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How Pipelines Make the Oil Market Work – Their Networks, Operation and Regulation

A Memorandum Prepared for the

Association of Oil Pipe Lines

And the

American Petroleum Institute's Pipeline Committee

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Pipelines Are Key to Meeting U.S. Oil Demand Requirements

Introduction

The U.S. consumes about 19.5 million barrels per day (b/d) of petroleum products. A complex and carefully choreographed network is in place to move the raw materials, which are mainly crude oils, from where they are produced to where they are processed, and the refined products[1] from where they are processed to where they are consumed. Distances involved can be enormous: crude and products arriving from the Middle East have already traveled more than 10,000 miles, and may be shipped thousands more across the U.S. This vast logistical ballet is the key to the oil market, and an outgrowth of the basic shape of the oil market. Areas that are relatively resource-rich supply areas that are relatively demand-hungry but resource-poor. This interplay of resource versus demand regions is a characteristic of world markets, where producing countries supply consuming countries, and of regional markets in the United States, where producing and refining areas supply consuming areas.

Each part of oil's journey from producer to consumer involves a special set of players. This memo focuses on the primary player or transportation mode in the United States: pipelines. It describes the pipeline networks for crude and products, how they operate and how they are regulated.

Why Pipelines?

The outbreak of World War II engendered a watershed event in petroleum transportation. Reflecting historical demographic and economic factors, the East Coast was the largest consuming region in the U.S. (as it remains, but less dominantly so), but it relied on tanker shipments to supply its regional refineries and to move refined petroleum products from the U.S. Gulf Coast. With the involvement of the U.S. in the War, German submarines began sinking tankers along the Gulf and Atlantic Coasts and in the Caribbean, thus disrupting the flow of oil. A joint industry-government effort found alternative transportation in the form of a technological breakthrough: long distance, large diameter pipelines. The new capability to transport large quantities of oil over long distances subsequently fueled the post-War economic boom, and changed the shape of the petroleum industry.

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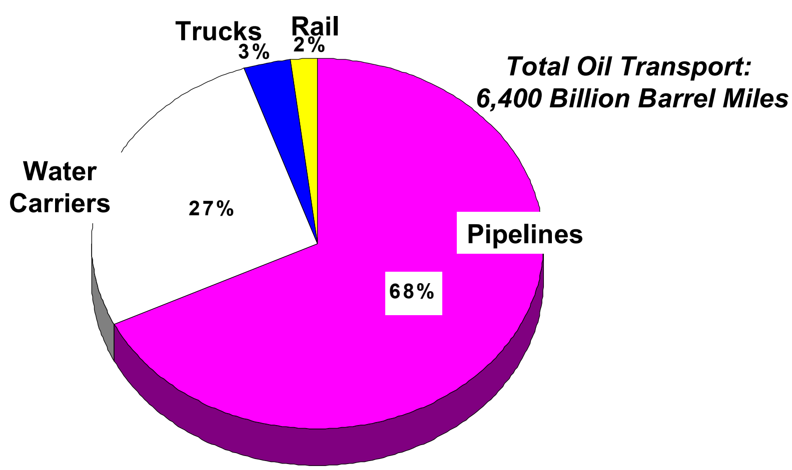
[1] The main refined petroleum products are gasoline, diesel fuel, jet fuel, and home heating oil.

Pipelines are the irreplaceable core of the U.S. petroleum transportation system and hence the key to meeting petroleum demand. Without oil pipelines, petroleum products would not reach the millions of consumers in all fifty states. Oil pipelines transport roughly two-thirds of the petroleum shipped in the United States. They deliver over 14 billion barrels (more than 600 billion gallons) of petroleum per year. Because many volumes are shipped more than once (as crude oil and then again as refined product, for instance), these annual pipeline shipments are equal to more than twice the actual U.S. consumption of oil.

Domestic Shipments of Petroleum, 1999



Source: Estimated from Association of Oil Pipe Lines, *Shifts in Petroleum Transportation*, 2000

Furthermore, oil pipeline shipments account for more than 17% of the freight moved nationally, but less than 2% of the national freight cost.[2] The United States has the largest network of oil pipelines of any nation. All of Europe, for instance, has a pipeline network that is only 1/10 the size of the U.S. network.

Shippers select transportation modes principally on the basis of cost, and economics favor pipelines. Trucking costs escalate sharply with distance, making trucking the most expensive mode of petroleum transportation. In addition, of course, the logistics of truck transport for high volume/long distance shipments are so daunting as to be impractical. Assuming each truck holds 200 barrels (8,400 gallons) and can travel 500 miles per day, it would take a fleet of 3000

[2] R.A. Wilson, *Transportation in America*, Eighteenth Edition (Washington, D.C.: Eno Transportation Foundation, Inc., 2001).

trucks, with one truck arriving and unloading every 2 minutes, to replace a 150,000-barrel per day, 1,000-mile pipeline. Consequently, in spite of the fact that trucks are ubiquitously available, trucking is generally limited to short haul movements where alternatives are often unavailable: between product terminals and retail outlets or consumers, and to small crude shipments from marginal producing areas to storage points where crude is aggregated into pipeline-size volumes for shipment to a refinery. However, despite generally being small in terms of both volume per shipment and distance, such truck movements are essential to both the completeness and the competitiveness of the overall oil distribution system.

While railroad tank car costs do not rise as sharply with distance traveled, their costs, too, remain a multiple of pipeline and waterborne alternatives. Replacing the same 150,000-barrel per day pipeline with a unit train of 2000-barrel tank cars would require a 75-car train to arrive and be unloaded every day, again returning to the source empty, along separate tracks, to be refilled. Furthermore, rail transportation is far from universally available in the United States.

While waterborne shipments can be priced competitively with pipelines, their use, of necessity, is limited by geography. Where rivers and coasts allow their use, tank barges and tank vessels compete aggressively against pipelines. In most areas of the nation's interior, petroleum is delivered almost entirely by pipelines rather than by water or other modes.

