TOPIC PAPER #12

INFRASTRUCTURE

On July 18, 2007, The National Petroleum Council (NPC) in approving its report, *Facing the Hard Truths about Energy,* also approved the making available of certain materials used in the study process, including detailed, specific subject matter papers prepared or used by the Task Groups and their Subgroups. These Topic Papers were working documents that were part of the analyses that led to development of the summary results presented in the report's Executive Summary and Chapters.

These Topic Papers represent the views and conclusions of the authors. The National Petroleum Council has not endorsed or approved the statements and conclusions contained in these documents but approved the publication of these materials as part of the study process.

The NPC believes that these papers will be of interest to the readers of the report and will help them better understand the results. These materials are being made available in the interest of transparency.

The attached Topic Paper is one of 38 such working document used in the study analyses. Also included is a roster of the Subgroup that developed or submitted this paper. Appendix E of the final NPC report provides a complete list of the 38 Topic Papers and an abstract for each. The printed final report volume contains a CD that includes pdf files of all papers. These papers also can be viewed and downloaded from the report section of the NPC website (www.npc.org).

NATIONAL PETROLEUM COUNCIL

INFRASTRUCTURE SUBGROUP OF THE SUPPLY TASK GROUP OF THE NPC COMMITTEE ON GLOBAL OIL AND GAS

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Supply Task Group

Infrastructure Cross Cutting Team

Team leader: Roger Smith
Date submitted: March 16, 2007

Executive Summary

Transportation infrastructure plays a vital role in delivering energy and other commodities from resource locations to manufacturing plants for processing and ultimately to demand centers for consumption. The transportation system as a whole is an immense network of pipelines, railways, waterways and roadways that has been in continuous development for the past two centuries. ("Rome was not built in one day") The system today is a highly complex, robust delivery network that operates in a safe, reliable manner and serves as the foundation for the country's economic growth.

Transportation infrastructure also contributes to a strong national defense system. The ability to transport military equipment and personnel, fuel, food, and other commodities in an efficient manner has long been recognized as a strategic priority. Since the establishment of the United States Army Corp of Engineers in 1802, the federal government has led national build outs of infrastructure at key points in the nation's history. In the early 1800's, the federal government began earnestly forming navigable waterways for both commercial and national defense purposes. The transcontinental railroad was developed using private capital, but made possible because, after the Civil War, it became a national priority to connect the nation by improving communication and the flow of commerce. During World War II the strategic importance of pipelines emerged as the federal government promoted the development of pipelines in order to ensure a reliable supply of crude oil and transportation fuels. After World War II, the nation embarked on the construction of an interstate highway system in order to improve national defense and strengthen the nation's economy. Clearly there is a strong historic relationship between transportation infrastructure and national security and economic prosperity. The nation may, once again, be at a point in time where the federal government needs to lead a national effort to build infrastructure.

The state of transportation infrastructure today is reaching a tipping point. Much of the existing capacity has been in place since the 1970s with little expansion since then. Despite limited growth in infrastructure, shipments of goods have increased substantially across all modes of transport. Industry has coped with this demand growth in several ways. Across all modes utilization rates have increased through improvements in operations and additions of motive power. Technological advances and asset rationalization have also led to greater utilization and productivity of the existing assets. While quantitative data that clearly supports the need to add capacity is not available, the general sense among industry professionals is that the continuous growth in transportation needs over the past twenty plus years is placing unprecedented demand on the system. The spare capacity and redundancies in the various infrastructure systems that existed 25 to 30 years ago are not there today. New capacity additions to the transportation system are required to allow for future economic growth and provide for national defense.

In 2002, over 19 billion tons of freight was delivered across the transportation system. Roughly one-third of the freight shipped in the United States by weight is made up of energy commodities – coal, natural gas, crude oil, and petroleum products. The tons of freight shipped are expected to grow 72% to nearly 33 billion tons by 2030; shipments of energy commodities are expected to total 11.4 billion tons by then. The main modes of transport for energy commodities are pipelines, tankers/barges, and railways. In addition, roadways are the primary delivery mechanism for transportation fuels from blending facilities to consumer filling stations.

Determining the total requirements for new infrastructure over the forecast period to 2030 is difficult to assess with any certainty. Energy supply and demand forecasts do not account for infrastructure requirements in their models. Models of future demand/supply typically assume transportation infrastructure will be built if it is economically viable to do so. In other words, these forecasts have no built in constraints around the ability, or lack there of, to finance, permit and build the infrastructure required to support the model's predicted outcomes.

These models also tend to be developed at a national or global level, the results of which do not allow for accurate evaluations of future infrastructure needs. For example, most models predict the need for the United States to increase imports of natural gas by 2030. However, the models do not provide any detail as to where the new imports come from. New natural gas imports from Canada have very different infrastructure requirements compared to new imports from liquefied natural gas. Without these sorts of distinctions it is not possible to adequately assess infrastructure requirements.

On global level, energy markets rely heavily on the availability of a few international routes. In 2000, about 35 million barrels of petroleum liquids were transported across international boundaries every day. Over 70% of these global petroleum liquids pass through either The Strait of Hormuz or the Straits of Malacca. Other important passages are the Bosporus, the Bab el-Mandab, Russian pipelines and Suez Canal/Sumed pipeline. Global liquids trade is projected to grow 57% to about 55 mmbpd by 2030. These routes are vulnerable to blockades or other geopolitical events that could severely impact delivery of energy supplies.

Energy transportation infrastructure needs to become a national priority to ensure economic prosperity and national security. The federal government should consider expanding funding of data collection and analysis of energy transportation systems to enable informed transportation policy decisions. The federal government should lead a nationally coordinated permitting process for pipelines and other critical infrastructure in a similar manner as the EPA 2005 envisioned for electric transmission lines. Doing so would improve the timely development of needed infrastructure. The federal government should reconsider the balance of public funding of infrastructure to encourage the transport of commodities on the most economically efficient mode of transport.

The federal government should also consider means to reduce reliance on delivery of foreign petroleum liquids that pass through choke points. The government should continue to protect international sea lanes and promote the development of alternative routes of transport. The government should encourage domestic development of energy resources to reduce dependence on foreign supplies. These steps will improve the reliability of the nation's energy transportation infrastructure and foster national and economic security.

Infrastructure

1. Scope of Work

Recognizing the broad and vague nature of the term infrastructure, the team quickly defined and narrowed the boundaries of the study to transportation infrastructure. That is primarily liquid and gas pipelines, waterways, railways, roadways and associated ports and terminals. The team focused on the transport of specific energy commodities: crude oil, natural gas, coal and refined petroleum liquids. The team did not evaluate the adequacy of electric transmission systems. Because the overall NPC study is focused on implications for the United States, the infrastructure team mainly considered North American energy transportation infrastructure.

In addition, the team considered international choke points that have direct implications on energy supplies to the United States. The international choke points section focused on pipelines and sea lanes. Since liquefied natural gas and its associated infrastructure resides within a separate cross cutting team, the Infrastructure team mainly focused on the flow of crude oil and petroleum liquids. We further focused primarily on the physical constraints of these bottlenecks even though the team recognized that geopolitics tends to play a significant factor.

Our goals for this infrastructure review were three fold:

- Determine the current state of infrastructure and identify existing constraints, barriers and vulnerabilities
- Based on the range of supply/demand forecasts, evaluate the adequacy of the existing infrastructure and estimate additional requirements
- Propose policy recommendations for the United States to mitigate any identified issues.

2. Overview of Methodology

A core team was formed with each member responsible for a separate mode of transport. The Infrastructure cross cutting team comprised of the following individuals:

Harry Homan	Fluor Corporation
Eric von Moltke	Fluor Corporation
Francis Pilley	TransCanada

Craig Rockey	Association of American Railroads
Douglas Sheffler	The American Waterways Operators
Roger Smith	Fluor Corporation
Tianjia Tang	U.S. Department of Transportation
Cheryl Trench	Allegro Energy Consulting
Kristen Walsh	Anadarko

The team adhered closely to the principle that we were not attempting to create a new study. Therefore the team's methodology consisted of collecting data from two primary pathways. The first path consisted of a data survey template that was sent to a wide range of constituents requesting their forecast for energy transport as well as asking qualitative questions related to the infrastructure assumptions built into their supply and demand forecasts. The second path consisted of collecting and reviewing existing transportation studies that forecast future transportation needs.

The team supplemented the studies by conducting informal consultations with government, association and industry professionals across the various modes of transport. In all, the team collected over 130 studies and talked to approximately 30 organizations in total. From these reports and discussions with industry professionals, the team developed findings and proposed policy recommendations. Many of the industry professionals acted as reviewers of our findings.

Organizations the team contacted:

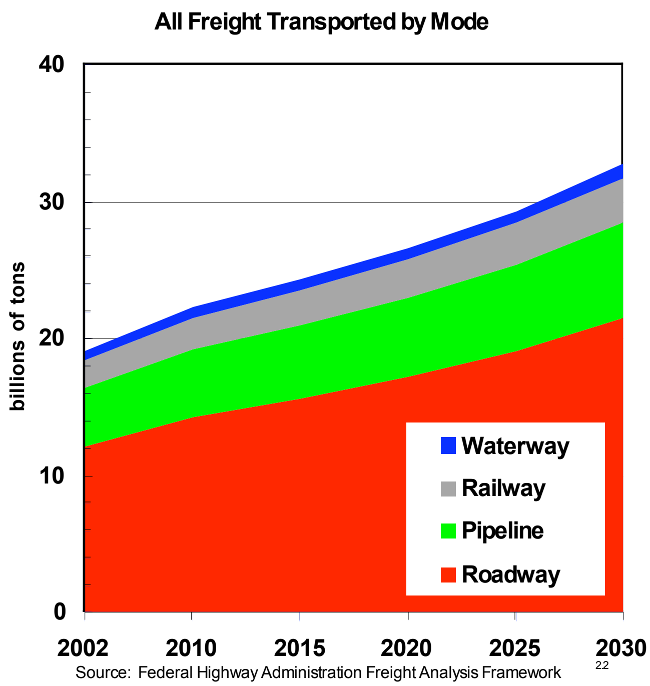
General	DOT	Department of Transportation
	BTS	Bureau of Transportation Statistics
	AASHTO	American Association of State Highway and Transportation Officials
	TRB	Transportation Research Board
Pipelines	DOE	Department of Energy
	EIA	Energy Information Agency
	FERC	Federal Energy Regulatory Commission
	OPS	Office of Pipeline Safety
	AOPL	Association of Oil Pipe Lines
	INGAA	Interstate Natural Gas Association of America
	AGA	American Gas Association
	AGF	American Gas Foundation
	PFC	PFC Energy
		Wood Mackenzie
	CERA	Cambridge Energy Research Associates
	PIRA	PIRA Energy Group
		Allegro Energy
Waterways	AAPA	American Association of Port Authorities

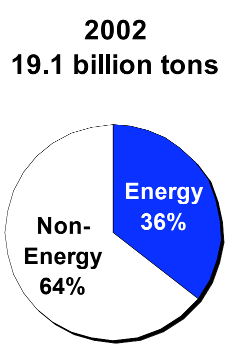
	AWO	American Waterways Operators
	IRPT	Inland Rivers Ports & Terminals
	MARAD	Maritime Administration
	USACE-IWR	United States Army Corp of Engineers – Institute of Water Resources
Railways	AAR	American Association of Railroads
	FRA	Federal Railroad Administration
	STB	Surface Transportation Board
	BNSF	Burlington Northern Santa Fe
Roadways	FHWA	Federal Highway Administration
	ATA	American Trucking Association

2. Background

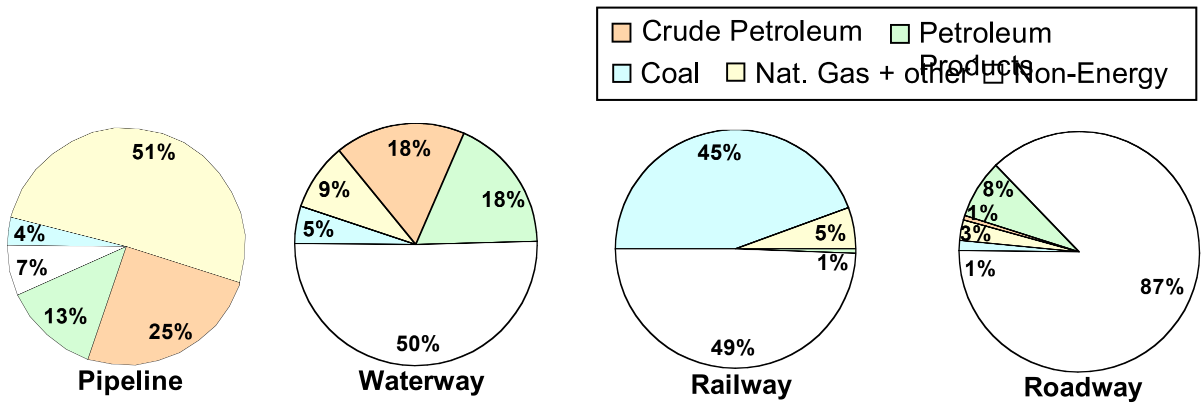
Transportation infrastructure within North America is a highly complex, integrated system made up of six major modes of transport: air, pipelines, rails, roads, waterways and wires. For the purposes of this study, air transport and electric transmission were not evaluated since energy commodities typically are not transported by aircraft and electricity delivery was determined to be out of scope for this portion of the study. The system the team evaluated represents the bulk of the freight transportation system and is composed of over 500,000 miles of pipe; 140,000 miles of Class I railroad; 12,000 miles of navigable waterways; over 9,000 ports and terminals; and 45,000 miles of interstate highways. While each mode has many independent private actors regulated by different state and federal agencies, they all work together to deliver freight from their point of origin to their destination in a safe and reliable manner.

The chart to the right provides an overall picture of U.S. freight transportation. It indicates that 19.1 billion tons of freight was shipped in 2002 and projects the total freight shipments will approach 33 billion tons by 2030. The main mode of transport is roadways which accounted for 63.5% of all the tons shipped in 2002. This percentage share is projected to increase to 65.6% by 2030; indicating a shift towards roadway shipments and away from pipelines and waterways. While a 2% shift may seem small, by 2030 it equates to an additional 700 million tons of freight shipped on roadways than otherwise would be shipped by another mode if roadways maintained its 2002 share. To put that value in perspective, 700 million tons of freight on roadways works out to be 70,000 to 150,000 more trucks per day.





This study focused on the transportation of crude oil, natural gas, coal and refined petroleum liquids. According to the FHWA FAF[2.2], energy commodities make up 36% of all the tons shipped across all modes of transport. These commodities are typically transported by pipeline, waterways, railways and roadways. While pipelines tend to ship dedicated commodities the other modes of transport are shared with a multitude of other goods. The following pie charts indicate for each mode of transport the percentage of tons shipped in 2002 by commodity.



A Note about Transportation Forecasts

The team set out to find forecasts of transportation demand and estimates of future capacity additions. After extensive research, the team concluded that very few forecasts exist that actually project future transportation needs or estimate future capital expenditures out to 2030. There are no such forecasts for liquid pipelines, railways or waterways. The team held discussions with industry participants and industry associations for these modes of transport and found the following:

- forecasting typically performed only by individual companies;
- only for their own infrastructure;
- they only forecast 2-3 years;
- and forecasts are not public information

There are proprietary models for gas pipelines developed by energy consultants. The NPC used EEA's natural gas model in their Balancing Natural Gas Policy study released in 2003. The infrastructure team used the NPC study on natural gas as a starting point for evaluating natural gas pipelines.

The only publicly available integrated transportation model identified by the team is the Federal Highway Administration's Freight Analysis Framework (FAF). This model forecasts US freight flows for 43 commodities across seven modes of transport in five year intervals out to 2035. While the FAF model is useful in estimating aggregated flows for transportation modes, it has limitations especially for energy commodities. Please see the separate note on the FAF.

As expected pipelines transport mainly energy commodities. Roughly 93% of the tons transported through pipelines were energy commodities. About half the tons were natural gas[1], about one quarter of the tons were crude petroleum, followed by 13% petroleum products and 4% coal slurries. The 7% non-energy commodities were primarily carbon dioxide and ammonia.

The tons shipped on waterways and railways consist of about half energy commodities and half non-energy commodities. Coal represents the main energy commodity shipped on the railways, while the waterways are balanced across the four energy commodities. The non-energy commodities shipped on the waterways are primarily bulk goods such as grain, aggregates, chemicals, fertilizers and metals. Railways transport similar non-energy commodities as waterways, however, the transport of intermodal containers are growing in importance for railways. Only 13% of the tons shipped on roadways are energy commodities. The bulk of which are petroleum products being shipped to end users and filling stations for retail consumption.

Each mode of transport has different characteristics that make them unique and provide certain advantages over other modes of transport. The types of characteristics include public ownership/involvement, cost of service, speed of delivery, flexibility, shared with people, multi-commodity, cost to add capacity and environmental footprint. Roadways and waterways are publicly owned infrastructure, while railways and pipelines are privately owned.

The current transportation system has been continuously in development for the past two centuries. The development of the transportation network occurred through both public and private leadership and funding. With the establishment of the Corp of Engineers in 1802, the federal government began earnestly forming navigable waterways for both commercial and national defense purposes. The transcontinental railroad was developed using private capital, but made possible because, after the Civil War it became a national priority to connect the nation by improving communication and the flow of commerce. From the 1930s through the 1950s the majority of the nation's pipeline systems were constructed. During World War II the strategic importance of pipelines emerged as the federal government promoted the development of pipelines in order to ensure a reliable supply of crude oil and transportation fuels. After World War II, the nation embarked on the construction of an interstate highway system in order to improve national defense and strengthen the nation's economy. Clearly there is a strong historic relationship between transportation infrastructure and national security and economic prosperity.

[1] The FAF model uses 43 categories of commodities; five of which are energy commodities: coal, crude petroleum, gasoline, fuel oil, and coal and petroleum products plus not elsewhere classified. The last category is often abbreviated as coal + n.e.c. In aggregate, the coal + n.e.c. category is about 80% natural gas; therefore, for this report the category is renamed natural gas + other. Also, for this report gasoline and fuel oil are combined and renamed petroleum products.

Freight Analysis Framework

The Freight Analysis Framework (FAF) is a model of freight transportation developed by the Federal Highway Administration. It models the origin and destination of freight throughout the United States for 114 nodes, 43 commodities and 7 modes of transport. The model approximates the flows via actual routes by modeling 114 demand centers across the United States. It also estimates the flow of commodities across borders with Canada and Mexico as well as waterborne imports and exports. The model output estimates the tons shipped by mode and by commodity for each origin and destination in 5 year increments from 2010 to 2035.

The FAF model relies on actual 2002 transport data to forecast future commodity flows. The actual data is collected from the Commodity Flow Survey produced by the US Department of Commerce, Census Bureau, BTS, DOT and Foreign Waterborne Cargo data developed by the US Army Corp of Engineers as well as several other sources. Future data projections are based on Global Insight's proprietary regional economic and freight modeling packages.

The FAF is the only model that integrates the flow of commodities and transport modes. Most other models only forecast aggregate commodity flows for one mode of transport or one commodity flow across all modes of transport.

The primary purpose of the FAF model is to estimate freight flows on highways and roads. Other modes are modeled to account for the impact of freight movements on the roadways. The primary data source, the 2002 Commodity Flow Survey (CFS) does not include shipments of crude oil or natural gas; these are out of scope commodities for the CFS. Furthermore, significant discrepancies exist between the CFS and other published sources for petroleum products. FHWA supplemented data from EIA, US ACE, AOPL and other data sources to estimate flows of crude oil and natural gas. Modeling of commodity flows through pipelines are not well understood and therefore combined with commodities shipped by "unknown" forms of transport. Because of these data deficiencies results from the FAF model for energy commodities may be suspect and drawing any definitive conclusions solely from FAF data may be inappropriate.

For further information about the Freight Analysis Framework visit the FHWA's website at http://ops.fhwa.dot.gov/freight/freight_analysis/faf/index.htm.

3. Preliminary Observations

3.1 Energy supply and demand forecasts do not account for energy infrastructure requirements

As part of the supply/demand survey template sent to International Oil Companies, National Oil Companies and other organizations, the Infrastructure Cross Cutting Team included a template requesting forecasts for petroleum liquids, natural gas and coal trade movements across geographic regions. In addition, the template included several qualitative questions regarding assumptions about infrastructure in their energy supply and demand forecasts. The infrastructure data templates were not completed by any of the data suppliers. The team believes that energy transport forecasts are not performed as part of supply/demand forecasts.

The qualitative feedback thus far indicates that most entities do not account for energy infrastructure requirements in their forecasts. The general assumption among forecasters is that infrastructure will be built when needed. Their models are not constrained by infrastructure bottlenecks or by delays in expanding infrastructure due to permitting, construction costs or resource limitations. Typical responses to questions about infrastructure include:[2]

"No bottlenecks assumed."
"Not considered."
"No regulatory obstacles are assumed to impact liquids supply"
"No specific constraints beyond 'normal'"

The survey also inquired about new sources of supply (e.g., new discoveries) and the availability of known resources that are currently inaccessible (e.g., ANWR) which might require significant new infrastructure to bring supply to market. Many forecasts do not factor in the potential for new discoveries and the ones that do consider new discoveries only do so in a general context. Therefore, it is not possible to evaluate the infrastructure requirements associated with potential new discoveries.

Many forecasts do not consider the availability of known resources that are currently inaccessible. The assumption is made that regulatory or other barriers that prevent the accessibility of the resources today will remain in place throughout the forecast period. The one common exception is ANWR. Several responses identified access to ANWR as

[2] Following quotes come from qualitative data collected from proprietary data surveys.

an assumption in their supply forecast, however, specific on-stream dates were not provided.

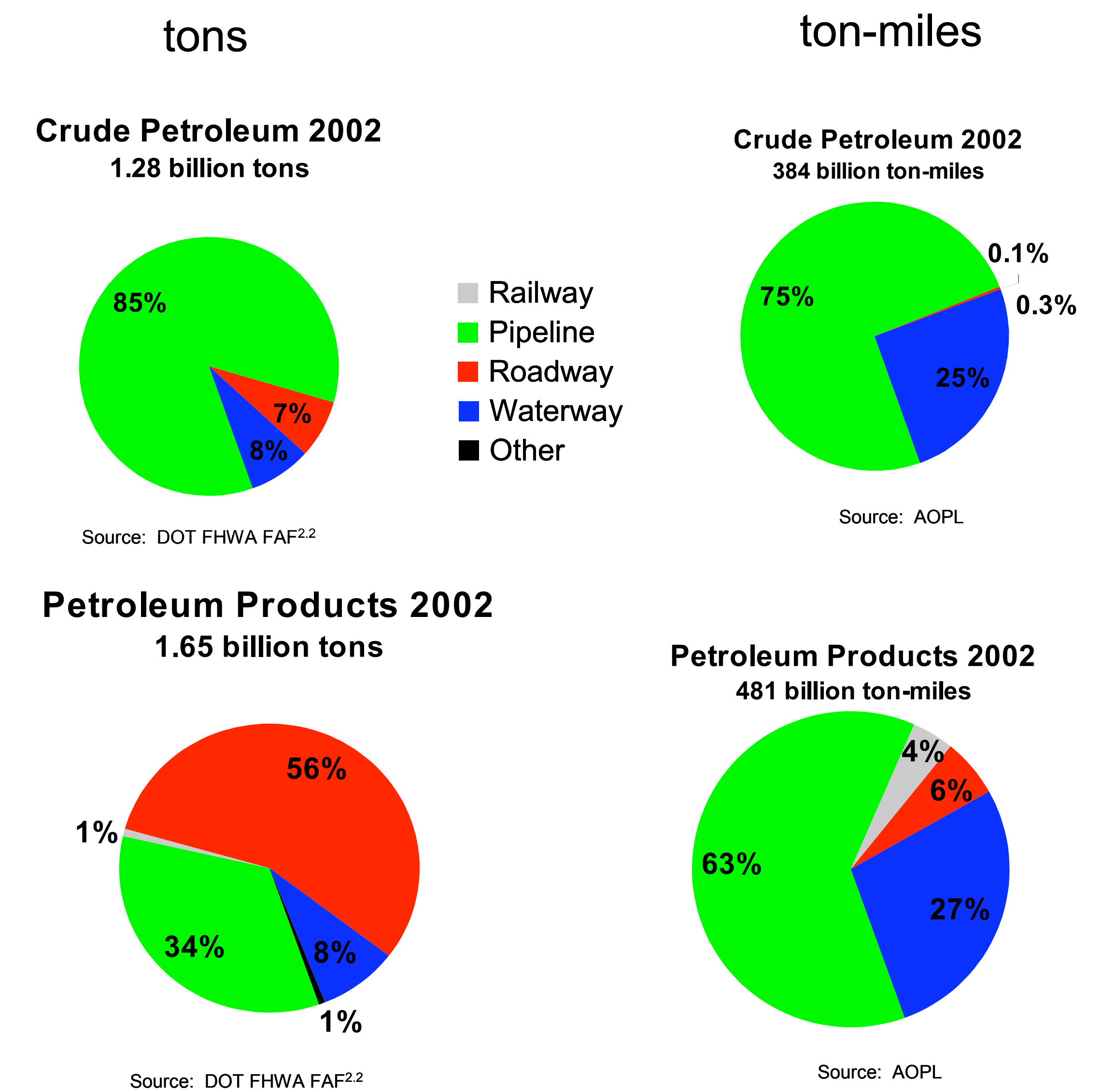
Most of the available forecasts are developed at a national or international level making it difficult to forecast impacts on existing infrastructure systems. In order to understand the impacts of future energy demand on infrastructure, the team required forecasts of energy flows through the pipes, waterways and on the railways and roadways. The best forecasts provide national supply and demand forecasts which only enable us to determine net imports or exports from a particular country. While that data is useful, it alone does not lend itself to evaluating infrastructure requirements within a country. Furthermore, forecasts provide little understanding of where net exporting countries send their products to or where net importers receive their products from.

Based on the lack of data and qualitative feedback from the surveys, it seems that most energy supply/demand forecasters make implicit assumptions around the continued future availability of transportation infrastructure. These assumptions may lead to optimistic timelines for bringing on new energy supplies and may lead to inaccurate forecasts of the energy mix.

3.2 Data not available to estimate future infrastructure requirements

The team spent several months collecting and reviewing reports as well as communicating with industry professionals with the purpose of identifying future infrastructure needs. Estimates of future transportation infrastructure requirements are not available. The availability of historical data ranged widely depending on the mode of transport. Generally speaking, the more public the mode of transport the more likely data was publicly available. For instance, historical data for liquid pipelines is very limited and data for roadways is extensive. The team contacted multiple agencies, associations and consultancies none of which had any data on liquid pipeline capacity or forecasts of future liquid pipeline requirements. Available data for public infrastructure such as roads and waterways consisted mainly of historical data.

The Problem of Defining Capacity
One of the difficulties in evaluating the adequacy of transportation infrastructure is the problem of defining capacity. According to the Transportation Research Board there is no generally accepted measure or even definition of system capacity in transportation. One reason is that transportation has many characteristics like the rate of flow, the distance traveled, the time of travel, reliability of delivery and the origin – destination. Further complicating the problem is constituents place differing values on each of the characteristics.



While defining transportation capacity is problematic; ton-miles is the primary physical measure of freight transportation. A ton-mile is the movement of a ton of freight the distance of one mile. According to the Bureau of Transportation Statistics (BTS) ton-miles is the single best measure of the overall demand for transportation infrastructure because it allows for the measure of infrastructure utilization.[3]

The above pie charts illustrate the importance of using the right units of measure in evaluating infrastructure needs. The charts on the left indicate the distribution by mode of crude petroleum and petroleum products measured in tons. The delivery mix measured in tons shows that crude is primarily shipped by pipeline (no surprise) and waterways and roadways have equally small single digit shares. The delivery mix measured in tons for petroleum products shows one-third of the tons were shipped by pipeline and 56% were

[3] Improvements in BTS Estimation of Ton-Miles, Working Paper 2004-002-OAS, Bureau of Transportation Statistics, Issued August 2004, p. 1

shipped by truck. The large percentage for trucks seems reasonable considering the large volumes that are delivered to a filling station. It would seem roads are, perhaps, the most important delivery mode for refined fuels.

However, when analyzing the data using ton-miles different conclusions are drawn. As shown in the upper right pie chart, pipelines are still the dominant mode of transport for crude oil but waterways are shown to play a much more prominent role while the contribution of roadways nearly disappears. The affect on petroleum products is much more significant. Using ton-miles as the measure, the lower right pie chart shows that pipelines and waterways provide for the bulk of petroleum product deliveries while roads play, albeit vital, but much smaller role.

The fundamental problem is that ton-miles are not systematically measured and collected for most commodities and modes of transport. "There does not presently appear to be any complete, reliable estimate of this basic transportation measure"[4] There are databases on commodity and movements by truck, rail, waterway and air. Each database delineates a few features of the transportation system and provides a glimpse of reality, but it is very difficult to assemble a complete and comprehensive picture of the freight system from these databases without a major investment of time and effort.[5] Furthermore, no forecasts of ton-miles exist by commodity or by mode. This basic lack of understanding of future freight flows limits the industry's ability to identify infrastructure needs. It also hinders the ability for government to develop effective policy options.

3.3 Energy infrastructure investments are not keeping pace with infrastructure demands

The state of transportation infrastructure today is reaching a tipping point. Much of the existing capacity has been in place since the 1970s with little expansion since then. Despite limited growth in infrastructure, shipments of goods have increased substantially across all modes of transport. The infrastructure has coped with this demand growth in several ways. Over the past two decades industry participants have taken up slack capacity, improved utilization, added motive power such as compressors, pumps, locomotives and tugs. In addition, technological and operational improvements have led to greater utilization and productivity of the existing asset base. While quantitative data that clearly supports the need to add capacity is not available (see section 3.2), the general sense among industry professionals is that the continuous growth in transportation needs over the past twenty plus years is placing unprecedented demand on the system.[6] The spare capacity and redundancies in the various infrastructure systems that existed 25 to 30 years ago are not there today. New capacity additions to the transportation system are believed to be necessary to allow for economic growth. Without new expansion, increased supply disruptions and greater price volatility for energy commodities are likely.

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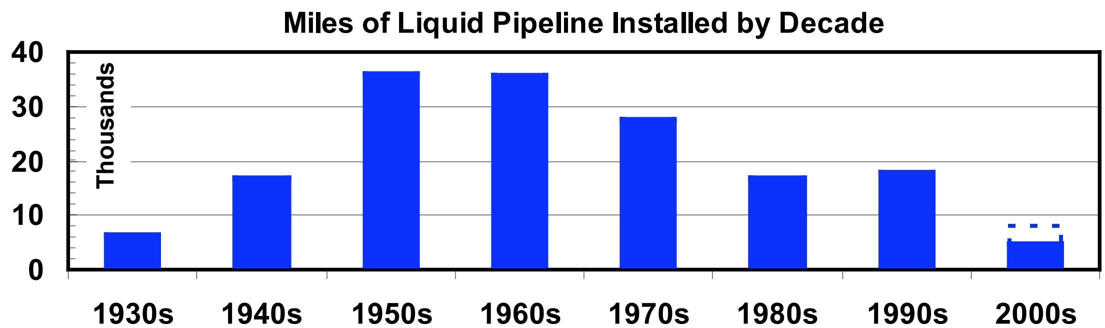
[4] Improvements in BTS Estimation of Ton-Miles, Working Paper 2004-002-OAS, Bureau of Transportation Statistics, Issued August 2004, p. 2

[5] Transportation Policy: Evolution of Federal Freight Transportation Policy, Cambridge Systematics, p. 14

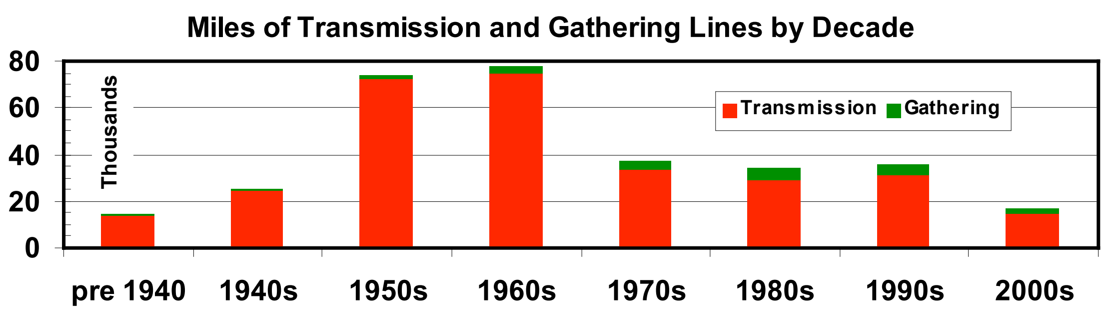
[6] Freight Capacity for the 21st Century, Transportation Research Board, Special Report 271, 2003, p. 2

In 2002, over 19 billion tons of freight was delivered across the transportation system. Roughly one-third of the freight shipped in the United States by weight is made up of energy commodities – coal, natural gas, crude oil, and petroleum products. The tons of freight shipped are expected to grow 72% to nearly 33 billion tons by 2030; shipments of energy commodities are expected to total 11.4 billion tons by then. The main modes of transport for energy commodities are pipelines, tankers/barges, and railways. In addition, roadways are the primary delivery mechanism for transportation fuels from blending facilities to consumer filling stations. The bulk of the nation's transportation infrastructure was built in the 1950s, 60s and 70s.

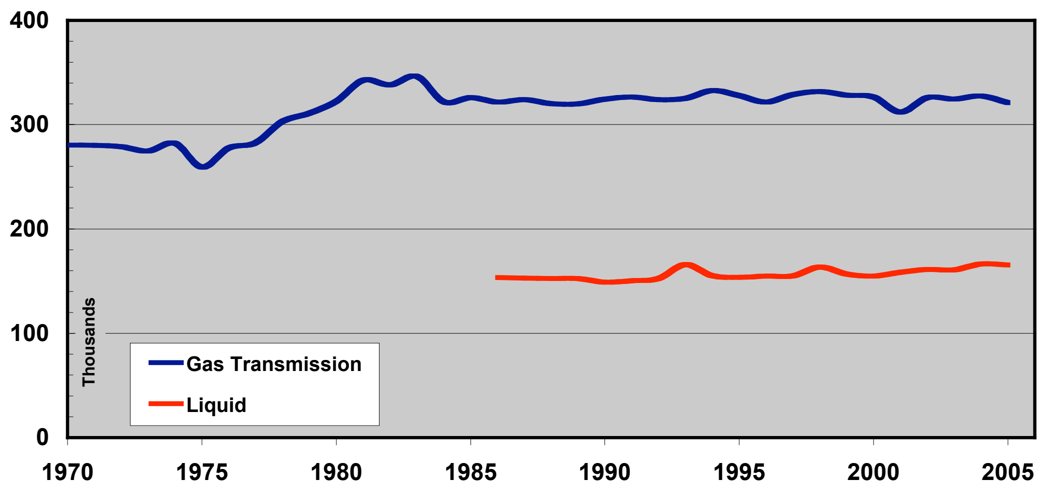
The following sets of charts illustrate the lack of investment in transportation over the past 25 years. The first two bar charts show the miles of pipeline installed by decade for liquid and gas pipelines, respectively. In both cases, roughly 60-65% of the pipeline infrastructure was installed between 1950 and 1980.



