United States Fuel Resiliency

Volume III

U.S. Fuels Supply Infrastructure Vulnerabilities and Resiliency

FINAL REPORT

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Data related to fuels supply and movements and descriptions of infrastructure were current at the time this report was prepared. The global and U.S. oil, natural gas, and refined products markets, supply patterns, and infrastructure are changing rapidly.

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List of Units

Bbl	Barrel (1 barrel = 42 gallons)
MBbl	Thousand barrels
MMBbl	Million barrels
Bbl/d	Barrels per day
MBbl/d	Thousand barrels per day
MMBbl/d	Million barrels per day
Mcf	Thousand cubic feet
MMcf	Million cubic feet
Bcf	Billion cubic feet
Tcf	Trillion cubic feet
Mcf/d	Thousand cubic feet per day
MMcf/d	Million cubic feet per day
Bcf/d	Billion cubic feet per day
Gyr	Gallons per year
MGyr	Thousand gallons per year
MMGyr	Million gallons per year
BGyr	Billion gallons per year
Btu	British Thermal Unit (~1055 joules)

Abbreviations

AFDC	Alternative Fuels Data Center
ARRA	The American Recovery and Reinvestment Act of 2009
ATB	Articulated Tug Barge
BOEM	Bureau of Offshore Energy Management
CNG	Compressed Natural Gas

DLA	Defense Logistics Agency
DOE	U.S. Department of Energy
E&P	Exploration and Production
EAP	Energy Assurance Plan
EC	East Coast
EERE	U.S. Department of Energy Office of Energy Efficiency and Renewable Energy
EIA	U.S. Department of Energy, Energy Information Administration
EPA	U.S. Environmental Protection Agency
EPCA	Energy Policy and Conservation Act
EPSA	U.S. Department of Energy Office of Energy Policy and Systems Analysis
ESF	Emergency Support Function
FEMA	U.S. Federal Emergency Management Agency
FERC	U.S. Federal Energy Regulatory Commission
GC	Gulf Coast
IEP	International Energy Program
IG	Inspector General
LDC	Local Distribution Company
LNG	Liquefied Natural Gas
LOOP	Louisiana Offshore Oil Port
NARUC	National Association of Regulatory Utility Commissioners
NE	Northeast
NEHHOR	Northeast Home Heating Oil Reserve
NGL	Natural Gas Liquids
NREL	U.S. Department of Energy National Renewable Energy Laboratory
NRF	National Response Framework
NYH	New York Harbor
OCS	Outer Continental Shelf
OE	U.S. Department of Energy Office of Electricity Delivery & Energy Reliability
PADD	Petroleum Administration for Defense Districts
QER	Quadrennial Energy Review
R&M	Refining and Marketing
RFS	Renewable Fuel Standard
SE	Southeast
SPR	Strategic Petroleum Reserve
SW	Southwest
TS&D	Transportation, Storage, and Distribution
ULCC	Ultra Large Crude Carriers
ULSD	Ultra-low sulfur diesel
USACE	U.S. Army Corps of Engineers
VLCC	Very Large Crude Carriers
WC	West Coast
WTI	West Texas Intermediate

I. Resiliency to TS&D Infrastructure and Supply Disruptions

A. Introduction

Volume I of this study characterized the nation's oil and natural gas transportation, storage, and distribution (TS&D) infrastructure. Volume II described and discussed the nature, probability, and supply impacts of various vulnerabilities of the TS&D infrastructure to natural disasters, physical and human threats, supply chokepoints, and system interdependencies. Industry, government leaders, and policy makers must also understand the ability of this infrastructure to recover from disruptions and the ability of the fuels TS&D system to meet the fuels demand of industrial, commercial, and private consumers in affected markets.

Vulnerability and Resiliency: Building on the information and data presented in Volumes I and II, Part III of this study evaluates the ability of the TS&D system to respond to and recover from natural disasters and intentional acts, system chokepoints and interdependencies, and other supply interruptions, such as external market distortions or political acts.

For the purpose of this analysis, "resiliency" is considered in several ways:

- Infrastructure resiliency refers to the amount of time it takes to restore a damaged element of infrastructure to operations.
- Supply resiliency refers to the ability of the overall system to ensure the adequacy of fuels supply to markets affected by infrastructure or supply disruptions, regardless of cause.

Natural Disasters and Threats: Recent high-profile natural disasters like Hurricane Sandy, Hurricane Katrina, the 2012 Mid-Atlantic Derecho, and the 2013-2014 Polar Vortex event have tested regional fuel resiliency along the Gulf Coast, in the Midwest, and on the East Coast.

- The hurricanes flooded refineries and petroleum terminals, shut down pipelines, sank offshore platforms, and disrupted transportation.
- The derecho knocked out power to millions, created local gas shortages, and brought prolonged restoration times.
- The most recent polar vortex event shut in production at wells, caused chaotic winter storms throughout the South, and created propane and natural gas shortages in the North, leading to price spikes and emergency imports from Europe.

These natural disasters provided valuable lessons in infrastructure and fuel supply resiliency.

Volume II of this study provided a comprehensive look at nine types of natural disasters that could disrupt fuel supplies in the United States and thereby threaten both the economy and the nation's security. These threats, and their primary effects based on past events, are shown in Table 1 and Figures 1and 2 below. The table highlights the key issues that need to be addressed in regional fuel resiliency.

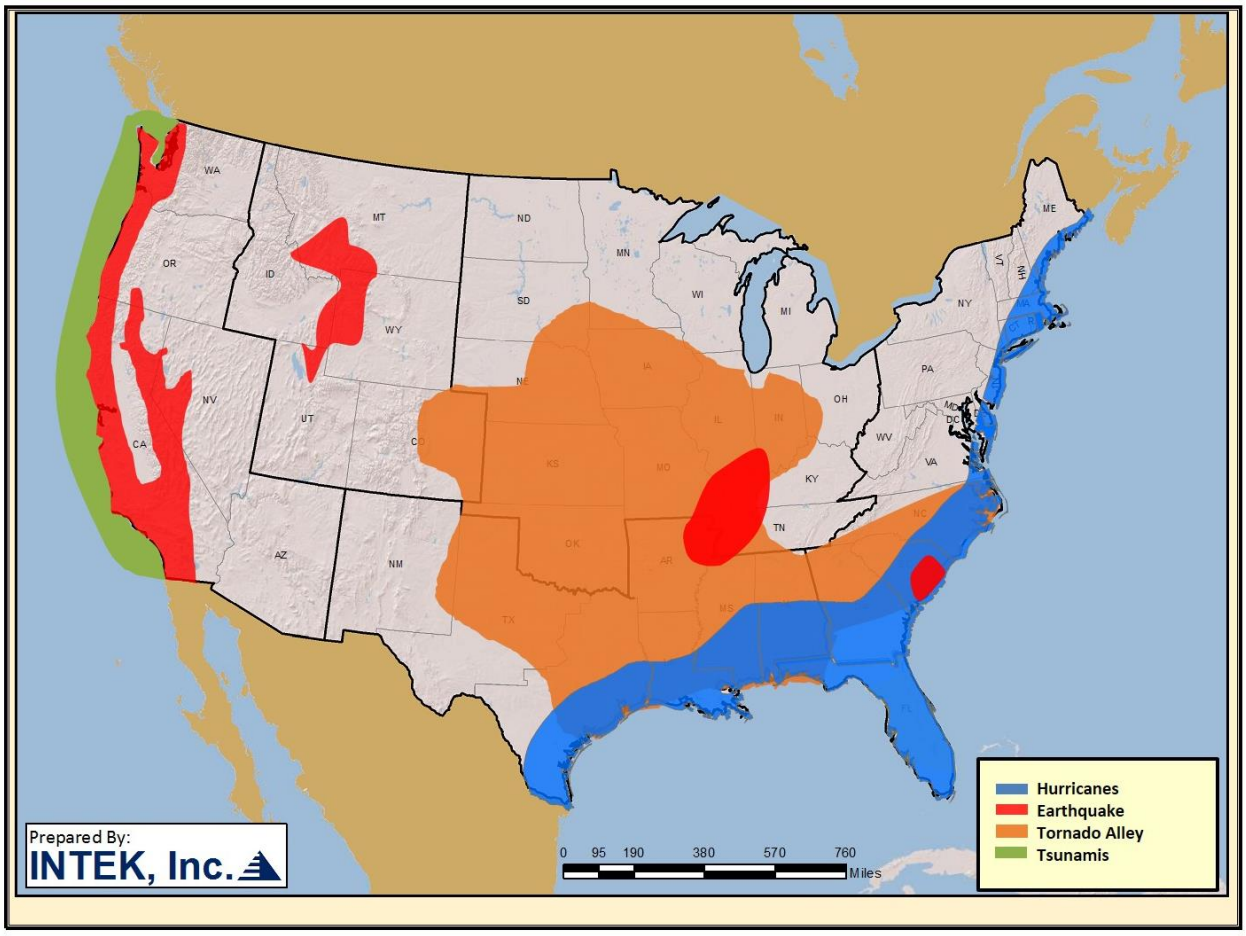
Table 1: Summary of Potential Natural Disaster Impacts on TS&D Infrastructure

Natural Disaster	Effects	Likely Impacts on Fuel Supply
Hurricanes	Wind damage, storm surges, flooding	Refineries and gas processing plants shut down, terminals flooded and inaccessible, pipelines (particularly Colonial and Plantation) shut down, large production losses in the Gulf of Mexico, and closure of major ports.
Earthquakes	Ground displacement, structural damage	Possible extensive damage to pipelines, ports, refineries, and terminals. Possible isolation of major West Coast markets.
Tsunamis	Massive coastal flooding, structural damage	Disruption of imports, damage to coastal terminals and rail lines. Massive local shortages in devastated areas.
Tornadoes	Extreme wind and debris impact damage	Low probability of infrastructure impact due to the disaster's extreme localization. Wells destroyed, refinery cooling towers destroyed, terminals heavily damaged.
Heat Waves /Droughts	Damage due to sagging, buckling, and kinking; agricultural losses	Insignificant transportation disruptions due to kinking and low river levels. Major ethanol feedstock loss. Water restrictions might affect refineries and fracking operations.
Derechos	Wind damage, flooding, and lightning	Local distribution affected due to widespread power outages. Insignificant wind and lightning damage to terminals, pumping stations, and refineries also possible.
Wildfires	Fire damage	Insignificant impacts on infrastructure due to typically rural fire locations and experienced mitigation efforts.
Polar Vortex	Prolonged freezing temperatures, equipment malfunctions, and transportation disruptions	Wellhead freeze-off leading to production losses. Constrained natural gas and propane supplies due to high consumption rates. Insignificant equipment malfunctions at refineries, terminals, and pumping stations.
Flooding	Flooding, erosion, debris impact damage	Damage to terminals and refineries in flood zones. Possible widespread ethanol feedstock loss.

Due to the variable climate and vast geography of the United States, certain natural disasters occur in or impact certain regions with much greater frequency and severity than others. Therefore, regional fuel

resiliency will largely depend on the nature and variety of threats faced by a given region. A generalized schematic of regional threats is provided in Figure 1.

Figure 1: Major Natural Disaster Hazard Regions in the Continental U.S.

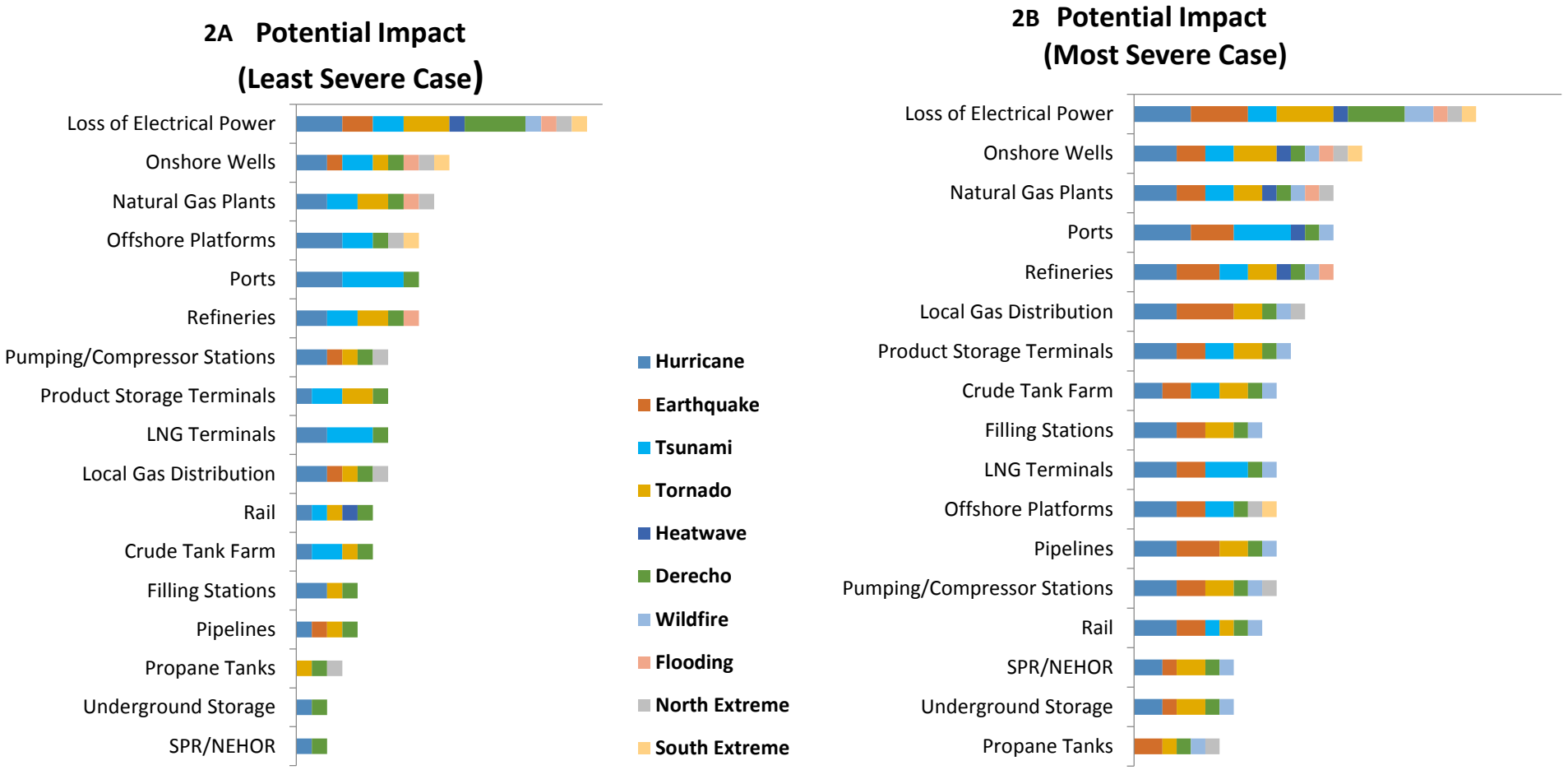


The relative vulnerability of various types of infrastructure to the full range of potential natural disruptions is reflected in Figures 2A and 2B. Figure 2A ranks infrastructure according to its the vulnerability to the least severe instances of specific types of natural disasters (excluding insignificant damage), and Figure 2B ranks infrastructure vulnerability to the most severe instance of such damaging events. While electric power deliverability ranks the highest, regardless of event severity, the relative vulnerability of other fuels supply infrastructures varies somewhat with event severity.

The frequency and severity of natural disasters, and the vulnerability of specific type of fuels supply infrastructure, also vary regionally.

Physical and Human Threats: Supply disruptions can come in the form of physical or humans threats, either through intentional malice (terrorism, criminal acts, sabotage) or unintended error (accidents, mismanagement, equipment failure), that disrupt infrastructure. While there have not been any recent physical attacks on oil and gas systems, accidents can also cause disruptions. Most are localized and temporary. Some, however, such as the BP Horizon Oil Spill in the Gulf of Mexico or the Lac-Megantic oil train derailment in Quebec, were severe enough to cause regional and national consequences.

Figure 2: Relative Vulnerabilities of Fuels Infrastructure Types for Various Event Severities



Human threats can also include politically or economically motivated supply disruptions such as embargoes. While domestic and global fuels markets have changed dramatically in recent decades, the continued dependency of the United States and some PADDs in particular, on crude oil and refined petroleum product imports, underscores the essential need to be able to respond to a disruption of foreign sources of supply.

Regional Supply Balances, Dependencies, and Resiliency: The United States is vast, with diverse geographic, climatological, political, and economic regions and sub-regions. Some regions, such as the Gulf Coast, are major producers and suppliers of oil, natural gas, or refined products. Others are almost wholly reliant on natural gas and refined products supplied by other regions. Understanding the oil, refined product, and natural gas supply and demand balances of each of the major PADDs provides insight in to the criticality of the infrastructure that serves each PADD and the other PADDs that it supplies or upon which it is dependent. These balances are illustrated statistically in Section II. The flows of crude oil, products, and natural gas between PADDS and Sub-PADDs are illustrated graphically in the regional discussion of vulnerabilities, dependencies, and resiliency that follows. Section III of this report describes each PADD and Sub-PADD in terms of its infrastructure vulnerabilities and dependencies, supply resiliency, and deficiencies, and offers options and recommendations for consideration by policy makers to address these needs.

SPR and Other Government Reserves: Supply resiliency is achieved in two primary ways. The first is in the stocks of crude oil, refined products, propane, and natural gas that are maintained in storage by industry to meet the changing demands of consumers. The second is the reserves of crude oil and refined products that have been established by the U.S. Government which serve to respond to interruptions in crude oil supply to domestic refiners and ensure adequate supplies of home heating fuels, or motor fuels, in areas that are most vulnerable to supply disruptions or sharp peaks in demand. Section IV of this volume describes the capabilities, limitations, and potential enhancements of the nation's Strategic Petroleum Reserves (SPR), Northeast Home Heating Oil Reserve (NEHHOR), and Northeast Regional Refined Petroleum Product Reserve (NERRPPR) to address supply resiliency requirements.

Federal and State Energy Assurance Plans: Infrastructure and supply resiliency is not, however, the sole province of the Federal government. Building on the lessons learned from past events, including Gulf Coast Hurricanes, East Coast Hurricanes, West Coast earthquakes, tornados, derechos, distortions to the Polar Vortex, and other supply disruptions, many state and even local governments have begun to develop and implement energy assurance plans that define public and private procedures, requirements, and policies for responding to energy supply disruptions. These plans, where public and available, are summarized in Section V of this volume.

Resiliency Stress Tests: It is not sufficient to understand the potential impacts of infrastructure and supply disruptions from a qualitative and descriptive perspective. It is critically important to assess the potential supply loss from such events in order to assess the true resiliency of the TS&D system to meet national and regional needs when an event occurs. Section V of this volume presents the results of a series of "stress tests" that were conducted to evaluate resiliency under a variety of interruption scenarios. These stress tests range from hurricanes of various intensities making landfall at various

locations, disruptions of crude oil exports to U.S. or global markets from sources in the Middle East, Africa, or South America, or loss of supply from Russia to global markets.

Fuel Resiliency Options for Policy Makers: A range of near-term and longer term options are available to policy makers for actions that can reduce vulnerability or improve resiliency of the TS&D infrastructure in the United States. These options relate to one or more of three major strategies:

- **Hardening: Encouraging, expediting, or facilitating hardening** or strengthening of the physical infrastructure to make it less vulnerable to damage by natural disasters or intentional acts.
- **Preparedness** to respond to supply interruption events, when they occur, through the establishment of plans, procedures, and capabilities that facilitate and expedite infrastructure and fuels supply recovery
- **Supply replacement** strategies to expeditiously provide alternative or back-up sources of fuels stocks to bridge the supply interruption until such time as damaged infrastructure and interrupted fuels production or transport operations can be restored to pre-event levels.

Much of the relevant TS&D infrastructure is privately owned and maintained. As such, the government's role in hardening and preparedness may be to encourage and incentivize industry to act, facilitate cooperation and interaction among industry participants, facilitate industry and governmental interactions, support research, technology development and application, and facilitate and expedite fuels-related emergency preparedness and response activities.

Where infrastructure is publicly owned and maintained, such as coastal and inland waterways, locks and navigation systems, or crude and refined product stocks and reserves, government's roles in assuring supply resilience are broader. These roles may include maintaining operability of physical infrastructure, conforming the composition of stocks to market requirements, and maintaining effective distribution and deliverability capabilities.

Options for improving resiliency are presented at the Sub-PADD level in Section III of this volume. Section VIII of this report summarizes the options and recommendations identified in the foregoing sections of this volume to provide a concise set of options and recommendations for consideration by policymakers.

II. Regional Fuels Supply Dependencies

This section describes the crude oil, refined product, and natural gas supply, demand, and movements for each PADD. The products considered in this section are: motor gasoline (including blending components and fuel ethanol), distillates (including ultra-low sulfur diesel (ULSD) and heating oil), and kerosene type jet fuel. Propane is considered separately. The section also describes the major pipeline, rail, and barge movements of crude oil, products, and natural gas in and out of the PADD.

A. Crude Oil

Crude oil is the essential feedstock used to produce refined products such as motor fuels, distillates, propane, and other petroleum products. An analysis of the 2013 crude oil production and consumption was conducted (Table 2) to determine the supply and demand balances for crude oil, refined products, and natural gas at the PADD level.

Table 2: 2013 Crude Oil Supply and Demand (MBbl/d)

	PADD I	PADD II	PADD III	PADD IV	PADD V
Demand	**1,038**	**3,406**	**7,952**	**578**	**2,339**
Local Supply	**38**	**1,394**	**4,382**	**525**	**1,111**
Balance	**(1,000)**	**(2,012)**	**(3,570)**	**(53)**	**(1,228)**
External sources of crude to meet the balance					
Other U.S.	38	1,154	541	70	
Canada	214	1,796	128	247	193
Rest of the World	573	43	3,636		902

Source : EIA Data

This analysis, based on EIA data, revealed several key observations:

- PADD III (Gulf Coast and Southwest) is the largest and most complex refining center in the United States and is home to nearly half of the nation's refining capacity. Less than half of PADD III's crude oil demand is met by local sources. In 2013, approximately 70% of all non-Canadian oil imports into the U.S. were received in PADD III.

- PADD I (East Coast) accounts for 32% of the total U.S. refined product demand but only 6% of the refining. PADD I is highly dependent on PADD III for its refined products. PADD I is highly dependent upon foreign crude oil imports to supply its refineries.
- PADD V (West Coast) produces less than 50% of the crude needed by local west coast refineries. The physical difficulty in sending crude from other parts of the nation leaves PADD V refineries heavily reliant upon imported oil from South America, Africa, and the Middle East.
- PADD II (Midwest) produces only 40% of the crude oil required by its refineries. Nearly half of its demand is met by imports from Canada. The remainder comes from other PADDs. Incoming Canadian heavy oil production is pushing out crude oil imports from other foreign sources.
- PADD IV (Rockies) has the smallest concentration of refining in the U.S. It is dependent upon local sources and Canadian imports to meet demand.

B. Products

Crude oil is refined into fuels products – motor gasoline, jet fuel, distillates, and others – which literally drive the nation and the economy. There is an imbalance in the volume of product demanded and the volume of refined products produced (including motor gasoline, motor gasoline blending components, distillates, jet fuel, and fuel ethanol) among the nation's PADDS. While some regions have product deficits, they are offset by the surpluses in other regions or from imports. Products are also exported from the U.S. Gulf coast and swapped for transportation fuels that are needed in the United States.

Table 3: 2013 Product Supply and Demand (MBbl/d)

	PADD I	PADD II	PADD III	PADD IV	PADD V
Demand	**4,218**	**3,699**	**2,468**	**569**	**2,361**
Local Supply	**976**	**3,881**	**7,321**	**536**	**2,237**
Imports	730	10	44	1	72
Exports	117	47	1,497	0	209
Balance = (Local supply + Imports) – (Demand + Exports)					
Balance	**(2,629)**	**145**	**3,400**	**(31)**	**(260)**

Source: EIA Data

An analysis of the volumes produced and consumed in each PADD in 2013 (Table 3) has led to several key observations:

- PADD III is the largest source of refined products in the United States. It produces 50% of the total supply for the nation. Production in the region far exceeds local demand PADD III demand.

Nearly two-thirds of the refined products produced in PADD III are exported to other PADDs or foreign markets. PADD III is the source of 80% of the products exported from the United States

- The East Coast refineries in PADD I produce less than 25% of the products required in the PADD. PADD I is heavily reliant on the PADD III Gulf Coast refineries to meet the balance of its fuels demand. PADD I is the single greatest destination for foreign refined product imports.
- Local refineries in PADD V provide 95% of the PADD's demand, but 5% must be supplied by other PADDs or imported. The largest markets are in California. Products from Gulf Coast refineries can only be received via seaborne tankers and barges sent through the Panama Canal.
- PADD II refineries produce more products than are demanded within the PADD. It sends products to PADD III and PADD IV.

C. Propane

Propane is used primarily for industrial uses but is also critically important for residential heating and cooking in regions, such as parts of New England, where conventional natural gas is not available. An analysis was conducted of the regional production and consumption of propane in 2013 (Table 4).

Table 4: 2013 Propane Supply and Demand (MBbl/d)

	PADD I	PADD II	PADD III	PADD IV	PADD V
Demand	**165**	**250**	**341**	**30**	**61**
Local Supply	**80**	**282**	**841**	**110**	**59**
Imports	33	55	0	10	5
Exports	4	4	283	0	10
Balance = (Local Supply + Imports) – (Demand + Exports)					
Balance	**(57)**	**83**	**217**	**90**	**(7)**

Source: EIA Data

It has led to the following key observations:

- Propane demand in PADD I is more than twice the local supply. PADD I is dependent upon imports and other regions. This dependence can, as seen in previous winters, result in fuel shortages and price spikes.
- In PADD V, the local supply nearly meets the local demand. Because there are no propane pipeline connections to the major propane hubs outside of PADD V, the balance of the propane demanded must be supplied by rail, truck, or marine vessel.

- PADD III is the largest producer of propane in the United States. The PADD supplies propane to eastern portions of PADD II and to PADD I. PADD III is also the source of 94% of U.S. propane exports.
- PADD II produces more propane than it consumes. The remainder is sent to PADDs III and I.
- Two main propane hubs located in Conway, KS and Mont Belvieu, TX supply propane to most of the Midwest and eastern United States.

D. Natural Gas

Natural gas plays a vital role across the entire economy. It is used to generate electricity and for industrial purposes. It is also used in the commercial and residential sectors for heating and cooking. An analysis of dry gas production and the total consumption of natural gas in 2012 was conducted (Table 5).