Pipeline Movements Help Balance the Oil Market

The Oil Market Dictates Pipeline Flow from Region to Region

As noted, globally and regionally, the oil market's infrastructure moves oil from the producing regions to the consuming regions. The profiles below and the accompanying graphics sketch these inter-regional flows in the U.S.

- *The Gulf Coast* (PADD 3[3]) is the largest supply area of the U.S., accounting for 55% of the nation's crude oil production and 47% of its refined product output. It is the largest oil supplier in interregional trade, accounting for 90% of the crude oil shipments and 80% of the refined petroleum production shipments among PADDs. Most of the crude oil goes to refineries in the Midwest, while most refined products go to the East Coast and, to a lesser extent, to the Midwest.

- *The East Coast* (PADD 1) has virtually no indigenous crude oil production, limited refining, and the highest regional, non-feedstock demand for refined products[4]. Its refineries process predominately foreign crude oil. To meet regional demand, their output is augmented by refined product shipments from the Gulf Coast as well as imports from abroad. The East Coast receives more than 60% of the refined products shipped among regions and almost all of the refined product imported into the U.S.

- *The Midwest* (PADD 2) has significant regional crude oil production, but also processes crude oil from outside of the region: Canadian crude oil imported directly via pipeline, crude oil imported from other nations and then shipped to the Midwest via the Gulf Coast, and crude oil produced in the Gulf Coast region. These supplies from outside of the region – imports and domestic – account for 88% of its refinery input. Refined product output from regional refineries is also supplemented with supplies from outside the region, primarily shipments from the Gulf Coast.

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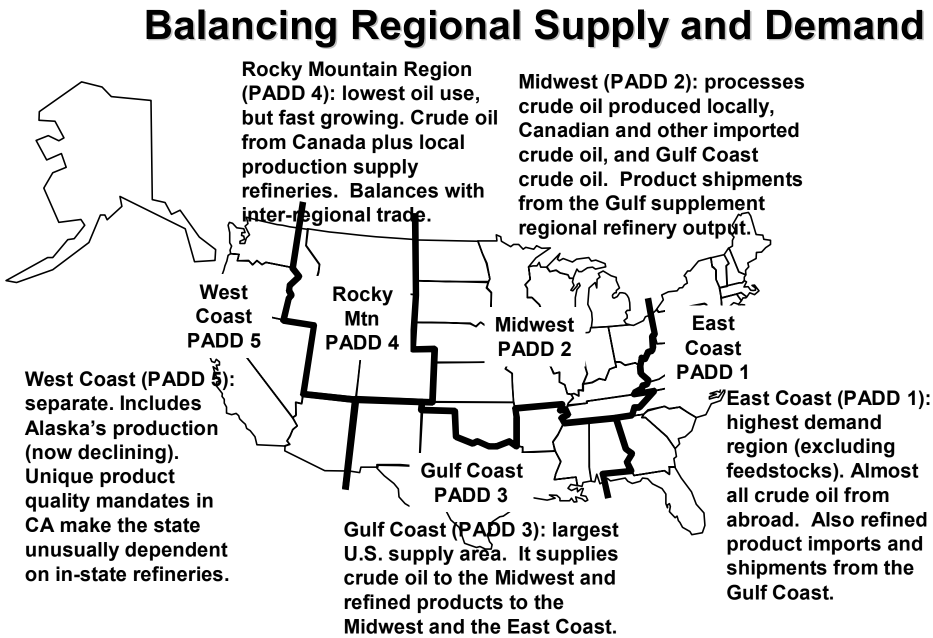
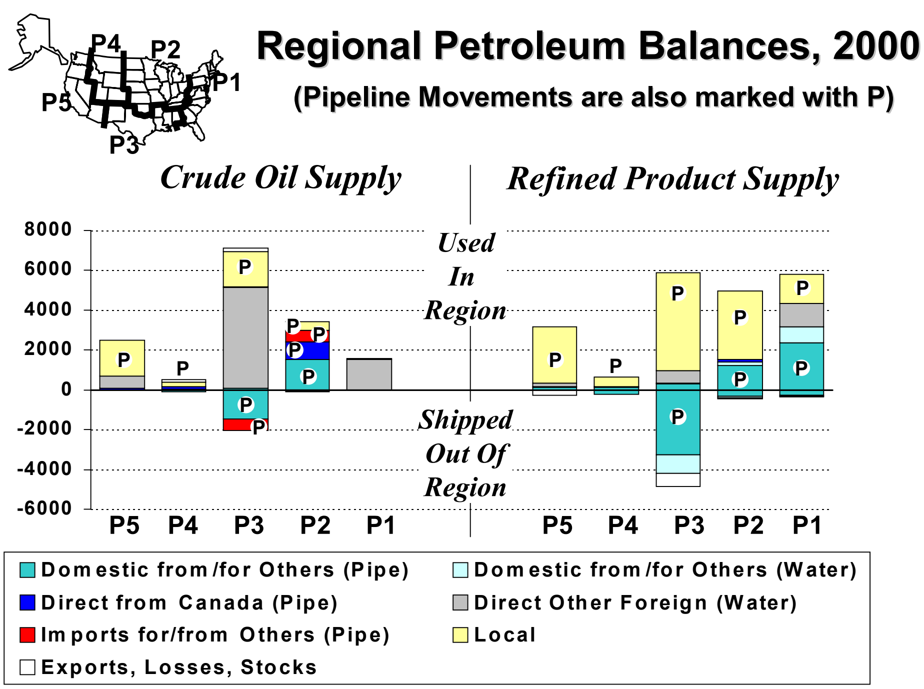
[3] The five regions referred to as "Petroleum Administration for Defense Districts," or PADDs, were delineated during World War II. Broadly speaking, the five PADDs cover the East Coast (PADD 1), the Midwest (PADD 2), the Gulf Coast (PADD 3), the Rocky Mountain Region (PADD 4) and the West Coast (PADD 5). The U.S. Department of Energy's Energy Information Administration still collects and publishes oil supply data by PADD.

