, phased out.

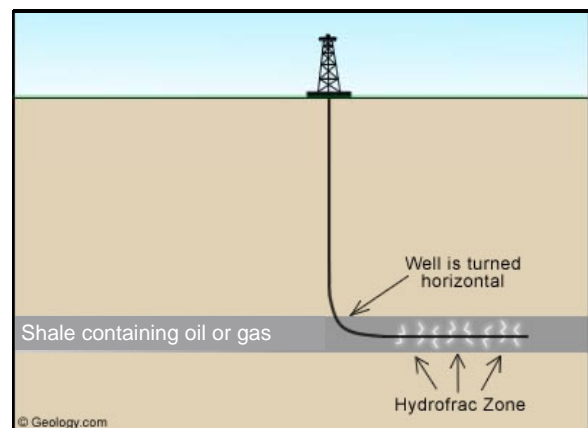
Beyond providing transportation capacity, railroads offer energy market participants the ability to shift deliveries quickly to different markets, enabling producers to sell their product to the market offering the best price. Additional pipelines will probably be built in the years ahead, but the competitive advantages railroads offer will keep them in the crude oil transportation market long into the future.

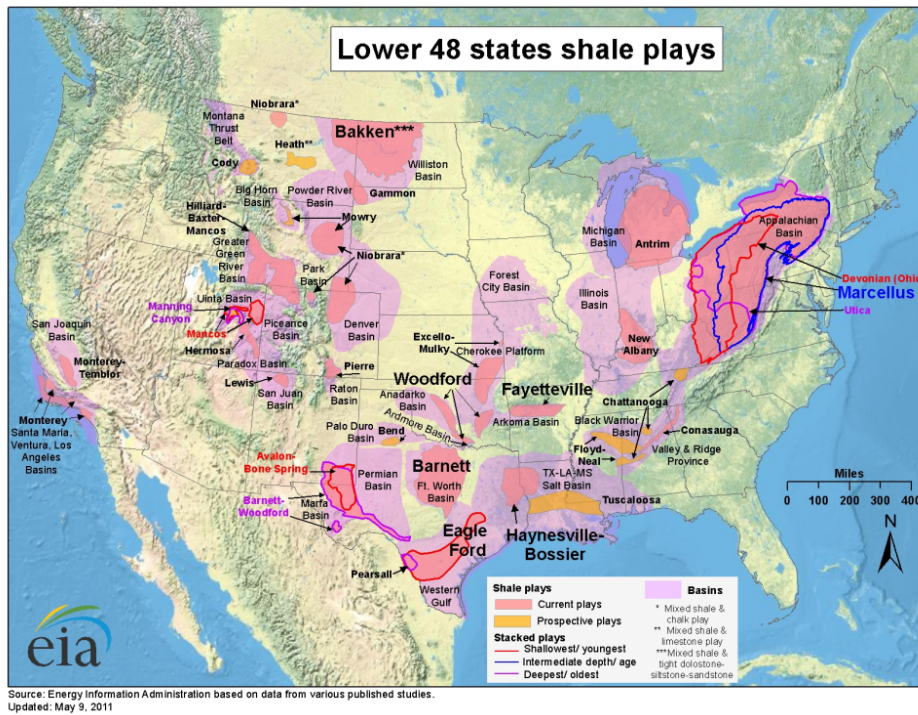
The Shale Revolution

Throughout the world, huge quantities of crude oil and natural gas are trapped in non-permeable shale rock. Over the past few years, technological advances — especially in hydraulic fracturing and horizontal drilling — along with higher crude oil prices have made recovery of much of this oil and gas economically feasible.

Hydraulic fracturing, or “fracking,” involves pumping a mixture of water, sand and chemicals down a well at high pressure to create thin cracks in the shale rock, thereby freeing oil and gas trapped inside and allowing it to be brought to the surface.

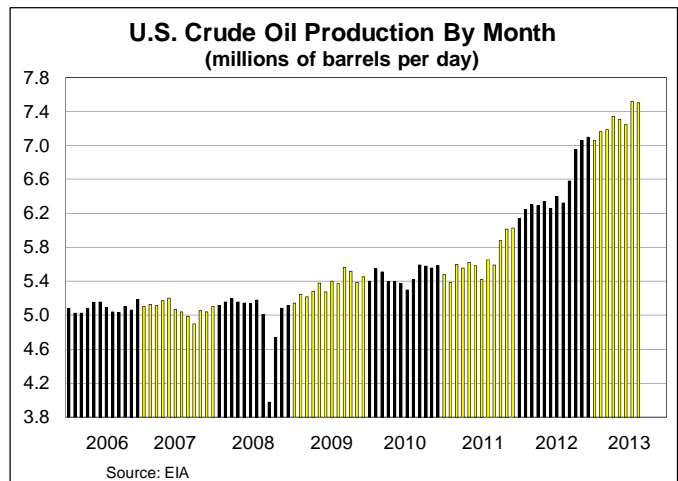
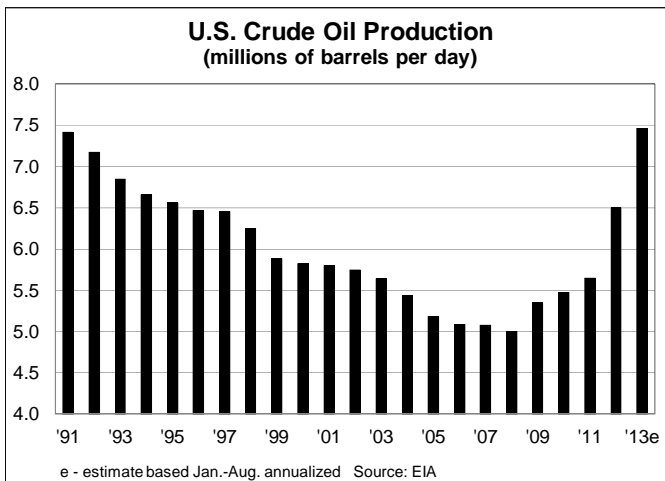
Horizontal drilling involves creating an initial vertical bore of up to several thousand feet, then turning the drill and continuing horizontally for up to several miles.



