U.S. Department of Energy
Washington, DC 20585

Date: **August 8, 2014**

To: **Members of the Public**

From: **Quadrennial Energy Review Task Force Secretariat and Energy Policy and Systems Analysis Staff, United States Department of Energy**

Re: **QER Public Stakeholder Meeting: Rail, Barge, and Truck Transportation, Chicago, Illinois**

1. Introduction

On January 9, 2014, President Obama issued a Presidential Memorandum establishing a Quadrennial Energy Review (QER), an interagency effort to examine the nation's energy systems and to recommend energy policies to improve our economy, protect the environment, and enhance our national security. The focus of the first year's efforts is on the nation's infrastructure for the transmission, storage, and distribution of energy. The Secretary of Energy provides support to the interagency QER Task Force, including coordination of activities related to the preparation of the QER report, policy analysis and modeling, and stakeholder engagement.

On Friday, August 8, 2014, 8:30 a.m. CDT, at the University of Illinois-Chicago Student Center East - Illinois B Room, located at 750 South Halstead Street in Chicago, Illinois, the U.S. Department of Energy, acting as the Secretariat for the QER Task Force will host a public meeting to discuss and receive comments on issues surrounding the rail networks, waterborne commerce, and bridge and highway infrastructure that are essential means of carrying energy products throughout the nation. Following remarks by government officials, three expert panels will explore evolving trends in these sectors, followed by an opportunity for public comment via an open microphone session. The session will be webcast at www.energy.gov/live. For more information on the QER and stakeholder meetings, see www.energy.gov/qer. Written comments can be submitted to QERcomments@hq.doe.gov.

2. Background

Over the past decade, the U.S. has seen a dramatic transformation across virtually every aspect of its energy profile. Every day presents changes in how the nation both produces and utilizes multiple forms of energy, including crude oil and refined petroleum products, coal, ethanol and other bio-based and alternative fuels and natural gas liquids. With these changes come new opportunities and challenges in reconfiguring the infrastructure and vehicles for transportation, storage and distribution of these goods.

This memo explores some of the baseline characteristics and trends associated with movement of energy via railroads, waterways, roads and, for comparison, pipelines. Where possible, it includes the most up-to-date data that are publicly available. However, given the wide range of products and infrastructures that are in scope here, the wide range of public and private resources for these data, and the rapid pace of change in these sectors, data may be incomplete, inadequate, or inconsistent. This is especially the case for "intermodal" shipments that entail more than one mode of transportation to get products to intermediate points and end-users.

2.1 Crude Oil and Products

A longstanding assumption underlying U.S. energy policy has been one of declining U.S. oil production coupled with increasing demand, and thus, increasing imports of foreign crude. U.S. domestic crude oil production peaked in 1970 at 9.6 million barrels per day (MMBbl/d), and then began, with some exceptions, a steady decline until hitting 5 MMBbl/d in 2008 - production levels not seen since the late 1940s. The crude oil refining, transportation, storage and distribution (TS&D) infrastructure system was configured largely to move crude north from off-shore production in the Gulf of Mexico to refineries in the interior, with refineries on the coasts configured to receive much of their oil from overseas by tanker and, for west coast refineries, from Alaska and some local production. However, since 2008, U.S. oil production has grown rapidly, reaching over 8.4 MMBbl/d in April of 2014.[1] Conservative EIA estimates project growth to continue until roughly 2020, again reaching the peak of 1970, and EIA's high-resource estimates project growth through the mid-2030s, reaching over 13 MMBbl/d.[2]

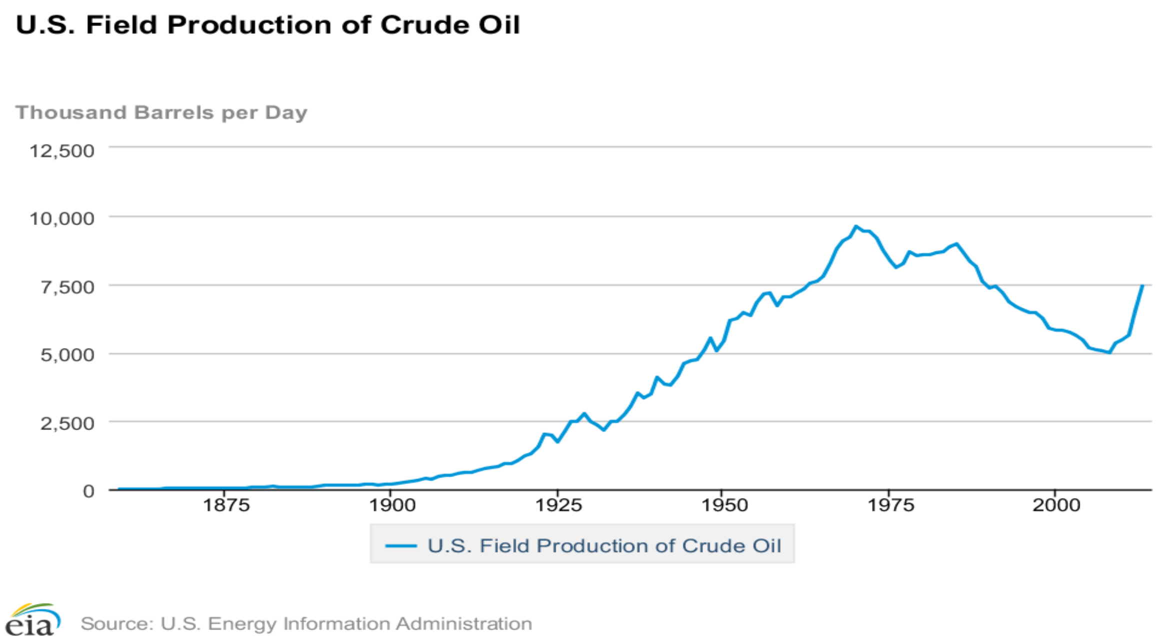

Figure 1: U.S. field production of crude oil

The domestic oil boom is due largely to new production of light, sweet crude from unconventional tight-oil formations in North Dakota (Bakken) and Texas (Eagle Ford and Permian Basin), using the same technologies that propelled U.S. shale-gas production from 3.5 billion cubic feet per day (bcf/d) in 2007 to over 35 bcf/d in mid-2014[3]. Together, these two states now account for nearly half of total domestic crude oil production, with Texas topping 3 MMBbl/d this year for the first time since the late 1970s, and

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[1] U.S. Energy Information Administration (EIA), Petroleum Supply Monthly – Daily average, April 2014, http://www.eia.gov/dnav/pet/pet_sum_snd_d_nus_mbblpd_m_cur.htm.
[2] EIA, Short Term Energy Outlook, July 8, 2014, http://www.eia.gov/forecasts/steo/outlook.cfm; EIA, Annual Energy Outlook 2014, http://www.eia.gov/forecasts/aeo .
[3] EIA, Natural Gas, Shale Gas Production, April 10, 2014, http://www.eia.gov/dnav/ng/ng_prod_shalegas_s1_a.htm.

North Dakota production breaking 1 MMBbl/d for the first time in history, nearly tripling its production in three years.[4] Texas onshore production in May increased 27% over May of 2013.[5]

In 2012, the United States achieved the largest annual increase of oil production in U.S. history by adding almost one million barrels per day of production, a record then surpassed again in 2013. In 2014, the U.S. became the largest producer of liquid fuels[6] in the world, overtaking Saudi Arabia and Russia. The growth in domestic production has also contributed to a dramatic decline in petroleum imports. The share of total U.S. liquid fuels consumption met by net imports fell from 60% in 2005 to an average of 33% in 2013. EIA expects the net import share to decline to 22% in 2015, which would be the lowest level since 1970.[7]

The rapid production increase in both U.S. shale oil and Canadian oil sands is upending markets and transforming patterns and modes of crude oil and petroleum product TS&D infrastructure within the U.S. The existing TS&D system is largely configured for moving crude northwards from the Gulf to refineries in the interior, with coastal refineries receiving much of their oil from overseas and Alaska, so there is currently no pipeline capacity to take crude from interior production areas to refineries on the East and West coasts. This is especially problematic for takeaway of light sweet crude from North Dakota and heavy crude from Canada, both of which must trade at a significant discount to account for the transport costs to refineries that are optimized for those grades.

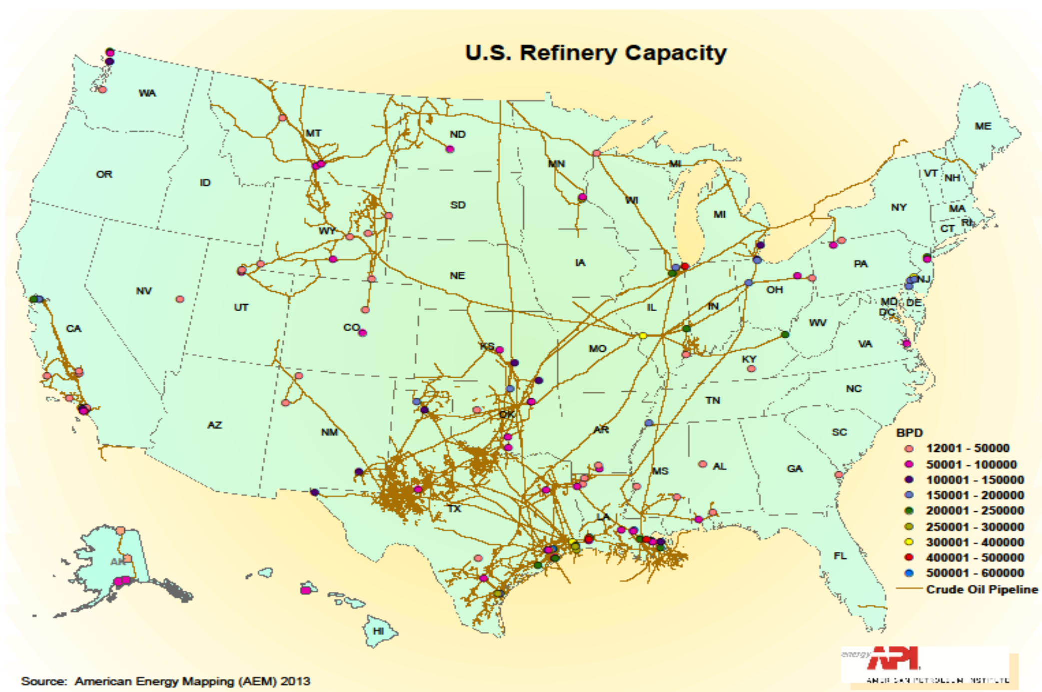

Figure 2. Major Crude Oil Pipeline and Refineries.

Source: American Energy Mapping

[4] EIA, Petroleum Supply Monthly, 2014, http://www.eia.gov/petroleum/supply/monthly/.
[5] Railroad Commission of Texas, Monthly Oil and Gas Statistics.
[6] This includes crude oil, natural gas liquids, and biofuels.
[7] EIA, Short Term Energy Outlook, July 2014, http://www.eia.gov/forecasts/steo/pdf/steo_full.pdf.