[4] The majority of consumers use oil as a source of energy, to provide either heat or power. A limited number of consumers, such as the petrochemical industry, uses oil as a raw material or feedstock. In the case of the US, these consumers use mainly ethane and other NGLs, rather than mainstream products like gasoline, and are concentrated in the Gulf Coast.


Balancing Regional Supply and Demand
Rocky Mountain Region (PADD 4): lowest oil use, but fast growing. Crude oil from Canada plus local production supply refineries. Balances with inter-regional trade.
Midwest (PADD 2): processes crude oil produced locally, Canadian and other imported crude oil, and Gulf Coast crude oil. Product shipments from the Gulf supplement regional refinery output.
West Coast PADD 5
Rocky Mtn PADD 4
Midwest PADD 2
East Coast PADD 1
West Coast (PADD 5): separate. Includes Alaska's production (now declining). Unique product quality mandates in CA make the state unusually dependent on in-state refineries.
East Coast (PADD 1): highest demand region (excluding feedstocks). Almost all crude oil from abroad. Also refined product imports and shipments from the Gulf Coast.
Gulf Coast PADD 3
Gulf Coast (PADD 3): largest U.S. supply area. It supplies crude oil to the Midwest and refined products to the Midwest and the East Coast.


Regional Petroleum Balances, 2000
(Pipeline Movements are also marked with P)
P4 P2 P1 P5 P3
Crude Oil Supply
Refined Product Supply
Used In Region
Shipped Out Of Region
8000
6000
4000
2000
0
-2000
-4000
-6000
P5 P4 P3 P2 P1
P5 P4 P3 P2 P1
Domestic from/for Others (Pipe)
Direct from Canada (Pipe)
Imports for/from Others (Pipe)
Exports, Losses, Stocks
Domestic from/for Others (Water)
Direct Other Foreign (Water)
Local

- *The Rocky Mountain Region* (PADD 4) has the lowest petroleum consumption, but has shown relatively rapid regional growth in recent years. It imports crude oil from Canada to augment local production for its refineries. Its distances are long, its topography steep and its infrastructure thin, however. Therefore, the inter-regional trade, while small in nationwide standards, is an important factor in keeping the region's supply and demand in balance.

- *The West Coast* (PADD 5) is logistically separate from the rest of the country. Its crude oil supply is dominated by production from the Alaskan North Slope oil fields, which now accounts for 55% of PADD 5 production, down from 65% when those fields were in peak production in the late 1980s. Essentially all of the rest of the region's production comes from California. Because of unique product quality requirements in California, the largest consuming state, essentially all of that state's refined product demand is met by output from the state's refineries.

As shown in the chart on the previous page, pipelines are the critical mode for moving oil between regions. (Volumes transported via pipeline are marked with a "P" for each supply category.) In 2000, for instance, pipelines moved virtually all of the crude oil and about 70% of the products transported between PADDs. Pipelines from the Gulf Coast carry both domestic and imported crude oil to the Midwest, and refined product to the Midwest, the East Coast and, in much smaller volume, to the Rocky Mountain region. Pipelines also carry the Canadian crude oil supplies vital to the Midwest and the Rocky Mountain refineries. Supplying approximately 1 million barrels per day to these regions, Canada is the third largest foreign crude oil supplier to the U.S., and accounts for about 25% and 30% respectively of the two regions' crude oil.

Pipelines are also irreplaceable in moving oil within the PADDs, from producing fields and coastal ports to refineries (crude oil and other refinery feedstocks) and from refineries and large redistribution centers to smaller regional supply centers, to airports, and even directly to large consumers (refined petroleum products).

Patterns of Pipeline Flow

The regional snapshots discussed above freeze the market's patterns and characteristics in order to profile them. In reality, the oil market is constantly changing. From a distance, the market usually looks unified and orderly. Up close, however, the "market" is comprised of constant movement and adjustments, and the decisions of many players. An analogy to a tuning fork illustrates: it sounds like a unified tone until one is close enough to perceive the resonating vibrations. In the following sections, we describe some of the market's many facets and how the continuous small iterations and adjustments are accomplished.

Logistics Hubs Allow the Market to Work, and Pipelines Allow Hubs to Work

To understand the importance of pipeline transport, one must understand the role of logistics hubs. Logistics hubs serve as gateways for regional supply. They are characterized by interconnections among many pipelines and, often, other modes of transportation – such as tankers and barges, sometimes rail, and usually trucks, especially for local transport – that allow supply to move from system-to-system across counties, states, and regions in a hub-to-hub progression. These hubs are also characterized by their substantial storage capacity. The availability of storage and transportation options at these hubs enhances supply opportunities and increases supply flexibility, both essential ingredients for an efficient market.

New York Harbor is a logistics hub for refined petroleum products: products from the Gulf Coast (having arrived by pipeline) and abroad (having arrived by tanker) are traded along with supplies from area refineries; the aggregate New York Harbor supplies are redistributed by many players to points west and northwest (pipeline) and northeast (barge). Similarly, Cushing, Oklahoma, is a hub for crude oil supplies: production of West Texas Intermediate and other domestic crude oils comes together with supplies imported through the Gulf Coast and is re-distributed northward to Chicago area refineries and, decreasingly, south to the Gulf Coast refineries. Other large transportation hubs in the United States include Chicago, Los Angeles, and the Texas-Louisiana Gulf Coast.

