

Transportation Policy Brief #2

# Texas Ports and the Panama Canal: Commodities and Infrastructure

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Panama Canal Authority



Panama Canal Authority



Texas Ports Association

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# **Texas Ports and the Panama Canal: Commodities and Infrastructure**

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## FOREWORD

The Lyndon B. Johnson School of Public Affairs at The University of Texas at Austin has established interdisciplinary research on policy issues as the core of its education program. A major part of this program is a nine-month policy research project (PRP), in the course of which two or more faculty members from different disciplines direct the research of 10 to 20 graduate students of diverse backgrounds on public policy issues of concern to a government or nonprofit agency.

During the 2016–2017 academic year, the Texas Department of Transportation (TxDOT) funded, through the Center for Transportation Research (CTR), a PRP addressing six key transport/logistics policy issues related to Texas international trade with foreign countries and domestic trade with other U.S. states. Overall direction and guidance was provided by Roger Schiller (TxDOT Maritime Division), who participated in classroom discussions at the beginning of the academic year.

As a consequence, the following policy issues were selected for study:

1. Panama Canal Utilization;
2. Texas Ports and the Panama Canal: Commodities and Infrastructure;
3. Global Logistics Hubs in Texas;
4. Texas-Latin American Trade;
5. Port Competition and Best Practices; and
6. Transportation and Trade Forecasts.

The findings of each policy issue are presented within the context of separate policy briefs. This particular policy brief, “Texas Ports and the Panama Canal: Commodities and Infrastructure,” was researched and written by Alex Payson and Chase Porter.

## ACKNOWLEDGEMENTS

This PRP would not have been possible without the generous contributions of assistance from numerous individuals and organizations. In particular, we would like to thank:

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- Zeke Reyna, Operational Excellence Coordinator, Research and Technology Implementation, Texas Department of Transportation
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- Miha Vindus, Ph.D. Candidate/Consultant, University of Texas at Austin

## EXECUTIVE SUMMARY

In June 2016, a new set of locks opened at the Panama Canal. The locks not only provide for a third lane of traffic—adding capacity to the congested Canal—but are significantly larger than the existing locks; the new locks allow for vessels carrying three times the cargo of those vessels traversing the older two sets of locks. These increases in capacity may have profound effects on Texas ports.

The purpose of this policy brief is to provide insight into the possible effects of the Panama Canal expansion on Texas ports. Additionally, the brief intends to draw a nexus between activities at ports to Texas' statewide transportation infrastructure. The brief approaches these goals through a commodity-specific approach—it identifies specific commodities and commodity groups impacted by the expansion from which Texas ports are best positioned to benefit.

The impacts of the Panama Canal expansion on Texas ports are mostly still unknown at this time, although they are taking shape. They will be commodity-specific and localized not only to individual ports, but sectors within ports. The nature and extent of the consequences of the expansion will depend on a number of factors, each deserving of their own study and deep consideration, ranging from the state of the worldwide economy and international trade agreements to the localized conditions at any singular port. With that in mind, this brief has not sought to produce a series of detailed and specific findings and conclusions for Texas' various ports. Rather, this brief provides general conclusions, identifies factors policymakers should consider when seeking to predict and measure the effects of the Panama Canal on Texas' ports, and employs case studies to illustrate the analysis and considerations needed to understand impacts of the Panama Canal expansion.

To this end, this brief provides the following:

- Overview of the new Panama Canal locks;
- General outlines of how the expansion will affect vessel traffic and commodity flows at Texas ports. The expanded capacity of the Panama Canal and the vessels transiting it will facilitate growth of container traffic through the Port Houston. Houston will see larger container vessels, and possibly an increase in the number of vessels overall. Ports with petroleum, chemical, and natural gas facilities will likely see the largest gains. Exports of plastic resins—a byproduct of hydrocarbon production—are expected to be a boon for Texas ports;
- An explanation of transshipment—a model where ship traffic utilizes Panamanian and Caribbean ports for a “hub-and-spoke” system. The development of transshipment would likely most affect container traffic at the Port of Houston;
- Profiles of Port Corpus Christi—a port with large liquid energy imports and exports—and the container terminals at the Port of Houston. These profiles identify current facilities and infrastructure, major recent and planned improvements, and a list of key considerations to keep in mind when evaluating the ability of Texas ports to benefit from the expanded Panama Canal;
- Two supply chain studies of perhaps the two largest expected “winners” for Texas maritime industry after the Panama Canal expansion—liquefied natural gas (LNG) and plastic resins. These studies illustrate the connection between Texas maritime trade and Texas' statewide infrastructure.

To assist in researching and preparing this brief, the research team made visits to Corpus Christi and Houston.

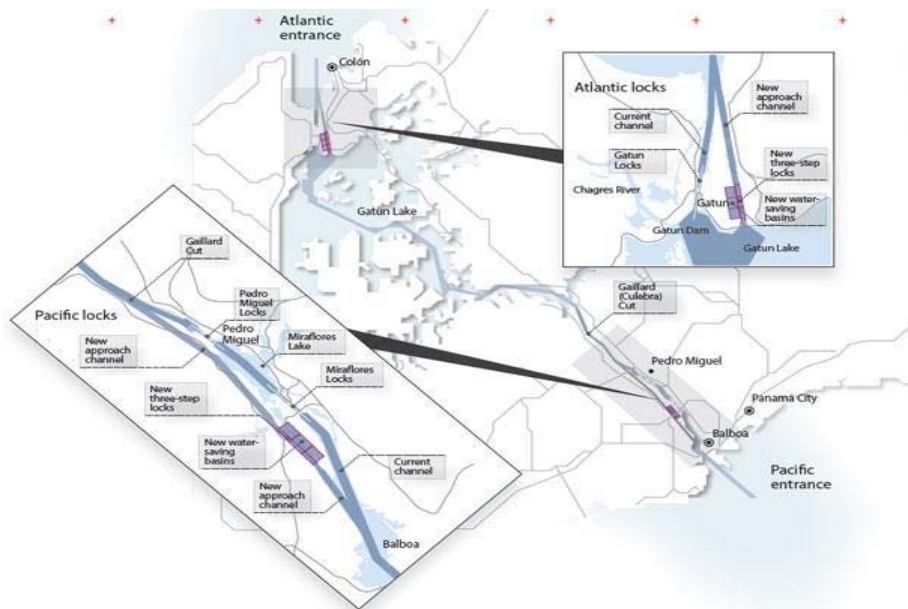


## OVERVIEW OF THE PANAMA CANAL EXPANSION

The Panama Canal is a 50-mile waterway connecting the Atlantic and Pacific Ocean sides of the Isthmus of Panama.<sup>1</sup> The canal uses a series of locks to raise ships from sea level to the level of an artificial lake and back down to sea level on the other side.<sup>2</sup> A complete transit of the canal typically lasts 8-10 hours.<sup>3</sup>

The new set of locks and connecting channels provide a third lane for vessels to traverse the Isthmus of Panama (Figure 1). Coming from the Pacific Ocean, vessels enter into a new channel, allowing the vessels to bypass the existing locks and use a new set of three-tier locks. Vessels then continue down a new channel before entering the Culebra Cut and Gatun Lake. After transiting the lake, vessels move through another three-tier set of locks before entering the Atlantic Ocean. Along with creating new channels, the Panama Canal Authority also widened and/or deepened the existing entrance channels, the Culebra Cut channel, and the Gatun Lake channels.<sup>4</sup>

Figure 1: New Panama Canal Locks<sup>5</sup>



Together, the new locks and channels allow three lanes of traffic to move through the canal. Crucially, the new locks are significantly larger than the existing locks, thus permitting much larger vessels to transit the Panama Canal. Table 1 compares the new and existing locks.

<sup>1</sup> "This Is the Canal." Canal De Panama. Accessed March 18, 2017. <http://www.acp.gob.pa/eng/acp/asi-es-el-canal.html>.

<sup>2</sup> Ibid

<sup>3</sup> "Frequently Asked Questions." Canal De Panama. Accessed March 18, 2017. <http://www.acp.gob.pa/eng/general/canal-faqs/physical.html>.

<sup>4</sup> *Proposal for the Expansion of the Panama Canal*. Publication. Panama: Panama Canal Authority, 2006. Accessed March 18, 2017. <http://www.pancanal.com/eng/plan/documentos/propuesta/acp-expansion-proposal.pdf>.

<sup>5</sup> Reagan, Brad. "The Panama Canal's Ultimate Upgrade." *Popular Mechanics*. February 03, 2015. Accessed February 15, 2017. <http://www.popularmechanics.com/technology/infrastructure/a1277/4212183/>.



**Table 1: The Existing and New Locks<sup>6</sup>**

	<b>Existing Locks (2 Lanes)</b>	<b>New Locks (1 Lane)</b>
Length	304.6 m, 1000 ft.	427 m, 1400 ft.
Width	33.5 m, 110 ft.	55 m, 180 ft.
Depth	12.8 m, 42 ft.	18.3 m, 60 ft.

Lock dimensions determine the size of vessels that can traverse the Panama Canal. The existing locks allowed “Panamax” vessels to navigate the canal. The new set of locks permit “Neopanamax”<sup>7</sup> vessels to move through the canal. The largest Neopanamax ships can carry up to 12,000 to 13,000 twenty-foot-equivalents (TEU) in cargo—2.5 to 3 times more than Panamax vessels—which could handle approximately 5,000 TEU. Panamax ships have draughts of approximately 40 to 42 feet, while the largest Neopanamax ships draft up to 50 feet.<sup>8</sup> Ports will need appropriate channel depths and dockside infrastructure to handle the larger vessels. An intermediate class of vessels called “Postpanamax” hold around 10,000 TEU and will be able to traverse the expanded set of locks and operate with a 45-ft draft.<sup>9</sup> Table 2 compares the two vessel types.

**Table 2: Characteristics of Panamax and Neopanamax Ships<sup>10</sup>**

<b>Vessel Category</b>	<b>Panamax</b>	<b>Neopanamax</b>
Length	294.13 m, 965 feet	366 m, 1,2000 feet
Width	32.31 m, 106 feet	49 m, 160.7 feet
Draught	12.04 m, 41.2 feet	15.2 m, 49.9 feet
TEU Capacity	5,000	13,000

Early results of the expansion show the Panama Canal saw a rebound in transits after the opening of the canal, coming off a global slowdown in sea trade.<sup>11</sup> Total tonnage also rebounded quickly.<sup>12</sup> By September 2016, the end of the canal’s fiscal year, total tonnage had increased over the previous year even though total transits were still below 2015 levels. This signals that, on the whole, larger vessels were using the canal. By mid-December, the Panama Canal reported the 500<sup>th</sup> Neopanamax vessel traversed the canal.<sup>13</sup> Commodity-wise, chemical tankers, liquefied petroleum gas (LPG), and LNG natural gas increased in fiscal year 2016 over 2015, while other commodity groups saw a drop. LNG saw a 750% increase, chemical tankers saw a 13.1% increase, and LPG saw a 6.9% increase by transits and a 3846%, 14%, and 13.5% increase in PC/UMS (Panama Canal Universal Measurement System) net tonnage, respectively.<sup>14</sup> Container

<sup>6</sup> *Proposal for the Expansion of the Panama Canal*. Publication. Panama: Panama Canal Authority, 2006. Accessed March 18, 2017. <http://www.pancanal.com/eng/plan/documentos/propuesta/acp-expansion-proposal.pdf>.

<sup>7</sup> For the purpose of this brief, the term neopanamax means ships that were too large to fit in the old Panama Canal locks. These ships carry 12,000 to 13,000 TEUs.

<sup>8</sup> “Panamax.” Maritime Connector. Accessed March 18, 2017. <http://maritime-connector.com/wiki/panamax/>.

<sup>9</sup> Ibid.

<sup>10</sup> Ibid.

<sup>11</sup> “Transit Statistics.” Canal De Panama. Accessed March 20, 2017. <https://www.pancanal.com/eng/op/transit-stats/>.

<sup>12</sup> Ibid.

<sup>13</sup> “Expanded Panama Canal Welcomes Its 500th Neopanamax Transit.” Canal De Panama. December 15, 2016. Accessed March 20, 2017. <https://www.pancanal.com/eng/pr/press-releases/2016/12/15/pr613.html>.

<sup>14</sup> “Transit Statistics.” Canal De Panama. Accessed March 20, 2017. <https://www.pancanal.com/eng/op/transit->

transits were down 3% yet saw a 4.1% increase in PC/UMS net tonnage.<sup>15</sup> In long tons, container traffic was down 1.8% while chemical traffic increased by 13.4% and LPG increased by 20.7%.<sup>16</sup> Crude product tankers saw an all-around decrease in 2016 over 2015, showing the limits of the global economy on the global energy-related trade. Transits decreased by 11.2%, net tonnage decreased by 14.8%, and long tonnage decreased by 20.3%.<sup>17</sup> More detailed study of the Panama Canal's post-expansion performance is included in the accompanying brief "Panama Canal Utilization."