The system has so far adapted via a rapid expansion in crude-by-rail shipments, pipeline modifications to increase throughput and reverse flow direction from northward to southward, as well as some repurposing of natural gas pipelines. Barge shipments of crude oil to refineries have also grown rapidly, while tanker shipments continues to decline, reflecting a decrease of crude imports into the U.S. Major new pipelines projects are in the works, though large pipeline projects typically require several years of planning, financing, permitting and construction.

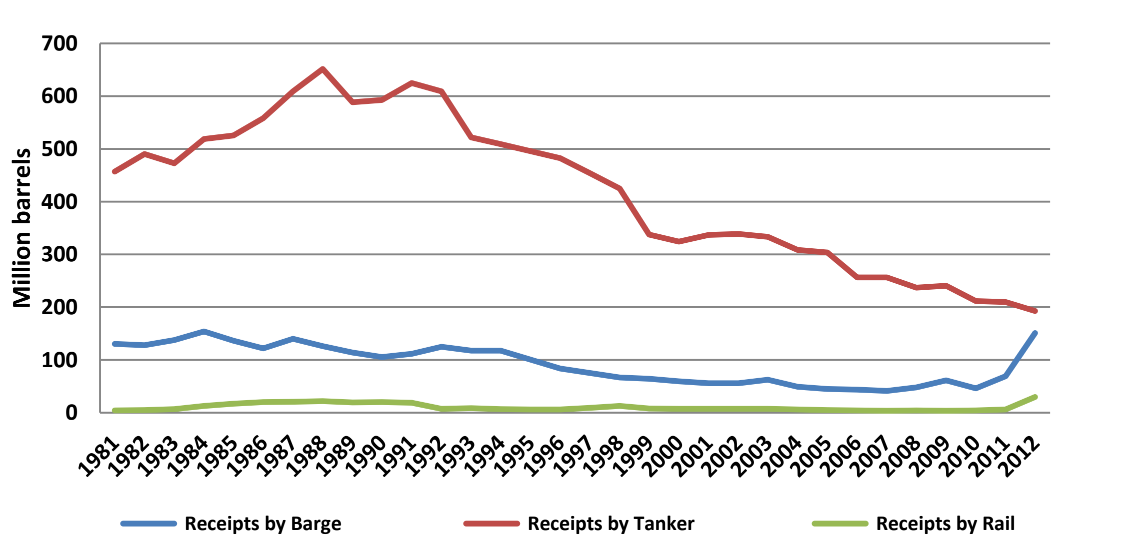

Figure 3. Comparison of U.S. refinery receipts of domestic crude by mode.

Source: EIA.

2.1.1 Intermodal competition and interdependency

Shipments of crude, petroleum products, coal, and other commodities (such as fertilizer, chemicals, and agricultural products) are increasingly intermodal, with both competition and interdependencies existing between pipeline, rail, truck, tanker and barge transport. Utilization depends on increasingly complex and time-dependent dynamics around factors such as the systems' capacities, price differentials, storage, and locational supply/demand uncertainty.

Despite new demand and emerging competition from other modes, Figure 4 below shows, pipelines still carry the majority of crude oil and petroleum products in North America,[8] with tankers comprising the next highest percentage. From 2011-2012 truck shipments increased 38%, rail shipments increased 423%, and barge shipments increased 53%. Figure 4 indicates only the mode used for the last leg of such shipments.[9]

[8] Association of Oil Pipe Lines, August 2013 (citing Freight Commodity Statistics in "Moving Crude by Rail," Association of American Railroads, May 2013, and FERC Form 6 Filing Information).
[9] Congressional Research Service, *U.S. Rail Transportation of Crude Oil: Background and Issues for Congress*, May 5, 2014, http://fas.org/sgp/crs/misc/R43390.pdf.

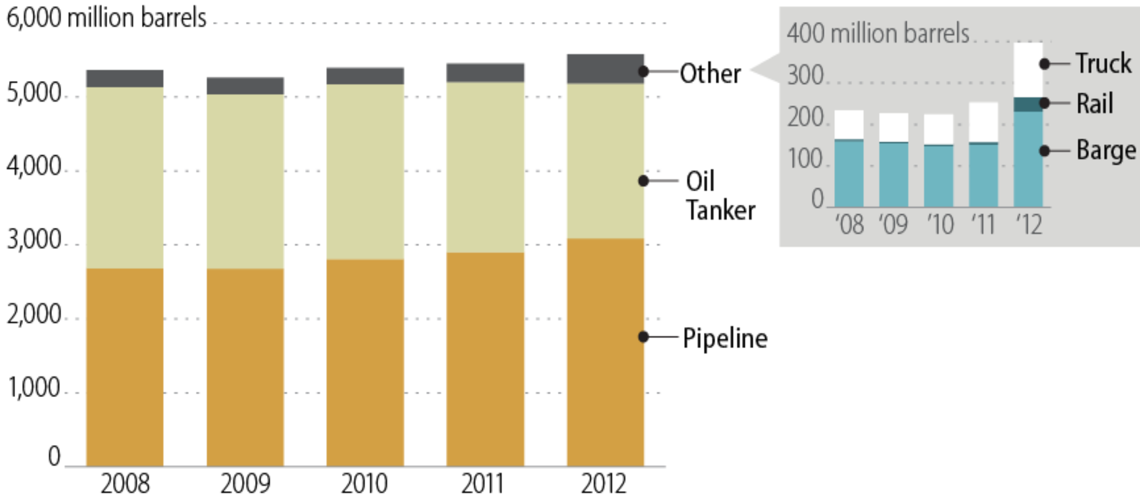

Figure 4. Increase in volume of crude oil carried by conveyance, 2008–2012.

Source: CRS, *U.S. Rail Transportation of Crude Oil: Background and Issues for Congress*

Generally, once built, pipelines can move product at lower cost and with less safety risk than other modes. However, the high capital costs and long-term contracts required to construct pipelines means that both investors and shippers must have confidence that future production and market demand are robust enough to guarantee long-term use of the infrastructure.

In markets where both pipeline and rail are available, rail transport of crude is typically disadvantaged in overall cost at $10–15 per barrel, depending on destination, compared to roughly $5 per barrel for pipelines.[10] Despite the higher cost, rail's faster response time to shifting supply/demand factors (flexibility) coupled with its shorter-term contracts (1-2 years or less, versus 15-20 year commitments for pipelines) make it a compelling alternative to pipelines. Rail also has extensive existing infrastructure, generally requiring only construction of crude loading and unloading terminals and expansion of the tank car fleet, which can be done relatively rapidly compared to pipeline build-out. Rail's flexibility also includes transporting crude directly to the Gulf Coast or to barges that then deliver the crude to the coast.[11]

In the case of transport of heavy crudes that require dilution be transported, rail shipment requires less diluent than pipelines, and railroads can also bring the diluents back to the shipment point using the

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[10] Department of State, Keystone XL Final Supplemental Environmental Impact Statement, Appendix C, Supplemental Information to Market Analyses, Table C1 and the attached ICF report., and Department of State, Draft Supplemental Environmental Impact Statement, Appendix C, Tables 3, 4, and 5. http://keystonepipeline-xl.state.gov/documents/organization/221218.pdf; http://keystonepipeline-xl.state.gov/documents/organization/205594.pdf

[11] *Oil and Gas Journal*, "Lagging Pipelines Create US Gulf Light Sweet Crude Glut," March 2014, http://www.ogj.com/articles/print/volume-112/issue-3/transportation/lagging-pipelines-create-us-gulf-light-sweet-crude-glut.html.

empty tanker cars which must be returned anyway. This makes rail especially important for transporting Canadian bitumen from oil sands.

Railroads also compete with and rely upon waterborne transport (inland barge and intra-coastal tankers) for moving new Canadian and U.S. crude oil production to refineries and markets. Some North Dakota production is taken by rail to Albany, New York and then barged down the Hudson River to East Coast refineries. Some crude is also railed to Minneapolis and Chicago and then barged to the Gulf Coast, or railed to Washington State to be refined there or barged to California refineries.

Barge transport can be competitive in cost with both rail and pipeline, even if water access is not direct. For instance, the distance between the Bakken region in North Dakota and refineries in the Northeast is approximately 1,800 miles, and the cost of railroad transport is $14 per barrel. The distance from Texas ports near the Eagle Ford region to the same refineries is about 2,100 miles, and tanker rates are $5 to $6 per barrel. Similarly, the overland distance from the Eagle Ford region to Los Angeles-area refineries is about 1,400 miles, and the estimated cost of railroad transport is $15 per barrel, while the water route through the Panama Canal is 5,200 miles and is estimated to cost $10 per barrel.[12]

2.2 Coal

The U.S. has the largest estimated recoverable reserves of coal in the world. In 2013, U.S. coal mines produced almost one billion short tons of coal, with more than 90% being used for electricity generation. However, U.S. coal production has declined by 188 million tons from 2008 to 2013.[13] While coal remains a major fuel source for electricity generation, its annual share of net generation has been declining due to a combination of slow growth in electricity demand, low natural gas prices, increased use of renewable technologies, and environmental regulations.[14] Powder River Basin coal mined in Wyoming (with some in Montana) is by far the single largest source of domestic coal production, accounting for roughly 95 of the 209.5 million short tons produced in the U.S. in the first quarter of 2014.[15]

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[12] Congressional Research Service, *U.S. Rail Transportation of Crude Oil: Background and Issues for Congress*, May 5, 2014, http://fas.org/sgp/crs/misc/R43390.pdf.

[13] American Association of Railroads, *Railroads and Coal*, July 2014, https://www.aar.org/keyissues/Documents/Background-Papers/Railroads%20and%20Coal.pdf.

[14] EIA, “What is the role of coal in the United States?” *Energy in Brief*, June 2, 2014, http://www.eia.gov/energy_in_brief/article/role_coal_us.cfm.