As noted above, hubs are at the core of the U.S. oil market's efficiency: its ability to respond to changes in supply and demand. The supply/demand balance in a hub is, therefore, the key to price levels in the surrounding region, dictating price differentials both between one hub and another that is an alternative source of supply, and between different crudes, products and product qualities. Any regional supply/demand imbalance is quickly reflected in prices at the region's hub. The hub's supply and storage options then allow market participants to take advantage of the price signals and adjust their supply and demand to restore balance. For example, a refinery fire in Chicago might cause diesel prices to spike in Houston, as the affected refiner and others scour the market for alternative supply. A diesel buyer in New York that normally receives product from the Gulf Coast via Colonial Pipeline may then choose to sell its product in Houston, rather than having it shipped to the northeast for its own consumption, and use inventory or turn to imports instead. This market-clearing function is a central role of the hub.

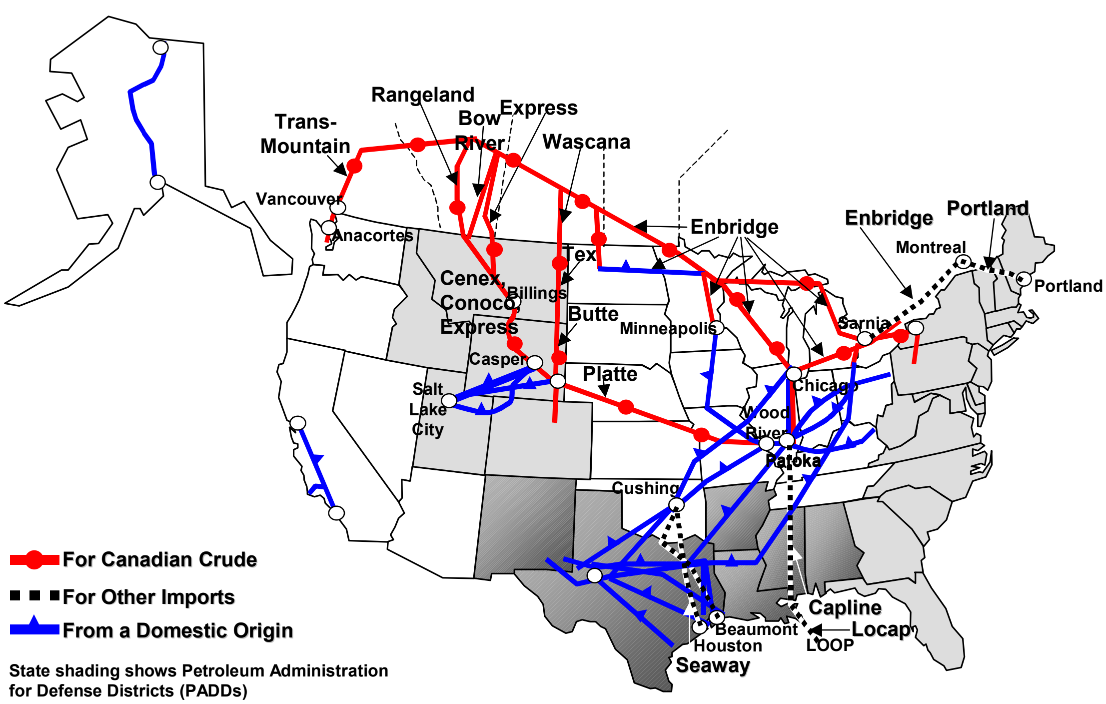
The pipeline maps on the following pages illustrate how pipelines carry petroleum between the hubs (such as between the Gulf Coast and Chicago, or the Gulf Coast and New York) and from the hubs to more distant consuming areas.

Crude Oil Flows

The United States is currently the third-largest producer of crude oil in the world. Its domestically produced volumes come from hundreds of thousands of producing wells. Because the United States is such a mature producing area, production is declining, and more crude oil is imported than produced domestically. The Gulf Coast's unparalleled refining capacity was originally positioned to take advantage of local crude oil supplies (generally high quality) and to utilize the historically cheaper supplies that could be imported. Due to modifications in recent decades, these facilities can now process a wide range of crude oil qualities, domestic and imported. Most refineries are located in coastal states, though substantial refining capacity exists in central and Midwestern states.

While many crude shipments are relatively short haul movements, from local producers to local refineries or to collection points where the production of a large number of small domestic wells is aggregated, there are also large volumes of crude shipped many hundreds of miles to inland refineries. The Capline pipeline system, for instance, transports more than one million barrels per day from the Gulf Coast to a southern Illinois crude oil pipeline hub (Patoka); other pipelines then move the oil to refineries throughout the Midwest. The Seaway crude system brings oil from the Gulf Coast to Cushing, Oklahoma; other pipeline