## THE INTERSECTION OF THE PANAMA CANAL EXPANSION AND THE FUTURE OF TEXAS PORTS

The new set of locks at the Panama Canal will alleviate congestion, allow for more transits, and accept larger vessels into the canal. This expansion of the Panama Canal intersects with the future of Texas ports in three ways.

First, shipments to West Coast ports may shift to Gulf and East Coast ports because larger ships are able to move through the canal to reach those areas. Additionally, portions of otherwise expected growth at West Coast ports might shift eastward. The extent of this shift proves difficult to predict and remains dependent on a number of factors. However, the consensus persists that a portion of maritime trade will shift eastward. This change is not expected to have a great impact on Texas ports. Should any cargo shift eastward, Texas' container terminals—particularly Houston's two deep-water container terminals—would likely see the majority of any such benefits.

This topic will be revisited below, as the brief discusses the factors that will contribute to the extent of this shift in trade patterns. The policy brief will also discuss the characteristics of ports best situated to draw traffic away from West Coast ports.

Second, the expanded Panama Canal will facilitate the organic growth of import demand caused by Texas' booming population in the "Texas Triangle" of Dallas-Fort Worth, Houston, and Austin-San Antonio. By 2040, the state's population is expected to grow from 25 million to 40 million, with 70% within the "Texas Triangle."<sup>18</sup> This growth will be directed to ports with the capabilities to best handle the vessels carrying those imports as well as those ports that offer the most cost-effective movements of imports to their inland destinations. Geographically, ports in the Houston area are expected to benefit the most from this organic growth. Most container growth will certainly be seen at the Port of Houston's two container terminals. Other commodity types could move through other Texas ports well-suited for certain commodity types. For example, the Port Freeport and Port of Galveston have sophisticated roll-on, roll-off infrastructure.<sup>19, 20</sup> The same factors that make Atlantic ports attractive to what was traditionally Pacific Coast traffic will make Texas ports the attractive destination for future imports.

Third, the greatest impact of the Panama Canal expansion on Texas ports will be the growth of several export commodities from Texas ports. Bulk energy exports, petrochemicals and petroleum-based products, grains, coal, and fertilizers are most likely to benefit from the

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[stats/](#). PC/UMS Net Tonnage is a measure of the total volume of a vessel traversing the Panama Canal. It is not equal to the weight of the actual cargo.

<sup>15</sup> Ibid.

<sup>16</sup> Ibid. Long tons measure the weight of the cargo on a vessel.

<sup>17</sup> Ibid.

<sup>18</sup> Bruce Mann Presentation. Personal Communication with the Port of Houston Authority.

<sup>19</sup> *Texas Port Report*. Publication. August 2014. Accessed January 20, 2017.

[https://texaswideopenforbusiness.com/sites/default/files/10/22/14/texasportprofiles\\_1.pdf](https://texaswideopenforbusiness.com/sites/default/files/10/22/14/texasportprofiles_1.pdf).

<sup>20</sup> *Port of Entry: Freeport Impact to the Texas Economy, 2015*. Publication. 2015. Accessed January 20, 2017.

<https://comptroller.texas.gov/economy/docs/ports/overview-freeport.pdf>.

expanded Panama Canal. In particular, LNG and plastic resins—a petrochemical byproduct—are expected to be the two biggest “winners” for Texas ports after the Panama Canal expansion.

#### CHANGES TO ATLANTIC AND PACIFIC PORT COMPETITION

Studies have predicted that up to 10% of container traffic between Asia and the United States will shift from America’s West Coast ports to those on the Atlantic side of the Panama Canal.<sup>21</sup> Other scholars predict a smaller shift, but still expect some level of a shift eastward.<sup>22</sup> Even a small shift could have major implications for America’s ports. A 5% shift would equate to the current combined traffic at the ports of Charleston and Savannah, two of the Atlantic Coast’s largest container facilities, or nearly 2.5 times the current container traffic seen at the Port of Houston.<sup>23</sup>

Currently, it is quicker and more cost effective for many containerized shipments to enter West Coast ports, transload, and travel via train or trucks to their final destinations. Under the right conditions, it could become more economical for many commodities destined for Midwestern sites such as Chicago, Detroit, and southern cities such as Memphis and Arkansas, to traverse the Panama Canal, unload at a Gulf or East Coast port, and then travel to America’s heartland.<sup>24</sup> It is important to note that shipment travel times from the East Coast will not substantially decrease, if at all; instead, cheaper transportation costs from the economies of scale offered by largest vessels would spur shifts in container traffic. Particularly time-sensitive commodities will find the canal route less advantageous. Particularly cost-sensitive commodities will find the canal route more advantageous.<sup>25</sup>

A number of factors will contribute to the magnitude of this shift in trade. West Coast ports service large numbers of container ships and experience intense congestion. This situation makes less congested container terminals on the East and Gulf Coast with strong dockside and landside infrastructure attractive. The following section discusses which characteristics will attract increased imports.

These factors include the toll structure at the Panama Canal, as well as fees at West Coast ports and on the truck and rail lines that carry commodities inland. The reliability of the expanded Panama Canal will be crucial in the future. Multiple contributors to this report agreed longer transit times through the canal will be acceptable as long as the transit times remain “reliable.” Shifts in manufacturing centers or the growth of certain population centers will affect trade patterns, as well. As manufacturing moves from East Asia to Southeast Asia, shippers may find it more advantageous to transit the Suez Canal or Cape of Good Hope to reach East Coast ports. Uncertainty regarding the future of multi- and bilateral trade agreements add another layer of create additional questions about the future of maritime trade patterns. The health of the Texas and American economy will significantly impact global container trade.

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<sup>21</sup> Bratton, Jennifer, Dustin Burke, Peter Ulrich, Sri Laxmana, and Steve Raetz. *Wide Open: How the Panama Canal Expansion Is Redrawing the Logistics Map*. Publication. June 2015. Accessed January 20, 2017.

<https://panamacanal.salini-impregilo.com/static/upload/bos/bostongrouponpanamajune2015.pdf>.

<sup>22</sup> “Panama Canal Expansion Will Affect Shipping - but How?” JOC. June 26, 2016. Accessed January 20, 2017.

[http://www.joc.com/port-news/panama-canal-news/panama-canal-expansion-will-affect-shipping-how\\_20160625.html](http://www.joc.com/port-news/panama-canal-news/panama-canal-expansion-will-affect-shipping-how_20160625.html).

<sup>23</sup> Bratton, Jennifer, Dustin Burke, Peter Ulrich, Sri Laxmana, and Steve Raetz. *Wide Open: How the Panama Canal Expansion Is Redrawing the Logistics Map*. Publication. June 2015. Accessed January 20, 2017.

<https://panamacanal.salini-impregilo.com/static/upload/bos/bostongrouponpanamajune2015.pdf>;

<http://www.inboundlogistics.com/cms/article/top-10-us-container-ports/>; usatrade.gov

<sup>24</sup> Ibid.

<sup>25</sup> U.S. Department of Transportation. *Panama Canal Expansion Study: Phase I Report*. Publication. November 2013. Accessed January 20, 2017. [https://www.marad.dot.gov/wp-content/uploads/pdf/Panama\\_Canal\\_Phase\\_I\\_Report\\_-\\_20Nov2013.pdf](https://www.marad.dot.gov/wp-content/uploads/pdf/Panama_Canal_Phase_I_Report_-_20Nov2013.pdf).

Most Texas ports are not anticipated to capture much traffic related to this shift. But any traffic that does reroute to Texas in containerized form will likely stop in Houston. The majority of import growth at Texas ports will be caused by the fast growth of Texas' large metropolitan areas. However, the principals of lower costs and reliable transit explain why Texas ports will be well positioned to continue to serve their state in the future. The dynamics of Pacific Coast/Atlantic Coast trade patterns should continue to be monitored to measure whether Texas container terminals are capturing container traffic from the West Coast.

#### IMPORTANT ASPECTS OF PORT INFRASTRUCTURE THAT WILL AFFECT PORT'S FUTURE AFTER THE EXPANSION OF THE PANAMA CANAL

Adequate dockside infrastructure—in the form of berth space, larger cranes and wharfs, channel depth, road and rail connections, and commodity-specific infrastructure—is crucial to any Texas port hoping to grow exports and imports. The ability to handle Post- and Neopanamax vessels will remain essential. Larger vessels will also need to unload or load respectively larger cargo loads while still expecting prompt service by the port. In short, Texas' ports will need both the *quality* and *quantity* of infrastructure to provide the reliable service expected by the world's shipping companies.

The Maritime Administration (MARAD) at the United States Department of Transportation identified a series of key infrastructure factors that will influence which ports vessels will choose to call at in the future<sup>26</sup>:

- **Navigability:** Ports need channels deep enough and wide enough to be navigable by larger vessels. MARAD states that ports need channels at least 47.6 feet to handle the largest Neopanamax ships.<sup>27</sup> Ports with channels at least 50 feet in depth are best positioned to attract the largest vessels.
- **Air Draft Restrictions:** Bridges over channels must be high enough to allow larger vessels to transit beneath them. This will most likely affect container vessels, which carry large stacks of containers well above the water, the most.
- **Terminal Capacity:** Ports will need adequate yard size, labor, cranes, and other terminal equipment to handle larger vessels in a timely fashion.
- **Landside Connectivity:** Ports, especially container terminals, create huge amounts of rail and truck traffic. The ability to move large, concentrated cargo loads on and off port property will be crucial to ensuring the reliability and economy of Texas ports. This implicates both port and off-port infrastructure. On-dock rail transfer facilities, and entrance/exit routes for trucks affect the speed in which commodities can be moved. Infrastructure further off port property will affect the reliability and economics of ports. In particular, the ability to move commodities in, out, and through metropolitan areas will affect the attractiveness of nearby ports.

This report includes profiles on the current and planned channel depths at two Texas ports, as well as a brief overview of their dockside facilities and landside connections. Maintenance and improvement of this infrastructure will be a key to supporting Texas ports' competitiveness in a Neopanamax world.

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<sup>26</sup> Maritime Administration. *Panama Canal Expansion Study: Phase 1 Report*. Publication. November 2013. Accessed January 20, 2017. [https://www.marad.dot.gov/wp-content/uploads/pdf/Panama\\_Canal\\_Phase\\_I\\_Report\\_-\\_20Nov2013.pdf](https://www.marad.dot.gov/wp-content/uploads/pdf/Panama_Canal_Phase_I_Report_-_20Nov2013.pdf).

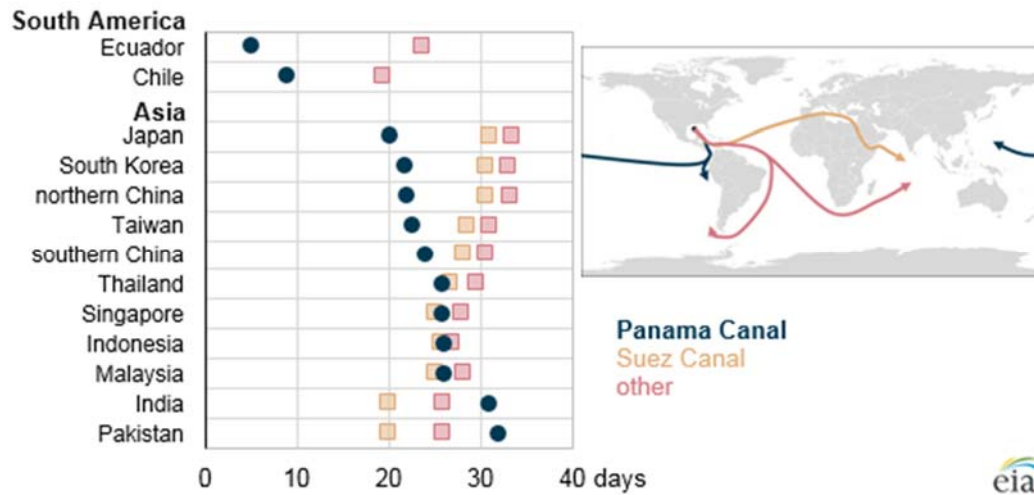
<sup>27</sup> Ibid.

For Texas ports, growth related to the Panama Canal expansion will mostly be industry-specific exports. Growth will depend on the current commodity strengths at the port, planned and future industry at and near a port, combined with its ability to handle increased traffic. Three elements—seaside, terminal operations and gate efficiencies—ideally integrate to raise port productivity and competitiveness.

Liquid bulk exports, such as petrochemicals, LNG, and other petroleum-related products (e.g., plastic resins), are expected to benefit greatly from the expanded Panama Canal.