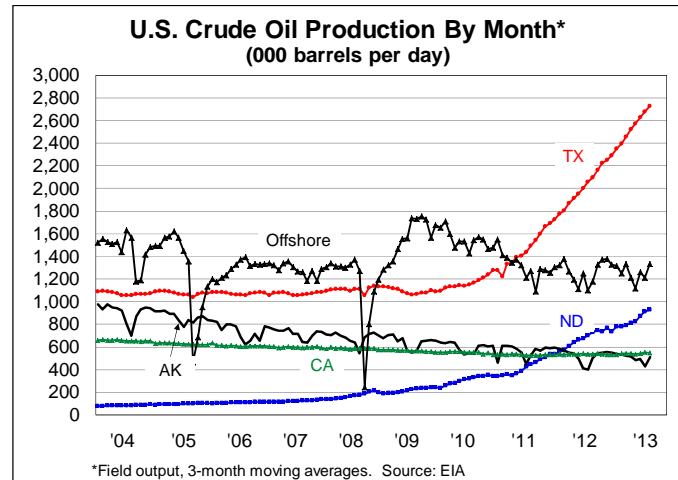


The map above shows the distribution of U.S. shale deposits. To date, the most important are Bakken in North Dakota and Montana; Barnett in Texas; and Marcellus in the east, especially in Pennsylvania and Ohio. Other key shale areas include Niobrara in Wyoming and Colorado, and Eagle Ford and Permian in Texas. Some areas contain more natural gas than crude oil; others contain more oil than natural gas. There are still many unknowns — including the long-term productivity of shale wells and the extent to which environmental concerns will limit fracking in the future — but it’s clear that, thanks to shale, economically recoverable U.S. gas and oil reserves are far higher than they were thought to be just a few years ago.

U.S. crude oil production peaked in 1970 at 9.6 million barrels per day, and by 2008 it had fallen to 5.0 million barrels per day as new production failed to keep pace with depletion of older fields. By 2012, though, U.S. crude oil production had risen to an average of 6.5 million barrels per day. Since November 2012, production has exceeded 7 million barrels per day — the first time that’s happened since 1992 — and by the summer of 2013 was 7.5 million per day.



Much of the recent increase in crude oil production has been in North Dakota, home to the Bakken Shale formation. Crude oil production in North Dakota rose from an average of 81,000 barrels per day in 2003 to around 900,000 barrels per day by mid-2013, making North Dakota the second-largest oil producing state. Crude oil output in Texas, the top producer, was relatively flat from 2003 to 2009, but has skyrocketed since then, exceeding 2.6 million barrels per day by mid-2013. Output in California and Alaska has been trending down for years.