[15] EIA, “Quarterly Coal Distribution Report,” June 19, 2014, http://www.eia.gov/coal/distribution/quarterly/

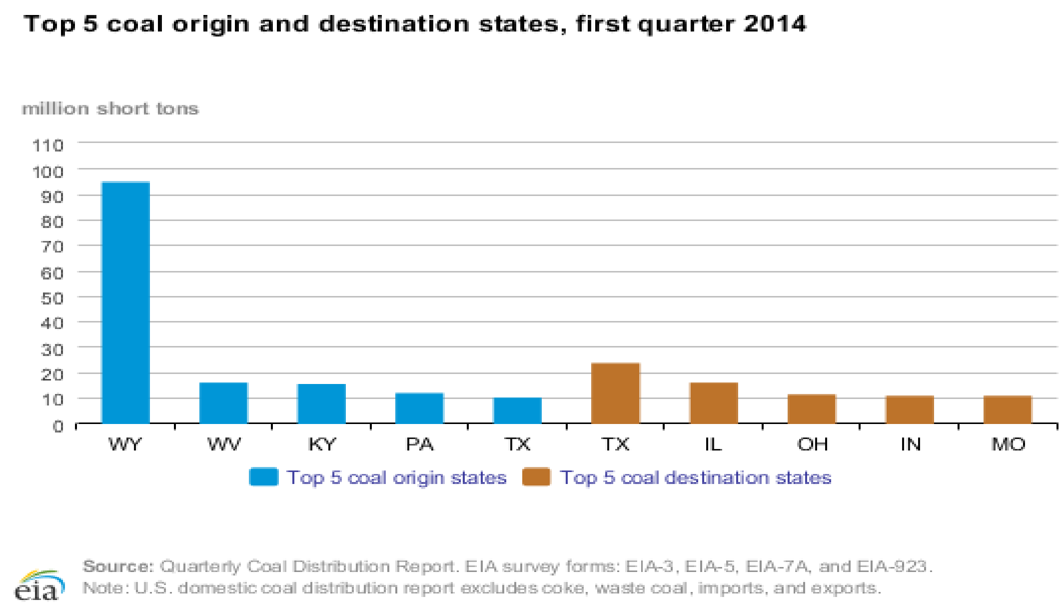

Figure 5. Top five coal origin and destination states, first quarter 2014.

The United States is a net exporter of coal. Between 2000 and 2010, an average of about 5% of coal produced in the United States was exported. Though it experienced growth in recent years, it appears that coal exports are flattening, primarily because of slowing world coal demand growth and increasing coal output in other coal-exporting countries. While overall exports for 2015 are projected to fall (to 95 million short tons),[16], the expectation of higher coal exports to Asia is the impetus for plans to build new coal export terminals in the Pacific Northwest.[17]

The U.S. also imports coal. In the first quarter of 2014, the most recent period for which data is available, U.S. imports increased 71%, to 2.4 million tons.[18] Power plants along the Gulf Coast sometimes opt for coal shipped by sea over coal shipped by rail or barge from Appalachia, the Illinois Basin, or from the Powder River Basin and the rest of the Western region.[19] Colombia accounted for 67% and Indonesian coal made up 23% of U.S. imports in the first quarter, according to EIA,[20] and generators are looking for other overseas sources.

Rail is the dominant transportation mode for coal, delivering nearly 70% of domestic coal shipments. Truck and waterborne modes (mainly barge on inland waterways) deliver 11% and 13% of U.S. coal

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[16] Energy Information Administration, "Short Term Energy Outlook, Coal," July 8, 2014. http://www.eia.gov/forecasts/steo/report/coal.cfm

[17] "The Rail Transportation of Coal: Volume 16," Association of American Railroads Policy and Economics Department, July 2014, at 8. https://www.aar.org/keyissues/Documents/Background-Papers/Railroads%20and%20Coal.pdf

[18] Energy Information Administration, "U.S. Coal Imports," March 2014. http://www.eia.gov/coal/production/quarterly/pdf/t18p01p1.pdf).

[19] EIA, "Coal Explained," July 2014, http://www.eia.gov/energyexplained/index.cfm?page=coal_imports.

[20] Mario Parker, "Hungry U.S. Power Plant Turns to Russia for Coal Shipment," Bloomberg.com, July 16, 2014, http://www.bloomberg.com/news/2014-07-15/hungry-u-s-power-plant-turns-to-russia-for-coal-shipment.html.

shipments, respectively.[21] Coal shipments likewise comprise a very large percentage of railroad traffic, accounting for 41% of total tonnage in 2012. However, coal's share of rail revenue has recently declined – from a high of over 25% of rail revenue in 2009, to less than 20% in 2013 – due in part to declining demand for coal shipments and increasing use of rail for crude and intermodal transportation of freight. The Burlington Northern and Santa Fe railroad (BNSF) hauled the most coal in 2013, comprising 38% of the North American total, though the other three U.S Class I railroads (UP, CSX, NS) all carried significant amounts.[22]

After the harsh winter of 2014, a number of coal companies complained about disruption in rail service, and some cited these disruptions as primary drivers for monetary losses in the first and second quarter of this year. In second quarter announcements, Peabody Coal said rail interruptions resulted in an estimated 15 million tons of lower shipments in the first six months of 2014.[23] Arch Coal also blamed underperforming rail service for cutting its Powder River Basin coal shipments by between 4 and 5 million short tons in the first half of 2014. "The story of the Powder River Basin this quarter was effectively the meltdown in rail service," said Chief Operating Officer Paul Lang said in a second-quarter earnings conference call.[24] Rail companies acknowledged the seriousness of recent service disruptions and have made commitments to address them, largely via investments.

2.3 Ethanol/Advanced Biofuels

The U.S. produces significant quantities of bio-based fuels, producing 14.7 billion gallons of ethanol and biodiesel in 2013, or 4.6% of U.S. transportation fuel consumption, up slightly from the 14.2 billion gallons produced in 2012.[25] According to the U.S. Department of Agriculture, 90% of ethanol is shipped by rail or truck and the other 10% is transported by barge or pipeline. Railroads alone account for 70% of ethanol shipping, with 341,000 carloads transported, typically in the same, 30,000-gallon "DOT 111" type tank cars used for hauling crude and petroleum products.[26] Ethanol accounts for 1.2% of total rail carloads, which is up from 0.1% in 2002. Trucks transport most corn used for ethanol production from farms to ethanol plants, while a small amount is moved by rail. The majority of domestically-produced ethanol originates in Iowa, Nebraska, South Dakota, and Illinois, while fuel handling facilities in Texas, New Jersey and California are the top destinations for ethanol rail cars.

Trucks and rail are used extensively for ethanol because fuel quality specifications, ethanol's water absorbing properties, and multiple owners of pipelines complicate the transport of ethanol in the same pipelines as petroleum products. A $4 billion dedicated ethanol pipeline project from the Midwest to the

[21] Association of American Railroads, Railroads and Coal, July 2014, https://www.aar.org/keyissues/Documents/Background-Papers/Railroads%20and%20Coal.pdf.
[22] Association of American Railroads, Class I Railroad Freight Commodity Statistics, Annual 2013 (updated July 2014).
[23] http://www.eenews.net/greenwire/2014/07/29/stories/1060003704
[24] Charlie Noh, "Arch says rail 'meltdown' cut coal shipments by 4-5 mil st in first half," Platts, July 29, 2014, http://www.platts.com/latest-news/coal/washington/arch-says-rail-meltdown-cut-coal-shipments-by-21988604.
[25] DOE/EIA, Monthly Energy Review, July 2014, Table 2.5, p. 31. http://www.eia.gov/totalenergy/data/monthly/pdf/sec2_11.pdf; http://www.eia.gov/biofuels/biodiesel/production/; http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=m_epooxe_ynp_nus_mbbld&f=a
[26] American Association of Railroads, Railroads and Ethanol, April 2013, https://www.aar.org/keyissues/Documents/Background-Papers/Railroad-Ethanol.pdf.

Northeast was considered by Poet and Magellan Midstream Partners, but abandoned in 2012 after it was determined to be economically infeasible without federal loan guarantees. Poet Ethanol is assessing the feasibility of building a dedicated ethanol pipeline from Minnesota and Iowa to New Jersey.[27]

3. Rail

According to the Federal Railroad Administration, the $60 billion freight rail industry includes 140,000 rail miles operated primarily by seven Class I railroads, along with 21 regional railroads, and 510 short line railroads.[28] In the U.S. Class I Railroads are line haul freight railroads with 2013 operating revenue of $467.0 million or more.[29] For 2013, Class I railroads carried commodities totaling 1.75 billion tons of freight, with gross revenues of $72.05 billion. Of that, coal accounted for 39.5% of the tonnage, and 19.9% of the revenues. As of the second quarter of 2014, crude oil carloads comprised 2.7% of U.S. rail traffic[30] and 3.1% of revenues.[31] The percentage of total freight and relative revenues can differ widely between railroads. Chicago sees a quarter of all U.S. rail traffic daily, roughly 37,500 cars a day.[32]

While railroads transport more coal than any other single commodity, recent declining coal demand has reduced the amount of coal transported by rail. In 2013, rail coal traffic was down 4.1% over 2012 and down 22.8% from peak 2008 levels.[33] However, due to consumption of low-sulfur Western coal by utilities around the country, the average length of haul for rail coal movements has trended upward over the years, reaching an all-time high of 848 miles in 2012. Rail coal movements exceeding 1,500 miles are not uncommon.[34]

[27] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Ethanol Production and Distribution, accessed February 13, 2014, http://www.afdc.energy.gov/fuels/ethanol_production.html.
[28] Federal Railroad Administration, "Freight Rail Today," U.S. Department of Transportation, accessed July 1, 2014. http://www.fra.dot.gov/Page/P0362.
[29] Association of American Railroads Policy and Economics Department, "Class 1 Railroad Statistics," July 2014, at 1, https://www.aar.org/StatisticsAndPublications/Documents/AAR-Stats.pdf.
[30] Association of American Railroads, "AAR Reports 2014 First Quarter Crude Oil Carloads, Increased Traffic for May and for the Week," June 5, 2014, https://www.aar.org/newsandevents/Freight-Rail-Traffic/Pages/2014-06-05-railtraffic.aspx#.U6we9JRdV0R.
[31] Id. at 3.
[32] Id.
[33] Association of American Railroads, "Railroads and Coal," July 2014, https://www.aar.org/keyissues/Documents/Background-Papers/Railroads%20and%20Coal.pdf.
[34] Id., at 10.

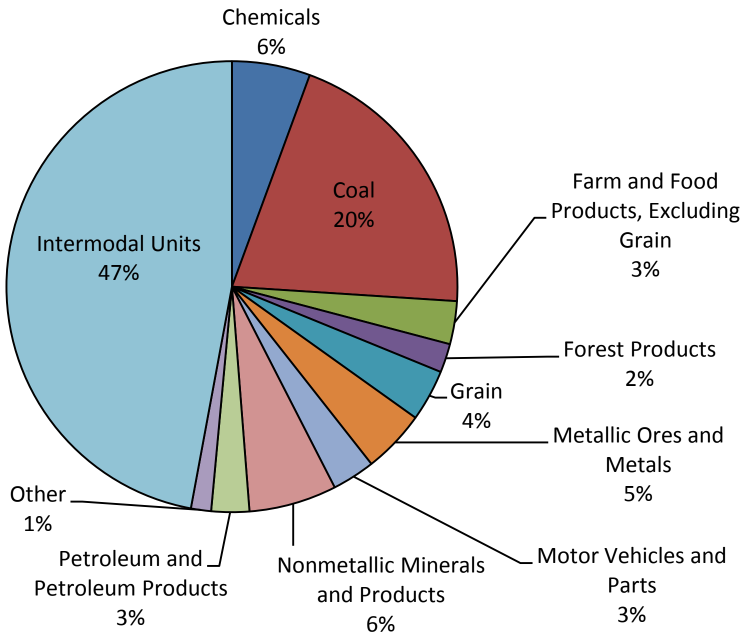

Figure 6. 2014 year-to-date U.S. rail traffic; week ending July 12, 2014

Source: Association of American Railroads.