Before the expansion, only about 6% of the world’s LNG vessels could transit the Panama Canal.<sup>28</sup> After the expansion, approximately 90% of the world LNG fleet can use the canal’s new locks. This means the LNG industry will see its transit times from export terminals along the Gulf Coast to Asia, Latin America, and beyond cut by 33% to 50% (Figure 2).

**Figure 2: Approximate Voyage Time from US Gulf Coast through Panama Canal or Other Routes<sup>29</sup>**



The Panama Canal has instituted a new toll structure to encourage LNG traffic through its new locks.<sup>30</sup> Similarly, many petrochemical and other chemical tankers that were too large for the old locks will now find similar benefits as LNG.

Dry bulk commodities—minerals, metals and ores, coal, fertilizers, and grain—depend heavily on transportation costs. Larger vessels transiting through the larger locks offer an economy of scale previously unrealized by Texas ports. Texas ports strong in grain, fertilizer, and coal exports may see increases in trade, thanks to the expansion.<sup>31</sup>

<sup>28</sup> "Expanded Panama Canal Reduces Travel Time for Shipments of U.S. LNG to Asian Markets." U.S. Energy Information Administration. June 30, 2016. Accessed January 23, 2017. <http://www.eia.gov/todayinenergy/detail.php?id=26892>.

<sup>29</sup> Ibid.

<sup>30</sup> Ibid.

<sup>31</sup> Maritime Administration. *Panama Canal Expansion Study: Phase 1 Report*. Publication. November 2013. Accessed January 20, 2017. [https://www.marad.dot.gov/wp-content/uploads/pdf/Panama\\_Canal\\_Phase\\_I\\_Report\\_-\\_20Nov2013.pdf](https://www.marad.dot.gov/wp-content/uploads/pdf/Panama_Canal_Phase_I_Report_-_20Nov2013.pdf).

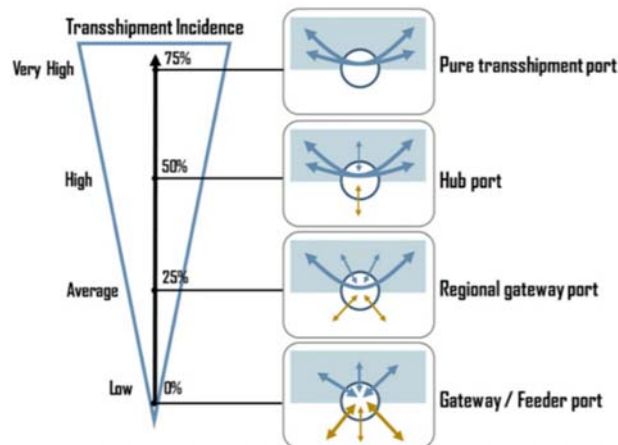


Another potential change in trade patterns results from the development of transshipment, the use of “hub and spoke” systems to move commodities around the world. Port and transportation experts are unsure transshipment will have a large impact on Texas ports, citing the increase in time and cost associated with additional loading/unloading activities could be prohibitive. Even so, research suggests that infrastructure costs to handle Neopanamax vessels and the profitability of shipping lines will make transshipment a viable option.<sup>32</sup> This section describes transshipment and the theory and dynamics behind possible future transshipment around the Gulf Coast and Caribbean.

Given the number of ports that dot the globe and the distances between these points, it remains impossible for all ports to connect directly. The rapid growth of containerized cargo also presents a problem because this growth can overwhelm ports. Transshipment—or the transfer of cargo from one vessel to another<sup>33</sup>—offers a solution to these problems.

Multiple types of transshipment ports exist. Figure 3 depicts the classification of ports based on the percentage of transshipment activity and access to hinterlands.

**Figure 3: Types of Transshipment Ports<sup>34</sup>**



When many transshipment points cluster in a given area, the area becomes a transshipment market. These ports are called markets because they remain detached from any one particular port. Instead, these hubs compete to service the larger region.<sup>35</sup> There are seven major transshipment markets around the world, encompassing Southeast Asia, Southern China and the Strait of Taiwan, the Mediterranean Sea, the Baltic Region, the Caribbean.<sup>36, 37</sup> Figure 4

<sup>32</sup> Personal Communication with port officials at the Port of Houston

<sup>33</sup> "What Is Transshipment?" BusinessDictionary.com. Accessed March 3, 2017.

<http://www.businessdictionary.com/definition/transshipment.html>.

<sup>34</sup> Rodrigue, Jean-Paul, and Asaf Ashar. "Transshipment Hubs in the New Panamax Era: The Role of the Caribbean." *Journal of Transport Geography* 51 (2016): 270-79. Accessed March 18, 2017. doi:10.1016/j.jtrangeo.2015.10.002.

<sup>35</sup> Rodrigue, Jean-Paul. "Transshipment Hubs: Connecting Global and Regional Maritime Shipping Networks." *PortEconomics*. September 17, 2015. Accessed March 23, 2017.

<http://www.porteconomics.eu/2015/09/17/transshipment-hubs-connecting-global-and-regional-maritime-shipping-networks/>.

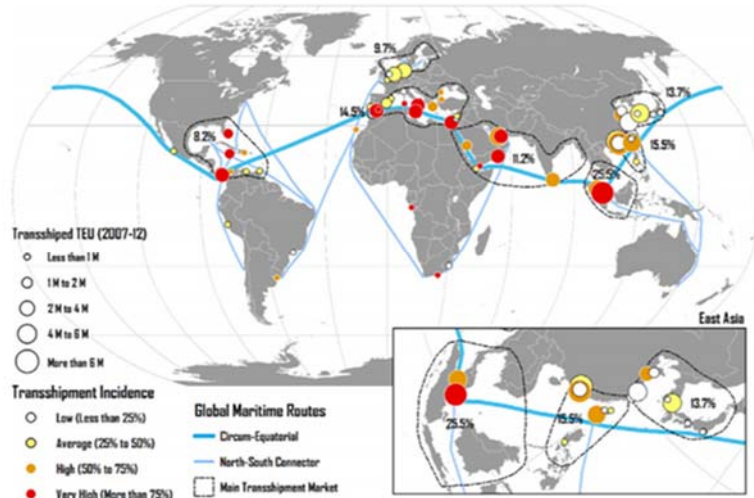
<sup>36</sup> Rodrigue. "World's Main Intermediate Hubs, 2007-12." *World's Main Intermediate Hubs, 2007-12*. Accessed March 1, 2017. [https://people.hofstra.edu/geotrans/eng/ch4en/conc4en/map\\_intermediaryhubs.html](https://people.hofstra.edu/geotrans/eng/ch4en/conc4en/map_intermediaryhubs.html).

<sup>37</sup> Gouvernal, Slack, and Debrie, "Dynamics of Change in the Port System of the Western Mediterranean."

details major transshipment hubs and markets worldwide.

Given the Caribbean's proximity to the Panama Canal and the Texas coast, this transshipment market looks to have the greatest impact on Texas ports.

**Figure 4: Transshipment Volume and Incidence by Major Ports, 2007-2012<sup>38</sup>**



As a note moving forward, transshipment data and figures used in this report were derived from previous reports, port authority websites, and correspondence with port officials. However, transshipment figures are not consistently published so averages of previous years were used in some cases. Table 3 outlines the percentage of port activity that is the result of transshipment.

<sup>38</sup> Rodrigue, Jean-Paul, and Asaf Ashar. "Transshipment Hubs in the New Panamax Era: The Role of the Caribbean." *Journal of Transport Geography* 51 (2016): 270-79. Accessed March 18, 2017. doi:10.1016/j.jtrangeo.2015.10.002.



**Table 3: Transshipment Activity at the Main Caribbean Hubs (TEU, 2012)<sup>39</sup>**

<b>Port</b>	<b>Total Traffic</b>	<b>Transshipment Traffic</b>	<b>Transshipment Incidence</b>
Panama Gateway Cluster	8,975,759	7,580,219	84.5%
Cartagena (Colombia)	2,205,948	1,425,042	56.2%
Colon (Panama)	3,518,672	3,131,618	81.3%
Balboa (Panama)	3,251,139	3,023,559	94.0%
Windward Passage Cluster	3,009,212	2,285,240	75.9%
Kingston (Jamaica)	1,855,425	1,426,822	86.3%
Caucedo (Dominican Republic)	1,153,787	858,418	69.2%
Bahamas Cluster	1,202,000	1,189,980	99.0%
Freeport (Bahamas)	1,202,000	1,189,980	99.0%
Eastern Caribbean	1,393,112	629,722	45.2%
Point Lisas (Trinidad & Tobago)	181,300	29,008	16.0%
Port of Spain (Trinidad & Tobago)	365,895	262,347	53.3%
Puerto Cabello (Venezuela)	845,917	338,367	40.0%
<b>Total</b>	<b>14,580,083</b>	<b>11,685,161</b>	<b>80.1%</b>

The majority of transshipment activity in the region occurs in the “Caribbean Transshipment Triangle.” This area includes Colon, Freeport, and the Port of Spain at its edges. Other ports—like San Juan, Cartagena, and Kingston—are nestled within the triangle. Proximity to trade routes, local traffic volume, port productivity, and cost, generally determine the location of these transshipment hubs. The Caribbean’s proximity to the Panama Canal offers a regional advantage.

However, not all industry experts agree with the triangle narrative. Others believe that transshipment clusters exist that compete for shipping lines. Two major clusters, the “Panama Gateway” cluster and the “Windward Passage” cluster, sit in the Caribbean region. The Panama Gateway hubs include Cartagena and Moin, which account for 52.5% of transshipment activity in the area. This route requires little deviation from the transatlantic and transpacific services that travel through the Panama Canal. Less deviation translates to lower costs, making these ports viable options for shipping lines.

The Windward Passage incorporates Kingston, Caucedo, and potentially Mariel, Cuba. This cluster employs the hub and spoke model, moving cargo between Caribbean and mainline services. These ports also benefit from their relative location to U.S. Gulf and East Coast ports.

The expansion of the Panama Canal means that larger ships with heavier loads will be traversing traditional shipping lanes. These ships only remain profitable if they keep moving,

<sup>39</sup> Rodrigue, Jean-Paul, and Asaf Ashar. "Transshipment Hubs in the New Panamax Era: The Role of the Caribbean." *Journal of Transport Geography* 51 (2016): 270-79. Accessed March 18, 2017. doi:10.1016/j.jtrangeo.2015.10.002.

causing shipping companies to minimize the number of direct services they offer at Gulf and East Coast ports. Existing service may be replaced by, and potential future service shifted to, feeder services, which presents an opportunity for growth in terms of Caribbean transshipment activities. Given these parameters, four theoretical configurations could service Gulf and East Coast ports via the expanded Panama Canal.<sup>40</sup>

First, it is important to take into account the different shipping patterns. See Figure 5 for a depiction of these shipping patterns. Some—like conventional and direct routes—would result in no noticeable increase in transshipment among Caribbean ports. Using the conventional service route, ships call at all main ports. This pattern increases transit time and requires more ships. To remedy these problems, many shipping companies have shifted to a direct shipping pattern. Direct shipping lines concentrate on a specific region of the East Coast of the Gulf Coast. This option allows larger ships to call at ports that have the capacity to handle them, while also providing greater port coverage to the coasts, in general.