Source: PHMSA Office of Pipeline Safety, Pipeline Statistical Datasets (ops.dot.gov/stats/stats.htm)

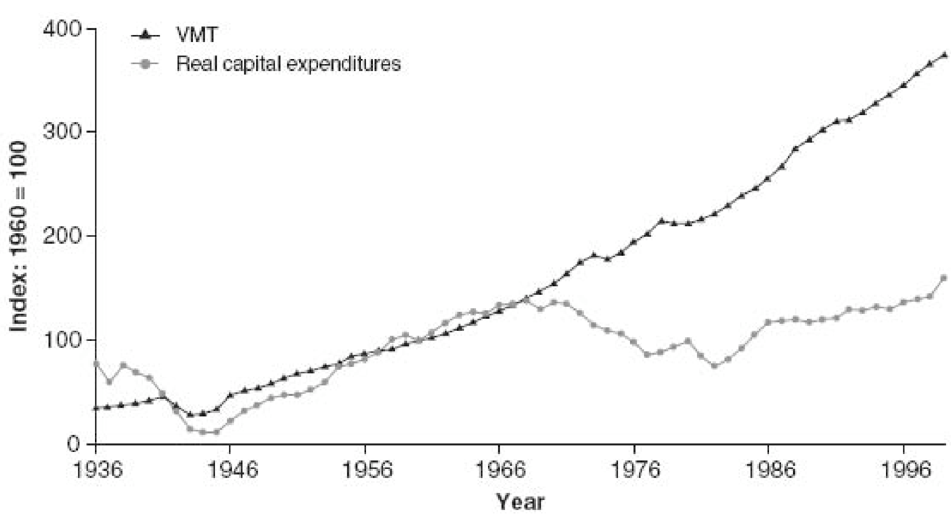


The next chart shows the growth of installed miles of natural gas transmission and liquid pipelines from 1970 to 2005. The chart illustrates the lack of growth in US pipeline systems over the past 20 years.

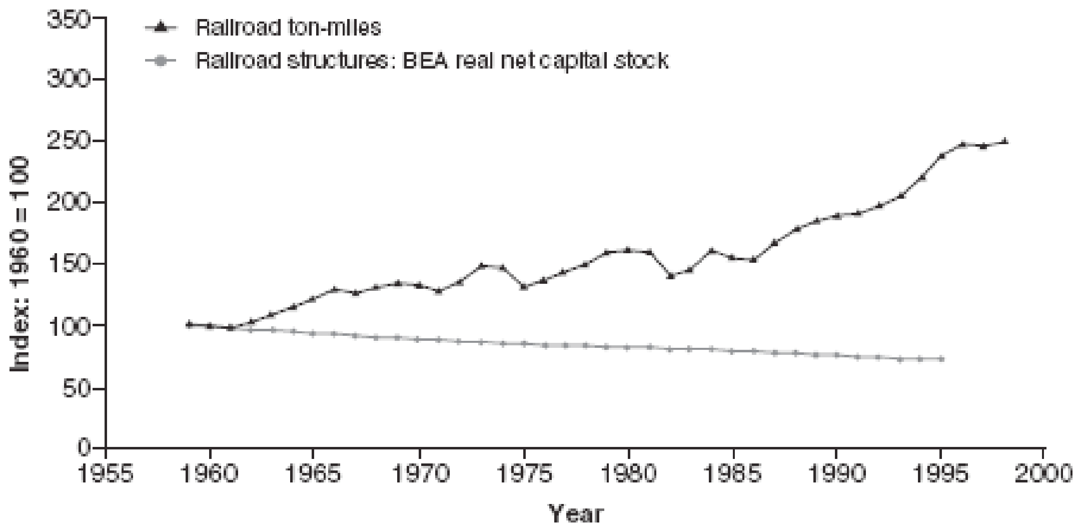


PIPELINES (Source: PHMSA Office of Pipeline Safety, Pipeline Statistical Datasets)

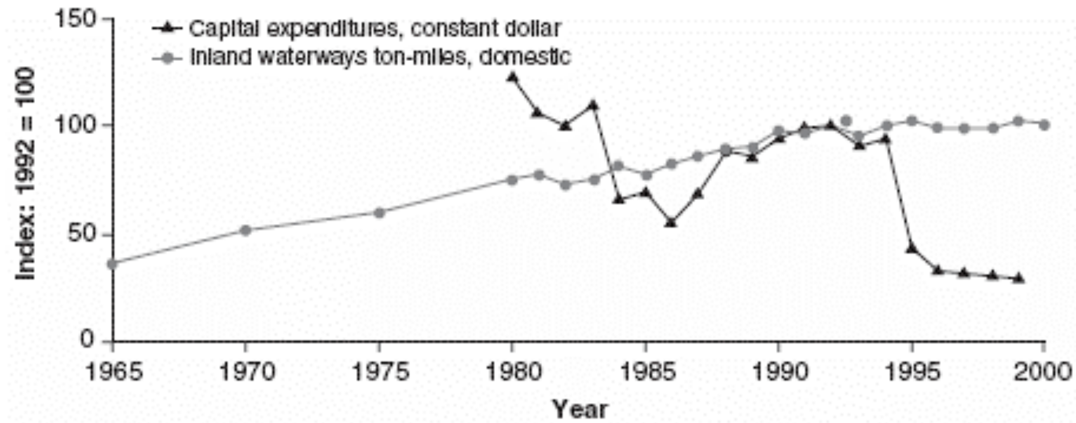
The other modes of transport have similar stories. The following charts show for each mode of transport the usage of infrastructure has outpaced the investment in the infrastructure over the past two to three decades. Capital expenditures for roadways are shown to drop off starting in 1970 while vehicle miles traveled continue to grow; the asset base for railroads has been shrinking since the 1960s while freight shipments have grown steadily; and capital expenditures in waterways have not kept pace with demand since 1995. The one exception is ports; recent investments for ports has occurred to support increased container traffic.



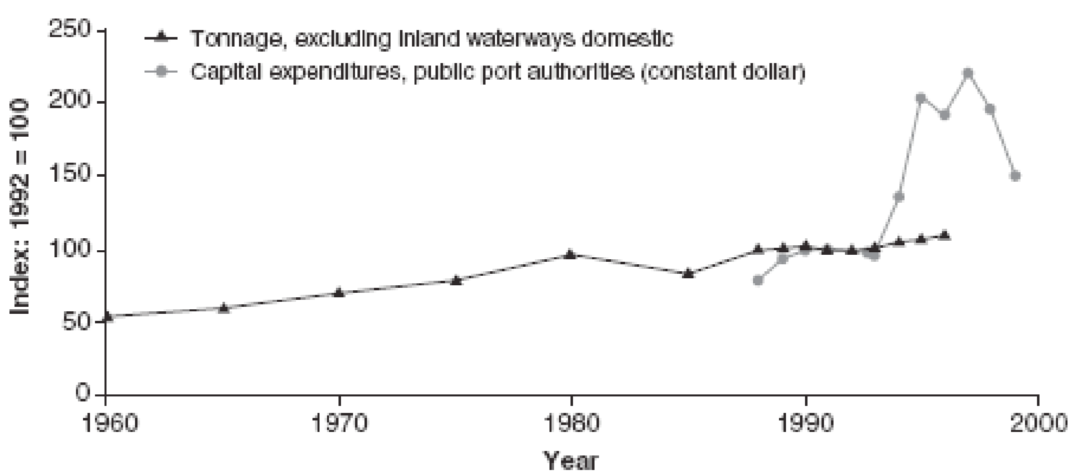
ROADWAYS (Source: Freight Capacity for the 21st Century, p. 53)



RAILROADS (Source: Freight Capacity for the 21st Century, p. 60)

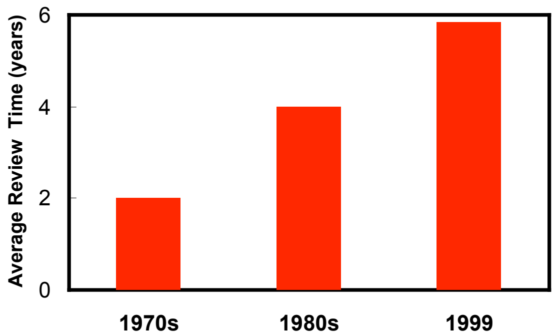


WATERWAYS (Source: Freight Capacity for the 21st Century, p. 72)



PORTS (Source: Freight Capacity for the 21st Century, p.67)

The most prevalent cause of limited infrastructure expansion is the difficult permitting processes required to implement a project. This is particularly true for infrastructure projects that cross multiple states. For such a project it is not uncommon to have to seek over a dozen permits from several federal agencies, multiple states, counties and local entities. Each agency has its own permitting process and its own time table. The chart below is illustrative of the problem. It shows the length of time to review a permit from the DOT for highway transit projects for different points in time.



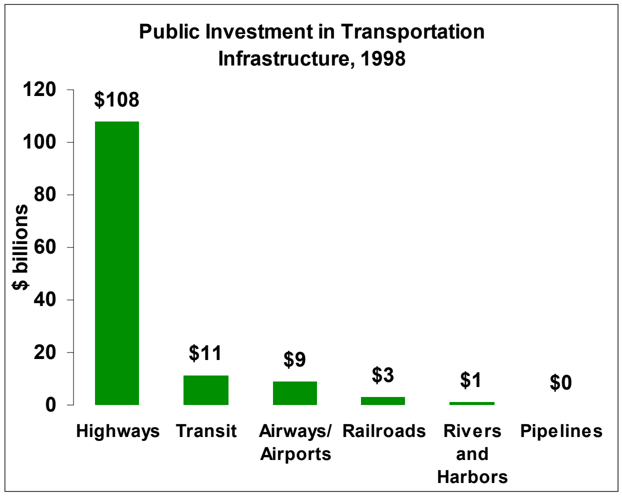
The average length of review time was 2 years in the 1970s, 4 years in the 1980s and nearly 6 years in 1999.[7] The added review time impacts the economic viability of new infrastructure. It adds uncertainty to the project which increases risk and therefore investors require a higher rate of return on their capital. Projects that cannot meet the higher levels of return do not go forward.

A contributing factor to permitting delays are competing land use issues which have been complicated by increased population density and urbanization as well as more restrictive environmental regulations.

[7] Freight Capacity for the 21st Century, Transportation Research Board, Special Report 271, 2003, p. 69

3.4 Public funds are primarily directed to roadways

The development and operation of transportation infrastructure has long been a joint venture partnership between public and private entities, however, most public funds are directed to roadways. The chart below shows the total federal and state expenditures for all transportation modes for the year 1998. The chart shows that $108 billion, or 82% of all public funds were used for highways. The construction and maintenance of pipelines are paid entirely by private funds. Railroads receive some public funding; however, these funds are mostly for passenger rail.[8]



Roadways and waterways infrastructure are paid with public funds. Trucking and barge companies pay for their own fleets and a portion of the infrastructure through fuel taxes. According to a study by the CBO, trucking companies only pay for about 80% of the highway costs attributed to them and barge operators only pay for about 20% of the amount the Corps of Engineers spends on navigation projects.[9]

It is understandable that public funds pay for public roads, because the public is the primary user of roads. However, the fact that trucks do not pay for the full cost of transporting freight creates an unintended subsidy for the trucking industry. This translates into lower operating costs for trucks which enables them to attract some freight shipments that could be carried at a lower overall cost by other modes of transport. This imbalance causes a less than optimal use of the country's resources and discourages investment in alternative transportation modes.

Trucks provide clear advantages over other modes of transport in the form of greater flexibility and faster delivery times, however, these advantages come at a price. Next to air shipments, trucks are the most expensive form of transport averaging about 5 to 10 cents per pound. In addition, trucks generate social costs that are not reflected in the shipping costs which are borne by the public. While all modes of transport generate some level of social costs, trucking produces more air pollution per ton-mile, contributes to road congestion, and generates more accidents per ton-mile than alternatives.[10] The cost of shipping commodities by truck do not account for these external social costs. As a result,

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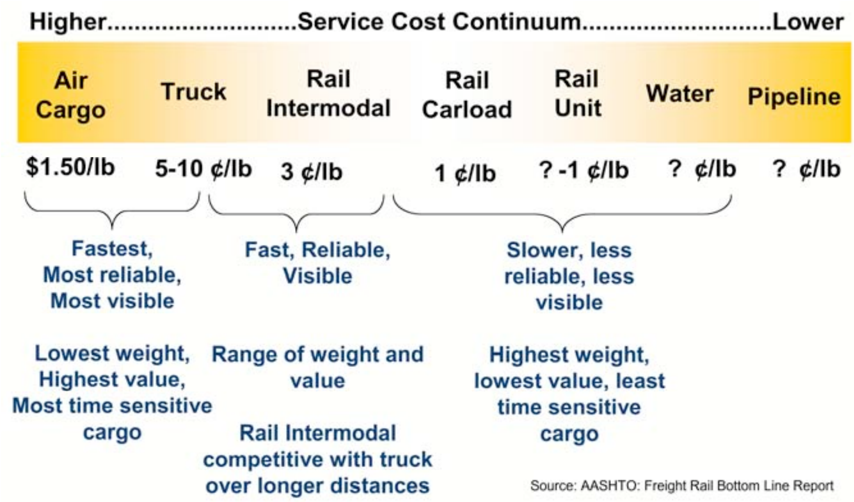
[8] Freight-Rail Bottom Line Report, AASHTO, p. 85

[9] Freight Rail Transportation: Long-Term Issues, Congressional Budget Office, January 2006, p. 17

[10] Freight Capacity for the 21st Century, Transportation Research Board, Special Report 271, 2003, p. 82-83

roadways appear to be less expensive than other modes of transport, leading to greater use of roads and the apparent need to build more roads. Efforts to rebalance the cost of shipments, such that trucks more fully bear the total cost to ship freight by roadways would lead to a more economically optimal use of transportation infrastructure.



Public funds for transportation infrastructure are raised through fuel taxes and other use taxes.

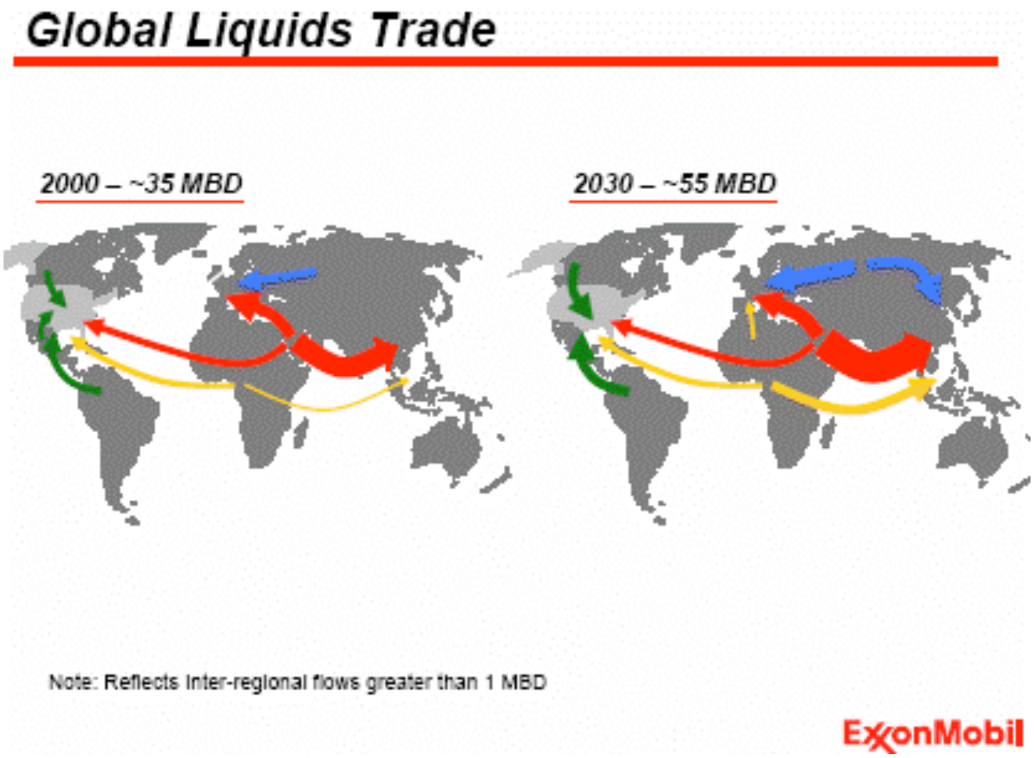
Tax Comparisons by Transportation Modes

	Railroads	Trucks	Barges	**Pipelines**	Aviation
Infrastructure (Right of Way) Costs					
Paid by	**Industry**	Government Subsidized	Government Subsidized	**Industry**	Government Subsidized
Method of Funding	**Private Capital**	24.3 Cent Fuel Tax	20.0 Cent Fuel Tax	**Private Capital**	21.8 Cent Fuel Tax
Tax Recovery Period (excluding repairs)	**7-50 Years**	1 Year	1 Year	**15 Years**	1 Year
AMT Exposure Due to Infrastructure	**Yes**	No	No	**Yes**	No
Property and Sales Taxes on Infrastructure	**Yes**	No	No	**Yes**	No

Note: Information in **Bold** indicates the mode is at a competitive disadvantage when compared to the other modes.

3.5 Global energy markets rely heavily on the availability of a few international routes

Global trade in petroleum liquids was estimated to be 35 mmbpd in 2000 and is projected to increase more than 50% by 2030, to 55 mmbpd.[11] Much of this increase is expected to move via seaborne tankers, often through narrow geographic channels or chokepoints. Global energy markets rely heavily on the availability of just a few international routes. Over 70% of petroleum liquids traded globally pass through either The Strait of Hormuz or the Straits of Malacca. Other important routes are the Bosporus, the Bab el-Mandab, Russian pipelines and Suez Canal/Sumed pipeline.[12]



Most of the so called choke points are at risk for geopolitical reasons and not physical constraints. The major risk is that the choke point will be shutdown by a naval blockade or by other means to effectively cut off the flow of petroleum liquids through that channel. The Bosporus is an exception, at only one-half mile wide at its narrowest point the Turkish Strait is one of the world's busiest and most difficult to navigate waterways. With that said, the constraint on the Bosporus is ultimately political rather than physical because Turkey has imposed a number of restrictions on tanker transit for safety and environmental reasons. Shutting off just one key international route would lead to severe supply disruptions and place the global economy at risk.

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[11] Exxon Mobil Annual Energy Outlook 2030
[12] World Oil Transit Chokepoints, EIA, November 2005

4. Potential Recommendations

The Infrastructure team recommends the federal government take a leadership role in formulating a national transportation policy that includes due consideration for private modes of transportation (pipelines and railways). Doing so will improve national security and enhance the economic prosperity of the nation.

The first priority should be to expand funding for the collection and analysis of energy transportation data. It is clear from the team's research that basic transportation data is simply not available making quantitative analyses impossible to perform. This lack of data leads to poor decision making about infrastructure needs.

The federal government needs to lead a coordinated permitting and land use process for pipelines and other critical infrastructure. The team does not advocate for the federal government to usurp state or local authority, rather the team recommends the development of a uniform process that ultimately reduces the timeline from permit submittal to permit decision.

The federal government should consider an integrated approach to transportation funding. The federal government should consider transportation infrastructure needs across all modes of transport taking into consideration both economic and social benefits. The federal government must recognize that subsidizing the cost of a particular mode of transport to the disadvantage of other modes will lead to that mode of transport being favored. (If you build it, the freight will come!) Furthermore, the federal government should consider the environmental and other benefits of removing freight off the public roadways and onto private modes of transport.

The team also recommends that the federal government encourages development of domestic energy resources to reduce dependence on deliveries of foreign energy supplies. The government should continue to protect strategic sea lanes to ensure the safe transport of petroleum liquids and it should continue to promote the development of alternate routes to alleviate the dependence on global chokepoints. Implementing these measures would greatly improve the nation's transportation infrastructure and lead to greater economic prosperity and energy security.

5. Modal Reports

5.1 Gas Pipelines

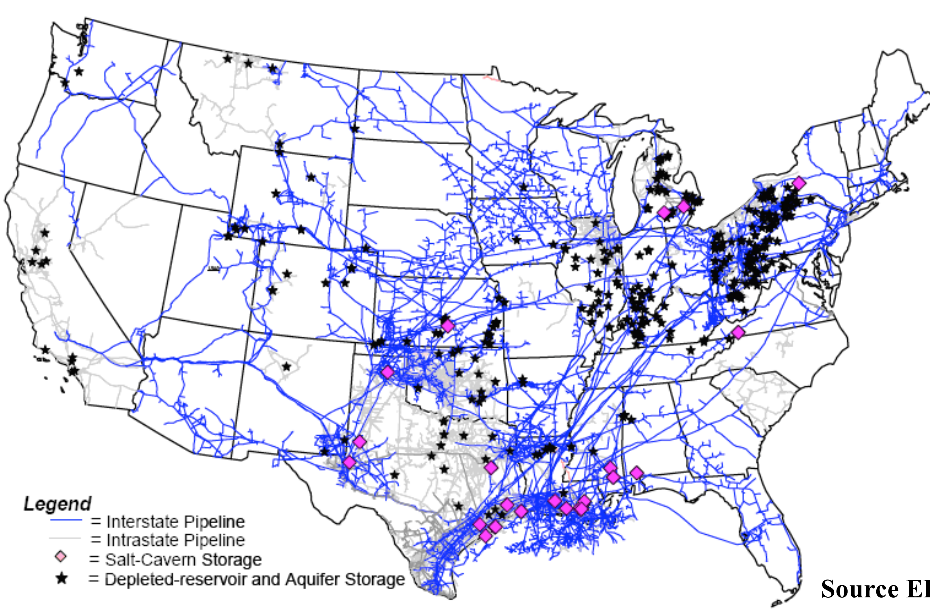
1. General Description

A. Overview

Natural gas infrastructure in the United States includes gas pipelines, storage facilities, LNG facilities and regasifaction terminals. The deregulated and integrated grid has a long standing reputation for safely and effectively moving natural gas from supply basins to regional markets.

An extensive network figure 1 of natural gas pipelines and underground storage facilities connects supply basins with regional markets. There are over 213,000 miles of interstate natural gas pipelines and 400 underground storage facilities throughout the United States. Balancing daily supply and demand across regions depends upon co-ordinating long-haul transmission pipelines with supply and market storage facilities. Underground storage facilities has working gas capacity of 4 tcf and maximum daily deliverability of 84 bcfd.

Figure 1 US Natural Gas Transportation Grid and Underground Storage Facilities (2005)



Source EIA

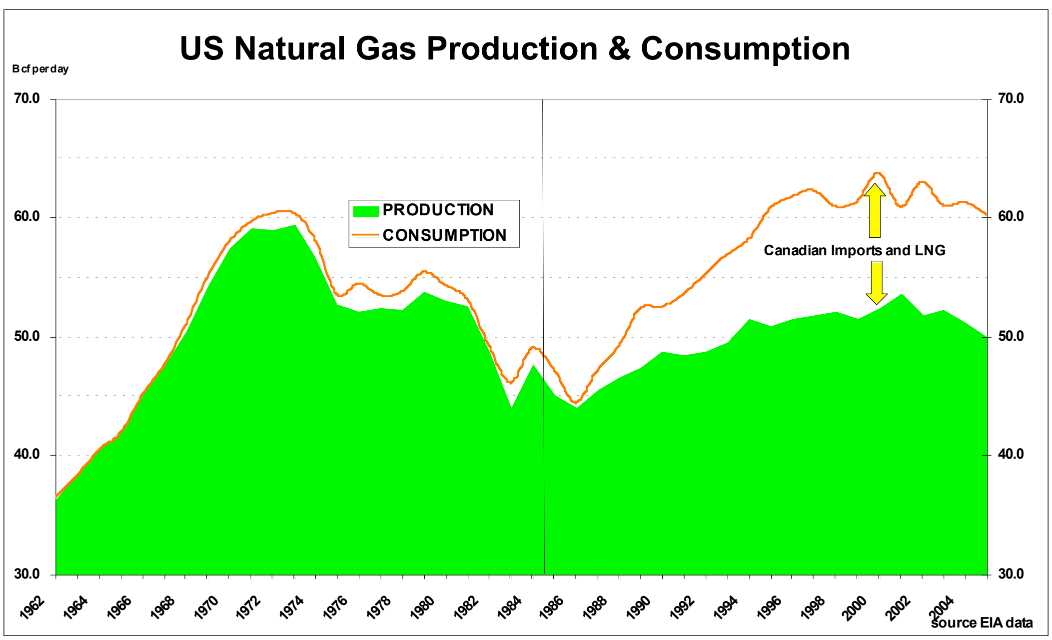
There is an extensive and integrated energy relationship between the United States and Canada. The existing infrastructure grid seamlessly connects to Canadian pipelines and storage facilities which currently move ~9 bcfd of natural gas into the United States.

At this time there is not as significant an energy relationship with Mexico. Today the United States is a net exporter (~1 bcfd) of natural gas to Mexico. From an infrastructure perspective, this review assumes there is potential for new LNG supplies to be imported from Mexico through a combination of existing, expanded or new pipeline capacity.

B. Imports Required to Meet Growing US Demand

For the past twenty years, demand for natural gas in the United States has grown at a faster rate than domestic production **figure 2**. The gap between production and consumption has largely been satisfied by increasing imports from Canada.

Figure 2 Historical Natural Gas Production and Consumption- Lower 48



Due to abundant Canadian supply and competitive prices, new and expanded pipelines were built to bring more natural gas to the lower 48. New capacity on pipelines such as GTN, Alliance, Northern Border, Iroquois, PNGTS and MN&E provided key integrated infrastructure connections needed to move supplies to regions of growing demand. There also were significant Canadian infrastructure investments to move more natural gas to the US border pipeline connection points.

Today the 'gap' between domestic production and consumption is roughly 10 bcfd but the forecasts considered in this review suggest that in spite of slight growth in domestic production, the 'gap' covered by the combination of Alaska's North Slope gas, LNG and Canadian imports will more than double to 25 bcfd by 2030.

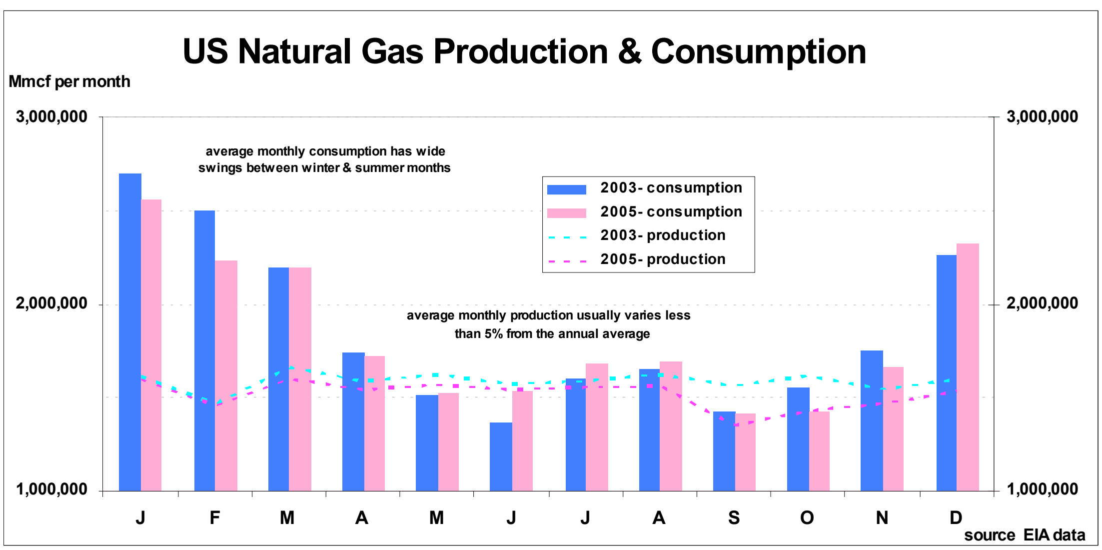
Over the next twenty years, changing supply and demand patterns combined with this growing 'gap' between domestic production and consumption will challenge us to ensure that natural gas infrastructure fulfills its role:

Safe, reliable and effective physical delivery of natural gas to meet daily gas demand in regional markets across the United States

C. Balancing Monthly Swings between Production and Consumption

Domestic production currently runs at close to full capability throughout the year. As the following chart **figure 3** illustrates, this results in flat monthly production except for small dips due mostly to maintenance and environmental (ie hurricane) issues. Domestic consumption has extreme swings in average monthly demand, driven by heating demand load across the United States.

Figure 3 Natural Gas Production and Consumption- Balancing Monthly Swings



The above chart shows 2003 and 2005 as representative trends in domestic production and consumption. Average monthly consumption has a 100% swing (from 44 to 87 bcfd) while production varies less than 10% (from 48 to 52 bcfd). Peak daily consumption can run even higher, reaching 115 bcfd during severely cold winter days. The chart represents averages for the entire country and doesn't show more extreme differences in the average monthly consumption for individual states and regions.

Natural gas infrastructure has developed over the years to balance differences between daily regional production and consumption. A combination of gas storage and pipelines connecting Canadian imports and LNG facilities has provided the needed flexibility to balance natural gas supply and demand.

The current challenge is how infrastructure can evolve to continue maintaining a daily balance between physical supply and demand. This is further complicated by:

1. increasing safety and security concerns
2. changing supply and demand patterns
3. increasing daily peak demand levels
4. increasing import requirements
5. increasing commercial risks

2. Current Natural Gas Infrastructure Grid

A. Advantages

The extensive natural gas infrastructure grid in the United States has been developed over a period of eight decades and has consistently provided safe, reliable and economic access to North America's natural gas supply. Safety, reliability and providing economic access to gas supply are important advantages of the current infrastructure grid.

Another important advantage is the flexible response of the infrastructure grid to the constantly changing supply and demand balance. The North American grid has responded and evolved to meet significant challenges over the years; from rapidly growing demand during economic expansion in the 1960-70's to a huge slump during the 1970-80's driven by deregulation issues, a faltering economy and the decision to eliminate natural gas as a fuel source for electric power generation. Again, during the 1990's, there were significant infrastructure investments in the United States and Canada to increase imports to meet growing gas demand.

The ability of the infrastructure grid to effectively store and retrieve large quantities of natural gas is essential to ensure that physical delivery meets daily demand. The highly seasonal gas demand for space heating likely could not be met without the ability to build inventories in storage prior to the high-demand winter period.

The integration of supply and market storage with the pipeline grid also provides an economic advantage for natural gas markets. Supply storage provides protection against supply interruption and supports a flatter and lower cost production profile. Market area storage was developed to reduce the investment in long-haul pipelines while meeting the huge seasonal swings in demand. The alternative would have been costly investments in additional pipeline capacity that would have been severely underutilized for most of the year.

The significant energy relationship between the United States and Canada is another key advantage. The existing infrastructure grid seamlessly connects to Canadian pipelines and storage facilities, moving timely Canadian imports to markets in the northern half of the United States.

The current North American infrastructure grid is an important advantage, providing spare capacity, expansion opportunities and access to existing right-of-ways as an integral part of the solution to future development requirements.

This review is focused on long-haul interstate infrastructure but it is also important to acknowledge the extensive intrastate and local distribution pipeline networks that provide the essential link to regional gas markets. The strong relationships and the co-ordination between these interstate, intrastate and local distribution companies have provided a huge advantage to the safe, reliable and effective physical delivery of natural gas. Many of the future challenges and issues facing infrastructure will require common resolution across federal, state and local jurisdictions.

B. Challenges

During the past twenty years, US demand grew by roughly 15 bcfd. The United States was positioned to take advantage of spare Canadian supply capability and a combination of spare capacity and economic pipeline expansions to satisfy its increasing demand. The forecasts considered in this review indicate that domestic consumption will increase by another 10-15 bcfd by 2030 with traditional supply basins struggling to keep production relatively flat.

Over the next twenty years, our critical challenge will be to maintain and develop gas infrastructure to connect 10-15 bcfd of new natural gas supplies to meet growing regional demand in a timely manner. New development will incorporate anticipated spare pipeline capacity and some expansion of the current grid, but it might also require significant new infrastructure investments to connect to new gas supplies.

Safety, security and reliability are over-riding values and priorities of the natural gas industry. Infrastructure expenditures to maintain existing capacity have been increasing in recent years and looking forward, that trend is expected to continue.

Most of the current natural gas infrastructure in the United States was sponsored and constructed during a highly regulated environment, supported by long term purchase, sale and transportation contracts. Today's deregulated natural gas industry does not encourage long term contracts. It uses market fundamentals, such as supply, demand and commodity prices, to support new supply and infrastructure projects. As a result, future development projects will face significant uncertainty on many levels.