Table 5: 2012 Natural Gas Supply and Demand (MMcf/d)

	PADD I	PADD II	PADD III	PADD IV	PADD V
Demand	**19,821**	**17,404**	**19,275**	**2,691**	**10,506**
Local Supply	**8,124**	**7,273**	**33,870**	**11,198**	**1,547**
Imports	1,532	2,333	72	3,803	855
Exports	208	2,423	1,320	12	472
Balance = (Local Supply + Imports) – (Demand + Exports)					
Balance	**(10,373)**	**(10,221)**	**13,347**	**12,298**	**(8,576)**

Source: EIA Data

From this analysis, it can be observed that:

- PADD III produces 55% of the total U.S. natural gas supply, but accounts for just 27% of the nation's demand. Having the largest volume of excess gas production in the country, PADD III is the most important source of gas for PADD II and PADD I.
- PADD V has the greatest imbalance between local supply and demand. It produces only 15% of the gas required. The PADD relies heavily on imports from Canada, PADD IV, and PADD III to meet demand.
- PADD I produces only 40% of the demand locally. It relies on imports, PADD II, and PADD III to meet the rest of demand.
- PADD II is dependent upon non-local supplies for nearly 60% of its natural gas demand. The major sources are Canada, PADD III, and PADD IV.

- PADD IV accounts for just 4% of the nation's demand, but provides 18% of U.S. gas production. It receives the most natural gas imports of any of the PADDs. It supplies gas to PADD II and the southern half of PADD V.

III. Regional Assessment of Fuels TS&D Vulnerabilities and Resiliency

A. Approach

A methodical approach was applied to evaluate the vulnerabilities, dependencies, and resilience of each region of the United States, at the PADD level and, where appropriate, the Sub-PADD level.

Vulnerabilities and Threats

Each discrete PADD and Sub-PADD is vulnerable to a wide variety of potential natural disasters and threats. In most cases, however, only a few of these threats occur with sufficient frequency or intensity as to merit major concern. These major vulnerabilities have been identified and the infrastructure at risk for each hazard or threat has been described.

- Direct vulnerabilities and threats are those that occur in the PADD or Sub-PADD and impact infrastructure within the area.
- Indirect threats may occur outside the geographic perimeter of the PADD or Sub-PADD, but may affect infrastructure or fuel supplies within the area.
- Other conditions or hazards, whether natural or human in origin, may also potentially threaten the supply or market infrastructure for fuels in a given PADD or Sub-PADD.
- Chokepoints -- or areas where either multiple sources of supply or elements of the transportation, supply, and distribution converge -- are also identified and assessed for vulnerability to natural disaster or intentional harm.

Where appropriate, the nature of the market impacts caused by an interruption of infrastructure or supply, within the area of interest, were also characterized.

Infrastructure Dependence

For each PADD or Sub-PADD, the specific infrastructure or conditions outside the area, on which the area is significantly dependent, were identified and described. The dependencies of each area on specific infrastructure were identified, assessed, considered and described for each major fuel supply commodity, including crude oil, refined products, heating oil / distillates, propane, and natural gas.

Resilience of Infrastructure to Supply Interruptions

In light of each of these threats and vulnerabilities, the ability of each PADD or Sub-PADD to meet its crude oil, product, and natural gas needs in the event of a supply disruption, due to natural disasters or intentional human acts, was determined and described, based on EIA data and other sources. In each case, potential sources of and modes for receiving alternative fuel supplies were identified. To do so, the average volumes of stocks in storage relative to the likely volume and duration of a potential supply disruption were determined, and the potential sources and infrastructure to supplement or replace local stocks until infrastructure can be restored were assessed.

The potential roles for government stocks in storage, such as those in the Strategic Petroleum Reserve (SPR), New England Home Heating Oil Reserve (NEHHOR), or the developing Northeast Region Refined Petroleum Products Reserve (NERRPR), to meet industry and consumer needs were considered.

Options for Consideration

Finally, where resiliency was determined to be inadequate to meet local or regional requirements, options were identified for consideration by policymakers that could potentially improve resiliency, either by improving the infrastructure at risk or by assuring the availability of alternative sources of fuels supply until traditional sources and infrastructures are restored. In many cases, identified resiliency improvement options are applicable in multiple regions.

The following pages summarize and highlight our findings regarding threats, vulnerabilities, dependencies, resiliency, and response options for each major PADD. In some instances, the summary is provided at the Sub-PADD level. These textual and tabular summaries are followed by a summary of the options that have been identified for consideration by the DOE, industry, and policy makers.

B. PADD I - East Coast

PADD I has very limited local crude oil production and is dependent upon other sources to meet their demand. The PADD receives crude oil and petroleum products through pipeline, rail, and waterborne routes. Pipelines bring crude oil from Canada to the New York harbor area where it is shipped using other means to refineries along the East Coast.

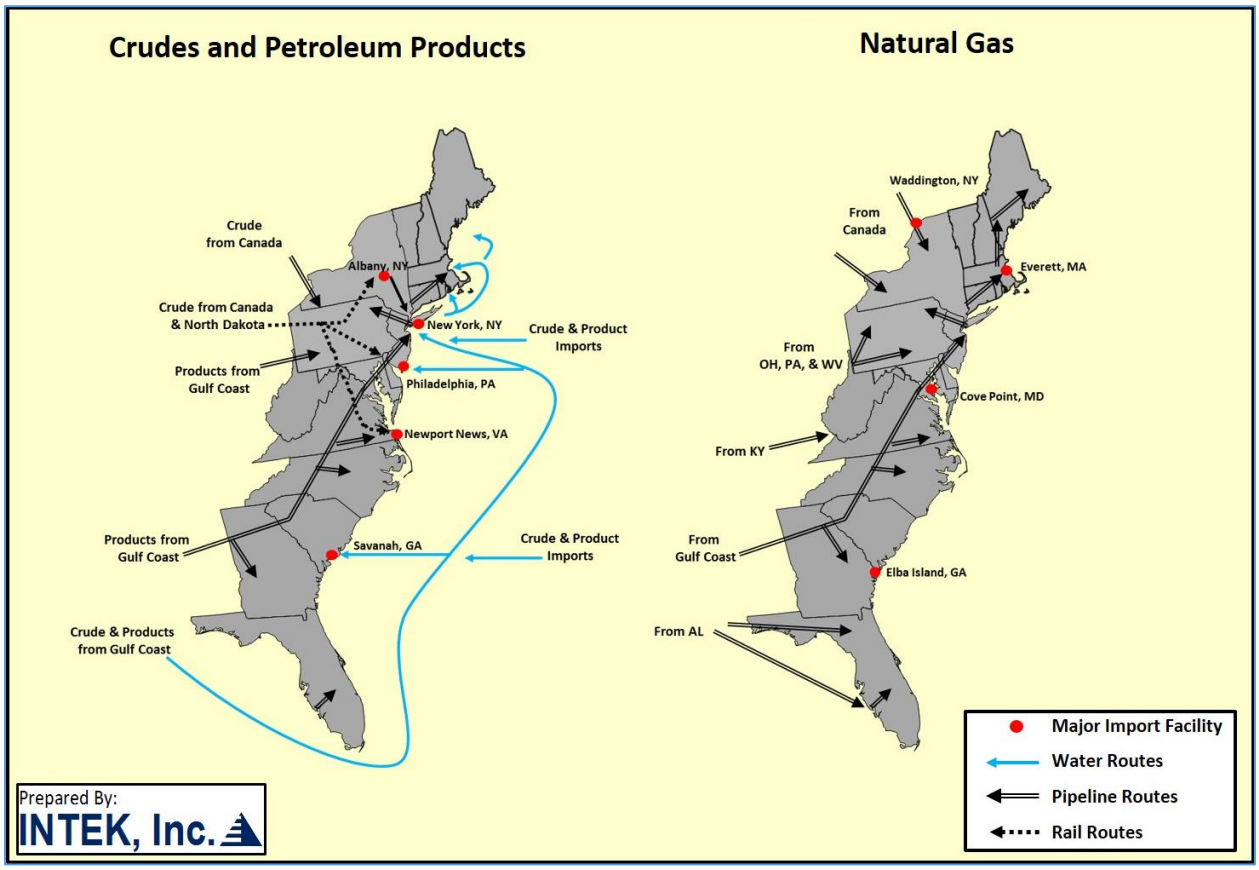
Pipelines from the Gulf Coast bring refined products to the East Coast either directly – through the Colonial and Plantation – or through PADD II. Rail is used to carry crude from the Bakken, in PADD II, to refineries in Delaware, Pennsylvania, and New York. Waterborne routes carry crude and products from the Gulf, from other countries, and from U.S. facility to U.S. facility. Major crude and product facilities can be found at Savanah, GA, Philadelphia, PA, and the New York Harbor in NY.

While PADD I produces natural gas in the states of New York, Pennsylvania and West Virginia, current production is not sufficient to meet the entire demand for the PADD. Much of the new shale gas production from the Marcellus formation in Pennsylvania is constrained by inadequate gathering and transmission infrastructure. The fracturing ban in New York is also preventing production of Marcellus and Utica formation shale gas in New York. The East Coast imports natural gas from Canada along routes into New York. PADD III, the Gulf Coast, provides the other major source of natural gas through pipelines connected to Florida, and pipelines through the Southeast states terminating in the New York area. (Figure 3)

PADD I constitutes the eastern seaboard of the United States and includes the New England States (Sub-PADD IA, the Mid-Atlantic states (Sub-PADD IB), and the Southeastern states (Sub-PADD IC).

The following presents our findings for each of these Sub-PADDs.

Figure 3: PADD I Movements of Liquid Fuels and Natural Gas



Sub-PADD IA (New England)

Sub-PADD IA is comprised of the New England States, including Connecticut, Rhode Island, Massachusetts, New Hampshire, Vermont, and Maine. The inhabitants and the fuels TS&D infrastructure in these states are subject to long, harsh winters, coastal storms and hurricanes, coastal flooding, sudden and intense squalls, and derechos (Table 6).

Because New England has neither oil and gas resources nor refining operations, its fuels are supplied by other U.S. regions and by foreign imports. As such, the region is not only dependent on its own ports, marine terminals, rail, and highway systems to receive and distribute fuels, it is also dependent on the fuel supplies and infrastructure of adjacent regions, particularly Sub-PADD IB, for its gas and liquid fuels supply (Table 7). An interruption of such infrastructure or supply would have to be made up from available stocks in storage or alternative sources or modes of supply, the failure of which can have significant human, market, and economic impacts.

Table 6: Vulnerabilities and Chokepoints in Sub-PADD IA

States:

Connecticut, Rhode Island, Massachusetts, New Hampshire, Vermont, Maine

Vulnerabilities and Threats

Direct:

- **East Coast Hurricane:** A hurricane tracking into New England could result in power loss, terminals flooded, and transportation disruption for refined products and propane.
- **Polar Vortex:** Extreme cold, snow, and ice from a Polar Vortex could cause power loss, instrument malfunctions, and product transportation disruptions.
- **Coastal Flooding:** Sub-PADD IA has no refineries, but marine terminals that receive refined product could be damaged or flooded, and surface rail and roads systems and controls could be damaged or obstructed.
- **Derechos:** Derechos could cause short-term power loss, and wind and lightning damage to marine terminals, bulk storage terminals, loading facilities, and distribution systems.

Indirect:

- **Gulf Coast Hurricanes:** Gulf Coast hurricanes pose no direct threat to the Sub-PADD but could cause product supply shortages from refinery shutdowns or transportation and distribution infrastructure damage for refined products in PADD IB, IC and III, impacting supplies to IA.
- **Market Effects:** Short term product price spikes could result from shortages of refined products or propane gas.

Other Threats/Disruptions

- Any disruption of Linden, NJ or New York Harbor (NYH) infrastructure, system interconnections, or associated power or communication systems could disrupt the receipt of stocks or their distribution, largely by barge and tanker, to terminals in New England.

Chokepoints

- **Products:** Linden, NJ and NYH area in PADD IB, including the Colonial and Buckeye systems, the Arthur Kill and Kill Van Kull waterways, and all of the marine and storage terminals that serve them. The NYH area is highly vulnerable to natural disasters (East Coast hurricanes and nor'easters.)
- **Natural Gas:** Tennessee Gas Pipeline interconnect and extension to CT, RI, and MA; interconnection with Maritimes and Northeast (Canadian) pipeline.

Table 7: Major Infrastructure Dependency and Resilience in Sub-PADD IA

IA	Major Infrastructure Dependence	Fuel Resiliency
Crude Oil	• There are no oil refineries or crude oil infrastructure in PADD IA.	• Not Applicable – there are no crude oil refineries in PADD IA.
Refined Fuels	• New England is highly dependent on critically important refineries and refined product storage and distribution infrastructure in the New York Harbor area (including NY and NJ) in adjacent PADD IB. • PADD IB product pipelines, bulk storage tanks, and ports and marine terminals receive and distribute most of the fuel supply to PADD IA via tanker trucks and seaborne vessels. • Major product infrastructure includes the Colonial and Buckeye pipeline systems. • Most ports in PADD IA can handle only smaller capacity vessels. Ports in IB (NYH) must be used to receive larger vessels.	• Local stocks may be depleted in 3-5 days. Depending on location and infrastructure impacted, some fuels could be supplied from other stocks in PADD I. • Of the stocks in NERRPPR only 300 MBbl of gasoline is available in PADD IA. ULSD is also available in the NEHHOR stocks. • Total industry and government stocks account for 4-7 days of demand. • **East Coast Hurricane:** Shipments could be sent from PADD III by marine vessels, but requires 10-14 days and Jones Act waivers. • **Gulf Coast Hurricane:** Resuming pipeline delivery of fuels to PADD IB via Colonial and Plantation could require up to 2 weeks.
Natural Gas	• Only a few natural gas transmission systems serve PADD IA. Gas is sourced from PADDs I, II, and III and Canada. • The Algonquin system, supplied by Texas Eastern pipelines, serves Connecticut and southern New England. • Portland Natural Gas Transmission System, supplied by RN North-east Pipeline (Canada), serves Maine and Massachusetts. • An LNG import terminal in Everett, MA also serves New England.	• The PADD IA gas transmission system is less resilient than other regions, due to the limited pipelines serving the region. • Pipeline repairs can be completed in a matter of days. • Aging local distribution systems may suffer insignificant damage due to flooding, but supply can usually be restored within a few days. • Transmission and delivery capability may be insufficient to meet future peak load gas demand for power generation.
Propane	• The Enterprise and TEPPCO pipeline systems provide propane to the market hub at Selkirk, NY. • Major storage facilities are located at Providence, RI and Newington, NH, with total propane storage capacity of 1 MMBbl. Propane is sourced from PADD II and PADD III.	• Sufficient storage capacity exists. Historically, about 6-8 days of propane stocks were available prior to peak demand season. • Competing markets resulted in less than 2 days of stocks in 2013. • Minimum stocks of 6-8 days are needed.

	• Other NGL demand is minimal in PADD IA.	• If Jones Act vessels are available, additional stocks can be acquired from PADD IB, IC, or III, but would require days or weeks to reach consumers.
Heating Oil	• The heating oil infrastructure is the same as for products with the same dependencies. Some heating oil is imported from Venezuela by tankers. • Interruption of supply could be offset by pipeline or seaborne shipments from PADD III.	• All of PADD IA is converting to ULSD to replace heating oil by 2016. ULSD and heating oil are supplied by the refined fuel TS&D system. • In the event of disruption, ULSD supply loss may be partially offset by drawdown of the 1 MMBbl Northeast Home Heating Oil Reserve (NEHHOR).
Ethanol	• Ethanol is received by rail or tanker from PADD II via IB.	• Stocks are sufficient to meet PADD IA requirements.

Options for Consideration (Sub-PADD IA)

Products:

- A larger northeast regional refined product reserve could improve resiliency to meet short-term PADD IA and PADD IB demand. This reserve could include all liquid fuels, including motor gasoline, ULSD, and aviation fuels for the major airports. A detailed assessment conducted by the Office of Petroleum Reserves could determine the size, location(s), configuration, and potential costs and benefits of a NE products reserve.

Natural Gas:

- Encourage and incentivize industry to install more natural gas transmission and distribution infrastructure in New England to serve power plant, transportation, commercial, and residential demand.
- Work with industry to enhance the local gas distribution system infrastructure.

Propane:

- Identify, assess, and implement policy options to cause industry to maintain adequate propane stocks in storage and assure sufficient stocks are in place ahead of the winter high-demand season.

Sub-PADD IB (Mid-Atlantic States)

Sub-PADD IB is comprised of the states of Delaware, Maryland, New York, New Jersey, and Pennsylvania. It also includes the nation's capital, Washington, D.C., as well as other major economic and population centers, including Baltimore, Philadelphia, Pittsburgh, New York, and Wilmington.

The Mid-Atlantic region and its fuels infrastructure is subject to cold harsh winters, East Coast storms and hurricanes, coastal flooding, and intense squalls and derechos. Its critical role in the nation's economy and leadership also makes this region's energy infrastructure an attractive potential target for intentional damage (Table 8).

Sub-PADD IB receives and refines both domestic and imported crude oil through its marine ports and terminal systems. It also receives, stores, and distributes large quantities of refined products by pipeline and marine terminals from PADD III that are consumed in the region and in New England.

This region is also dependent on the fuel supplies and infrastructure of adjacent regions, Sub-PADD IC and PADD III, and on seaborne imports (Table 9). An interruption of infrastructure, crude oil, or products supply would have to be offset by stocks in storage or alternative sources or modes of supply, the failure of which could have significant human, market, and economic impacts.

Sub-PADD IB is now a large producer of natural gas, but it also receives and distributes gas from PADDs II and III. Approximately 90% of NGL's are supplied to New York, Delaware and Pennsylvania refiners and distributors from PADDs II and III or imports from Canada, via pipeline, rail, and barge.

Table 8: Vulnerabilities and Chokepoints in Sub-PADD IB

States:

Delaware, Maryland, New York, New Jersey, Pennsylvania (and Washington, D.C.)

Vulnerabilities and Threats

Direct:

- **East Coast Hurricane:** A hurricane could cause power loss at refineries, terminals, pipelines, and storage facilities (northern New Jersey, the New York Harbor area, the Philadelphia and Wilmington areas, and Baltimore Harbor); cause refinery shutdowns; interrupt crude supply to refineries; flood terminals; and disrupt the receipt, transport, and distribution of refined products.
- **Polar Vortex:** Excessive cold, heavy snows, and ice associated with Polar Vortex conditions can result in power loss to refineries, pipelines and terminals; malfunctions of instrumentation, controls, and communications; and disruption of road, rail, and other transportation infrastructure. Freeze-offs of natural gas wellheads can interrupt gas production and supply.
- **Coastal Flooding:** Coastal flooding from hurricanes or major storms can flood coastal refineries, marine terminals, and storage facilities and damage and obstruct surface transportation routes and infrastructure, including roads and rail. Bridges and pipeline river crossings may also be impacted.
- **Derechos:** These intense, localized, and short duration storms can cause short-term power loss to TS&D infrastructure, as well as wind and lightning damage. Most damage can be repaired quickly.
- **Intentional Damage:** Much of the critical TS&D infrastructure in PADD IB is geographically concentrated, visible, and potentially accessible from major and ancillary transportation routes, making it vulnerable to intentional damage. Damage from an isolated small scale event could be quickly repaired with minimal impact on stocks and supplies.

Indirect:

- **Gulf Coast Hurricane:** A Gulf Coast hurricane in PADD III would cause no direct danger to PADD IB infrastructure, but refinery shutdowns or infrastructure damage in PADD III could interrupt or reduce the flow of products from PADD III to PADD I markets.

Market Effects: Short term product price spikes could result from refined product shortages.

Other Threats/Disruptions

- Any disruption of NYH infrastructure, system interconnections, associated power or communication systems, or crude or product deliveries could impact Sub-PADD IB supplies, markets, and deliveries to Sub-PADD IA.

Chokepoints

- Crude and Products: Linden, NJ marine terminals, pipeline interconnects (Buckeye & Colonial product pipelines), and waterways serving regional refineries are major chokepoints.
- Natural Gas: The Columbia Gas Transmission System's market hub is a gas system chokepoint.

Table 9: Major Infrastructure Dependence and Resiliency in Sub-PADD IB

IB	Major Infrastructure Dependence	Fuel Resiliency
Crude Oil	• The Philadelphia and New York Harbor areas contain critically important crude oil terminals and refineries. • Crude oil is sourced from PADD II, Canada, and other countries. • Most crude oil is received by waterborne transport (tankers and barges) at marine terminals associated with the major refineries. • The Buckeye Global terminal in Albany, NY receives Bakken crude oil by rail from PADD II West and ships it by barge to New York Harbor area refineries. • Philadelphia refineries receive Bakken crude by rail.	• To date, PADD IB East Coast refineries have never suffered a shortage of crude oil supply sufficient to curtail operations. Stocks in storage have always been sufficient to meet requirements, even during major hurricanes Irene and Sandy. • In the event of an import disruption, the SPR can supply crude from PADD III. However, the lead time for marine transport is approximately 2-3 weeks and requires U.S. flag tankers. • There is a current shortage of such Jones Act vessels, so Jones Act waivers could be required.
Refined Fuels	• The New York Harbor area contains critically important refined product storage and distribution infrastructure for both PADDS IA and IB. It receives products from other PADDs via the Colonial and Sun pipelines. Major ports receive imports and distribute products to PADDs IA and IB, using a complex infrastructure of pipelines, storage tanks,	• **East Coast Hurricane:** Refined products could be shipped from PADD III by marine vessels, but would require 10-14 days and Jones Act waivers. • **Gulf Coast Hurricane:** Local stocks may be depleted in 3-5 days. Refinery or pipeline recovery to provide products to PADD IB via Colonial and Plantation pipelines could require up to 2 weeks.

	and marine terminals. • Major product infrastructure includes the Colonial, Harbor, and Buckeye pipeline systems, interconnections, bulk storage, and terminals at Linden, NJ. • Major interconnect points and manifolds are particularly vulnerable. • Products received and stored in the New York Harbor area serve a densely populated region as well as several international airports. The area provides products to western Pennsylvania and upstate New York via the Buckeye system and to New England via barges.	• Current stocks in NERRPPR (1 MMBbl total) can meet less than 1 day of combined PADD IA and IB (Northeast) consumption. • New York State Strategic Fuel Reserve (SFR) includes: a 3 million gallon reserve on Long Island to supply the NYC area and a proposed 1 million gallon gasoline and 1 million gallon ULSD reserve distributed over 8 locations across the state.
Natural Gas	• Several major natural gas transmission systems traverse PADD IB with interconnections and market hubs around major metropolitan areas including Washington, Baltimore, Philadelphia, New York, and Pittsburgh. Systems include Columbia Gas Transmission, Old Dominion, Tennessee, and Texas Eastern. • Gas is supplied by local Marcellus producers, PADDs II and III. Local Marcellus wells are subject to freezing in severe winter weather conditions. • Gas processing plants, compression stations and custody transfer points (interconnects and market hubs) are vulnerable to damage by hurricanes, flooding, and intentional acts. • NYC receives all of its gas through two city gates, one from Transco serves lower Manhattan and the other from Iroquois which serves uptown.	• The natural gas transmission system is highly resilient. Multiple trunk lines within systems, interconnections between the lines, and interconnections between systems at numerous market hubs provide important redundancy. In the event of damage to a trunkline or transfer point, gas can be rerouted through the system to assure supply to city gates and local distribution systems. • In the event of a gas supply interruption due to a hurricane, gas can be sourced from other systems or withdrawn from underground storage to meet demand until production is restored. • Aging infrastructure within local distribution systems can cause gas supply loss and safety and reliability issues. • Local distribution systems may suffer damage due to flooding, but supply can usually be restored within a few days.
Propane	• The Enterprise and TEPPCO pipeline systems provide propane to the market hub at Selkirk, NY from PADDs II and III.	• Sufficient storage capacity and stocks provide adequate supply to allow repairs to any infrastructure damage that may occur from natural events or intentional acts.
Heating Oil	• The infrastructure for heating oil and ULSD used for heating is the same as for refined fuels and shares the same dependencies.	• By 2017 NY and NJ will convert to ULSD for heating oil. • In the event of disruption, some ULSD supply loss can be offset by drawdown

		of the 1 MMBbl Northeast Home Heating Oil Reserve (NEHHOR) located in Revere, MA and Groton, CT or USLD transportation fuel stocks. • Supply interruption could be offset by pipeline or marine shipment from PADD III, but requires 1 - 2 weeks to reach PADD IB.
Ethanol	• Ethanol is received by rail or tanker from PADD II.	• Stocks are sufficient to meet PADD IB requirements and supply PADD IA.

Options for Consideration (Sub-PADD IB)

Crude:

- The most likely approach to offsetting crude oil supply loss to Sub-PADD IB would be seaborne shipments from PADD III. Streamlined Jones Act waivers could expedite these shipments.

Products:

- A larger northeast regional refined product reserve could improve resiliency to meet short-term PADD IA and PADD IB demand. This reserve could include all liquid fuels, including motor gasoline, ULSD, and aviation fuels for the major airports. A detailed assessment conducted by the Office of Petroleum Reserves could determine the size, location(s), configuration, and potential costs and benefits of a NE products reserve.

Natural Gas:

- Work with industry to encourage modernization of the aging local natural gas distribution system infrastructure.
- Identify new approaches to detect and reduce methane leaks and emissions, and to improve transmission and distribution system efficiency. These approaches can include R&D, economic incentives, estimation of costs and benefits, and other recommendations.
- Encourage industry to apply best practices to prevent wellhead freezing in wet gas producing areas such as the Marcellus.
- Assess requirements for increased high deliverability gas storage to meet increasing gas fired power generation requirements in PADD IB and IA.

Sub-PADD IC (Southeast)

Extending from Virginia to Florida along the eastern seaboard, Sub-PADD IC enjoys more moderate climate that the northeastern states. Nonetheless, the region is vulnerable to East Coast storms and hurricanes, many of which make landfall between Florida and Virginia. Less common, but also potentially damaging to infrastructure are harsh winter storms resulting from distortions in the polar vortex, coastal flooding associated with tropical storms and hurricanes, intense isolated storms and

derechos, and mild earthquake activity. It is also heavily, though indirectly, impacted by Gulf Coast hurricanes and other events that could interrupt oil and gas production and refining in PADD III (Table 10).