Some of the decline in coal traffic is offset by the rapid increase in crude oil shipments. In 2013, over 407,500 carloads of crude oil were shipped on U.S. railways, compared to 9,500 carloads in 2008.[35] This equates to roughly 800 million barrels per day moving by rail, or nearly 11% of U.S. domestic crude oil production. Rails service every refinery in the country, and rail and related loading/offloading facilities can be built quickly, allowing them to keep pace with production and growth.[36] Still, the total number of carloads of rail transport dedicated to crude oil is relatively small compared to other commodities. Intermodal transportation (typically shipping containers and truck trailers moving on railroad flatcars), is the largest rail traffic segment at 47%.

Rail transportation of crude oil has increased dramatically due largely to the growth of oil production in Texas and North Dakota.[37] Total crude and petroleum products transported by rail rose 46% from 2011 to 2012, but then through 2013 and the beginning of 2014, the total carloads of crude oil stagnated, albeit still at higher volume levels than in 2012, and even declined briefly in one quarter.

[35] Association of American Railroads, "Moving Crude by Rail**,"** June 2014, https://www.aar.org/keyissues/Documents/Background-Papers/Crude%20oil%20by%20rail.pdf.
[36] Association of American Railroads, https://www.aar.org/keyissues/Documents/Background-Papers/Crude-oil-by-rail.pdf.
[37] EIA, "A number of western states increased oil production since 2010," *Today in Energy*, May 21, 2013, http://www.eia.gov/todayinenergy/detail.cfm?id=11351.

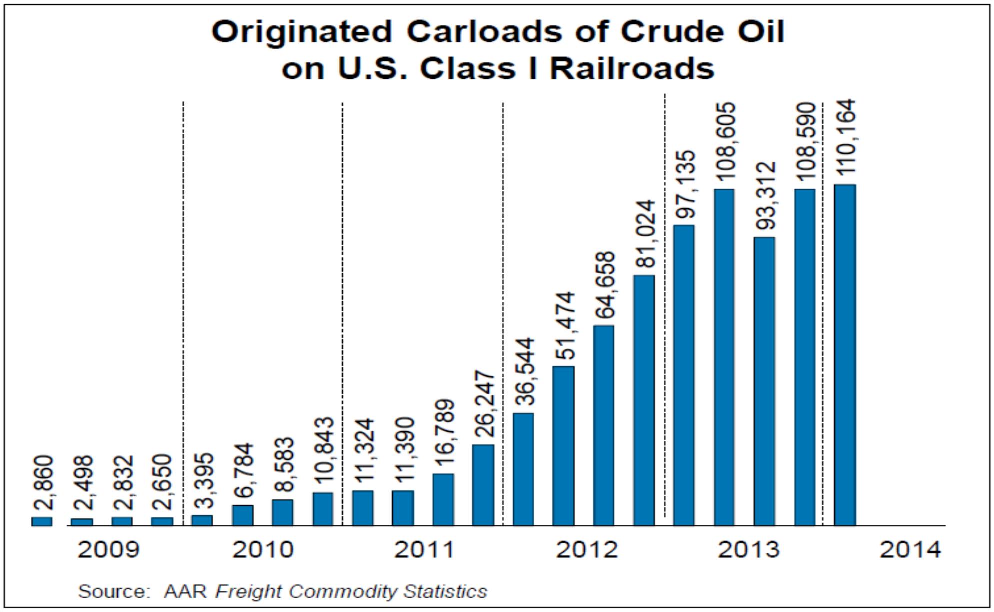

Figure 7. Originated rail carloads of crude petroleum on U.S. Class I railroads: Q1 2009–Q1 2014.[38]

Source: Association of American Railroads.

At its peak, rail comprised 70% of total Bakken oil shipments but has since fallen to 59% as of May of this year. This may be attributable to a number of factors, including increasing use of pipelines, slowing production, market conditions, and the availability of tank cars, locomotives and crew. [39] In addition to the increase in carloads of crude, there has been an increase in construction of loading and offloading facilities, and because of highly condensed supply locations, rail congestion issues are emerging in certain areas.

The following maps show the build-out of crude oil rail terminals between 2010 and 2013, demonstrating that rail fleet resources, like trains, additional track, and other facilities can be put in place quickly to handle rapid expansion.[40]

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[38] AAR Quarterly Commodity Statistics, https://www.aar.org/keyissues/Documents/Background-Papers/Crude%20oil%20by%20rail.pdf.

[39] Richard Nemec, "North Dakota Crude Oil Rail Shipments Continue to Decline," NGI's Shale Daily, July 16, 2014, http://www.naturalgasintel.com/articles/99030-north-dakota-crude-oil-rail-shipments-continue-to-decline.

[40] Julie M. Crey, "Rail emerging as long-term North American crude option," *Oil & Gas Journal*, August 5, 2013, http://www.ogj.com/articles/print/volume-111/issue-8/transportation/rail-emerging-as-long-term-north-american.html.

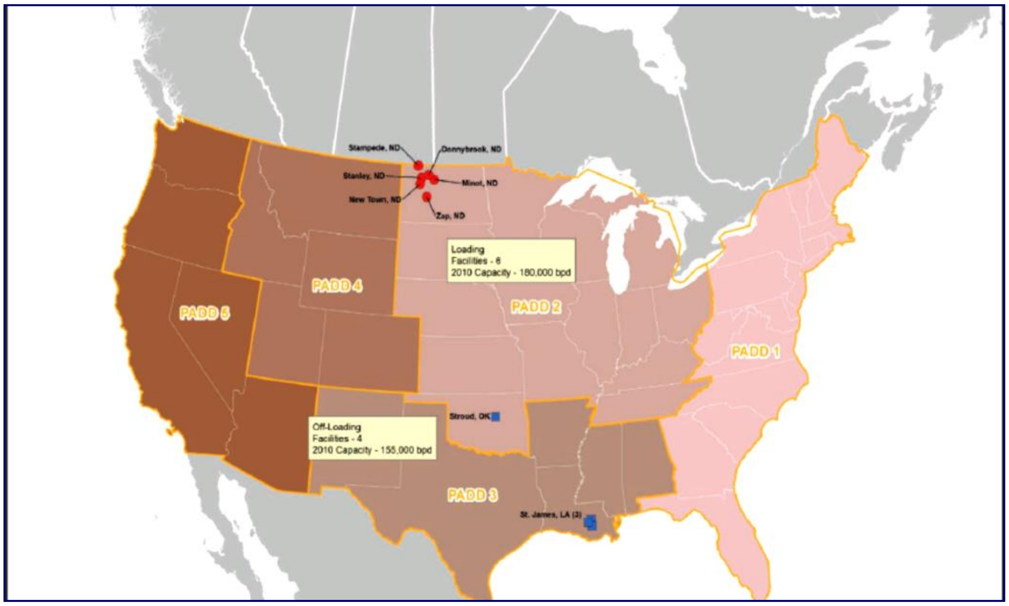

Figure 8. <u>2010</u> crude oil by train loading (red) and offloading (blue) facilities.

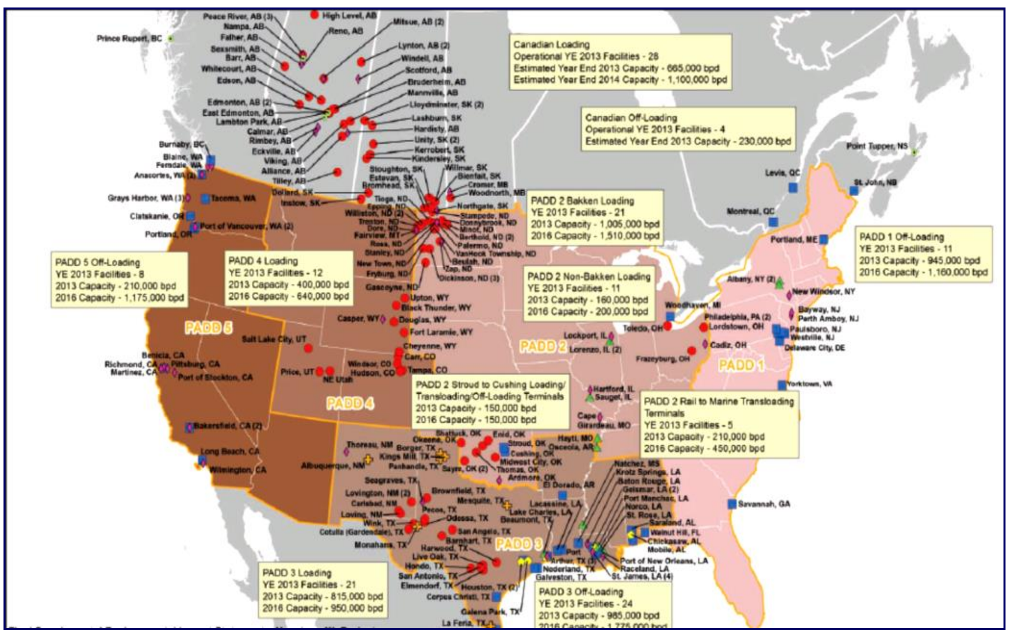

Figure 9. <u>2013</u> crude oil by train loading (red) and offloading (blue) facilities.

Source: U.S. Department of State. 2014. "Final Supplemental Environmental Impact Statement (SEIS): Keystone XL Project." Bureau of Oceans and International Environmental and Scientific Affairs. Accessed July 1, 2014. http://keystonepipeline-xl.state.gov/finalseis/index.htm.

3.1 Competition, Constraints and Commodities

In some regions, the growth in crude transport has consumed much of the excess capacity left in the railroad network by the recession starting in 2008. As rail utilization nears capacity, various constraints or bottlenecks appear and propagate quickly across the network, including delays along particular stretches of track, shortages or high prices for rail cars, locomotive shortages, or loading and unloading delays. With a fixed infrastructure, changes in the pattern of demand, such as the sudden rise in shipments of Bakken crude, can overtax pre-existing infrastructure and affect important seasonal patterns in rail shipments, such as the harvest in the Midwest and winter coal shipments to utilities. Rail system constraints often appear first as delays associated with seasonal peaks in demand.