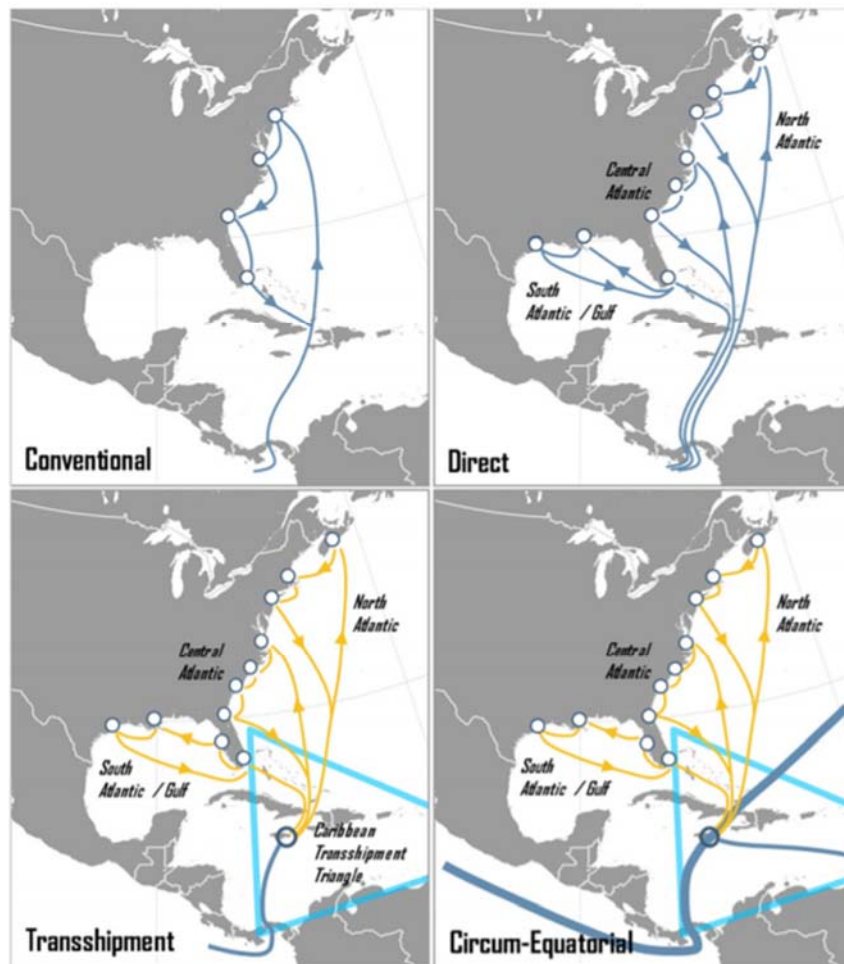
Transshipment offers an alternative to these models. A transshipment hub, most likely located in the Windward Passage, would replace direct services by creating feeder loops. Smaller ships would visit ports at a higher frequency than larger ships would be able to manage. Data shows that the number of ports serviced in the Gulf and on the East Coast by feeder vessels is much larger than those called at by direct services. Smaller ships also have the advantage of being able to call at ports with shallow channels and terminals—like the Gulf Coast ports. While conventional and direct routes have remained dominant through 2015, the expansion of the Panama Canal increases the odds that companies will engage in transshipment. As previously mentioned, large Post- and Neopanamax vessels will seek to make fewer stops, likely calling at the largest ports and leaving feeder ships to service the others.

Some research supports the circum-equatorial pattern. This pattern would use Neopanamax ships to make round-the-world trips. Previous attempts to use this type of shipping route have been hindered by the capacity of the Panama Canal and the inefficiencies of backhauling. However, this pattern moves in a circular route and only calls at major transshipment hubs, removing backhauls. The circum-equatorial pattern has the potential to vastly increase Caribbean transshipment as large ships would most likely select a transshipment hub in that region to service parts of North and South America.

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<sup>40</sup> Rodrigue, Jean-Paul, and Asaf Ashar. "Transshipment Hubs in the New Panamax Era: The Role of the Caribbean." *Journal of Transport Geography* 51 (2016): 270-79. Accessed March 3, 2017. doi:10.1016/j.jtrangeo.2015.10.002.

Figure 5: Potential Shipping Configurations of All-Water Routes<sup>41</sup>



#### OTHER POTENTIAL TRANSSHIPMENT PORTS: COROZAL AND MARIEL

Panama recognizes a need for a larger Corozal port terminal—located on the Pacific side of the Panama Canal—because increased Pacific terminal capacity could result in a loss of transshipment competitiveness on Pacific lanes.<sup>42</sup>

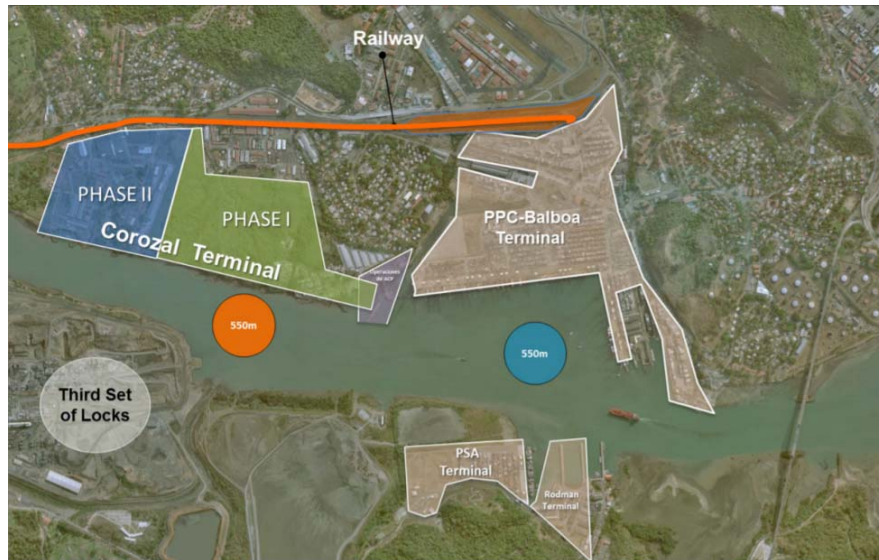
With the support of international consulting firms, the Panama Canal Authority has been conducting studies in recent years to develop a new port at Corozal (Figure 6). The canal agency has already been in contact with 13 potential bidders for the project.<sup>43</sup>

<sup>41</sup> Rodrigue, Jean-Paul, and Asaf Ashar. "Transshipment Hubs in the New Panamax Era: The Role of the Caribbean." *Journal of Transport Geography* 51 (2016): 270-79. Accessed March 3, 2017. doi:10.1016/j.jtrangeo.2015.10.002.

<sup>42</sup> "Corozal Port Project." Canal De Panama. 2015. Accessed March 3, 2017. <https://www.pancanal.com/eng/corozalport/Brochure-Corozal.pdf>.

<sup>43</sup> Leach. "Panama Canal Sets Sights on Transshipment Tied to New Locks." *JOC*. January 22, 2016. Accessed March 11, 2017.

Figure 6: Corozal Terminal<sup>44</sup>



Construction will take place in two phases and will be built on 120 hectares of land currently owned by the Panama Canal Authority. This construction will include a wharf, container yard, offices, warehouses, stores, and other port operation facilities.

The new port will accommodate five Neopanamax ships at a time. This requires a 53.5-ft-deep access channel in addition to 59 feet of depth along the dock. The port will have a capacity of 3 million to 5 million TEUs, depending on demand and expansion opportunities.<sup>45</sup> Construction is slated for completion in 2018.

The port at Corozal has the greatest chance of impacting trade along the U.S. Gulf Coast because of the Gulf's shallow waters. Capital improvement plans for dredging along the East Coast of the US lessen the need for transshipment options for these ports.<sup>46</sup>

The port at Mariel, Cuba became operational in January of 2014. Cargo volumes grew by 35% from 2014 to 2015, with little sign of slowing down. With the completed expansion of the Panama Canal, officials at Mariel hope to attract larger cargo volumes and Neopanamax vessels. The port currently has 2,296 feet of quay and is capable of handling 800,000 TEUs annually. Port officials plan to build an additional 984 feet of quay over the next two years to be able to off-load two Neopanamax ships simultaneously. The port of Mariel will finish dredging its channel in 2017.<sup>47</sup>

Port officials remain optimistic that shipping companies will choose Cuba over transshipment hubs in the Caribbean. Skeptics of the project have pointed out that the port may be too far away from the main shipping lanes and lose valuable time.

In the past, restrictions on trade with the U.S. have inhibited the growth of Cuban ports. The thawing of relations between the U.S. and Cuba offers hope for the future. Travel bans and financial restrictions have been removed. The Office of Foreign Asset Control also released a

<sup>44</sup> "Corozal Port Project." Canal De Panama. 2015. Accessed March 3, 2017.

<https://www.pancanal.com/eng/corozalport/Brochure-Corozal.pdf>.

<sup>45</sup> Ibid.

<sup>46</sup> Leach. "Panama Canal Sets Sights on Transshipment Tied to New Locks." JOC. January 22, 2016. Accessed March 11, 2017. [http://www.joc.com/port-news/panama-canal-news/panama-canal-sets-sights-transshipment-logistics-after-new-locks-open\\_20160122.html](http://www.joc.com/port-news/panama-canal-news/panama-canal-sets-sights-transshipment-logistics-after-new-locks-open_20160122.html).

<sup>47</sup> Miller. "Cuba's Fast-growing Mariel Targets Transshipment Cargo." JOC. May 18, 2016. Accessed March 11, 2017. [http://www.joc.com/port-news/international-ports/cuba-port-plans-be-transshipment-hub-after-us-lifts-embargo\\_20160518.html](http://www.joc.com/port-news/international-ports/cuba-port-plans-be-transshipment-hub-after-us-lifts-embargo_20160518.html).

statement in October of 2016 that issues a general licensee to waive the 180-day restriction on vessels entering a U.S. port that have previously called on a Cuban port.<sup>48</sup> This change of policy makes transshipment from Cuban ports another possibility.

## TEXAS PORT PROFILES

TxDOT's 2016 Freight Mobility Plan estimated that in 2014, 508 million metric tons of freight traveled through Texas' deep water ports and shallow draft channels.<sup>49</sup> The plan estimated an increase to nearly 725 million metric tons by 2040, representing over 20% of all statewide freight tonnage anticipated in 2040.<sup>50</sup>

This section provides profiles of two ports: the Port of Corpus Christi and the Port of Houston. Corpus Christi exemplifies a non-container port that is set to benefit from increases in petroleum and other bulk liquid trade due, in part, to the expansion of the Panama Canal. The profile of Houston focuses on the container operations at its Barbours Cut and Bayport container terminals. It incorporates a brief discussion of other industries at the Port of Houston, focusing on the growing plastic resins industry.

### PORT OF CORPUS CHRISTI

The Port Corpus Christi Authority's (PCCA) vision statement is "to be the energy port of the Americas."<sup>51</sup> In contrast to Houston, Corpus Christi has no facilities to handle containers, and has no definite plans to add such facilities. Consistent with its vision statement, Corpus Christi is, however, a prime example of the expansion of Panama Canal's impact on bulk liquids and other petroleum-based products. Port officials also believe there may be increased opportunities for grain exports from the port. Table 4 outlines this port's facilities and activity.

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<sup>48</sup> "Treasury and Commerce Announce Further Amendments to Cuba Sanctions Regulations." U.S. Department of the Treasury. October 14, 2016. Accessed March 11, 2017. <https://www.treasury.gov/press-center/press-releases/Pages/jl0581.aspx>.

<sup>49</sup> Texas Department of Transportation. "Texas Freight Mobility Plan." January 26, 2016, 9. Accessed February 20, 2017. <http://ftp.dot.state.tx.us/pub/txdot/move-texas-freight/studies/freight-mobility/plan.pdf>.

<sup>50</sup> Ibid.

<sup>51</sup> "Port of Corpus Christi." Port of Corpus Christi. Accessed April 1, 2017. <http://portofcc.com/>.

**Table 4: Port of Corpus Christi Details**

<b>Location</b>	Near Corpus Christi, Nueces County <sup>52</sup>
<b>Channel Depth (Mean Lower Low Water)</b>	45 feet
<b>Channel Width</b>	300 to 500 feet
<b>Air Draft</b>	137.5 feet
<b>Primary Road Connectivity</b>	IH 37, US 181, SH 35
<b>Rail Connectivity</b>	BNSF, Kansas City Southern, Union Pacific
<b>2016 Total Exports</b>	25,766,471,110 KG
<b>Primary Export Commodities</b>	Non-crude oils (from petrol/bitumen), crude oil, petroleum coke and bitumen, petroleum gases, cereals (grain sorghum and wheat)
<b>2016 Total Imports</b>	20.231 billion KG
<b>Primary Import Commodities</b>	Crude oil, non-crude oils, sulfur, pebbles/gravel, aluminum ore

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OVERVIEW OF PORT OF CORPUS CHRISTI INFRASTRUCTURE—EXISTING AND PLANNED MAJOR IMPROVEMENTS

PCCA and associated privately owned facilities are split between three distinct sectors around the Corpus Christi Bay area, including the Inner Harbor along the Corpus Christi Ship Channel; facilities on the north side of Corpus Christi Bay along the La Quinta ship channel; and a small grouping of PCCA and private facilities along Redfish Bay and on Harbor Island (a small island set between Mustang Island and San Jose Island along the Aransas Ship Channel near the entrance to the Gulf of Mexico).<sup>53</sup>

The Inner Harbor is accessed by vessels via the Corpus Christi Ship Channel. This ship channel is currently dredged to 45 feet<sup>54</sup>, with authorization to 52 feet. PCCA officials indicated that they hope to develop this channel to the authorized depth when federal funding is authorized and available. Landside, the Inner Harbor area is directly accessed by IH 37, US 181/SH 35, and a network of local roads. State Highways 44, 286, and 358 provide connectivity from the south and west to the Ih-37 and US-181/SH-35 corridor along the ship channel. Entrance to the channel is currently limited by Harbor Bridge (US 181/SH 35), which provides a vessel clearance of 138 feet.