With no indigenous crude oil or natural gas production (except for small quantities of gas produced in West Virginia) and no refineries, Sub-PADD IC is almost entirely dependent on refined products from PADD III and natural gas from PADD II and III to meet the needs of this very populous region (Table 11).

Natural gas and refined products are both received by major pipelines. Some refined products are also received by seaborne vessels at the ports of Savannah, GA, and Newport News, VA. The Colonial and Plantation product pipeline systems that originate in PADD III serve the majority of Sub-PADD IC, supplying local markets, terminals, and distribution systems and continuing through Sub-PADD IB to supply the New York Harbor area distribution system that serves much of the Northeast.

Table 10: Vulnerabilities and Chokepoints in Sub-PADD IC

States:

West Virginia, Virginia, North Carolina, South Carolina, Georgia, and Florida.

Vulnerabilities and Threats

Direct:

- **East Coast Hurricane:** A hurricane making landfall south of Maryland could result in massive power loss, marine and bulk terminals flooding, and surface rail and road transportation and distribution systems disruptions.
- **Polar Vortex:** Deep freeze, ice, and snow from a Polar Vortex disruption could cause power loss to marine ports, terminals, and product storage and distribution infrastructure as well as instrument malfunctions and disruption of surface transportation and distribution systems.
- **Coastal Flooding:** Marine terminals, pump stations, and bulk terminals could be flooded, and rail and surface roads could be obstructed.
- **Derechos:** These storms can cause short-term power loss to TS&D infrastructure as well as wind and lightning damage. Most damage can be repaired quickly.
- **Earthquake (insignificant):** Possible natural gas and refined product pipeline damages could occur. Most can be repaired quickly.

Indirect:

- **Gulf Coast Hurricane**: A Gulf Coast hurricane would pose no direct danger to Sub-PADD IC, but could result in refined product and or natural gas supply shortages or interruptions.
- **Market Effects:** Short term product price spikes could result from shortages.

Other Threats/Disruptions

- Any disruption of PADD III oil and/or gas infrastructure, system interconnections, or associated power or communication systems.
- Aging natural gas infrastructure.
- Visibility of and physical accessibility to some major infrastructure may invite or facilitate intentional damage.

Chokepoints:

- Major chokepoints in Sub-PADD IC include the Colonial and Plantation product pipelines and refined product and natural gas supplies from PADD III.

Table 11: Major Infrastructure Dependency and Resilience in Sub-PADD IC

IC	Major Infrastructure Dependence	Fuel Resiliency
Crude Oil	• There are no refineries in Sub-PADD IC and only two asphalt processing plants.	• Not applicable - there are no refineries in Sub-PADD IC and only two asphalt processing plants.
Refined Fuels	• PADD IC relies on the Colonial and Plantation pipelines to provide products from PADD III, as well as imports. • Products are also received by waterborne transport (barge and tanker) at the Port of Savannah (GA) and at the Port of Tampa (FL), as well as other coastal ports in the Florida panhandle.	• With no refineries, Sub-PADD IC has no inherent products supply resiliency. • Stocks in storage at bulk terminals and distribution centers can provide less than 3-5 days of supply. • A supply disruption from PADD III could have significant supply and market impacts. • Refinery or pipeline recovery from a major hurricane in PADD III could require up to 2 weeks.
Natural Gas	• Several major natural gas transmission systems traverse Sub-PADD IC with interconnections and market hubs around major metropolitan areas. • Gas is sourced primarily from PADD II and PADD III, as well as from some local (WV) production. The 3 main systems supplying the region are Columbia Natural Gas (WV and VA), Southern Natural Gas (GA and SC), and Transco (GA, SC, NC, VA). • Florida additionally is supported by only 2 systems: Gulfstream Natural Gas and Florida Gas Transmission.	• The natural gas transmission system is resilient due to multiple trunk lines and numerous interconnects. Most of the region relies primarily on 2 systems for most of its supply: Southern and Transco. • In the event of a gas supply interruption due to a Gulf Coast hurricane, gas can be sourced from other systems or withdrawn from underground storage to meet demand until production is restored. • Gas processing plants, compression stations and custody transfer points

		(interconnects and market hubs) are vulnerable to damage by hurricanes, flooding, and intentional acts. • Local distribution systems may experience temporary service loss due to flooding or as a result of aging infrastructure.
Propane	• The Enterprise Dixie Propane Pipeline provides propane to the region from PADD III.	• Sufficient storage capacity and stocks (approximately 15 days) provide adequate supply to allow repairs to any infrastructure damage that may occur to natural events or intentional acts.
Heating Oil	• The infrastructure for heating oil is the same as that for refined fuels and shares the same dependencies. • Heating oil is sourced from PADD III.	• The region is highly dependent on the Colonial and Plantation pipelines and waterborne transport from PADD III or imports.
Ethanol	• Ethanol is received by rail or tanker from other PADDs	• Stocks are sufficient to meet PADD IC requirements.

Options for Consideration (Sub-PADD 1C)

Products:

- Update and implement a plan for storage and distribution of refined products sufficient to meet needs of PADD IC and other PADD I markets in event of supply interruptions from PADD III to improve resiliency to 5 to 10 days of product demand. This reserve could help meet the needs of this critical market that is frequently impacted by the effects of Gulf Coast hurricanes in PADD III and other natural and human vulnerabilities.
- DOE EPSA and OPR should update their assessment of costs and benefits to reflect current supply, demand, infrastructure, and market conditions, based on the 2011 Refined Petroleum Product Reserve for the Southeast.

Natural Gas:

- Evaluate new transmission needs to support expanding gas fired power generation.
- Evaluate costs and benefits of proposals to convert compressor station to electric power, including effects on methane and carbon emissions as well as on TS&D system resiliency.

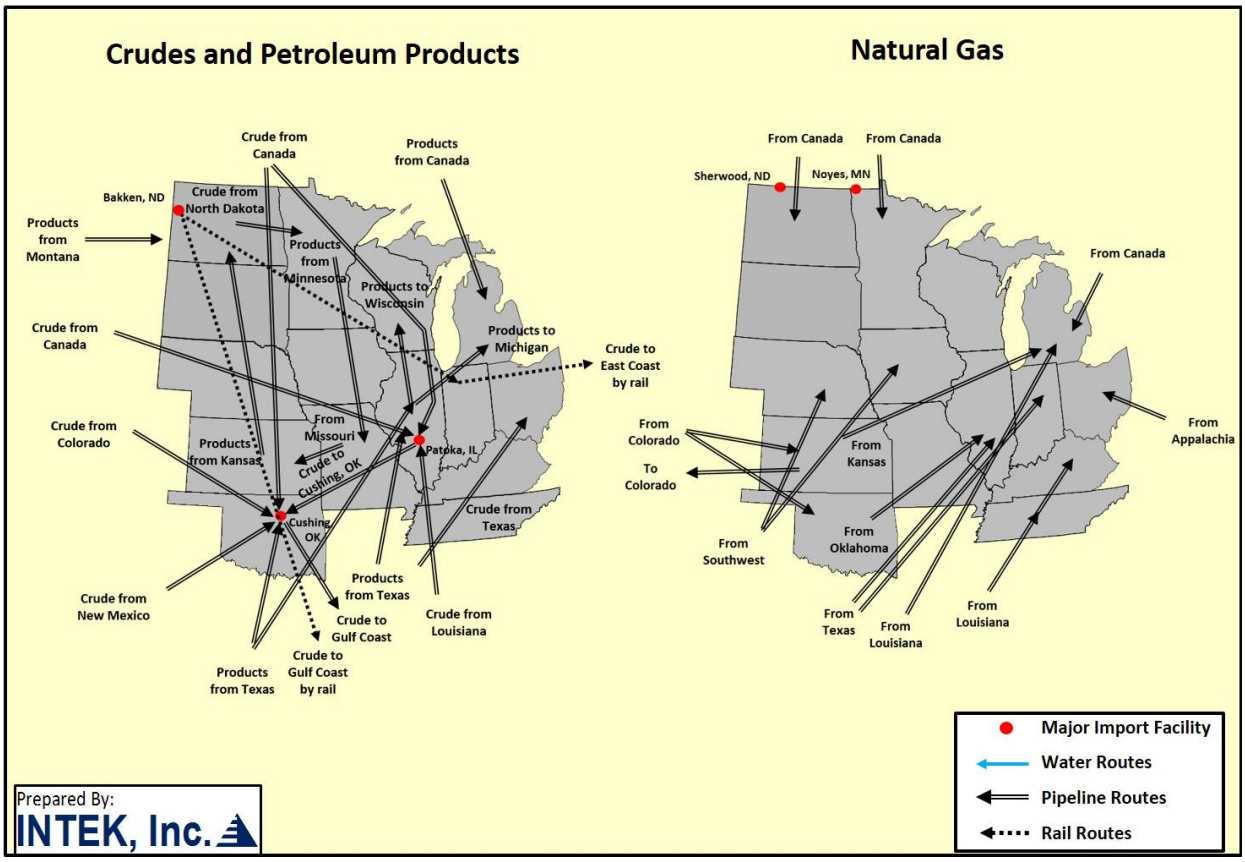
C. PADD II (Midwest States)

PADD II comprises the majority of the central portion of the United States, extending west from PADD I to Nebraska and from the southern border of Tennessee all the way to the Canadian border. It includes 15 of the lower-48 states. For the purposes of this analysis, it is divided into four Sub-PADDs.

- Sub-PADDs II East and North, including most of the Midwest states are addressed together.
- Sub-PADD II KS/OK describes the unique conditions and infrastructure in Kansas and Oklahoma.
- Sub-PADD II West describes the unique conditions in North and South Dakota.

Overall PADD II is reliant on external sources for about two-thirds of its crude oil and natural gas demand, but is a net producer and exporter of refined products to other PADDs and markets. PADD II produces crude oil in the Bakken and several other formations. It receives crude, via pipeline, from Canada, Colorado (PADD IV), New Mexico, and Louisiana (PADD III) (Figure 4). There are two major pipeline junctions at Patoka, IL, and Cushing, OK. Cushing has several major pipelines, including Seaway, which send crude to the Gulf Coast refineries. PADD II also receives products. The Explorer and TEPPCO pipelines bring products north from the Gulf and distribute them throughout the central and eastern portions of the PADD. Products are also received along Canadian pipelines into Michigan.

Figure 4: PADD II Movements of Liquid Fuels and Natural Gas



Conway, KS contains the largest propane storage facility and the origin for pipelines which transport propane throughout central portion of PADD II.

A large portion of the crude produced in the Bakken area of North Dakota is shipped via rail to refineries outside of the PADD. Major destinations include the East Coast, West Coast, and Gulf Coast.

PADD II receives natural gas from Canada, Colorado (PADD IV), New Mexico, Texas, Louisiana (PADD III), and the Appalachia (PADD I). Several pipelines run through eastern PADD II and supply gas to PADD I.

Sub-PADD II East and North

Sub-PADD II East includes the eastern oil and gas producing states of Michigan, Ohio, and Kentucky. Sub-PADD II North includes the central Midwest states of Illinois, Indiana, Iowa, Minnesota, Missouri, Nebraska, Tennessee, and Wisconsin, among which Illinois and Indiana are oil and gas producers. While generally immune to coastal threats such as hurricanes and tsunamis, these areas are susceptible to a broad range of other natural disasters, including tornadoes, derechos, flooding, and polar vortex distortions that can affect TS&D infrastructure. As part of the New Madrid Seismic Zone, earthquake risk extends from western Tennessee northwards into southern Illinois (Table 12).

This region includes several major population centers and markets for natural gas and refined products, the largest of which is the Chicago area. The Patoka area in southern Illinois is a major market hub and interconnect point for crude oil pipelines originating in Canada, from the Cushing, OK oil market hub, Sub-PADD II KS/OK, and from the PADD III Gulf Coast area. The Mississippi River flows through the Sub-PADD and serves as a major route for waterborne transit of oil and refined products to Midwest refiners, storage terminals, and end-use markets. As such, this area is indirectly vulnerable to Gulf Coast hurricanes and other natural disasters and threats in those areas.

This region also relies on natural gas from Canada, the Rockies, Sub-PADD II KS/OK, and PADD III. Several natural gas pipelines interconnect at a major market hub in central Illinois (Table 13).

Table 12: Vulnerabilities and Chokepoints in Sub-PADDs II East and II North

States:

II East: Michigan, Ohio, and Kentucky; **II North**: Illinois, Indiana, Iowa, Minnesota, Missouri, Nebraska, Tennessee, and Wisconsin;

Vulnerabilities and Threats

Direct:

- **Tornadoes:** The cyclonic winds and pressure of tornados can uproot or cause other major damage to structures, equipment and other infrastructure in the tornado's path. Tornados can cause loss of power to TS&D systems and facilities, wind damage to towers and power lines, and other structural damage caused by flying debris.
- **Derechos**: Derechos can cause short-term power loss to refineries, gas processing plants, and other TS&D infrastructure, as well as wind and lightning damage. Most damage can be repaired quickly.

- **Flooding:** Flooding due to heavy rains or spring thaw can cause damage to inland ports, terminals, locks, and low-lying facilities.
- **Polar Vortex:** Deep freeze, ice, and snow from a polar vortex disruption can cause power loss to marine ports and terminals, and product storage and distribution infrastructure as well as instrument malfunctions, and disruption of surface transport and distribution systems. Pipes and wellheads may be damaged. Prolonged cold temperatures may cause spikes in fuel oil or propane demand, testing the infrastructure.
- **Earthquakes:** Earthquakes are possible in this region, but quakes of sufficient magnitude to cause major damage are uncommon. Insignificant damage to oil and gas TS&D infrastructure could occur.

Indirect:

- **Gulf Coast Hurricane**: Hurricanes could disrupt traffic along the Mississippi River, GOM oil and gas production, and pipeline and port and river operations that supply crude oil and refined products.
- **Market Effects:** Supply loss to gas processing plants and refineries. Crude oil and gas and product price spikes due to shortage.

Chokepoints

- The Mississippi River and other high traffic waterways provide access between inland ports and terminals.
- Crude oil market hubs and storage at Cushing, OK (Sub-PADD II KS/OK) and Patoka, IL are major national and regional crude oil system interconnect locations.
- The Conway, KS propane storage facility (Sub-PADD II KS/OK) is a major regional hub for receipt, storage and distribution of propane.

Table 13: Major Infrastructure Dependence and Resiliency in Sub-PADDs II East and North

II E&N	Major Infrastructure Dependence	Fuel Resiliency
Crude	• Crude oil pipelines ship synthetic crude from Canada to PADD II refineries. • Rail infrastructure moves crude from Bakken (PADD II W) and other domestic producers to PADD II refineries. • Critical pipelines include Mid-Valley and Keystone pipelines, the Capline system, and pipelines from West Texas. • Mississippi River ports and marine terminals also supply oil to refineries.	• Pipeline reversals are limiting flows of crude oil from the Gulf of Mexico region to PADD II refiners, reducing supply resiliency. • Capline can only provide ~500 MBbl/d from SPR or Gulf of Mexico producers in the event of a disruption of crude supply from other sources.

Products	• PADD III refineries and terminals supply some refined products. (This is a minor dependence; most refined products are supplied from within PADD II.) • Magellan, Centennial, and Explorer pipelines provide products from PADD III.	• Local refineries with excess capacity could increase utilization to offset loss of products, but would need sufficient crude stocks. • Tennessee and Kentucky markets could be impacted by shutdowns of Colonial or Plantation pipelines if local demand exceeds stocks in storage and the production capacity of the refinery in Memphis, TN. • Stocks in storage average 5 to 7 days of demand, depending on the fuel.
Natural Gas	• Gas transmission lines from Sub-PADD II KS/OK, PADD III, and PADD IV and Canada provide two thirds of the required gas supply. • Canadian pipelines provide gas via Minnesota and Michigan.	• PADD II is a producer and net exporter of natural gas. • Gas supply loss due to interruption of production or processing plants can be offset from storage, imports or PADDS II West and KS/OK, other PADDs, or Canada.
Propane	• The Conway, KS propane hub stores and supplies propane received from Sub-PADD II KS/OK , PADD III and PADD IV. • Enterprise Mid-America, OneOK, Enterprise TEPPCO, and Enbridge pipelines provide propane within the region. • The Kinder Morgan Cochin propane pipeline is being reversed and will carry light condensate to Alberta, Canada.	• Multiple propane pipelines and storage facilities offer redundancy and resiliency to offset supply losses. • Conway has multiple supply sources and can re-route as necessary. • Propane stocks in storage average more than two weeks of demand. • The Cochin reversal could limit resiliency in the Great Lakes states.
Heating Oil	• TEPPCO, Explorer, and Centennial product pipelines supply heating oil and distillates from PADDs III, IV, I, and Canada. • Marine terminals and ports for imported volumes.	• Distillate fuels, including ultra-low sulfur diesel for heating, are supplied by the refined products transportation and distribution system.
Ethanol	• Sub-PADDs II North and East are large producers of ethanol. • Ethanol is supplied to blenders and	• Multiple sources and excess supply within the PADD provide resilience in the ethanol supply to fuel blenders and distributors.

	distributors by truck and rail.	• Stocks in storage average 5 to 15 days of demand. • Additional ethanol can be obtained by rail and truck from Sub-PADD II KS/OK. • Heatwaves, droughts, and flooding could result in shortage of corn/crop supplies for ethanol production.

Options for Consideration (Sub-PADD II East and North)

Crude:

- Accelerate maintenance for aging port and locks infrastructure on Mississippi River.
- Address issue of congestion due to increased barge traffic.
- Increase hardening and flood walls for refineries, terminals, and ports along the Mississippi River.

Products:

- The RPPR that has been recommended for the Southeast (PADD IC) could provide resiliency for product supply losses in Tennessee and Kentucky in PADD II East.

Natural Gas:

- Encourage or incentivize industry to apply technologies to prevent gas wellhead freeze-offs and associated gas supply interruptions.

Sub-PADD II KS/OK

Sub-PADD II KS/OK is evaluated separately from other parts of PADD II because of its role as a major crude oil and natural gas producing region, the central role played by Cushing, OK as a crude oil market and pipeline hub, and its pivotal role in transporting natural gas, crude oil, refined products, and ethanol to central and western portions of the nation.

While susceptible to winter weather and distortions of the polar vortex, the major threat to TS&D infrastructure in this oil and gas region is the number, frequency, and intensity of tornadoes. With over 80 million barrels of crude oil storage capacity and numerous pipeline interconnections, a direct hit from a major tornado in the Cushing area could cause extensive infrastructure damage with potentially significant crude oil loss leading to market impacts (Tables 14 and 15).

While new crude oil pipelines, crude by rail, lower volumes stored, and changing flow patterns may dampen these impacts, the Cushing area has critical oil TS&D infrastructure.

As major natural gas producers, Kansas and Oklahoma also contain critical gas infrastructure for gas processing, underground gas storage, and gas transmission to major demand markets in other PADDs.

Table 14: Vulnerabilities and Chokepoints in Sub-PADD II KS/OK

States:

Kansas and Oklahoma

Vulnerabilities and Threats

Direct:

- **Tornadoes:** The major natural threat to TS&D infrastructure in Kansas and Oklahoma come from tornadoes. The sudden and fast moving events with high circulating winds can cause loss of power wind damage, and structural damage (due to flying debris) to refineries, crude oil storage facilities (such as Cushing, OK), refined product storage and distribution terminals, gas processing plants, compression stations, interconnects, and surface transportation infrastructure including roads, bridges, rail lines, and river crossings. Environmental harm may also result from released and dispersed crude oil or refined petroleum products.
- **Derechos:** These storms can cause short-term power loss to TS&D infrastructure, as well as wind and lightning damage. Most damage can be repaired quickly.
- **Polar Vortex**: Excessive cold, heavy snows, and ice associated with polar vortex conditions can result in power loss to refineries, pipelines and terminals; malfunctions of instrumentation, controls, and communications; and disruption of road, rail, and other transportation infrastructure. They can also cause spikes in natural gas and heating oil demand and prices.
- **Flooding:** Some parts of eastern Kansas and Oklahoma are susceptible to flooding, generally during the spring. Only two small refining areas are located in these flood-prone areas. Flooding can cause damage and temporary interruptions to loading terminals along the Arkansas River.
- **Wildfires:** Wildfires are not uncommon in these areas but pose low threat to TS&D infrastructure.

Indirect:

Crude:

- Changes in pipeline infrastructure and flow patterns outside the Sub-PADD affect the composition of blending crudes available to PADD II KS/OK local refiners, directly or via Cushing.
- Gulf of Mexico hurricanes could disrupt traffic, offshore and onshore oil and gas production in PADD III, and pipeline operations supplying crude and products, with marginal impact to some refiners.

Other Threats/Disruptions

Chokepoints

- The crude oil market hub and storage facilities at Cushing, OK are major national and regional crude oil system interconnect points, receiving and distributing crude oil produced in other PADDs and in Canada to inland and coastal refineries.
- The Conway, KS propane storage facility (Sub-PADD II KS/OK) is a major regional hub for receipt, storage, and distribution of propane.

Table 15: Major Infrastructure Dependence and Resiliency in Sub-PADD II KS/OK

II KS/OK	Major Infrastructure Dependence	Fuel Resiliency
Crude	• Local producers supply much of the oil for KS/OK refineries. • Additional crude is supplied by pipelines from Canada (Keystone and Express), PADD II North (Spearhead South, and Coffeyville-Cherokee), PADD III West (Basin, Plains, and Centurion), and PADD IV (White Cliff). • The Keystone pipeline provides heavy Canadian synthetic crude oil to the major crude oil hub at Cushing, OK and to some Oklahoma refineries. • PADD II KS/OK is also served by rail lines that carry Bakken oil produced in PADD II West to Gulf Coast refineries.	• Multiple domestic and Canadian crude oil pipelines serve the Cushing market hub and PADD II KS/OK refineries. • A major tornado strike and damage or fire at Cushing could cause loss of stocks, infrastructure, and connectivity. • The Seaway pipeline reversal now limits the options for SPR deliverability to PADD II KS/OK refineries. • Decreasing stocks in storage at Cushing reduce Sub-PADD II KS/OK resiliency.
Refined Fuels	• PADD II overall is largely self-sufficient for products. • PADD II KS/OK receives refined products from Midland, TX (PADD III West) via the Magellan pipeline.	• Eight small refineries (each <200 MBbl/d) provide geographic distribution and some resilience. • Total refinery output in the Sub-PADD is ~600 MBbl/d. • Local stocks in storage total 5 to 7 days, likely sufficient to meet demand until repairs can be made in the event of a disruption.
Natural Gas	• Oklahoma and southern Kansas are major gas producers. • The PADD is minimally dependent on external infrastructure to receive gas. • Gas plants process gas produced within the Sub-PADD. • More than 20 gas storage reservoirs serve PADD II and other PADDs.	• PADD II is a major net exporter of gas. • Gas supply loss due to interruption can be offset from withdrawals from storage.
Propane	• The Conway, KS propane hub receives propane from PADD IV, PADD III, and local refiners and gas processors and distributes it locally and regionally. • Medford, OK provides a secondary propane hub.	• Multiple propane pipelines and storage facilities offer redundancy and resiliency to offset supply losses. • Conway, KS has multiple sources and can re-route as necessary. • Propane stocks in storage average over 120 days of supply.

Heating Oil	• Local refiners provide distillates to meet Sub-PADD needs.	• Heating oil and ULSD are supplied by the refined products transportation and distribution system. • Stocks in storage average more than five days of demand.
Ethanol	• PADD II KS/OK is a major ethanol producer. • It depends on rail and barge infrastructure to export ethanol to other PADDs and Sub-PADDs.	• Multiple sources and excess supply within PADD II provide resilience in the ethanol supply to fuel blenders and distributors. • Stocks in storage average about 4 days of demand.

Options for Consideration (Sub-PADD II KS/OK)

Crude:

- Identify options for sustaining Cushing, OK as a major oil market hub.
- Work with industry to develop strategies to improve tornado resistance, response, and oil supply resilience in the event of a major tornado, fire, or other disruptive event at the Cushing hub.
- Develop strategies to improve resilience and SPR connectivity due to the reversal of Seaway.

Natural Gas:

- Encourage and incentivize industry to develop and implement approaches to increase gas extraction rates from storage fields and sustain them for longer periods to respond to prolonged gas supply disruption.
- High deliverability gas storage may be needed in the future.

Sub-PADD II West

Sub-PADD II West, comprised of North Dakota and South Dakota, is notable because of its emerging role as a major producer of light sweet oil from the Bakken and Three Forks shale oil plays. North Dakota now produces over 1 MMBbl/d of oil, or more than 12 percent of U.S. daily production.

This new production, along with new production in other regions, is not only reducing the nation's reliance on crude oil imports, but rapidly changing the patterns of crude oil flow to the nations refining centers and the transportation, storage and distribution infrastructure that serves refiners and markets.

At the same time, increased exploration and production activity in this Sub-PADD is increasing its own demand for refined products, requiring infrastructure changes to meet the rising demand Tables 16 and 17).

Table 16: Vulnerabilities and Chokepoints in Sub-PADD II West

States:

North Dakota and South Dakota

Vulnerabilities and Threats

Direct:

- **Polar Vortex**: The major natural threat to TS&D infrastructure in North and South Dakota is severe winter weather, potentially exacerbated by the polar vortex phenomenon. Excessive cold, heavy snows, and ice associated with polar vortex conditions can result in power loss to crude oil terminals, pipelines, and refineries; malfunctions of instrumentation, controls, and communications; and disruption of road, rail, and other transportation infrastructure.

  (Freeze-offs of gas wellheads is less problematic in this region due to industry operating experience and best practices and technologies for operations in frigid climates. Wellheads may be enclosed or protected with anti-freeze solutions).

- **Tornadoes:** There is only a moderate risk of tornadoes in PADD II West. However, the sudden and fast moving events with high circulating winds can cause loss of power, wind damage, and structural damage (due to flying debris) to refineries, crude oil storage terminals, refined product storage and distribution terminals, gas processing plants, compression stations, interconnects, and surface transportation infrastructure including roads, bridges, rail lines, and river crossings.

- **Derechos:** Derechos in Sub-PADD II West are possible but uncommon. These intense, localized, and short duration storms can cause short-term power loss to TS&D infrastructure, as well as wind and lightning damage. Most damage can be repaired quickly.

- **Flooding:** Some eastern parts of the Dakotas are susceptible to flooding, generally during the spring thaw. Flooding can damage or obstruct rail lines and interrupt rail service.

Indirect:

- Interruption of rail service in PADD II, III, or V that facilitates crude oil shipments from N. Dakota.
- Disruption of refined product pipelines from Kansas could impact fuels supply and have a secondary effect on oil production, which could impact crude supply in other regions.
- Disruption of natural gas pipelines from Canada would impact gas supplies in some markets.