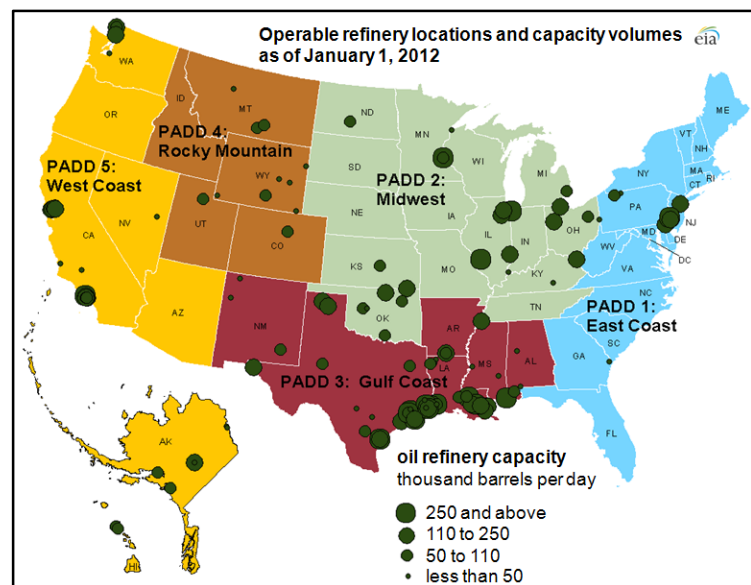


Transporting Crude Oil by Rail

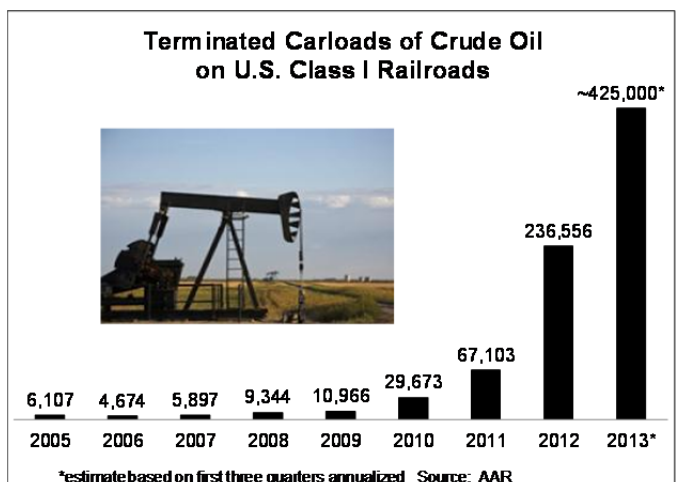
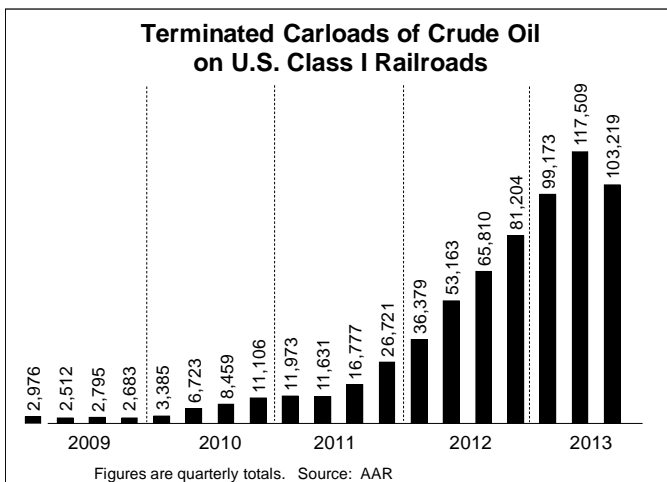
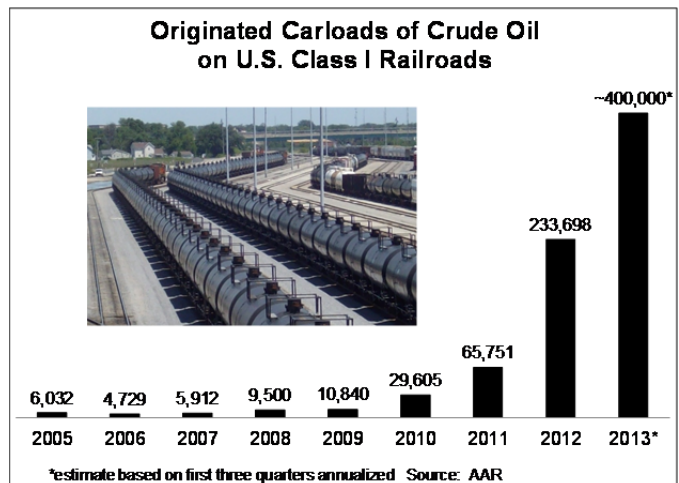
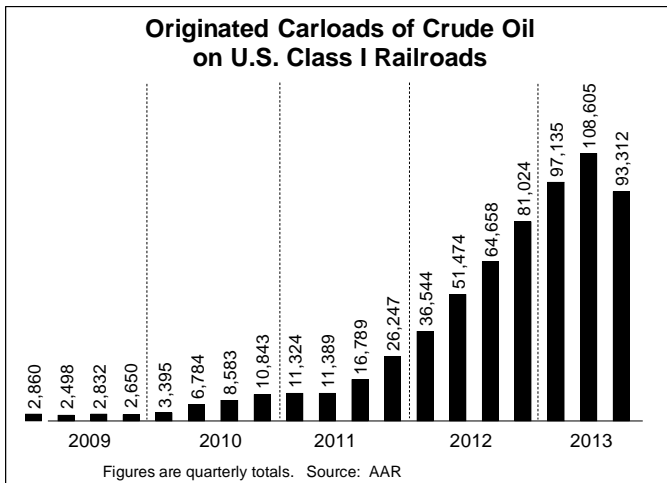
Crude oil has little value unless it can be transported to refineries, but most U.S. refineries are located in traditional crude oil production areas (Texas, Oklahoma) or on the coasts where crude oil transported by tanker is readily accessible (California, Washington, New England, Gulf of Mexico), rather than near up-and-coming crude oil production areas like North Dakota (see nearby map). In part because of the long, rigorous process required to obtain the necessary permits to build new refineries, it's basically impossible for refineries to come on line quickly near the new production areas.