TxDOT and PCCA are currently in the final phase—design and construction—of a new harbor bridge that will provide 206 feet of below clearance.<sup>55</sup> Deepening the channel and the new bridge will allow for most Neopanamax bulk vessels to access the Inner Harbor. The Inner Harbor offers access to three Class-1 railroads: the Union Pacific, Burlington Northern-Santa Fe, and the Kansas City Southern. PCCA has recently made significant improvements at the Inner Harbor’s on-property rail system to increase access to and reliability of the port’s major railroad

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<sup>52</sup> The port of Corpus Christi is not officially considered a part of Corpus Christi or Nueces County, nor of San Patricio County.

<sup>53</sup> "Business Directory." Port of Corpus Christi. Accessed April 1, 2017. <http://portofcc.com/business-directory/>.

<sup>54</sup> Channel depths are reported as Mean Lower Low Water.

<sup>55</sup> "US 181 Harbor Bridge Project." Harbor Bridge Project. Accessed April 1, 2017. <http://www.harborbridgeproject.com/>.



connections. The Harbor Bridge is 22.1 nautical miles from the Gulf of Mexico and the midway point of the Inner Harbor is 25.5 nautical miles from the Gulf of Mexico.

The Inner Harbor hosts a variety of facilities, including a dry bulk dock terminal with two docks, 14 PCCA-operated liquid bulk docks, and 21 additional private liquid bulk docks designed to handle a variety of petroleum and petrochemical products.<sup>56</sup> The largest dry bulk and liquid bulk facilities are over 1,000 feet long and have berth depths of 45 feet. PCCA also operates several wharfs and a roll-on/roll-off facility with berth depths of 38 feet. The Inner Harbor can also service break-bulk cargo at several general cargo docks located along the ship channel. These help facilitate movement of large pipes and energy-related project cargo—such as components of wind turbines.

The La Quinta area sits on the north side of Corpus Christi Bay near Portland, Gregory, and Ingleside. The La Quinta Ship Channel is 45 feet deep. Most vessels capable of transiting the expanded Panama Canal will be able to access La Quinta. The area can be accessed by State Highways 35, 89, and 361, as well as US 181. Unlike the Inner Harbor, no bridge restricts access to La Quinta. La Quinta is accessed by the Union Pacific Railroad.

La Quinta is comprised of private petroleum and petrochemical facilities. While PCCA officials noted there are no definite plans to develop container facilities at Port Corpus Christi, any such development would likely be on a 1,100-acre property along the La Quinta Ship Channel. This project would include lengthening the 45-ft ship channel, adding three ship berths with nine ship-to-shore cranes, 180 acres of container and cargo storage, and additional support facilities, including distribution and warehouse centers.<sup>57</sup> Without needing to clear a bridge, container vessels would have more certain access to a La Quinta Terminal.

Additional PCCA property is located on Harbor Island near the entrance to the Gulf of Mexico. Additional private facilities are located on Harbor Island and along the intercostal waterway on the west side of Redfish Bay.

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## PRIVATE FACILITIES AND IMPROVEMENTS

Much seagoing traffic at and around Corpus Christi depends on the development of private facilities, including production facilities as well as private docks to service those landside facilities. The Inner Harbor area is home to several refineries, pipeline manufacturers, mineral companies, and grain facilities. Recently, a plastic resins plant was developed along the Inner Harbor. Due to land availability and ease of access, much recent development has occurred at La Quinta. A new LNG terminal is opening at La Quinta, which is primed to take advantage of the expanded Panama Canal. Other existing and soon-to-be-operational industry at La Quinta includes pipeline manufacturers, offshore oil rig manufacturers, and a bevy of bulk liquid producers. This includes Permian oil refiners, LPG producers, ethylene producers, propane producers, and refrigerant producers.

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## PRIMARY ASIAN AND PACIFIC COMMODITY TRADE<sup>58</sup>

In 2016, Corpus Christi exported over 4.1 million metric tons to Asia, over half of which was for grain sorghum. The rest of its mix was 1.100 million metric tons of crude oil and 518,000 metric tons in non-crude oils. Corpus Christi's crude oil trade with Asia is new to 2016. Grain exports have been steady in recent years.

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<sup>56</sup> "Moving America's Energy." Personal Communication with Port of Corpus Christi officials.

<sup>57</sup> Ibid.

<sup>58</sup> "USA Trade Online." U.S. Census Bureau. Accessed April 1, 2017. <https://usatrade.census.gov/>.



Corpus Christi imported 4.436 billion KG from Asia in 2016, almost entirely from crude oil. Small amounts came from non-crude bitumen oil, iron, and sulfur. Imports were up over 1 billion from 2015 levels but in line with most recent years.

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## KEY TAKEAWAYS

A study of Port Corpus Christi and discussions with PCCA officials reveal several key considerations when evaluating the ability of ports to benefit from the expanded Panama Canal, and increased seagoing traffic in general.

- Channel depth is a direct limiting factor for access to ports. Channel depths of at least 45 feet are needed to handle the largest ships traversing the expanded Panama Canal. Authorized depth is important to understanding the long-term situation at a port, but funding can be uncertain and difficult to attain.
- Ports without overhead limitations, such as the Harbor Bridge, have more certain opportunity to capitalize on hosting larger vessels. Overhead clearance can be a larger concern at container terminals than for other commodity groups.
- Distance from open water to port facilities can have a small effect on vessels' choices of ports. Shorter distances allow for quicker trips.
- Rail connectivity and reliability can be a significant factor in inviting the development of, and vessels carrying, commodities tending to depend on rail—such as bulk liquids and dry bulk such as grains.
- Road connectivity and reliability can also be a significant factor for ports. Multiple access points and lanes help alleviate congestion, adding speed and reliability.
- Ports and surrounding communities often depend heavily on private investment and development at and near ports. Available property and reliable seaside and landside access and service are keys to attracting new and expanded industrial facilities.
- Location of particular industry will affect traffic patterns of vessels, but also railroads and trucks. For example, increased grain shipments and a new plastic resins facility will affect traffic to and from the Inner Harbor. Increased bulk liquid and petroleum-based shipments may be seen at the Inner Harbor. But the area's new LNG facility is located at La Quinta along with a number of other recent oil, LPG, and other bulk liquid developments.

## PORT HOUSTON

Port Houston, including facilities operated by the Port of Houston Authority (POHA) and the many privately operated facilities along the Houston ship channel, is Texas' largest port. It handles more waterborne tonnage than any other port in the United States<sup>59</sup> and is one of the largest ports in the world. PH is the premier handler of containerized cargo for Texas and the Gulf Coast. The primary goal of this profile is to highlight the PH's container trade, but it will briefly touch on other key aspects of the Port Houston. PH officials believe they will see increased container traffic, if only due to population growth across the state of Texas. Whether the container terminals will see more vessels calling is unknown. At the least, PH officials are confident the terminals will not see fewer calls. Since its opening, the port has serviced calls by

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<sup>59</sup> "USA Trade Online." U.S. Census Bureau. Accessed April 1, 2017. <https://usatrade.census.gov/>.

Neopanamax vessels using the new Panama Canal locks. Table 5 outlines this port’s facilities and activity.

**Table 5: Port of Houston Details**

<b>Location</b>	Harris County
<b>Channel Depth (Mean Lower Low Water)</b>	45 feet
<b>Channel Width</b>	530 feet
<b>Air Draft</b>	Dependent on location. Unlimited at container terminals. As low as 135 feet at turning basin.
<b>Road Connectivity</b>	IH 10, IH 45, IH 610E
<b>Rail Connectivity</b>	BNSF, Kansas City Southern, Union Pacific, Gulf Coast Rail District, Port Terminal Railroad Administration
<b>2016 Total Exports</b>	87 million tons
<b>Primary Export Commodities</b>	Non-crude oils (bitumen/petrol), Organic chemicals, petroleum gases, petroleum coke and bitumen products, cereals, plastics
<b>2016 Total Imports</b>	70,223 million tons
<b>Primary Import Commodities</b>	Containerized goods, crude oil, non-crude oil, various mix of other commodities (primarily pebble/concrete/rock, organic chemicals, and iron)

OVERVIEW OF PORT HOUSTON CONTAINER INFRASTRUCTURE—EXISTING AND PLANNED MAJOR IMPROVEMENTS

PH operates two large container terminals at Barbours Cut and Bayport. The authority has handled approximately 2 million TEUs in recent years, approximately 67% of container traffic for the Gulf Coast and 95% of container traffic for the Texas ports.<sup>60</sup>

The Barbours Cut facility is located in the City of Morgan’s Point at the northwest corner of Galveston Bay.<sup>61, 62</sup> Barbours Cut is accessed by a recently deepened 45-ft channel. Landside, the container terminal is accessed by local roads that connect to SH 146 near SH 225. The terminal is the largest intermodal facility on the Gulf Coast. The Union Pacific (UP) and Burlington Northern Santa Fe (BNSF) offer Class-1 railroad access to the terminal via Port Terminal Railroad network.

The Barbours Cut terminal includes six continuous 1,000-ft berths. It contains a total of 47 cranes, including 11 wharf cranes (WC) and 36 rubber tired gantry (RTG) cranes<sup>63</sup>. The terminal has room for approximately 24,500 grounded TEU and can provide power outlets termed refer plugs for more than 2,500 refrigerated units. The trucking entrance to the terminal includes 27 total lanes—15 inbound and 12 outbound—and 8 optical character recognition (OCR) lanes at the gate<sup>64</sup>. Barbours Cut, as well as the Bayport terminal, uses heavily automated systems to facilitate quick movement at the terminals entrance and exit gates, as well as on

<sup>60</sup> “Three Ports Building for the Future.” February 23, 2017. Accessed April 1, 2017. <https://www.SCMR.com>.

<sup>61</sup> “Welcome to the Port, Port of Houston Authority.” Personal communication with officials at the Port of Corpus Christi.

<sup>62</sup> “Port of Houston Authority Map of Properties.” Personal communication with officials at the Port of Houston.

<sup>63</sup> Rubber Tyred Gantry crane

<sup>64</sup> Optical Character Recognition gate

terminal grounds. POHA has recently replaced most cranes at both terminals with cranes capable of handling Neopanamax vessels.

The Bayport container terminal is located in the Bayport Industrial District, on the west side of Galveston Bay.<sup>69</sup> It currently offers 3,300 continuous feet of berths. It contains a total of 36 cranes—9 WC and 27 RTG units. Entrance on and off property is facilitated by 32 total lanes—20 inbound and 12 outbound lanes—with 6 OCR gates inbound and outbound.

The Bayport facility is in the middle of an expansion. At full build-out, POHA plans for Bayport to have seven berths and a yearly capacity of 2.3 million TEU per year. POHA is currently building an additional berth, and will build the remaining three as demand dictates. POHA is also improving the rail connections at Bayport.

## BRIEF OVERVIEW OF NON-CONTAINER FACILITIES AT THE PORT HOUSTON

Port Houston includes an array of over 150 private industrial facilities that could benefit from the expanded Panama Canal.<sup>70</sup> Private petrochemical and petroleum-based facilities line the Houston Ship Channel. Plastic resin exports in particular are expected to thrive at the Houston Ship Channel.<sup>71</sup> Together, these developments combined with expected plastic resin ventures by various major petrochemical companies are expected to support 500,000 TEU of traffic at the Port of Houston.<sup>72</sup> Plastics and related products will be containerized and handled at the container facilities. Box 1 provides examples of both production and packing plants that will impact Port Houston in the near future.

A number of other developments are expected in and around the Port Houston in the coming years. Notably, several developments are expected at or near the profiled Bayport Container Terminal, such as a 300,000-square-ft

### Box 1. Examples of Plastics Production and Packing Plants

#### LaPorte

- A 470-kiloton/year high-density polyethylene facility for which construction was completed in 2016
- A 500-kiloton/year facility scheduled for completion in 2019<sup>65, 66</sup>

#### Baytown

- A plastic resin packing plant at AmeriPort Industrial Park is set to come on line in April 2017.<sup>67</sup> The plant will provide off-plant packaging as well as railcar storage and switching services.
- A distribution and manufacturing facility at the Cedar Port Distribution Park. This plant is designed to handle more than 2 billion pounds per year of plastic resins is expected to open in the coming years.<sup>68</sup>

<sup>65</sup> "INEOS, Sasol Break Ground on \$500M La Porte HDPE Plant." BIC Magazine. December 08, 2014. Accessed March 09, 2017. <http://www.bicmagazine.com/expansions/downstream-subsection/ineos-sasol-hdpe-plant-laportegroundbreaking/>.

<sup>66</sup> "LyondellBasell Will Build High Density Polyethylene Plant at La Porte, Texas, Complex." LyondellBasell. September 9, 2016. Accessed March 15, 2017. <https://www.lyondellbasell.com/en/news-events/corporate--financial-news/lyondellbasell-will-build-high-density-polyethylene-plant-at-la-porte-texas-complex/>.

<sup>67</sup> Esposito, Frank. "Resin Packaging Plant under Construction on Gulf Coast." Plastics News. December 21, 2016. Accessed March 02, 2017. <http://www.plasticsnews.com/article/20161221/NEWS/16122979/resin-packaging-plant-under-construction-on-gulf-coast>.