Market Effects: Crude oil and gas and product price spikes could occur with a supply shortage.

Other Threats/Disruptions

- None

Chokepoints

- Inadequate pipeline capacity to transport produced crude to other light oil markets.
- Crude oil market hub / storage at Cushing, OK (although now less a problem with crude by rail)

Table 17: Major Infrastructure Dependence and Resiliency in Sub-PADD II West

II W	Major Infrastructure Dependence	Fuel Resiliency
Crude	• Local producers supply crude to the Mandan Refinery. • Bakken crude will supply two new 20 MBbl/d diesel refineries.	• Sub-PADD II-West is a net exporter of crude oil to other PADDs. • Heavy synthetic crude oil passes through PADD II West from Canada.
Refined Fuels	• Tesoro Mandan refinery, near Bismarck, ND produces 60 MBbl/d of products. • PADD II West depends on refined fuels from PADD II KS/OK via the 50 MBbl/d NuStar East Pipeline between Arkansas City, KS and Jamestown, ND. NuStar serves 8 terminals in South Dakota and 6 in North Dakota.	• Only one 60 MBbl/d refinery is operational in North Dakota. • Two new refineries are under construction to produce diesel and distillates for the local market, and diluent for heavy crude oil. • Military bases in the Sub-PADD maintain limited stocks.
Natural Gas	• Natural gas pipelines from Canada serve PADD II West via the Alliance Pipeline from Saskatchewan and the Viking Pipeline from Manitoba to North Dakota. • The Williston Pipeline from Billings, MT serves the Rapid City, SD area of II-West.	• Three Canadian pipelines have some interconnection. • Gas supply loss due to a pipeline interruption can be offset by with-drawals from storage or by re-routing gas among systems. • Most pipeline interruptions can be repaired within a few days.
Propane	• The Enbridge Express pipelines supply propane to supplement local production. • The Kinder Morgan Cochin pipeline, which used to deliver propane, has been reversed to carry condensate to Alberta, Canada.	• LPG is produced by the Mandan refinery near Bismarck, ND. • The propane terminal and storage facility at Conway, KS can provide additional sources of supply and can re-route as necessary. • Propane stocks in storage average 1.2 days of demand in Sub-PADD II West, but stocks are available by rail or truck from PADD II KS/OK.
Heating Oil	• ULSD and other refined products are supplied by pipeline from Kansas.	• Heating oils are supplied by the refined products system from KS. • Stocks are about 5 days of demand.
Ethanol	• Ethanol is locally produced in significant quantities from numerous facilities.	• Ethanol is locally produced in significant quantities from numerous facilities. It can also be supplied by rail and tanker truck from PADD II KS/OK and PADD II North.

Options for Consideration (Sub-PADD II West)

Crude:

- Identify and implement strategies to remove barriers and encourage multiple options for transporting crude oil from the Bakken area to refining markets, including rail, rail-to-barge, and pipeline modes.
- Work with industry to Improve the safety and reliability of the rail network to transport crude oil to existing and planned local refineries and to export crude to other domestic refiners in other Sub-PADDs, particularly PADD III and PADDs II and IB. Encourage and incentivize industry to accelerate adoption of DOT standards for rail cars transporting volatile crude oil.
- Encourage industry to construct and increase pipeline capacity to distribute PADD II West crude oil and condensate to other refinery markets, as needed.

Products:

- Sub-PADD II West is dependent on KS/OK refineries for refined fuels. Increased refining capacity in Sub-PADD II West could make Sub-PADD II West less dependent on the KS/OK refineries for refined products, reduce vulnerability to pipeline and surface transport disruptions, and improve resiliency in the Sub-PADD and connected regions.

Natural Gas:

- Encourage and facilitate the expansion or development of gas gathering and transmission infrastructure to reduce methane emissions and flaring of stranded natural gas produced in association with tight oil.

D. PADD III (Gulf Coast, Texas, and New Mexico)

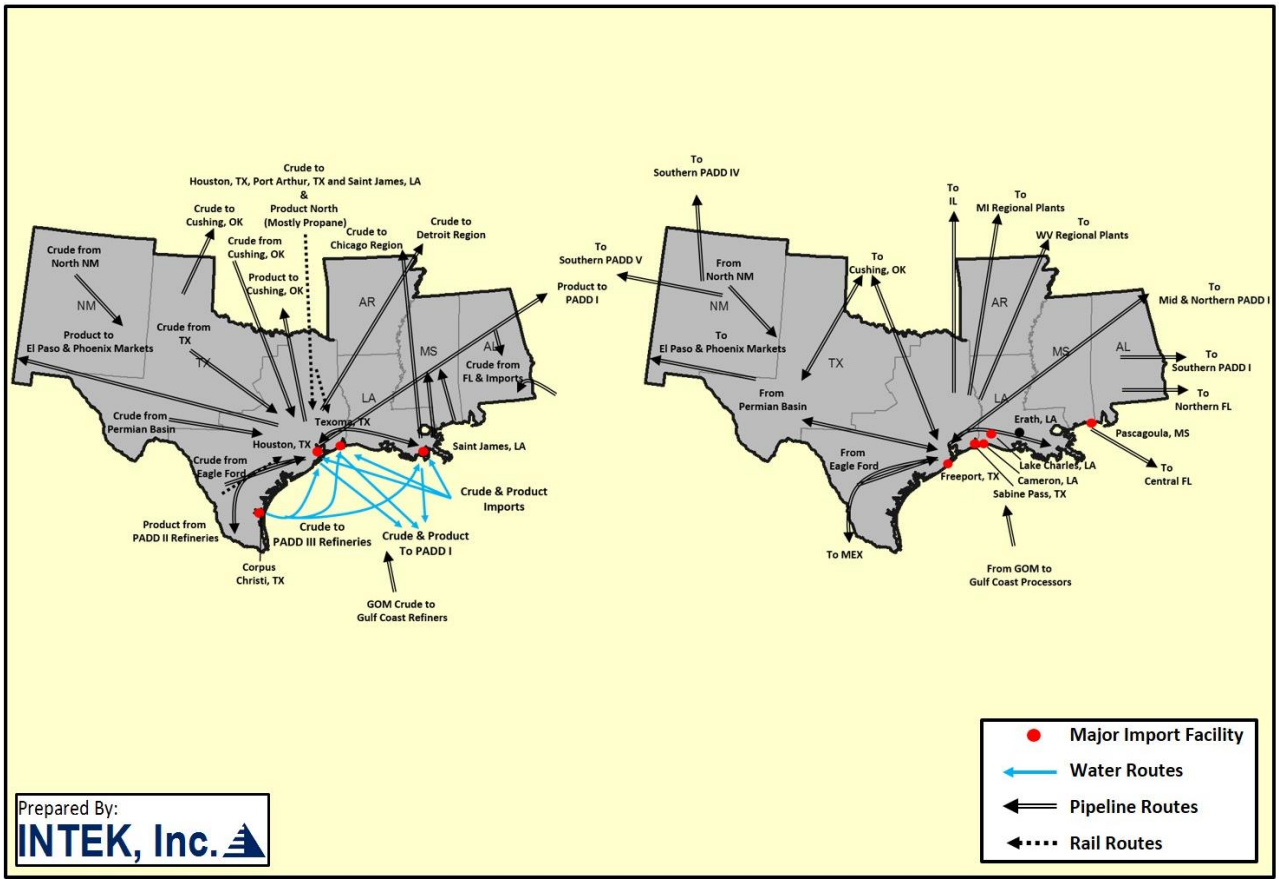
PADD III, including the states of Alabama, Mississippi, Arkansas, Louisiana, Texas, and New Mexico, and including the Federal offshore Gulf of Mexico, is the largest oil and gas producing, refining, and processing region in the United States. Its refineries are the recipients of the majority of the crude oil produced in the United States and the source of most of the refined products received and consumed in the eastern and southern regions of the United States. It is also a major source of refined products to the Midwest, the southern Rocky Mountain states, the southwestern states, and southern California.

In PADD III crude oil is brought to the Gulf Coast and products are sent outward. Crude is brought into the region via the Longhorn, Seaway, Ho-Ho, and other pipelines. Rail is used to bring crude from the Bakken and other sources into hubs in St. James, LA and Port Arthur, TX. Barges are used to bring crude oil, produced in the Eagle Ford, from Corpus Christi, TX to other destinations along the Gulf Coast. In addition, tankers and other marine vessels carry large volumes of foreign imports into the region.

Pipelines are used to transport refined products to markets in the East Coast and Northeast (via the Colonial and Plantation) as well as the Midwest (via the Explorer and TEPPCO). PADD III also contains one of the major propane storage hubs at Mont Belvieu in Texas. Pipelines owned by Enterprise,

transport propane to markets in the Southeast and Mid-Atlantic. Barges and other vessels are used to carry products to markets along the East Coast and West Coast (Figure 5).

Figure 5: PADD III Regions and Movements of Liquid Fuels and Natural Gas



The PADD III local supply of natural gas, produced in the Haynesville, Eagle Ford, Permian, and other locations, is very large. Pipelines provide additional sources of gas from Oklahoma and plays in PADD II. Many pipelines carry natural gas from PADD III to other regions.

These include the West Coast, Midwest, Southeast, and Mexico. LNG liquefaction facilities along the Gulf Coast are used to transport LNG to other markets around the world.

For the purpose of this analysis of vulnerability and resiliency, PADD III is discussed in two parts:

- **PADD III Gulf Coast** discusses the vulnerabilities of the Gulf Coast Louisiana and Texas areas, including Mississippi, Alabama, Arkansas, and the Gulf of Mexico.
- **PADD III West Texas / New Mexico** discusses the western portion of PADD III which is not on the Gulf of Mexico and which is far less susceptible to the natural hazards, including hurricanes, that are common on the Gulf Coast.

Sub-PADD III Gulf Coast

The Gulf Coast portion of PADD III is susceptible to a wide variety of natural hazards including hurricanes, tornadoes, coastal flooding, derechos, and even earthquakes. The most frequent, severe, and impactful of these vulnerabilities on oil and gas TS&D infrastructure are Gulf Coast hurricanes (Tables 18 and 19).

Table 18: Vulnerabilities and Chokepoints in Sub-PADD III Gulf Coast TX and LA

States:

- Alabama, Arkansas, Louisiana, Mississippi, East Texas (RRC District 1-6).
- Includes LA, MS, AL, and TX Federal offshore.

Vulnerabilities and Threats

Direct:

- **Gulf Coast Hurricane:** Hurricanes can interrupt oil and gas production in the Gulf of Mexico and onshore, damage rigs and platforms, shut down crude and product pipelines, down gas processing and oil refining facilities, cause wind damage to structures and systems, knock out electric power to populations and critical infrastructure, and cause coastal flooding of ports, terminals, refineries, and storage facilities due to their storm surge and torrential rains. Surface road and rail transportation and waterborne transport in the Gulf, major ports and seaways, and the critical Mississippi river can all be damaged or curtailed.
- **Coastal Flooding:** Coastal flooding may be caused by hurricanes, tropical storms, major rain falls, or sudden thaws that flood the Mississippi River delta. In this part of PADD III, refineries, marine terminals, crude and product storage areas, and product terminals may be flooded; rail lines and surface roads may be damaged, destroyed, or obstructed.
- **Tornadoes:** There is a moderate risk of tornadoes in PADD III Gulf Coast, which is heightened during and after Gulf Coast hurricanes. However, these sudden and fast moving events can cause loss of power, wind damage, and structural damage (due to flying debris) to rigs and platforms, refineries, crude oil storage terminals, refined product storage and distribution terminals, gas processing plants, compression stations, interconnects, and surface transportation infrastructure including roads, bridges, rail lines, and river crossings.
- **Derechos:** Derechos can also occur in this area. These intense, localized, and short duration storms can cause short-term power loss to TS&D infrastructure, as well as wind and lightning damage. Most damage can be repaired quickly.
- **Earthquakes:** While earthquakes are possible in PADD III Gulf Coast, they are uncommon and generally of low intensity. They can, however, cause insignificant damage to oil and gas TS&D infrastructure, including pipeline ruptures.
- **Physical Attack:** The very high concentration of oil and gas production, ports and terminals, processing, and refining facilities in this region, and the very close physical and visual proximity of this infrastructure to major transportation infrastructure put the TS&D infrastructure at risk of intentional harm.

Vulnerabilities and Threats

Indirect:

- **GC Hurricane:** Other Gulf of Mexico hurricanes, specifically those which remain and dissipate in the Gulf of Mexico or make landfall along the coast of Mexico, can indirectly impact fuel TS&D infrastructure. Specifically, they may disrupt tanker traffic in the offshore and coastal areas of the Gulf of Mexico, interrupt receipt of imports, and interrupt offshore oil and gas production, shipments, and supplies.
- **Market Effects:** Interruptions of the critical fuels TS&D infrastructure in this region may result in supply loss to gas processing plants and refineries, interruptions of product supplies to major markets, and associated crude oil, natural gas, and refined product price spikes due to shortage.

Other Threats/Disruptions

- **Ship Channel Disruptions:** Ship channel disruptions can result from oil spills, accidents, or even fog. Such disruptions can impeded the flow of crude oil to marine terminals and refineries and the flow of refined products to intermediate and end markets via waterborne vessels.
- **Mississippi River:** Similarly, spills, accidents, obstructions, or other disruptions along the Mississippi River can also interrupt the transport of crude oil and refined products to refineries, and local or distant end-use markets.
- **Import Disruption:** The PADD III Gulf Coast oil refining industry and infrastructure is also vulnerable to supply disruption by virtue of import disruptions, whether intentional or caused by events at their points of origin or in transit.

Chokepoints

Several major chokepoints in and near the PADD III Gulf Coast area include:

- Houston Ship Channel, Louisiana Offshore Oil Port (LOOP), Mississippi River, Sabine Pass, and other high traffic waterways.
- Crude oil market hub / storage at Cushing, OK.
- Mt. Belvieu propane processing and storage facility.
- Henry Hub and other natural gas market hubs and system interconnects

Table 19: Major Infrastructure Dependence and Resiliency in Sub-PADD III Gulf Coast TX and LA

III GC LA/TX	Major Infrastructure Dependence	Fuel Resiliency
Crude	• **Louisiana Offshore Oil Port:** LOOP is the only marine terminal in PADD III that can receive oil imports via very large crude carriers (VLCCs). With declining imports, LOOP is also used to bypass bottlenecks in the Gulf Coast crude pipeline system. • **Ports and Terminals:** Crude oil ports, GOM ship channels, marine terminals, and crude	**Gulf Coast Hurricane:** Crude oil supply to operating refineries may be interrupted: • Strategic Petroleum Reserve facilities can currently drawdown and deliver up to 4.5 MMBbl/d to gulf refiners.

	storage facilities are essential to receive oil from foreign and domestic sources for refining. • **Pipelines:** A complex network of crude pipelines and market hubs supplies crude from the PADD III WTX/NM; PADD II; and Canada to the Gulf Coast refineries. • **Rail Network:**The rail network transports crude from new production areas, such as Bakken (ND) and Eagle Ford (TX), where pipeline capacity or bottlenecks limit flow of oil to GOM refiners. • **Seaway and Houston-to-Houma (Ho-Ho) Pipelines:** Seaway now carries crude from Cushing, OK, and other northern sources, to Gulf Coast refineries. The Ho-Ho pipeline carries crude within PADD III from the Texas to Louisiana Gulf Coast.	• Increased crude oil imports may be achieved by diverting shipments. • Domestic crude shipments on other pipelines may be increased.
Refined Fuels	• None -- The Gulf Coast is a net exporter of refined products to other PADDs.	• **Gulf Coast Hurricane:** Local stocks should meet PADD III demand until refinery repairs, power restoration, or pipeline recovery is complete. • Exports of refined products to other PADDS, including critically dependent PADD I, may be interrupted.
Natural Gas	• **Gas production platforms and rigs**: Onshore and offshore wells and platforms supply high volumes of gas to the nation. • **Offshore and onshore gas pipelines**: Offshore and onshore gas pipelines carry produced gas to processing facilities, which, supply dry gas to the transmission and distribution system and NGLs to refiners and other end users.	• The major impact is the likely loss of significant production and gas supply while offshore platforms are shut-in. • A gas supply shortage will cause processing plants to reduce or shut down operations, reducing gas supply to the transmission system. • Gas supply loss may be offset by withdrawals from storage or consumption of gas in the system until gas production resumes.
Propane	• **Mt. Belvieu storage, OneOK and DCP Sandhills Pipelines**: These are critical infrastructure that receive, store, and transport propane to industrial users and end use markets.	• Sufficient storage capacity and stocks provide adequate supply to allow repairs to any infrastructure damage that may occur.

	• **South LA and Hattiesburg Market Hubs:** These hubs provide local storage and distribution for PADD III propane users. • **Enterprise TEPPCO and Dixie pipelines:** The Enterprise TEPPCO and Dixie propane pipelines receive and transport propane to end-use markets in PADDs IC and PADD II.	
Heating Oil	• None. The Gulf Coast is a net exporter of refined products to other PADDs.	• Distillate fuels, including ultra-low sulfur diesel used for heating fuel, are supplied by the refined products transportation and distribution system.
Ethanol	• Ethanol is produced locally and imported from PADD II via rail and barge.	• Stocks in storage are adequate to offset any short-term supply disruption.

Options for Consideration (Sub-PADD III Gulf Coast TX / LA)

Crude:

- Accelerate maintenance for aging ports and navigation system infrastructure.
- Dredge the Houston Ship Channel to ensure continued tanker accessibility.
- Address issue of port and waterway congestion due to increased barge traffic.
- Increase hardening and flood walls for refineries and ports along the gulf coast.

Government-Owned Stocks in PADD III Gulf Coast

It is critical that the SPR maintain the ability to address severe global oil supply disruptions and carry out U.S. obligations under the International Energy Program. To address the vulnerabilities and infrastructure changes discussed in this report, and respond to recent recommendations of the DOE Inspector General, the SPR should review its above-ground facilities, storage capacity, composition (crude oil vs. refined products), and the location of stocks in the context of evolving oil market risk.

The SPR must also take steps to adapt to changing North American petroleum flows and unprecedented supply logistics. Specifically, the SPR should:

- Prepare a long-term strategic review which addresses vulnerabilities to U.S. oil supply, SPR requirements and release authorities, and engineering considerations such as maintenance and upgrades to above ground site facilities and cavern integrity.
- Perform a comprehensive assessment of SPR distribution capability in response to a congested crude oil distribution system and reduced import demand. Recommendations may include building new pipeline connections to commercial marine terminals or building dedicated SPR docks.
- Develop and implement a plan to optimize the SPR to meet new drawdown, storage, and distribution requirements, to support PADD III and other PADDs.

Options for Consideration (Sub-PADD III Gulf Coast TX / LA) - Continued

Other Issues:

- Evaluate costs, benefits, including impacts on PADD III refineries, and effects on U.S. oil price volatility, of allowing exports of crude oil to global markets.

Natural Gas:

- Incentivize industry to develop additional storage capacity to meet peak demand.
- Encourage and incentivize industry to develop and implement approaches to increase gas extraction rates and deliverability from storage fields to respond to prolonged GOM gas supply disruptions to PADD III and other PADD III-dependent regions.

Sub-PADD III West Texas and New Mexico

Sub-PADD III West Texas and New Mexico differs greatly from PADD III Gulf Coast. It is a major producer of oil and natural gas, but has limited refining capacity and infrastructure. PADD III WTX/NM supplies crude oil from the Permian Basin to PADD III refineries, and to the oil market hub in Cushing, OK. A refinery in El Paso supplies products to key markets in Phoenix and Tucson, AZ. PADD III WTX/NM also produces and supplies gas to the nation's transmission system, sending it east to Texas and eastern markets and west to Arizona and California. Out of the path and reach of most Gulf Coast hurricanes, major vulnerabilities are to wildfires, drought, tornadoes, and perhaps, earthquakes (Tables 20 and 21).

Table 20: Vulnerabilities and Chokepoints in Sub-PADD III West Texas and New Mexico

States:

West Texas (RRC Districts 7b-10); New Mexico

Vulnerabilities and Threats

Direct:

- **Wildfires and Drought:** Wildfires and drought may cause damage to production wellheads, gathering systems, pipelines, or controls. Drought may limit water supplies for some oil and gas E&P and refining operations, reducing production.
- **Tornadoes:** Tornadic winds can cause loss of power, wind damage, and structural damage (due to flying debris) to rigs and platforms, gathering systems, refineries, crude oil storage terminals, refined product storage and distribution terminals, gas processing plants, compression stations, interconnects, and surface transportation infrastructure including roads, bridges, rail lines, and river crossings.
- **Earthquakes:** Minor earthquakes in this area may cause limited damage to oil and gas TS&D infrastructure and transport systems.
- **Gulf Coast Hurricanes**: It is possible, though unlikely, that a westward tracking storm may retain strength after land fall causing major rain fall and flash flooding events.

Indirect Threats/Disruptions

Chokepoints

- Pipelines transporting produced crude oil to PADD III GCTX refineries.
- Hobbs, NM and Skelly, TX propane hubs;
- TEPPCO product pipeline.

Table 21: Major Infrastructure Dependence and Resiliency in Sub-PADD III West TX and New Mexico

III GC WTX/NM	Major Infrastructure Dependence	Fuel Resiliency
Crude	• There is no crude oil dependence due to local production. • Reversals of pipeline direction have reduced bottlenecks .	• Increasing crude oil production and limited infrastructure may cause crude oil to become stranded in the Permian Basin, causing negative price impacts for producers. • Additional pipeline and/or rail capacity may needed to resolve potential future bottlenecks and move crude to Gulf Coast refineries or Cushing, OK
Refined Fuels	• The TEPPCO products pipeline is a critical source of products to Abilene, TX.	• Refined products can easily be provided from PADD III GCTX area. • Exports of refined products to Arizona could be interrupted by a disruption affecting the El Paso refinery or Kinder Morgan's SFPP East Line between El Paso, TX and Tucson and Phoenix, AZ.
Natural Gas	• None due to local production.	• The risk of loss of gas production is minimal. Redundancies and interconnects in the natural gas transmission network minimize supply loss to local markets.
Propane	• Local markets and hubs store and transport sufficient quantities of propane.	• Damage to processing centers and hubs can be repaired quickly with minimal impact on stocks or consumer markets. • MAPL Rockies pipeline from PADD IV to Hobbs, NM; Front Range pipeline; and secondary hubs and local supply.
Heating Oil	• None	• Same as for refined fuels.
Ethanol	• Ethanol is received by rail from PADD II.	• Stocks in storage are likely sufficient to meet demand until infrastructure can be restored.

Options for Consideration (Sub-PADD III West TX / NM)

Crude:

- Monitor increasing oil production in Permian Basin and study requirements for future pipeline and rail transportation, as needed.

Products:

- Assess options to provide products storage and supply to support Arizona markets in the event of a supply disruption from El Paso or Utah refiners.

Natural Gas:

- No significant vulnerabilities exist that warrant public action at this time.

E. PADD IV Rocky Mountain States

PADD IV is comprised of the Rocky Mountain states of Colorado, Idaho, Montana, Utah, and Wyoming. Of these states, Colorado, Utah, and Wyoming are significant producers of natural gas as well as producers and refiners of crude oil. The flows of crude oil, refined products, and natural gas in and out of PADD IV reflect the rugged topography of the region as well as geographic separation of producing areas from the more populous demand centers (Figure 6).

Canadian crude oil supplies refineries in the Guernsey, WY area. Refined products from PADD II North also supply markets in Montana and Wyoming. Products from Guernsey, WY flow to Utah and northern Colorado, while products from the Utah refineries flow to markets in Nevada and Washington. Similarly, Canadian gas supplies much of the gas demand in the northern area of PADD IV, while the southern states export gas to California, New Mexico, Kansas and other markets.

The northern location and mountainous terrain of PADD IV subjects it to cold winters, significant snowfall, and icy conditions that can result in flooding during periods of thaw. Warm summers and arid conditions make some areas prone to drought, and wildfires are common.

PADD IV receives crude oil from Canada and ships crude to Cushing by pipeline. Products are received from North Dakota and transported from Salt Lake City, UT to Washington and Nevada. Natural gas imported from Canada and Kansas is sent to South Dakota, California, New Mexico, and Kansas.

PADD IV is also vulnerable to earthquakes, although activity tends to be of low frequency and intensity (Tables 22 and 23).