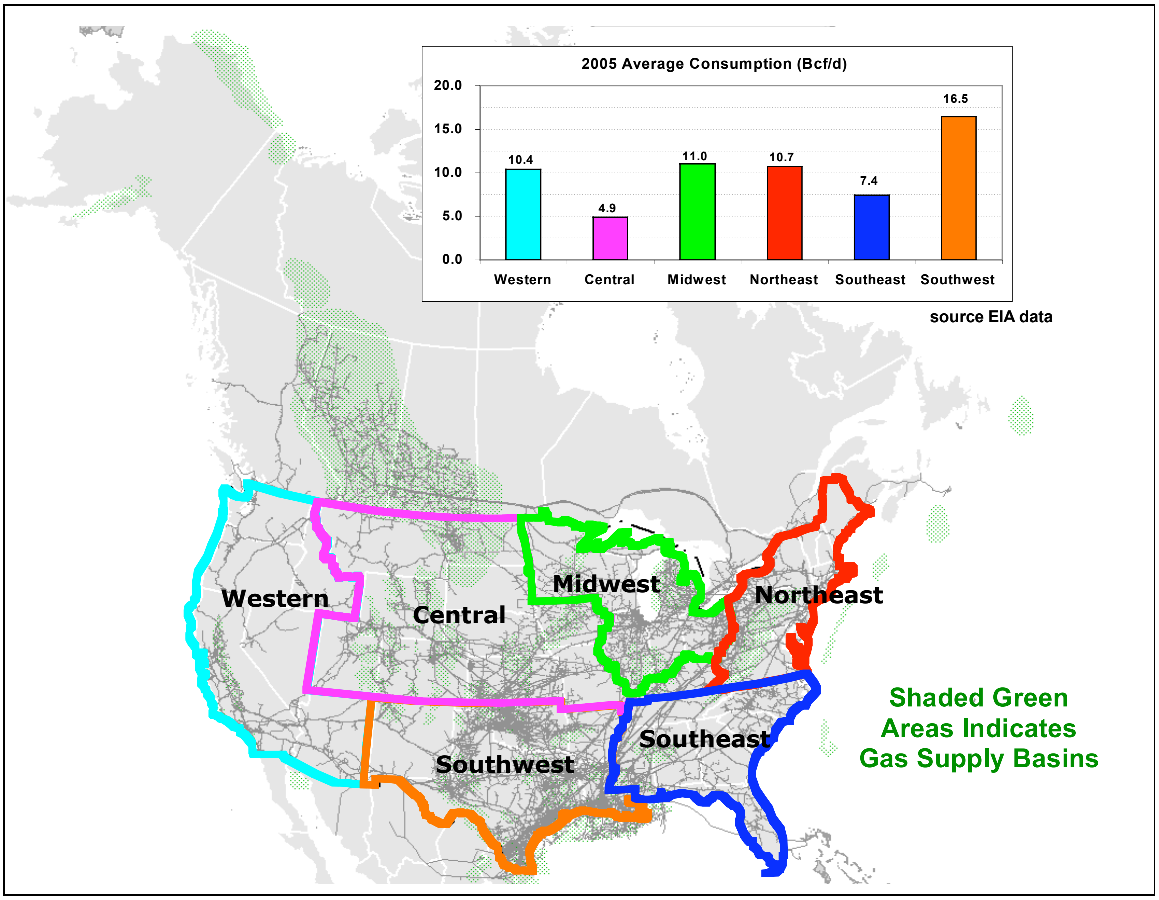
The key issue of this development challenge is how to deal with uncertainty. There is significant volatility around natural gas supply, demand and price forecasts and trends, so this uncertainty raises many important questions the industry is struggling to answer:

- how much will sustainable gas demand increase
- where and when will that demand increase occur
- how will traditional supply basins perform as demand increases
- which new supply options (ie Rockies, Alaska, LNG, Barnett Shale, etc.) will be economic and available in time to meet increasing demand
- what infrastructure commitments (ie size and timing) will be necessary to connect new (anticipated) supplies with (anticipated) increasing demand
- who supports new infrastructure with long term contracts- supply or market
- will long term prices support the development of new supplies and infrastructure
- infrastructure concerns on managing uncertainty
  - regulatory uncertainty- process, opposition, timing, returns
  - increases in front-loaded development costs
  - construction cost overruns
  - supply underperformance
  - market underperformance

C. Capacity and Flows

The major North American natural gas supply basins run through Western Canada and follows the Continental Divide through the Rockies into the Southwest United States and offshore into the Gulf of Mexico. Almost 3/4 of current natural gas supplies are produced in this corridor but 2/3 of domestic consumption occurs in the four other regions. figure 4

Figure 4 Natural Gas Supply Basins, Major Pipelines and US Consumption (2005)

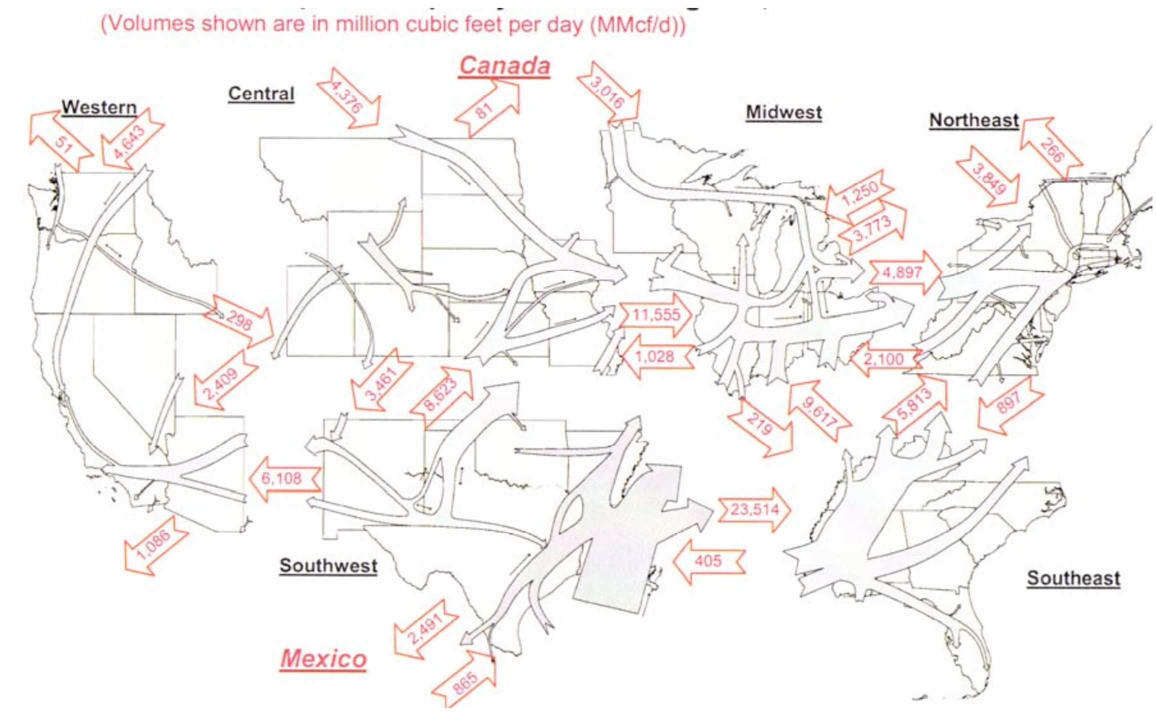


The above diagram shows the major gas pipeline network is aligned to move supply to key markets in the United States. Supply area storage is generally located in Alberta and the Southwest United States while most market area storage is located in Ontario and the Midwest United States. Underground storage facilities are salt cavern, depleted reservoirs or aquifer storage. Underground gas storage facilities are limited by geography. figure 1

C. Capacity and Flows (continued)

The following map figure 5 shows pipeline capacity between Canada, Mexico and the six distinct US regions; Western, Central, Midwest, Northeast, Southwest and Southeast.

Figure 5 Natural Gas Pipeline Capacity Between Regions (2005)



If this map is overlaid on a diagram figure 4 of supply basins and major pipelines, these capacities illustrate that (a) some supply basins can deliver to more than one market and (b) some markets can receive supply from more than one basin. This delivery flexibility is important in assisting market forces to work correctly in setting competitive regional prices.

Most studies agree that the North American natural gas balance is currently very tight. At different times, high utilization rates on certain infrastructure paths results in volatile commodity prices. When there is a capacity bottleneck in moving natural gas away from a supply region, commodity prices are pushed lower. When there is a capacity bottleneck in moving natural gas into a market region, commodity prices are pushed higher.

Currently, most of these capacity bottlenecks are short term and market forces cause a correcting shift in demand or supply to relieve the pressure. When fundamentals indicate that the problem could continue longer term due to changing supply or demand patterns, new-expansion infrastructure projects are proposed to relieve the bottleneck and return the supply-demand balance.

3. Looking Forward

A. Throughput and Capacity Requirements

Predicting change in natural gas flows and specific capacity requirements over the next twenty years would require running sophisticated forecasting models using daily supply, demand and price trends in key regions of the United States. This review did not sponsor new runs of sophisticated forecasting models but instead refers to recent detailed studies on infrastructure throughput and capacity.

The first point of reference for predicting change in natural gas infrastructure capacity is the National Petroleum Natural Gas Study that was completed in September 2003. The following diagram figure 6 shows the sophisticated model's capacity forecasts under the NPC study's *Balanced Future* scenario.

Figure 6 2003 NPC Study- New Pipeline and LNG Capacity (2003-2025)

Figure T-5. New Pipeline and LNG Capacity Change from 2003 to 2025 in Balanced Future Scenario (Million Cubic Feet Per Day)

Reviewing the results today, many of the conclusions are still valid but unexpected supply and demand developments combined with timing shifts has changed the outlook for new capacity requirements.

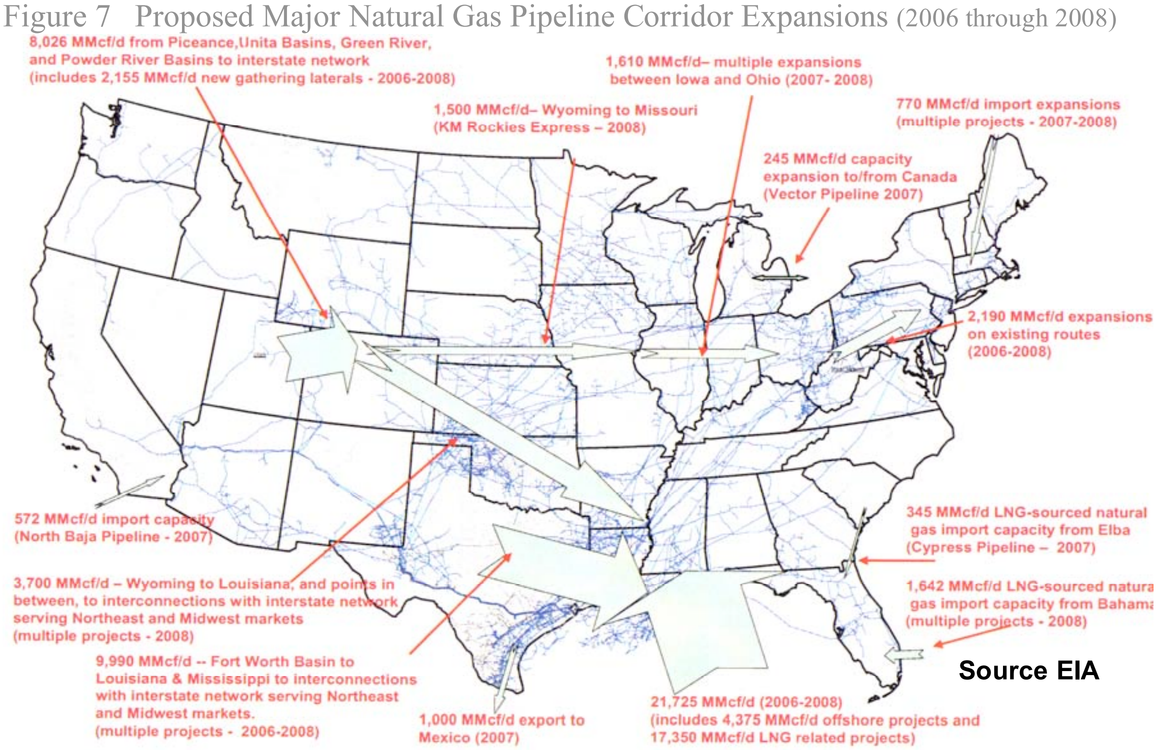
A. Throughput and Capacity Requirements (continued)

A few observations on how the view towards natural gas infrastructure development has changed since the 2003 Study:

- total investment in pipeline infrastructure since 2003 has exceeded projections
- construction in the Northeast is proceeding slowly due to significant hurdles
- costs of capacity expansions has been more expensive than projected
- LNG imports levels are lagging predictions and progress is slow in building new import terminals on the west or east coast
- costs for pipeline capacity to support new LNG import terminals in the Gulf have been significantly more expensive than projected
- timing of Alaska North Slope gas has slipped to 2018, increasing the possibility of using spare & expanded capacity on existing pipelines to connect to the lower 48
- new pipe projects could move 2 bcfd of gas from the Rockies eastward
- new pipe projects to expand capacity out of Louisiana and East Texas- driven by unexpected supply development in those areas
- new storage development has been in supply, not market areas
- new and expanded storage is expected to have higher than projected costs

Predicting potential long term infrastructure projects is influenced by changing market pressures, but a useful reference is the slate of corridor expansions being discussed today. The following EIA diagram figure 7 provides a view of current pipeline proposals.

Figure 7 Proposed Major Natural Gas Pipeline Corridor Expansions (2006 through 2008)



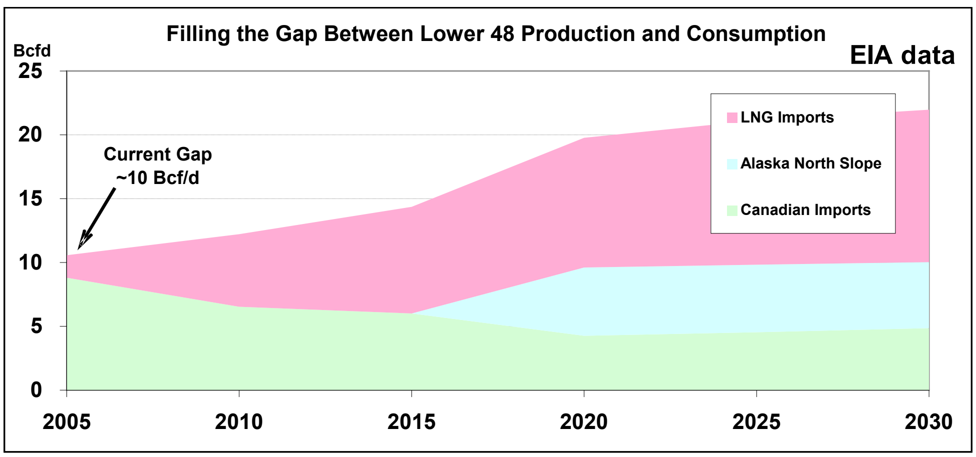
A. Throughput and Capacity Requirements (continued)

The greatest challenge facing infrastructure over the next twenty years will be how to connect new supply sources to growing domestic markets in a safe, reliable, timely and effective manner. The likely solution is a combination of spare and expansion capacity on existing pipelines along with new large transmission projects.

The first challenge is to connect new domestic supplies to the existing infrastructure grid. As the previous diagram figure 7 suggests, the market will decide which projects will proceed to move new supplies from the Rockies, East Texas and the Gulf to markets.

The second challenge is to connect the supplies that will fill a growing 'gap' between domestic production and consumption. Most studies figure 8 suggests that a combination of Alaska North Slope gas and LNG will be the new supply sources.

Figure 8 Filling the Gap Between Production and Consumption (2005-2030)



Various forecasts have differences around the timing and quantity of new supplies to fill the gap, but new infrastructure development must consider that:

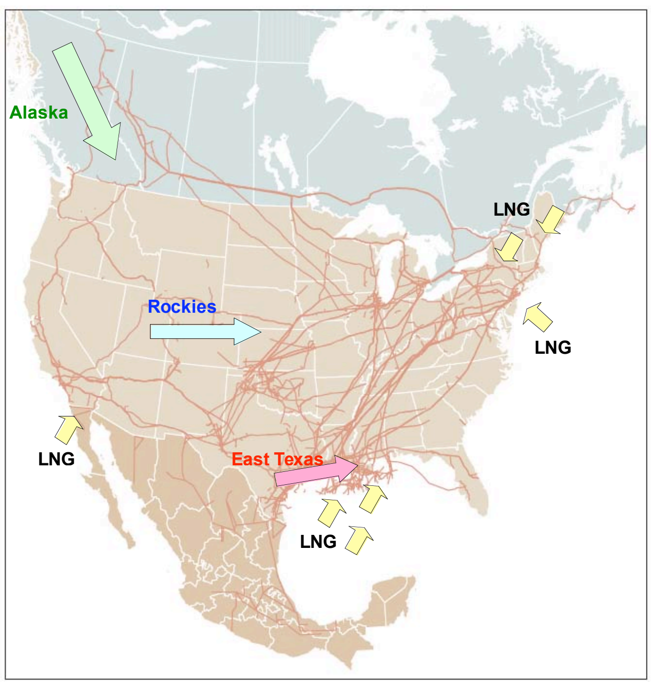
- gap size is driven by
  - accuracy of demand forecasts considering volatile prices
  - slope of decline in Canadian imports
  - domestic production improvements
- imports of LNG from Mexico and Canada will help fill the gap
- Alaska North Slope remains the preferred supply source, but it requires a 10 year timeline after a commitment to start new pipeline development

B. Spare Capacity and Economic Expansion

The combination of an extensive infrastructure grid with the maturation and expected decline in currently producing basins should provide opportunities to use spare capacity and to expand existing pipelines to help move these new supplies figure 9.

- LNG arriving from Mexico can connect to existing and expanded infrastructure in both the west (ie Baja) and the east (ie Gulf)
- LNG arriving from Canada can connect to existing and expanded infrastructure in the Maritimes and Eastern Canada to satisfy both Northeast and Midwest markets
- LNG arriving directly in the Northeast can connect to the existing and expanded infrastructure grid to satisfy local markets
- LNG arriving in the Gulf can connect to the existing and expanded infrastructure grid in the Southeast and Southwest
- Alaska supplies can connect to existing and expanded infrastructure in Alberta to connect to pipelines moving gas to markets in the Western, Central, Midwest and Northeast regions
- Rockies supplies moving further east on new pipelines can connect to the existing infrastructure in the Midwest and Eastern Canada and continue to major Northeast markets (also has key connections to market area storage)
- East Texas supplies can connect to the existing and expanded infrastructure grid in the Southeast and Southwest
- Deepwater Gulf supplies can connect to the existing and expanded infrastructure grid in the Southeast and Southwest

Figure 9 Integrating New Supplies into the Existing Pipeline Grid (24" diameter and greater)



C. Infrastructure Investment

The first reference for investment in infrastructure capacity is historical activity. Gas pipeline transmission expenditures averaged $2.7 billion per year during the 1970's and the 1980's. During the 1990's when new Canadian supplies were connected to the grid, pipeline transmission expenditures averaged $3.3 billion per year.

The second reference is the National Petroleum Natural Gas Study that was completed in September 2003. The following diagram figure 10 shows the required capital expenditure forecast for the NPC study's *Balanced Future* scenario.

Figure 10 2003 NPC Study- Required Infrastructure Capital Expenditures (2003-2025)

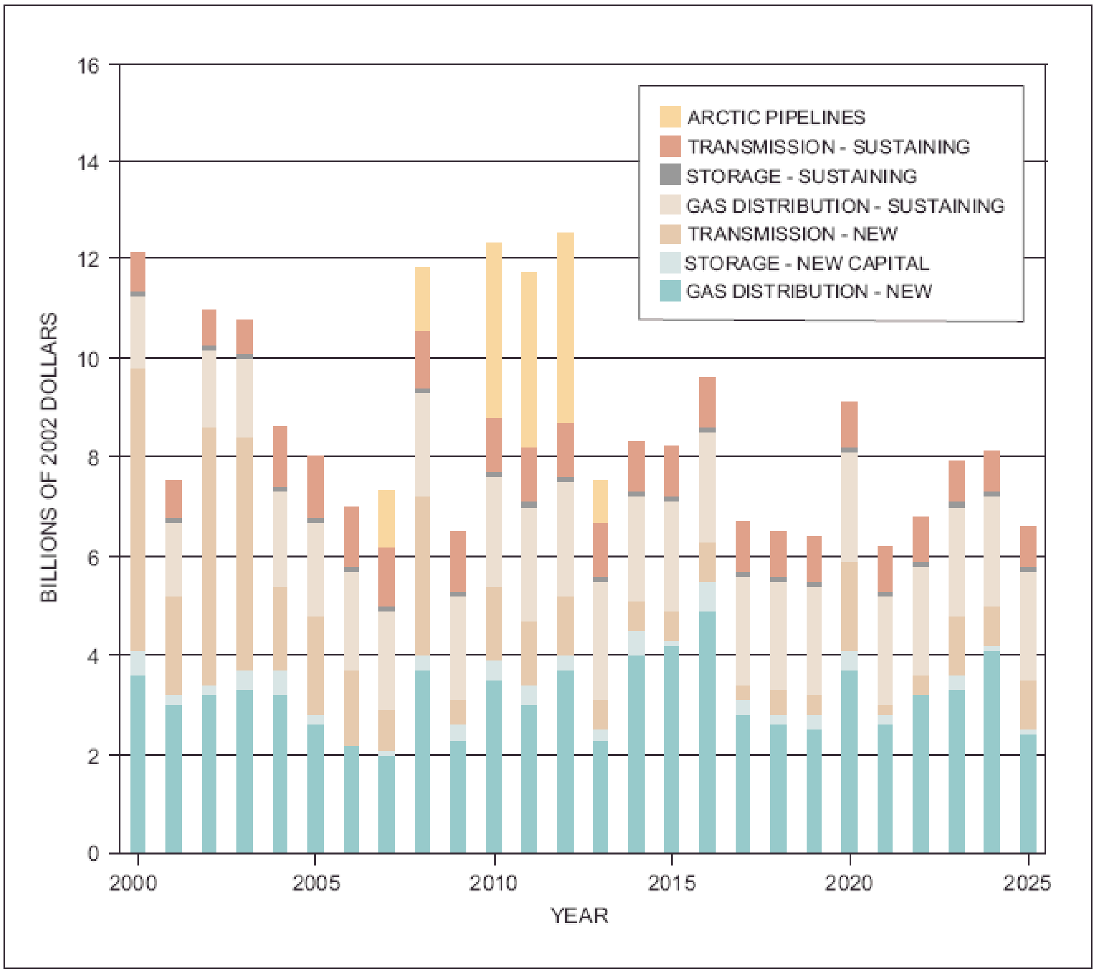


Figure T-2. Detailed North America Capital Expenditures for Transmission, Distribution, and Storage in Balanced Future Scenario

The above investment forecast is based upon a sophisticated capacity model run under the NPC study's *Balanced Future* scenario. The estimate includes investments in storage, distribution and transmission infrastructure. There is also a split between investments for new capacity and to maintain existing capacity. Investment in the Mackenzie and Alaska pipelines is shown separately.

C. Infrastructure Investment (continued)

While it was completed several years ago, the NPC Study findings emphasize the need for significant (~$7.5 billion/year) investments beyond new large transmission projects.

- significant new distribution investments will be required
  (new distribution investments exceed transmission investments by 2 to 1)
- significant investment needed to maintain safety and reliability
  (sustaining infrastructure investments exceed new infrastructure by 3 to 2)
- significant investment, even without new large transmission projects
  (investments* average ~$7.5 billion per year between 2005 and 2025)
  *excluding investments in the Mackenzie and Alaska pipelines

A later study prepared for the INGAA Foundation also reached similar conclusions on the level of investment needed for new and sustaining transmission infrastructure in the United States.

Several important factors will affect future gas infrastructure investments. The first is new technology driving cost efficiency. This includes everything from high strength steel pipe (lighter), to better inspection tools (smarter pigs) and more effective operating and maintenance techniques.

Another important factor is the increasing trend in pipeline costs. These costs include labor, steel, right-of-way and other costs of installing new gas pipelines. A recent study by the *Oil and Gas Journal* showed that the installation costs for 30-36 inch pipelines has increased from $1.0 million/mile in 1993 to $1.5 million/mile in 2003 and reached almost $2.5 million/mile in 2005.

There are a number of misconceptions around the infrastructure investment decision for new projects; how can we change them ?

- no worries around the timing of new infrastructure
- new capacity will be available when demand needs it
- no concerns about who will commit (guarantee) to new projects
- delays in the regulatory-permitting processes are not an important issue
- capital recovery over 15-25 years isn't an issue for new infrastructure investments
- private capital considers the current risk-reward equation attractive for investment in new infrastructure projects
- growing pressure for increased property and sales taxes from many jurisdictional levels is not a problem for infrastructure projects

4. Major Issues Facing Infrastructure

A. Constraints, Vulnerabilities and Bottlenecks

Development Cost Uncertainty

The cost of developing new infrastructure projects is extremely volatile. Over-runs from hot market factors, project opposition, few (large diameter pipe) suppliers and regional factors (proximity to cities and other infrastructure) are more frequently an issue on new projects

Timing Issues

There is a gap between the timing when the market indicates it is ready to commit to new infrastructure projects and how long it takes supply and infrastructure to respond. If infrastructure utilization approaches 100% utilization, the value of infrastructure capacity increases in the market. The problem is even though prices increase, this usually cannot result in an immediate increase in capacity.

Capital Recovery Uncertainty

Major infrastructure projects today are often sponsored by Producers who are reluctant to commit (ie cost of warranty) for longer than 10-15 year terms. Since regulated recovery of capital is usually for longer (ie 25 years) terms, infrastructure developers are uncertain of recovering new capital investments.

Less Spare Flexibility

Most current infrastructure was sponsored and constructed during a highly regulated environment when the market supported development with long term purchase, sales and transportation contracts. The demand increase of the past twenty years absorbed much of the previously excess supply and capacity in the system, so demand increases over the next twenty years could have a more difficult time aligning new supplies to infrastructure developments.

Importance of Size and Scale

Most of the major new supply sources, such as Alaska North Slope and the Rockies, are a long distance from markets. Any new long-haul pipeline will depend upon pipe size and scale to provide the economic justification for development. This can cause problems at both ends of the pipe to justify supply and infrastructure development costs:

- new supplies need to reach a critical mass and have a reasonably long life
- new demand needs to be fairly constant and continue far into the future
- prices have to remain fairly robust over time
- development costs have to be on-budget

A. Constraints, Vulnerabilities and Bottlenecks (continued)

Changing Demand Patterns

Most of the current infrastructure was built using storage to meet seasonal demand instead of building additional pipeline capacity that would be under-utilized for much of the year. If growing demand significantly alters the seasonal pattern and requires existing summer pipeline capacity that currently is used to re-fill storage, there will be additional infrastructure needed to provide the safety margin to meet peak winter demand.

Supply Flexibility- new sources

New domestic supply (ie Rockies, Alaska, East Texas, etc) sources are generally expected to produce in a relatively flat, base-load pattern. If LNG is an important new source to meet anticipated seasonal demand swings, then new infrastructure and supply contracts would have to be designed to provide that flexibility.

Supply Composition- new sources

New LNG could potentially have a much higher BTU content than current domestic supplies. The existing infrastructure grid, from the interstate to the intrastate to the local distribution companies to their customers might have problems accepting such 'hot' gas. This could require additional infrastructure (ie liquids stripping facilities) or limit receipts to locations where the 'hot' gas could be co-mingled with significant volumes of leaner gas.

B. Conclusions and Policy Considerations

The extensive natural gas infrastructure grid in the United States has developed over a period of eight decades and has consistently provided safe, reliable and economic access to North America's natural gas supplies.

Over the next twenty years, demand is expected to increase significantly. Forecasts of changing supply and demand patterns, exasperated by a growing 'gap' between domestic production and consumption, will challenge us to ensure that gas infrastructure continues to fulfill its vital role, providing:

Safe, reliable and effective physical delivery of natural gas to meet daily gas demand in regional markets across the United States

Our existing infrastructure grid provides us an incredible advantage to deal with future needs. While changing supply and demand patterns could take advantage of anticipated spare pipeline capacity and will also encourage expansion of the current grid, it will also require significant new infrastructure investments to connect new gas supplies.

B. Conclusions and Policy Considerations (continued)

To support the significant new infrastructure investments that will be required in a timely manner, there are a number of specific policy considerations that have been suggested by several recent studies:

Policy Considerations

- regulatory certainty around cost recovery and contracting- clear and unchanging roles and rules
- timing certainty around total permit review process- joint agency reviews
- address barriers to long term contracting
- flexibility to configure rates and terms to meet changing market needs
- support collaborative research to improve efficiency and costs
- support public education and outreach programs to inform about new infrastructure projects
- support balanced and informed evaluation of the risk and benefits of new infrastructure projects
- incorporate an understanding of infrastructure growth and needs into future studies and plans to support future energy growth and the forecast impact of changing supply and market patterns

5.2 Liquid Pipelines

Overview

The United States pipeline industry is complex, diverse and essential to the nations economy. Natural gas and crude oil combined account for more than 60 percent of the U.S. energy consumption. Liquid pipelines move nearly 2/3 of the nations oil supply through roughly 200,000 miles of pipe. These pipelines carry crude oil, gasoline, jet fuel, kerosene, diesel fuel, heating oil and other liquids to various cities throughout the country. Pipeline transportation is the nation's most important petroleum supply line and is the safest and most efficient mode of delivery.[13]

Pipeline Type	Mileage
Crude	
Trunk lines	~55,000
Gathering lines & Other	~40,000
Petroleum Products	~95,000
Total	~200,000

The Evolution of Liquid Pipelines

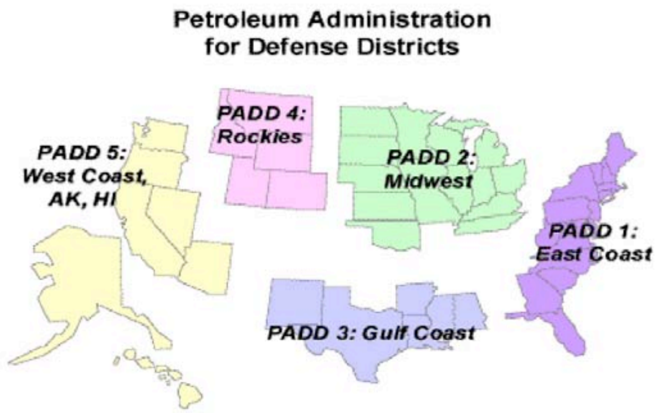
Crude oil supply is either produced in the US, on-shore or coastal waters, or imported from a foreign source. Generally, until the 1950s, crude oil was produced, gathered, and processed in the US from on-shore fields, predominantly in Pennsylvania and Ohio. Over time, larger fields in East and West Texas, Oklahoma, Louisiana, California, Alaska and the Rocky Mountains were discovered. With new field discoveries, it was necessary to invest in a pipeline infrastructure to gather, then transport crude to refineries. Demand for petroleum products grew during WWII and thereafter, tripling between 1950 and 2000. Crude consumption grew from 6 mmbbls/d in 1950 to 16.2 mmbbls/d in 2002. During the 1940s - 60s domestic production increased to meet the nation's needs with a little help from foreign supplies. However, during the 1970s inland production became to decline while Alaska and the Gulf of Mexico emerged as large supply areas. With increasing demand and inadequate supply to meet demand, crude imports grew significantly. This supply change dramatically impacted the pipeline system as gathering systems and new pipeline were constructed to satisfy deep water gulf production, and the pressure to move Canadian and Alaskan crude further south into the US lead to the construction of long haul pipelines, hundreds of miles in length, to supply to new refinery locations.[14],[15]

[13] *The Liquid Pipeline Industry in the United States: Where It's Been Where It's Going;* Richard A Rabinow, April 2004

[14] *The Liquid Pipeline Industry in the United States: Where It's Been Where It's Going;* Richard A Rabinow, April 2004

[15] *The Role of Energy Pipelines and Research in the United States: Sustaining the Viability and Productivity of a National Asset*; Cheryl J. Trench, 2006

Petroleum Administration for Defense Districts

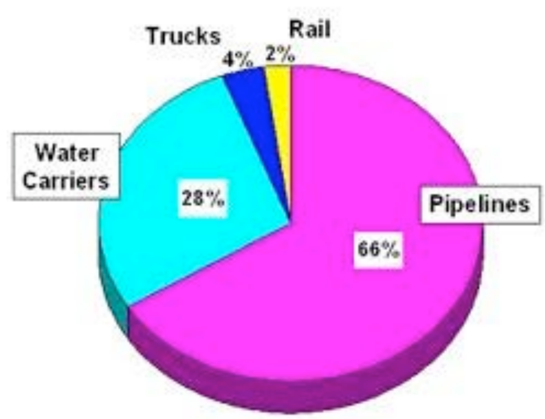


Liquid Pipeline Network

The pipeline network is composed of different types of lines serving three distinct functions. Gathering lines bring oil from the production field to a processing facility or trunk line. They are usually low volume, short haul pipes. Transmission and trunk lines are the super highways of the grid and carry fuel long distances through large diameter pipes from producing regions to refining centers, and from refining centers to import terminals and locations of high demand. Distribution and delivery lines are smaller diameter pipes and move product to distribution junctions and its final destination. For the most part, all liquid fuel is transported through the same pipeline grid and "batched" by fuel type to maintain product grade and quality.[16]

The U.S. Department of Energy divides the United States into five geographic regions called the Petroleum Administration for Defense Districts (PADD) areas. These areas were established to ensure standard terminology for energy measurement and analysis during WWII and are still used today for ease of common reference and pricing differentiation. Below is a brief description of each PADD and production associated with it.[17]

Source: How Pipelines Make the Oil Market Work



PADD1 The East Coast has low crude oil production and limited refining. The refineries mostly process foreign oil.

PADD2 The Midwest has significant crude production. Refineries process Midwest crude as well as Canadian and foreign crude transported from the Gulf Coast.

PADD3 The Gulf Coast is the largest producing region in the US accounting for 47% of refined products and 55% of crude production. The majority of crude coming from this PADD goes to Midwest refineries while most of the

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[16] *The Liquid Pipeline Industry in the United States: Where It's Been Where It's Going;* Richard A Rabinow, April 2004

[17] *How Pipelines make the Oil Market Work – Their Networks, Operations and Regulation*; Allegro Energy Group, December 2001

refined products go to the East Coast.

PADD4 The Rocky Mountains has the lowest crude consumption with rapid production growth.

PADD5 The West Coast is separated from the rest of the country and crude supply is dominated by Alaskan production (55%) with the remainder of the region crude production from California. California, the largest consuming state, has special quality requirements so almost of all the state's product demand is met by the state's refineries.