<sup>68</sup> Smith, Cara. "Global Plastics Distributor Nabs 200 Acres in Southeast Houston." Bizjournals.com. October 25, 2016. Accessed April 02, 2017. <http://www.bizjournals.com/houston/news/2016/10/25/global-plastics-distributor-nabs-200-acres-in.html>.

<sup>69</sup> Ibid.

<sup>70</sup> *Port of Entry: Houston - Port of Houston Impact to the Texas Economy, 2015*. Publication. 2016. Accessed December 20, 2016. <https://comptroller.texas.gov/economy/docs/ports/overview-houston.pdf>.

<sup>71</sup> "Port Houston Navigator." Issuu. Fall 2016. Accessed April 29, 2017. [https://issuu.com/portofhouston/docs/fall\\_navigator](https://issuu.com/portofhouston/docs/fall_navigator).

<sup>72</sup> "Houston Container Volumes to Soar on New Petrochemical Plant Demand." Houston Container Volumes to Soar on New Petrochemical Plant Demand. February 20, 2016. Accessed April 09, 2017. [http://www.joc.com/port-news/us-ports/port-houston/houston-container-volumes-soar-result-new-petrochemical-plants\\_20160220.html](http://www.joc.com/port-news/us-ports/port-houston/houston-container-volumes-soar-result-new-petrochemical-plants_20160220.html).

temperature-controlled facility for perishable products is expected online by summer 2017 and a 56-acre “built-to-suit” facility with dock and rail access<sup>73, 74</sup>. There is considerable growth in other activities that will benefit Port Houston trade. Tanking operations are expanding and Enterprise PLC recently announced another facility at Morgan’s Point. Although these are on non-Port Authority land, all are likely to feed chemicals to Asia through the Panama Canal.

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#### PRIMARY ASIAN AND PACIFIC COMMODITY TRADE<sup>75</sup>

Houston exported over 26.2 million tons to Asia in 2016, having shown steady growth over the past several years. These exports to Asia increased from 19.5 million tons in 2015. Petroleum gases comprised over 40% of all Asian exports, with nearly 3.3 million tons of non-crude oil exports and over 2.2 million tons in petroleum coke and bitumen products. Petroleum gases nearly doubled over 2015 levels, as did petroleum coke and bitumen. Non-crude oils have stayed mostly steady.

Over 18.7 million tons was imported from Asia through the Port of Houston facilities. Crude oil comprised over 40% of the mix, at 8.58 million tons. In addition, 1.6 million tons non-crude oil was imported. Over 2.2 million tons of iron products were imported, as was 1.3 million tons of organic chemicals. A long list of various commodities came from Asia as well, including furniture, plastics, wood, aluminum, ceramics, and other container traffic. Overall imports increased from 2015’s 17.3 million tons but are off 2014’s level of 21.8 million tons. Crude oil was up, while iron imports were down from 2015.

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#### KEY TAKEAWAYS

Studying the Port Houston highlights several key considerations and points relating to the expanded Panama Canal.

- Container traffic at the Port Houston has thrived, particularly trade with eastern Asia. This trade will directly benefit from the expanded Panama Canal.
- The nature of vessel traffic and patterns is difficult to predict. Port Houston will continue to see an increase in vessel traffic, but the size and frequency of container vessels that will be calling at the Port Houston is as yet unknown. Larger ships will create more periods of high peak traffic at container terminals while smaller ships will create more sustained periods of traffic at terminals.
- Port officials continue to assume that container traffic will, generally, follow the cheapest path. From a port’s standpoint, this requires speed and reliability dockside and high efficiencies at the inbound and outbound terminal gates.
- Length of berths, storage area, and facilities directly affect the speed and reliability of a container terminal to service vessels. Delays and slowdowns dockside hurt the attractiveness of ports. “Container vessels are losing money if they are not moving” is a common maxim encountered in research reports.
- Rail connections are important, but reliable road connections are vital to the movement

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<sup>73</sup> Carder, Doug. "Cold Facility Planned for Port of Houston." The Packer. February 17, 2016. Accessed April 1, 2017. <http://www.thepacker.com/news/cold-facility-planned-port-houston>.

<sup>74</sup> Meredith, Catherine. "Ridge Development Will Develop 55 Acres At Port Of Houston." Bisnow. February 19, 2016. Accessed March 28, 2017. <https://www.bisnow.com/houston/news/industrial/ridge-development-will-develop-55-acres-at-port-of-houston-56208>.

<sup>75</sup> "USA Trade Online." U.S. Census Bureau. Accessed April 1, 2017. <https://usatrade.census.gov/>.

of containers on and off port property and throughout the regions served by a port.

- Currently, back-ups at traffic signals at Barbours Cut Boulevard and SH 146 and impacting drayage flows and under review with the TxDOT Houston District.
- Plastic resins are expected to flourish due to increased petrochemical demand and the expanded Panama Canal allowing larger vessels to transit it to Asian markets.

## SUPPLY CHAIN CASE STUDIES OF PRIMARY AND HIGH GROWTH COMMODITIES

This section draws a nexus between the LNG and plastic resins—perhaps the two commodities best positioned to benefit from the expanded Panama Canal—and Texas’ statewide infrastructure by illustrating the supply chains for these two projects.

### PLASTIC RESINS

Plastic resins are created from materials derived out of natural gas. The increased extraction from shale in Texas has produced a large supply of natural gas, which gives Texas’ plastic resin industry a competitive advantage.<sup>76</sup> As of 2014, Texas was the fourth largest exporter of plastic resins—valued at \$14.7 billion. Table 6 lists the major plastic resin employers in the state.

**Table 6: Major Plastic Resin Employers in Texas<sup>77</sup>**

<b>Company</b>	<b>Location(s)</b>	<b>Products</b>
ExxonMobil Chemical Co.	Baytown, etc.	Plastic Resins
Chevron Phillips Chemical Co., LLC	The Woodlands, etc.	Plastics and Plastic Resins
The Dow Chemical Co.	LaPorte	Urethanes and Ethylene Products
Formosa Plastics	Point Comfort	Plastics and Plastic Resins
Goodyear Tire & Rubber Co.	Beaumont, Houston	Synthetic Rubber and Plastic Resins
LyondellBasell Industries	Houston, etc.	Plastic Materials and Resins

The majority of plastic resin manufacturing in Texas occurs along the Gulf Coast; a moderate amount takes place in the Dallas/Fort Worth area. Houston, Beaumont, and Dallas boast large plastic resin facilities as well as the labor force to operate them.<sup>78</sup> ExxonMobil, Chevron Phillips, and Dow Chemical remain the largest manufacturers in this sector for the state of Texas. Figure 7 identifies the Texas’ Workforce Development regions with the largest concentration of resin workers relative to the size of the local labor force.<sup>79</sup>

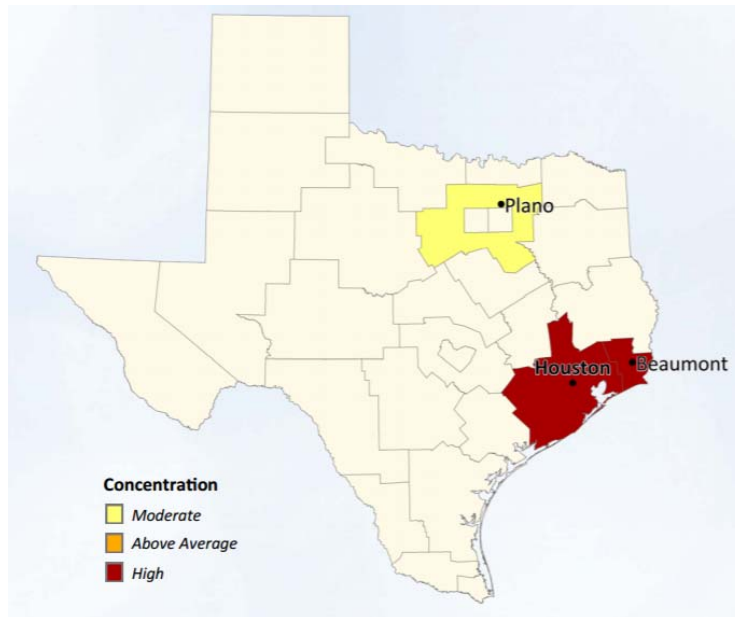
<sup>76</sup> "Statistics on the Plastic Resins Industry." American Chemistry Council. Accessed December 28, 2016. <https://plastics.americanchemistry.com/Jobs/EconomicStatistics/Plastics-Statistics/>.

<sup>77</sup> Ibid.

<sup>78</sup> Ibid.

<sup>79</sup> "Resin Manufacturing." Texas Wide Open for Business. 2014. Accessed January 25, 2017. <https://texaswideopenforbusiness.com/sites/default/files/11/13/14/profileplasticresins.pdf>.

Figure 7: Plastic Resin Employment Concentrations<sup>80</sup>



The greatest demand for plastic resins lies in Asia. IHS Markit Chemicals forecasts that plastic resin exports from the US will rise from 7.8 million metric tons to 11.2 million metric tons by 2020. Asian demand for plastic resins will rise from 20.5 million metric tons to 25.3 million metric tons, over the same period. Petrochemical manufacturers in Texas are expected to increase plastic resin exports by 300,000 to 500,000 additional TEUs by 2020. The majority of these exports are destined for Asia.<sup>81</sup>

Plastics are created from hydrocarbon gas liquids and natural gas processing. In Texas, the plastic resin supply chain begins with the extraction of oil and natural gas. The oil or gas is then moved via pipeline to a refinery or gas processing plant. At the gas processing plant, natural gas is separated into methane and other natural gas liquids or NGLs, especially ethane. A pipeline again transports these products, including ethane, to a petrochemical plant—also known as a *cracker facility*. High-temperature furnaces in the plant crack the ethane and propane into ethylene and propylene (Box 2). The ethylene and propylene travel via a pipeline to a plant where a catalyst gets added to the ethylene and propylene to form small plastic polyethylene pellets through the process of polymerization.<sup>82</sup>

**Box 2. Naphtha Cracking**

Ethylene is also produced from naphtha cracking and is notable because the gas cracking vs. naphtha cracking dynamic is the key to why the U.S Gulf Coast globally competitive in plastics production.

—Jordan Frisby, Economic Analyst, Port Houston; July 2017

The plastic pellets then travel by rail to a transit yard where they wait until they are moved to a bagger or packaging facility in either Texas or California. Once at the bagger facility, the pellets are put into 25 KG bags which are usually palletized, then loaded into a maritime

<sup>80</sup> Ibid.

<sup>81</sup> Bonney, Joseph. "Container Line Services Hold Key to US Gulf Resin Exports." JOC. December 5, 2016. Accessed March 20, 2017. [http://www.joc.com/port-news/us-ports/port-houston/container-line-rates-hold-key-us-gulf-resin-exports\\_20161205.html?destination=node%2F3310831](http://www.joc.com/port-news/us-ports/port-houston/container-line-rates-hold-key-us-gulf-resin-exports_20161205.html?destination=node%2F3310831).

<sup>82</sup> "What Is a Cracker and Why Should I Care?" American Fuel & Petrochemical Manufacturers. 2017. Accessed February 10, 2017. <http://education.afpm.org/petrochemicals/what-is-a-cracker-and-why-should-i-care/>.



container for oceangoing ship transit.<sup>83</sup> Again there are two routes to consider. The pellets move from the production plant to a Texas packaging facility where they are loaded into marine containers which then are moved by rail to a West Coast port like Los Angeles or Long Beach. They arrive at the rail intermodal container transfer facility (ICTF) where the containers are then moved by dray trucks to the export terminal. The likely alternative over the next five years is that the pellets will travel to a Texas packaging facility and the loaded container is then moved to a containerized Texas port—such as Houston<sup>84</sup>.

The increased supply of Texas plastic resin exports is destined for Asia, Latin America and the EU markets, and the Panama Canal expansion offers more opportunities for all-water transit routes to Asian countries. While Texas ports—like Houston and Freeport—are well positioned to capture a large portion of the expanding plastic resin market, Texas ports face several challenges. The Port of Houston has a historically tight supply of empty containers, meaning that shipping lines would have to reposition to make Houston viable. This shortage any handicap the port's ability to compete with intermodal rail routes, like BNSF, that push for overland routes to California ports.<sup>85</sup> As of November 2014, it was cheaper to transport the pellets to California and then ship them to Asia, rather than use a Texas port.<sup>86</sup> Port analysts robustly challenge this assertion—see Box 3—and clearly 2014 cost calculations need careful checking before strategic investments are undertaken.