Historically, most crude oil has been transported via pipelines. However, in places like North Dakota that have seen huge increases in crude oil production, the existing pipeline network lacks the capacity to handle the higher production. Pipelines also lack the flexibility and geographic reach to serve many potential markets. Railroads, though, have the capacity and flexibility to fill this gap.

Small amounts of crude oil have long been transported by rail, but since 2009 the increase in rail crude oil movements has been enormous. As recently as 2008, U.S. Class I railroads (including the U.S. Class I subsidiaries of Canadian railroads) originated just 9,500 carloads of crude oil. By 2011, carloads originated were up to nearly 66,000, and in 2012 they surged to nearly 234,000. In the first three quarters of 2013, Class I railroads originated 299,652 carloads of crude oil, 96 percent higher than the 152,676 carloads originated in the first three quarters of 2012. Based on the first nine months of the year, crude oil originations in 2013 will probably total around 400,000 carloads. Crude oil accounted for 1.4 percent of total Class I originated carloads in 2013 through September, up from just 0.03 percent in 2008.



The vast majority of crude oil moving by rail in the United States both originates and terminates on U.S. Class I railroads, so the number of carloads originated by Class I carriers (see top charts below) is always close to the number of carloads terminated by Class I carriers (see bottom charts below). However, some crude oil that originates on U.S. Class I railroads might be delivered to U.S. short lines or to railroads in Canada for termination. These carloads would be included in the top charts, but not in the bottom charts. In addition, some crude oil that terminates on U.S. Class I railroads might originate on railroads in Canada or on U.S. short line railroads. These carloads would be included in the bottom charts, but not in the top charts.



Assuming, for simplicity, that each rail tank car holds about 30,000 gallons (714 barrels) of crude oil, the 299,652 carloads of crude oil originated in the first three quarters of 2013 equal approximately 784,000 barrels per day moving by rail. As a point of reference, according to EIA data, total U.S. domestic crude oil production in the first three quarters of 2013 was approximately 7.3 million barrels per day, so the rail share was around 11 percent — up from a negligible percentage a few years ago.

Barring unforeseen circumstances, deposits of oil and gas in shale formations all over the country will be developed. In recent years, though, North Dakota, and the Bakken region more generally, have accounted for the vast majority of new rail crude oil originations. According to

estimates from the North Dakota Pipeline Authority, as of mid-2013, approximately 640,000 barrels per day of crude oil were moving out of North Dakota by rail, equivalent to more than 60 percent of North Dakota's crude oil production.

Advantages of Transporting Crude Oil by Rail

Historically, pipelines have been the dominant mode for transporting crude oil long distances. That's still the case, but railroads have become critical players in crude oil transportation. In addition to the critical fact that railroads provide transportation capacity in many areas where pipeline capacity is insufficient, railroads offer a number of other advantages for transporting crude oil:

- **Geographical Flexibility.** By serving almost every refinery in the United States and Canada, railroads offer market participants enormous flexibility to shift product quickly to different places in response to market needs and price opportunities. Railroads deliver crude oil to terminals not only in Louisiana and other places in the Gulf region, but also to locations on the East Coast, the West Coast, and elsewhere.
- **Responsiveness.** Rail facilities can almost always be built or expanded much more quickly than pipelines and refineries can be. Essentially, railroads are the only transportation mode that can invest in facilities quickly enough to keep up with production growth in the emerging oil fields.

- **Efficiency.** As new rail facilities are developed, railroads are involved every step of the way. For example, at origin and destination sites, railroad economic development and operations teams help facility owners decide where to locate assets and how to lay out rail infrastructure on the site to maximize efficiency.

Railroads also help crude oil customers find ways to load and unload tank cars more quickly and reduce en-route

delays. Promoting unit train shipments is often a key part of this process. Unit trains are long trains (usually at least 50 and sometimes 120 or more cars) consisting of a single commodity. These trains use dedicated equipment and generally follow direct shipping routes to and from facilities designed to load and unload them efficiently — say, from a gathering location near oil production areas to an unloading terminal at or near a refinery — and generally have much lower costs per unit shipped than non-unit trains. A single large unit train might carry 85,000 barrels of oil and be loaded or unloaded in 24 hours.

- **Underlying Infrastructure.** Over the past few years, railroads have invested hundreds of millions of dollars to replace and resurface tracks, buy new locomotives, build new