Customers

From a pipeline perceptive there are two types of customers, firm and interruptible. Customers desiring firm transport for a specific commodity and set capacity pay a higher demand rate for a guaranteed service; an example would be a Local Distribution Company (LDC). Customers that are able to accept interruptible transport service are able to pay a reduced rate, with interruptions usually occurring during peak periods.[18]

Ownership

Traditionally, most liquid petroleum pipelines have been owned by fully integrated energy companies that needed reliable, dependable transportation of their product. However, over the last decade, ownership interest by integrated companies has fallen to about 1/3 of total ownership. During that time, ownership structure has shifted as the oil industry has consolidated via mergers, acquisitions, and divestments. The primary drivers for this change was the need for owners to be profitable, manage cost efficiently, minimize business risk, and achieve economies of scale while complying with the regulatory environment. Another driver was the increasing pressure for integrated energy companies demanding every business segment be economical on its own rather than supporting the company's primary business unit. With this paradigm shift, many new entrants have entered the market with the sole purpose of being a pipeline transportation and related services company. Today, there are a variety of ownership types: a single entity, an integrated energy company, an MLP, LLC, investor groups or various other corporate entities. MLP have increased in popularity, created by the 1986 Tax Reform Act and were designed for the development, production and transportation of natural resources. MLP ownership provides tax and liability benefits and allows for the ability to provide capital for acquisitions or improve profitability of a new/existing asset while providing an attractive return to a wide ownership base. Some examples of MLPs are Sun, Williams, Buckeye, Kanab, TEPPCO, Kinder Morgan, Plains All American and Enterprise.[19]

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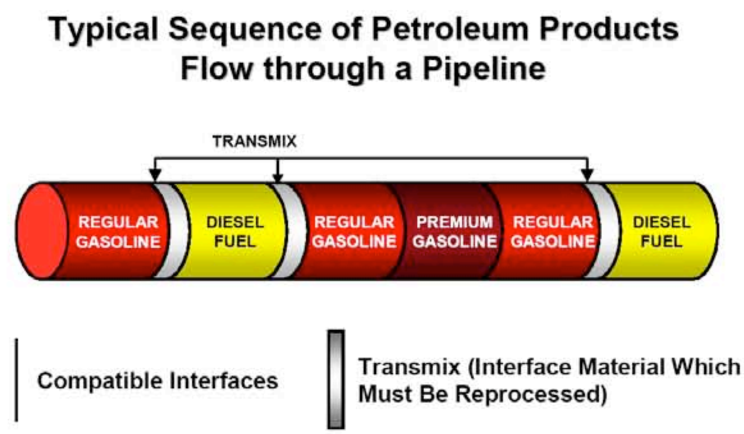
[18] *The Role of Energy Pipelines and Research in the United States: Sustaining the Viability and Productivity of a National Asset*; Cheryl J. Trench, 2006

[19] *The Liquid Pipeline Industry in the United States: Where It's Been Where It's Going;* Richard A Rabinow, April 2004

Improving capacity through existing pipelines

<u>Pipeline product flow</u>

Liquid pipelines carry many different fuel types of multiple grades. It can be from crude oil to refined petroleum products including motor gasoline, kerosene, aviation fuels, diesel and heating oil. Liquid pipelines also include carbon dioxide, coal slurry, anhydrous ammonia, natural gas liquids (NGLs), and petrochemical feedstock. NGLs and petrochemical materials are typically referred to as highly volatile liquids (HVLs), they are gases at atmospheric temperature and pressure, but liquids at pressure in the pipeline.[20]



Source: How Pipelines Make the Oil Market Work

To move these different products along the same pipeline, grades of the same products are "batched" together than sequenced through the same pipeline. A refined product or crude oil grade is injected into the line, followed by another product or grade, then another. Between the first and second product there is always a certain amount of intermixing at the point where the two products meet, this is called the interface. If the products are similar, such are two different grades of the same product, than the resulting mixture is added to the lower grade. If the products are dissimilar, such as gasoline and diesel fuel, the "transmix" or by product created will be put into a separate storage facility and reprocessed.[21]

The increase in different grades of products both regionally and seasonally has put pressure on pipeline capacity. For example, the Colonial Pipeline which carries refined products from Texas to New York carries up to 100 distinct grades of gasoline on annual basis. The advent of new product grades requires more batching and lessens pipeline flexibility. Due to the increase number of interfaces, more products are downgraded from

[20] *The Liquid Pipeline Industry in the United States: Where It's Been Where It's Going;* Richard A Rabinow, April 2004

[21] *How Pipelines make the Oil Market Work – Their Networks, Operations and Regulation*; Allegro Energy Group, December 2001

one grade to a lower grade as well as increased the number of transmix products needed to be reprocessed to meet required specifications and maintain product integrity.[22]

Scheduling and flow

Pipeline schedules are created months in advance. A shipper desiring to move heating oil from the Gulf Coast to the New York area knows the date ahead time on the particular pipeline and location of the injection. A shipper must "nominate" volumes or ask for a certain amount of space on a given pipeline on a monthly schedule. It isn't uncommon for tendered volumes to differ from nominated volumes. The pipeline operator is obligated to balance the pipe so last minute changes to volumes are essential. As long as shippers meet the required published conditions of service, pipelines can not refuse service to any shipper. If a shipper nominates more volumes then a line can accommodate, pipeline space is allocated via firm vs. interruptible transport contracts than via a pro rata system. As pipelines are regulated, space can not be allocated to the highest bidder, nor on a first come, first serve basis.[23]

During peak season, bottlenecks are likely to occur. Such bottlenecks invite competition from pipeline alternatives and other modes of transportation.[24] However, when bottlenecks occur several steps can be taken to increase the operational efficiency of an existing line, including raising the operational pressure, readjusting batch schedules, reducing down time through improvements in operations and maintenance practices, and employing new technology to allow for a higher flow rate. Owners also look for possibilities to add additional capacity such as converting different liquid product lines to meet new demand.[25] The need to allocate space also encourages capacity expansion.[26]

Rates, Tariffs & Regulation

Pipeline safety, environmental issues, operations, and pricing are all highly regulated on all US pipelines. On a state level, lines are subject to the same laws as other forms of commerce, as well as any regulations that are specific to pipelines such as the Public Service Commission or in some states the Transportation Railroad Commission. There are many government agencies involved but on a federal level The Department of Transportation (DOT) and Hazardous Materials Safety Administration regulate liquid

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[22] *How Pipelines make the Oil Market Work – Their Networks, Operations and Regulation*; Allegro Energy Group, December 2001

[23] *How Pipelines make the Oil Market Work – Their Networks, Operations and Regulation*; Allegro Energy Group, December 2001

[24] *How Pipelines make the Oil Market Work – Their Networks, Operations and Regulation*; Allegro Energy Group, December 2001

[25] *The Role of Energy Pipelines and Research in the United States: Sustaining the Viability and Productivity of a National Asset*; Cheryl J. Trench, 2006

[26] *How Pipelines make the Oil Market Work – Their Networks, Operations and Regulation*; Allegro Energy Group, December 2001

pipeline operations and the Federal Energy Regulatory Commission (FERC) closely regulates and approves rates charged for transportation along interstate pipelines.[27]

Pipelines provide a transportation service in exchange for certain rate, which is a small percentage of the final delivered cost of energy. Since 1906 the government has regulated these rates for oil pipelines. Rates have two components, a volume charge and a demand charge. The volume charge recoups the pipe's variable cost and the demand charge recovers its fixed price. Rates are not able to exceed a set annual amount per a given year and companies are unable to raise rates in response to short term market volatility. Rates are regulated by the FERC and are not directly tied to a commodity price. Companies must go through a lengthy process for tariff increases/decreases regardless of changes in supply and demand. In general, the tariff rate is based on a variation of a Cost of Service (COS) calculation.[28]

Infrastructure

Investment in the liquid pipeline industry is a demand responsive industry with little thought given to planning and forecasting future pipeline needs. There is scarce information available on future infrastructure needs from governmental, private, and commercial sources. Pipelines are only constructed once there is an established and continuous need.[29]

<u>Demand</u>

Permanent changes in the balance of supply and demand give way to the need for additional capacity. The US produces 8% of the world's oil supply but consumes 25% of it. The regions where oil is produced verse the regions with the most demand are often very far apart. Pipelines are responsible for 67% of domestic oil shipments and are the primary mode of transportation used for imports of crude from Canada, the top exporter for oil to the US. The key drivers of regional demand are population, established heating oil market in the Northeast, oil-fired peak units at East Coast utilities, refineries and petrochemical plants in the Gulf Coast and Midwest. Transportation is vital to oil distribution and the demand for oil is less sensitive to seasonal changes than natural gas as only 6 % of total demand is residential and commercial. Canadian oil sands production has increased the capacity needed to transport heavier crude to refineries in the Gulf Coast. Demand growth is expected to parallel the current growth forecast for total energy provided by the EIA. Two EIA key assumptions are (1) US GDP will grow 3% annually and (2) oil and gas prices will decline from high market prices over the next ten years and then increase. Oil prices in 2025 are expected to be around $54/barrel ('04 dollars) or

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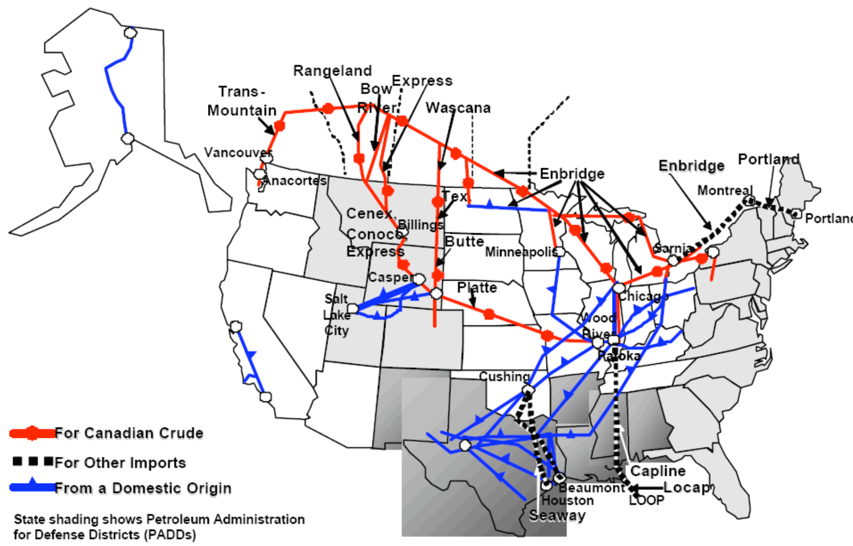
[27] *The Role of Energy Pipelines and Research in the United States: Sustaining the Viability and Productivity of a National Asset*; Cheryl J. Trench, 2006

[28] *The Role of Energy Pipelines and Research in the United States: Sustaining the Viability and Productivity of a National Asset*; Cheryl J. Trench, 2006

[29] *The Role of Energy Pipelines and Research in the United States: Sustaining the Viability and Productivity of a National Asset*; Cheryl J. Trench, 2006

$90/barrel (nominal dollars). The EIA excluded Arctic National Wildlife Refuge (ANWR) in its production forecasts due to its restrictions on oil development. However, if restrictions were lifted, there would be little change for the next decade but around 2015; Alaska could be the most important growth region for US oil.[30]



Source: How Pipelines Make the Oil Market Work

Through 2030, the US petroleum demand is expected to increase 9.5 million barrels/day (48%) with 2/3 of growth in transportation fuels. During that same time, inland crude production is expected to decline 900 thousand barrels/day, particularly in Texas, Louisiana, Oklahoma and the Rockies while the Gulf of Mexico production likely will increase by 500 thousand barrels/day. Refining capacity is expected to increase by 3.3 million barrels/day mostly in Texas and Louisiana, resulting in a demand increase of 4 million barrels/day and refined products up 6.3 million barrel/day.[31]

Supply

According to the EIA, by 2015 oil production will return to a long-term decline and by 2025 average below 5.0 MMB/d. Oil production is expected to make a regional shift where the Rockies, Southwest regions (New Mexico & West Texas) and the Deepwater Gulf of Mexico become the anchor areas and regions to the west and east diminish in importance. Currently, crude oil is the primary liquid fuel transported in the US but by 2025 the EIA predicts that crude drops from 2/3 to 1/2 of transported liquid. Additionally, supply of domestic non crude liquids is expected to grow by 70% between 2004 and 2025. The growth in the increase of other liquids is to due to coal-to-liquids plants, ethanol, and Refinery Processing Gain, rather than a drop in crude. By 2025, almost 2 out of every 3 barrels of oil consumed domestically will be from a foreign source. Crude will continue to be the most important component of petroleum imports. The refined products vs. crude increase appears contradictory on the surface with the total imports of finished/unfinished

[30] *The Role of Energy Pipelines and Research in the United States: Sustaining the Viability and Productivity of a National Asset*; Cheryl J. Trench, 2006
[31] *The Liquid Pipeline Industry in the United States: Where It's Been Where It's Going;* Richard A Rabinow, April 2004

products and blend stocks growing by half by 2025, however the refined products share of total imports minimally and the imported product share of total US oil supply is not expected to increase significantly. The EIA excluded Arctic National Wildlife Refuge (ANWR) in its production forecasts due to its restrictions on oil development. However, if restrictions were lifted, there would be little change for the next decade but around 2015; Alaska could be the most important growth region for US oil.[32]

Between 1996 and 2003 all refining capacity added was through expansion of existing plants. The EIA assumes continue financial and legal issues will remain resulting in most of the expected capacity growth to be through existing refinery facilities. In 2005, high gasoline prices gave rise to concerns about refining deficits and import dependence which triggered legislative moves for new construction facilities. Additional capacity, including product pipelines, is expected to be in today's refining centers, the Gulf Coast and Rockies due to increasing population. 3

Decade	Construction %
Pre 1940s	9%
1940s	13%
1950s	22%
1960s	13%
1970s	17%
1980s	9%
1990s	7%
2000+	>1%

From a pipeline perspective, one of the more important characteristic of future imports is how the products arrive, by land or by sea. For example, as previously mentions, Canada primarily uses land transportation to import its crude and NGLs. Canadian crude exports are expected to increase by 40% by 2025. For the first time, its crude oil is now being transported to refineries in the Gulf Coast. Ultimately, additional pipeline expansion to transport new supplies will be needed. 3

Future Infrastructure Needs

Assuming the forecast of changes in demand and supply are somewhat accurate, it is then reasonable to the forecast the infrastructure needs:

- Addition of trunk lines in the Gulf of Mexico (move increased production in Deepwater Gulf of Mexico to refineries)
- Addition of larger diameter shorter distance lines between marine terminals and gulf coast refineries (accommodate the growth in crude imports)
- Addition of crude trunk line capacity from Canada (accommodate Canadian imports to market)
- Rationalization of inland crude transmission and gathering systems from the older producing regions (as production declines)
- Addition of trunk lines capacity from Gulf Coast to the market
- Addition of crude gathering and truck line capacity in the Rockies to the market (Midwest)

[32] *The Role of Energy Pipelines and Research in the United States: Sustaining the Viability and Productivity of a National Asset*; Cheryl J. Trench, 2006

- Adjusting pipeline system to handle heavier or synthetic crude[33]

New Pipeline Construction

Once there is an established need, the decision to build a pipeline is really determined by a handful of factors; cost, revenues, competition, risk, and profitability. Companies must evaluate the cost to operate and maintain a new system and the revenues associated with it including regulated tariffs, and changes in volume (supply/demand) over time. Possible changes in competition in the future and the advent of additional capacity and business risks, both operating and regulatory, also need to be considered. The venture needs to be profitable, providing the investor an acceptable rate of return.[34]

Cost

In today's competitive transportation market, pipeline companies are driven to manage costs effectively in order to attract business and remain profitable. Shippers apply tremendous pressure on pipeline companies to maintain low tariffs by either reminding pipeline companies there are other transportation modes available, or by vigilantly challenge tariffs via a regulatory procedure when applicable. The largest cost to operate a pipeline is Outside Service expense (22% of total Operating and Maintenance cost). Within the last decade, companies have outsourced many services previously held in-house, allowing them to become more efficient and economical. Fuel and power expense is the second largest expense, accounting for 21% of total O&M costs, followed by salaries and wages at 14% and supplies and expenses at 9%. However, expenses associated with capital cost are based on the market cost of the pipe, equipment and construction of the facilities.[35]

Capital investment in pipelines has become more challenging with every project being required to stand on it own. In an intergraded energy company, a pipeline project has to compete for dollars along side higher IRR E&P investments. As the industry has shifted from integrated companies to MLP ownership, sources of capital have become more diverse. This new source of capital requires a clear understanding of risk vs return on investment. Rewards include a steady, long term cash flow at an acceptable rate of return (particularly for companies with lower cost of capital). However, new industry risks might make it more difficult to attract capital for the long term. In addition to the already existing business risks, new difficulty in obtaining permits and right-of-ways, operations in hard environments (deep water), potential new design requirements imposed on

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[33] *The Liquid Pipeline Industry in the United States: Where It's Been Where It's Going;* Richard A Rabinow, April 2004

[34] *The Liquid Pipeline Industry in the United States: Where It's Been Where It's Going;* Richard A Rabinow, April 2004

[35] *The Liquid Pipeline Industry in the United States: Where It's Been Where It's Going;* Richard A Rabinow, April 2004

operators, and the application of new technologies will prove most challenging in the future.[36]

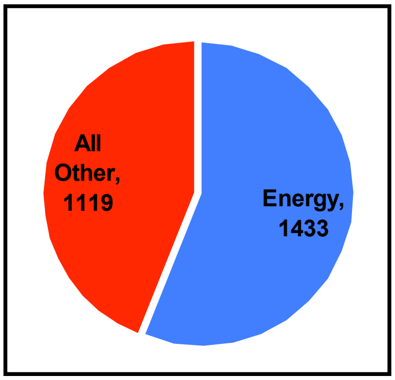
Potential Challenges to Growth

To accommodate pipeline growth suitable right-of-ways will need to be available. Land use issues will be essential to meet growing and changing demand and to meet the nation's needs for years to come. Securing right-of-ways may be a primary challenge to growing the infrastructure going forward. Early on right-of-ways were relatively easy to secure and pipes were located in less populated areas. As the nation has become increasingly more urbanized, securing rights-of-way have become a lengthy and expensive project, sometimes resulting in years of litigation, taking more time in court than the construction of the pipeline itself. Financial issues and safety concerns are the primary drivers to the extended time to secure right-of-ways. Competing interest and financial gains for a parcel of land coupled with concern regarding the devaluation of property once a pipeline run through it are huge obstacles. Safety issues are important and many people are hesitant about the proximity of a pipeline to their resident (NIMBY).[37]

[36] *The Liquid Pipeline Industry in the United States: Where It's Been Where It's Going;* Richard A Rabinow, April 2004

[37] *The Liquid Pipeline Industry in the United States: Where It's Been Where It's Going;* Richard A Rabinow, April 2004

5.3 Waterways, Ports and Terminals



Introduction

In 2004 roughly 2.5 billion tons of freight was shipped on US waterways. About 56% of the freight shipped or 1,433 million tons were energy related products like coal, crude petroleum and petroleum products. The remaining 44% of freight consists mainly of other bulk materials such as grains, aggregates, chemicals, metals and agricultural products.[38]

From 1984 to 2004 tonnage shipped via waterways has grown at a consistent rate of 1.7% per year. Over the same period, the mix between energy and other freight has been stable at 55-59% energy.[39]

The quantity of freight shipped via US waterways is small relative to other modes of transport. Waterways transported about 6% of the total tons of all freight shipped by all modes. Energy flows transported on waterways also makes up a small percentage of the total energy transported throughout the country. Roughly 3% of coal and 8% of petroleum liquids are transported via US waterways. Generally speaking, crude oil is transported via coastal waterways to major refinery systems in the Gulf, Atlantic and Pacific coasts where the crude oil is refined into various liquid petroleum products. Some of these liquid products are transported via inland waterways to consumer markets.

Nevertheless, waterways play an important role in the transport of energy and other goods, especially in multi-mode transport where waterways transport over half of all tons shipped by more than one mode. Plus most freight traded internationally continues to be transported by water. Waterways provide a competitive alternative for shipment of bulk materials that do not require time constrained delivery schedules. Waterways also provide significant public benefits beyond freight transportation including irrigation, hydropower, recreation and flood control.

Regulation/Jurisdiction

US laws governing domestic freight transportation by water were established by the Merchant Marine Act of 1920, commonly known as the Jones Act. In order to ensure a strong US merchant marine for both national defense and economic security, the nation's domestic waterborne commerce is reserved for vessels built in the US, owned and crewed by American citizens, and registered under the American flag.[40] The United States Army Corp of Engineers (USACE) has jurisdiction for the entire system which includes

[38] The U.S. Waterway System – Transportation Facts, Navigation Data Center, U.S. Army Corps of Engineers, December 2005, p. 2
[39] An Overview of the U.S. Inland Waterway System, IWR Report 05-NEIS-R-12, November 2005, p. 10
[40] Domestic Shipping, "Vital to the Nation's Economy, Security and Transportation", Maritime Administration

responsibility for operating and maintaining all waterway infrastructure needs. Common activities include constructing, operating and maintaining waterway dams and locks as well as dredging the waterway channels.

Federal funding for waterway projects include two trust funds: The Inland Waterways Trust Fund (IWTF) and the Harbor Maintenance Trust Fund (HMTF). The IWTF was first established through the Inland Waterways Revenue Act of 1978 which originally assessed a 10 cent per gallon tax on motor fuel used by barge operators. The fee was subsequently increased to 20 cents by the Water Resources Development Act of 1986 (WRDA-86). Half of all federal spending on capital projects for locks, dams and other inland waterway infrastructure were supposed to be drawn from the IWTF. Operations and maintenance expenses were to be part of the general fund.

The WRDA-86 also established a 12.5 percent tax on the value of cargo shipped into and out of US ports. This new revenue stream was to go into the newly established HMTF and used for O&M expenses for US harbors. Neither trust fund includes legislation ensuring that revenues paid into the trust funds would actually be spent on waterway projects. The harbor maintenance tax is being contested on several levels. In 1998, exporters no longer had to pay the tax because the US Supreme Court ruled that the tax was unconstitutional. Importers to the US continue to challenge the tax claiming it violates rules under the WTO. Support for user financing is low because there is no federal commitment to ensure monies generated by user fees are reinvested into waterway infrastructure.

Physical Description

US waterways consist of nearly 12,000 miles of commercially important, navigable waterways with 275 lock stations located at 230 lock sites.[41] The waterways reached their size and scope decades ago and there are no plans to expand the waterways geographically in any significant way. The US ACE divides the US waterways into four major parts:

- Atlantic Coast
- Gulf Coast, Mississippi River System and Antilles,
- Great Lakes
- Pacific Coast, Alaska and Hawaii.

Every state east of the Mississippi River has access to the waterway system and the combined system serves all but nine of the fifty states.[42]

Atlantic Coast

The Atlantic Coast waterway system includes the major New England waterways: the Chesapeake, Delaware Canal and the Cape Cod Canal; and series of channels over 700 miles long that extend from Virginia to Florida. While used primarily by recreational

[41] An Overview of the US Inland Waterway System, IWR USACE,1 NOV 2005, p. ii
[42] An Overview of the US Inland Waterway System, IWR USACE,1 NOV 2005, p. 1

boaters, the Atlantic Coast is an important set of waterways for delivering heating oil, gasoline and other energy products to the east coast.[43]

Gulf Coast, Mississippi River System and Antilles

The Gulf Coast, Mississippi River System and Antilles is the backbone of the US waterways comprising most of the inland river system. This system is divided further into three sub-systems

Mississippi River System (MRS)

The Mississippi River system consists of 9,000 miles of navigable waterways. The main rivers are the Mississippi, Illinois, Missouri and Ohio. The MRS stretches from Minnesota to the Gulf of Mexico. Over 700 million tons of goods are transported on the MRS every year. Coal is the largest commodity transported on the MRS making up about 25% of the total tons shipped. Coal is followed closely by Food and Farm Products at 23% and Petroleum and Petroleum Products at 21%.

Ohio River Basin System (ORB)

The Ohio River Basin system consists of 2,800 miles of navigable waterways. The main rivers are the Ohio, Tennessee, Cumberland, Monongahela, Allegheny, Green, Kanawha and Big Sandy. The ORB connects nine states: Alabama, Illinois, Indiana, Kentucky, Mississippi, Ohio, Pennsylvania, Tennessee and West Virginia. Nominally 275 million tons of goods are transported on the ORB every year. The ORB offers three major benefits: connection to the Mississippi River System, the Ohio River connects five other navigable waterways, and located next to large coal deposits. Coal makes up about 54% of all tons transported on the ORB system, followed by aggregate materials at 24% and petroleum and petroleum products at 6%.

Gulf Coast and Gulf Intercoastal Waterway System (GIWW)

The Gulf Intercoastal Waterway system contains 1,109 miles of navigable waterways. The GIWW is principally made up of the coastal waterway stretching from Brownsville, Texas to Key West, Florida and include various small river systems that penetrate the US along the Gulf Coast. Nearly 120 million tons of goods are transported on the GIWW annually. The primary commodity shipped is petroleum (48%) followed by chemicals (22%) and aggregates (18%).

Great Lakes

Sometimes referred to as the nation's "fourth" coast, The Great Lakes are made up of seven waterways linked by a dozen lock sites. About 350 terminals are located on US shoreline of the Great Lakes including six ports that rank in the top 50 US ports in terms of total tonnage. The Great Lakes are linked to the Atlantic Ocean by the St. Lawrence Seaway.[44]

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[43] The Maritime Transportation System and the Federal Role, Transportation Research Board, 2004, p. 31

[44] The Maritime Transportation System and the Federal Role, Transportation Research Board, 2004, p. 32

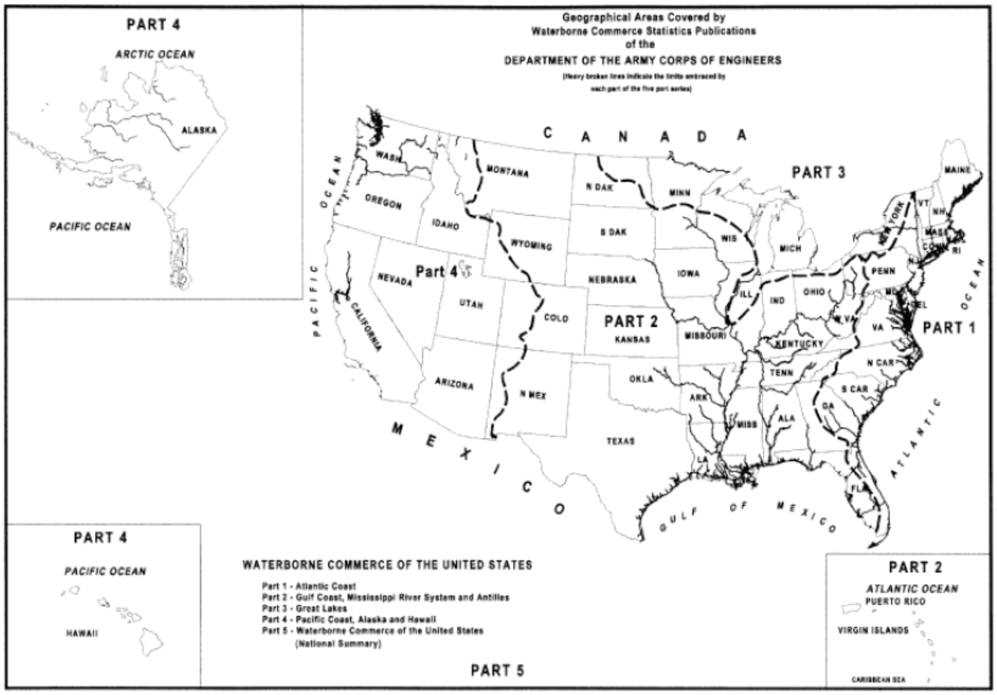
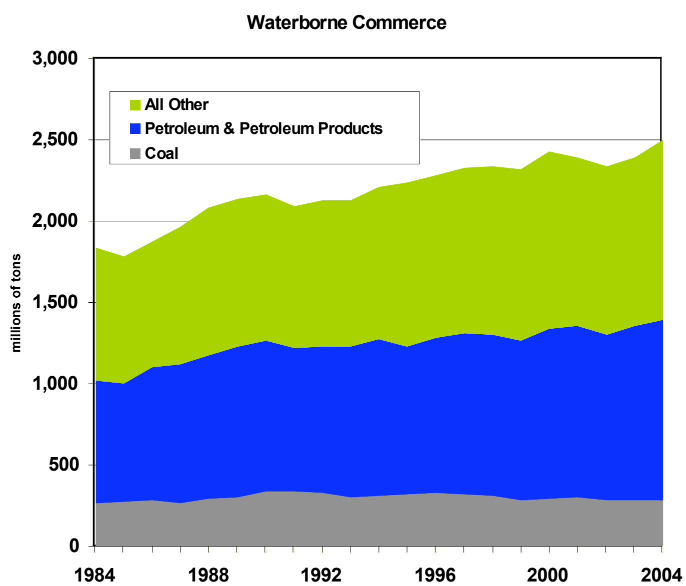


Figure 1: US Navigable Waterways[45]

<u>Pacific Coast, Alaska and Hawaii</u>

The Pacific Coast System (PCS) contains nearly 600 miles of navigable waterways and eight locks on the Columbia, Snake and Willamette rivers. The PCS main products include agricultural, petroleum, chemicals and primary manufactured goods. Shipments between Alaska and Hawaii and West Coast ports are important long haul routes for both states.[46]



Current Throughput

The US waterways transported roughly 2.5 billion tons of goods in 2004. Tons shipped have grown steadily at an average rate of 1.7% per annum. Coal shipments have been relatively static over the past 20 years with only a 0.3% average growth rate while petroleum liquids and all other freight experienced steady growth of 1.9% and 1.6%, respectively. The vast majority of goods transported are bulk goods like petroleum liquids, coal, grains, aggregate

[45] An Overview of the US Inland Waterway System, IWR USACE,1 NOV 2005, p. 3
[46] An Overview of the US Inland Waterway System, IWR USACE,1 NOV 2005, p. iv-v

materials and chemicals. The following table provides a list of the primary commodity types shipped by waterways in 2004.

Commodity	**Millions of Tons**
Crude Petroleum	616
Petroleum Products	511
Coal and Coal Coke	306
Food and food Products	266
Sand and Other Aggregates	225
Chemicals and Fertilizers	180
Iron ore, iron, non-ferrous ore and scrap	107
Manufactured Goods	90
Primary Metal Products	70
Primary Non-metal Products	64
Lumber, Logs, Wood Chips and Pulp	45
Total	2,480

Source: 2004 Region to Region Public Domain Data Base, Waterborne Commerce Statistics Center

As the table shows energy commodities dominate the waterways on a tonnage basis. Crude petroleum, petroleum products and coal make up 56% of the total waterborne tons shipped in 2004. The mix between energy products and other commodities has been consist for the past 20 years, with energy maintaining a range of 55 – 59% of the total tons shipped via waterways.

Crude Petroleum

Not surprisingly waterborne crude petroleum predominately originates from overseas. In 2004, 82% of all crude petroleum shipped on US waterways originated from outside the United States. The table below illustrates that there is a significant concentration of crude petroleum delivered to the Gulf Coast. Almost two-thirds of the overseas crude petroleum was destined for the Gulf Coast and the quantities of crude petroleum shipped to the Gulf Coast are nearly 4 times greater than the second most common destination, the Atlantic Coast.

Destination of Overseas Crude Petroleum, 2004

Destination	**Millions of Tons**
Gulf Coast	322
Atlantic Coast	82
Pacific Coast	39
Other	64
Total	507

Source: 2004 Region to Region Public Domain Data Base, Waterborne Commerce Statistics Center
Note: Other includes Hawaii, Alaska and unknown

Alaska and Canada are a distant second and third to overseas sources of crude petroleum. Alaska provides about 8% of the crude petroleum delivered via the US waterways while Canada provides about 4%. The remaining 6% of crude petroleum traveling US waterways have the same origin and destination region. For example, about 18 million tons of crude petroleum originating in the Gulf Coast travels on Gulf Coast waterways to a destination in the Gulf Coast. The same is true for the Atlantic and Pacific coasts as well as other regional waterways.

The majority (91%) of Alaskan crude was destined for the Pacific coast about evenly split between the Washington/Oregon and California coasts. The balance of Alaskan crude shipped by waterway either remained in Alaska or was destined for Hawaii. Over 90% of the crude petroleum originated in Canada traveled down the eastern seaboard to the North and South Atlantic coasts.

Petroleum Products

Over 500 million tons of petroleum products were transported on US waterways in 2004. Petroleum products travel along all US waterways but primarily originate from the Gulf Coast and from Overseas. The following table identifies the top origin and destination regions:

Crude Petroleum Shipments on US Waterways
Top Origins and Destinations

Origin	Millions of Tons	Destination	Millions of Tons
Gulf Coast	185	Gulf Coast	185
Overseas	149	Atlantic Coast	177
Atlantic Coast	80	Overseas	59
Pacific Coast	32	Inland Areas	32
Inland Areas	21	Pacific Coast	28
Other	24	Other	10
Total	491	Total	491

Source: 2004 Region to Region Public Domain Data Base, Waterborne Commerce Statistics Center

The data show that the US both exports and imports significant quantities of refined products to and from overseas. The data likely reflects the market situation in which the US is long fuel oil and short gasoline, while some overseas markets are long gasoline and short fuel oil. Overall the US is a net importer of petroleum products.

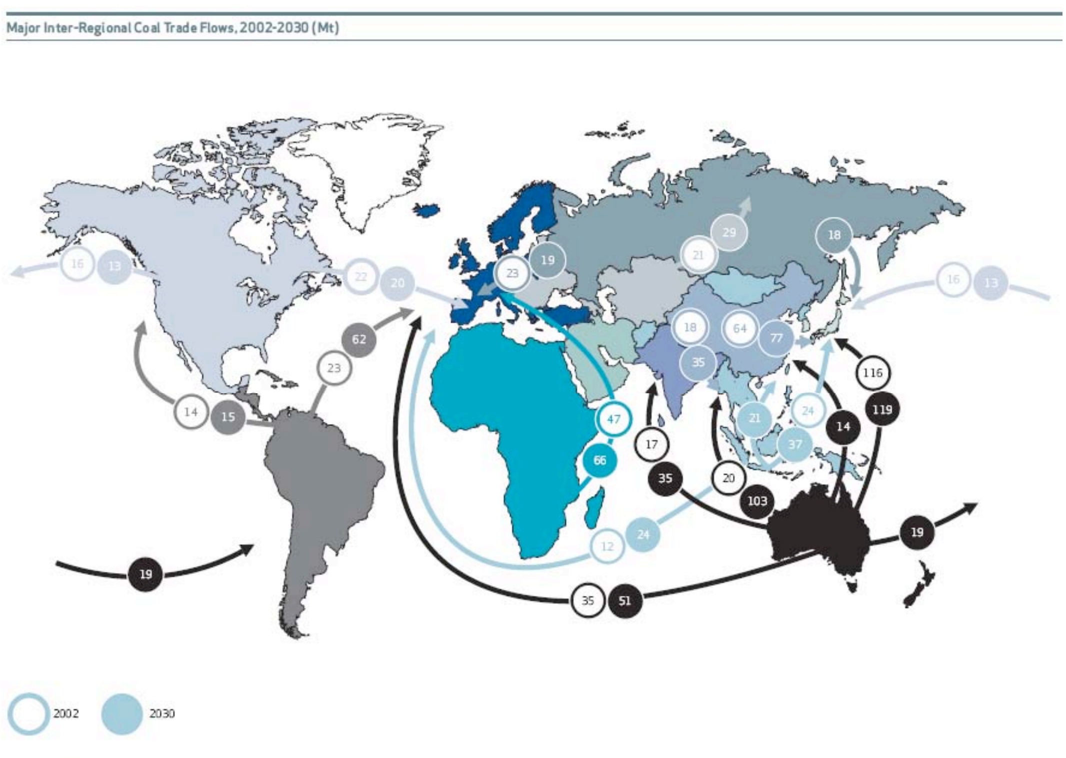
Coal and Coal Coke

Coal and coal coke ("coal") are primarily shipped relatively short distances within a single waterway system. About 126 million tons or 44% of the coal transported on US waterways originates from the Ohio River System. Of that amount, 117 million tons or 93% of the coal transported on the Ohio River System was destined for a port within the Ohio River System. The table below shows for each origin the top destination and the tons of coal delivered to that destination. For the top 3 origins, representing 72% of the total coal shipped by waterway, the prominent destination for their coal was a port within their own region.

Coal Shipments on US Waterways Top Origin and Origin Destinations			
Origin	**Millions of Tons**	**Top Destination**	**Millions of Tons**
Ohio River System	129	Ohio River System	118
Great Lakes System	39	Great Lakes System	21
Gulf Coast	38	Gulf Coast	26
Atlantic Coast	34	Overseas	26
Overseas	28	Gulf Coast	14
Other	19	Ohio River System	8
Total	287		
Source: 2004 Region to Region Public Domain Data Base, Waterborne Commerce Statistics Center			

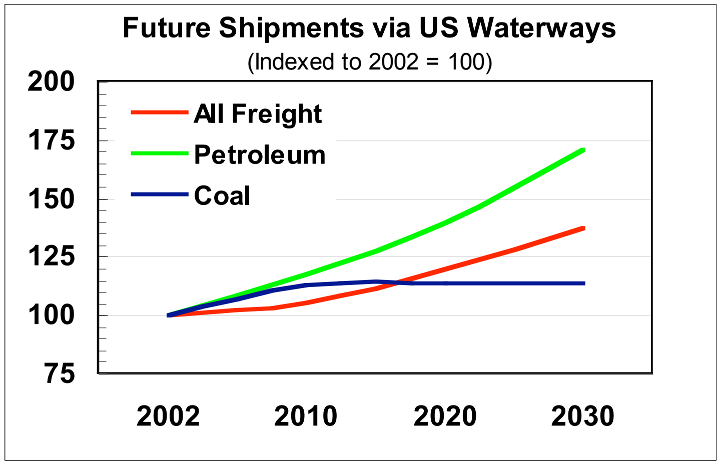
Foreign Trade of Coal

Roughly 10% of coal transported on US waterways originates from overseas locations the majority of which is destined for the Atlantic and Gulf coasts. Nominally 12% of the coal transported on US waterways is destined for overseas, 70% of which originates from the mid-Atlantic region.



Future Throughput

Publicly available forecasts for freight transported on domestic waterways are not generally available. The FHWA Freight Analysis Framework (FAF) includes a forecast for freight shipments on waterways, but its forecasts only include a portion of the total freight shipped by water. For example, the FAF model only includes about 700 million tons of freight shipped by waterways in 2002. However, according to data from the Army Corp of Engineers total shipments of freight on waterways totaled 2.3 billion for 2002.[47] So the FAF is modeling only a portion of the waterways freight and is not a good tool for forecasting total freight shipments on US waterways. Even so, the growth rates projected by the FAF model may be instructive.