**Box 3. Empty Containers for Houston Exports**

The issue of availability of empty containers on the lanes that serve energy and energy byproducts like plastics are exaggerated because shippers can move additional empty containers into Houston to feed export demand. This was done on a massive scale about a decade ago and it would be easy for the steamship lines to ramp empty repositioning back up if needed.  
—Jordan Frisby, Economic Analyst, Port Houston; July 2017

However, Houston believes it can attract new all-water Panama Canal services by offering proximity to major markets, including the Texas Triangle megaregion, ample storage areas, lower dwell times and extending gate hours. In 2016, 2M Alliance Partners Maersk Line and Mediterranean Shipping Co. began a new Neopanamax Canal services with a direct call to Houston. As the port finishes its new wharfs at the Bayport Terminal, the port will create additional capacity to handle an expanded resin trade.<sup>87</sup> Figure 8 depicts a simplified export resin supply chain to highlight the role of Texas ports.

<sup>83</sup> Prozzi, Jolanda, and Megan Kenney. "The Plastic Resin Export Supply Chain." Transportation Policy Research Center. December 16, 2016. Accessed March 27, 2017. <https://ti.tamu.edu/policy/freight/moving-texas-exports/the-plastic-resin-export-supply-chain/>.

<sup>84</sup> New overweight containers laws passed by the 2017 Texas Legislature strengthen the Port of Houston routing alternative.

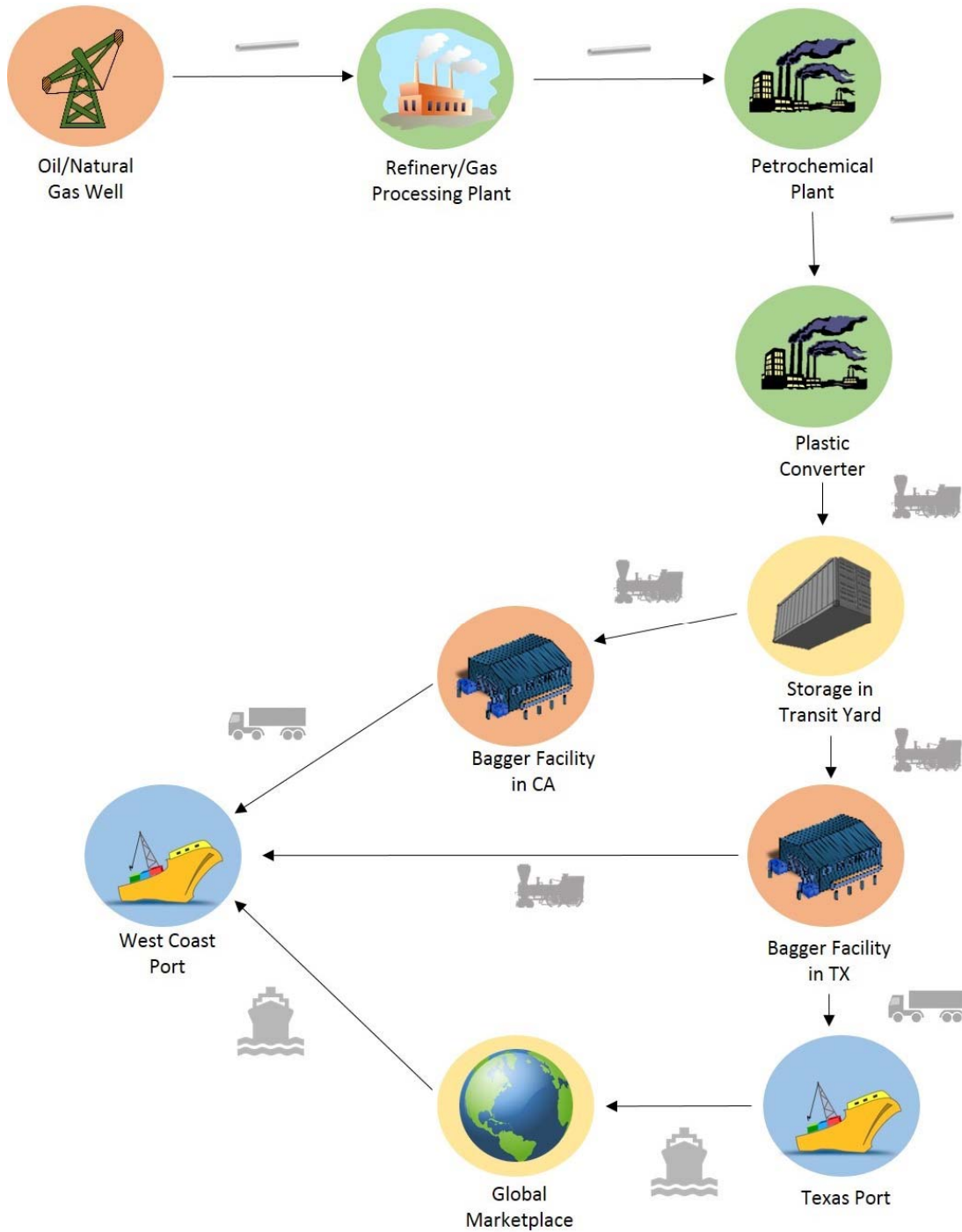
<sup>85</sup> Bonney, Joseph. "Houston Prepares to Battle for Growing Petrochemical Trade." JOC. November 27, 2016. Accessed March 20, 2017. [http://www.joc.com/port-news/us-ports/port-houston/houston-prepares-battle-growing-petrochemical-trade\\_20161127.html](http://www.joc.com/port-news/us-ports/port-houston/houston-prepares-battle-growing-petrochemical-trade_20161127.html).

<sup>86</sup> Ibid.

<sup>87</sup> Ibid.



Figure 8: Texas Export Plastic Resin Supply Chain<sup>88</sup>



<sup>88</sup> Infographic created by Alex Payson based on various reports.

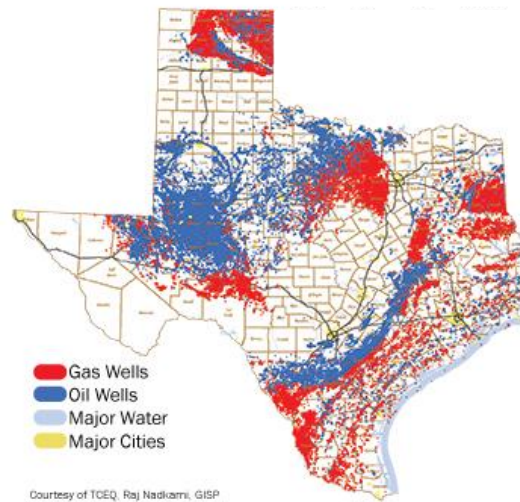
## LIQUEFIED NATURAL GAS (LNG)

Texas has been producing natural gas at an increasing rate in recent years as the production of shale gas has lowered the cost of natural gas production. LNG exports have risen dramatically in response to these lower prices. Four areas of Texas provide the largest amounts of natural gas:

- Anadarko Basin in the Texas Panhandle
- Barnett Shale in the Dallas/Fort Worth and Arlington region
- Bossier/Haynesville Shale of East Texas
- Eagle Ford Shale in South Texas<sup>89</sup>

Figure 9 highlights these areas of Texas as of 2015.<sup>90</sup> As of 2014, more than 98,000 producing natural gas wells were operating in Texas.<sup>91</sup> The state also holds 37 active storage facilities for LNG.<sup>92</sup>

**Figure 9: Active Oil and Gas Wells 2015<sup>93</sup>**



The natural gas moves from place to place via a large system of pipelines. The state also houses natural gas market hubs, the largest of which are located in Carthage, Henry, and Egan, Texas. Figure 10 shows this extensive network of intrastate and interstate pipelines.<sup>94</sup>

<sup>89</sup> Prozzi, Jolanda, and Megan Kenney. "The Liquefied Natural Gas Export Supply Chain." Transportation Policy Research Center. December 06, 2016. Accessed February 10, 2017. <https://tti.tamu.edu/policy/freight/moving-texas-exports/the-liquefied-natural-gas-export-supply-chain/>.

<sup>90</sup> "The Value of Habit and Land Stewardship." Texas Parks and Wildlife. Accessed February 18, 2017.

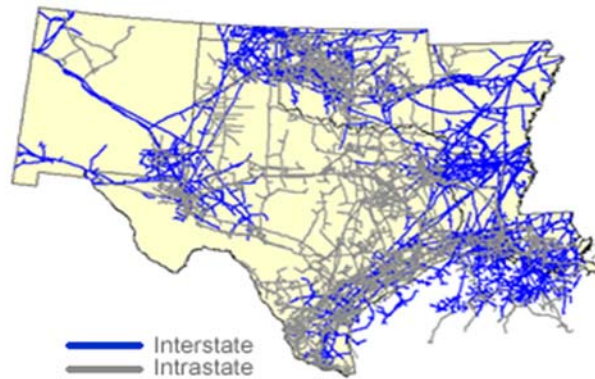
<sup>91</sup> Prozzi, Jolanda, and Megan Kenney. "The Liquefied Natural Gas Export Supply Chain." Transportation Policy Research Center. December 06, 2016. Accessed February 10, 2017. <https://tti.tamu.edu/policy/freight/moving-texas-exports/the-liquefied-natural-gas-export-supply-chain/>.

<sup>92</sup> "Texas State Profile and Energy Estimates." U.S. Energy Information Administration. Accessed March 18, 2017. <https://www.eia.gov/state/analysis.php?sid=TX>.

<sup>93</sup> "The Value of Habit and Land Stewardship." Texas Parks and Wildlife. Accessed February 18, 2017.

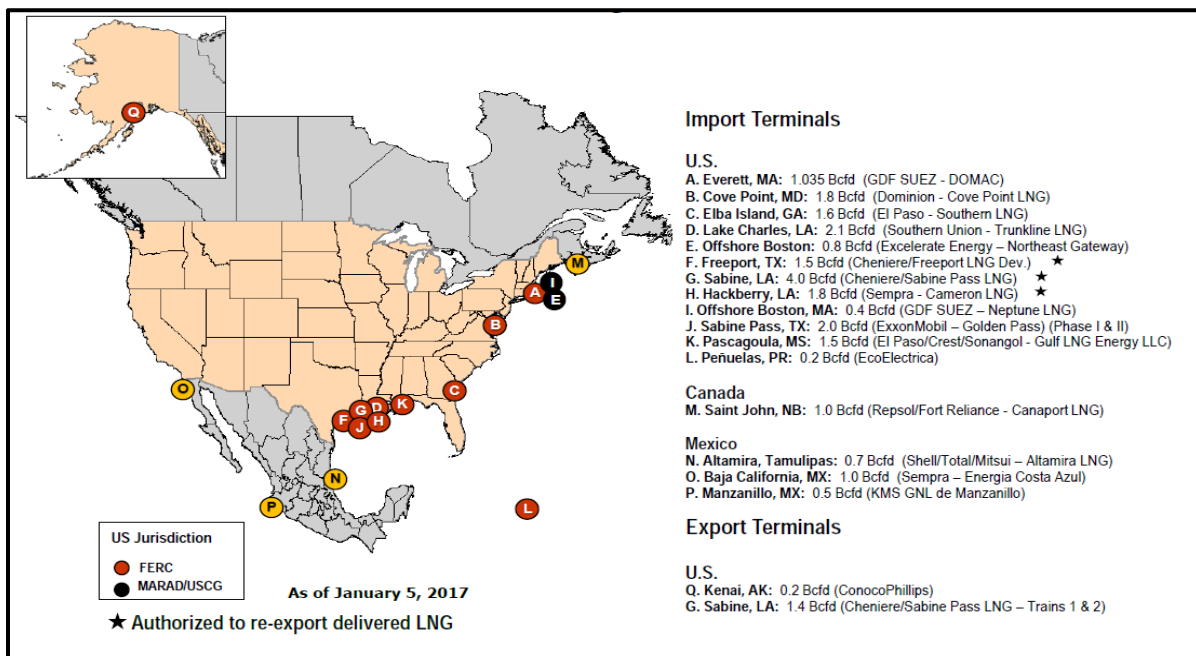
<sup>94</sup> Roper, David. "Natural-Gas and Crude-Oil Pipelines in the United States." October 14, 2016. Accessed March 1, 2017. <http://www.roperld.com/science/minerals/PetroleumPipelines.htm>.

Figure 10: Intrastate and Interstate Pipelines<sup>95</sup>



A number of LNG facilities located in Texas handle the natural gas and prepare it for export. With the growing value of LNG, other facilities are being proposed and constructed. The Federal Energy Regulatory Commission (FERC) keeps track of all such projects. A number of these facilities currently exist and are planned for Texas.<sup>96</sup> See Figures 11 through 13.