Figure 6: PADD IV Movements of Liquid Fuels and Natural Gas

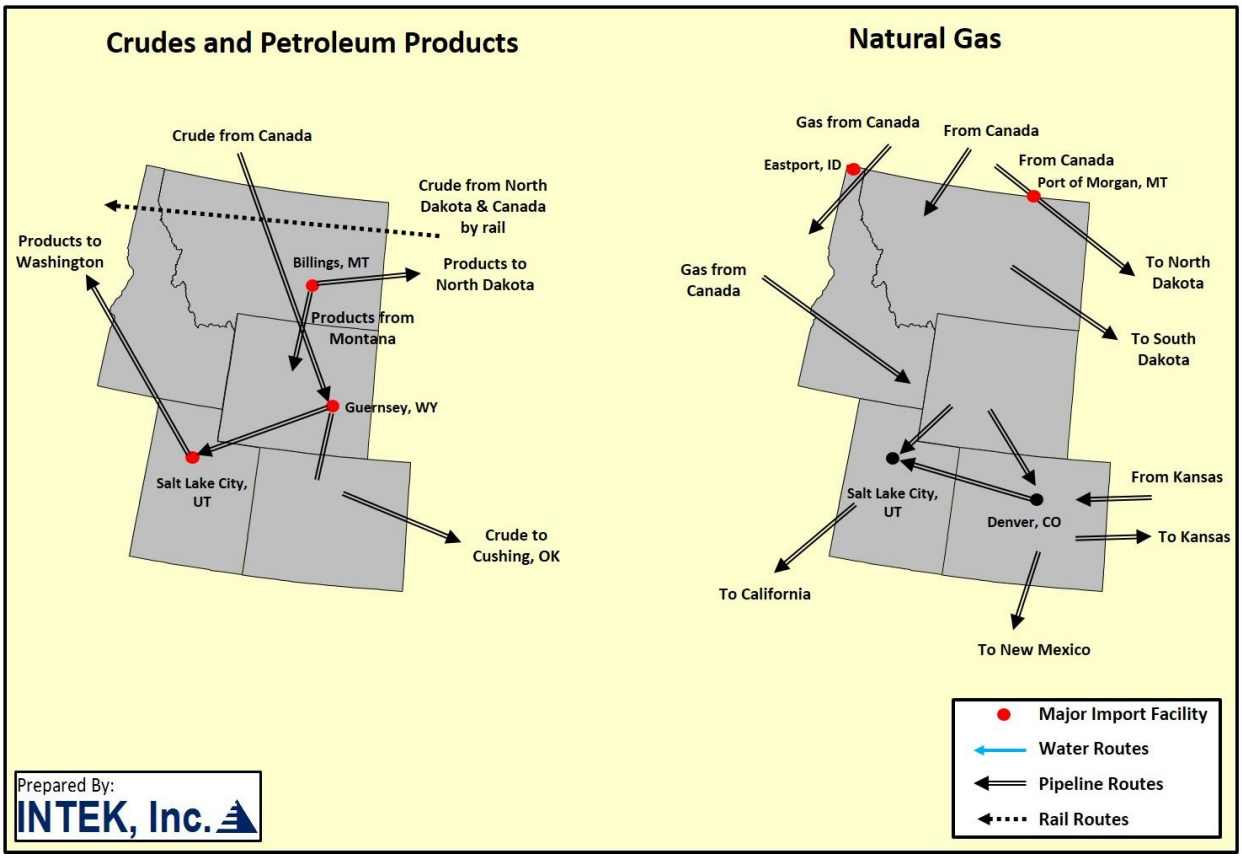


Table 22: Vulnerabilities and Chokepoints in PADD IV

PADD IV States: Colorado, Idaho, Montana, Utah and Wyoming
Vulnerabilities and Threats **Direct:** • **Flooding:** Seasonal thawing of winter snowpack can cause flash floods • **Wildfire/Droughts/Heatwave:** Possible fires, power outages. • **Earthquakes:** (Typically occur in remote and lightly populated areas) - Potential major damage to crude and product pipelines, regional refineries in Wyoming and Utah; power supply, roads, mountain passes, rail transportation, and communications. **Indirect:** • Gulf Coast Hurricanes or other disruptions of pipelines from PADDs II and III could affect product and natural gas supplies in eastern Colorado. • Earthquakes in PADD V could disrupt some gas flows to western parts of PADD IV.

Other Threats/Disruptions

Chokepoints

- Canadian / U.S. entry points for crude oil and natural gas, include the Express and Butte pipelines.

Table 23: Major Infrastructure Dependence and Resiliency in PADD IV - Rocky Mountains

IV	Major Infrastructure Dependence	Fuel Resiliency
Crude	• About one quarter of oil supplied to PADD IV refineries (in CO, WY, UT) is heavy synthetic crude supplied via Canadian pipelines or from PADD II. The rest is produced locally in Colorado, Utah, and Wyoming.	• Crude oil stocks in storage average nearly 30 days of supply, which is sufficient to offset any likely disruption.
Refined Fuels	• 90% of refined products are supplied by PADD IV refiners, with the balance being supplied by PADD II refiners. • ~ 50% of jet fuel is supplied by pipelines or rail from PADD II. • Some areas receive fuels from outside the PADD via the Phillips 66 and NuStar pipelines from Amarillo, TX to Denver, CO and the Magellan pipeline from Midland, TX.	• Product stocks in storage average six to seven days, which is sufficient to meet any likely disruption in PADD IV. • Additional products could be supplied from PADD III via pipeline, rail, or tanker trucks.
Natural Gas	• PADD IV exports nearly four times the natural gas it consumes. • Some areas are dependent on gas supplies from outside PADD IV: Idaho receives gas via a pipeline from PADD V. • Eastern Colorado (including the Denver area) receives gas through the Questar Pipeline, the Colorado Interstate Gas system, and the Kinder-Morgan Interstate gas system.	• Multiple gas lines, systems, and interconnects provide resiliency for most markets within PADD IV. • Most pipeline interruptions can be repaired or restored in 3-5 days.
Propane	• PADD IV is a large producer and net exporter of propane to other PADDs. • Some parts of PADD IV receive propane from PADD II or Canada.	• Stocks in storage are sufficient for a short term disruption. • Shortages due to refinery or gas plant interruption would require deliveries by rail or truck.
Heating Oil	• Less than 5% of distillate demand is supplied from outside the PADD.	• Distillate fuels, including ultra-low sulfur diesel used for heating fuel, are

		supplied by the refined products transportation and distribution system. Stocks in storage are about seven days of supply.
Ethanol	• PADD IV produces about 50% of its ethanol demand. • The remainder is supplied by truck or rail from PADD II.	• Stocks in storage are likely sufficient to meet demand until infrastructure can be restored.

Options for Consideration (PADD IV)

Crude:

- No significant vulnerabilities warrant public actions at this time.

Products:

- No significant vulnerabilities warrant public actions at this time.

Natural Gas:

- No significant vulnerabilities warrant public actions at this time.

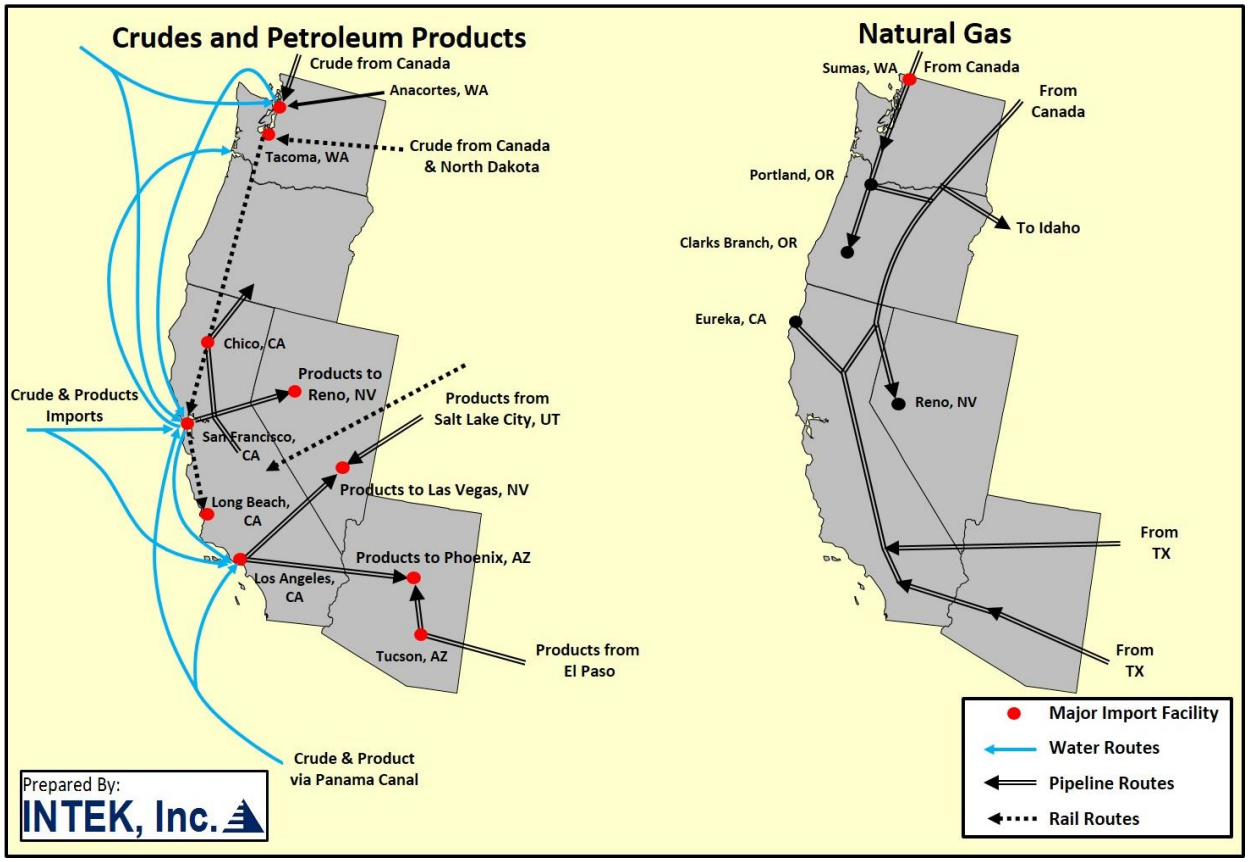
Ethanol:

- Encourage industry to maintain sufficient ethanol stocks to meet requirements for a supply disruption of short duration. Consider maintaining sufficient ethanol stocks in government owned product reserves.

F. PADD V West Coast

Extending from the nation's border with Mexico in the south to the Canadian border in the north, PADD V includes the lower-48 states of Arizona, California, Nevada, Oregon and Washington. Alaska and Hawaii are also included in PADD V. With the exceptions of Tucson and Phoenix in Arizona, and Las Vegas and Reno in Nevada, the major continental population and fuels demand centers are in the coastal regions of California, Oregon, and Washington. Hawaii and Alaska are largely independent of the lower-48 PADD V markets and infrastructure (Figure 7).

Figure 7: PADD V Movements of Liquid Fuels and Natural Gas



Crude oil and petroleum products enter PADD V by pipeline, waterborne vessels, and rail. Barges and tankers bring crude and products from Alaska, Washington, the Gulf Coast, and other countries. Major import facilities include Anacortes and Tacoma in Washington, and San Francisco and Los Angeles in California. Crude is also brought to the West Coast from the Bakken by rail. Crude is shipped west to Tacoma and then sent south to the refineries in California. Small volumes of Utah crude are now entering the California market. Pipelines bring products into the Las Vegas market and, via Tucson, AZ, into Phoenix. These markets are also supplied by product pipelines connected to refineries in the Los Angeles area.

Natural gas flows into the region along four pipelines. Two of these pipelines, originating in Canada, supply the north part of the region; two originating in PADD III supply Arizona and Southern California.

The vast extent of PADD V from north to south makes it various areas subject to a wide variety of natural threats and vulnerabilities, ranging from flooding in northern areas to drought and wildfires in the south. The major concern in PADD V, however, is earthquakes, which, depending on their locus and intensity have the potential to cause major harm to critical fuels TS&D infrastructure (Table 24).

Of the PADD V states, only Alaska and California are significant producers of oil and natural gas. Local crude oil production supplies less than half of the crude oil demand of PADD V refineries, which are located in the Los Angeles area, the San Francisco area, and the Anacortes, WA area. About 10 percent of PADD V's crude supply comes from other PADDs and about 5 percent is imported from Canada. Crude oil is transported to San Francisco and Los Angeles refiners by barge and tanker. Increasingly, Bakken crude from PADD II is also being transported by rail to PADD V refiners.

PADD V depends on imports from South America and the Middle East for more than one-third of its crude oil supply, much of which travels through the Panama Canal to West Coast ports, and refineries. (Alaska and Hawaii refineries partially supply those self-contained markets). Most of PADD V's refined products are supplied from local refineries; about 10% are imported by tankers from Latin America. The major concern in PADD V is that there are few alternative sources of oil or refined products to meet major market demands in the event of a major supply disruption. Consequently, stocks in storage need to be sufficient to meet market requirements until disrupted infrastructure can be restored (Table 25).

Table 24: Vulnerabilities and Chokepoints in PADD V

PADD V States:

Arizona, California, Nevada, Oregon, Washington, Alaska and Hawaii

Vulnerabilities and Threats

Direct:

- **Earthquakes:** Earthquakes can cause major damage to ports, crude and product pipelines, power supply, surface transportation, and communications.
- **Tsunamis:** Tsunamis caused by offshore earthquakes may cause damage to ports and coastal infrastructure, including coastal flooding.
- **Wildfire / Heatwave:** Heatwaves and droughts may cause fires and power outages.
- **Volcanoes:** Eruptions of volcanoes in Hawaii and Washington can damage refineries and TS&D infrastructure from ground motion, ash emissions, and possibly lava flows.
- **Pacific Hurricanes:** Pacific coast hurricanes rarely affect the western United States or Hawaii.

Indirect:

- Refinery or pipeline disruption in PADD III WTX/NM may interrupt product flows to AZ markets.
- Events causing disruptions of crude supply from Alaska or Canada may impact PADD V refineries.

Other Threats/Disruptions

- Imports from South America and Middle East provide 40% of crude feedstocks and 12% of refined products consumed in PADD V.
- A Panama Canal shutdown could curtail oil imports from Middle East;
- A major oil spill could close marine ports and terminals.

Chokepoints

- The Port of Los Angeles and LA area refineries; San Francisco area; Anacortes, WA area; and the Panama Canal are chokepoints where congestion or obstruction may affect supplies of crude and products.

Table 25: Major Infrastructure Dependency and Resilience in PADD V - West Coast

V	Major Infrastructure Dependence	Fuel Resiliency
Crude	• Seaborne imports from South America and Middle East provide ~40 % of PADD V refinery crude oil feedstocks, much of it transported via the Panama Canal. Some is shipped by tanker via Colombia's Pacific Coast ports. • Barges and tankers ship oil from Washington to San Francisco and Los Angeles. • Alaska and Canadian ports, pipelines, and shipping supply crude oil to Anacortes and other northwest refineries. • Rail networks supply Bakken and Canadian crude to some San Francisco and Long Beach area refineries. • Hawaii is 100% dependent on imported crude oil from South America, Asia, and the Middle East for its two refineries.	• Crude storage is insufficient to meet a major crude supply disruption. • SPR would require 21-30 days to deliver crude to West Coast refineries via the Panama Canal. • If the Panama Canal closure is the source of crude supply loss, SPR crude would require up to 50 days to deliver by seaborne vessels around South America. • Jones Act waivers would be required.
Refined Fuels	• Seaborne imports from South America and Middle East provide ~12% of fuels consumed in PADD V through ports of Los Angeles and	• Product storage, averaging 5 to 6 days of demand, is insufficient to respond to a major refinery disruption. Alternative sources and modes of supply are

	Long Beach. • The SFPP East Line supplies refined fuels from El Paso and PADD III refiners to Phoenix and Tucson AZ markets. • The CALNEV pipeline supplies fuels from S. California to Las Vegas, NV including McCarran Intl Airport and Nellis AFB. • Some fuel is supplied from UT refineries to Las Vegas area. • SFPP pipeline from San Francisco provides fuel to Reno, NV. • SFPP provides refined products to Phoenix, AZ. • Oregon receives refined products from Chico, CA.	limited. • Loss of the pipeline from southern California could significantly reduce product supply to Phoenix, AZ. Some of the loss could be offset by increased shipments from PADD III El Paso refinery. • Loss of SPPL pipelines from San Francisco would curtail supplies to Reno, NV. • Loss of CALNEV would curtail most refined products supply to Las Vegas area, although it could be provided by pipeline from the Salt Lake City, UT refineries.
Natural Gas	• Gas transmission lines from PADD III WTX/NM via Transwestern Pipeline system and U.S. and Canadian Rockies. • Washington, Oregon, California, and Reno, NV depend on Canadian gas pipelines. • Arizona and southern California also receive natural gas from PADD III WTX/NM, in addition to associated gas produced in Southern California.	• Most pipeline interruptions can be repaired /restored in 3-5 days.
Propane	• PADD V propane markets have negligible reliance on imports from Canada and other foreign sources.	• Stocks in storage are sufficient for a short term (12 day) disruption. • Shortages due to refinery or gas plant interruption would require delivery by rail or truck.
Heating Oil	• Heating oil is largely supplied by local refiners.	• Distillate fuels, including ultra-low sulfur diesel used for heating fuel, are supplied by the refined products transportation and distribution system. • Stocks in storage are less than 10 days' supply.

Ethanol	• Ethanol is received by rail from PADD II	• PADD V produces only 10% of its ethanol demand. • Ethanol stocks in storage total about 9 days of demand. • Supply interruptions would require increased imports or waivers.

Options for Consideration (PADD V)

Crude:

- A study is needed to evaluate and assess the costs and benefits of a West Coast Crude Oil Reserve, including location options.
- A study should be conducted to assess the basis for Hawaii's total dependence on foreign crude oil, including alternative domestic sources and barriers constraining use of those sources.

Products:

- A centrally located refined product reserve for the Los Angeles/Southern California area could ensure that stocks in storage can meet a 5-10 day product supply disruption. DOE EPSA and SPR could conduct a detailed study to evaluate and assess the costs and benefits of a West Coast Refined Petroleum Product Reserve at a centrally located site outside of the fault areas that would provide 5-10 days of supply.

Natural Gas:

- Work with industry to develop a plan for modernizing the aging gas distribution system infrastructure, to detect and reduce methane leaks and emissions, avoid events such as occurred in San Bruno in 2010, and to improve system efficiency.

IV. Infrastructure Hardening and Damage Prevention

It can be effectively argued that there are three essential elements to assuring the effective continuation of fuels supply to markets and consumers that are vulnerable to supply interruption from natural disasters or other intentional or intentional damage or interruption. These include:

- **Hardening or strengthening** of physical infrastructure to make it less vulnerable to damage by natural disasters or intentional acts.
- **Preparedness** to respond to supply interruption events, when they occur, through the establishment of plans, procedures, and capabilities, that expedite infrastructure and fuels supply recovery, and
- **Supply replacement** strategies to expeditiously provide alternative or back-up sources of fuels stocks to bridge the supply interruption until such time as damaged infrastructure and interrupted fuels production or transport operations can be restored to pre-event levels.

An approach that incorporates some or all of these elements is likely to be the most robust and effective in assuring the continuation of energy supply to affected markets and communities.

A. Infrastructure Hardening

Infrastructure hardening can be construed in terms of physical and procedural changes to infrastructure that make it less susceptible to potentially damaging forces or acts or that reduce the impacts of those forces or events should they indeed occur.

Procedural hardening measures may include:

- Improving the security of vulnerable facilities to restrict awareness, visibility of, and access to vulnerable infrastructures.

Physical hardening refers to the physical modification or enhancement of infrastructure to protect it from exposure to, or impacts of, natural or other forces or events. Examples of physical hardening would include:

- Elevation, encasement, or protection by permanent or temporary floodwalls or other measures of water-sensitive infrastructure (generators, cabling, pumps, motors, sensors, communications, and controls, etc.) from flood-vulnerable areas.
- Strengthening, anchoring or weighting of structures, such as refinery towers or storage tanks, that are vulnerable to damage or movement by the force and pressure of high winds, heavy rains, or storm surge or explosive or incendiary devices.

Learning from the lessons of recent East Coast (Irene and Sandy) and Gulf Coast (Gustav/Ivan and Katrina/Rita) hurricanes, West Coast earthquakes, and Midwest tornados and derechos, industry has

already made major investments and achievements in hardening fuels production, transportation, storage, and transportation infrastructure in event vulnerable areas and facilities.

B. Petroleum Industry Hardening Against Disruptive Events

In response to recent Gulf Coast hurricanes, an August 2010 Department of Energy report identified a number of key areas where industry and government entities have made and continue to make significant efforts to harden and improve the resiliency of fuels TS&D infrastructure.[1]

Flooding Protection and Hardening

Among the most common and expensive storm damage to fuels TS&D infrastructure is flooding, due to heavy rains, storm surge, or river flooding, which damages electrical equipment and disrupts operations of refineries, pipelines, and terminals for extended periods.

Common flood protection measures implemented by Industry, as well as the U.S. Army Corps of Engineers (USACE), include construction of floodwalls, levees, and berms.

- USACE built a 15-foot-high concrete floodwall that protects the BP, Marathon, and Valero refineries near Texas City, Texas.
- USACE also built the Mississippi River levee system, which provides flood protection to 15 feet for refineries located near New Orleans.
- Refiners built floodwalls along the Houston Ship Channel and around Pascagoula to contain a 100-year storm surge.
- One refiner reported that it erected a 12-foot high, one-half-mile-long floodwall in 2004 for approximately $4 million.

Investments have also been made to elevate many substations, control rooms, and pump stations above the likely flood level, in some cases elevating facilities as much as 15 - 25 feet above ground. Depending on the size of the unit, how much power is carried, and how much wind and storm surge the unit is designed to withstand, costs to elevate infrastructure may be as much as $500-900 per square foot.

Hardening for Wind Damage Protection

Storm winds may be less destructive to petroleum infrastructure than flooding. Wind damage from hurricanes, tornados, or even derechos can severely damage and obstruct access to refineries, pipelines, crude and refined product storage tank terminals, and fueling stations. Refinery distillation columns, gas plant columns, and cooling towers are especially susceptible to wind damage. Distillation columns can be toppled.

High winds can cause cooling tower fan blades to detach, disabling the cooling tower and creating airborne shrapnel that can damage other infrastructure. It has been reported that during Hurricane Rita in 2005, fifty percent of the cooling towers at Port Arthur refineries were damaged and fifty-four percent were damaged at Port Neches.[2] Many refiners have installed special braces to stop the fan blades from dislodging.

Storage tanks may buckle, lose their roofs, or be moved off their foundations by severe hurricane or tornado force winds. Many tank operators have taken steps to harden their tanks by installing wind girders that can deflect wind and improve the structural integrity of the tank, preventing a collapse.

Command, Controls, and Communications

Many companies have also invested in updating and shielding control room electrical systems and technologies and improving telecommunications and information technology systems to maintain communications during natural disasters or other disruptions. In some cases, some controls and communications have been moved offsite. In others, hardened command centers have been established on site.

C. Industry Preparedness for Fuels Supply System Resiliency

Major progress has been made in the petroleum industry to anticipate and prepare for natural disasters and the possibility of accidents or other events that could disrupt supply, production, transportation, storage, or fuels distribution operations.

An extensive body of industry-tested "best practices" has been accumulated from experience and applied to establish industry readiness to plan for, respond to, and expeditiously recover from potentially disruptive events. While these plans vary by company, by facility, and by the type and magnitude of the anticipated event, industry organizations such as the American Petroleum Institute and others facilitate the accumulation and sharing of industry best practices and the development of standards and procedures for protecting worker safety, infrastructure hardening, and event preparedness and response.

Planning for Power Loss

One of the most common causes of refinery, processing plant, pipeline, storage terminal, or distribution shutdown is power loss. These facilities have large power requirements to operate control systems and to drive the motors and pumps that keep fluids moving through the systems. Even if a facility is undamaged by an event, its power supply may be interrupted by damage to or shut down of a power plant, power lines, transformers, or substations that transmit power to the facility.

Most companies' event response plans include purchasing or leasing portable generators to provide electricity to critical facilities during outages. Purchasing a typical 2-MW trailer-mounted generation unit may cost $1 million or more with accessories and financing.[3] For refineries and gas processing plants, these backup generators can power lighting, communications, and facility operations that are essential to recovering from a disaster. However, they do not provide sufficient generation to run the refinery or gas processing operation. Conversely, back-up power can be extremely effective in maintaining or restoring crude oil, refined product, and natural gas pipelines, pumping stations, marine terminals, tank farms, and, importantly, retail sales points. For example:

- During the 2005 hurricane season, Colonial Pipeline purchased 12 trailer-mounted Mitsubishi portable generators, seven transformers, and miles of associated cabling in 2006.[4]

- Companies reported pre-wiring and pre-positioning smaller generators at key service stations along evacuation routes.
- Florida has enacted legislation requiring gas stations within a half mile of evacuation routes be equipped with a back-up electrical generator. In addition, all owners of more than ten gas stations in a county must (within 24 hours) have a generator installed at 10 percent of fuel outlets.[5]
- New York has passed legislation providing and incentivizing wiring for and use of back-up generators at retail fueling stations to enable service during power outages.

Personnel Safety and Availability

An essential requirement for all refineries and gas processing plants, most gas and product pipeline infrastructure, and all marine terminals, storage terminals, distribution points, and retailers is the availability of key personnel to operate their facilities safely and securely.

Even if a refinery or other major fuels TS&D system component is undamaged or has power restored, required evacuations of local populations in anticipation of or response to a natural disaster or other catastrophic event may prevent or prohibit personnel from reporting to work and thereby deprive a facility of a critical operational element, its skilled and trained employees, for a matter of days or even weeks depending on the severity of the event and its impacts.

All of the refinery and pipeline operators for the study indicated that the safety of their employees is paramount. Petroleum companies have numerous methods of keeping track of their employees and communicating with them before, during, and after a hurricane. These methods include websites, hotlines, and media channels, and are aimed at ensuring employee safety and enabling a quick and coordinated response after a storm has passed.

Stocks in Storage

Industry and government continue to make progress in hardening TS&D infrastructure to prevent or minimize damage and facility disruption that may be caused by a natural disaster or other disruptive event. Most elements of the TS&D system have developed disaster plans to anticipate, prepare for, respond to, and recover from disruptive events. The major benefits of these ongoing efforts are to protect human life, to reduce damage to infrastructures, and to shorten the period of disruptions and reduce the volume of supply loss when disruptions do occur. Most interruptions can now be restored in a matter of days or weeks, depending on the extent and magnitude of the event.

A major requirement for assurance of continued supply of products and natural gas to consumers and local and regional economies is the availability of emergency stocks of crude oil, refined products, heating fuels, propane, and natural gas that can bridge the supply gap while physical infrastructure, facility operations, and system integrity area being restored. The Strategic Petroleum Reserves provides this back-up supply for refineries. More recently, NEHHOR has been established to mitigate against heating oil supply disruptions or shortfalls, and refined product reserves are being established in the Northeast. Additional reserves to serve the most vulnerable markets could be very beneficial.

V. Government Reserves and Stocks of Oil and Refined Products

A. History of the U.S. Strategic Petroleum Reserve

Created in response to the economic implications of the historic Arab Oil Embargo, the U.S. Strategic Petroleum Reserve serves to provide oil to U.S. refineries in the event of a major supply disruption. Forty years later, in an unprecedented era of North American oil production, speculation of significant import decline, and major budgetary uncertainties, the historical mission of the SPR must be revisited.

Mission Overview

As described in DOE's *2014-2018 Strategic Plan*, the Department of Energy's Mission serves "***to enhance U.S. security and economic growth through transformative science, technology innovation, and market solutions to meet our energy and environmental challenges.***" The Office of Fossil Energy has committed "to ensure that the nation can continue to rely on traditional resources for clean, secure and affordable energy while enhancing environmental protection." At the Office of Petroleum Reserves, the U.S. SPR serves "to reduce the adverse economic impact of a major petroleum supply interruption to the United States and to carry out the obligations of the United States under the International Energy Program."