The chart above shows future flows of coal, petroleum and all freight indexed to the tons shipped in the year 2002 from the FAF model. The FAF model predicts a relatively rapid growth in coal shipments through 2010, followed by a leveling off for the remainder of the forecast period. The FAF model shows a consistent 1.9% growth for petroleum – both crude and finished products – through 2030 which is inline with historical trend. The forecast for all freight is projected to average 1.1% growth per year through 2030 which is significantly below the historical rate of 1.7% per year.

There are a few older public and proprietary (Global Insight) forecasts available. These forecasts have similar growth rates as the FAF model. Older forecasts by the US ACE are shown in the table below:

Forecasts of Long-term Annual Growth Rates[48]

Commodity	USACE 1998[a]	USACE 2002[b]	FAF 2006[c]	1984 – 2004 Actual[d]
Coal	1.1	0.2	0.5	0.3
Petroleum	1.0	0.5	1.9	1.9
All Freight	1.3	1.0	1.1	1.7

[a]Forecast only for the Inland Waterway System (1995/1998 – 2020); [b]Forecast only for the Upper Mississippi River System 2000 – 2025; [c]Forecast for the Total US Waterway System 2002 – 2030; [d]Based on data from the US ACE Waterborne Commerce Database

47 An Overview of the US Inland Waterway System, IWR USACE,1 NOV 2005, Table 1-2, p. 10

48 The Marine Transportation System and the Federal Role, Special Report 279, Transportation Research Board, 2004, p. 57-58

The table indicates a dramatic range from one forecast to the next which highlights the difficulty in forecasting maritime transportation demand. There are many factors that potentially influence demand that cannot be predicted or planned. Examples include new technologies, changes in consumer preferences, changes in trade policies and unpredictable shocks such as a lasting drought, major political shifts or war.[49]

It is difficult to assess whether current forecasts of waterway transportation predict low growth because demand is expected to be low or whether there is an expectation among forecasters that waterway infrastructure is limited and investments will not be made to allow for greater demand growth.

Tankers and Barges

While the US waterways provide a path for commodities to travel to their destinations, it is the tankers and barges-tugs that actually provide the means of transport. The tables below provide recent growth in domestic and foreign tanker capacity.

Tanker Capacity Calling at US Ports (DWT in thousands)

	1998	1999	2000	2001	2002	2003	2004	2005
Domestic	299,919	274,067	268,317	268,050	246,177	273,399	248,801	267,793
% double hull	16%	21%	27%	31%	38%	40%	49%	54%
Foreign	856,547	896,113	983,737	1,006,401	956,037	1,065,970	1,116,639	1,181,830
% double hull	44%	47%	54%	59%	69%	75%	78%	89%
Total	1,156,466	1,170,180	1,252,054	1,274,451	1,202,214	1,339,369	1,365,440	1,449,623
% double hull	37%	41%	48%	53%	63%	68%	73%	83%

Source: Tank Vessel Market Indicators, July 2006, US Maritime Administration

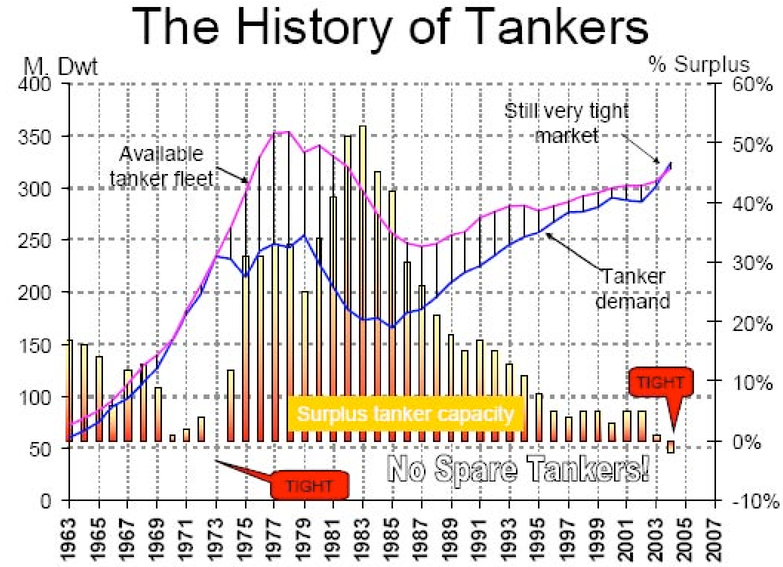
United States Cargo Tankers and Towboats

	1985	1990	1995	2000	2003	2004
Tankers						
No. of Vessels	232	213	178	135	104	103
Horsepower (thousands)	3,282	2,820	2,219	1,697	1,259	1,222
Cargo Capacity (millions of short tons)	14.6	12.7	9.3	6.7	5.2	5.3
Towboats						
No. of Vessels	4,954	5,210	5,127	4,995	5,172	5,314
Horsepower (thousands)	8,030	8,710	9,108	9,348	9,834	10,012
Barges, Tanker						
No. of Vessels	4,252	4,003	3,985	4,011	4,031	4,069
Cargo Capacity (millions of short tons)	10.8	10.8	11.2	11.7	11.9	12.2

Source: Waterborne Transportation Lines of the United States, Volume 1 - National Sumamaries, Calendar Year 2004, Institute for Water Resources US Army Corp of Engineers, p. 6

Recent history of tanker capacity follows capacity of other forms of infrastructure. Significant over capacity developed in the early 1970s and the industry continued to

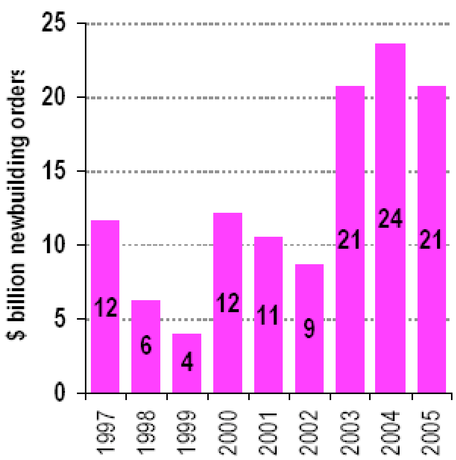
[49] The Marine Transportation System and the Federal Role, Special Report 279, Transportation Research Board, 2004, p. 59-60



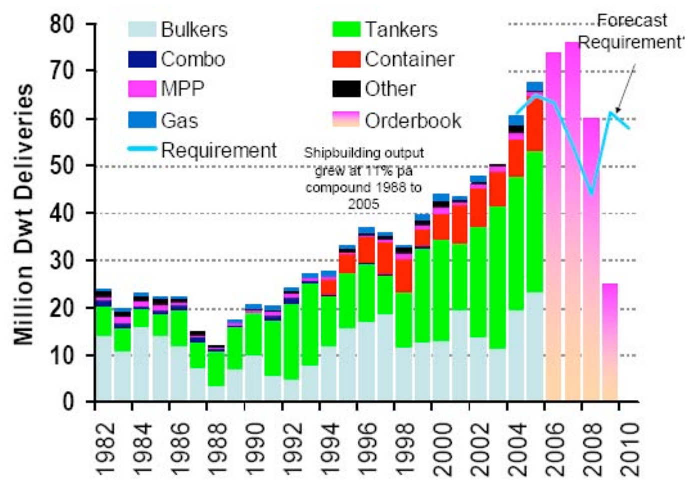
experience surplus capacity market for many years. Tight surplus began to develop in the mid 1990s, however, industry was slow to respond.

Source: Stopford, Martin, "The Tanker Market: Back to the Future", Intertanko Singapore Event, March 2006, p. 10

Tanker Deliveries



Tanker New Orders



The delay in industry response was, in part, due to the long history of over-capacity created cautious mindset with regard to investments in new capacity. Industry needed assurance that there would be a sustained tanker demand before committing to firm tanker orders. While the tanker market continues to be tight, tanker surplus continues to be slightly positive. The charts above indicate a significant recent response to the tight tanker market. New orders have more than doubled for the 2003-2005 time frame compared to recent history.

Near-term shortages of tanker and barge capacity are likely, however, there do not appear to be long-term constraints to ship capacity. The double hull conversion is well underway and expected to meet the 2015 deadline. Typically incremental additions to the Tanker and barge fleet are made as demand is identified. Typical lead times for new barges and tankers range from 12-36 months.

Two issues related to tankers and barges are conversion from single hull vessels to double hull vessels and the trend of building larger vessels with deeper drafts. The Oil Pollution Act of 1990 required many changes to make oil shipments environmentally safer. Among these changes was a plan to phase out all shipment of oil cargoes in single-hull vessels in US waters from 1995 through January 1, 2015. The act phases out single-hull tank vessels over time, with the first phase-outs occurring in 1995 and the last in 2015. The act based each vessel's specific phase-out deadline on the vessel's age, gross tonnage, and hull configuration. Generally, older, larger vessels without double sides or double bottoms were given earlier phase-out deadlines, while newer, smaller vessels with double sides or double bottoms have later deadlines.[50] International laws passed by several nations have similar requirements and deadlines.

Currently 56% of the 6,042 global tanker fleet is double hulled. The industry is aggressively pursuing the 2015 target with over 1,300 new tankers on order.[51] Current projections indicate the industry is on target to meet capacity requirements in 2015. In addition, the legislation allows for the use of single hull tankers after 2015 in the event double hull tankers are in short supply. Therefore, the conversion to double hull tankers, while still a major issue for the industry, it seems the conversion is being managed proactively and no capacity constraints due to double hull conversion are expected at this time.

Tanker economics are driving companies to build larger and larger ships. The growing size of ships come with wider beams and deeper drafts which require deeper dredging of waterways and ports. US ACE tracks the number of constrained ports of call due to draft depth. In the year 2000, the top 15 US coastal ports had nearly 70% of the constrained calls. In that year 8,868 calls were constrained out of a total 14,401 tanker calls to the top 15 ports, representing 60% of all calls.[52] Industry deals with these constraints by lightering the larger vessels. Lightering is the practice of off-loading product from a VLCC/ULCC into a smaller vessel that meets the draft requirements of the particular

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[50] As US Single-Hull Oil Vessels Are Eliminated, Few Double-Hull Vessels May Replace Them, United States General Accounting Office, April 2000, GAO/RCED-00-80, p. 6
[51] Tank Vessel Market Indicators, MARAD Office of Statistical and Economic Analysis, July 2006, p. 8
[52] National Dredging Needs Study of US Ports and Harbors: Update 2000, IWR Report 00-R-04, May 2003, Appendix C

destination port. USACE has an investment plan forecast out to 2020 which alleviates some of these constraints. Based on their current plan they expect to reduce constrained calls in the top 15 ports to 7,618 calls or 40% of the total calls to the top 15 ports. Constrained calls are expected to continue to be an issue going forward, investments by the US ACE should keep the problem at a manageable level and should be no more problematic than today provided US ACE maintains funding for these projects according to their investment plan.

Ports

There are 9,188 ports[53] in the waterway system, of which 4,869 facilities are considered deep-water. The largest ports are located along coastal waters accounting for 9 of the top 10 ports in terms of tons shipped. Despite the large number of ports, there is a significant concentration of tonnage shipped within the US port system. The 10 largest ports handle 48% of the total tonnage and the top 50 ports handle 92% of the total tonnage.

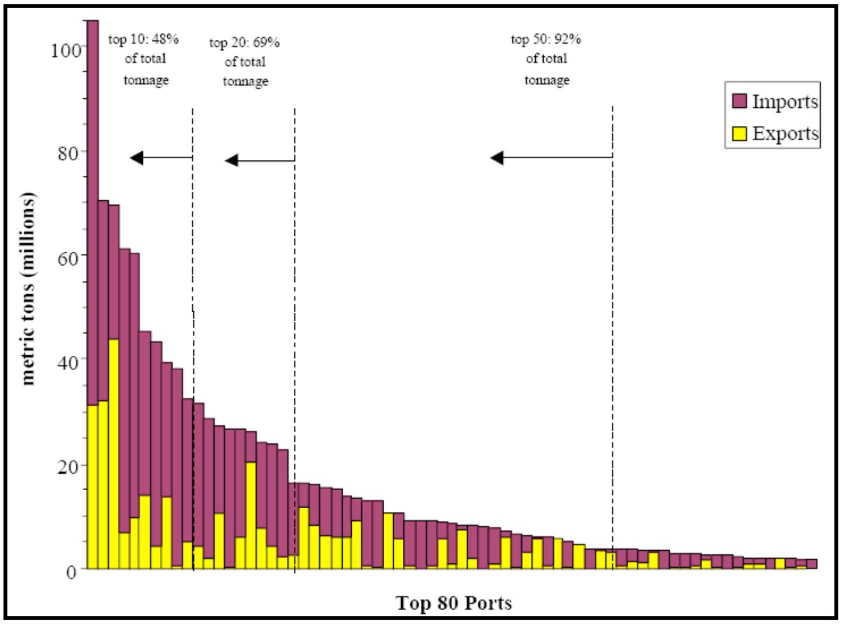

Figure 2: Tonnage Distribution for US Ports[54]

Port capital expenditures reflect this trend as well. In 2003, 77% of public port capital expenditures were allocated to the top 10 ports.[55] The major focus in recent years for port development has been on the shift toward container shipments. Nearly half of all expenditures in 2003 were directed toward specialized general cargo which includes container, roll on/roll off and auto facilities. The following table provides a summary of 2003 public port expenditures:

Public Port Expenditures, 2003

Category	Expenditure ($mm)	
General Cargo	163	9.7%
Specialized General Cargo	820	48.8%
Dry Bulk	23	1.4%
Liquid Bulk	11	0.7%
Passenger	82	4.9%
Infrastructure	192	11.4%
Dredging	263	15.7%
Other	127	7.5%
Total	$1,681	

Source: US Public Port Development Expenditure Report, MARAD Office of Ports and Domestic Shipping, November 2005, p. 4

Intermodal Container Shipments

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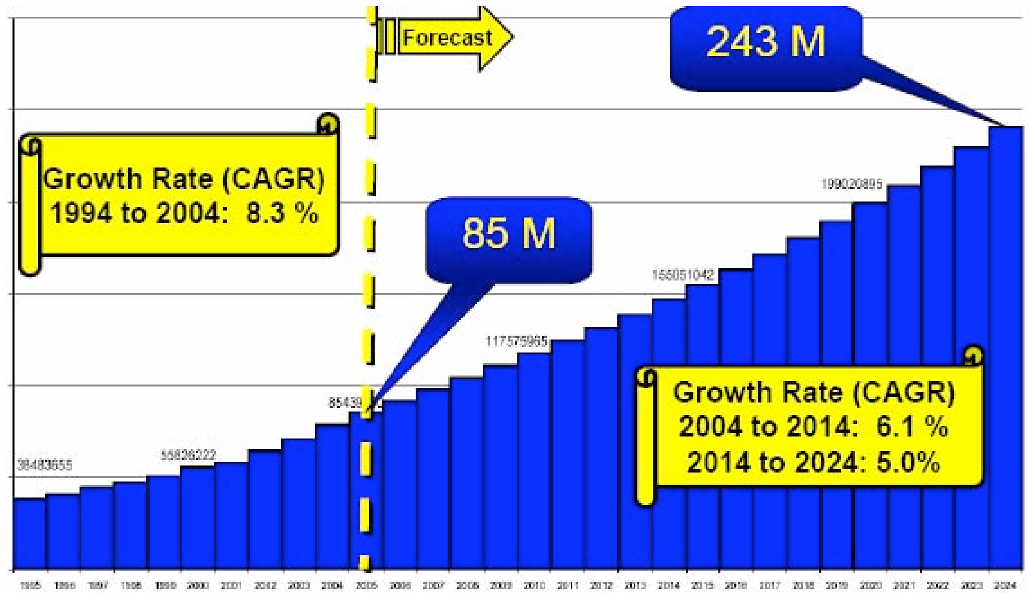
[53] An Overview of the US Inland Waterway System, IWR USACE,1 NOV 2005, p. 4

[54] National Dredging Needs Study of US Ports and Harbors: Update 2000, IWR USACE, May 2003, p. 63

[55] US Public Port Development Expenditure Report, MARAD Office of Ports and Domestic Shipping, November 2005, p. 8

While not directly related to the shipment of energy commodities, the recent shift in shipping merchandise in intermodal containers has far-reaching effects on waterway infrastructure as well as other transportation modes. The past two decades have seen a massive increase in container traffic. In the next two decades, container shipments are projected to continue rapid growth.



Source: Vickerman, M. John, "Keeping Our Trade Doors Open: East Coast Port & Intermodal Capacity Assessment", June 2006, p. 18

The recent impact is that the singular focus of waterway funding has been to enable ports and other waterway infrastructure to meet future container traffic. The concern for energy commodity shipments is the potential neglect of bulk handling facilities and the potential displacement of energy shipments by container traffic.

Constraints and Bottlenecks

Constraints and bottlenecks are difficult to quantify in any real systematic way. The following excerpt from the Transportation Research Board's Special Report 279, "The Marine Transportation System and the Federal Role" published in 2004 (pages 134-135) describes the situation best:

> Various databases and sources of information are available to measure and monitor the performance of parts of the US waterway system. For the most part, however, the databases are disconnected from one another and are designed to meet specific legislative and program requirements. The data are seldom used to address the system wide issues that decision makers face in allocating resources and responsibilities to the various federal programs in support of marine transportation, and they are not

> always well suited to this purpose. Much of the information gathered by industry and government on system performance and needs is based on narrowly construed surveys of users, which do not provide a complete and objective assessment. The absence of system wide performance data and the lack of efforts to bring such information together have hindered evaluation of the critical needs facing the marine transportation sector. Such information is needed to guide and assess the effectiveness of federal programs in furthering marine safety, environmental protection, commerce, and national security.

With that said, there are several qualitative issues raised in several reports on waterway infrastructure:

The average age of all operating locks is 55 years. Most of the locks in place are 600 feet in length or less which is relatively small compared to modern tow capabilities which often reach 1,200 feet in length. Smaller locks add greatly to the average delay time for towboats.

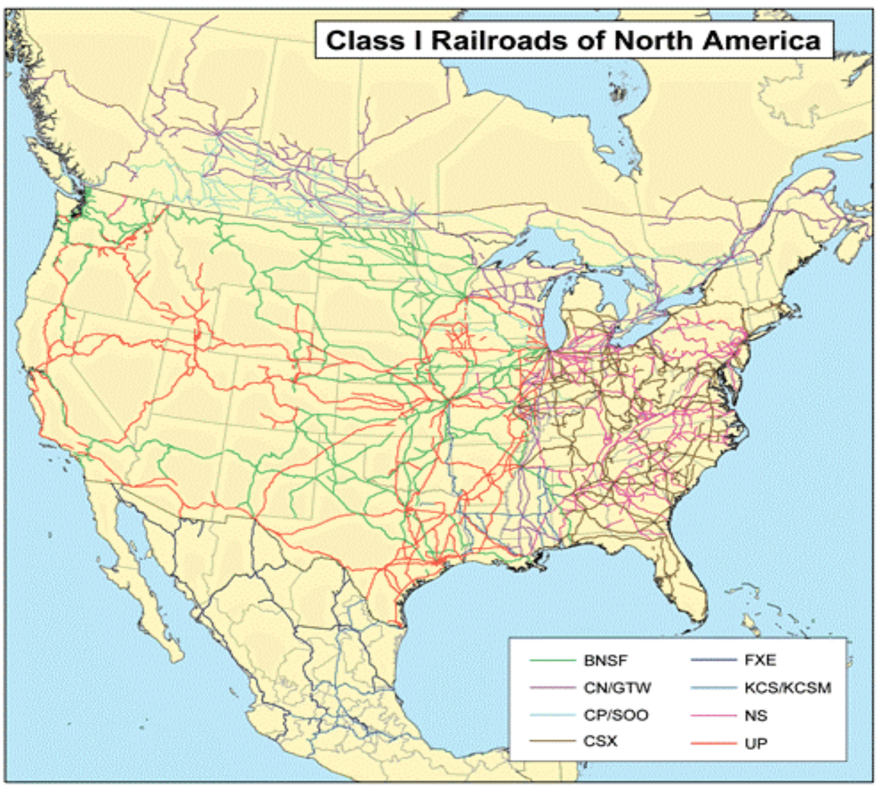
Industry is currently experiencing tight tanker capacity. Conversion to double-hull tankers is adding to the tight supply situation, however, this is likely a short-term issue as new tanker capacity is projected to come online to meet double-hull capacity requirements.

The drive to build larger ships is stressing the in-place infrastructure. Both length and depth of ships and barges are reaching limitations due to existing port and lock requirements. Dredging costs are likely to increase with the increase in ship draft.

The natural characteristics of the waterways themselves make it difficult to expand capacity in a meaningful way without significant capital expenditures.

5.4 Railways

There are many issues that are facing the railroad industry in North America, but none more prevalent than the capacity constraints which are affecting suppliers that are reliant on railroads for transportation. The freight rail system is a massive system of tracks and locomotives that carries 10 percent of the nation's tonnage, 40 percent of intercity ton-miles, and six percent of freight value[56]. Ever since the Staggers Rail Act of 1980 deregulating the railroad industry, there has been a major consolidation of Class I railroad companies in North America, dropping from 14 in 1990 to 7 in 2005[57]. The railroad industry has also reduced every aspect of their operations by cutting 35 percent less track, 32 percent fewer locomotives, 27 percent fewer railcars, and 60 percent fewer employees, but there has been an increase of over 50 percent freight shipments across North America[58]. There was a long period of excess capacity that the railroad industry was facing, but times have changed and there has been a major constraint on capacity across North America. The domestic and international freight tonnage is expected to increase by 67 percent by 2020[59], which will put a major strain on the rail industry to maintain their current market share.



Railroads are a major source of transportation in North America moving 42 percent (measured in tons of miles) of America's freight, which ranges from coal to farm

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[56] *Freight – Rail Bottom Line Report* p.1
[57] 2004 FRA Freight Study
[58] John Vickerman "North American Trade and Transportation Tends" presentation slide 79.
[59] *Freight – Rail Bottom Line Report* p.45

products, oil to automobiles, and chemicals to pulp and paper. According to the Association of American Railroads (AAR) railroads make up a 201,854 mile network across North America, and of that 171,061 miles are located in the United States, as of 2005[60]. Class I rail carriers comprise 93 percent of total rail freight revenue and operate 68 percent of industry miles operated, so for the purposes of this report it will focus on the seven Class I railroads, which reflects the industry very closely. The seven Class I rail companies according to the Surface Transportation Board (STB) are Union Pacific (UP), BNSF Railway, CSX Transportation, Norfolk Southern Railway (NS), Canadian National Railway (CN), Canadian Pacific Railway (CP), and Kansas City Southern Railway Company (KCS). In 2005 Class I railroads carried over 1.8 billion tons in freight and had over $46 billion in gross revenue, while having 1,287,920 freight cars in service.

According to the Congressional Budget Office's (CBO) report "Freight Rail Transportation: Long-Term Issues" the demand for freight transportation "is derived from the demand for the goods themselves. No intrinsic values, or utility arises from moving a trainload of coal… rather, the value of the transportation derives from the value of consuming or using the good at its destination"[61]. Railroads deliver many different products and the AAR breaks down the segment revenue and tons shipped below.

Type of Freight Carried 2005 Class I[62]

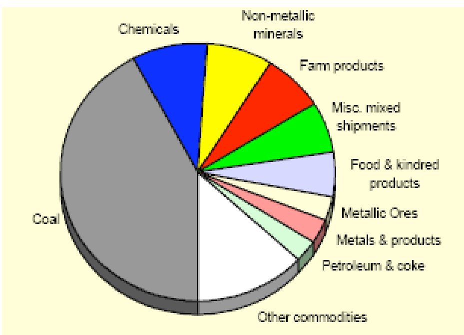
Commodity Group	Tons Originated (000)	Tons Originated % of Total	Gross Revenue (million)	Gross Revenue % of Total
Coal	804,139	42.4 %	$9,393	20.1 %
Chemicals & Allied Products	167,199	8.8 %	5,509	11.8 %
Non-Metallic minerals	145,697	7.7 %	1,293	2.8 %
Farm Products	140,441	7.4 %	3,628	7.8 %
Misc. Mixed Shipments	119,835	6.3 %	6,998	15.0 %
Food & Kindred Products	102,191	5.4 %	3,253	7.0 %
Metallic Ores	59,941	3.2 %	485	1.0 %
Metals & Products	57,851	3.0 %	1,789	3.8 %
Petroleum & Coke	55,611	2.9 %	1,424	3.0 %
Stone, Clay & Glass	55,231	2.9 %	1,505	3.2 %

[60] AAR "North American Freight Railroad Statistics" p. 1
[61] CBO "Freight Rail Transportation: Long-Term Issues" p. 3
[62] AAR "Class I Railroad Statistics" p. 3

Other	190,585	10.0 %	11,466	24.5 %
Total	**1,898,721**	**100 %**	**$46,743**	**100 %**

The main source of revenue for the railroad industry is coal, comprising over 42 percent of their shipments and 20 percent of their gross revenue. Coal is primarily used in the United States to generate power at coal-fired plants. Coal represents approximately half of all U.S electricity generation, and the railroads are in charge of over two thirds of U.S. coal shipments[63]. According to the *Freight Analysis Framework* (FAF) produced by the Federal Highway Administration, the expected growth from 2002 – 2035 for coal shipments is 100 percent driven by the increased demand for more electricity and new coal-fired plants being built across the U.S.

2005 Class I Railroad Tons Originated



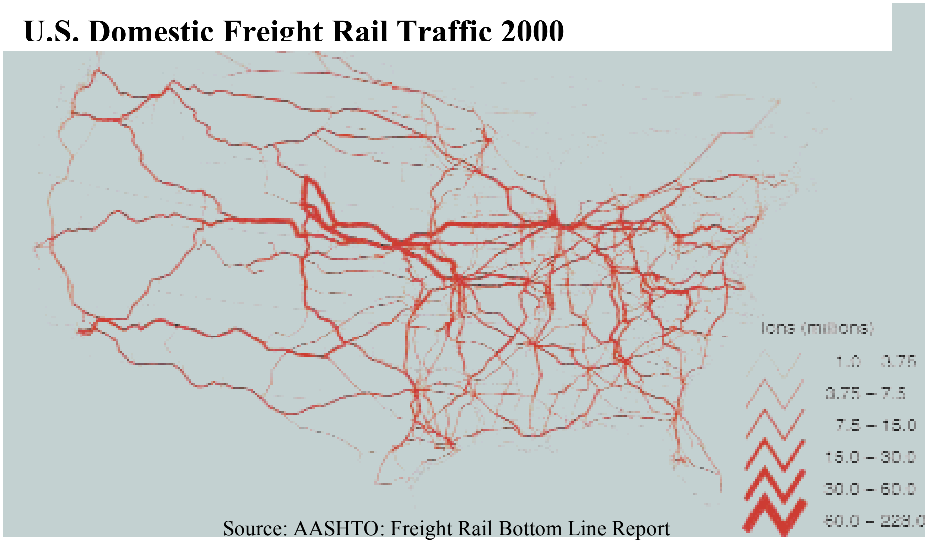
Source: AAR "Class I Railroad Statistics"

Petroleum & coke products represent a much smaller portion of the freight rail industry with only 2.9 percent of their total tons shipped, representing 3.0 percent of their total revenues. Petroleum & coke companies do not ship the majority of their petroleum products through railroads, because it only represents 21.6 ton miles (2.39 percent) compared to pipelines, which represents 599.6 ton miles (66.44 percent), in 2004[64]. The FAF expects petroleum freight shipments to grow 127 percent from 2002 – 2035 which signifies a 130 million ton increase in shipments.

The railroad industry is facing a major capacity crunch and has been forced to spend tremendous amounts of capital expenditures in order to meet the growing demand and to reduce the effects of bottlenecks. There have been several studies recently exploring the capacity constraint, including a report written by the American Association of State Highway and Transportation Officials (AASHTO) called the *Freight- Rail Bottom Line Report*. This report states that, with the expected growth in demand for rail transportation and what the railroads have currently been spending on investment, they will not be able to maintain their current share of the freight market[65]. U.S. railroads typically spend $15 billion to $17 billion per year on capital and maintenance expenses, representing an average of 17.8 percent of total revenue compared to a 3.5 percent average for all manufacturing companies in the U.S. Over the past 25 years railroad companies have invested over $360 billion in capital spending and there is still an estimated $200 billion more needed to facilitate enough capacity to meet the expected demand. Of the

[63] AAR Overview of U.S. Freight Railroads p.3
[64] Association of Oil Pipe Lines June 14, 2006
[65] *Freight – Rail Bottom Line Report* and CBO "Freight Rail Transportation: Long-Term Issues" p. 3

$200 billion, $40 billion to $60 billion is an unfunded annual need for freight-rail infrastructure[66].



Source: AASHTO: Freight Rail Bottom Line Report

As of 2005, Class I railroad companies own and operate 95,830 miles across North America, which is around 35 percent less than what existed before the Staggers act of 1980. The decreased amount of track miles coupled with the increases in freight transportation has caused major bottleneck areas around the U.S. Bottlenecks are created when there is too much freight and not enough trains, or there are not enough lines of track to allow trains to utilize it efficiently. Coal companies are facing bottleneck issues across the U.S., primarily in the Powder River Basin (PRB) of Wyoming[67]. Bottlenecks on the rail systems are the most important constraint on the amount of PRB coal that can be supplied to generators in the East[68], and the inability of railroads to meet demand for coal shipments has caused states, like Georgia, to seek international sources, such as Columbia or Indonesia[69]. Major bottlenecking issues have increased dramatically at ports around North America due to the rise in intermodal traffic. The increased demand for international goods, especially from China, will increase the container tonnage in America's ports by two or three times by 2020. The increased demand for intermodal goods combined with the expansion of the Panama Canal could potentially result in capability constraints for North America's East Coast ports which would also constrain the connectivity for rail shipments in the surrounding hinterland[70]. Another cause for bottlenecks, is the congestion caused when multiple railroads, commuter and freight, converge on a major city. Chicago has been a major bottleneck for railroad companies for many years, but it has also been a huge source of output for the industry. The Chicago area

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[66] AAR Importance of Adequate Rail Investment p. 1
[67] The U.S. Coal Review "When improved service lags demand, PRB must be at issue" Section No. 1612 September 18, 2006.
[68] Sutherland, Timothy "More Rail Capacity Needed for PRB Coal" Hart Energy; October/November 2005.
[69] Energy Washington Week "Coal Supply Concerns Jumpstart Congressional Rail Reform" Vol. 3 No.22
[70] Ashar, Asaf "Long-Term Development Trends of US Ports" National Ports and Waterways Institute; December 21, 2004.

contains 2,796 miles of track and has over 37,500 rail cars per day travel through the area, which is expected to increase to 67,000 by 2020[71]. The major freight-rail gateways and corridors that are currently thought to be most at risk because of congestion are the following[72]:

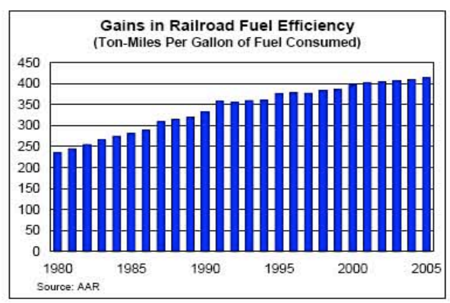
- The **Chicago rail hub**, which is critically important for freight-rail traffic moving from Pacific ports to Midwest and East Coast markets, and Midwest exports moving to U.S. and global markets;
- The **Mid-Atlantic rail network**, which connects the South and Southeast to the Washington D.C.-New York-Boston megalopolis;
- The **Alameda Corridor East**, the second leg of the rail corridor connecting the Ports of Los Angeles and Long Beach to the transnational rail network; and
- The **Pacific Northwest West Coast ("I-5") rail corridor**, which connects British Columbia, Washington State, and Oregon to the large Southern California markets.
- The **Powder River Basin (PRB),** where rail performance still lags behind what utilities expect and from a delivery perspective, demand is exceeding railroad capacity.
- The **United States East Coast Sea Ports**, which, following the Panama Canal's expansion, will be unable to maintain their present service patterns, and could potentially constrain the surrounding hinterland connectivity.

[71] CREATE Program Final Feasibility Plan p. 37.
[72] FWHA Office of Transportation Policy Studies "An Initial Assessment of Freight Bottlenecks on Highways" p. 2-12

Advantages and Disadvantages

There are many forms of transportation for suppliers to ship their goods in North America and each mode has its advantages and disadvantages to both the supplier and the community. Freight rail transport benefits the general public by being more fuel efficient, safer, easier on the environment, and reducing the level of highway traffic. The advantages for the suppliers are created through the rail company's ability to transport large amounts of goods cheaper than other modes of transport, but their inability to be flexible in their destinations creates a disadvantage as well.

As the number of motorists on the road increase along with the levels of freight shipments, it is creating congestion that is extremely costly to the American economy. "Highway congestion costs the U.S. economy more than $63 billion per year", states Edward R. Hamberger President and CEO of the AAR in a presentation to the U.S. House of Representatives April 26, 2006[73]. According to Hamberger one intermodal train can take up to 280 trucks (1,100 cars) off of the highways, while other forms of freight can take up to 500 trucks (2,000 cars) off the highways. Transferring more freight to rail could potentially save cities millions of dollars, for example, in Baltimore "shifting 25 percent of freight from trucks to freight trains would decrease drivers' commutes by 41 hours. In addition, such a shift would save each commuter $842 in annual congestion costs"[74]. A similar report was done for the Chicago area where a 25 percent shift could save 42 hours in commutes and $809 in annual congestion costs for each commuter[75].

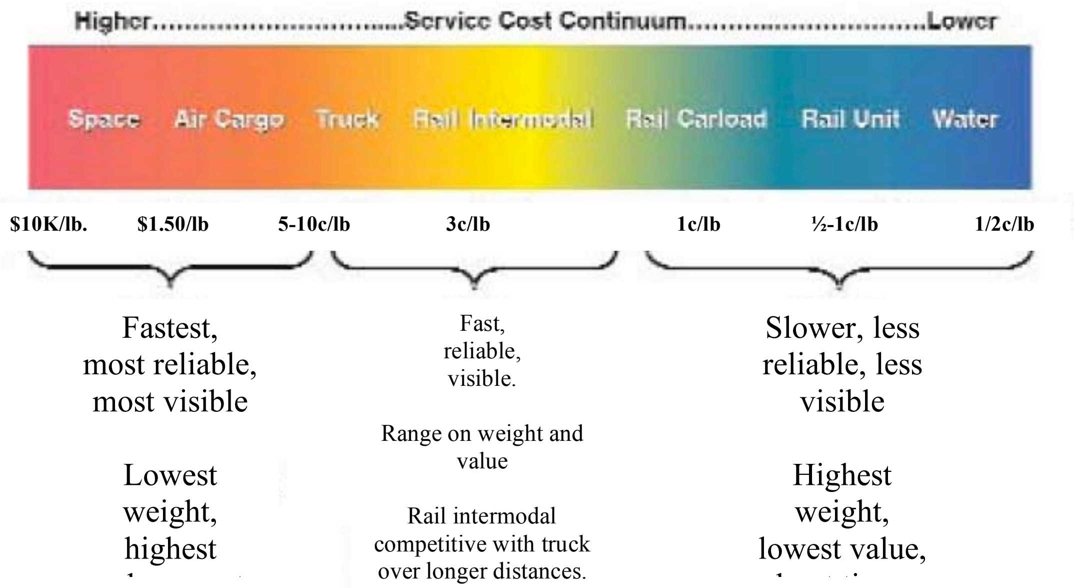


With today's rising fuel costs, operating costs have become a major concern for shippers. Railroad companies have the ability to ship goods three of four times more efficiently than trucks, which results in lower rates charged to shippers. Railroads are able to transport a ton of freight nearly 414 miles per gallon of fuel, which is up from 235 miles in 1980. The increased fuel efficiency from 1980 saved the industry 3.1 billion gallons of fuel in 2005 alone. Hamberger states that if just 10 percent of intercity freight is moved from trucks to rail there could be a potential savings of almost one billion gallons per year[76].