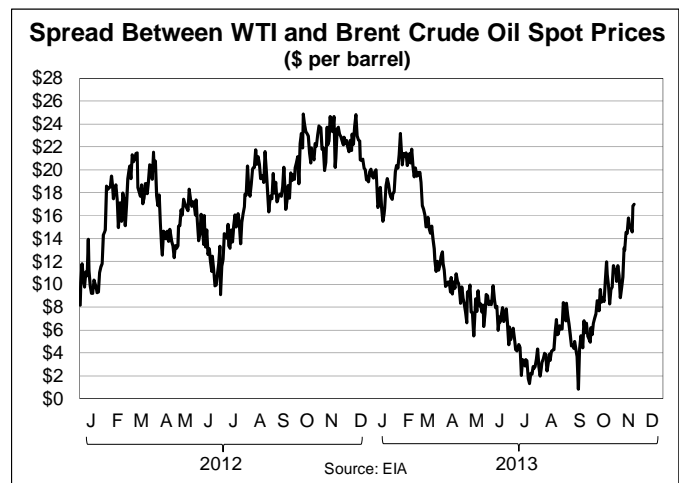
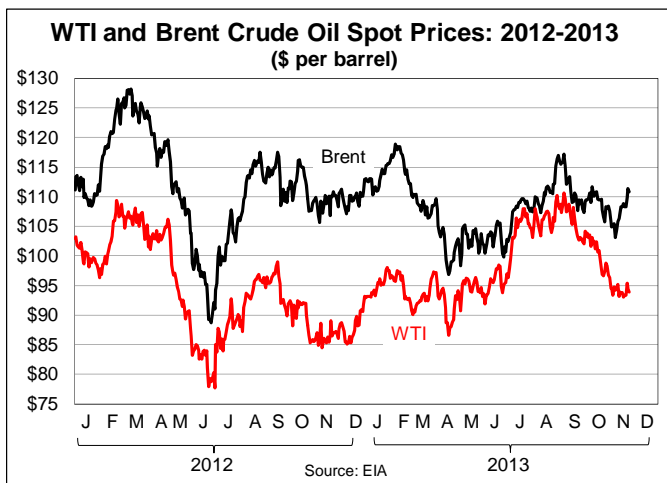
terminals and track capacity, hire new employees, and take other steps to enhance their ability to transport crude oil. Rail investments related to crude oil service are just a small part of a much larger set of ongoing rail investments. In recent years, U.S. freight railroads have been reinvesting more than ever before, including a record \$25.5 billion in 2012, to create and maintain a freight rail network that is second to none in the world.

- **Product Purity.** The composition of crude oil varies from region to region, even from well to well within a region. Consumers of crude oil often desire a specific type of crude oil. Shipping crude by rail allows “pure barrels” to be delivered to destination in ways that are not always possible with pipelines.

Crude oil producers and other market participants have made huge investments in both the infrastructure and the tank cars needed to move crude by rail, signaling confidence in the long-term viability of rail service in this market. Even as more pipelines are built or expanded, railroads will continue to provide a set of advantages — especially flexibility — that will enable them to continue to play a key role in the petroleum-related market long into the future.

Brent vs. WTI

The crude oil market is extremely complex, with lots of moving pieces and different players pursuing different goals. That said, in the case of crude oil — as in the case of every commodity that railroads haul — railroads face a variety of competitive constraints and market factors that, together with rail rate and service levels, collectively determine traffic levels.



One such factor involves crude oil prices. The chart above left shows the West Texas Intermediate (WTI) and Brent spot oil prices since January 2012. The chart above right shows the “spread” between the two. Historically, the spread typically has been just a few dollars, but over the past couple of years it’s been as high as \$28, thanks to a surge in U.S. oil production that caused a glut of crude oil inventories at Cushing, Oklahoma, where WTI is priced. The spread narrowed considerably in the third quarter of 2013. This narrowing — in addition to pipeline expansions in some areas — made some crude by rail movements (especially in Texas) less competitive compared to pipelines and resulted in a decline in crude by rail movements in the third quarter of 2013 compared with the second quarter of 2013. Clearly, in the months ahead, Brent-WTI spread will continue to play a key role in crude oil markets and, therefore, in crude by rail.

Moving Crude Oil Safely

Railroads have an excellent crude oil safety record — better, in fact, than pipelines in recent years. Based on data from the U.S. Department of Transportation’s Pipeline and Hazardous Materials Safety Administration, the “spill rate” for U.S. railroads from 2002-2012 was an estimated 2.2 gallons per million crude oil ton-miles generated. The comparable spill rate for pipelines is nearly three times the rail rate at approximately 6.3 gallons per million ton-miles.

Pipelines carry —and spill — much more crude oil than railroads do. From 2002-2012, an estimated 19.9 million gallons (474,000 barrels) of crude oil were spilled in pipeline incidents, compared with an estimated 95,000 gallons (2,300 barrels) of crude oil spilled in rail incidents over the same period. The rail figure is less than 1 percent of the pipeline figure.

From 2002-2012, there were 148 incidents involving releases of crude oil from railroads, of which 109 involved releases of less than five gallons. Railroads are required to report spills of any size, including very small spills. By contrast, in most cases pipelines only have to report spills of at least five gallons. Just 39 of the 148 railroad incidents had releases of more than five gallons. By contrast, pipelines reported 1,785 spills of at least five gallons from 2002-2012, more than 45 times the number of rail incidents.

	Number of Incidents		Total Gallons Spilled	Total Barrels Spilled	Estimated Spill Rate*
	< 5 gallons spilled	> 5 gallons spilled			
Railroads	148	39	95,000	2,300	2.2
Pipelines	unknown	1,785	19.9 million	474,000	6.3

*Gross gallons spilled per million ton-miles generated Numbers for 2012 are preliminary.
Source: AAR based on data from the Pipeline and Hazardous Materials Safety Administration

The bottom line, though, is that both railroads and pipelines are safe, reliable ways to transport crude oil. Each enhances our energy security and benefits consumers.