The Strategic Petroleum Reserve (SPR) is the world's largest emergency stockpile of crude oil maintained to assure the energy and economic security of the United States. The federally-owned oil stocks are stored in 62 solution-mined caverns, with a total of 118 wells, developed in salt domes at two Louisiana and two Texas storage complexes. Those sites are:

- Bryan Mound, Freeport TX
- Big Hill, Winnie TX
- West Hackberry, Hackberry LA
- Bayou Choctaw, Plaquemine LA

SPR's core capabilities are: to respond to a major energy supply interruption by maintaining the ability to supply 4.4 MMBbl/d for 90 days to the U.S. refineries, to respond to short-term emergencies such as hurricanes and other specific energy sector supply disruptions, and to respond to energy supply emergencies.

SPR Sites, Delivery Points, and Current Status

SPR storage sites are connected to refineries through local pipelines, interstate pipelines, and marine terminals. The SPR's four storage facilities: Bryan Mound, Big Hill, West Hackberry, and Bayou Choctaw, are incorporated into three major commercially-owned distribution systems. Recent changes to these distribution systems do pose deliverability issues to SPR systems as they have brought increased utilization to Gulf Coast crude transportation infrastructure (Table 26).

Table 26: Strategic Petroleum Reserve Systems (SPR 2014)

Distribution System	SPR Site	Drawdown Rate (MMBbl/d)	Current Inventory / Authorized Capacity (MMBbl)	No. of Sweet Caverns, (Inventory in MMBbl)	No. of Sour Caverns, (Inventory in MMBbl)
Seaway	Bryan Mound	1,350	240 / 254	7, (64)	14, (176)
Texoma	Big Hill	1,100	164 / 170	6, (68)	8, (96)
	West Hackberry	1,300	217 / 227	10, (108)	12, (109)
Capline	Bayou Choctaw	515	74 / 76	2, (22)	4, (52)

Seaway System

The Bryan Mound storage facility is located southwest of Houston, TX and is the only SPR site within the Seaway distribution system. The site currently has a maximum drawdown rate of 1,350 MBbl/d and delivery points at the Freeport and Texas City Seaway Terminals. Bryan Mound's drawdown rate has been reduced from 1,500 MBbl/d to 1,350 MBbl/d since 2009 due to an out-of-service staging tank. The Seaway system can deliver oil to vessels at two marine terminals with a total marine distribution capability of 700 MBbl/d.

Texoma System

The SPR has two storage sites in the Texoma Distribution System: Big Hill, located southwest of Port Arthur, TX, and West Hackberry, situated just south of Lake Charles, LA. Big Hill can deliver oil to the eastbound Shell Ho-Ho Pipeline, the Sunoco Nederland Terminal, and the Chevron Nederland Terminal; however the 2014 DOE Test Sale revealed that the site's equipment configuration cannot support simultaneous oil deliveries to multiple delivery points. West Hackberry can deliver to the Sunoco Nederland Terminal and the Lake Charles metering station which further feeds the east bound Shell Ho-Ho pipeline and two Lake Charles refineries.

The Texoma Distribution system is DOE's most strategic reserve asset. It relies on five docks at the Sunoco and Chevron terminals with a total marine distribution capability of 1,375 MBbl/d. The system is connected to all local refineries and can pump oil to PADD II via the Mid-valley pipeline.

Capline System

The Bayou Choctaw site is located west of St. James, LA. The Capline system relies on dedicated docks at the Shell St. James terminal with a total marine distribution capability of 400 MBbl/d. In the event of a significant disruption, DOE has authority to overtake all operations at the marine terminal. Similar to Texoma, the Capline system can also deliver oil to PADD II via the Capline pipeline.

B. SPR Natural Disaster Deliverability Issues

Natural disasters in the Gulf Coast could potentially strike SPR sites and hinder their distribution and deliverability capabilities. Although SPR crude oil is securely stored underground, DOE relies on critical equipment for emergency drawdown and deliveries. The critical components utilized in an SPR drawdown are the crude and brine water pumping systems, the proofer and metering equipment, and the electrical instrumentation controlling these systems. Examples of the types of damage that could hinder SPR system deliverability include power outages, structural wind damage, equipment flooding, and water damage.

Hurricanes, tornadoes, and flash floods present the largest threats to SPR distribution systems. The Texas and Louisiana Gulf Coasts are historically susceptible to hurricane landfalls, are situated adjacent to the major 'tornado alley' in the mid-continent, and are low in elevation relative to sea level. In the past, Hurricanes Katrina, Rita, Ike, and Gustav made landfall in regions adjacent to SPR sites. The Texoma and Capline systems are unique in that, if unaffected by a hurricane, they have the ability to send crude to PADD II at ~500 MBbl/d through the northbound Mid-Valley and/or Capline Pipelines. PADD II refineries could then increase utilization to offset product lost from affected refineries.

SPR sites are equipped with back-up power systems as are most commercial terminals. In the rare event of complete power loss, cavern wells can be opened manually, but SPR sites will lose ability to pump liquids. Severe flooding may pose issues to the pumping and metering systems and cause power loss. Tornadoes have the potential to completely destroy critical drawdown components. A source of information to characterize the hardness of pipe, pump, and wellhead equipment is currently unavailable at this time.

Historically the Gulf Coast and SPR systems have never suffered severe weather events like tsunamis, earthquakes, or prolonged wildfires. Although droughts are sapping available water resources in southern U.S. regions, the SPR does not utilize freshwater or groundwater resources in its drawdown processes. Raw water pumping systems draw brine water from the Gulf's inter-coastal waterways. The concentration of salts in the brine exceeds the saline saturation point; this prevents further leeching of the cavern structural during drawdown.

On the next page, estimations for maximum drawdown and deliverability options are listed for various weather scenarios affecting various regions (Table 27). The timely availability of marine vessels and dock utilizations in drawdown situations are critical factors in executing SPR's maximum deliverability. Deliverability differs from drawdown in that some regions may only be relieved through marine access. Corpus Christi, TX, Eastern Louisiana, and the Lower Mississippi River Delta cannot be reached via pipeline.

SPR maintains connectivity to major pipeline systems in Houston, TX; Port Arthur, TX; Lake Charles, LA; and Houma, LA. Port Arthur, TX and Houma, LA are connected to Patoka, IL and Canton, OH. All remaining refineries on the East and West coast must be reached by ship. In the meantime, SPR's pipeline connectivity is changing rapidly which is increasing demand for additional marine capabilities as well as creating another facet of physical system deliverability issues.

Table 27: Natural Disasters Affecting SPR Drawdown and Deliverability (SPR 2014)

	Region Affected	Bryan Mound	Big Hill	West Hackberry	Bayou Choctaw
Gulf Coast Hurricane	**Corpus Christi, TX**	Unaffected	Unaffected	Unaffected	Unaffected
	Houston / Texas City, TX	Flooding, Power Outage, Equipment Damage	Unaffected	Unaffected	Unaffected
	Port Arthur, TX / Lake Charles, LA	Unaffected	Flooding, Power Outage, Equipment Damage	Flooding, Power Outage, Equipment Damage	Unaffected
	Baton Rouge / New Orleans, LA	Unaffected	Unaffected	Unaffected	Unaffected
	Pascagoula, MS	Unaffected	Unaffected	Unaffected	Unaffected
East Coast Hurricane	**Southeast Atlantic Coast (GA, SC, NC, VA)**	Unaffected	Unaffected	Unaffected	Unaffected
	Philadelphia, PA / Wilmington, DE	Unaffected	Unaffected	Unaffected	Unaffected
	New York / New Jersey Harbor	Unaffected	Unaffected	Unaffected	Unaffected
Tornados	**West Texas Gulf**	Power Outage, Equipment Damage, Structural Wind Damage, Fires	Unaffected	Unaffected	Unaffected
	East Texas Gulf, West Louisiana Gulf	Unaffected	Power Outage, Equipment Damage, Structural Wind Damage, Fires	Power Outage, Equipment Damage, Structural Wind Damage, Fires	Unaffected
	East Louisiana Gulf	Unaffected	Unaffected	Unaffected	Power Outage, Equipment Damage, Structural Wind Damage, Fires
Flooding	**West Texas Gulf**	Flooding, Power Outage, Equipment Damage	Unaffected	Unaffected	Unaffected
	East Texas Gulf, West Louisiana Gulf	Unaffected	Flooding, Power Outage, Equipment Damage	Flooding, Power Outage, Equipment Damage	Unaffected
	East Louisiana Gulf	Unaffected	Unaffected	Unaffected	Flooding, Power Outage, Equipment Damage

C. Petroleum Product Reserves

The severe impact of weather events to the Northeast region has prompted DOE to develop and implement regional petroleum product reserves. Most recently, the North East Regional Refined Petroleum Product Reserve (NERRPPR) was developed as a second product reserve component of the SPR. This increases total SPR product stocks to 2 million barrels split between five strategic locations.

Northeast Home Heating Oil Reserve - NEHHOR

Creation of emergency product reserves was first directed by President Clinton in July of 2000. A two million barrel distillate reserve was established as the first Northeast component of the SPR. Initially, DOE contracted commercial storage in storage three locations: Groton, CT; New Haven, CT; and Linden, NJ (Figure 8 and Table 28). Emergency heating oil stocks serve as supply buffers large enough to suppress price hikes and allow companies to resume operations during weather-related shortages.

Table 28: NEHHOR Locations and Inventory

Product Reserve	Terminal Location	Products Stored	Inventory (MBbl)
NEHHOR	Groton, CT	Ultra Low Sulfur Diesel	500
	Revere, MA		500

Figure 8: Current NEHHOR Configuration

Source: SPR 2014

Starting in 2011, changes to fuel requirements in Northeast state legislation began taking effect. Most Northeast states will be restricted to use ULSD (15 ppm or less) instead of traditional heating oil. In 2012, the NEHHOR was reduced in size to 1 million barrels of ULSD stored in Revere, MA and Groton, CT.

NEHHOR was used to provide fuel to emergency personnel and first responders for the first time after Hurricane Sandy caused severe damage to the Northeast energy infrastructure.

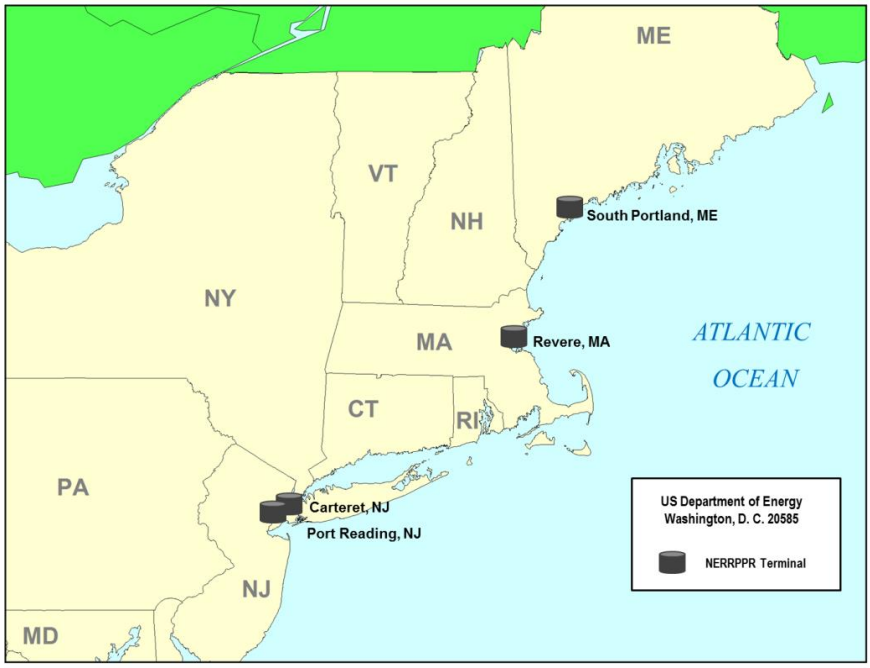
Northeast Regional Refined Petroleum Product Reserve – NERRPPR

As a result of the lessons learned from Hurricane Sandy, DOE began considering the possibility of storing gasoline, in a similar fashion as the ULSD stored in NEHHOR. The vulnerability of the New York/New Jersey Harbor to storm surges was made clear during the event. The highly interconnected network of marine terminals was completely offline, causing fuel disruptions for emergency personnel and first responders. Additional gasoline reserves would enable states, localities, and retailers to resume operations during times of crisis. Following a Secretarial Finding to develop and implement emergency gasoline reserves, DOE began collaborating with Defense Logistics Agency (DLA) to solicit storage and begin fuel acquisition in March of 2014. Commercial storage contracts were awarded in early July 2014 at three locations: South Portland, ME; Revere, MA; and Port Reading, NJ. (Figure 9 and Table 29). Fuel deliveries were made in late July and early August.

Table 29: NERRPPR Locations and Inventory

Product Reserve	Terminal Location	Products Stored	Inventory (MBbl)
NERRPPR	South Portland, ME	CBOB Gasoline	100
	Revere, MA	RBOB Gasoline	200
	Port Reading, NJ		500
	Carteret, NJ		200

Figure 9: Current NERRPPR Configuration



Source: SPR 2014

VI. Federal and State Emergency Management and Energy Assurance Plans

A. Introduction

Plans to mitigate fuel shortages during disasters have been developed at the national, state, and local levels. The Federal Emergency Management Agency (FEMA), within the Department of Homeland Security (DHS) is responsible for overseeing the relief efforts to disaster-affected areas in the United States. FEMA will only become involved if the governor of a state declares an emergency and the state is unable to adequately respond to the event with its own resources. State plans are developed either through the United States Department of Energy's Energy Assurance Program, which was established in 2009, or as part of a state-based initiative to create a general Emergency Operations Plan.

B. Federal Emergency Management Agency

The Natural Disaster Recovery Framework (NDRF) was developed by FEMA as required in the Emergency Management Reform Act of 2006. The Framework was developed in partnership with Federal, state, local, tribal, private, and non-profit partners who have a stake in the recovery following a disaster.[6]

The Framework coordinates recovery planning at all levels of government before and after a disaster. It also defines the roles and responsibilities of each stakeholder. As part of the Framework, six recovery support functions were organized:

- Community planning and capacity building recovery support function
- Economic recovery support function
- Health and social services recovery support function
- Housing recovery support function
- Infrastructure systems recovery support function
- Natural and cultural resources recovery support function[7]

The energy sector is included in the infrastructure systems recovery support function. The outcomes of this function are:

- Resilience, sustainability, and mitigation are incorporated as part of the design for infrastructure systems and as part of the community's capital planning process.
- Infrastructure systems are fully recovered in a timely and efficient manner to minimize the impact of service disruptions. The private sector critical infrastructure has the incentive and the means to support a unified community and national recovery effort.
- The capacity of all infrastructure systems is adequately matched to the community's current and projected demand on its built and virtual environment. [8]

The NDRF is aligned with the National Response Framework (NRF). While the NRF primarily addresses actions during a disaster response, the NDRF also includes guidance on effective recovery support for disaster-impacted areas.

Emergency Support Function 12 (ESF-12)

Emergency Support Functions are part of the NRF and can be activated depending on the scenario emerging from a disaster. Their activation allows coordination between different government agencies and the establishment of a team to address problems created by the crisis. Emergency Support Function 12 (ESF-12) is activated by the DOE's Office of Electricity Delivery & Energy Reliability (OE) in the event of an energy emergency.

Most often, these activations occur when there is a natural disaster that causes widespread power outages. When activated, the ESF-12 team collects and evaluates information to share with state and local governments and energy stakeholders. They can also provide technical support and issue waivers for affected areas.

While coordinated by the DOE, there are several other agencies that help support ESF-12. These are: the Department of Agriculture, the Department of Commerce, the Department of Defense, the Department of Homeland Security, the Department of the Interior, the Department of Labor, the Department of State, the Department of Transportation, the Environmental Protection Agency, the Nuclear Regulatory Commission, and the Tennessee Valley Authority.

In addition, state and local governments may have their own ESF-12 protocols and teams that mirror the structure of the Federal Emergency Support Functions.

FEMA and the Defense Logistics Agency (DLA)

FEMA currently has a contract with the DLA to supply fuel resources in the event of an emergency. The relationship between FEMA and DLA began in the aftermath of Hurricane Katrina. DLA Energy provided FEMA with thousands of gallons of ULSD and gasoline over the course of 18 months to fuel their trucks and aircraft, which provided emergency supplies to the affected areas. The event pushed FEMA and DLA Energy into an interagency agreement in March 2006 in which DLA would supply FEMA with the fuel necessary to achieve its logistical goals during a disaster.

The agreement dictates which agency is responsible for what actions during a national disaster and is guided by Joint Publication 3-28, which provides "***overarching guidelines and principles to assist commanders and their staffs in planning, conducting, and assessing defense support of civil authorities (DSCA).***"[9]

DLA supports FEMA under this mission. While the agreement covers commodities that extend beyond just energy, Annex B deals specifically with the fuel support provisions. It is reviewed every year, updated if necessary, and tested through tabletop and readiness drills at least bi-annually.

Since Katrina, the FEMA/DLA fuels agreement has been activated seven times including during Hurricanes Gustav and Ike in 2008, a major Kentucky ice storm in 2009, the spring 2011 tornado outbreak that devastated parts of the Southeast, and Superstorm Sandy.

Thus far the contract has primarily focused on covering hurricane prone states. The current four-year contract between the agencies covers the entire Southeast, the Atlantic coast as far north as North Carolina, and some Midwest states including Missouri, Illinois, and Indiana. After Hurricane Sandy, DLA is working with FEMA to expand its coverage to the entire continental United States.

As part of the agreement, and in preparation for future disasters, the DLA is required to participate in readiness drills with FEMA. As the focus is mostly hurricanes, these drills are scheduled for right before the start of the typical hurricane season, namely January through June. DLA also monitors weather events to pre-emptively see which areas could possibly require support, even before FEMA activates the fuels plan.

When a disaster looks likely, the following chain of actions will occur:

- FEMA's Logistic Management team will send a warning to DLA's Energy Operations anywhere from 7-10 days before the event to have them on alert for when they request fuel supplies.
- DLA's Energy Operations Center will notify DLA's Joint Logistics Operation Center which assesses the affected region and develops options for fuel supply and delivery.
- DLA will start prepositioning fuel supplies while they await specifics from FEMA.
- FEMA will issue their fuel order which will give specifics as to quantity, type, and location for delivery. If an affected region is not supported by the contract, FEMA can opt for a one-time, emergency fuel buy.
- Once a specific request is received, DLA has 48 hours to deliver fuel to the specified area.

It is also important to note that the two agencies are in constant, informal contact throughout the process as disaster response requires a fair amount of flexibility. For instance, FEMA will provide a general location for fuel supplies to be sent, and will follow up with more specific details as they establish their staging area.

DHS has conducted extensive assessments of critical infrastructure, auditing and reviewing sites to identify areas for improved protection and resilience.

C. Emergency Waivers of Federal and State Regulations

A critical factor in responding to natural disasters and other events that impact the supply and availability of crude oil, refined products, heating fuels, and propane is the ability of industry and government to take swift action to facilitate emergency response and availability of essential fuels and products to first responders and consumers.

Many federal and state laws impose regulatory requirements, restrictions, and permitting requirements on government and industry, for which temporary waivers may be necessary and justified for facilitate expeditious emergency response.

Federal and state agencies have identified and made provisions for such a wide variety of such waivers, including those shown in Table 30.

Table 30: Federal and State Waivers for Fuels Supply Assurance (API 2013)

Agency	Waiver	Used for	Allows
EPA	40 CFR 80.78(a)(7)	RFG	Allowing non-RFG (reformulated gasoline) fuels to be used
EPA	40 CFR 80.510 and 80.520	ULSD	Allows the use of higher sulfur diesel in older cars, generators, and for home heating
EPA	40 CFR Part 60 Subpart XX and Part 63 Subparts R,Y, and BBBBBB	Vapor Recovery	Allows fuel terminals to forego the use of vapor recovery equipment
EPA	Air permits waived for specific terminals	Tank Roof Landing Emissions	Allows greater emissions caused by the filling and re-filling of floating roof tanks
DOT	49 CFR 390	General Administrative Requirements	Allows transporters to forego regulatory requirements regarding vehicle labelling and record-keeping
DOT	49 CFR Part 192 and 195, Subpart N	General Administrative Requirements	Waives the safety and training requirements of operators to allow them to work on different projects with different companies
DOT	49 CFR Parts 391-3 and 396	Driver Qualifications	Relaxes standards used to evaluate a driver's capability to move hazardous substances
DOT	49 CFR Part 395	Hours of Service	Waives rest and work-time limitations for truck drivers
DOT	49 CFR Parts 173.242 and 172 Subparts C,D,F, and I	HazMat Specifications	Relaxes standards for vehicles used to ship fuel
DOT	46 U.S.C. 551	Jones Act	Allows foreign vessels to deliver goods between US ports.
DOT	46 U.S.C. § 55113	Foreign Oil Spill Response Vessels	Expedites allowances of foreign vessels to help in containing and cleaning oil spills
DOT	46 U.S.C. § 501	Anchor Handling	Allows the use of foreign vessels to position offshore drilling units
IRS	Publication 510 of Internal Revenue Code	Diesel Fuel Penalty	Waives requirement for reporting sales of dyed-diesel generally used for farming, for use on roads
Coast Guard	Captain of the Port Order 33 U.S.C. 1221	Vessel Movement	Allows Coast Guard to use discretion in controlling vessels through hazardous areas
State	State	RVP	States can wave RVP requirements to allow imports from less-regulated states
State	State	Biofuel Blending	Allows the lifting of blending fuel quotas
State	State	Stage I Vapor Recovery	Allows fuel terminals to forego the use of vapor recovery equipment
State	State	Weight Limits	Allows states to waive weight limits for trucks carrying fuels
State	State	Distributor License	Waives the fees and license requirements for transporting fuel
State	State	Hours of Service	Waives rest and work-time limitations for truck drivers
State	State	Retail Labelling Requirements	Allows sale of fuels that don't contain the mixture labelled at the pump

State	State	Importer/Exporter Licenses	Waives fees and licenses for importers moving across state lines
State	State	IRP/IFTA	Waives the IRP and IFTA which act as interstate fuel taxes

D. State Emergency Energy Plans

States also retain their own energy emergency response plans. Many states have created emergency support functions that parallel the NRF at the state level. Therefore a state's ESF-12 would coordinate responses to energy emergencies through state agencies analogous to federal agencies. In addition, states maintain broad State Emergency Operations Plans (SEOPs) and energy-specific Energy Assurance Plans (EAPs). States recently received funding through the American Reinvestment and Recovery Act (ARRA) to update or create EAPs. These plans are comprehensive energy response plans and thereby include energy issues outlined in SEOPs. However, not all states have publicly-available EAPs as many discuss sensitive information about specific state vulnerabilities.

Therefore, for the purposes of this report, EAPs will be given first priority when discussing state plans. If a state does not have an EAP available then the SEOP and state ESF-12 will be examined for energy-specific procedures.

State Energy Assurance Plans

Under the ARRA, states were granted nearly $38 million in funding to update or create EAPs. These plans, developed through the Department of Energy's Office of Electricity Delivery and Energy Reliability (OE), were designed to address emergency energy preparedness. Some states had emergency energy plans before 2009, but the national initiative sought to create standards for the plans and increase awareness of threats faced by the states. Many states used the funding to outline responses to energy disruptions associated with relevant risks and vulnerabilities in their state.

The two primary goals of the EAP initiative are energy assurance and resiliency. Resiliency, which is also the primary focus of this study, is defined as the ability to respond effectively to an energy emergency. Energy assurance includes not just mitigation and response, but also education, planning, outreach, and coordination.

While each state was charged with tailoring their own specific plan, the DOE's OE, in conjunction with the National Association of State Energy Officials (NASEO), set out some basic guidelines for the states to follow. In the instructions, these guidelines are summarized as:

- List state actions that will ease the impacts of short-term energy disruptions;
- Recommend long-term strategies and options for dealing with sustained disruptions or outages;
- Define critical infrastructure protection and set context for energy assurance;
- Describe coordination of state organizational relationships and responsibilities;

- Identify information that states need to know about specific fuels as well as pertinent government and industry contacts;
- Identify steps that state and territory officials can take to work with industry to minimize and resolve the impacts of an energy supply disruption; and
- Describe public information and crisis communication plans.[10]

The state plans examine threats that more or less parallel those in this report, including natural disasters, human threats, and interdependencies. Many state plans focus on both supply interruptions and protecting critical infrastructure. Common strategies of state EAPs include:

- Granting environmental and trucking waivers
- Promoting diversification of fuels and power supplies
- Using state agencies to provide information and updates to the public
- Increasing and streamlining coordination of responses and sharing of information between agencies and industries
- Encouraging voluntary measures to reduce demand in times of shortages
- Creating mandatory measures when voluntary ones fail. These commonly include:
  - Rationing based on odd/even days
  - Closing government offices or restricting work hours
  - Limiting fuel purchases or requiring a minimum purchase to prevent "topping off"
  - Limiting or reducing work week days
- Implementing Fuels Set-Aside and Priority End-User programs
- Updating Emergency Support Functions that parallel those under the National Response Framework

Fuels Set-Aside Programs

Many states have a Fuels Set-Aside program that allows the government to procure and direct petroleum stocks during an energy emergency. The program was enacted after the Arab Oil Embargo under the Federal Mandatory Petroleum Allocation program. When that program ended in 1981, many states wrote legislation that would allow the program to be activated in the future if necessary. The goal of the program is to allow a state emergency office to ensure that emergency responders have fuel to carry out their duties. For instance, California, a state with a long-standing Fuels Set-Aside program, can invoke the program through an executive emergency order by the governor. This order gives the state's Energy Commission the power to purchase fuel directly from the state's refineries for use of emergency services. States without refining capacity are able to reserve fuels directly through suppliers. The programs do not represent a seizure of fuels, but allow the states to purchase them at market price.

NASEO has noted that Fuels Set-Aside programs, while useful for prolonged energy crises, can do little to alleviate temporary shortages.[11] In these more common situations, they instead advocate for a priority end-user program which can be a much more rapid and simpler approach to emergencies caused by

natural disasters or singular instances of human malevolence. Rather than require a certain percentage to be set-aside, a priority end-user program would ensure that suppliers continue to provide normal volumes of fuel to emergency services during a crisis. If the crisis continues for a prolonged period then states can activate the Fuels Set-Aside programs.

State Energy Guidelines by Fuel Type

State EAPs generally focus on liquid fuels, natural gas, and electricity generation. Given the purpose and scope of this report, guidelines for electricity resiliency will not be discussed even though they serve as a key interdependency in fuel resiliency. It is also important to note that natural gas contributes more and more to electricity production, especially in the years since the guidelines were written. Therefore, concerns over natural gas supply in recent state plans often specifically reflect concerns over electricity resiliency.