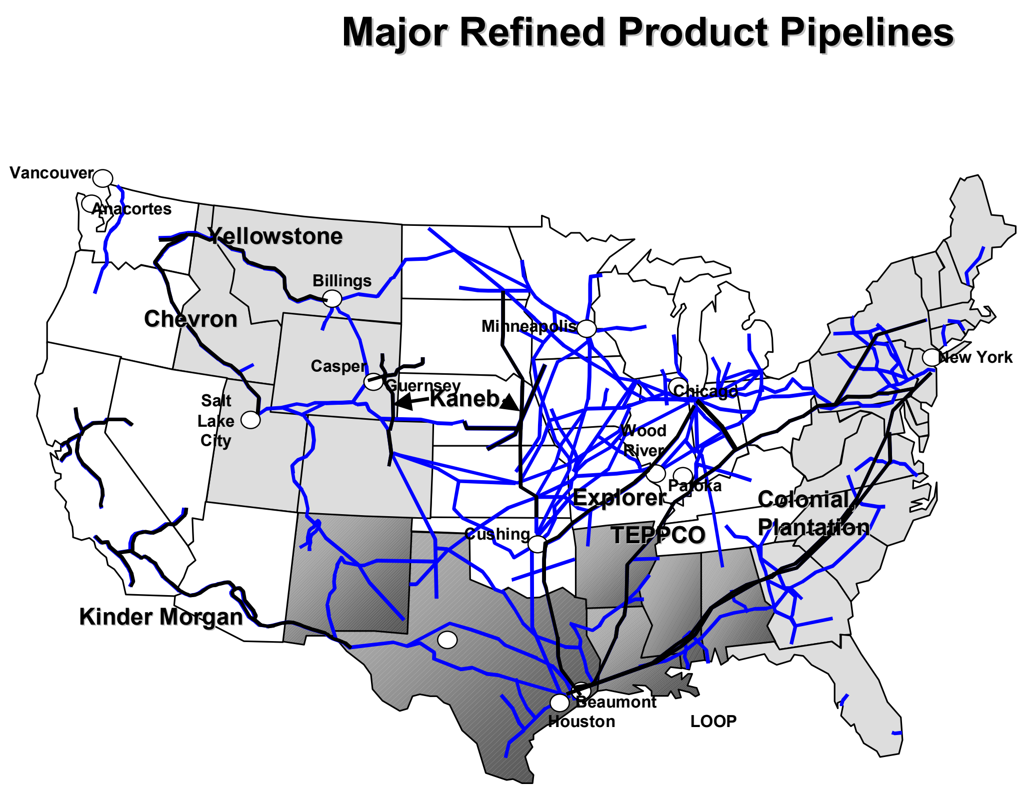
Selected Crude Oil Trunkline Systems



systems carry crude oil from Cushing to southern Illinois and to the Chicago area. Almost all of the supplies from Canada, the third largest crude oil import source, come to the U.S. via pipeline.

The map of Selected Crude Oil Trunkline Systems is coded to differentiate among lines carrying predominately domestic crude oil, those carrying Canadian crude oil and those carrying a mix of foreign and domestic supplies inland from the U.S. Gulf Coast.

Refined Products Flows



Refined products move from refinery to consuming region to consumer. The availability of product from the Gulf Coast refineries – some of the most sophisticated in the world in their ability to process crude oil into the most desirable mix of consumer products – is central to the supply balance in both the East Coast and the Midwest. Pipeline shipments from the Gulf Coast, for instance, account for 40% of the East Coast's supply of refined product and for just under 20% of the Midwest's. Examples of these long distance product movements in large diameter pipelines are the run from the Gulf Coast to the East

Coast via Colonial Pipeline (1,500 miles) or Plantation Pipe Line (1,100 miles) and from the Gulf Coast to the Midwest via Explorer Pipeline (1,400 miles) and TEPPCO, LP (1,100 miles).

Most refined product shipments are shorter than these and are intra-regional, and move in smaller diameter pipelines. Although the large diameter pipelines have the high volumes, the smaller diameter lines are crucial to supply in more localized areas. (While these shipments may go across state boundaries, they are only captured by Energy Information Administration statistics such as those discussed earlier if they cross PADD boundaries.)

Each market is of course slightly different. In the *Pacific Northwest*, for instance, the Yellowstone Pipeline out of Billings, Montana, and the Chevron pipeline out of Salt Lake City compete with each other and with barge traffic along the Columbia River for the market in eastern Washington. In the *Rocky Mountain region*, the long distances and sparse population create a challenge to keep volumes above the minimums required for the smooth and efficient running of the pipeline infrastructure. These pipelines strive to meet this challenge by limiting the number of specialized products they carry. As a consequence, the market needs for off-highway diesel fuel (farm use, for instance) are often met by diesel that conforms to on-highway specifications. In the *Southwest*, the Phoenix market is supplied by Kinder Morgan's SFPP system out of western Texas and out of southern California. There is currently no pipeline into California from another area. In the *Northeast*, New England has several local pipelines, but no connections to the rest of the national pipeline grid. Thus, supplies that arrive in the New York Harbor area from the Gulf Coast via pipeline can only be transported to New England via barge.

How Oil Pipelines Work

Different Operations for Different Roles

The discussion above illustrates that pipelines fill diverse roles. That diversity of supply pattern and consumer need precludes the industry from being monolithic. Pipelines are serving different regions with different consuming patterns. Even within a region, there are additional scheduling and operational challenges presented by contrasts among the output mix of different refineries, the consumption patterns of large consumers on a system, and even seasonal consumption patterns in a region. Pipelines compete with each other and with other modes of transportation in filling these needs.

One illustration of the contrast between different types of pipelines is the operation of the long-haul lines versus the short-haul lines. The product pipeline systems such as Colonial Pipeline, Explorer Pipeline and TEPPCO, LP mentioned above are "trunk" lines along their main lines, bringing refined products in large diameter pipe from the Gulf Coast refining area to a consuming region. From large central terminals in the consuming region – the logistics hubs – smaller diameter pipelines or "delivering" lines may then further distribute the petroleum products, often over hundreds more miles. Examples of delivering carriers would be Buckeye Pipe Line serving markets in the Northeast and Midwest, and other carriers in the Midwest such as Wolverine, Marathon Ashland Pipe Line, West Shore, to name a few. In addition, many of the inter-regional carriers operate as trunk lines on their main, large diameter pipelines, and then as delivering lines via spurs off their main lines.

A trunk line has relatively larger volumes going to relatively fewer delivery points. The delivering line has smaller shipments going to more delivery points. Generally, the trunk system operates in "fungible" mode: the shipper receives the same quality of product that it tendered for transport, but not the same molecules, while the delivering line operates in "batch" mode: the shipper receives the same molecules that it tendered for shipment. The two types of systems face different economics. The trunk carrier tends to have relatively fewer employees, is more capital intensive, and receives lower revenue per unit of throughput.

Managing Oil Pipeline Flow

Moving the Oil

Oil is generally propelled through pipelines by centrifugal pumps. The pumps are sited at the originating station of the line and at 20 to 100 mile intervals along the length of the pipeline, depending on pipeline design, topography and capacity requirements. Most pumps are driven by electric motors, although diesel engines or gas turbines may also be used.