While the impacts are unclear, energy-related shipments represent a significant change in the pattern of demand. On the BNSF Railway, for instance, petroleum crude carloads grew 2118% from 2009 to 2013.[41] Recently, some freight shippers have expressed concerns that timely delivery of non-oil commodities (agricultural, chemicals, coal) and other products could be hampered if railroads show preference for moving crude-by-rail. Farmers and grain producers argued at a recent Surface Transportation Board (STB) hearing about long delays in the delivery of rail cars from the BNSF and CP railways,[42] and the Chrysler Corporation asserted that vehicle shipments from Detroit have stalled because of rail car shortages.[43] Both railroads acknowledged difficulties in service due to recovery from extreme winter conditions in the mid-west and an unexpected surge in grain exports, but farmers implied that the railroads' alleged poor service to grain producers is more a result of diverting locomotives and crews to handle the oil traffic. Some rail slow-downs at Chicago have been blamed on Bakken oil shipments, which have slowed coal deliveries to power plants from the upper Midwest to the Southeast and have purportedly been a factor in NYMEX coal prices rising to over $60 a ton.[44]

Winter rail service disruptions have left utilities with less coal in storage,[45] with January 2014 showing the lowest total coal storage since 2006.[46] According to BNSF CEO, Carl Ice, the railroad will take all year to rectify problems originating in the Bakken. BNSF has deployed 300 additional crew members to its northern region and plans to add 500 locomotives and 5,000 rail cars to ease the congestion.[47] Bakken-related problems have been blamed for problems with other commodity movements. For instance, ethanol futures in April 2014 reached $3.517 a gallon on the Chicago Board of Trade, the highest level in more

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[41] Surface Transportation Board – Quarterly Freight Commodity Statistics.
[42] Sara Wyant, "Slow go: Farmers, shippers concerned about impact of rail delays," FarmForum.net, accessed July 1, 2014, http://m.farmforum.net/news/columnists/slow-go-farmers-shippers-concerned-about-impact-of-rail-delays/article_2175d4ab-a939-59ef-a414-4f6be06f49de.html?mode=jqm.
[43] Dave Battagello, "New minvans sit on Detroit riverfront due to shortage of trains," *Windsor Star*, April 23, 2013, accessed July 1, 2014, http://blogs.windsorstar.com/2014/04/23/finished-minvans-sit-on-detroit-riverfront-due-to-rail-car-shortage/.
[44] Mario Parker and Eliot Caroom, "Chicago 30-Hour Tie-Up for Buffett's Trains Slows Coal: Freight," Bloomberg.com, April 11, 2014 (citing numerous sources), http://www.bloomberg.com/news/2014-04-10/chicago-30-hour-tie-up-for-buffett-s-trains-slows-coal-freight.html.
[45] Id.
[46] Id. (citing EIA, "Electric Power Monthly," January 2014, http://www.eia.gov/electricity/monthly/current_year/january2014.pdf).
[47] Parker and Caroom, "Chicago 30-Hour Tie-Up."

than seven years, purportedly due in part to sidetracking of ethanol cars.[48] Barges, trucks, and/or pipelines are alternatives for some commodities in some locations. In many cases, however, bulk commodity shippers have only rail loading facilities available in a particular location, and are hence vulnerable to delays or changes in conditions of service, regardless of cause.

3.2 Growth Projections and Outlook for 2030

Freight rail volume is estimated to grow 22% between 2013 and 2035.[49] Already congested bottlenecks across all transportation infrastructures are estimated by American Society of Civil Engineers (ASCE) to cost the U.S. economy about $200 billion a year, or 1.6% of U.S. economic outlook. ASCE's 2013 Report Card for America's Infrastructure gave the U.S. rail system a "C+" grade.[50]

A 2013 IHS Global study projected that $9.3 billion worth of direct capital investments would be spent on rail for crude oil during 2014-2025, as shown in Table 1 below.[51] IHS highlights that rail capacity for moving crude will reach saturation under the high case, resulting in very little difference in direct capital investments going toward rail under the two cases for crude. For Natural Gas Liquids and Liquid Petroleum Gas, there is an 11% difference from the base case to the high case.

Table 1. Forecasted Direct Capital Investment for Crude and NGL/LPG Related Rail Infrastructure (2014–2025)

	Base Case	High Case	Difference
Crude Oil Rail	$9.3 billion	$9.3 billion	0%
NGL & LPG Rail	$6.7 billion	$7.5 billion	11%

Source: Oil & natural gas transportation & storage infrastructure: status, trends, & economic benefits, IHS Global

3.3 Investments and Costs

The Association of American Railroads estimates that rail companies re-invest 17% of their revenue in capital (compared to 3% to 5% by manufacturers), and that since 1980, the industry has reinvested $550 billion in new and replacement rail networks, with $25 billion invested in 2013 and another $26 billion planned for 2014.[52] Reinvestment by the freight railroads to the network averages about 40 cents of every dollar of revenue earned - a trend that continued even during the economic downturn – in enhancements such as "twinning" tracks next to existing tracks, straightening curved tracks, expanding tunnel heights to accommodate double-stacked intermodal freight, and modernizing bridges. Each owner of the rail

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[48] Mario Parker and Eliot Caroom, "Chicago 30-Hour Tie-Up for Buffett's Trains Slows Coal: Freight," Bloomberg.com, April 11, 2014 (citing numerous sources), http://www.bloomberg.com/news/2014-04-10/chicago-30-hour-tie-up-for-buffett-s-trains-slows-coal-freight.html.

[49] U.S. DOT Federal Rail Administration, National Rail Plan Progress Report, September 2010, http://www.fra.dot.gov/Page/P0528

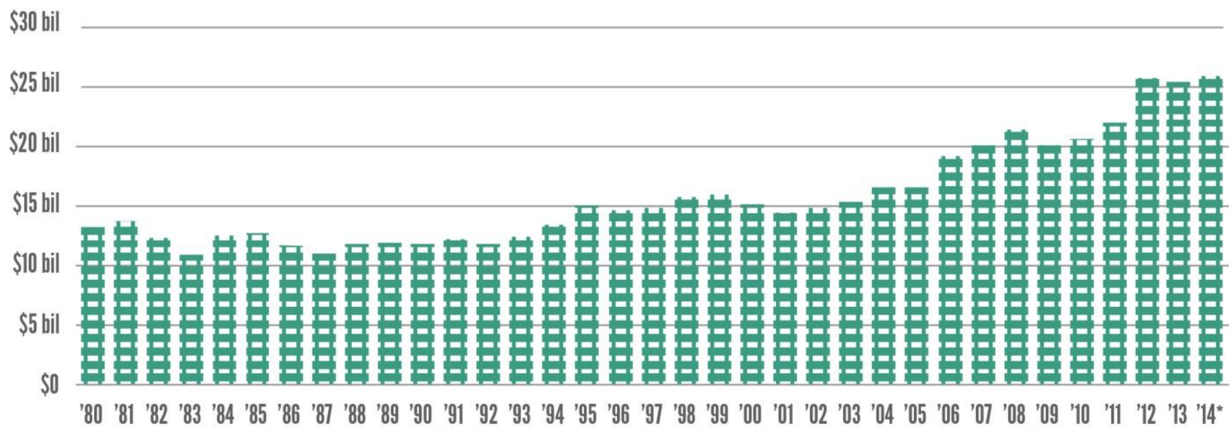
[50] For current and future rail investments, the American Society of Civil Engineers (ASCE) study provides an interactive map with links to project specific information on their 2013 Report Card for America's Infrastructure website: American Society of Civil Engineers, "Rail Investment Projects," ASCE, 2013, accessed July 1, 2014, http://www.infrastructurereportcard.org/a/#e/rail-investment-projects.

[51] IHS Global, "Oil & natural gas transportation & storage infrastructure: status, trends, & economic benefits," December 2013, http://www.api.org/~/media/Files/Policy/SOAE-2014/API-Infrastructure-Investment-Study.pdf .

[52] Freight Rail Works, Private Rail Investments Power America's Economy, accessed August 1, 2014, http://freightrailworks.org/future/.

network is responsible for maintaining the condition of its track and right of way, as well as railroad bridges and tunnels on its system. Some railroad reinvestment is supplemented with government funding, including TIGER grants from the U.S. Department of Transportation (DOT). [53]

Figure 10. U.S. Rail Investment Trends Since 1980 (Source: Association of American Railroads)[54]



3.4 Car Backlog

While investment in infrastructure has been heavy in recent years, rail has been constrained in terms of specialized tank cars available for oil transport, a backlog in locomotive power,[55] and crews to staff the additional trains required to meet the surge in demand. According to data from the Railway Supply Institute, there was a 52,600 unit backlog of tank cars as of Q2 2014. Tank cars now comprise 53% of industry backlog, down from the peak level of 86% in Q1 2013.[56] While tank car backlog was the main driver of industry backlog growth in 2011 and 2012, non-tank car backlog appears to be driving recent growth, including cars used for shipping sand for hydraulic fracturing.

3.5 Rail Safety

The railroad industry is rushing to meet this new demand while balancing the unique risks of hauling unprecedented volumes of petroleum. In 2013 and 2014, several rail accidents highlighted the possible need for increased monitoring, enforcement, and new regulations for tank cars. This was most evident from the catastrophic accident at Lac-Mégantic, Quebec, Canada on July 6, 2013, that killed 47 people and resulted in extensive damage to the town's center. [57] On December 30, 2013, at Casselton, ND, a train

[53] U.S. DOT – Federal Railroad Administration, TIGER Discretionary Grant Program Fact Sheet, http://www.fra.dot.gov/eLib/Details/L04475
[54] Freight Rail Works, http://freightrailworks.org/future/.
[55] Thomas Black, "Buffett's BNSF Leads Locomotive Surge to Ease Railroad Cargo Jam," Bloomberg News, March 12, 2014, http://www.bloomberg.com/news/2014-03-11/buffett-s-bnsf-leads-locomotive-surge-to-ease-railroad-cargo-jam.html.
[56] Progressive Railroading, "Both tank-car and non-tank-car backlogs grew in Q2, Stern Agee says," July 21, 2014, http://www.progressiverailroading.com/mechanical/news/Both-tankcar-and-nontankcar-backlogs-grew-in-Q2-Stern-Agee-says--41120.
[57] A summary of recent accidents can be found in USDOT Emergency Order of May 7, 2014, http://www.dot.gov/briefing-room/emergency-order.

derailment resulted in an unintended release of crude oil that ignited and burned, causing a voluntary evacuation of the city and surrounding area. On April 30, 2014, a train derailed near downtown Lynchburg, Virginia, causing several tank cars to breach and catch fire in the James River.

In response to these incidents, the US Department of Transportation issued several emergency orders and called upon railroad companies to take voluntary actions.[58] On August 1, 2014, PHMSA published a notice of proposed rulemaking to improve the safe transportation of large quantities of flammable materials by rail and is currently seeking comments to the proposed rule. The NPRM proposes enhanced tank car standards, a classification and testing program for mined gases and liquids and new operational requirements for high-hazard flammable trains (HHFT) that include braking controls and speed restrictions.[59] PHMSA concurrently issued an Advance Notice of Proposed Rulemaking which seeks further information on expanding comprehensive oil spill response planning requirements for shipments of flammable materials. [60]

The various crude oil and refined fuel types shipped by rail all have different flash points – the lowest temperature at which an oil sample will ignite on application of a flame. Crudes produced in the Bakken and Eagle Ford regions have lower flash points than other typical crudes, due to their higher content of light hydrocarbons, making them more volatile. In addition, transporting heavy Canadian oil sands requires blending bitumen with roughly 30% lighter diluents. These diluents lower bitumen's flash point from about 300°F to about -40°F for diluted bitumen (dilbit).