Figure 11: Existing LNG Export/Import Terminals in North America<sup>97</sup>

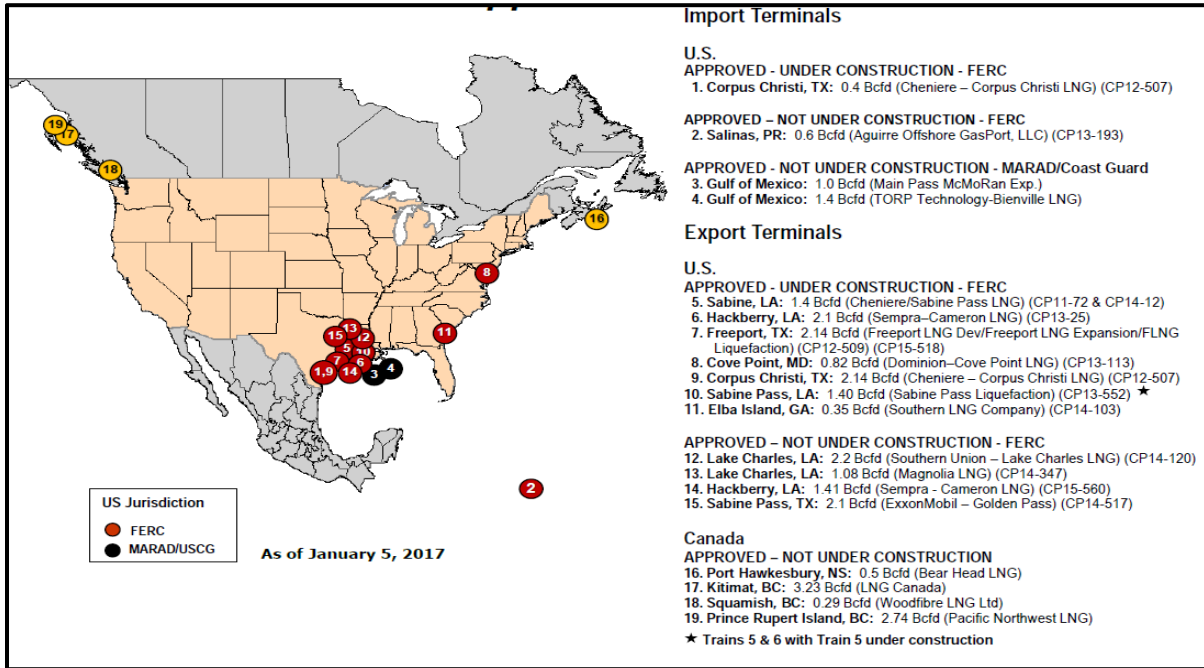


<sup>95</sup> Ibid.

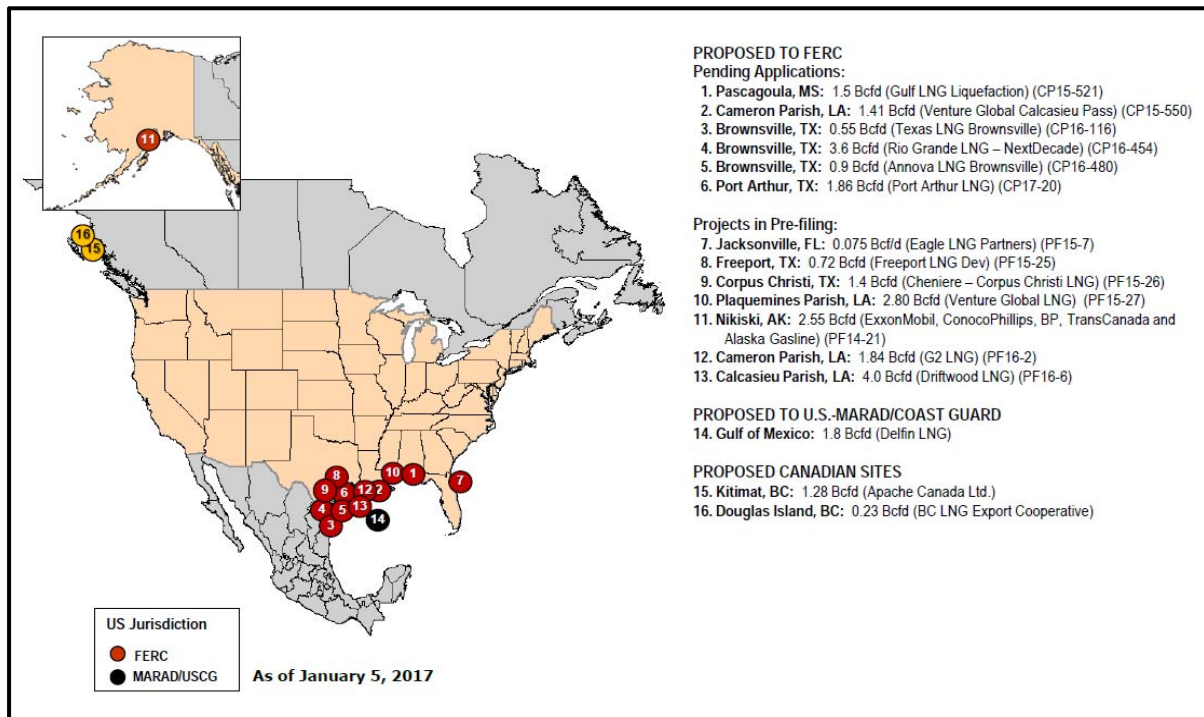
<sup>96</sup> "LNG." Federal Energy Regulatory Commission. February 22, 2017. Accessed February 26, 2017. <https://www.ferc.gov/industries/gas/indus-act/lng.asp>.

<sup>97</sup> "LNG." Federal Energy Regulatory Commission. February 22, 2017. Accessed February 26, 2017. <https://www.ferc.gov/industries/gas/indus-act/lng.asp>.

**Figure 12: Approved LNG Export/Import Terminals in North America**



**Figure 13: Proposed LNG Export/Import Terminals in North America<sup>98</sup>**

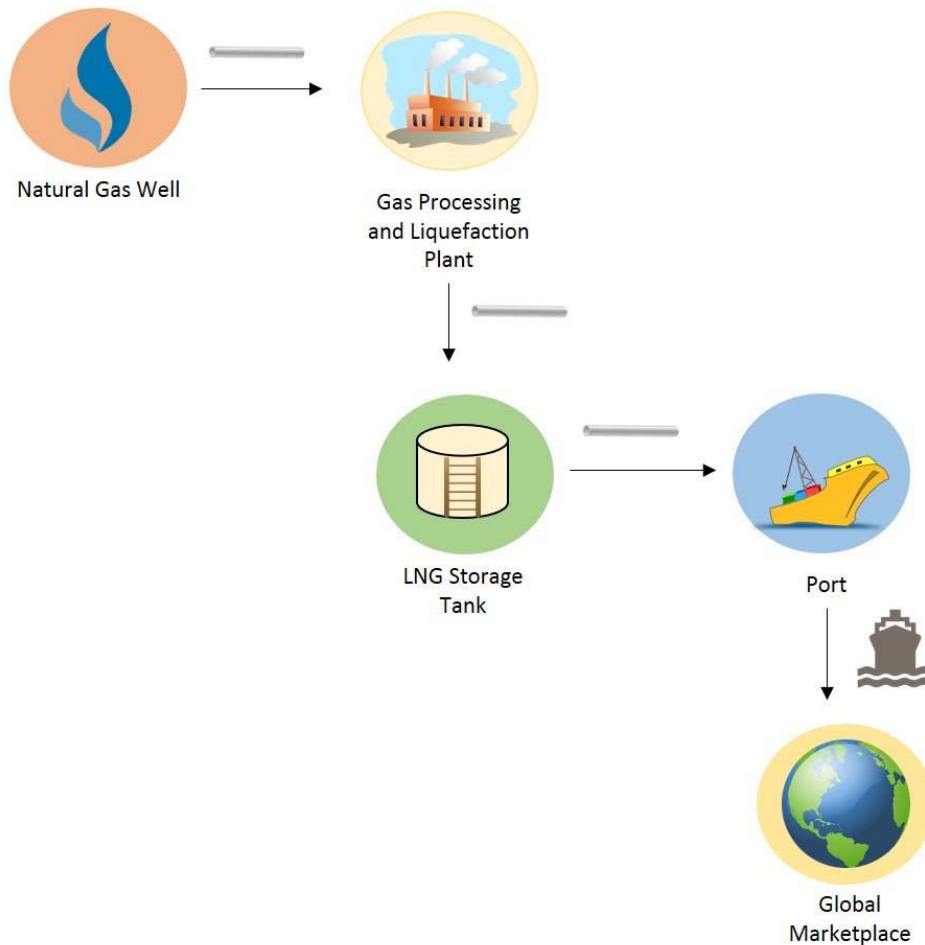


<sup>98</sup> "LNG." Federal Energy Regulatory Commission. February 22, 2017. Accessed February 26, 2017. <https://www.ferc.gov/industries/gas/indus-act/lng.asp>.

The LNG supply chain (Figure 14) starts at these natural gas wells, shown above. Once the LNG is out of the well, it travels by pipeline to a processing and liquefaction plant. While at the plant, contaminants are removed from the natural gas to prevent damage to the facility equipment as the gas is cooled. This purification process can create LNG that is almost entirely methane. Once this process is complete, liquefaction commences. During liquefaction, the LNG is cooled to -256°F. At this temperature, the LNG's volume falls to 1/600<sup>th</sup> of the same amount of LNG at room temperature and atmospheric pressure.<sup>99</sup>

Once the LNG finishes at the liquefaction plant, it is transported by pipeline to storage tanks. The LNG is held in double-walled containers at atmospheric pressure until it is time for the LNG to be moved. The LNG is then pumped into LNG ships. These vessels are double-hulled in order to prevent leakage from the ship in the event of an accident. The ships also keep the LNG at -256 °F and at atmospheric pressure.<sup>100</sup>

Figure 14: Texas LNG Supply Chain<sup>101</sup>



<sup>99</sup> Prozzi, Jolanda, and Megan Kenney. "The Liquefied Natural Gas Export Supply Chain." Transportation Policy Research Center. December 06, 2016. Accessed February 10, 2017. <https://tti.tamu.edu/policy/freight/moving-texas-exports/the-liquefied-natural-gas-export-supply-chain/>.

<sup>100</sup> Foss, Michelle. *Introduction to LNG: An Overview on Liquid Natural Gas, Its Properties, the LNG Industry, and Safety Considerations*. Publication. June 2012. Accessed February 10, 2017. <http://www.beg.utexas.edu/energyecon/INTRODUCTION%20TO%20LNG%20Update%202012.pdf>.

<sup>101</sup> Infographic created by Alex Payson from various reports.



## CONCLUSIONS AND RECOMMENDATIONS

The expanded Panama Canal is open for business; it allows the passage of more and larger vessels, accommodating ships with capacities up to approximately 13,000 TEU, or 1,200 feet long, 49.9 feet in draught, and 160.7 feet wide. This expansion will facilitate increased volumes of trade at Texas ports capable of handling larger ships and ports with the surrounding industries. Gains in imports and exports at Texas ports will be commodity-specific. Imports of containers are likely to increase with the Texas population growth, while exports of bulk energy liquids and related products in containers will also increase. In particular, exports of LNG and plastic resins are expected to substantially grow at Texas ports. Other bulk exports—most notably grains—may increase after the Canal expansion.

The Port of Houston's two container terminals will experience the bulk of this increase in container imports. Recent, ongoing, and planned infrastructure improvements at Houston will facilitate this growth. TxDOT should further model and project increases in container imports due to both population growth in Texas and a shift in container trade from the West Coast; this brief recommends working with port officials to measure the port's ability to timely and reliably move containers on and off vessels and port premises. TxDOT should track the size and frequency of vessels calling at Texas ports; these factors will directly impact the nature of demand on infrastructure.

Exports of LNG, plastic resins, grains, and other bulk commodities are likely to grow at ports up and down the Gulf Coast. These increases will depend heavily on existing and planned private industry facilities near ports. Impacts at ports and surrounding transportation connections will be location-specific within individual ports. Numerous new and upgraded facilities are planned at Texas ports. TxDOT should identify these individual facilities and, using a supply-chain approach, understand the demands that industries make of transportation networks. TxDOT should monitor the state and federal permitting and economic situations of proposed LNG terminals and other industrial facilities.

Overall, impacts are mostly speculative at this point, but possibilities for any commodity type can be narrowed by understanding the capabilities and limits for Texas ports and state industries. TxDOT should combine the profiles in this report with other infrastructure studies to predict and model localized impacts due to the Panama Canal expansion as well as the growth of the Texas population and Texas industry.

In the future, TxDOT should utilize time series data from the Panama Canal, the US Census Bureau (i.e., the USA Trade Online site), and other sources to measure the commodity trade through the canal and at Texas ports to predict the magnitude of impacts and more accurately understand the localized impacts of growing imports and exports through Texas ports.



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