Pipeline employees using computers remotely control the pumps and other aspects of pipeline operations. Pipeline control rooms utilize Supervisory Control And Data Acquisition (SCADA) systems that return real-time information about the rate of flow, the pressure, the speed and other characteristics. Both computers and trained operators evaluate the information continuously. Most pipelines are operated and monitored 365 days a year, 24 hours per day. In addition, instruments return real-time information about certain specifications of the product being shipped – the specific gravity, the flash point and the density, for example – information that are important to product quality maintenance.

Oil moves through pipelines at speeds of 3 to 8 miles per hour. Pipeline transport speed is dependent upon the diameter of the pipe, the pressure under which the oil is being transported, and other factors such as the topography of the terrain and the viscosity of the oil being transported. At 3-8 mph it takes 14 to 22 days to move oil from Houston, Texas to New York City.

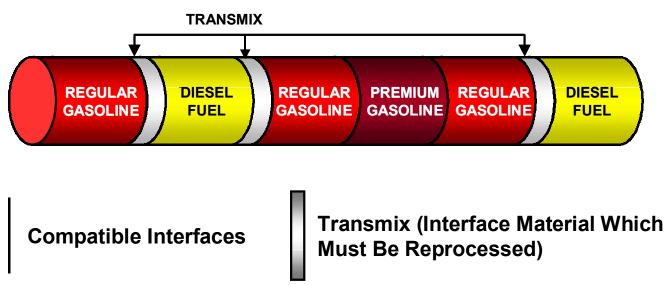
Sequencing Product Flow

Pipeline operators ship different petroleum products or grades of the same product in sequence through a pipeline, with each product or "batch" distinct from the preceding or following. (A pipeline operating in fungible mode also uses batch sequencing, but on larger size batches.) One refined product or crude oil grade is injected and begins its journey, then another, and another. A batch is a quantity of one product or grade that will be transported before the injection of a second product or grade.

Each pipeline publishes its batch size based on the characteristics – the logistics needs – of its shippers and on pipe size. For a pipeline operating in fungible mode, products that meet common specifications can be mixed and sent through the pipeline together as a batch. For example, a products pipeline will establish the acceptable specifications for regular grade gasoline. Shippers whose gasoline meets that pipeline's specifications can obtain transport services for smaller volumes because their gasoline will be added to gasoline of the same quality and grade from other shippers. A shipper whose product either does not meet common specifications or for other reasons must be kept separate from other products in the line, must meet a higher minimum batch size volume before transport will be economic for the pipeline.

Batching petroleum for pipeline transport has become more complex with the proliferation of product qualities (discussed more fully below). Colonial Pipeline, for instance, publishes specifications for over 100 different grades of gasoline. Crude oil pipelines, too, must meet market demands for delivering various crude types – such as high sulfur or low sulfur grades – to refineries to align with the refineries' schedules for producing jet fuel, asphalt, diesel, and other products and to the refineries' equipment. Lakehead Pipe Line's 1.3 million barrel per day system, for instance, can contain up to 50 batches of crude oil of distinct qualities.

Typical Sequence of Petroleum Products Flow through a Pipeline



There is always a certain amount of intermixing between the first product and the second at the "interface," the point where they meet. If the products are similar, such as two grades of gasoline, the resulting mixture is added to the lower value product. If the products are dissimilar, such as diesel and gasoline, the "transmix," the hybrid product created by intermixing at the interface, must be channeled to separate storage and reprocessed.

Scheduling Product Flow

Pipeline operators establish the batch schedules well in advance. A shipper desiring to move product from the Gulf Coast to New York Harbor knows months ahead the dates on which Colonial will be injecting heating oil, for instance, into the line from a given location. On a trunk line, a shipper must normally "nominate" volumes – ask for space on the line – on a monthly schedule. Delivering lines, by their nature, have more changeable schedules; shippers can secure space on them with a shorter lead-time, possibly even the same day.

It is not uncommon for tendered volumes to differ from nominated volumes, especially on delivering lines. These lines, by their nature, are closer to the end-user and must be responsive to the changing needs of shippers and their customers. Hence, the last minute changes that are essential to the oil market balance are a routine part of pipeline operations.

As common carriers, oil pipelines cannot refuse space to any shipper that meets their published conditions of service. If shippers nominate more volumes than the line can carry, the pipeline operator allocates space in a non-discriminatory manner, usually on a *pro rata* basis. This is often referred to in the industry as "apportionment." (Space cannot be allocated to the highest bidder, nor on a first come, first serve basis. Pipeline rate structures are discussed in more detail below.)

During the peak seasons, it is common for some pipelines to be using apportionment. Such bottlenecks invite competition, of course, either from other modes of transportation or from pipeline alternatives. The need to allocate space also encourages capacity expansion. The supply of gasoline to the Midwest from the Gulf Coast provides an example. Explorer Pipeline recently announced a capacity expansion, and Centennial Pipeline, a line newly converted from natural gas to refined products transport, will offer competing service beginning in 2002.

This Gulf Coast-to-Midwest refined products capacity expansion is just one example of how the pipeline industry responds to structural shifts taking place in oil markets. There are many others: the conversion to product service (or in a few cases to natural gas service) of a number of crude oil lines idled or underutilized by declining crude oil production; new pipeline initiatives to supply refined products to the Salt Lake City area from PADD 3; and also in the Salt Lake City area, newly increased pipeline utilization from using Canadian crude oil to meet newly developed local market needs rather than shipping the crude through PADD 4 into PADD 2, as a recent pipeline expansion had anticipated. There are also the changes brought about by refinery closures. These plants have become uneconomic for a variety of reasons, including the imposition of a new set of emissions standards as the plants install new equipment to meet new product mandates. The supporting infrastructure – crude oil lines into, and refined product pipelines out of the facility – cannot necessarily be adapted to the new supply pattern that develops to substitute for the refinery's supply, so many of these lines are being idled.