Enhancing Tank Car Safety

Crude oil is transported by railroads in tank cars. The North American tank car fleet consists of about 335,000 cars. Railroads themselves own less than 1 percent of these cars; the vast majority are owned by rail customers and leasing companies.

Thousands of different commodities are carried in tank cars. Of the 335,000 tank cars in the North American fleet, around 92,000 are used to transport crude oil and other flammable liquids. A typical carload of crude oil contains around 30,000 gallons.

In the United States, federal regulations pertaining to tank cars are set by the U.S. Department of Transportation’s Pipeline and Hazardous Materials Safety Administration (PHMSA). Transport Canada (TC) performs a similar role in Canada.

Meanwhile, the AAR Tank Car Committee sets industry standards regarding how tank cars used in North America are designed and constructed that are above and beyond federal



standards. The tank car committee is comprised of the AAR, rail car owners, manufacturers, and rail hazmat customers, with active participation from the U.S. DOT, Transport Canada, and the National Transportation Safety Board (NTSB).

The rail industry has been aggressive in finding ways to improve the safety of crude oil transport. For example, in March 2011, the tank car committee petitioned PHMSA to adopt more stringent requirements for new tank cars used to transport certain types of hazardous materials, including crude oil. These tougher standards called for a thicker, more puncture resistant tank car shell; extra protective “head shields” at both ends of tank cars; and additional protection for the fittings on the top of a car that enable access to the inside of the car.

In July 2011, after it had become clear that PHMSA approval of the committee’s proposal was not imminent, the committee adopted what it had proposed to PHMSA as the basis for new industry standards for tank cars used to carry ethanol or crude oil. The new standards apply to new tank cars ordered after October 1, 2011. To date, some 14,000 tanks cars have been built to this tougher standard.



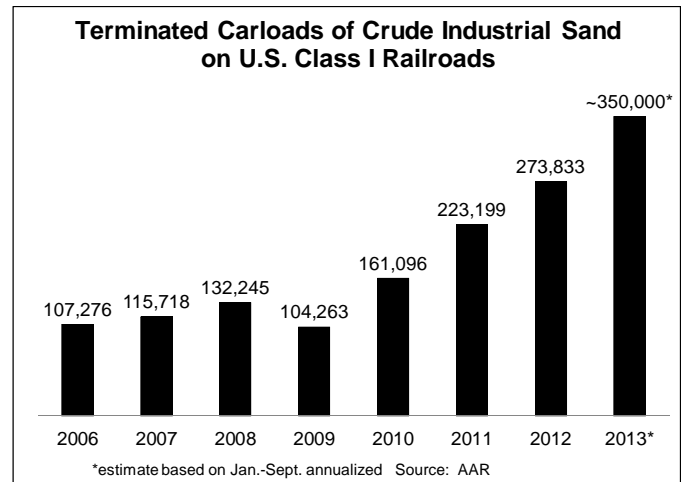
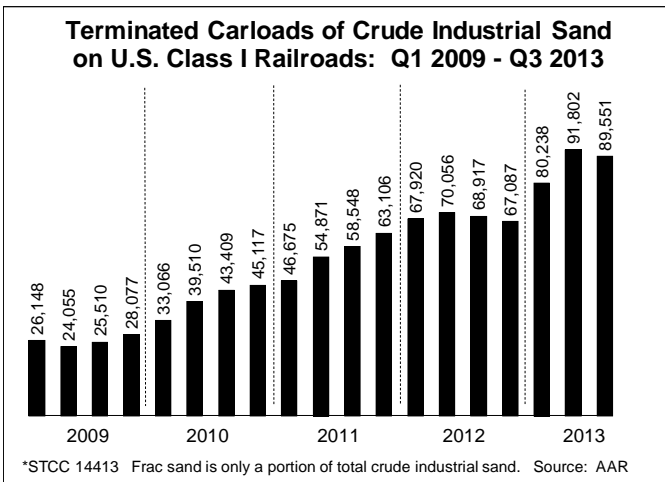
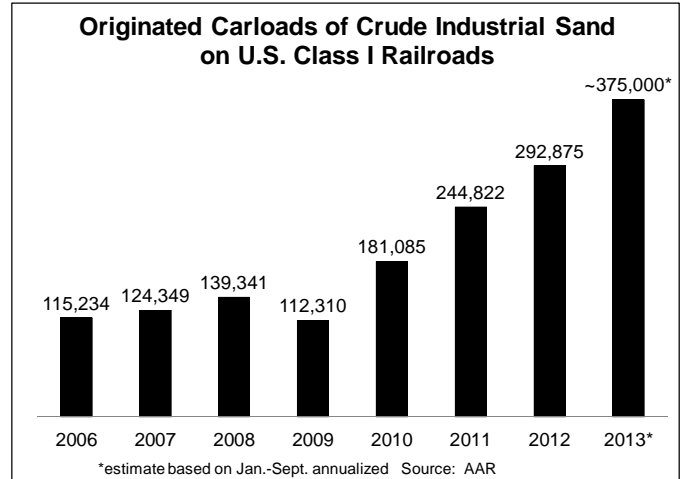
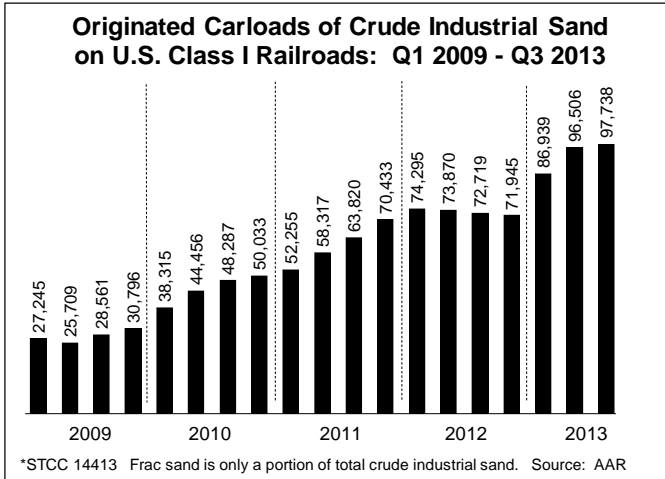
More recently, in November 2013, the rail industry called on PHMSA to require the 92,000 tank cars used to transport flammable liquids, including crude oil, to be retrofitted with enhanced safety features or, if no upgrades are made, aggressively phased out. These retrofits would substantially reduce the likelihood of a release of potentially dangerous products if affected tank cars are involved in accidents. Railroads will continue to work with PHMSA, their customers, tank car builders, and others to ensure that tank car safety continues to improve.