Railroad companies are traditionally safer for the environment and public, and emit much lower levels of pollutants - nitrogen oxides, particulates, and carbon dioxide - than trucks. The U.S. Environmental Protection Agency (EPA) states that trucks emit six to 12 times more pollutants per ton-mile than do railroads[77].

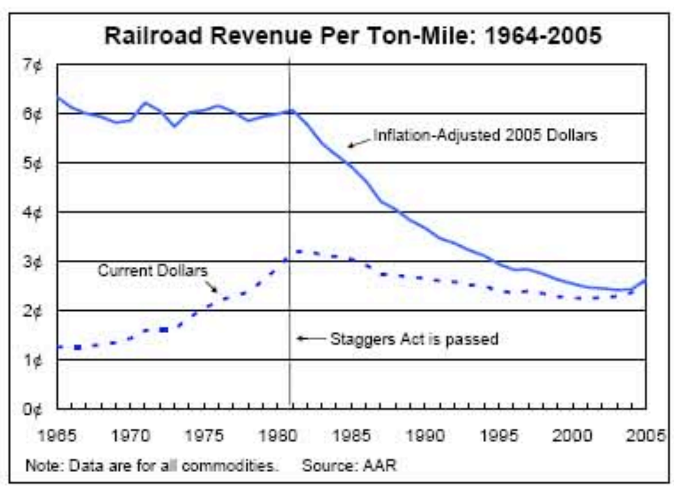
[73] Edward R. Hamberger "Hearing on Railroad Capacity" April 26, 2006 p.26
[74] Wendell Cox "Put America on track to better freight system" The Baltimore Sun August 4, 2006 p. 15A
[75] Wendell Cox "Moving more freight by rail cuts gridlock" Chicago Sun Times July 29, 2006 p. 12
[76] Edward R. Hamberger "Hearing on Railroad Capacity" April 26, 2006 p. 26
[77] *Freight – Rail Bottom Line Report* p.29

The main competitors for railroad companies in the "freight transportation service spectrum" are water and trucks, which compete with rail transport for heavy, lower-value, less time-sensitive commodities, and they also compete with trucks for the high value shipments moved over longer distances.



Source: AASHTO: Freight Rail Bottom Line Report

The railroad companies provide shippers with a more cost-effective way of shipping their heavy large volume materials than the trucking industry, and depending on the density of the commodity, a single rail car can carry the same amount of weight as four or five trucks. Products such as coal, liquid petroleum, or agricultural goods are much easier to move by train due to their sheer size and weight. Rail companies prefer to ship these types of goods due to their ability to efficiently offload the products at one main distribution center, instead of having to make several trips that they can not logistically execute. In order to determine the value of rail compared to trucks, a hypothetical study was done by the AASHTO where shippers did not have access to rail in 2000. In 2000 rail carried 1,239 billion tons of freight and charged $0.024 per ton for a total cost of $25



Source: CBO "Freight Rail Transportation: Long-Term Issues billion, but if suppliers had to pay the usual $0.080 charged by trucks the cost would have been $99 billion, an increase of $69 billion.

Tax Comparisons by Transportation Sector

	Railroads	Trucks	Barges	Pipelines	Aviation
Infrastructure (Right of Way) Costs					
Paid By	**Industry**	Government Subsidized	Government Subsidized	**Industry**	Government Subsidized
Method of Funding	Private Capital	24.3 Cent Fuel Tax	20.0 Cent Fuel Tax	Private Capital	21.8 Cent Fuel Tax
Tax Recovery Period (excluding repairs)	**7-50 Years**	1 Year	1 Year	**15 Years**	1 Year
AMT Exposure Due to Infrastructure	**Yes**	No	No	**Yes**	No
Property and Sales Taxes on Infrastructure	**Yes**	No	No	**Yes**	No

Note: Information in **Bold** indicates the sector is at a competitive disadvantage when compared to the other sectors.

Source: AAR "Railroad Tax Burdens"

The transportation of coal has been the most important source of revenue for the railroad industry comprising over 20 percent of their revenues, and was the highest source of revenue for the rail industry, until being surpassed by the intermodal goods in 2006. Railroads are efficient at moving heavy, dense, low time-sensitive goods across large distances, and shipping coal across the U.S. fits this profile. Railroads get their advantage over other modes of transport due to their experience and efficiency and are thought to have the worlds most comprehensive and efficient transportation system. Railroads became efficient at shipping coal by transporting around 95 percent of the total shipments through unit trains, which are trains dedicated to the shipment of coal and nothing else. This reduces the costs per unit shipped and is more attractive to coal suppliers. The amount of coal being shipped per year has been the main reason why it has generated the most revenue; however it is one of the most unattractive commodities in terms of revenue per ton. The average revenue per ton for coal in 2005 was $11.68 compared to the average of all commodities at $24.62, and in a 2004 study by the Energy Administration Agency (EIA) found that coal rates fell nearly 42 percent from 1984 to 2004[78].

[78] AAR "Railroads and Coal" p. 4-7

Current/ Expected Throughput and Capacity

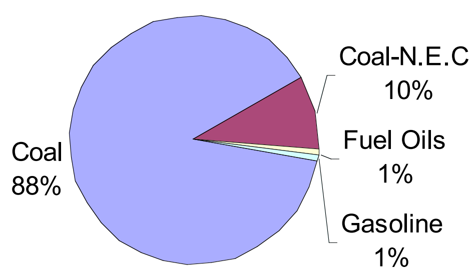
American railroad companies as a whole are responsible for the transport of over ten percent (2 billion tons) of the nation's freight in 2002 according to the FAF database, and of that, 14 percent (950 million tons) of all energy products. Railroads shipped almost 70 percent of all of the coal in the US for 2002, and a very small percentage of coal n.e.c., fuel, and gasoline products.

Percent of Total Energy Commodities Transported by Rail

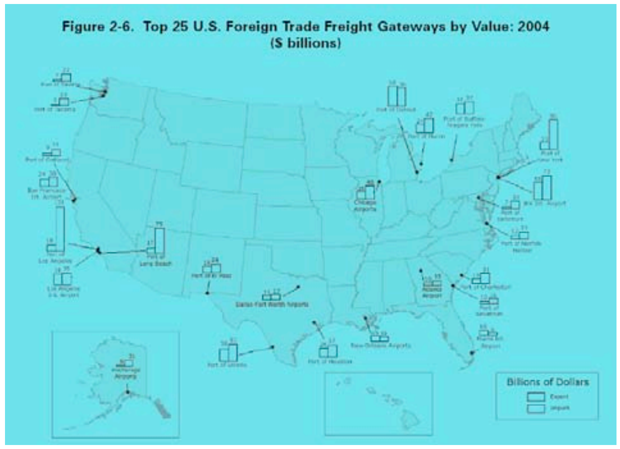
	2002	2005	2010	2020	2025	2030	2035
Coal	67.13%	68.06%	68.34%	68.99%	69.11%	69.45%	69.75%
Coal-n.e.c.	3.46%	3.82%	3.85%	3.94%	4.04%	4.15%	4.28%
Fuel oils	1.02%	1.06%	1.05%	1.04%	1.05%	1.06%	1.11%
Gasoline	0.67%	0.80%	0.74%	0.68%	0.63%	0.59%	0.57%
All Energy	**13.84%**	**14.39%**	**14.46%**	**14.63%**	**14.73%**	**14.87%**	**15.02%**

Coal is the largest commodity transported by railroads in 2002 and will continue to be until 2035. Coal represented 88 percent of all rail shipments and the majority of the shipments originated in Wyoming (37 percent), West Virginia (16 percent), or Kentucky (10 percent). The coal was shipped all across America and internationally, but Texas received the largest amount of coal at 12 percent of the total tonnage. Only three percent of the coal was shipped internationally with Canada receiving two percent and Europe receiving the other one percent. Coal n.e.c. products consisted of 10 percent of total rail energy transport, and the bulk of that was in Texas. Texas shipped 30 percent of all coal n.e.c. products and received 38 percent of the total tonnage with a quarter of that being intrastate shipments. Kentucky also was a primary shipper of coal n.e.c. products transporting 13 percent of all tonnage. America received 13 percent of their coal n.e.c. products from international countries and was the only product transported by rail across American borders. Canada was the primary exporter of coal n.e.c. products to America shipping over half of the international tonnage. Fuel oils only represents one percent of the total energy shipments made by railroads. Almost 41 percent of the shipments originated in Wisconsin and 21 percent of the tonnage ended in Texas. Gasoline shipments represented less than one percent of all energy products moved by rail and over half of that was in Alaska.

2002 Truck Shipments of Energy Products

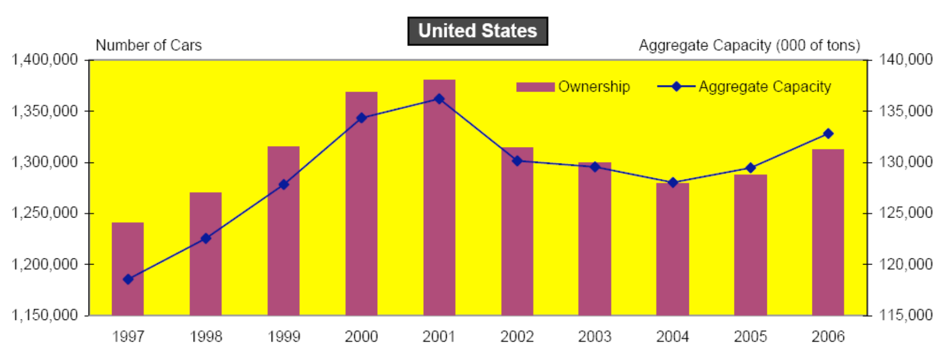


The majority of the rail shipments were made domestically and only five percent of the tonnage was imported or exported. The major commodity that was passed through America's borders or ports was coal (62 percent), and 15 percent of that originated from Latin America. West Virginia and Wyoming shipped a third of the international coal shipments. Coal n.e.c. products that were transported through America's borders and ports comprised 37 percent of the tonnage and a third of that came from Canada.



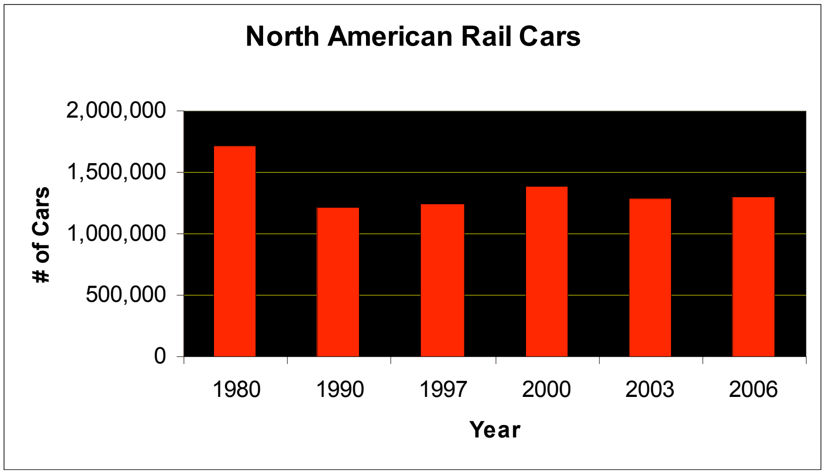
Source: U.S. DOT, Federal Highway Administration, Freight Facts and Figures 2005, p.13

Railroad companies currently have about 1.5 million rail cars in North America as of January 1, 2006, up 23,078 cars (1.5%) from the previous year, with a total aggregate capacity of 154 million tons. Union Pacific (UP) has over 140,000 rail cars which is more than any other railroad company, while BNSF, CSX, and Norfolk Southern (NS) are all competing for second with over 100,000 rail cars. There are 22 major classes of rail cars according to the "Railroad Equipment Report" by AAR and of those, four types of cars would be used for coal, and seven would be used for petroleum and coal products. Hoppers and Open Gondolas would be used for the transportation of coal and commodities such as minerals and wood products, and their capacity ranges from 101 – 115 tons. Petroleum and coal products are also shipped by Hoppers and Gondolas, but they are also transported in Tankers and Refrigerated cars, with a combined total capacity of 108 million tons by over one million cars. In 2004, there where a total of almost 40 million carloads transported by North American railroad companies, and 22 percent of the total carloads were coal shipments, while only two percent where petroleum and coal products[79]. Investments into hoppers and gondolas are expected to grow over the next few years to meet the increased production of coal, especially out of the PRB. Another source of demand that will be driving investment into these types of rail cars is ethanol, which will tighten car capacity for grain transportation.

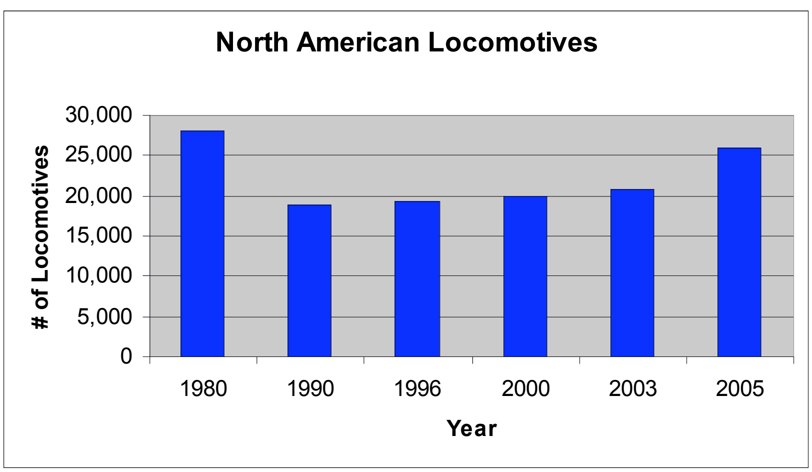


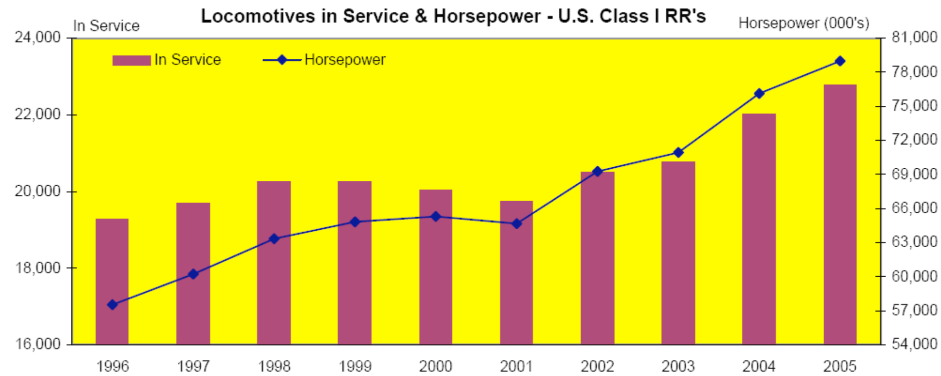
Source: AAR Railroad Equipment Report 2006

[79] AAR "Railroad Equipment Report" September 2006



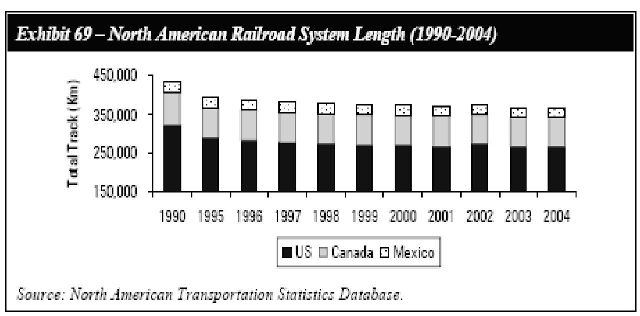
North American railroad companies have over 26 thousand locomotives as of December 31, 2005, which has increased by 2,600 (11 percent) since 1997. The largest operator of locomotives is UP with over eight thousand locomotives, while BNSF being the second largest with almost six thousand. In order to meet future capacity constraints, some of the Class I railroad companies have been investing heavily in their locomotive operations. BNSF has agreed to acquire 845 locomotives by 2009 and have already taken delivery of 403 of those in 2006. NS has also agreed to purchase almost 200 locomotives by 2007, which would bring their total fleet to almost 4,000. CSX is planning on adding 100 more locomotives in 2006 which would bring their total to 3,900. However, the amount of locomotives added is not reflective how much of an impact that they have, because locomotives have become much more horsepower and are able to carry larger loads.





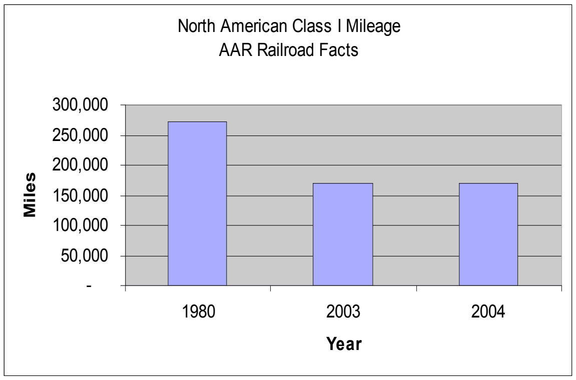
Source: AAR Railroad Equipment Report 2006

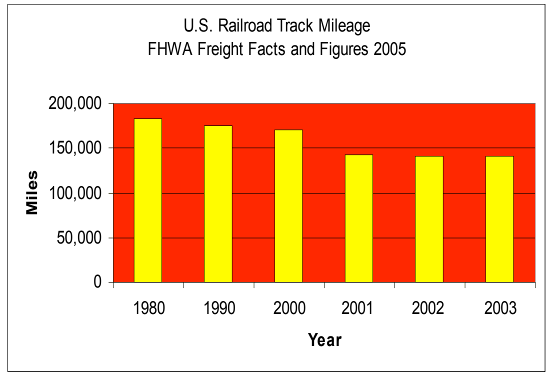
Another factor influencing the railroad companies is the amount of track miles in North America. After the Staggers Act railroad companies were able to address the unprofitable areas of their business and get rid of things that were unprofitable. After the deregulation in 1980, Class I railroad companies began to shift unprofitable track lines to short-line railroad companies who were able to address the local market more efficiently. The miles of track owned by Class I railroad companies fell from 271,000 in 1980 to 169,000 in 2003 and has hovered around 170,00 ever since[80]. The lack of investment in track lines and the increased demand for freight traffic has been a major reason for the congestion of track lines in North America. In the next few years, there will be major capital investments towards laying new track lines in areas where there are congestion issues, such as Chicago, PRB, and the East Coast.



Source: Scotia Capital "North American Freight Rail Sector" by James David

[80] CBO "Freight Rail Transportation: Long-Term Issues" p. 8





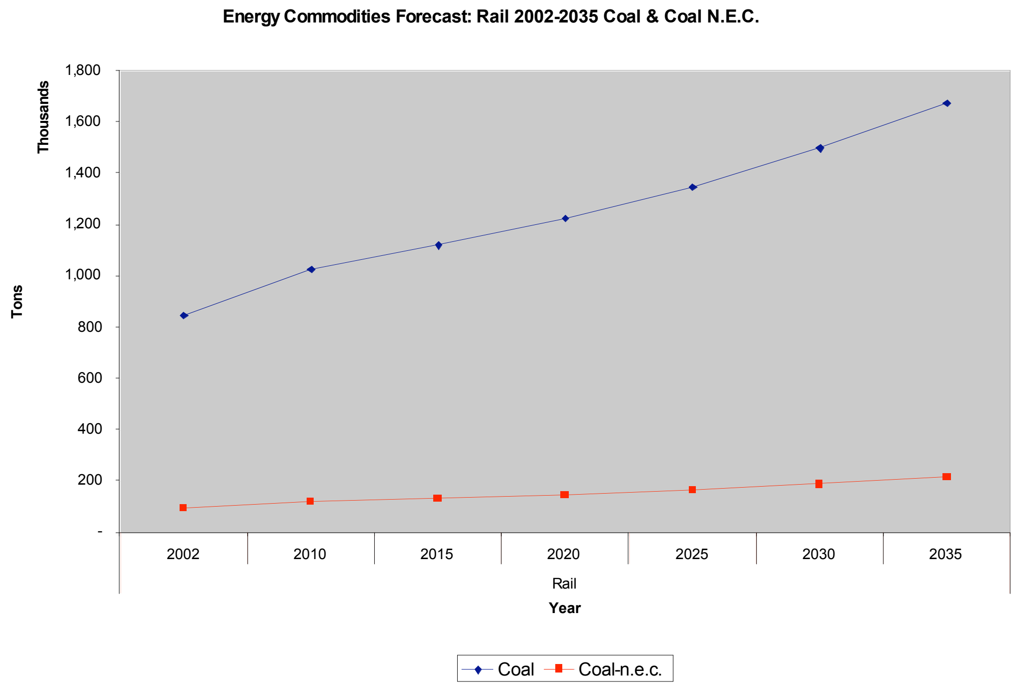
There has been a recent push by railroad companies to increase their hiring levels to expand capacity. The industry has been in a decline for almost half a century and the labor force has dropped nearly eighty percent, from about 1.2 million in 1955 to 223,000 in 2003[81]. Since 2003, however, the number of employees has increased and is expected to keep increasing in the near future. The number of Class I employment has increased eight percent from December 2003 to December 2005, and their train and engine employees rose 14 percent during the same time period. Railroad employment is primarily comprised of engineers, conductors, maintenance of way, and structures employees[82].

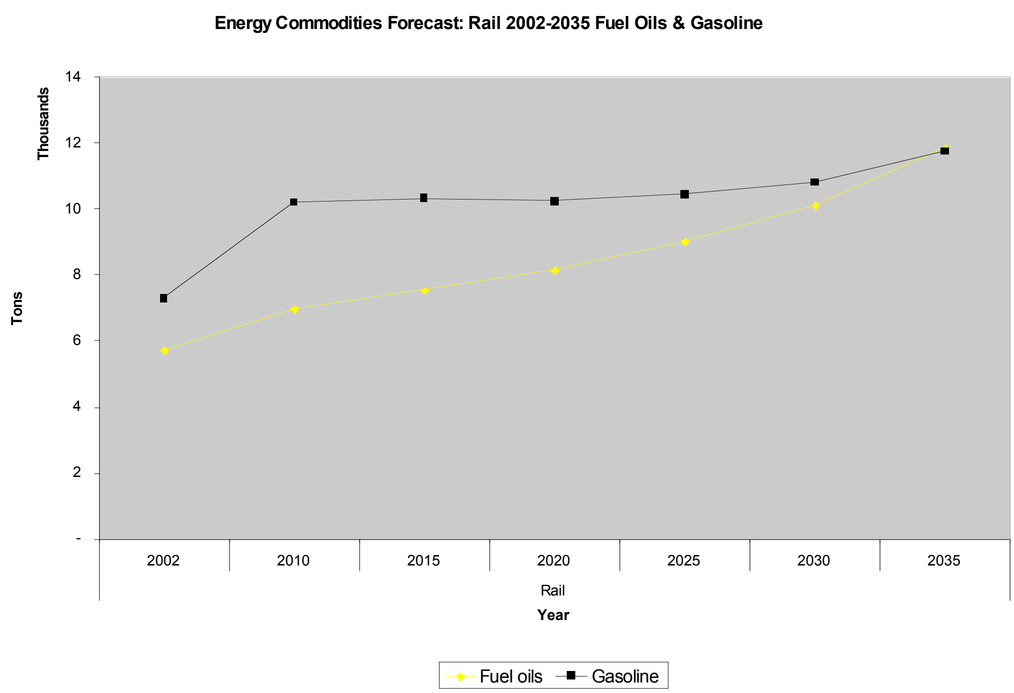
[81] CBO "Freight Rail Transportation: Long-Term Issues" p. 10
[82] Edward R. Hamberger "Hearing on Railroad Capacity" April 26, 2006 p. 13

Expected Throughput and Capacity

The railroad companies are expecting a large increase in shipments as the American economy continues to grow. The freight industry is projected to almost double by 2035 and the railroad industry is estimating that they will also see a large increase in freight tons by 87 percent. The FAF database estimates that the railroad companies will carry twice as much energy products, with coal continuing to be the main source of tonnage. The shipments of coal are expected to double for the industry and are going to reach almost 1.7 billion tons by 2035. The flow of coal products will continue to be similar to the current flows, with Texas being the main importer, and Wyoming, West Virginia, and Kentucky being the main exporter. However, Wyoming will take a larger share of the exporting coal market by having almost 60 percent of the total tonnage originating there, and West Virginia will see a decrease to nine percent from 16 percent. Coal n.e.c. products will continue to maintain their 10 percent market share with an expected increase of 124 million tons. Like coal, the flow of these products will continue to be very similar to the current situation; however Kentucky will increase their export of coal n.e.c. products to 33 percent of the total tonnage. Texas will continue to be the major importer of these products, receiving almost a third of the tonnage, but a tenth of the tonnage is expected to flow into Michigan. Fuel oils and gasoline shipments will also see increases in tonnage but will still only represent a small portion the energy products. Fuel oils will begin to see a shift in flows by 2035, however. Wisconsin is expected to ship only twenty percent of the total, down from 36 percent, and New Mexico will now ship over 40 percent, up from 11 percent. Texas will continue to be the main importer of fuel oils but they are now going to import over half of all fuel shipments. The two charts below project the tonnage that railroads will transport from 2002 – 2035[83].

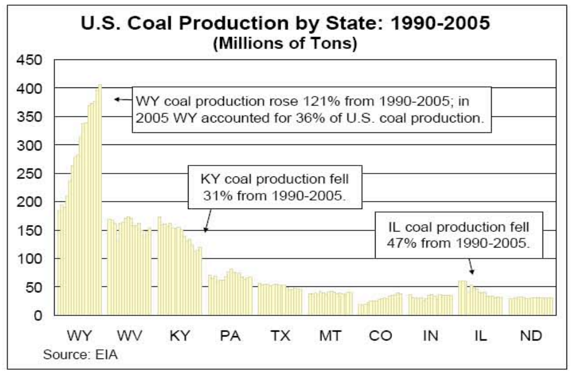
[83] Freight Analysis Framework[2]





Railroad shipments will continue to be dominated by domestic movements, but international shipments will increase 70 percent maintaining the five percent share of the total tonnage. Coal exports and imports will still represent two thirds of the shipments, but Latin America will become a major source of coal in 2035 representing 30 percent of all coal imports. Alabama will receive the bulk of the coal imports from Latin America, and almost half of the shipments that are passing through our ports and borders will go through there. A third of the shipments consist of coal n.e.c. products and Canada will continue to be the main source of these products, while Texas will receive the most tons through their ports and borders. Canada's shipments are spread out across the Northern borders and ports, while almost all of our imports from Africa pass through Texas.

Coal is one of the most important sources of revenue for the railroad industry and it will continue to be the number one transported commodity for railroad companies. In 2005, the EIA states that the U.S. produced 1.13 billion tons of coal in 2005, and two thirds of that amount was shipped through rail. Currently coal represents over 80 percent of total tons shipped for railroad companies and 20 percent of their revenues, and according to the FAF, coal is expected to grow almost 100 percent by 2035. The growth in coal production is driven by the increased demand that the U.S. has for coal-fired power plants which are addressing the electricity shortages across the nation. Not only has the increased demand for coal put pressure on the railroad industry to increase capacity and shipments, but the decision for coal-fire power plants to reduce their stockpiles by over 20 percent since 1980 has caused railroad companies to be able to ship coal on a just in time basis. Capacity constraints combined with the expected increases in demand could result in capacity shortfalls and delays in providing coal to power plants that are relying increasingly on 'just in time' shipments to reduce inventory costs[84]. There are currently twenty coal producing states in three major regions, with the largest being the Western region and the PRB, which has increased production 121 percent from 1990 – 2005 and accounts for 36 percent of U.S. coal production. The EIA is projecting the Western coal production to increase 1.1 billion tons by 2030, which is going to be a major source of growth for the rail industry[85]. The reason for expansion is the estimated 140 coal-fired generating plants in 41 states representing 85 gigawatts of power that have been announced or are in development, and could potentially increase U.S. coal requirements by 300 million tons per year[86].



Source: "Hearing on Coal Supplies" by Hamberger

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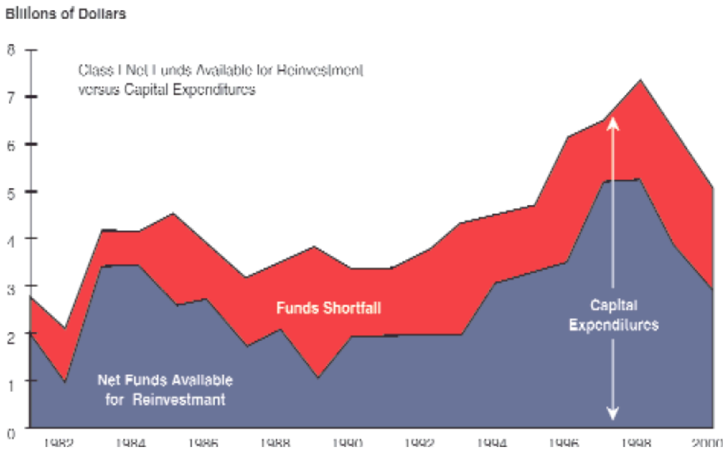
[84] National Energy Policy Development Group "America's Energy Infrastructure: A Comprehensive Delivery System" Chapter 7 pg. 16. May 2001.
[85] CBO "Freight Rail Transportation: Long-Term Issues" p. 5
[86] Edward Hamberger "Hearing on Coal Supplies" p. 2-8

Estimated Investment Requirements

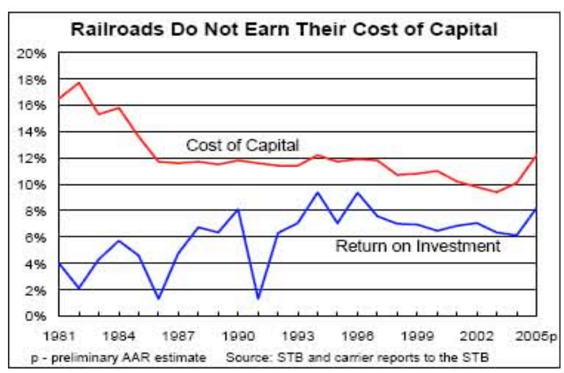
Railroads traditionally spend more money on capital expenditures than most manufacturing industries, and in order to meet the expected increase in demand they will have to continue with this trend. As stated before, U.S. railroads typically spend $15 billion to $17 billion per year on capital and maintenance expenses, and over the past 25 years railroad companies have invested over $360 billion in capital spending. Even with the large amounts of investments railroads have made, there is still an estimated $200 billion more in capital spending needed to facilitate enough capacity to meet the expected demand; and of the $200 billion, $40 billion to $60 billion is an unfunded annual need for freight-rail infrastructure[87]. The industry usually invests 15 to 20 percent of their investments for capacity expansion, while the remaining 80 to 85 percent goes to maintenance of the current conditions[88]. Railroad company's costs are so much higher than most manufacturing companies due to the vast levels of capital spending that are required to expand and maintain the industry. There are many areas that the railroad industry will need to invest in the future in order to meet the high demand that they will be facing. Major areas of concern are ports for intermodal freight transfer, high traffic areas like Chicago, and areas where there are large amounts of commodities needed for export.

Needed Capital Expenditures Exceed Class I



Source: AASHTO: Freight Rail Bottom Line Report

The Staggers Act of 1980 deregulated the rail industry, and in doing so transferred the costs of maintaining and building new rail lines to railroad companies, who in turn, transfer the costs to suppliers. The new infrastructure costs put railroad operators at a disadvantage to the trucking industry, who do not have to pay for their infrastructure because the government pays for new roads. The railroad historically has a very wide gap between cost to capital and return on



Source: "Hearing on Coal Supplies" by Hamberger

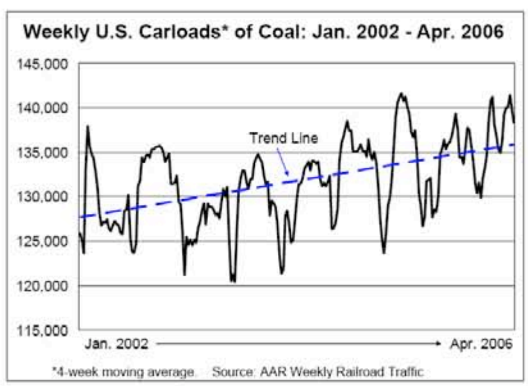
[87] AAR "Importance of Adequate Rail Investment" p. 1
[88] CQ Congressional Testimony "Rail Capacity Crunch" by Joseph Boardman April 26, 2006

investment (ROI) which deters them from wanting to expand their operations because they will not get the financial return needed. Even with the low ROI, railroad companies have extremely high levels of capital expenditures, 17.8 percent of revenue compared to the average 3.5 percent, and in order to maintain their competitive rates and current market share they will need to spend more on capital expenditures[89]. This issue has brought an argument in front of congress to enact tax incentives for rail companies that would give them a 25 percent tax credit for investments in new track, intermodal facilities, yards, locomotives, and other infrastructure projects that expand rail capacity[90]. According to the AAR trucking companies only pay 40 to 50 percent of the cost of damage they cause to the roads, while railroads pay all, also railroad companies have to pay property taxes for the tracks they own, while trucks pay nothing. These costs get transferred to suppliers, but if railroads want to stay competitive they can not pass all of the costs to their suppliers so their revenues are reduced[91].

The pending increase in coal demand has caused a focus on capital expenditures for direct lines dedicated to coal shipments. They are focusing on increasing capacity to meet the output produced by suppliers, increasing productivity, and becoming more coordinated with suppliers in order to better adjust to the cyclical patterns of the coal supply. Each of the seven Class I railroad companies are making investments in their capacity and service performance[92].

- BNSF has taken delivery of 1,300 coal cars and 90 locomotives in 2005, and in 2006 they plan to add about 180 more locomotives to coal transport. Planned investments for their coal business are estimated to be $500 million to $800 million on track and terminal expansions; over $1 billion on new locomotives; and $1.2 billion for aluminum rapid discharge sets over the next few years.

- UP has spent more than $1 billion on locomotives and an additional $8 billion on track capacity enhancements over the past eight years. In 2006 they are taking delivery of over 500 new coal cars and a dozen new locomotives. They are spending over $70 million in specific coal producing areas like the PRB and the Denver bypass.



Source: "Hearing on Coal Supplies" by Hamberger

- BNSF and UP agreed to build more than 40 miles of main line tracks over the next few years to

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89 AAR "Importance of Adequate Rail Investment" p. 1
90 AAR "Tax Incentives for Freight Railroad Capacity Expansion" p. 2
91 AAR "Railroad Tax Burdens" p. 3
92 Edward R. Hamberger "Hearing on Coal Supplies" May 25, 2006 p. 12-22

meet the demand from the PRB.

- CN will spend $1.3 billion on capital programs across North America in 2006.

- CP just finished their biggest capacity enhancement project in over 20 years in the Port of Vancouver which raised capacity of their western network by 12 percent.

- CSX is planning to spend $1.4 billion per year on capital expenditures for 2006 and 2007 with much of the spending benefiting coal. They are focusing on the Southeast Express Corridor from Chicago to Florida to increase efficiency of coal shipments, and a new connection at Willows, Illinois to improve the St. Louis gateway. They are also rebuilding and repairing over 2,400 cars and acquiring 300 new locomotives from 2005-2007.