Natural Gas

Natural gas systems are generally more resilient than both electric and petroleum systems due to their built-in redundancy and primarily underground distribution infrastructure. However, when disruptions do occur in the system, they can often cause greater problems for both supply and public safety. Leaks in pipelines can cause explosions, and if gas is shut off to a large number of customers, it can take prolonged periods to resume service. Moreover, during energy emergencies, the onus of restoration generally falls on the LDC as they control the entirety of the end-user distribution system, and consumers do not have the option to easily switch suppliers. For these reasons, federal law requires LDCs to have their own emergency plans in the event of disruptions. These plans often include:

- Purchasing and transporting additional gas to meet demand
- Increasing withdrawals from storage
- Increasing withdrawals from other operating systems
- Increasing pipeline pressure if possible
- Asking that customers consumer less
- Attempting to purchase imports of LNG
- Interrupting the supply to selected customers
- Cutting off gas as a last resort[12]

Given the nature and structure of natural gas delivery, there are few options a state government has to mitigate an energy shortage. Basic measures states can take include reviewing company plans, monitoring conditions, and requesting federal assistance. Only about half of states are able to implement curtailment policies which would force natural gas providers to shut off gas service. However, because a large number of states rely on others for natural gas deliveries, curtailments in supply could create gas shortages in downstream states and amplify the crisis. To better understand how curtailment policies would affect a state's gas supply, the National Association of Regulatory Utility Commissioners (NARUC) developed a mapping tool that shows state policies and natural gas consumption patterns.[13]

Petroleum

Unlike natural gas and electricity, petroleum products are not normally considered a utility and therefore face an altogether different emergency preparedness challenge. The petroleum supply chain relies on both a variety of specialized firms to deliver products, as well as large dominating firms that control product all the way from the wellhead to the consumer. Therefore, state emergency plans call for the coordination of multiple firms and energy stakeholders to ensure fuel deliveries.

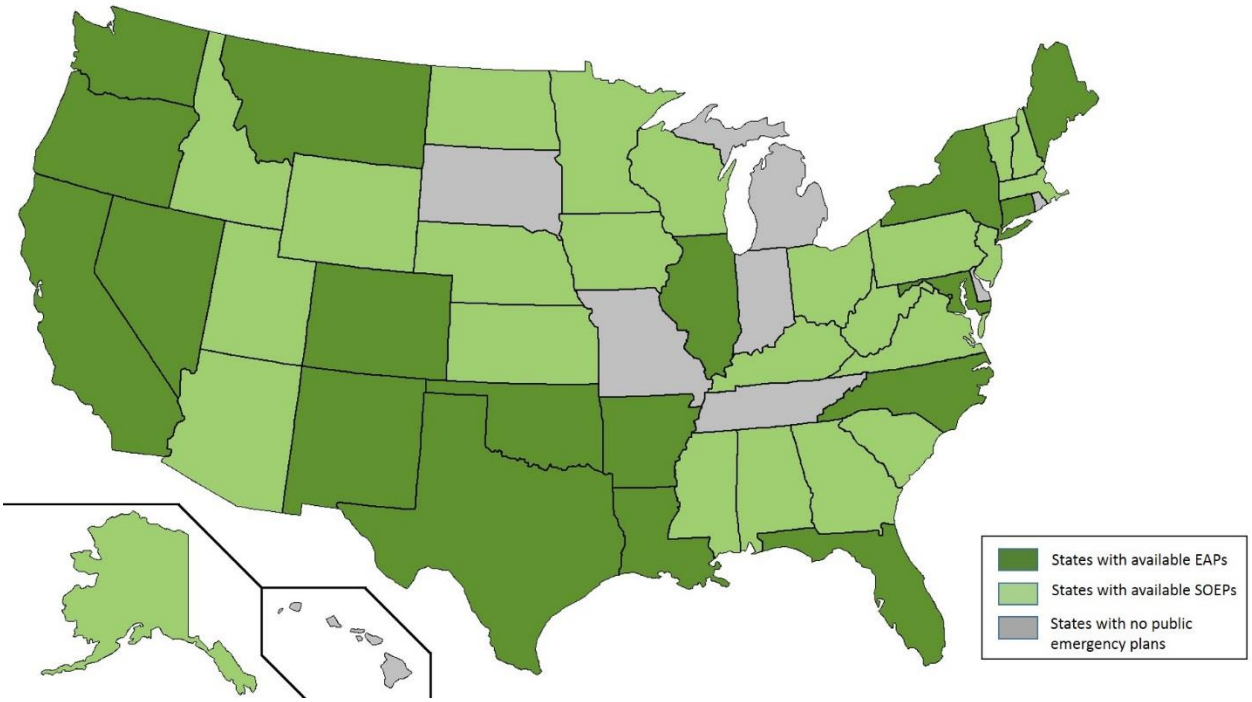
Petroleum supply also faces an entirely different vulnerability structure than natural gas. First, states rely on foreign imports to supply either crude or products. In contrast, the U.S. imports only small quantities of natural gas, and nearly all of it comes from Canada by pipeline. States are unable to control situations overseas and other external factors which may affect the supply of oil. Studies also suggest that the demand for natural gas is more inelastic than the demand for gasoline, meaning that given a price increase, consumers will reduce their demand for gasoline more quickly than they would for natural gas given a similar price hike. Therefore, states often favor a free market approach to petroleum shortages. If there is less supply of petroleum, the price will rise and people will consume less, naturally balancing the market.

However, there are times when disruptions in supply and energy emergencies are not solved naturally by market forces. In these cases, states have a large array of strategies they can use that focus on short-term emergency mitigation and long-term preparation through energy assurance. One popular long-term plan is the promotion of alternative fuels such as ethanol flex vehicles and CNG for public transportation fleets. These diversification strategies help to ease reliance on a single energy source and can provide more flexibility in dealing with a shortage of any one fuel. Other strategies recommended for states are:

- Requiring localities to develop their own emergency fuel plans
- Requesting voluntary actions from consumers, such as:
    - Carpooling, telecommuting, flexible work schedules, and other demand-reduction
    - Encouraging reductions in energy use; including reducing energy use in state facilities
- Working with the EPA to request waivers for gasoline outside of local air quality requirements
- Working with the DOE to obtain Jones Act waivers to allow foreign ships to relocate petroleum products within U.S.
- Working with the Federal Motor Carrier Safety Administration to obtain waivers for truck driver hours of service restrictions
- Pursue mandatory policies if the emergency becomes severe, such as:
    - Establishing a “Priority End User Program” to allocate resources to emergency services
- Establishing a “Fuels Set-Aside” program to allocate fuels to critical services and industries.[14]

All but three of the 50 states have completed State Energy Assurance Plans supported by funding from the DOE Office of Energy Assurance. Per statutory requirements or at the discretion of the respective states, some of these plans are publically available, while others are deemed confidential (Figure 10).

Figure 10: States with Publicly Available EAPs and SOEPs



Source: INTEK Inc., 2014 and Internet Sources

The major fuels supply provisions of the publically available state energy assurance plans are summarized in an Appendix III-1 to this document.

VII. Resiliency Stress Tests for Selected Supply Interruption Scenarios

A. U.S. Import Dependence

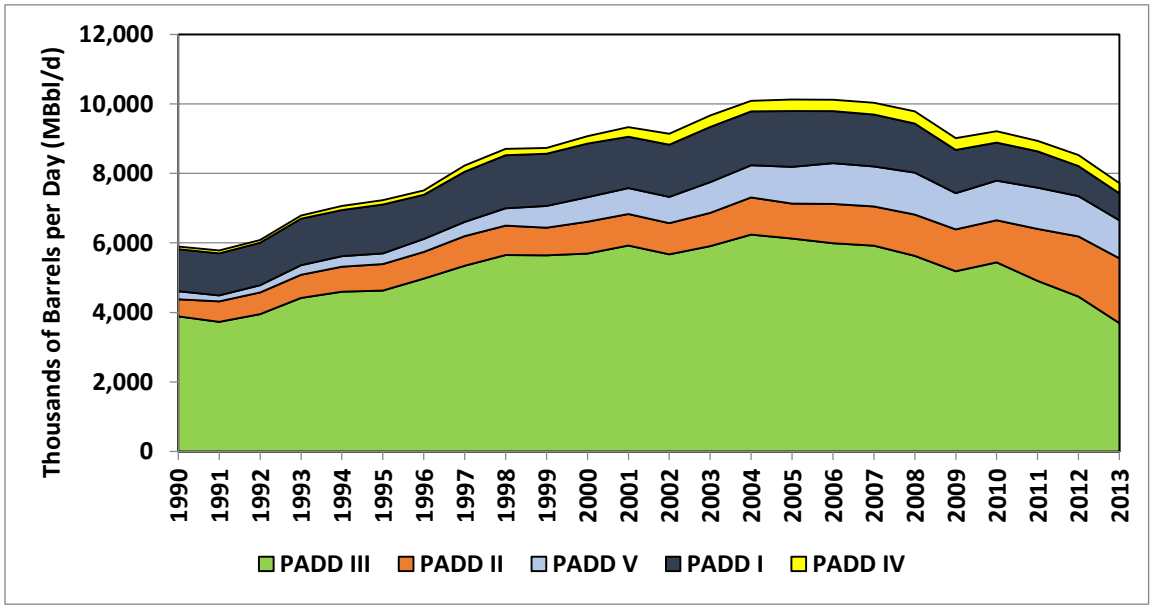
Import Volume and Quality

Gross crude imports to the U.S. were 7.72 MMBbl/d in 2013 and have been on the decline since 2010 (Figure 11). PADD III experienced significant decline, while PADD II saw moderate increases from Canada. These trends are both attributed to the rapidly increasing supply of North American crude.

- Bakken and Eagle Ford crudes are now flowing to Gulf Coast markets, facilitated by rail and barge shipping routes, pipeline reversals, and an extensive makeover of the U.S. crude pipeline infrastructure.
- Canadian crudes have flooded PADD II and are becoming more accessible to PADDs I, IV, and V as new pipeline projects and rail facilities become increasingly integrated into existing infrastructure networks.

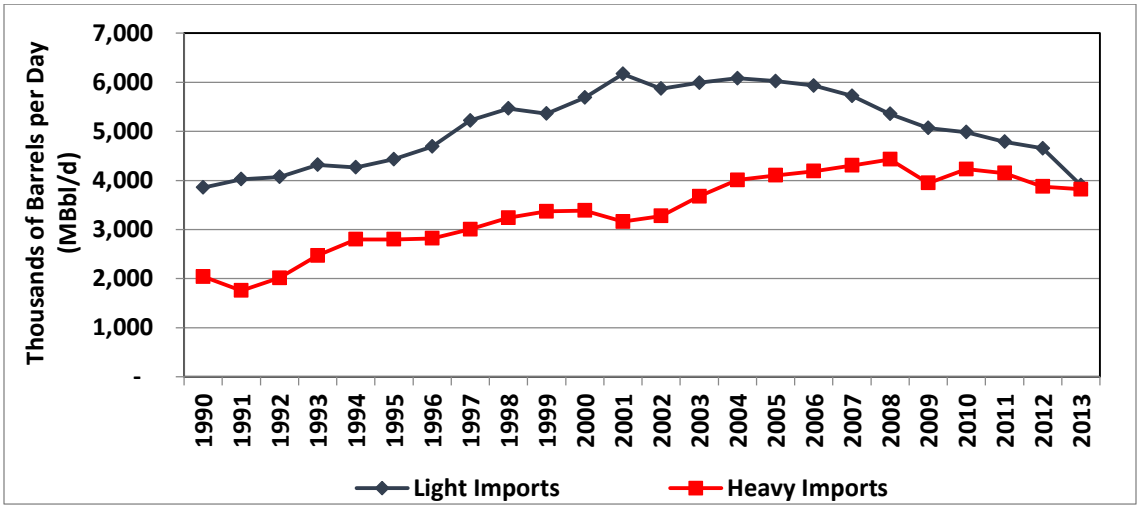
The North American crude renaissance has provided primarily lighter grades of crude with a low sulfur content which is consistent with an overall decline in light grade imports. Imports of heavy oil grades however, remain relatively constant (Figure 12).

Figure 11: Gross Crude Imports by Area of Entry



Source: EIA, Petroleum & Other Liquids, U.S. Imports by Area of Entry

Figure 12: Heavy vs. Light Crude Oil Imports

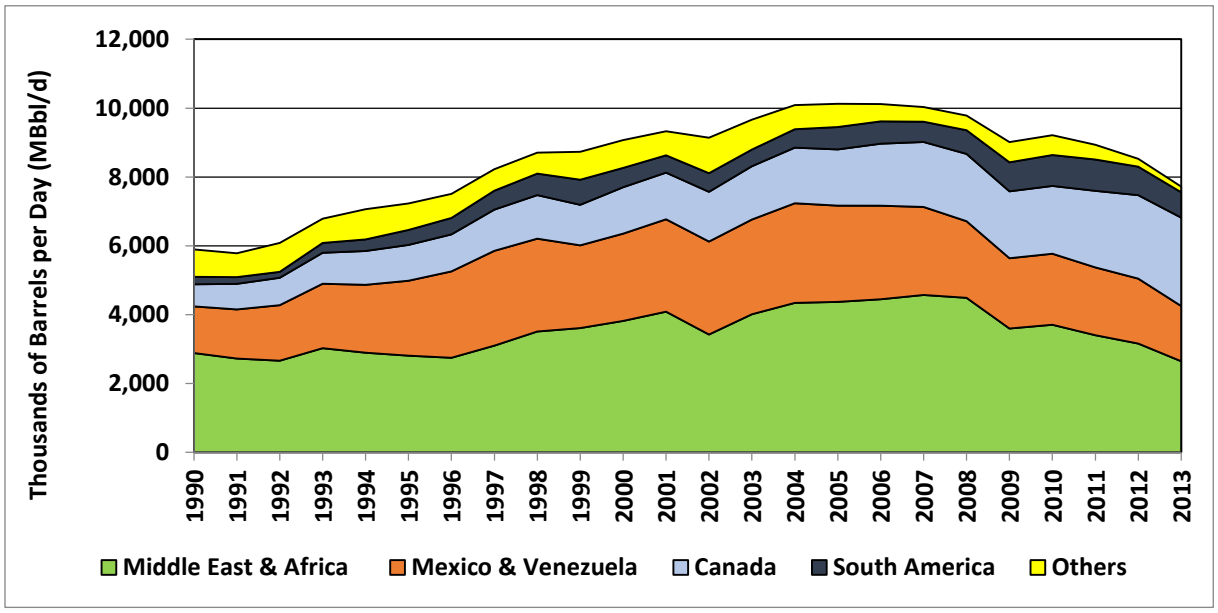


Source: EIA, Petroleum and Other Liquids, Percentages of Total Imported Crude Oil by API Gravity

B. Origins of U.S. Imports and Quality

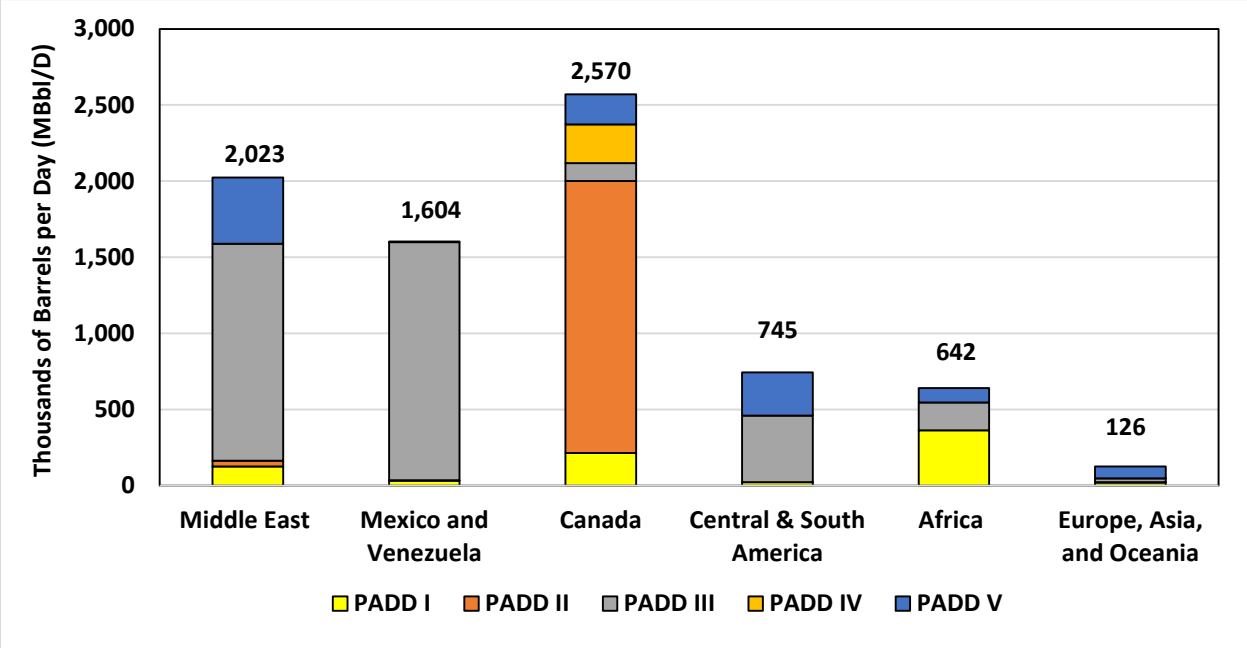
The United States imports the majority of its crude from across the Atlantic in the Middle East or Africa, across the Gulf of Mexico from Mexico and Venezuela, or from Canada (Figure 13). Excluding Canada, imports from other regions of the globe have all declined in recent years.

Figure 13: U.S. Crude Oil Imports by Region of Origin



Source: EIA, 2014

Figure 14: U.S. Crude Oil Imports Destinations



Source: EIA 2014

Middle Eastern and African countries are geographically situated to supply the East and Gulf Coasts. Larger volumes of Middle Eastern crude reach PADD V due to its larger export volumes and access to larger ocean-going tankers (Panamax). PADD V refineries also favor light sour oil, making Saudi blends more favorable than African light sweet. As the domestic light sweet supply increases, analysts expect to see light grade imports from the Middle East, Africa, Europe, Asia, and Oceania decline(Figure 14).

Most of the heavy sour oil refined in the United States originates in either Central or South America. Mexico and Venezuela accounted for almost 40 percent of U.S. heavy sour imports in 2013. Canada also provided 40 percent of heavy sour imports in 2013, but the majority was refined in PADD II.[15] Heavier crude grades are also favored by PADD III refineries due to the common Gulf Coast 'deep conversion' refinery scheme.[16] Deep conversion increases the share of middle distillates and lowers the share of heavy products and residuals. Geographically, PADD III is situated for convenient shipping routes across the Gulf of Mexico, making Mexico and Venezuela strategic sources of heavy crude.

As imports of Mexican and Venezuelan crudes decline, and Canadian supplies increase, refiners in PADD III are looking to Canada as an alternative source of heavy, sour crude. With the new southbound pipeline capacity and the possibility of the Keystone XL, PADD III refineries may be able to rely mainly on North American crude oils.

Canadian crude oil production is expected to grow steadily to 2030. Heavy crude from oil sands production was 1.8 MMBbl/d in 2012 and is projected to reach 5.2 MMBbl/d by the end of the outlook.[17]

C. Import Disruption Stress Tests

The United States imports the majority of its crude from across the Atlantic in the Middle East or Africa, across the Gulf of Mexico from Mexico and Venezuela, or from Canada. Excluding Canada, imports from other regions of the globe have all declined in recent years.

Due to geopolitical situation and volatility in world crude markets, U.S. supplies could be disrupted by as much 2.5 MMBbl/d depending on the countries involved in conflict and the duration of such conflict.

The following disruption scenarios were developed and ranked based on probability of occurrence, magnitude of disruption, and its potential impact on U.S. crude supplies and economy.

1. Venezuelan strikes
2. Iraq conflict worsens
3. Temporary restriction of cargo through Straits of Hormuz
4. Russian conflict with western world
5. Disruption to Saudi Arabia's export facilities
6. Disruption to Mexican oil infrastructure
7. Infrastructure damage and ports closures in Nigeria

1. Venezuela Disruption

Description of Disruption: Due to a labor strike or political unrest in the country, all exports from Venezuela are halted to the United States and other importing countries for one month.

Background:

In 2013, Venezuela was the largest supplier of heavy crude oil to the United States.

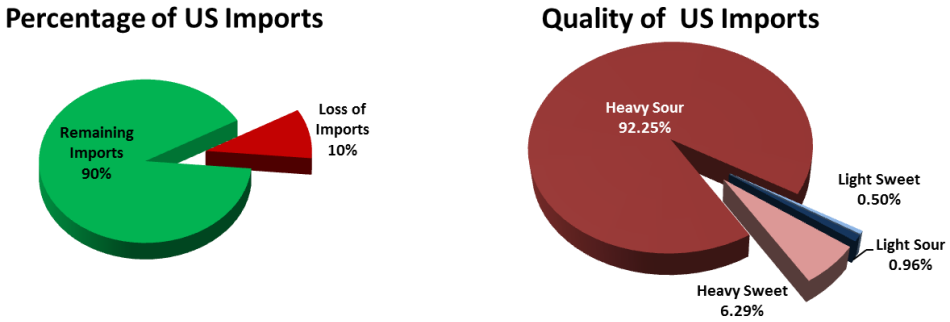
Venezuela consistently ranks as a top U.S. supplier and is located close to Gulf Coast refineries and the Panama Canal. In recent years, an increasing share of exports have been delivered to Asian markets due to foreign investments.

The Venezuelan government seeks to offset production declines by placing financial pressures on foreign operators.

U.S. imports from Venezuela have been declining in recent years. In 2013, the United States imported approximately 754 MBbl/d of crude oil and petroleum products from Venezuela, a decline of 49% from a decade ago (Figure 15).

Estimated U.S. Crude Import Loss	
PADD	**Imports Lost (Bbl/d)**
I	27,420
III	721,090
V	5,200

Figure 15: Effects of Venezuelan Disruption on U.S. Crude Oil Supply



Options to Mitigate Supply Loss:

- The United States could release oil from SPR to meet the demands of U.S. refineries. U.S. refiners will process SPR light sour instead of Venezuela Heavy
- U.S. refiners may increase utilization to meet product demand from stocks in storage.

Resiliency Options:

PADD I	• Minimal loss of products. • Refiners may find alternate suppliers during the disruption or switch suppliers.
PADD III	• Increased refinery utilization. • Release of crude oil from SPR to meet demand as a result of disruption.
PADD V	• Minimal loss of products. • Refiners may find alternate suppliers during the disruption or switch suppliers.

2. Iraq Disruption

Description of Disruption: Due to geopolitical tensions, Iraq's Persian Gulf ports are unable to export any crude. As a result, refineries in the United States, India, China, South Korea and other Asian countries will not receive any crude from Iraq. Disruption could last anywhere from one week to about two months.

Background

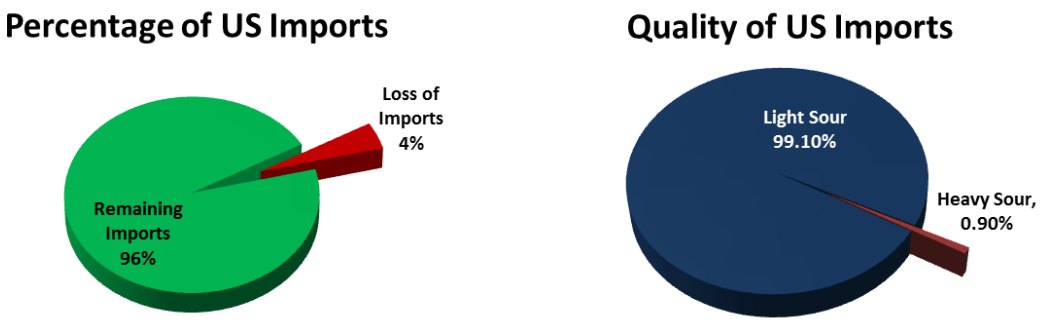
Iraq was the world's eighth largest producer of total petroleum liquids in 2012 and has the world's fifth largest proven petroleum reserves. Despite its large reserves, Iraq's oil production potential has suffered due to infrastructure constraints and political instability.

Iraq exports about 2.1 MMBbl/d of crude oil per day from its Persian Gulf ports. However, the United States receives only 16 percent, about 320 MBbl/d.

Iraq provides 4 percent of total U.S. imports, nearly all of which is light sour crude. PADD V (West Coast) could lose 15 percent of its crude oil imports (Figure 16).

Estimated U.S. Crude Import Loss	
PADD	**Imports Lost (Bbl/d)**
I	8,930
III	187,370
V	145,480

Figure 16: Effects of Iraqi Crude Disruption on U.S. Crude Oil Supply



Options to Mitigate Supply Loss:

- IEA collective action may be needed.
- The United States could release oil from SPR to meet the demands of US refineries.

Resiliency Options:

PADD I	• SPR crude could be delivered (Transit time ~10-14 days) with Jones Act waivers. • Products could be either shipped from PADD III, or NERRPPR stocks may be used.
PADD III	• Increased refinery utilization. • Release of crude oil from SPR to meet demand as a result of disruption. • Participate in any IEA collective action.
PADD V	• Release of crude oil from SPR will take 14-21 days to reach the West Coast. • Commercial products stocks are 6-9 days.

3. Strait of Hormuz Disruption

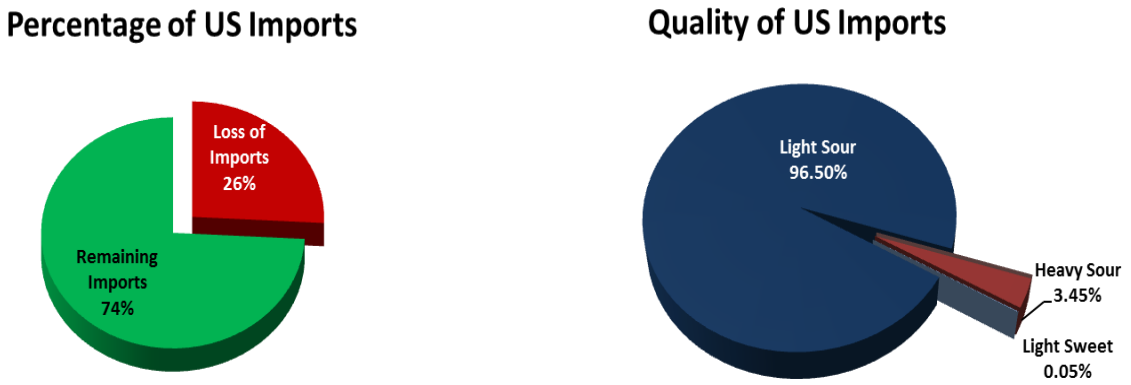
Description of Disruption: Geopolitical conflict or military action results in the closure of Strait of Hormuz, cutting supplies from Persian Gulf countries. Restricted flow from the Strait will cause massive global crude and product supply disruptions.