Product Quality Mandates Reduce Flexibility

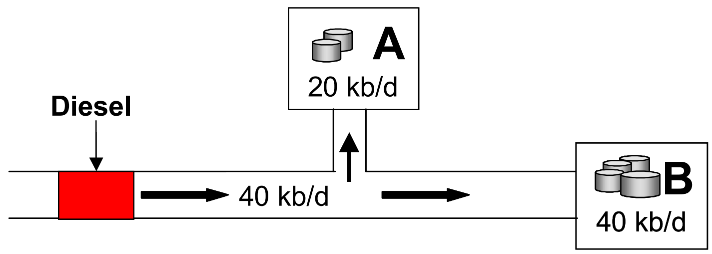
The mandate for different products regionally and seasonally has led to the infrastructure being more tautly stretched. This makes it more difficult to accommodate the routine and frequent changes described above, that are at the core of the oil market's reality and its efficiency. A major product pipeline like the Colonial Pipeline, which carries refined product from Texas to the New York City area, must carry many different grades of gasoline in order to accommodate product quality mandates that vary both seasonally and regionally; Colonial Pipeline, as noted, publishes specifications for 100 distinct grades of gasoline on an annual basis.

The new products require more batching and allow less scheduling flexibility. They also increase the number of interfaces, and thus require more product to be downgraded from one grade to the next lower grade. The most stringent regulations have increased the volume of transmix, the amount of product that must be reprocessed to meet specifications. The proliferation of distinct grades has effectively reduced the capacity of both the refinery and the distribution system.

Terminals are a critical part of the delivery infrastructure and impact pipeline operations. In some instances, shippers on the pipeline or independent operators own the terminals. In other instances, the pipeline transporter provides storage (terminal) services. The proliferation of mandated product grades leads to underutilization of tankage and other assets, creating challenges for any terminal operator and all pipelines alike.

A good example comes from the changeover to a new mandated product such as the special "reformulated gasolines" required in some areas (a one-time event for each phase of the program over a matter of years), or the seasonal changeover to the gasoline meeting more restrictive summer volatility requirements (an annual occurrence). Tanks must be almost completely drained of the old product that meets the less stringent requirements before being filled with the new product that meets the more stringent requirements. This forced underutilization reduces system flexibility and complicates product flow. This changeover generally occurs with enough lead-time before the regulatory deadline to allow several shipments of the more stringent (new) product to flush out the less stringent (old) product. Many tank farms operate at capacity and do not have the space or permitting flexibility to add new tankage. As a result, tank farms must anticipate product usage during the seasonal cusp period – the shoulder season – in order to accomplish this turnover without encountering product shortages. Any disruption in the supply of product to the terminal during this shoulder season or any unexpected surge in demand can lead to localized product shortages.

For delivering lines, a seasonal or other upheaval in terminal logistics can be particularly disruptive. These lines depend on delivering each product to each terminal in sequence. If the tank at a near terminal cannot accept the shipment, and if the pipeline does not have a more distant substitute customer for the product, pumping may need to stop. In addition to the inefficiency and loss of capacity, stopping a pipeline's flow, even in a planned manner, presents a number of operational challenges, including maintaining the interface. Further, many of the terminals along a delivering line cannot accept shipment at the full rate of flow. Pipelines routinely "strip" deliveries into these facilities, diverting a portion of the flow to the terminal, with the remainder of the flow continuing to more distant points. If there is no customer for a particular special product further down the line, the entire pipeline must slow to the rate of flow that the near terminal can accept. This enforced slowing, too, creates an inefficiency and loss of capacity (see box).



How Terminal Restrictions Can Slow A Pipeline

Suppose a pipeline:

- can pump 40 thousand barrels per day (kb/d) of oil
- has a batch of 10,000 barrels of diesel between batches of gasoline
- is delivering diesel to Terminal A, with maximum receiving capacity of 20 kb/d, followed by Terminal B, with maximum capacity of 40 kb/d

Case 1: All diesel to Terminal B

- Result: pipeline can continue to pump at its 40 kb/d maximum

Case 2: 5,000 barrels diesel each to Terminal A and Terminal B

- Result: pipeline can continue to pump at 40 kb/d by stripping 20 kb/d of the diesel off to Terminal A and sending the other 20 kb/d on to Terminal B

Case 3: All diesel to Terminal A

- Result: pipeline must slow its flow down to 20 kb/d to accommodate the low delivery rate at Terminal A. Only after the 10,000-barrel parcel has been delivered to Terminal A can the pipeline raise its pumping rate back to 40 kb/d.

These operational challenges will be magnified in transporting the newly-mandated Ultra Low Sulfur Diesel (ULSD). The Environmental Protection Agency's comprehensive rule on heavy truck engines and diesel fuel quality requires that beginning with the 2007 model year, heavy trucks meet new emissions standards. The new sulfur content regulations for diesel fuel are a corollary, requiring that on-highway diesel fuel contain no more than 15 ppm sulfur beginning in mid-2006. During the phase-in period, to 2010, a refiner may continue to produce some 500-ppm diesel fuel such as that now required for on-highway use – up to 20% of its on-highway diesel fuel output, or more if it purchases trading rights to do so. Pipelines will be carrying both the 500-ppm product and the new 15-ppm product, and must maintain product integrity of the separate specifications. For the limited time of the phase-in, then, pipelines will be meeting the demands for tankage and other logistical difficulties presented by the introduction of an additional (not a substitute) product.

There are a variety of challenges with respect to maintaining product integrity of the new fuel regardless of the phase-in rules.

- There is no experience in carrying such a low sulfur product in a common system; in the few European cities where ULSD is required, it is carried in a dedicated system.

- Specific gravity, the only mechanism now used for marking the end of one batch and the beginning of the next in the pipeline sequence, will not be a fine enough tool to make a cut that protects the integrity of ULSD.