- KCS is integrating their Mexican subsidiary into their company and is spending $120 million in the U.S. and $96 million in Mexico in 2006. They are focusing on their Shreveport hub by making improvements to make the line more efficient and modern.

- NS is purchasing over 220 locomotives from 2005 to 2006 with the majority of them used for coal transportation. They are also focusing on rail car rehabilitations and investing $60 million to add track capacity for coal movements between Memphis and Macon, and an additional $42 million to build five miles of new line to improve rail service at a coal-fired power plant.

Major Issues

Many of the major issues facing the railroad industry have already been discussed in previous sections, such as the major capacity crunch, rapid increase in demand, need for higher ROI, bottlenecks that are slowing delivery, and higher operating costs. All of these issues are impeding the industry from expanding rapidly enough to meet the surge in demand, and the lack of investment in the industry is creating other issues that are affecting efficiency. Issues such as a government intervention, deteriorating infrastructure, and track closures due to weather are now affecting specific parts of the industry.

There are five major unique transportation corridors in North America that are each significant in terms of the type of commodities shipped and their dependence on rail transportation. The five major corridors are[93]:

- I-5 from Washington to California
- Southern California/ Chicago/ NYNJ
- Northeast/ Southeast Atlantic
- Powder River Basin
- Detroit to Mexico

The I-5 corridor extends 1,200 miles between Seattle, Washington, and San Diego, and the major rail carrier servicing this region is UP who competes with BNSF in certain areas. The mountainous terrain only allows for a single track line which is inefficient and susceptible to inclement weather causing shutdowns. There are also places in Oregon that do not have clearances for double-stack containers which greatly reduce the efficiency of the network. Bottlenecking issues are also found in the Los Angeles and San Diego areas due to the high amount of passenger service trains that get priority to track lines.

The I-5 corridor is expected to have 57 million tons of freight pass through by 2020, and of that 31 percent will be moved by rail. There are a lot of commodities that are shipped through this corridor – including food or kindred products, lumber and wood products, pulp and paper products, metals, and farm products. Railroads primary commodity shipped are pulp and paper products, and other major commodities are lumber and wood, food, metals, and chemicals. Cross border shipments account for only 17 percent of the total tonnage shipped through the I-5 corridor, and petroleum and coal products make up only a small portion of the tonnage shipped.

The Southern California corridor extends 3,000 miles between Southern California to the New York/ New Jersey area and travels through highly congested Chicago. This network handles the majority of the intermodal rail traffic and is the major link for Asian

[93] *Freight – Rail Bottom Line Report* p.68

goods to the Northeast/ Mid Atlantic region. There are four railroad companies that compete for these corridors; UP and BNSF in the Southern California area, and NS and CSX for the Chicago - New York/ New Jersey line. There a couple areas of concern for the rail industry, however the major area of concern is Chicago which handles more rail freight tons than any other area in North America. There is a huge project currently taking place in the area called the Chicago Region Environmental and Transportation Efficiency Program (CREATE) in which they are investing $1.5 billion into the local rail transportation network in order to make it more efficient. This project is a joint effort between the AAR, BNSF, CN, CP, CSX, NS, UP, and other various rail transportation agencies, and their mission is to "restructure, modernize and expand the freight and passenger rail facilities and highway grade separations in the Chicago metropolitan area while reducing the environmental and social impacts of rail operations on the general public"[94]. The other areas of concern are the ports in which the future growth of intermodal freight transport is going to hit the hardest, and railroad companies are trying to make their operations at these ports much more efficient.

The corridor that lies between Southern California and the East Coast is expected to transport 81 million tons of freight by 2020, and 67 percent of the total tons shipped will be moved by rail. Majority of the traffic that will be shipped will be intermodal (56 percent of the tonnage), with a large part of the remainder of the shipments made up of miscellaneous, mixed shipments. Food, lumber, farm, chemicals, and metals make up the other major commodities that are shipped through this corridor.

The Northeast/ Southeast corridor stretches 1,500 miles between Maine and Florida and passes through many urban areas such as Boston, New York, Baltimore, Atlanta, and Miami. It also handles a lot of intermodal and cross border transport, and the major railroad companies that operate on this segment are NS, CSX, CP, and the CN. This area faces many similar constraints that are faced in the Chicago and Western states which are highly congested urban areas and tough terrain. The slow areas are felt between New England and the Southeast where they have to take a non-direct route through Albany due to the lack of crossings along the Hudson, and there is also a choke point along the Shenandoah Valley created by the single line tracks that go through hilly terrain which have slow speed limits. There is a proposal from the Mid-Atlantic Rail Operations Study that wants to address the choke points faced in these areas, and the estimated cost for this proposal is $6.2 billion[95].

There are a lot of commodities that are shipped along the Northeast/ Southeast corridor, with no one commodity dominating. Freight flows are projected to reach 37 million tons by 2020, and 26 percent of the total will be shipped by rail. Major commodities that will be shipped include lumber, paper, and clay products, which combined account for three-quarters of rail tonnage. There is an estimated 27 percent of total tonnage transported cross-border due to NAFTA trade with Canada.

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[94] CREATE Program Final Feasibility Plan p. 9
[95] *Freight – Rail Bottom Line Report* p.70

The PRB is a section in northeastern Wyoming that has the primary responsibility of shipping low-sulfur coal to power plants in the Midwest and South. This is a major source of revenue for railroad companies so they focus a lot of capital expenditures in order to make this a very efficient and highly profitable operation. About 74 percent of U.S. low-sulfur coal reserves are located in Montana and Wyoming and demand for clean coal is expected to increase due to its environmental benefits. However, rail capacity problems in the PRB have created a bottleneck in the coal transportation system[96]. The area is primarily serviced by BNSF and UP, but there are also many smaller railroad companies that focus on direct unit rail transport of coal to power plants. Due to the large amounts of coal moved and the existing track lines that run through the area, it is a source of congestion and new track lines have been put into place to try and deal with congestion. Various lines in this region are susceptible to inclement weather due to the mountainous terrain. In May of 2005 there were various train derailments and a stoppage of shipments from the PRB due to a snow storm in the area. There is an expansion currently in planning from the Dakota, Minnesota & Eastern Railroad (DM&E) companies in which they are building 280 miles of new track from South Dakota to the PRB, and they are rebuilding 600 miles of track from Minnesota to Nebraska[97]. DM&E is planning on shipping 100 million short tons a year with the new line and is waiting on a $2.4 billion loan from the Federal Railroad Administration.

Freight flows in the PRB are expected to reach 418 million by 2020. Rail transportation dominates this area, 84 percent of total tonnage, with the primary focus on the shipment of coal. Chemicals, non-metallic minerals, petroleum and coal products, and clay comprise the remainder of shipments made in this area but make up only a small portion of shipments.

The Detroit to Mexico line primarily deals with the shipment of automobiles and parts from Detroit to Mexico through Texas and St. Louis. All of the Class I railroad companies except for CP deal with this line, and there are various points of congestion that will need to be the focus of companies in the future. The main areas that are creating bottlenecks are the borders along Mexico, the Houston terminal where there are shipments of chemical products are received, and the interchanges between the Eastern and Western carriers. This corridor will have a large amount of demand in the future with Mexico becoming a focal point for future intermodal transport from Asia. KCS in investing heavily in this area to anticipate the future growth in intermodal transport through their subsidiary KCS de Mexico, and is focusing on Lazaro Cardenas which is one of the busiest ports in Mexico. The annual capacity is 100,000 containers and is expected to increase to 700,000 units by 2007, but the eventual capacity is expected to be two million units by 2020, much smaller than the 14 million units expected in Los Angeles and Ling

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[96] National Energy Policy Development Group "America's Energy Infrastructure: A Comprehensive Delivery System" Chapter 7 pg. 16. May 2001.

[97] Platts Coal Outlook "Fuel buyer, railroad official disagree on Dickensian analogy" by Steve Hooks. Transportation pg. 10 Vol. 30 No. 38.

Beach98. There are also plans for a one billion dollar Greenfield port development project at the Punta Colonet Harbor, Baja Peninsula, and "Within seven years, Punta Colonet could be processing the equivalent of a million 20-foot-long containers annually, 6 million by 2025… The volume predicted for Colonet is comparable to that at the ports of Los Angeles and Long Beach, which are the largest on North America's West Coast"99.

A potential major bottleneck that could develop would be at Texas' seaports due to the expansion taking place at the Panama Canal. The congestion at the Ports of Los Angeles and Long Beach, decreasing costs and decreasing reliability on the U.S. intermodal system, have combined to make the Panama Canal route a more attractive option to shippers. The Canal's share of total container shipments between Asia and the US has increased 11 percent in 1999 to over 38 percent in 2004, and volumes are expected to increase nearly six percent annually over the next several years without the current expansion. As of 2005, approximately 35 percent (98 million tons) of the total tonnage passing through the canal are containers while dry and liquid bulk containers represent 32 percent (89 million tons), with the Canal receiving 279 million tons of cargo. By 2025, the Canal is expected to grow to 508 million tons with containers growing to 296 million tons (202 percent increase) and dry and liquid bulk tonnage increasing to 101 million tons (13 percent increase). The increase in tonnage will be transferred to seaports all across the North American coast, especially Texas100. Without the expansion, Texas' seaports are expected to see an increase of over 40 percent in tonnage from 2003 to 2035, and they would definitely see more tonnage than that once the expansion is completed. The increase tonnage will create a significant bottleneck for railroads at these seaports because they currently handle over 18 percent of the total tonnage, and will play a larger role with the increase shipments of containers and bulk shipments101.

The corridor that lies between Detroit and Mexico is expected to receive about 16 million tons by 2020, and 52 percent of that will be shipped by rail. Transportation equipment makes up the majority of products shipped by rail in this corridor, and the rest are made up of lower-volume commodities, such as machinery, farm products, chemicals, clay, primary metals, food, and petroleum and coal products.

The major issues that are facing the railroad industry affect all levels of goods that are transported, because it slows down delivery time and causes suppliers to look at other forms of transport if they are available. Coal shipments in the future do not face any major issues other than the capacity and bottleneck ones discussed before. Railroads are focusing a lot of their capital expenditures on the coal transportation network because they know how valuable coal is to their revenues. However, one issue is the decrease in rates

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[98] The Kansas City Star "Full speed ahead for the holidays; RAILROADS: Industry rebounds" by Randolph Heaster. August 22, 2006. Section D p. 1
[99] San Diego Sun "Mexico plans an alternative to the jammed docks in L.A., Long Beach" by Diane Lindquist. August 14, 2005.
[100] Cambridge Systematics, Inc "Effects of the Panama Canal Expansion on Texas Ports and Highway Corridors" October 2006 Section 2 pg. 1-11
[101] Cambridge Systematics, Inc "Effects of the Panama Canal Expansion on Texas Ports and Highway Corridors" October 2006 Section 4 pg. 1

charged for coal shipment which has been reducing revenue per cars shipped. According to the EIA, they found that rates fell nearly 42 percent on a revenue per ton basis from 1984 to 2001 and there was a 60 percent drop in revenue per ton mile for coal from 1979 to 2001. Coal is also near the bottom among all major commodities in terms of gross revenue per carload, with an average of $1,304 in 2005; 15 percent lower than the comparable inflation adjusted average for 1990. Ordinarily a drop in rates would result in a lower incentive to put capital expenditures into the coal industry, but the ability of the railroad industry to enhance their productivity has counteracted the declining returns. However, if the rates keep decreasing they will have a tough time investing in the industry while others are more profitable and attractive, and they will also need to generate enough revenues to reinvest in order to meet the future increase in demand[102].

The oil & gas industry for either the suppliers or the Class I railroad companies has not been a focal point for transporting on railroads. The issues that are facing the entire industry are also facing the oil & gas shipments due to lower levels of service and slower delivery times. However, the oil & gas shipments are more exposed to shifts of demand in the shipment of commodities. With only three percent of their revenues and gross tons shipped represented by petroleum and coke products, it is not a priority for railroad companies for a sustainable source of revenue. The rates charged to suppliers ($25 average) and revenue per ton miles for petroleum products are higher than coal ($12 average), but the amount of coal shipped eclipses that of petroleum products to make it a more attractive commodity[103]. As demand starts to increase and railroad companies face capacity constraints, they will be much more careful to invest on more profitable commodities and use their cars and locomotives for these goods. With the growth of certain industries, like intermodal shipments who charge an average rate of $55, there is potential for railroad companies to shift their operations away from petroleum and coke.

[102] Edward R. Hamberger "Hearing on Coal Supplies" May 25, 2006 p. 14-15
[103] Consumers United for Rail Equity http://www.railcure.org/pdfs/captivitychart.pdf

Conclusion

The railroad industry is a very important part of the freight transportation network in North America, and is facing a future of strong growth and uncertainty. Railroad companies are in charge of shipping tens of thousands of railcars daily across North America, and play a pivotal role in many North American industries. The freight-rail system is facing congestion and capacity choke points along national corridors across North America. In order for the railroad industry to meet the increase demand and fix the issues that are expected to arise, freight-rail companies will need to invest more capital to relieve the congestion and capacity constraints.

The two ways that rail companies are going to try and address the congestion and capacity issues are through a market-driven evolution of investment, or a public-policy-driven expansion. As shown before, railroad companies do not have sufficient funds to invest in the industry to meet the future demand. They are looking to the public sector for the needed investment into the system to help maintain their market share and relieve the congestion on the highways. Hambereger is an advocate for public intervention into the rail industry and states that:

> "*Railroads are committed to meeting these increased capacity needs… but only if the regulatory structures give the railroads an incentive to make the necessary investments. Policymakers can help ensure the rail capacity is adequate to meet future freight transportation needs by… engaging in more public-private partnerships…, and instituting targeted tax incentives for projects that expand rail capacity.*"[104]

[104] Edward R. Hamberger "Hearing on Railroad Capacity" April 26, 2006 p. 30

Government Policy Considerations

Public-Private Partnerships

The majorities of U.S. freight railroad companies are privately owned, and, therefore finance their infrastructure investments through their own earnings and loans from the Railroad Rehabilitation and Infrastructure Financing (RRIF) or the Transportation Infrastructure Finance and Innovation Act (TIFIA) programs. Capital providers demand that railroad companies focus their investment on projects that provide direct financial benefit, and many of these projects have public benefits that are a secondary focus for railroad companies and their investors. The idea is for "private entities should pay for private benefits and public entities should pay for public benefits"[105]. This has been shown in the CREATE project in Chicago where the State of Illinois and the City of Chicago have taken on a lot of the $1.5 billion investment to improve many parts of the city.

Investment Tax Credit

The goal of government policies for the future in the rail industries are primarily geared to reduce the gap between the what should be invested into the rail infrastructure and what railroads can afford. The investment tax incentive that is currently in congress tries to solve this dilemma by allowing companies to be eligible for a 25 percent tax credit for capacity expansions. Examples of what would be considered capacity-expanding investments are the raising of tunnel clearances, upgrades on single or more track lines, strengthening current infrastructure, constructing intermodal terminals, new locomotives, and laying new track lines. The tax credit would extend to any taxpayer that makes an expenditure that qualifies, and they do not have to be a railroad company.

Re-regulation

There has been a recent movement towards a system that gives ownership back to the government. There have been a few variations of government regulation – such as, "forcing railroads to allow other railroads access to their tracks under confiscatory terms, or directly or indirectly capping rail rates at below-market levels"[106]. The idea for creating these policies is to increase the amount of rail – rail competition and to place a restriction on differential pricing models used by railroad companies. The table below shows the competitive (Non-captive) rates versus the non-competitive (Captive) rates that four of the Class I railroads charged in 2002:

[105] Edward R. Hamberger "Hearing on Railroad Capacity" April 26, 2006 p.28
[106] AAR "Overview of U.S. Freight Railroads" p. 5

The Cost of Captivity, by Industry 2002[107]

	CSX	NS	BNSF	UP
Coal, Captive Rate	$15.85	$15.79	$18.43	$18.70
Coal, Non Captive Rate	$7.67	$7.25	$7.79	$8.30
Pulp and Paper, Captive Rate	$38.70	$37.41	$559.92	$55.07
Pulp and Paper, Non Captive Rate	$18.73	$17.17	$25.32	$24.46
Chemicals, Captive Rate	$32.83	$36.08	$48.43	$42.18
Chemicals, Non Captive Rate	$15.88	$16.56	$20.46	$18.73
Petroleum, Captive Rate	$31.09	$28.85	$45.69	$35.32
Petroleum, Non Captive Rate	$15.04	$13.24	$19.31	$15.69
Intermodal, Captive Rate	$54.11	$45.42	$115.70	$91.42
Intermodal, Non Captive Rate	$26.18	$20.85	$48.88	$40.60
All Commodities, Captive Rate	**$27.27**	**$27.07**	**$40.06**	**$37.67**
All Commodities, Non Captive Rate	**$13.20**	**$12.42**	**$16.93**	**$16.73**

The re-regulation of the railroad industry to increase competition and restrict the rates charged by railroad companies is aimed at reducing the difference between the captive and non-captive rates. Railroads and advocates of the industry have strongly opposed the re-regulation of the industry because it would prevent them from earning enough revenues to adequately reinvest into the industry. While advocates for the Consumers United for Rail Equity (CURE) believe that the increased competition and reduced rates will result in lower and equal charges for suppliers across North America.

[107] Consumers United for Rail Equity http://www.railcure.org/pdfs/captivitychart.pdf

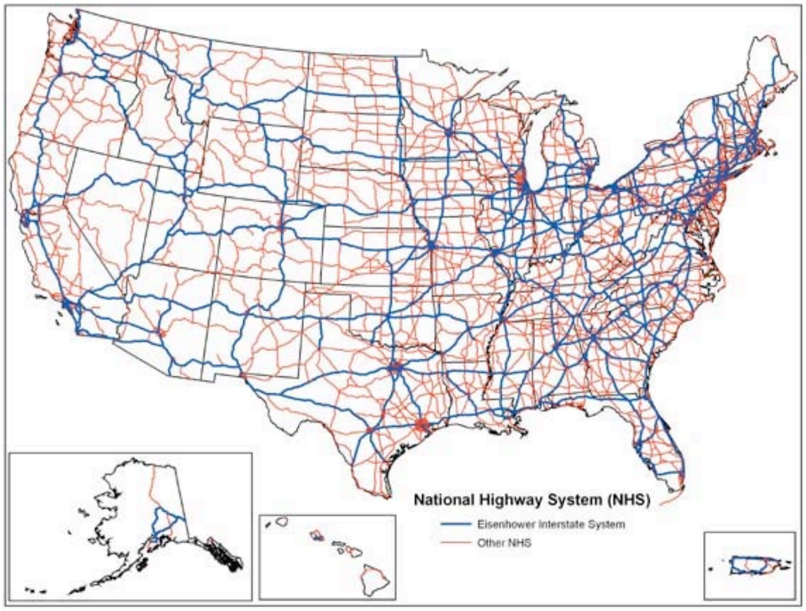
5.5 Roadways

A vital part of the North American freight transportation network is the trucking industry which carries more freight than any other mode of transport. Freight levels are expected to increase dramatically over the next twenty years, which will cause a strain on the trucking industry. Congestion and capacity problems that are affecting the industry are expected to increase because highway capacity is expanding too slowly to keep up with demand. The slow expansion is resulting in upward pressure on freight transportation prices, slower transportation times and more congestion on North America's already overcrowded highways.

As of 2002, the trucking industry is made up of over 5.5 million trucks, carrying over 12.2 billion tons of freight, and the Federal Highway Administration (FHWA) is expecting trucks to carry over 100 percent more tons by 2035[108]. Trucking represents over 60 percent of the total tonnage shipped in 2002[109] and 87 percent ($671 billion) of the US commercial freight transportation market, as of 2004[110]. The trucking industry transports a wide array of goods, and the industry relies on the ability to ship many different products to keep revenues constant. The three major products shipped in terms of tonnage in 2002 were gravel (15 percent), nonmetal mineral products (8 percent), and cereal grains (8 percent). Energy products shipped by trucks in 2002 only represented 12 percent of the total tonnage, with gasoline (40 percent of energy products) being the largest commodity shipped. The other four energy commodities shipped were coal n.e.c. (not elsewhere classified) products, fuel oils, coal, and crude petroleum representing 22 percent, 19 percent, 11 percent, and seven percent of all energy products shipped, respectively[111].

The American trucking network is comprised of almost four million miles of public roads, of which, 161 thousand miles are dedicated to our national Highway System (NHS)[112]. The NHS is a collection of subsystems and roadways that are important to the nation's economy, defense, and mobility. The NHS only represents four percent of America's roads, but carries more than 75 percent of heavy truck shipments[113].

[108] Cambridge Systematics, Inc. "An Initial Assessment of Freight Bottlenecks on Highways" Section 2 p.10
[109] US DOT Federal Highway Administration "Freight Facts and Figures 2005" p. 11
[110] West, Andrew "Standard & Poor's Industry Surveys Transportation: Commercial" p. 10
[111] Freight Analysis Framework 2002
[112] US DOT Federal Highway Administration "Freight Facts and Figures 2005" p. 23
[113] Rodney E. Slater "The National Highway System: A Commitment to America's Future" Vol. 59 No. 4 Spring 1996.



Source: FHWA "The National Highway System"

Advantages and Disadvantages

The trucking industry represents over 60 percent of all freight transportation in America. Trucks tend to ship lightweight, high-value, low time sensitive manufactured goods that are moved 750 miles or less[114]. Trucks have an advantage over rail, water, pipelines, and air due to their ability to ship products anywhere and are not limited by geography. Trucking companies do not have to pay for their own infrastructure, which can be an advantage or a disadvantage at times.

Trucking companies do not pay for the system of highways and bridges that they use to transport freight across America[115]. This is an advantage over the rail and pipeline industries that bear the cost of implementing new capacity expansions. Trucking companies therefore require less capital investment than other modes, which lowers the rate that is charged to customers. The disadvantage for trucking companies not having to pay for their rights-of-way is that they rely on the government to allocate funds to build highways and roads. Their reliance on the government to provide them with roads makes them more vulnerable to the economy and the government budget. During slower economic times the Federal government will have fewer funds to spend on roads and highways which cause inefficiencies and slower travel times. However, recently the Federal government has allocated funds to the NHS through the Safe, Accountable,

[114] West, Andrew "Standard & Poor's Industry Surveys Transportation: Commercial" p. 20
[115] Transportation Research Board "Critical Issues in Transportation" p. 9 2005

Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA_LU), a $286.4 billion investment into the highways and transportation network[116].

The advantage that is created for the trucking industry through lower capital investment is partially offset by lower levels of fuel efficiency. The fuel efficiency of trucks has been at all time lows for tractor-trailer combinations, and as new technologies are developed they are expected to increase fuel efficiency to 9.5 miles per gallon by 2015, which will result in a savings of 950,000 barrels of fuel a day[117]. This is compared to railroads that moved a ton of freight 414 miles per gallon, which is up from 235 miles in 1980[118].

	Base fuel economy (mpg)	New fuel economy in 2015 (mpg)	Fuel savings in 2025 (MBD)
Large tickups and SUVs (8,500-10,000 lbs GVW)	13.9	19.2	0.15
Platform trucks, Delivery vans, Super-duty pickups, etc (10,000 – 26,000 lbs GVW)	7.8	10.1	0.16
Tractor-trailer trucks (26,000^{+} lbs GVW)	5.3	9.5	0.95

Source: Kodjak, Drew "Policy Discussion Heavy-Duty Truck Fuel Economy

[116] Federal Highway Administration "Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users" Office of Legislation and Intergovernmental Affairs August 25, 2005
[117] Kodjak, Drew National Commission on Energy Policy "Policy Discussion- Heavy-Duty Truck Fuel Economy" August 29-September 2, 2004
[118] AAR "Economic Impact of U.S. Freight Railroads" December 2006 p. 3

Current Throughput and Capacity

As stated before, the trucking industry shipped over 12.2 billion tons of commodities in 2002, and of that, 1.5 billion tons (12 percent) consisted of energy products. According to the Freight Analysis Framework (FAF) energy products are classified as coal, coal n.e.c., fuel oils, crude petroleum, and gasoline. Trucks carry over 60 percent of all freight in America, and 22 percent of all energy products. Trucks ship more than half of all gasoline and fuel products and are expected to carry about sixty percent by 2035.

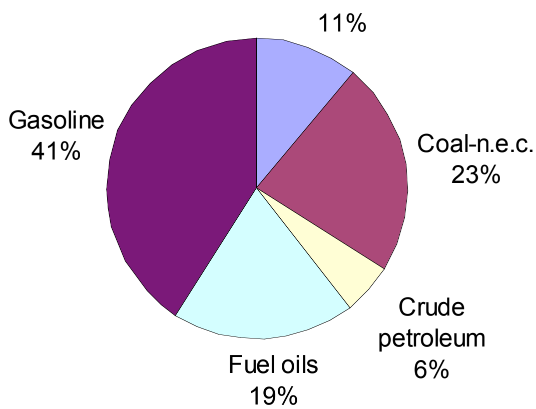
Percent of Total Energy Commodities Transported by Truck

	2002	2005	2010	2020	2025	2030	2035
Coal	13.41%	12.96%	12.68%	12.26%	12.07%	11.77%	11.48%
Coal-n.e.c.	12.89%	13.84%	13.95%	14.08%	14.26%	14.44%	14.57%
Crude petroleum	6.83%	6.86%	6.64%	6.32%	5.86%	5.41%	4.97%
Fuel oils	52.35%	52.97%	54.08%	55.33%	56.44%	57.49%	58.14%
Gasoline	57.60%	58.08%	59.07%	60.28%	61.26%	62.25%	62.75%
All Energy	**22.15%**	**22.56%**	**22.79%**	**23.06%**	**23.35%**	**23.60%**	**23.74%**

Source: Freight Analysis Framework[2]

The majority of energy shipments transported by trucks were gasoline products, representing 40 percent, or 628 million tons. Most gasoline shipments made were intrastate (82 percent) and the two states that transported the most tonnage were Texas and California with a combined share of 25 percent. International imports of gasoline transported by trucks only represented four percent of the total tonnage, and trucks carried less than one percent of gasoline products destined for international countries. Coal products that were not elsewhere classified, which is made up of natural gas, selected coal products, and products of petroleum refining (excluding gasoline, aviation fuel, and fuel oil), represented 23 percent (348 million tons) of truck shipments. Like gasoline products, coal n.e.c. products are also primarily shipped intrastate (74 percent) and 28 percent of shipments were made in Texas and California. Fuel oil shipments comprised 19 percent of total tonnage, or 293 million tons, and were spread out all over the country, but 85 percent were made intrastate. Trucks shipped 174 million tons (11 percent) of coal products and the majority of shipments were made in Kentucky and Virginia. Coal shipments were not as reliant in intrastate shipments as the other commodities, with only 67 percent made intrastate. Crude petroleum was the final energy product shipped by trucks in America and that only represented 6 percent, or 111 million tons, of the total tonnage. Crude petroleum shipments made by trucks were reliant on imports with 93 percent originating internationally. The final destination of the crude petroleum products was primarily in the North East, where Pennsylvania, Maine, Delaware, and New Jersey received almost 70 percent of the tonnage.

2002 Truck Shipments of Energy Products



Source: Freight Analysis Framework[2]

The majority of shipments made by the trucking industry for all energy products were domestic intrastate shipments, but 11 percent (167 million tons) of the total shipments passed through a border crossing or sea port. Border crossings saw only seven percent (12 million tons) of the total international shipments with the only commodity being coal n.e.c. products, and 70 percent traveled through either New York, Michigan, or Texas. America's sea ports saw the majority of international shipments, and the primary product that was passed through the ports was crude petroleum, making up over half of the tonnage. Gasoline, coal n.e.c., and coal made up the rest of the shipments passed through a port, and fuel oils were not transported through a sea port or border crossing. Almost half of the tonnage that passed through America's sea ports by a truck was in the North East, primarily Pennsylvania, Delaware, and New Jersey.

The ability for the trucking industry to meet demand is very reliant on the number of trucks that are available. In 2002, there were over 5.5 million trucks[119] in the US,

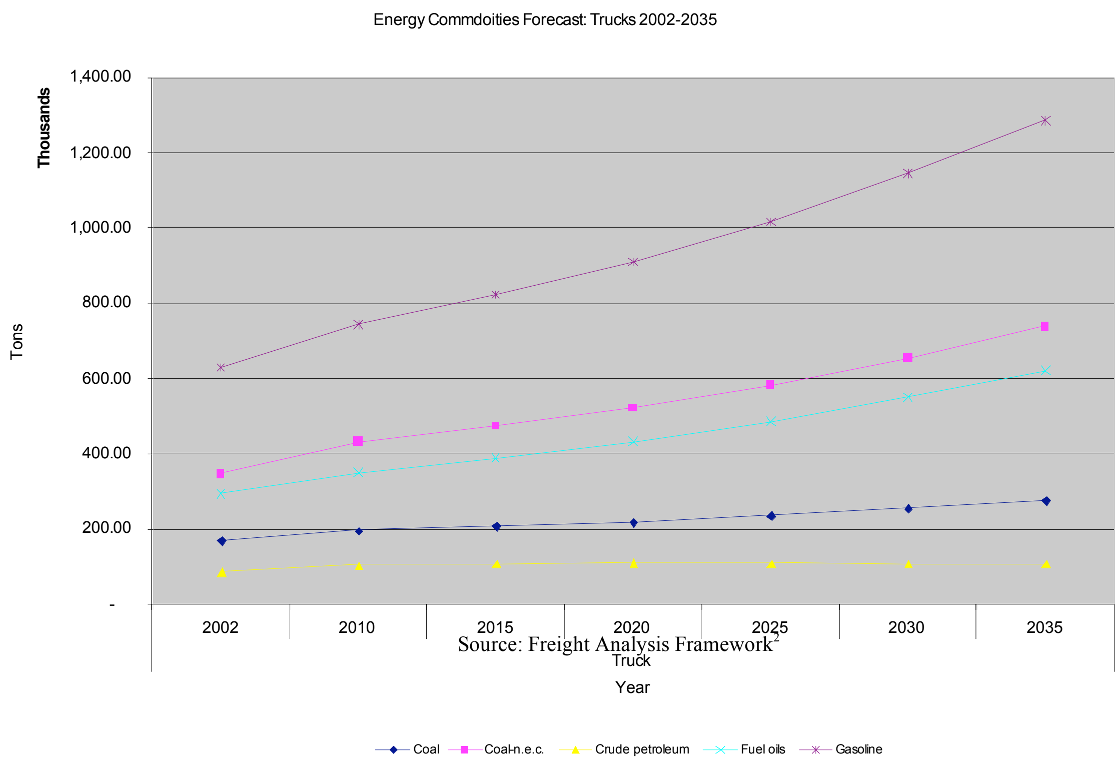
[119] US Census Bureau "2002 Economic Census *Vehicle Inventory and Use Survey"*

which made up only three percent of total vehicles, and trucks only comprised eight percent of the total highway vehicle miles in 2003[120]. There are two types of trucks that are used to carry oil and gas products which are dry bulk tankers, or liquid and gas tankers. The Census Bureau also classifies trucks under two categories of either single-unit, which are trucks that are permanently attached to the power unit, or truck-tractors, in which the body type is defined by the type of trailer pulled. The US Census *2002 Vehicle Inventory and Use Survey* found that there were 54,400 dry bulk tankers with over 80 percent of those in the heavy-heavy category in which the average vehicle weight is over 26,000 pounds. The average annual mileage for a single-unit dry bulk tanker in 2002 was 7,400 miles, down 41 percent from 1997, and the average annual mileage for the truck-tractor tankers was 65,600 miles, down five percent since 1997. There were 247,300 liquid or gas tankers in 2002 and almost 60 percent of those were in the heavy-heavy category. The average annual miles per liquid or gas single-unit tankers in 2002 was 12,900 miles, down 17 percent from 1997. Liquid or gas truck-tractor combination tankers averaged 69,000 miles in 2002, which was a decrease of four percent from 1997. The shortage of drivers, higher fuel prices, and cost differentials have caused the trucking industry to shy away from the longer cross country routes and move towards shorter hauls, which is the reason for the drop in annual average miles per truck in 2002[121].

[120] US DOT Federal Highway Administration "Freight Facts and Figures 2005" p. 12
[121] West, Andrew "Standard & Poor's Industry Surveys Transportation: Commercial" p. 18

Expected Throughput and Capacity

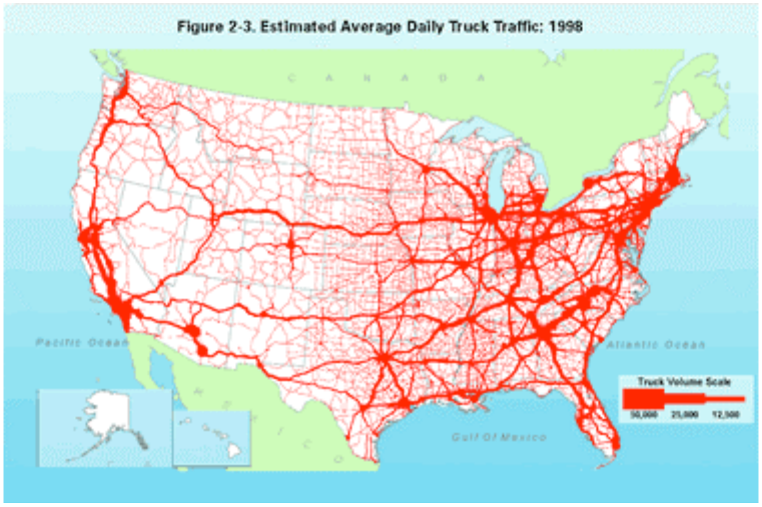
The freight industry in America is expected to grow exponentially in the next twenty years and the US DOT released the FAF which forecasts the level of freight that will be transported in America from 2002 – 2035. The FAF predicts that the trucking industry will see twice as much freight by 2035 with a total tonnage of 24 billion tons, and are expecting energy products to double to 3 billion tons. Energy products will still remain at a constant 12 percent of the total tonnage transported by trucks. Gasoline will continue to be the dominant energy product transported by trucks with an expected increase of over 650 million tons. Coal n.e.c. products and fuel oils will both see a doubling in the amount of tons shipped, while coal will only see a 60 percent increase. Crude petroleum will only see a modest increase of 23 percent and will actually start to decline from 2025 to 2035 by a million tons.



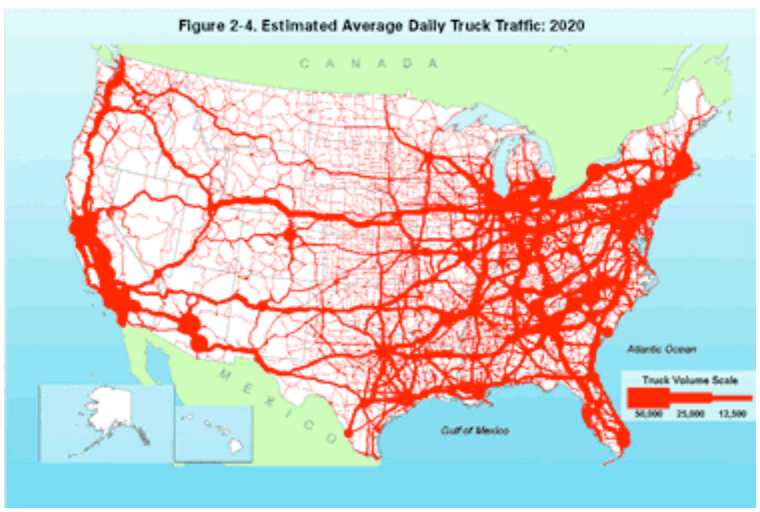
Source: Freight Analysis Framework[2]

The transportation of goods through the trucking industry that has originated from or destined for international countries is not a big portion of their tonnage. The tonnage is expected to increase 40 percent from 2002 with the bulk of that continuing to be transported through sea ports. In 2002, these shipments only made up 11 percent of the total tonnage and are going to stay constant at that percentage through to 2035. The North East will remain the main area for the arrival and departure of international goods, but southern states like Florida, Texas, and Louisiana will begin to transport a greater portion. Crude petroleum will continue to be the main commodity that is transported through ports and borders. Coal products will see the biggest increase of international shipments by almost 30 million tons by 2035 with over half of the shipments arriving from Latin

America. The increased levels of freight expected to flow across America in 1998 versus 2020 is shown in the two maps below.