4. Waterborne Transport

Waterborne transport of energy is overseen by multiple government agencies. For instance, in the Federal Government: the DOT and the U.S. Army Corps of Engineers (USACE) analyze and have jurisdiction over commerce on U.S. waterways; the USACE is responsible for study, design, construction and operation and maintenance of federally authorized coastal harbors and channels and inland waterways; and the U.S. Coast Guard oversees the safety of shipments. DOT uses a broader definition of what constitutes U.S. waterways, to account for multi-modal shipment. DOT refers to the systems as the Marine Transportation System (MTS), the constituent parts of which include ocean, coastal, and inland waterways; ports, intermodal connections (freight and passenger), and vessels; and commercial, military, and recreational users.[61]

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[58] Pipeline and Hazardous Materials Safety Administration (PHMSA), "Chronology," accessed August 1, 2014, http://www.phmsa.dot.gov/hazmat/osd/chronology.

[59] PHMSA, Hazardous Materials: Enhanced Tank Car Standards and Operational Controls for High-Hazard Flammable Trains, 49 CFR Parts 171, 172, 173, 174, and 179, http://www.phmsa.dot.gov/pv_obj_cache/pv_obj_id_9F3CE4CB7A6FCBD43CE1757CD2E41F85A4C41000/filename/Signed_Proposed_Rulemaking-for_High-Hazard_Flammable_Trains.pdf.

[60] PHMSA, Hazardous Materials: Enhanced Tank Car Standards and Operational Controls for High-Hazard Flammable Trains, 49 CFR Parts 171, 172, 173, 174, and 179, http://www.phmsa.dot.gov/pv_obj_cache/pv_obj_id_9F3CE4CB7A6FCBD43CE1757CD2E41F85A4C41000/filename/Signed_Proposed_Rulemaking-for_High-Hazard_Flammable_Trains.pdf.

[61] The Committee on the Marine Transportation System (CMTS), "Federal Funding Handbook: Marine Transportation System Infrastructure," April 2013 (citing CMTS, "National Strategy for the Marine Transportation

The MTS primarily includes:

- 25,000 miles of USACE navigable coastal channels and harbors and inland waterways
- 242 locks at 198 locations
- The Great Lakes and St. Lawrence Seaway
- More than 3,700 marine terminals
- Recreational marinas
- More than 1,400 designated intermodal connections
- 926 Coastal Ports and Waterways

The Bureau of Transportation Statistics estimates that the value of marine freight will increase by 43% domestically and 67% internationally between 2010 and 2020. Trade volume through ocean ports is expected to more than double between 2012 and 2021, and to double again after 2030.

There are two navigation-related trust funds, the Inland Waterways Trust Fund (IWTF), which pays a share of the construction and major rehabilitation costs for inland waterways and infrastructure, and the Harbor Maintenance Trust Fund (HMTF), which reimburses costs associated with the operation and maintenance of coastal harbors and channels. Revenues for the IWTF are generated from a $0.20/gallon fuel tax levied on commercial towing activities on inland and intra-coastal waterways. IWTF revenues have generally been flat or decreasing in recent years. The balance in the IWTF was $33.8 million on September 30, 2014. The revenues for the HMTF are generated by a 0.125% ad valorem tax on the value of imported and some domestic cargoes and have increased to about $1.5 billion annually in recent years. The balance in the HMTF was $7.8 billion on September 30, 2014.

Aiding in the regulation of port security and maritime safety on a local level are Harbor Safety Committees, which were established under the Marine Transportation System initiative. Defined as a "local port coordinating body whose responsibilities include recommending actions to improve the safety and efficiency of a port or waterway," these Committees are comprised of local authorities, government agencies, industry organizations, and public interest groups. In addition, the Committees monitor environmental impacts of shipping and promote maritime situational awareness. Port authorities, vessel owners/operators, harbor pilots, and shipping agents are included in committee membership as well.[62]

4.1 The Inland Marine Transportation System (IMTS)

The USACE is responsible for operating and maintaining nearly 12,000 miles of navigable inland and intra-coastal waterways, and 13,000 miles of coastal harbors and channels, known collectively as the Inland Marine Transportation System (IMTS). The IMTS enables the annual movement of over 565 million tons of commodities worth over $180 billion. Over 57% of the tonnage is the movement of coal and coke and petroleum products. Commodities are typically transported for hundreds of miles and must traverse many of the almost 200 lock sites on the IMTS. In total, there are annually around 265 billion

System: A Framework for Action," July 2008) http://www.cmts.gov/downloads/MTS_Funding_Handbook_(Final).pdf.

[62] United States Coast Guard, "Harbor Safety Committee Desk Reference," U.S. Coast Guard Headquarters Waterways Management Directorate. pp:1-2, November 2006, http://www.sfmx.org/support/hsc/archivedocs/2006/hsc_desk_ref_110606.pdf.

ton-miles of commodities movements on the IMTS.[63]

Waterborne transport is an highly energy efficient way to move large quantities of bulk commodities such as grain, raw materials, coal and other energy products like crude and petroleum products, and tends to be less expensive on a cost per ton/mile than land or air-based transportation. For example 1 gallon of fuel for inland towing can carry 1 ton of cargo 576 miles, while 1 gallon of fuel for rail can carry 1 ton 413 miles, and 1 gallon of fuel for truck freight can carry 1 ton 155 miles. While water transportation is also attributed with taking a significant number of trucks from interstate roads, it is most effective when paired with rail and highway modes to accumulate and disperse commodities to end users. As with railroads, container and intermodal shipping is expected to grow with improved handling

4.2 Waterborne Transport of Petroleum

Inland barges were used to transport oil on Pennsylvania's Allegheny River as early as 1861 (Pees, 2004).[64] In the following decades, pipelines and rail tank cars overtook barges as the preferred method of moving oil. Even so, today, approximately 200 ports, including both ocean-going and inland waterway locations, handle movements of petroleum or petroleum products.

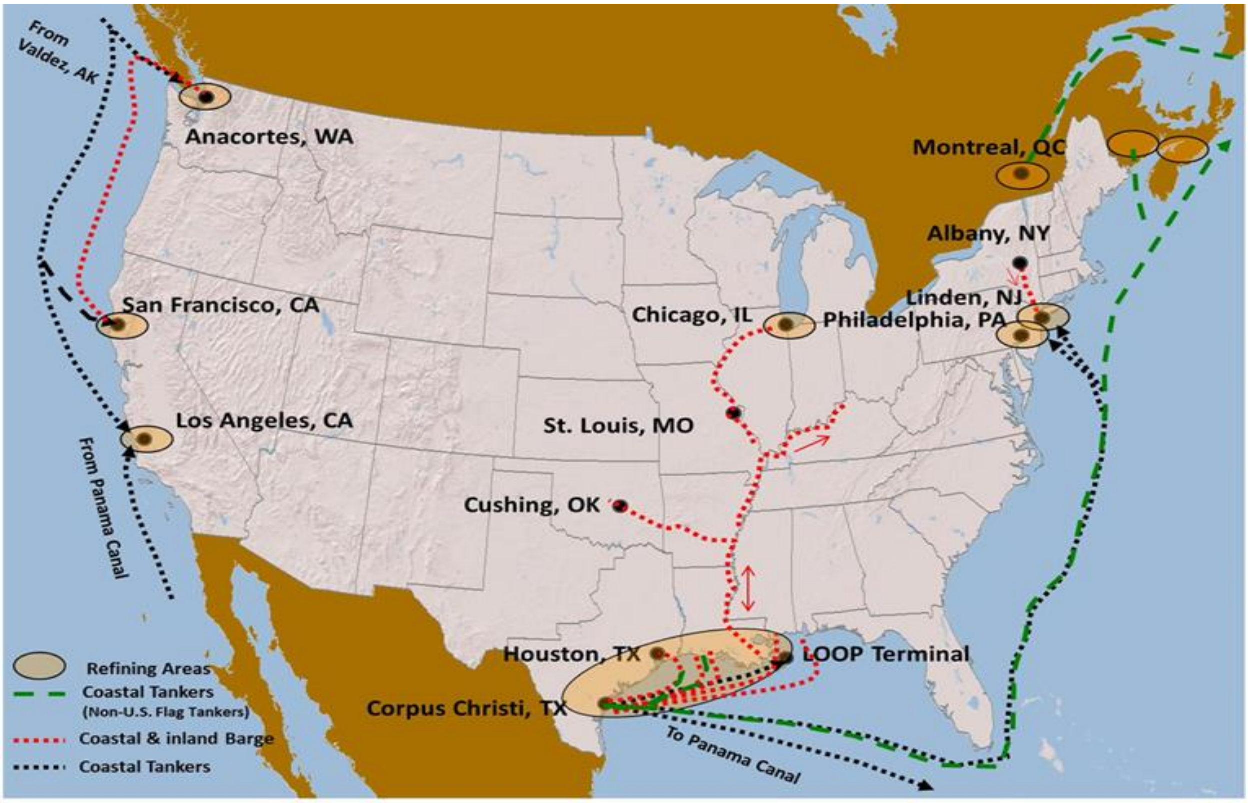

Figure 11. U.S. waterways for petroleum shipments.

Source: Intek/RBN Energy

[63] U.S. Army Corps of Engineers, Waterborne Commerce of the United States, Calendar Year 2012.
[64] Samuel Pees, "The First Oil Barges: Early Bulk Boats," Oil History, accessed August 1, 2014, http://www.petroleumhistory.org/OilHistory/pages/barges/Barges.html.

The declining trend is now reversing. Domestic shipments of crude by barge have increased significantly, from under 50 million barrels in 2010 to over 150 million in 2013, driven primarily by booming Bakken and Eagle Ford shale oil production. According to a BB&T Capital study authored by Kevin Sterling and cited by the Maritime Executive Magazine, "In less than two years, crude-by-barge pricing has increased three-fold and now nearly a third of the inland fleet is moving oil and about 15% of the coastal fleet is transporting crude." The study also states that, "Just a few years ago, crude-by-barge was essentially nonexistent and today it has become one of the largest commodities moved by the barge industry."[65]

With respect to crude moved by inland waterways, the main mechanism is intermodal in nature whereby railroads transfer oil to barges, typically for the last leg of the trip to refineries. Locations where railroads transfer crude oil to barges include St. Louis and Hayti, Missouri; Osceola, Arkansas; Hennepin, Illinois; Albany, New York; Yorktown, Virginia; and Anacortes, Washington. In addition, crude produced at Eagle Ford, TX, which is located near ports, is being moved along the Gulf Coast area by either barge or ship.[66] Tankers could also come in as the last leg of moving Bakken oil from the Gulf Coast up to Northeastern refineries after the oil has been railed to the Great Lakes ports. As EIA data show, U.S. refinery receipts of crude by barge, particularly domestic crude, have risen sharply in recent years.