Frac Sand and Other Petroleum-Related Commodities

In addition to moving crude oil, railroads also transport large amounts of “frac sand” to crude oil and natural gas producers. A single horizontal well typically uses between 3,000 and 10,000 tons of sand. A typical rail car of frac sand contains around 100 tons.

Sand is used in many different industrial and construction applications, of which hydraulic fracturing is just one. Data on rail shipments of frac sand alone are not available, but data on rail shipments of industrial sand in total are. In 2009, U.S. Class I railroads (including the U.S. subsidiaries of Canadian railroads) originated just over 112,000 carloads of industrial sand. In 2012, Class I railroads originated nearly 293,000 carloads of sand and are on track to originate approximately 375,000 carloads in 2013. While it’s not possible to determine precise percentages, frac sand is almost certainly the primary driver behind the increased industrial sand movements on railroads over the past few years.

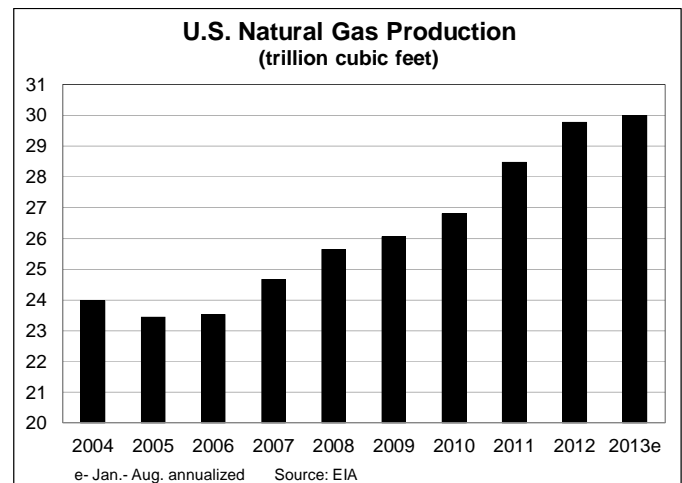
A number of short line and regional freight railroads also carry frac sand; their movements are not included in the charts on the next page. Railroads are also key players in the movement of iron ore, scrap steel, and other raw materials to steel plants that produce the pipes used in crude oil and natural gas production, and in the delivery of those pipes from steel plants to crude oil and natural gas production areas.