- The neighboring product will contaminate the ULSD much faster (see box), because the difference between the sulfur concentration in the ULSD and the neighboring product will be so much greater than it now is. In addition, with such a low allowable sulfur content, off-specification ULSD is unlikely to be as easily blended down to specification range again. An off-specification batch could easily therefore lead to a "lockout" at a terminal, where the off-specification product freezes the use of a tank until the product can be removed.

The Rapidity of ULSD Contamination at the Interface

The product carried next to ULSD in a pipeline will quickly contaminate the unforgiving new product. Currently, a pipeline might carry on-highway diesel fuel (allowed to have 500 ppm sulfur, but likely tendered to the pipeline at 300 ppm) next to an off-highway distillate, at 2,000 ppm sulfur. With a margin of 200 ppm between the actual product quality and the maximum sulfur content allowed for on-highway diesel fuel, the batch could absorb as much as 15% high sulfur distillate before the on-highway material no longer met the sulfur specification. In contrast, a batch of ULSD (tendered to the pipeline at 10 ppm) could absorb only 0.3% of 2,000-ppm distillate – 30 barrels in 10,000 – before the ULSD would exceed the allowable 15-ppm sulfur. This represents one minute of flow in a 10" pipeline flowing at a typical 4 MPH.

There are additional concerns over testing, the behavior of sulfur molecules, the possible creation of transmix that cannot be processed in the existing purpose-built facilities, and a host of other unknowns. Pipeline operators are investigating these concerns by testing and experimentation, but do not yet have answers.

Oil Pipeline Rates Are Regulated

Oil Pipelines Are Common Carriers

Generally, oil pipelines provide transportation, temporary storage and logistics services; they do not own the product they transport. Most oil pipelines are "common carriers" under the Interstate Commerce Act.[5] As noted above, shippers – refiners, marketers and others who own oil they want to move – contract for space on an oil pipeline. If the requests for space on the pipeline exceed the line's capacity, the space is allocated among shippers in a non-discriminatory manner, usually on a *pro rata* basis. It is not provided based on the highest bid, nor on a first-come, first-serve basis. Pipelines must allocate space to all shippers who meet their conditions of service. These conditions of service are publicly posted and must not be unduly discriminatory.

FERC Regulates Rates and Conditions of Service

The Federal Energy Regulatory Commission (FERC) regulates the rates that an interstate pipeline can charge for its services. (Pipelines are also regulated as to safety, environmental protection and other aspects of operations by other federal and state agencies. States generally also regulate rates for intrastate pipelines.) Prior to FERC rate regulation, the Interstate Commerce Commission determined an oil pipeline's tariff rates to be "just and reasonable" based on an allowed rate of return on the "valuation" of the pipeline's common carrier assets. When the FERC assumed jurisdiction, it explored a number of different methods for determining "just and reasonable" rates.

Under a regulatory system established in 1995, an interstate oil pipeline carrier may use a variety of methods to justify new tariff rates. These include a percentage change in accordance with a government-set economic index, application of market based rates, application of the former cost of service standard and negotiated rates for service that have been agreed to between the oil pipeline carrier, and relevant shippers. The vast majority of oil pipeline industry tariff rates now in effect were set under the economic index method. The second most used method of tariff rate justification is agreement on negotiated rates between the pipeline and its shippers. The fastest growing application is market-based rates, which requires the Commission to determine that the pipeline lacks market power in the applicable regional market.

[5] Most intrastate pipelines are regulated by an equivalent state law. The interstate system accounts for roughly 80 percent of pipeline mileage and volume transported.

The *cumulative* change in the allowable rates under the index method over the period from January 1, 1995 to July 1, 2002 is 3.5%, well under the rate of inflation over the period. The erosion in the allowable rate, furthermore, has coincided with increased costs associated with handling a greater array of mandated product qualities and meeting a variety of other regulatory mandates. These requirements, such as increased requirements for testing and inspection of pipelines and tanks, the implementation of new rules on operator qualification, and the adoption of integrity management programs, have imposed significant additional costs, causing more pipelines to seek cost-of-service rate relief .

Pipeline Rates Are a Tiny Share of Consumer Prices and Independent of Oil Prices

The regulatory system under which oil pipelines operate precludes pipeline rates from fluctuating with oil prices, even in the case of market-based rates. Thus, the high prices experienced in mid-2001 were totally unrelated to pipeline rates or revenue.

Pipeline charges under any of the allowable methods account for a tiny share of the total cost of petroleum to a consumer. For instance, the rate for moving a gallon of gasoline from Houston to New Jersey is about 2.5 cents per gallon, or from Houston to Chicago is about 2 cents per gallon, well below 3% of the lowest national average monthly retail price of gasoline in the last 5 years. In the vast majority of cases, such rates are significantly lower than those charged by other modes of oil transportation.

Summary

In the decades since large diameter, long distance pipelines have been available, they have developed into a key part of the thousands of movements and schedules and transactions that make up the oil market in the United States. Their ability to move large volumes long distances fueled the post-War economic boom, and shaped U.S. demography and development. In addition to moving the large volumes from producing regions to consuming regions, pipelines fill a critical role in moving smaller quantities of oil from market hubs to more distant consuming areas. Pipeline operations over the years have accommodated a greater number of unique products, carrying products that meet regional and seasonal environmental quality mandates. They are the only practical mode of transportation for most overland movements, and the cheapest. It is not surprising, therefore, that pipelines are by far the most important mode of transportation for oil in the United States.

For Further Information

The Association of Oil Pipe Lines' website (www.aopl.org) has more information on oil pipelines and how they work, and on their safety and environmental record. The links below may be of interest.

For information about pipelines, their role and operation:
http://www.aopl.org/about/pipelines.html

For a summary of the oil pipeline safety record:
http://www.aopl.org/safety/record.html

For Fact Sheets on oil pipelines: http://www.aopl.org/pubs/facts.html

For reports on oil pipelines' safety and environmental record:
http://www.aopl.org/pubs/reports.html

For news releases and copies of *Pipeline Monthly*:
http://www.aopl.org/news/content.html

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