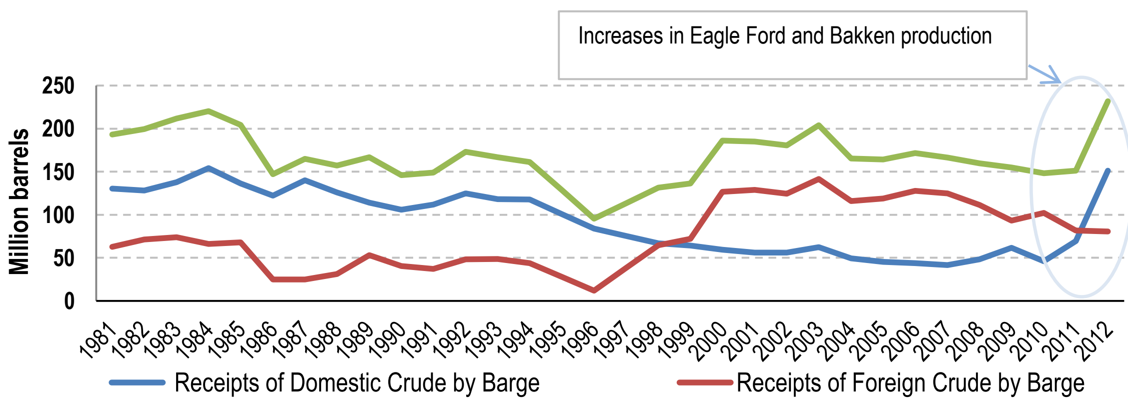

Figure 12. Fall and rise in U.S. refinery receipts of domestic, foreign, and total crude by barge (1981–2012).

Source: EIA.

[65] Jack O'Connell, "Crude-by-Barge: U.S. maritime cashes in on the shale oil boom - finally!" *The Maritime Executive*, October 15, 2013, http://www.maritime-executive.com/magazine/CrudebyBarge-2013-10-15.

[66] Congressional Research Service, *U.S. Rail Transportation of Crude Oil: Background and Issues for Congress*, May 5, 2014, http://fas.org/sgp/crs/misc/R43390.pdf

EIA data also show that domestic crude moved by tankers has been relatively flat, and foreign crude moved by tankers (at a much bigger volume compared to domestic crude) has declined in recent years.

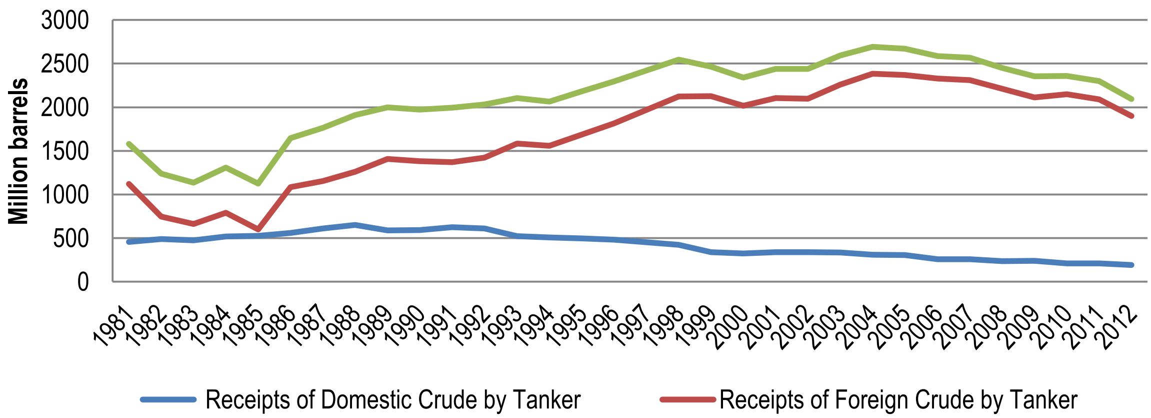

Figure 13. Trends in U.S. refinery receipts of domestic, foreign, and total crude by tanker (1981–2012).

Source: EIA.

In terms of capacity, one river barge can hold up to 30,000 barrels of oil, roughly equivalent to 45 rail tank cars. Two to three river barges are typically tied together in a single tow that carries 20,000 to 90,000 barrels, about the same load as a unit train. Coastal tank barges designed for open seas, known as articulated tug-barges, or ATBs, can hold 50,000 to 185,000 barrels, although newer ATBs can carry as much as 340,000 barrels, comparable to the capacity of coastal tankers. Crude oil tankers moving Alaska oil to West Coast refineries have capacities of 800,000 to over 1 million barrels.[67]

U.S. ports and the inland waterway system accounted for 311 million tons of crude and petroleum products.[68] Of that total, 81% was transported in barges on the inland waterway system, in the Great Lakes, from port to port along the coast, or in intra-port transfers.[69] Of the 79 million tons of domestically moved crude, 62% was carried by barges.[70] For all commodity groups transported in domestic or foreign commerce by any U.S. waters, regardless of vessel size, type, or type of facility, petroleum and petroleum products made up 42% of traffic in 2011.[71]

[67] Congressional Research Service, *U.S. Rail Transportation of Crude Oil: Background and Issues for Congress*
[68] Institute for Water Resources, U.S. Army Corps of Engineers (IWS, USACE), Navigation Data Center, Table 2-1, at 2-1; *also see* MARAD, "Marine Transportation System," Unlike the USACE, MARAD accounts for petroleum and petroleum product shipments on a fiscal year basis, and for FY 2012, the amount of crude handled by U.S. ports and waterways was 472.5 million tons, and the amount of petroleum products at 531.3 million tons. http://www.marad.dot.gov/ports_landing_page/marine_transportation_system/MTS.htm .
[69] Id., "Table 2-3: Domestic Barge Traffic by Type of Traffic and Commodity," at 2-8.
[70] IWR, USACE, "Table 2-3."
[71] IWR, USACE, "Waterborne Commerce of the United States, Calendar Year 2011, Part 5 – National Summaries," November 2012, Figure 2-2, at 2-13, http://www.navigationdatacenter.us/wcsc/pdf/wcusnatl11.pdf.

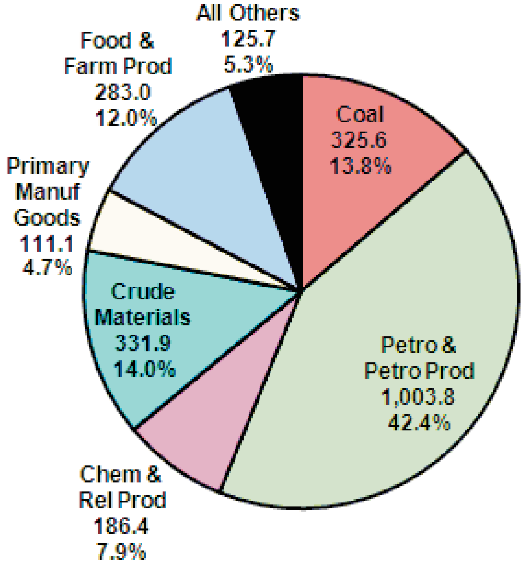

Figure 14. Shares of domestic and foreign generated commodities moved by U.S. waters (2011). [72]

According to IHS Global, direct capital investments flowing into marine transport will need to increase by 73% during 2014–2025, in part because rail transport of crude is believed to saturate around 2015–2016 under their "high" case scenario of their 2013 study.[73]

Table 2. Forecasted Investment in Marine and Common Infrastructure for Moving Hydrocarbons (2014–2025)

	Base Case	High Case	Difference
Crude Oil Marine	$6.7 billion	$11.5 billion	73%
NGL & LPG Marine	$3.0 billion	$4.0 billion	32%
Common Infrastructure	$48.0 billion	$51.5 billion	7%

Source: IHS (2013).

In terms of ports needed to handle the hydrocarbons, IHS groups these under a 'common infrastructure' category along with and roads. Ports and roads combined are projected to require about $50 billion of direct capital investments in 2014–2025. IHS envisioned the following specific waterways / ports for servicing regular to high volumes of the oil trade in the projected period: Delaware River, New York Harbor, Houston Ship Channel, the Port of Corpus Christi, and the inland waterway lock repairs

[72] Id.
[73] *Source:* IHS (Information Handling Services) Global Inc. 2013. Oil & Natural Gas Transportation & Storage Infrastructure: Status, Trends, & Economic Benefits. Report for the American Petroleum Institute. Washington, DC: IHS Global Inc. December. http://www.api.org/~/media/Files/Policy/SOAE-2014/API-Infrastructure-Investment-Study.pdf.

mentioned above. Terminals, storage and offloading facilities that make possible the transfer of oil from one mode of transportation to another are also important and are being built or expanded at a rapid pace.

4.3 Safety and environment

Waterborne shipments of crude have seen a similar surge as rail, and with it, an uptick in incidents where oil was released into waterways. However, unlike the relatively new phenomenon of rail transport of crude oil, barges and tankers and have been carrying crude in very high volume for decades, and many spill prevention and mitigation measures are in place already.

The Oil Pollution Act of 1990 was signed into law in the wake of the Exxon Valdez grounding, which spilled 11 million gallons of crude into Prince William Sound. It was the largest US oil spill at the time, and the law required companies to develop spill prevention, containment and cleanup plans, as well as $75 million in liability insurance for spills. It also phased in a requirement for double hulls.

Overall safety and environmental impact - including air emissions and spills - is also enhanced through the replacement of existing tugs and barges with larger and more efficient crafts; dredging of channels to reduce grounding; as well as improved vessel tracking through real-time GPS Tracking and improved waterways traffic management using AIS and electronic charting, reducing the chance of collision between vessels or with structures.

Figure 15 below shows that oil spills from tank barges has generally declined in the last twenty years, with a few exceptions where a single spill will account for the large majority of the volume spilled that year. Nearly all of the oil spilled in both 2005 and 2008 came from single collisions, while 2010 saw the lowest spill volume on record. Of the 90 spills recorded in 2013, over half were of one gallon or less, while 75% of the volume came from two incidents, one of which resulted in the temporary closure of the Mississippi River to traffic.[74] This indicates that despite the increased volume of crude-by-barge traffic, the risk of spills remains relatively low, while showing that a single incident can have a large impact.

[74] U.S. Coast Guard (USCG), American Waterways Operators Safety Report, July 30, 2014.

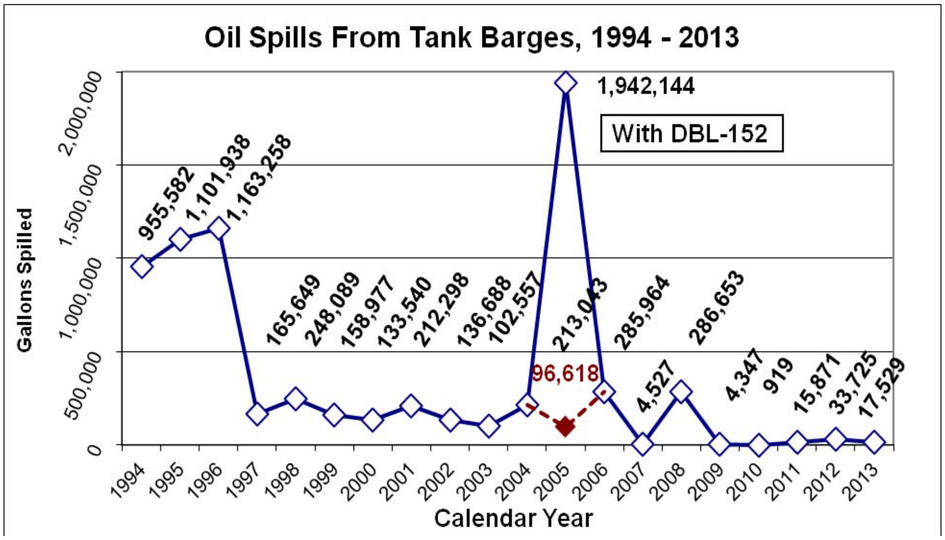

Figure 15. Oil spills from tank barges, 1994–2013.