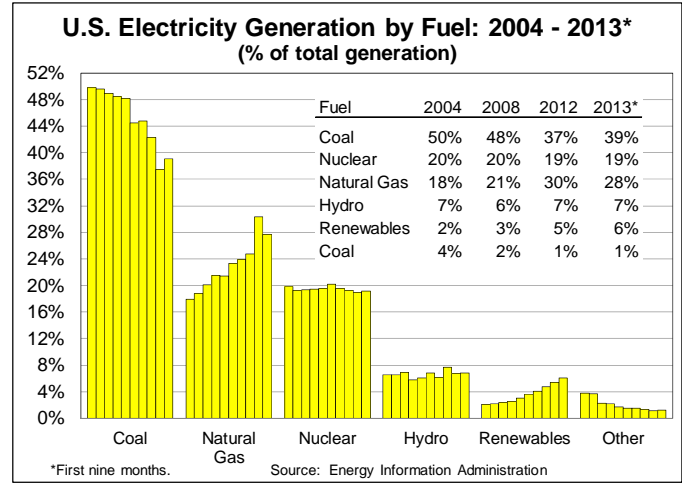
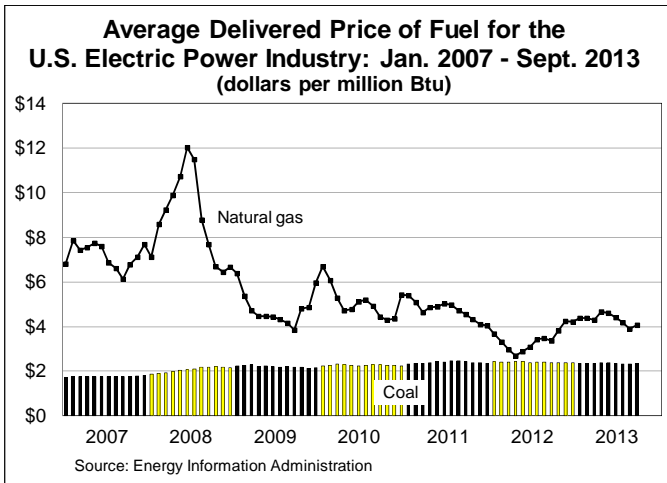
The Shale Revolution and Coal

The “shale revolution” has led to higher U.S. rail carloads of crude oil and frac sand, but it’s also led to sharply lower rail carloads of coal. Fracking and horizontal drilling have led to sharply higher U.S. natural gas production (see the chart at right), which in turn has meant sharply lower natural gas prices to utilities (see the chart on the top left of the next page). This has made electricity generated from natural gas more competitive in the electricity marketplace relative to electricity generated from coal.

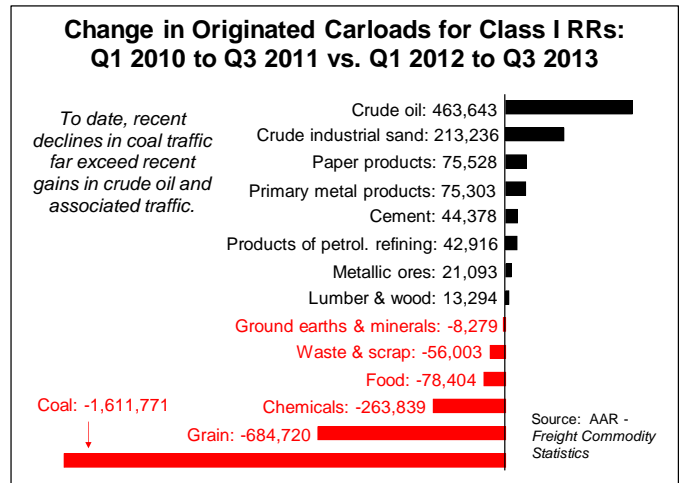
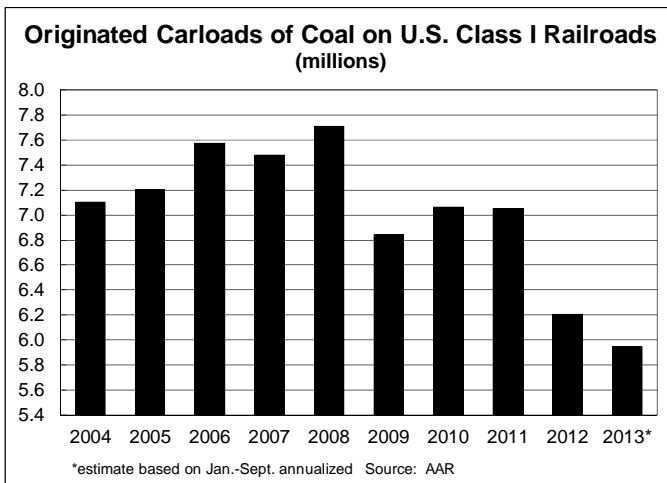
Consequently, natural gas’s share of total U.S. electricity generation has surged in recent years to record highs, while electricity generated from coal has fallen correspondingly. The coal share of electricity generation was 50 percent or higher each year from 1980 through 2003 and 48 percent as recently as 2008, but was down to 37 percent in 2012 before rising a bit in



2013 (see the chart below right). The growth of renewable energy and increasingly stringent environmental constraints have also played roles in coal's declining share of electricity generation.



Reduced electricity generation from coal has meant a big decline in rail carloads of coal. U.S. Class I railroads originated 6.2 million coal carloads in 2012, the lowest annual total since 1993. Coal carloads could dip below 6 million in 2013 (see the chart below left). Over the past few years, the decline in coal carloads has far exceeded the increase in carloads of crude oil and frac sand for U.S. railroads (see the chart below right).



Conclusion

The United States is experiencing an unprecedented boom in oil and natural gas production, with most of the increase coming from dense shale rock formations. Among other things, this means North America is likely to move closer to energy self-sufficiency. U.S. freight railroads are playing a critical role. Rail shipments of crude oil have skyrocketed in recent years due to the flexibility and other advantages that moving crude oil by rail offers. Railroads are continually working with energy firms and others to find ways to further improve the safety, reliability, productivity, and cost effectiveness of their service offerings to the energy market.