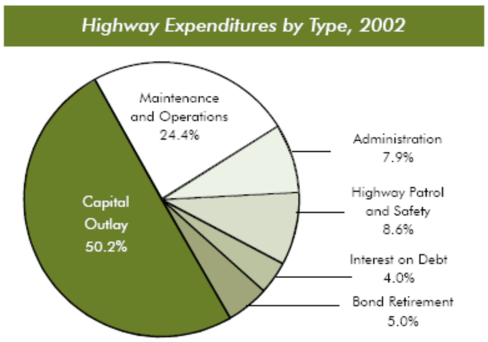
Source: FHWA Freight Facts and Figures



Source: FHWA Freight Facts and Figures

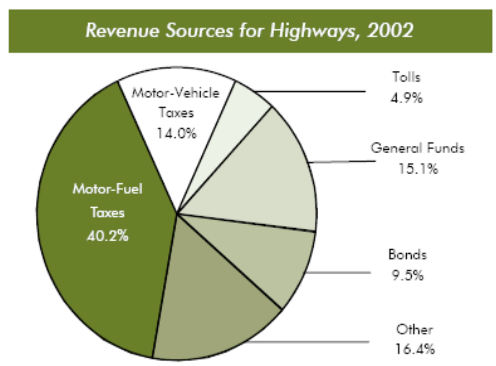
Estimated Investment Requirements

Trucking companies do not have to pay for the roads and infrastructure that they use for transportation because the government is in charge for building and maintaining our system of roads and bridges. All levels of government spent $135.9 billion in 2002, and the Federal government was responsible for $32.8 billion (24.1 percent). Total expenditures increased 33.3 percent from 1997, and of the $135.9 billion spent, $68.2 billion went towards capital outlay. State and local governments spent $35.8 billion of capital funds towards the preservation of their existing roads and bridges, while $12.9 billion went for new roads and bridges; $13.6 billion went for adding new lanes to existing roads; and $5.9 billion went for system enhancements[122].



Source: US DOT 2004 Status of Highways and Bridges

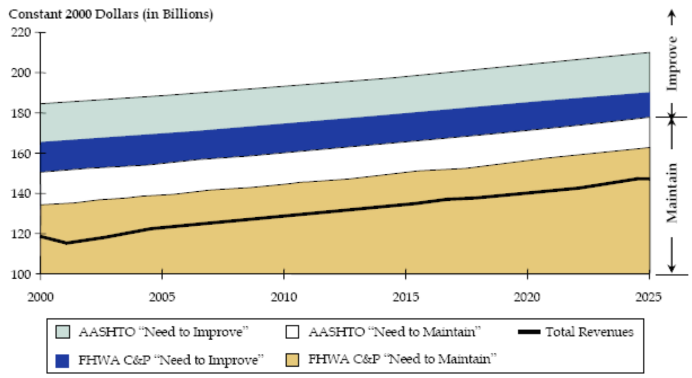
All levels of government received $134.8 billion in 2002, and highway-user revenues - generated through motor-fuel taxes, motor-vehicle fees, and tolls - totaled $79.6 billion in 2002. The remainder of the revenues came from funds, bonds, and property taxes, while the $1.1 billion difference from spending to revenues was taken from reserves by various governmental units. The gap between revenues and expenditures is expected to grow for the next twenty years. The FHWA and the American Association of State Highway and Transportation Officials (AASHTO) have forecasted the level of investment that is needed for maintaining and improving the performance of the nation's highways. Using current revenue numbers and projecting them out to 2025, annual revenues will only be able to maintain the highway system, not provide new capacity. The graph below shows the difference between the revenues and expected needed investment[123].



Source: US DOT 2004 Status of Highways and Bridges

[122] US DOT 2004 Status of the Nation's Highways, Bridges, and Transit: Conditions & Performance Executive Summary p. ES-10

[123] Cambridge Systematics, Inc. "An Initial Assessment of Freight Bottlenecks on Highways" Section 2 Figure 2.5



Source: Cambridge Systematics

According to the US DOT report on the status of the nation's highways, there are two potential investment strategies that are discussed; the Cost to Maintain or the Maximum Economic Investment. The Cost to Maintain Highways and Bridges "represents the investment required by all levels of government so that critical indicators of overall conditions and performance will match their year 2002 values"[124]. Over a twenty year period from 2003 – 2022 the Cost to Maintain is projected to be an average of $73.8 billion annually, with over half (54 percent) of that to be used for system preservation. The remainder would be used for system expansion (37 percent) and system enhancement (9 percent).

The Maximum Economic Investment (Cost to Improve) "scenario represents the investment by all levels of government required to implement all cost-beneficial improvements on highways and bridges"[125]. The total average annual cost is estimated to be $118.9 billion, and would address the existing backlog of highway ($398 billion) and bridge ($63 billion) deficiencies. System preservation still comprises the bulk of the spending at 47 percent, but spending towards system expansion is much higher at 44 percent, while system enhancement remains at 9 percent[126]. A break down of investment into different functional classes for highways and bridges is shown below:

[124] US DOT 2004 Status of the Nation's Highways, Bridges, and Transit: Conditions & Performance Executive Summary p. ES-14
[125] US DOT 2004 Status of the Nation's Highways, Bridges, and Transit: Conditions & Performance Executive Summary p. ES-14
[126] US DOT 2004 Status of the Nation's Highways, Bridges, and Transit: Conditions & Performance Executive Summary p. ES-14

Functional Class	System Preservation Highway	System Preservation Bridge	System Preservation Total	System Expansion	System Enhancements	Total
Rural Arterials & Collectors						
Interstate	$2.6	$0.7	$3.3	$2.5	$0.7	$6.4
Other Principal Arterial	$4.3	$1.0	$5.3	$1.7	$1.1	$8.1
Minor Arterial	$4.2	$1.0	$5.2	$1.0	$0.6	$6.8
Major Collector	$6.1	$1.5	$7.6	$0.6	$0.5	$8.7
Minor Collector	$1.2	$0.6	$1.8	$0.4	$0.2	$2.4
Subtotal	**$18.4**	**$4.8**	**$23.2**	**$6.1**	**$3.1**	**$32.4**
Urban Arterials & Collectors						
Interstate	$4.9	$2.1	$7.0	$15.9	$1.9	$24.9
Other Freeway & Expressway	$2.1	$0.7	$2.8	$8.3	$0.7	$11.8
Other Principal Arterial	$5.6	$1.3	$6.8	$7.7	$1.6	$16.2
Minor Arterial	$3.8	$0.9	$4.6	$5.4	$0.7	$10.7
Collector	$2.1	$0.4	$2.5	$2.5	$0.6	$5.7
Subtotal	**$18.4**	**$5.3**	**$23.7**	**$39.8**	**$5.6**	**$69.2**
Rural & Urban Local	$6.4	$2.3	$8.8	$6.9	$1.5	$17.2
Total	**$43.2**	**$12.5**	**$55.7**	**$52.9**	**$10.2**	**$118.9**

Source: US DOT 2004 Status of Highways and Bridges

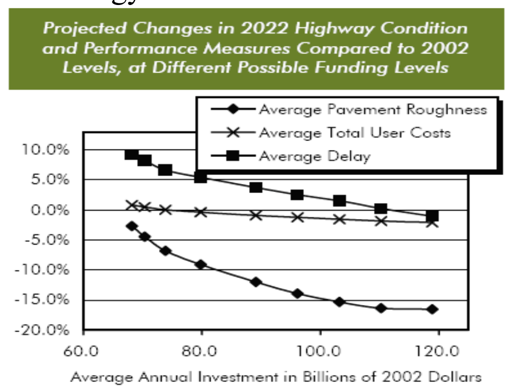
The levels of investment required for both scenarios exceed the current capital outlay that the government has dedicated to highways and bridges. In order for the government to meet the scenario of the Cost to Maintain they would have to increase capital outlay by eight percent, and 74 percent in order to get to the level of investment required for the Maximum Economic scenario. The gap between the government capital outlay and previous estimates by the DOT have been decreasing since 1997 from 21 percent for the Cost to Maintain and 109 percent for the Maximum Economic Investment due to more government funding[127].

	2002 Capital Outlay ($Billions)	Investment Requirements (Billions of 2002 Dollars)			
		Cost to Maintain	Percent Difference	Maximum Economic Investment	Percent Difference
Highway Preservation	$24.5	$31.1	26.5%	$43.2	76.0%
Bridge Preservation	$11.3	$8.9	-21.0%	$12.5	10.8%
System Expansion	$26.5	$27.5	3.9%	$52.9	99.9%
System Enhancements	$5.9	$6.4	8.3%	$10.2	74.3%
Total	**$68.2**	**$73.8**	**8.3%**	**$118.9**	**74.3%**

Source: US DOT 2004 Status of Highways and Bridges

[127] US DOT 2004 Status of the Nation's Highways, Bridges, and Transit: Conditions & Performance Ch. 8 p. 7

The two different investment scenarios are predicted to have different effects on the status of the roads and bridges for the next twenty years. If the Maximum investment strategy were to be pursued, the average pavement quality would improve by 16 percent, but would only increase by seven percent if the Cost strategy was followed. The road conditions would improve under these investment strategies, but the efficiency of the network will still continue to decline in some cases. At the current spending levels the total delay per vehicle mile traveled (VMT) is expected to increase by 9.2 percent and only increase by seven percent while spending the Maintenance level of investment. The Maximum level of investment would decrease the total delay per VMT by one percent, but there still would be an increase of 7.4 percent in congestion delays per VMT[128].



Source: US DOT 2004 Status of Highways and Bridges

Major Issues

The trucking industry is affected by many different variables that have negative impacts on the industry and have started to change the strategy of the trucking industry. Their heavy reliance on fuel make them very susceptible to fluctuating energy prices, their reliance on the government to provide an efficient system of highways makes them vulnerable to the government budget and economy, increased vehicle traffic has caused expensive delays for freight shipments, and labor shortages have not allowed the industry to affectively address the increased demand. The combination of these effects has caused the industry to shift from the traditional long-haul routes to shorter distance routes, and truck trips of less than 50 miles account for 80 percent of trips made, 74 percent of tons carried, and 66 percent of revenues earned[129].

The trucking industry is heavily effected by the fluctuating cost of fuel, and has thought to have been the cause of a few trucking fleet bankruptcies[130]. The trucking industry consumes an average of more than 650 million gallons of diesel and 250 million gallons of gas each week. The correlation of increasing fuel prices and the closure of trucking industry arose when "more fleets closed their doors in the first nine months of 2005 than in all of 2004"[131] according to the *Transport Topics,* a weekly publication by

[128] US DOT 2004 Status of the Nation's Highways, Bridges, and Transit: Conditions & Performance Ch. 9 p. 3-8
[129] AECOM Team "Benefit-Cost Analysis of Highway Transportation Improvements in Relation to Freight Transportation: Microeconomic Framework" FHWA February 26, 2001
[130] West, Andrew "Standard & Poor's Industry Surveys Transportation: Commercial" p. 5
[131] West, Andrew "Standard & Poor's Industry Surveys Transportation: Commercial" p. 5

the American Trucking Association (ATA). Taxation plays a large role on the cost of fuel for the trucking industry with an average of 50.1 cents a gallon in 2004. Fuel costs in 2003 and 2004 for trucking companies was about 12 percent to 15 percent of revenues, and was about 16.5 percent of revenues and 18 percent of operating expenses in the first nine months of 2005[132]. The higher fuel costs have caused trucking companies to cover their charges through rate surcharges and improving fuel efficiency in their fleet[133].

Companies in many industries are finding it difficult to find experienced, qualified people, and the trucking industry is no different by struggling to find drivers. The trucking industry has been affected with a high turnover rate and lower trucker productivity due to new government regulations. Companies have been experiencing a turnover rate of 100 percent a year, and recruitment and training can cost the industry $3 billion annually. The Truckload Carriers Association claims that the typical cost to replace a driver is about $3,000, and up to $24,000 to replace a senior driver. The industry is facing a major shortage of drivers over the next ten years, and the American Trucking Industry (ATA) has estimated that the supply of long-haul heavy-duty truck drivers to grow at an average annual rate of 1.6 percent versus the projected 2.2 percent growth in drivers needed. The ATA estimated a current shortage of 20,000 drivers, but is expected to grow to 111,000 by 2014. The demand for drivers is driving up the cost of operations for trucking companies because they are increasing wages six to seven percent over the next three years[134].

The increased investment into the nation's highways has had a positive effect and provided better physical conditions, however the growth in freight and vehicles has outpaced the investment levels and operational performance has dropped. From 1997 to 2002 the ride quality on America's NHS has increased from 89 percent to 91 percent, and the proportion of deficient bridges fell from 30 percent to 27 percent. However, the operational performance has continued to drop even with the higher levels of investment. Congestion has continued to increase, and the level of travel under congested conditions increased from 27 percent to 30 percent, and the additional travel time increased seven percent. The average annual hours of traveler delay in urbanized areas have also increased from 19 hours to 24 hours, but the rate of change for these indicators has decreased in recent years. The decreased efficiency on the NHS has caused a major congestion problem for the trucking industry and is creating bottlenecks in high areas of traffic[135].

Highway bottlenecks are a major concern for the trucking industry and the federal government because they are a national problem for the freight transportation system. According to the Chairman of the U.S. House Subcommittee on Highways, Transit and Pipelines, Tom Petri, "bottlenecks accrue significant truck hours of delay, totaling

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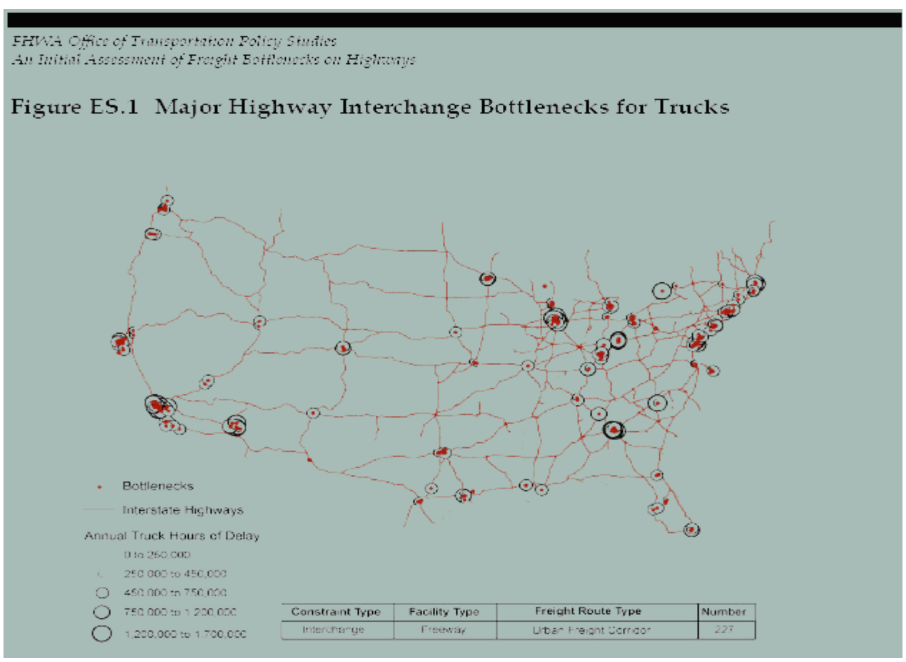
[132] West, Andrew "Standard & Poor's Industry Surveys Transportation: Commercial" p. 5-6
[133] West, Andrew "Standard & Poor's Industry Surveys Transportation: Commercial" p. 6
[134] West, Andrew "Standard & Poor's Industry Surveys Transportation: Commercial" p. 15-16
[135] US DOT 2004 Status of the Nation's Highways, Bridges, and Transit: Conditions & Performance Ch. 9 p. 3-11

upwards of 243 million hours annually. At a delay cost of $31.25 per hour, the direct user cost of these bottlenecks is about $7.8 billion per year"[136]. The costs are taken on by both the motor carriers and the shippers, and the estimated cost of congestion to the highway freight sector in 1997 was $10 billion (2002 dollars), with a cost to motor carriers of about $2.5 billion and about $7.6 billion to shippers[137]. The FHWA also estimates that increases in travel time cost shippers and carriers an additional $25 to $200 per hour depending on the product, and the cost of unexpected delays can add another 50 percent to 250 percent[138]. Congestion on the highways is caused in a few ways, such as accidents, work zones, weather, etc., but bottlenecks cause 40 percent of all congestion on the highways[139]. The major highway interchange bottlenecks are presented below, and you can see that the bottlenecks are located in major urban areas with high levels of traffic. The largest bottlenecks according to the Cambridge Systematics report are located in Buffalo, NY; Atlanta, GA; Phoenix, AZ; Chicago, IL; and Los Angeles, CA. These corridors experience over 489 thousand trucks daily and these trucks average 25 million hours of delay a year, which equates to a cost of $781 million[140].



Source: Cambridge Systematics

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[136] Tom Petri "Chairman Petri's Statement From Today's Hearing on Highway Capacity & Freight Mobility"
[137] US DOT 2004 Status of the Nation's Highways, Bridges, and Transit: Conditions & Performance Ch. 13 p. 5
[138] Cambridge Systematics, Inc. "An Initial Assessment of Freight Bottlenecks on Highways" Section 2 p.3
[139] Cambridge Systematics, Inc. "An Initial Assessment of Freight Bottlenecks on Highways" Section 2 p.14
[140] Cambridge Systematics, Inc. "An Initial Assessment of Freight Bottlenecks on Highways" Section 5 Table 5.2

Conclusion

The trucking industry carries more tons of freight than any other mode of transport, and is an integral part in the movement of freight across North America. America's reliance on trucks to move freight has caused large congestion problems on the NHS, which are resulting in billions of dollars in direct user costs. Freight demand is expected to increase dramatically over the next thirty years, and the government needs to increase investment into the nation's highway system in order to efficiently meet this demand. However, at the current levels of investment, the trucking industry will be unable to efficiently meet the future demand and the highways will begin to deteriorate and will result in billions of dollars more in direct user costs. The investment gap that has been created by the government's lack of funding has caused a new search for financing, and the industry is turning to the private sector for additional funds. Public-private partnerships are going to be the main source of funds for the future and are going to help close the gap between what has been invested and what is needed meet the future demand on the trucking industry.

> *"In a time of funding shortages at all levels of government, it is particularly important that we look to opportunities for the private sector to participate in funding transportation infrastructure improvements." – FHWA Administrator Mary Peters*[141]

[141] US DOT "Report to Congress on Public-Private Partnerships" December 2004 p.41

Policy Recommendations

Public-Private Partnerships (PPP)

In order for the government to bridge the gap between current investment levels and what is needed to expand America's highways, they will need to incorporate PPP agreements to receive the extra funding from private sources. PPP projects refer to "contractual agreements formed between a public agency and private sector entity that allow for greater private sector participation in the delivery of transportation projects"[142]. The benefits of using PPP's are an expedited completion compared to conventional project delivery methods, cost savings, improved quality and system performance, substitution of private resources and personnel, and access to new sources of private capital. A recent example of a PPP project has been the SAFETEA_LU, where the Administration recommended seven initiatives to facilitate public-private partnerships[143].

[142] FHWA "PPPs Defined" http://www.fhwa.dot.gov/ppp/defined.htm
[143] US DOT "Report to Congress on Public-Private Partnerships" December 2004 p.4

5.7 International Chokepoints

Executive Summary

Global trade in petroleum liquids is projected to increase more than 50% by 2030, to 55 million b/d. Much of this increase is expected to move via seaborne tankers, often through narrow geographic channels or chokepoints.

The most important chokepoints are the Strait of Hormuz, the Strait of Malacca, the Bosporus, and a collection of Russian pipelines/export ports.

Overview of Methodology

The report drew from a number of published sources, including:

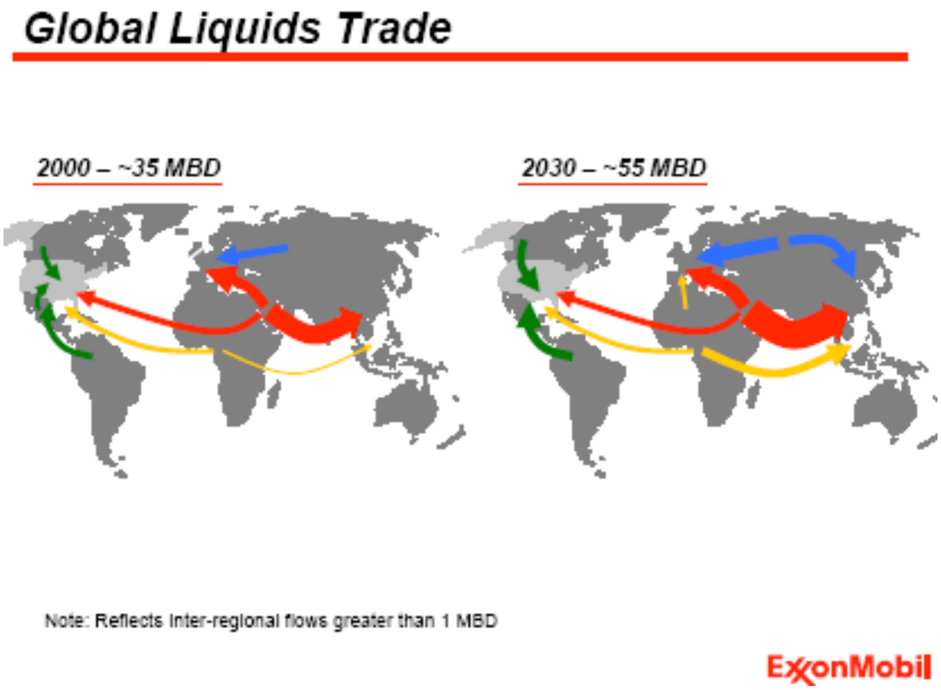
- The Outlook for Energy: A View to 2030, ExxonMobil, December 2006.
- World Energy Outlook 2006, International Energy Agency.
- "Global Oil Security: Risks by Region and Supplier," Anthony H. Cordesman, The Center for Strategic and International Studies, November 13, 2006.
- "Country Analysis Brief: World Oil Transit Chokepoints," Energy Information Administration, November 2005.
- "Where are the world's oil transit chokepoints?" Gordon Fellers, Pipeline & Gas Journal, June 1, 2004.
- "Turkey to Become East-West and North-South Energy Corridor," presentation by Turkish Prime Minister Recep Tayyip Erdogan at CERA's 9th Annual East Meets West Istanbul Conference, June 2, 2006.
- "Iran Might Try to Disrupt Hormuz Oil flow if Attacked by U.S.," Tony Capaccio, Bloomberg.com, May 5, 2006.
- "Bypassing a Major Oil Choke Point," The Wall Street Journal, November 14, 2006.
- "Guarding the Chokepoints," The Wall Street Journal, December 19, 2006.
- Petroleum Argus FSU Energy, December 15, 2006.
- Straits, Passages and Chokepoints: A Maritime Geostrategy of Petroleum Distribution, Jean-Paul Rodrigue, Hostra University, December 2004.
- Russia/Belarus: Moscow learns to avoid transit states, Oxford Analytica, January 15, 2007.

Background

Typical forecasts[144] indicate that global petroleum liquids trade will increase more than 50% by 2030, with increasing volumes originating from the Middle East and

[144] The Outlook for Energy: A View to 2030, ExxonMobil, December 2006.

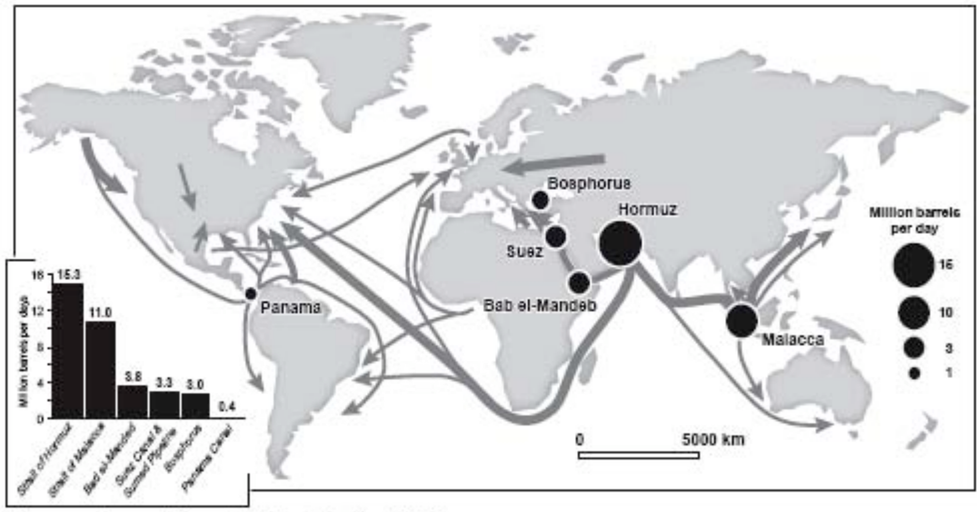
Russia/Caspian regions. North American supplies come from a very diverse set of sources.



Discussion

About two-thirds of the world's oil trade moves by tanker, generally along a fixed set of maritime routes. Along the way, it passes through a number of narrow channels, or geographic chokepoints, which often transport additional commodities as well. These include, in roughly decreasing order of criticality:

- The Strait of Hormuz
- The Strait of Malacca
- The Turkish Straits/Bosporus
- Russian oil and gas pipelines/export ports
- Bab el-Mandab
- Suez/Sumed



Source: Energy Information Administration (2003)

More than 17 million b/d of oil – one fifth of the world's oil consumption -- flows through the Strait of Hormuz on the way out of the Persian/Arabian Gulf.

- Located in Iran and Oman, the strait consists of two-mile wide channels for inbound and outbound tanker traffic, plus a two-mile wide buffer zone.
- Oil exports through the strait go to the U.S., Japan and Western Europe.
- The U.S. naval command in the Gulf claims that is has the capability to keep the straits open and clean them up if necessary. But it says that Iran's Revolutionary Guard-controlled navy has many small, fast-attack ships armed with torpedoes and missiles which could be used in an attempt to choke off oil exports through the strait.
- Closure would require the use of much longer (if available) alternate routes such as the 5 million b/d East-West Pipeline and 290,000 b/d Abqaiq-Yanbu pipelines across Saudi Arabia to the Red Sea.
- One bypass solution which has been mooted would run from Abu Dhabi to Oman.

The Strait of Malacca, which handles 12 million b/d of oil, links the Indian Ocean with the Pacific Ocean (and therefore links the oil producing regions of the Middle East with the major consuming markets in Asia).

- The narrowest point is the Phillips Channel in the Singapore Strait, which is 1.5 miles wide at its narrowest point, raising the risk of collision, grounding or piracy.
- More than 50,000 vessels transit the Strait of Malacca each year, which is the shortest sea route between the world's most populous nations.
- If the strait were closed, nearly half of the world's fleet would have to sail further, absorbing much tanker capacity.

The Bosporus is a 17-mile waterway that divides Asia from Europe and connects the Black Sea and Mediterranean Sea.

- Only half a mile wide at its narrowest point, the Turkish Straits are one of the world's busiest (50,000 vessels per year) and most difficult-to-navigate waterways.

- Oil exports, mainly to Europe, are just over 3 million b/d, but are under heavy pressure to grow due to the buildup in oil production capacity in the Caspian region.
- Turkey is concerned that the projected increase in large oil tankers would pose a serious navigational safety and environmental threat to the Turkish Straits, and has imposed a number of restrictions on tanker transit through the Bosporus. Although a 1936 pact agreed that commercial shippers are free to move about the Bosporus during peacetime, Turkey's prime minister recently commented[145] "We are not going to allow growing oil transportation through the heart of Istanbul."
- Delays for vessels moving through the Turkish straits have reportedly increased to around 12-14 days for a round trip.
- The response has been an increase in pipeline options, most notably the new 1 mmb/d Baku-Tbilisi-Ceyhan pipeline. Also planned are Nabucco, the Turkey-Greece-Italy pipelines, a line which would bring Egyptian gas through Jordan and Syria to Turkey, the Samsun-Ceyhan pipeline and the completion of the South Caucasus pipeline from Shah Deniz through Georgia to the Turkish border.
- The main bypass routes under consideration at the moment are Samsun-Ceyhan in Turkey and Burgas-Alexandroupolis (discussed further below). The former puts more power in the hands of Turkey; both have heavy Russian influence. The West wants them to be commercially viable; Russia is more concerned about control than cost.

Russia sends petroleum westward through a network of pipelines that criss-cross Belarus, Ukraine, Hungary, Slovakia, the Czech Republic, and Poland, and ports in the Baltic seas and the Gulf of Finland.

- Total pipeline exports through Russia are just over 4 mm b/d, including 3.6 mm b/d of Russian crude. Most exports are aimed at Europe.
- Major oil export ports include Novorossiysk (Russia, Black Sea), Primorsk (Russia, Baltic Sea/Gulf of Finland), Tuape (Russia), Ventspils (Latvia) and Odessa (Ukraine).
- Major current and planned oil pipelines include Druzhba (1.2 mm b/d), Baltic Pipeline System/Primorsk (1.3 mm b/d), CPC (Kazakhstan to Novorossiyak, 1.2 mm b/d). Karyaga-Indiga, Murmansk-Baltic, and Eastern Siberia/Perevoznaya Bay.
- In an attempt to bypass the crowded Bosporus, Russia has been promoting a 700,000 b/d Burgas-Alexandroupolis pipeline which would allow oil to move by ship from the Russian port of Novorossiyak across the Black Sea to the Bulgarian port of Burgas, then by pipeline to the Greek port of Alexandroupolis on the Aegean Sea.
- Export levels have been impacted by political moves. In January 2007, for example, Russia halted crude oil exports to Belarus, whose Druzhba (Friendship) pipeline carries about half of Russia's oil exports to Europe (roughly 1.5 mm b/d,

[145] "Turkey to Become East-West and North-South Energy Corridor," presentation by Turkish Prime Minister Recep Tayyip Erdogan at CERA's 9th Annual East Meets West Istanbul Conference, June 2, 2006.

or 12.5% of European crude consumption) due to a spat related to oil export and transit taxes. A year earlier it temporarily cut gas exports to the Ukraine. It is also pressuring the Caspian Pipeline Consortium to support a Turkish straits bypass by blocking an expansion of CPC and withholding a license to load oil at its terminal near Novorossiyk.

- The Belarus incident in particular could have consequences. After Russia raised gas prices and imposed a duty on crude exports at the end of 2006, Belarus retaliated by imposing a transit fee and taking oil from Druzhba as a payment in kind. Russia responded by briefly halting oil exports via Druzhba to Germany, Poland, Slovakia, Hungary and the Czech Republic. This damaged Russia's reputation as a supplier to Europe, and increased Russian resolve to reduce dependence on transit states. On the gas side, it is emphasizing Nord Stream, Blue Stream and LNG. On the oil side, it would like to expand the Baltic Pipeline System; build lines from Western Siberia to Indiga, Varandey or Murmansk; and develop an Eastern pipeline to the Pacific. To reduce dependence on Russia, the EU is thinking of expanding the Polish oil terminal at Gdansk and supporting the Odessa-Brody and Nabucco (from Azerbaijan/Iran) pipelines.
- As of November 2006, 625,000 b/d of crude (including 26,400 b/d of Kazakh exports) moved by rail to CIS and non-CIS destinations: 103,000 b/d to Belarus, 216,000 b/d to China, 109,000 b/d to CPC, 63,000 to Arkhangelsk on the White Sea, 60,000 to Novorossiyk on the Black Sea.
- Russia is also a major exporter of natural gas to Europe via pipeline through the Ukraine. PGNiG and Gazprom are already sparring over control of the Polish section of the Yamal-Europe gas line. A major interruption to gas flows could put additional pressure on crude oil markets.

Bab el-Mandab, bordered by Djibouti, Eritrea and Yemen, connects the Red Sea with the Gulf of Aden and the Arabian Sea. It handles over 3 million b/d of oil exports destined to Europe, the U.S. and Asia.

- If it were closed, tankers from the Gulf would be unable to reach the Suez Canal/Sumed Pipeline, and tanker traffic would be diverted around the southern tip of Africa (the Cape of Good Hope).
- This would add greatly to transit time and cost, and tie-up additional tanker capacity.
- In 2002, the French oil tanker Limburg, carrying 60,000 tons of oil, was attacked in a Yemeni port in the area; U.S. officials blamed al Qaeda.

The Suez Canal and Sumed Pipeline connect the Red Sea and Gulf of Suez with the Mediterranean Sea. Northbound oil flows are about 4 million b/d -- 2 ½ million b/d via the pipeline and 1 ½ million b/d via the canal. Closure of the Suez Canal and/or Sumed Pipeline would divert tankers around the southern tip of Africa, adding greatly to transit time and tying up additional tanker capacity.

A minor chokepoint, the Panama Canal extends 50 miles from Panama City on the Pacific Ocean to Colon on the Caribbean Sea. Oil flows are approximately 0.5 million b/d, and only about 1% of total U.S. petroleum imports transit the canal en route to American ports. There is a long term program to expand the canal.

Though not a chokepoint per se, the Gulf of Guinea currently produces in excess of 3 mm b/d. The region's biggest producer, Nigeria, has been hit by a series of attacks against onshore and offshore fields, shuttering as much as 700,000 b/d of production capacity. The pirate-infested waters are also hoe to oil smugglers whco make off with an estimated 70,000 to 300,000 b/d.

A number of additional possible constraints to world oil flows are discussed in other sections of this report. These include:

- Risks which are geopolitical, rather than physical, in nature. These include the stability of oil exporting nations; terrorism, asymmetric attacks, sabotage; proliferation of WMD; embargos and sanctions; and ethnic conflicts and strife.[146]
- LNG facilities.
- The Alaska and Mackenzie Delta gas lines. There is also a near-term (2009-2009) issue with respect to the availability of pipeline capacity to accommodate the increase in oil sands output; longer-term, 12 announced pipeline projects should lead to more than adequate capacity.

Potential Policy Implications

Attacks on shipping, pipelines and key facilities are a serious threat to global energy flows, and it should be a U.S. policy goal to protect:

- Oil, gas and product exports from the Middle East. The U.S. has a role to in ensuring Gulf security and protecting the sea lanes in view of Iraq, Iran, Arab-Israel, counterterrorism and immigration tensions.
- Russian, Caspian and Central Asian exports. This partly involves pipeline politics.
- West African and Latin American exports. This is internal threat driven
- Key pipelines and energy bottlenecks. The U.S. needs to project seapower to counter local threats, escalating asymmetric weapons and technology.

The U.S. may also want to encourage development of reliable alternate routes around chokepoints such as the Bosporus and encourage development of North American oil and gas resources.

[146] "Global Oil Security: Risks by Region and Supplier," Anthony H. Cordesman, The Center for Strategic and International Studies, November 13, 2006.

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