4.5 Operations and maintenance issues, including costs, financing and policy

Inland waterways across the country suffer from age and rapidly growing reliability issues. The average age of USACE locks is 60 years. In 2010 the USACE completed baseline Operational Condition Assessments (OCA) on all assets associated with every IMTS lock site (e.g. locks, dams, buildings, utilities, etc). Despite the fact that that over 60% of the lock chambers on the IMTS are over 50 years old – and some are over 100 years old without appreciable rehabilitation – a large percentage of the mission critical components exhibit only normal wear and tear and perform as designed and expected. However, a few "high use" waterways, such as the Ohio and Illinois, are slightly below this average, and the Gulf Intracoastal Waterway is lower yet. Since 2002 there has been an approximately 50% increase in unavailability of USACE locks due to unscheduled *and* scheduled outages to repair failures of critical components, with an estimated direct economic impact on industry of $50-60 million annually (not including impacts on the commodity recipients). To enhance the reliability of the IMTS, the USACE is currently assessing the critical component failures and unscheduled outages and, using the detailed OCA condition information combined with risk analysis, prioritizing critical investment requirements for annual maintenance and other capital investments.

According to a 2013 report by the American Society of Civil Engineers (ASCE), while port terminals have received significant new investment and improvements, the connections to the ports or the navigation channels leading to the docks, as well as the landside connections, need to be brought to modern standards. Construction and rehabilitation costs for the inland waterways, including the locks, are shared between the federal government and users through the Inland Waterway Trust Fund (IWTF). Operations and maintenance costs for inland waterways are covered in full by the federal government.

ASCE estimates that the cost to upgrade U.S. port and waterways infrastructure to address the problems of aging and inadequate infrastructure to be over $30 billion[75] and that, by 2020, full investment of this $30 billion would protect $270 billion in exports, $697 billion in GDP, and 738,000 jobs.[76] At the current rate, according to the best-case scenario schedule developed by the USACE[77], the USACE's major planned inland water projects (new and rehab) will not be completed until 2090.

4.6 Ports

While the total number of vessel calls in ports has decreased, the average size of container ships has increased, largely in anticipation of the Panama Canal expansion project. Trade volume through ocean ports is expected to more than double between 2012 and 2021, and to double again shortly after 2030. Many very large vessels are in the planning stage and some Super Post Panamax[78] container vessels are being built, all of which require deeper navigation channels. However, in 2010, only five Atlantic ports and one Gulf port could accommodate moderately large vessels (more than 5,000 20-foot equivalent units).

According to the American Association of Port Authorities, U.S. ports and their private sector terminal partners plan to spend more than $46 billion over the next five years on port terminal facilities. While local investment makes up the majority of the funding for ports, the accommodation of large vessels requires dredging, paid for in large part by the federal government through the Harbor Maintenance Trust Fund.

5. Truck Transportation

Trucks are a critical element in U.S. freight transportation. In 2012, trucks accounted for 63% of the value of freight shipment in the United States, and 67% of the tonnage.[79] By both value and tonnage, most freight in the United States moves distances of less than 100 miles, and trucks account for more than 80% of both the value and weight of shipments less than 100 miles. At distances greater than 1,000 miles, trucks account for 40-50% of the value of shipments, and 20-30% of the tonnage.

Trucks are dependent on public road infrastructure. In the United States, roads are primarily built and maintained by State and Local Governments, with supplementary formula funding from the Federal Government. In 2010, governments spent roughly $100 billion on roads, along with operations and

[75] ASCE, "Anchoring the U.S. Economy," Infographic (relying on data in ASCE, "Failure to Act: The Economic Impact of Current Investment Trends in Airports, Inland Waterways, and Marine Ports," 2012), http://www.asce.org/uploadedImages/Infrastructure/Failure_to_Act/ASCE_SeaportWaterwayInfrastructurehires.jpg; http://www.asce.org/uploadedFiles/Infrastructure/Failure_to_Act/Failure%20To%20Act%20Ports%20Economic%20Report.pdf.
[76] Id.
[77] Estimates made prior to passage of the Water Resources Reform and Development Act of 2014 (WRRDA)
[78] http://maritime-connector.com/wiki/panamax/
[79] USDOT, *Freight Facts and Figures 2013*, http://www.ops.fhwa.dot.gov/freight/freight_analysis/nat_freight_stats/docs/13factsfigures/pdfs/fff2013_highres.pdf

maintenance expenditures of $48 billion.[80] In 2012 about 70% of funding was drawn from gasoline taxes, tolls, and vehicle taxes, with the remainder derived from other public revenues.[81]

The set of inter-city highways generally called the "Federal-aid highway system" make up roughly 25% of the road mileage in the U.S., but account for 85% of vehicle-miles traveled (VMT).[82] The Federal Highway Administration (FHWA) surveys and reports to Congress every three years on the conditions of the Federal-aid highway system, and provides estimates of the volume of road spending required to maintain system condition and performance.[83]

5.1 Trucks and Energy Transportation

The rapid growth in domestic crude production also brings a corresponding growth in the utilization of heavy duty trucks. However, freight reporting suggests that energy commodities still account for small fraction of both the value and tonnage of cargo moved by truck. There are three broad categories for which truck transportation is indispensable in energy: local fuel delivery, support for fuel production, and enhancing system reliability.

5.1.1 Local Delivery of Fuels

Virtually all retail gasoline and on-road diesel consumed in the United States is delivered from local storage depots to gas stations by truck. Similar arrangements are required for the delivery of home heating oil and propane. Many larger airports receive jet fuel by pipeline, but smaller airports and even some large airports receive delivery by truck. The typical round trip haul distance for local delivery is likely to be less than 100 miles, with volumes too small and destinations too diverse to justify other transportation modes. Alternative fuels, including ethanol, LNG, CNG, and hydrogen, would require a similar local distribution infrastructure.

5.1.2 Support for Fuels Production

Coal production: While large mines generally deliver their coal directly to rail cars, smaller mines often use local drayage, with coal being dumped into trucks and then hauled to rail terminals. Often, smaller coal consumers take delivery by truck. In 2012, reported coal deliveries were 245 million tons of coal, or about 24% of domestic production.[84]

Oil and Gas Drilling: Delivery of seismic survey and drilling crews, as well as very large volumes of fracking water, have required heavy utilization of trucks. Trucks are also used for short-haul drayage of crude oil from the wellhead to gathering pipelines or rail loading terminals for long-distance transport. In

[80] USDOT/FHWA, *Federal Highway Statistics, 2011*, Table HF-2 https://www.fhwa.dot.gov/policyinformation/statistics/2011/hf2.cfm
[81] Id. Table HF-10, https://www.fhwa.dot.gov/policyinformation/statistics/2012/hf10.cfm
[82] USDOT/FHWA, *2013 Status of the Nation's Highways, Bridges, and Transit: Conditions & Performance* (2014), http://www.fhwa.dot.gov/policy/2013cpr/overviews.htm#part1
[83] Id.
[84] Id.

North Dakota, well drilling has outstripped the development of gathering systems, leaving about 44% of Bakken production to be delivered to pipeline and rail terminals by truck.[85]

The rapid decline in production that is typical of shale wells also plays a role in that sizing gathering systems for brief periods of high rate production may be more costly than trucking the peak production while building a system for lower prolonged throughput. Similarly, some wells may have production rates too low to justify construction of any gathering system. In those cases, producing the oil into a stock tank and periodically retrieving it via truck is an approach to sustaining low volume wells.

A typical North Dakota Bakken Shale well requires some 2,000 truckloads of material – and Bakken drilling is running about 200 wells per month at present – adding to congestion of rural roads in North Dakota. Similar problems are being seen in Texas and other high production zones. Rural roads may not be designed to accommodate the volumes of heavy trucks required by shale drilling. Rural roads may often be on long replacement and repair cycles, based on the expectation that traffic levels would continue to be low, and state and local budgets must be adjusted to accommodate more frequent maintenance. Additionally, road design may not incorporate modern safety standards.

Biofuels Production: The density of biomass crops is relatively low, and they typically must be gathered up by truck from surrounding farms and delivered to a central plant or refinery for processing. Even biodiesel plants typically require collection of used cooking oil by a fleet of trucks.

5.1.3 Reliability Enhancement

Another benefit of having multiple transportation modes in general, and trucking in particular, is reliability enhancement. There are several parts of the United States that receive petroleum products largely from a single pipeline. When primary modes of energy transport are shut down, due to accident, weather, or even routine maintenance, trucks can often serve as a backup transportation mechanism. Though costly, the ability to mobilize large numbers of trucks reduces the impact of local or regional infrastructure outages, damping price shocks.

6. Key Questions for public input

Key questions raised for stakeholder input regarding rail, barge, and truck transport include:

1. What rail, highway, and waterway infrastructure modifications are needed to accommodate the shifts in the North American energy profile?
2. Is the current level of investment in these infrastructures – rail network, locks and dams, ports, highway and bridge – adequate to address trends in utilization out to 2030?
3. What are the key energy-related interdependencies between rail, waterway and highway infrastructures and that of other sectors?
4. What are the major threats to the resilience and reliability of this infrastructure, and what modifications are needed to make the system more resilient and reliable? Do existing policies present problems for maintaining and enhancing system resilience and reliability?

[85] Justin Kringstad, Presentation to Energy Development and Transmission Committee, North Dakota Pipeline Authority, 8 July 2014. https://ndpipelines.files.wordpress.com/2012/04/kringstad-edt-7-8-2014.pdf

5. Is the United States producing enough civil engineers, skilled tradesmen and other critical energy workforce to support a growing energy industry? What is the outlook for the rail, waterway, and trucking workforce supply and demand, generally?
6. How are factors such as rail flexibilities, pipeline permitting uncertainties, shale well production curves, flat and declining domestic energy demand, and shifts in contracts and investment strategies causing long-term changes in utilization of rail, trucks, and waterborne transport of energy?
7. What effect will increasing the use of rail and barges for oil transport have on other rail and barge energy and non-energy cargos and passenger travel?
8. Does increased oil-by-barge transport present new safety or environmental risks and, if so, how should these be addressed?
9. What is the appropriate role of local, state, and federal government entities in ensuring that changes to the rail, barge, and truck-related infrastructure for energy strike a balance between the wide range of private and public interests? What information could better inform policy decisions about this infrastructure?