Background

In 2013, approximately 17 MMBbl/d moved through the Strait of Hormuz to global markets. The United States received just shy of 2 MMBbl/d. A large scale disruption may cause the United States to lose at least 2-2.5 million barrels per day or more of imports as exports from Europe, Africa, and MENA normally destined for the United States will be diverted to European and Asian markets. IEA collective action will be needed to meet the demands of the IEA member countries and dampen price shocks from the shortage. A disruption would have significant impacts on PADD V (Figure 17).

Estimated U.S .Crude Import Loss	
PADD	**Imports Lost (Bbl/d)**
I	96,730
III	1,463,130
V	434,770

Figure 17: Effects of Straits of Hormuz Disruption on U.S. Crude Oil Supply



Options to Mitigate Supply Loss:

- IEA collective action will be needed to mitigate supply disruption.
- The United States could release oil from SPR to meet the demands of U.S. refineries and possibly also look into exporting crude to European refiners; Jones Act waivers will be required.

Resiliency Options:

PADD I	• Refiners may switch suppliers or receive crude from Canada and Bakken or SPR.
PADD III	• Release of crude oil from SPR will be required to meet demand as a result of disruption. • Jones Act waivers would be needed for faster delivery of SPR crude to refiners
PADD V	• SPR crude could be delivered (Transit time ~14-21 days) with Jones Act waivers. • Industry stocks are only 6-9 days. Other smaller product reserves should be considered to mitigate short term supply loss to PADD V refiners while waiting for crude supplies from SPR.

4. Russia Disruption

Description of Disruption: The United States and EU levy harsher economic sanctions, barring all trade with Russia. As a result, Russia stops exporting oil to European markets.

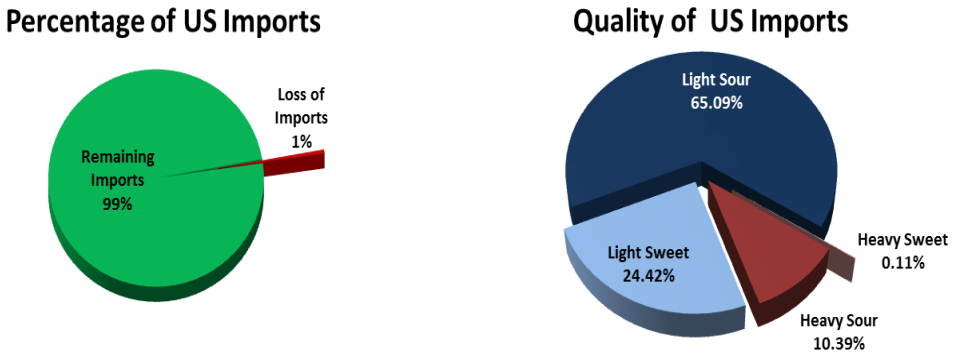
Background

Russia exports around 7 MMBbl/d. Any reduction in exports from Russia's Black Sea ports will cause significant supply shortages in Europe and have significant impact on global oil prices.

This event will reduce global crude oil supply and distribution by over 4 MMBbl/d. As the U.S. receives very little Russian crude oil, the indirect loss of crude oil will be at least 1 to 1.5 MMBbl/d as cargo ships destined to U.S. refiners will be diverted to European refiners (Figure 18).

Estimated U.S. Crude Import Loss	
PADD	**Imports Lost (Bbl/d)**
I	2,990
III	6,870
V	34,940

Figure 18: Effects of Russian Disruption on U.S. Crude Oil Supply



Options to Mitigate Supply Loss:

- IEA Collective Action may be needed to meet supply shortages to IEA member countries.
- The United States could release oil from SPR to meet the demands of U.S. refineries.

Resiliency Options:

PADD I	• SPR crude could be delivered (Transit time ~10-14 days) with Jones Act waivers.
PADD III	• Increased refinery utilization. • Release of crude oil from SPR (IEA collective action) to meet demand as a result of disruption. • Jones Act waivers are required to ship to PADD I and V.
PADD V	• SPR crude could be delivered (Transit time ~14-21 days) with Jones Act waivers. • Other options of smaller product reserves should be considered to mitigate short term supply disruption while waiting for crude supplies from SPR.

5. Saudi Arabia Disruption

Description of Disruption: A terrorist attack on Saudi Arabia's oil processing facility at Abqaiq results in temporary shutdown of export facilities restricting exports by 6 MMBbl/d for an extended period of time.

Background

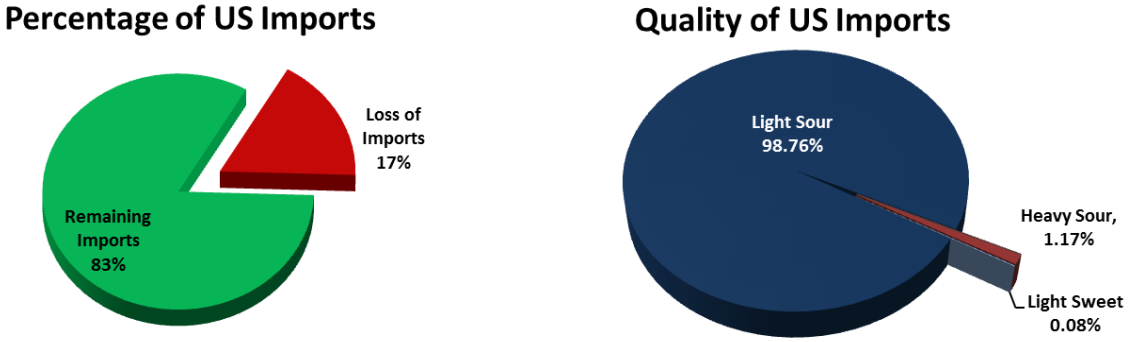
Saudi Arabia exported an estimated 8.84 MMBbl/d of crude oil in 2013. East Asia received an estimated 54 percent of Saudi Arabia's crude oil exports, as well as the majority of its refined petroleum product and natural gas liquids (NGL) exports.

Saudi Arabia exported an average of 1.32 MMBbl/d of crude oil to the United States in 2013, accounting for 17.2 percent of total U.S. crude oil imports. PADD V will lose almost 20 percent of its crude oil imports (Figure 19).

In addition to direct import losses, the United States may lose additional volumes of imports as crude destined for the United States may be diverted to other markets.

Estimated U.S. Crude Import Loss	
PADD	**Imports Lost (Bbl/d)**
I	87,810
III	964,020
V	271,520

Figure 19: Effects of Saudi Arabian Disruption on U.S. Crude Oil Supply



Options to Mitigate Supply Loss:

- IEA collective action will be needed.
- US could release oil from SPR to meet the demands of U.S. refineries and possible also look into exporting crude to European refiners. Jones Act waivers will be required

Resiliency Options:

PADD I	• SPR crude could be delivered (Transit time ~10-14 days) with Jones Act waivers.
PADD III	• Release of crude oil from SPR will be required to meet demand • Jones Act waivers will be needed if U.S. flag vessels are not available on Gulf Coast
PADD V	• SPR crude could be delivered (Transit time ~14-21 days) with Jones Act waivers. • Other options of smaller product reserves should be considered to mitigate short term supply disruption while waiting for crude supplies from SPR.

6. Mexico Supply Disruption

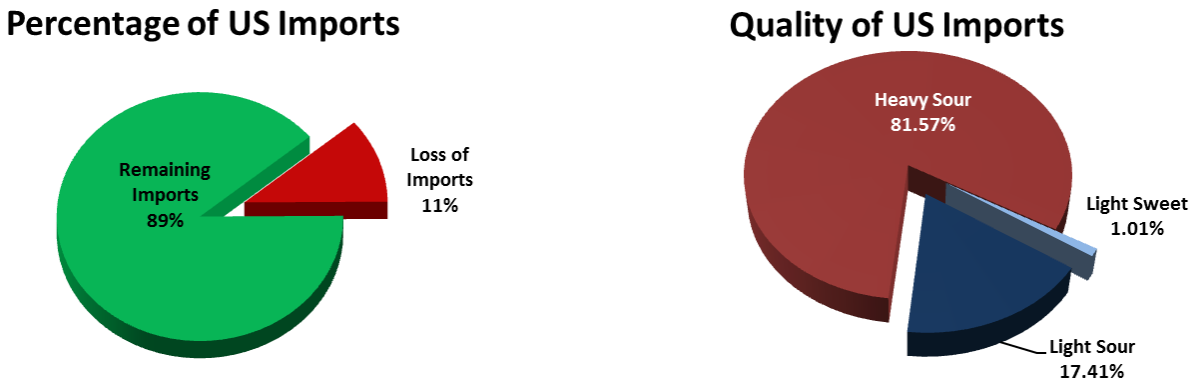
Description of Disruption: Production decline, a southern Gulf Coast hurricane, or illegal oil theft cripple Mexico's oil output. Supply disruptions from Mexico can last up to seven days and will have short term supply impact.

Background:

Mexico is a top ten world oil producer and third in the Americas behind Canada and the United States. In 2013, it produced 2.5 MMBbl/d of which nearly 40 percent was exported to the United States (Figure 20).

Estimated U.S. Crude Import Loss	
PADD	**Imports Lost (Bbl/d)**
I	7,030
III	843,660
V	0

Figure 20: Effects of Mexican Disruption on U.S. Crude Oil Supply



Options to Mitigate Supply Loss:

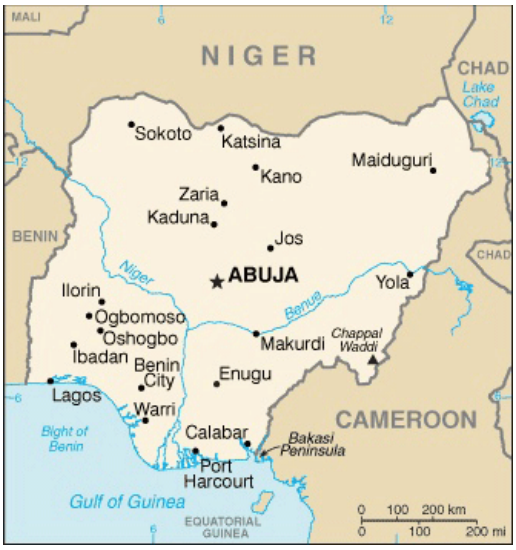
- The United States could release oil from SPR to meet the demands of U.S. refineries.
- U.S. refiners will process SPR light sour instead of Mexican heavy crude.
- Increased Canadian supplies of heavy crude could offset Mexican shortages.

Resiliency Options:

PADD I	• Refiners may switch suppliers or receive crude from Canada and Bakken or SPR. • SPR crude could be delivered (Transit time ~10-14 days) with Jones Act waivers.
PADD III	• Increased refinery utilization. • Release of crude oil from SPR will be required to meet demand. • Jones Act vessels may be needed if U.S. flag vessels are unavailable.
PADD V	• No action needed.

7. Nigeria Supply Disruption

Description of Disruption: Civil unrest in the Niger delta causes disruption of oil supplies to adjacent ports. Several pipelines are damaged by rebels and ports have been taken over causing oil export shutdown from Nigeria.



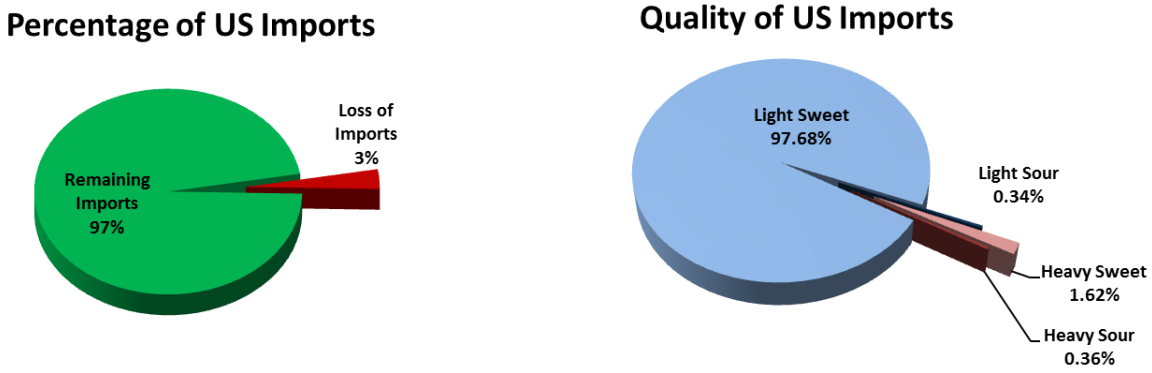
Background

Europe and India are the largest importers of Nigerian crude. Growth in U.S. light sweet crude oil production from the Bakken and Eagle Ford areas has resulted in a sizable decline in U.S. imports of crude grades of quality similar to Nigeria's.

Any disruption in Nigeria will result in about 2 MMBbl/d of crude shortage in global markets and will also significantly affect oil prices. Light crude cargoes may be diverted to European markets resulting in a cumulative loss of around 1 MMBbl to U.S. markets (Figure 21).

Estimated U.S. Crude Import Loss	
PADD	**Imports Lost (Bbl/d)**
I	169,300
III	65,740
V	3,980

Figure 21: Effects of Nigerian Disruption on U.S. Crude Oil Supply



Options to Mitigate Supply Loss:

- Refiners will require more light crude.
- IEA collective action may be required.

Resiliency Options:

PADD I	• Extra shipments from Bakken, Eagle Ford could be diverted to meet the demand. • SPR crude could be delivered (Transit time ~10-14 days) with Jones Act waivers.
PADD III	• Increased refinery utilization. • Release of crude oil from SPR to meet demand as a result of disruption.
PADD V	• Minimal loss of refined products.

Import Stress Test Analysis Summary

Four geographical regions and their crude export qualities were ultimately highlighted from the stress test results: Central and South America supplying heavy sour oil, the Middle East supplying light sour oil, and Nigeria and Russia supplying light sweet and sour oils. Any disruption of foreign imports could result in direct domestic crude losses anywhere from 350 to 2,000 MBbl/d. PADD III, as the largest refining center, will be affected by all disruptions, but is mainly vulnerable to heavy oil imports from Mexico and Venezuela. PADD I and V refineries are more reliant on light oils and will be mainly vulnerable to light Middle Eastern sour blends.

Depending on the size and duration of the event, global import disruptions pose direct and indirect domestic supply vulnerabilities. In all cases, U.S. coastal refiners will be affected, but the magnitude may rise indirectly as international oil movements respond to increased global demand and price spikes.

The level of threat to domestic and international refiners was assessed for each case (Table 31). Disruptions from Venezuela, Mexico, and Persian Gulf countries pose medium to high threats to domestic refiners, but DOE studies have shown that refiners can substitute light and heavy imports with SPR oil. With increased supply of North American light oils, domestic refiners will not be severely impacted by light oil disruptions from Russia and Nigeria; however, these disruptions, along with the Middle East cases, present high global threats which may require IEA collective actions to mitigate.

Table 31: Oil Supply Disruption Threat Levels

Disruption Case	Oil Quality	Domestic Threat Level	Global Threat Level
Venezuela	Heavy Sour	Medium - High	Low - Medium
Mexico	Heavy Sour	Medium - High	Low - Medium
Strait of Hormuz	Light Sour	High	High
Saudi Arabia	Light Sour	High	High
Iraq	Light Sour	Low - Medium	High
Russia	Light Sweet & Sour	Low	High
Nigeria	Light Sweet & Sour	Low	Medium - High

In the past, the SPR has released oil to international markets in IEA-coordinated actions such as with the Libyan crisis in 2011, and also to domestic refiners under Presidential authority during the Gulf War conflict in Iraq. The SPR can deliver oil to PADDs I, III, and V in disruption scenarios, however its marine capabilities will be constrained by availability of ocean vessels and dock utilization and transit time.

Options to Mitigate

1. IEA Collective Action will be required to mitigate high threats from large global disruptions.
2. SPR can supply oil to coastal refineries, but is constrained by vessel and dock availability.

Options to Consider

1. To assess increased marine capacity for SPR
2. Evaluate options for crude or product reserve in the West Coast as PADD V is highly vulnerable to large supply disruptions and SPR crude can take up to 21 days to reach the West Coast.

D. Hurricane Stress Tests

Scenarios were modeled using the hurricane disruption model developed for the Office of Petroleum Reserves. This model is based on past hurricane disruptions in the PADD III Gulf of Mexico region. This model has been regularly calibrated against current storms and uses a probabilistic approach to define refinery capacity outages and loss of products to the Gulf Coast as well as the Southeast states.

For the purpose of this study, the model was used to predict shortfalls in Southeast and Gulf of Mexico for three potential hurricane landfall locations, each at various levels of intensity, ranging from Category One to Category Three. Loss of GOM natural gas and oil production was also estimated for various storm strengths.

The three hurricane paths and landfall locations analyzed are:

- Galveston, TX;
- Port Arthur, TX, and
- East New Orleans, LA.

The Regional Fuels Resiliency GIS model was used to identify major oil and gas TS&D infrastructure in the paths of these hurricanes.

The following cases summarize the analyses conducted and results achieved for each of these three hypothetical landfall locations.

1. Hurricane Landfall – Galveston Bay, TX

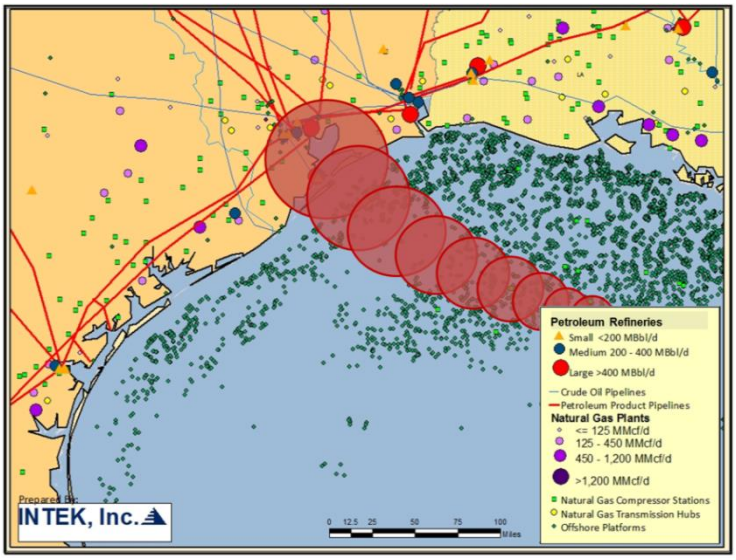
As with Hurricane Ike, a hurricane making landfall in the Galveston Bay area is could shut down more than 95 percent of crude oil and natural gas production in the Gulf of Mexico. Landfall in the area would cause significant wind damage, flooding, storm surge, and power outages resulting in suspended operations of ports, pipelines, terminals, and refineries. All imports and exports will be restricted due to flooding of major waterways and port facilities. Crude and product transportation operations will be unavailable with terminals and pipelines offline as a result of damage, flooding, or power loss. Depending on the size and strength of the hurricane, as much as 2,338 MBbl/d of refining capacity in the Houston - Texas City area will be offline. This represents 13 percent of the U.S. refining capacity and nearly 26 percent of Gulf Coast refining capacity. Additionally, Port Arthur refineries to the east may experience indirect outages due to supply shortage or weather impacts elsewhere. Thus, a Galveston landfall could indirectly affect another 2,395 MBbl/d of Gulf Coast refining capacity.

Crude and Product Infrastructure Outages

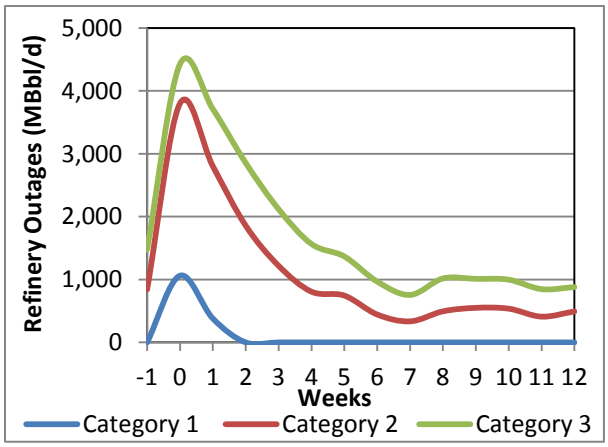
- **Crude Pipelines**: Magellan, Ho-Ho, Amdel, Texas, West Texas Gulf, Seaway, Longhorn
- **Refineries**: 9 - 20
  Capacity (MBbl/d): 2,091 - 4,543
- **Petroleum Terminals**: 49 - 83
  Capacity (MMBbl): 181 - 256
- **Product Pipelines**: Colonial, TEPPCO, Explorer, Magellan, Central West, Centennial
- **SPR Sites:** Bryan Mound
  Total Inventory (MMBbl): 240

Natural Gas Infrastructure Outages

- **Processing Plants**: 5 - 37
  Capacity (MMcf/d): 443 - 6,130
- **Compressor Stations**: 13 - 86
- **Transmission Hubs**: 3 - 8
  Capacity (MMcf/d): 3,750 - 7,960



At Week 0 (landfall), the hurricane model predicts from 1.1 to 4.5 MMBbl/d of refining capacity outages. Refineries experiencing Category 1 damage may recover by Week 2. From 80 to 90 percent of refineries will initially recover from Category 2 and 3 damage between Weeks 4 and 5. The pace of refinery recovery will depend on power supply restoration. Complete recovery may take from 5 to 12 weeks, for more significant repairs. Refining outages of this size and duration could disrupt from 11 to 185 MMBbl of product supply. A Category 3 landfall will displace ~168 MMBbl of Gulf Coast products over the full 14 week period. Houston is the primary injection point to the Colonial pipeline. From 1 to 17 MMBbl of products could also be lost to Southeast states by Colonial Pipeline downtime.



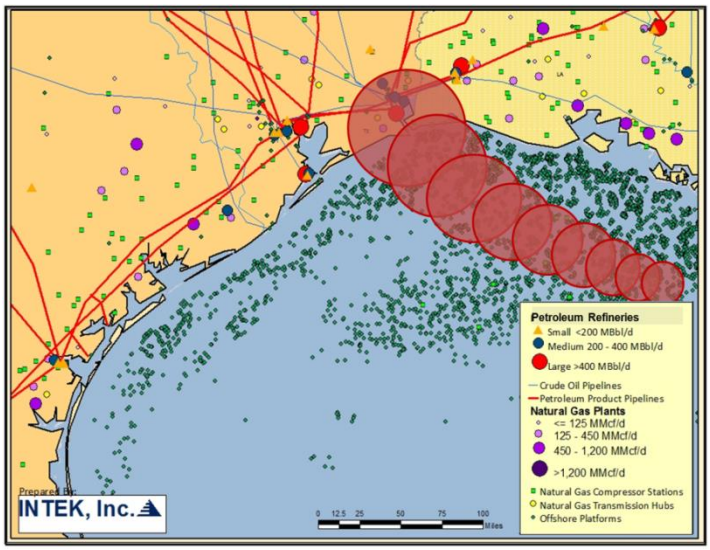
Area Affected	Category 1	Category 2	Category 3
Gulf Coast Product Shortfall (MBbl)	10	107	168
Southeast Product Shortfall (MBbl)	1	8	17

2. Hurricane Landfall – Port Arthur, TX

Just east of Galveston, Port Arthur's TS&D infrastructure is also highly susceptible to Gulf Coast hurricanes. By Hurricane Rita's landfall, 100 percent of Gulf of Mexico crude oil production was shut in, and only 15 percent of natural gas production remained online. Landfall in the area will affect all ports, waterways, terminals, pipelines, and refineries due to flooding, storm surge, wind damage, and power outages. The Port Arthur area represents approximately 26 percent of total Gulf Coast refining capacity. Similar to the Galveston Bay case, the proximity of Port Arthur and Houston area refineries could both be impacted by a landfall in either area. Together, these areas make up 52 percent of Gulf Coast refining capacity and are major, interdependent hubs for oil and natural gas TS&D infrastructure.

Crude and Product Infrastructure Outages

- **Crude Pipelines**: Ho-Ho, Amdel, Texas, West Texas Gulf, Longhorn, Seaway, North Louisiana System
- **Refineries**: 8 - 21
  Capacity (MBbl/d): 2,205 - 4,623
- **Terminals Affected**: 24 - 83
  Capacity (MMBbl): 73 - 257
- **Product Pipelines**: Colonial, TEPPCO, Explorer, Centennial, Central West
- **SPR Sites:** Big Hill, West Hackberry
  Total Inventory (MMBbl): 375

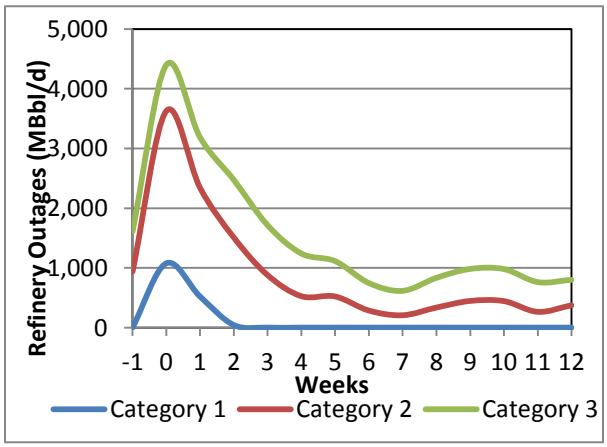


Natural Gas Infrastructure Outages

- **Processing Plants**: 6 - 39
  Capacity (MMcf/d): 1,675 - 7,492
- **Compressor Stations**: 14
- **Transmission Hubs**: 2 - 14
  Capacity (MMcf/d): 750 - 12,470

Similar to the Galveston case, at landfall, model predictions suggest anywhere from 1.1 up to 4.5 MMBbl of daily refining capacity outages. Refineries experiencing Category 1 damage may be fully recovered by Week 2.

More significant damage from Category 2 and 3 landfalls will extend initial recovery periods anywhere from 2 to 12 weeks, or more. Approximately 80 to 90 percent of refineries will initially recover from Category 2 and 3 damage between Weeks 4 and 5.



In the worst case, refining outages caused by a Category 3 landfall may displace approximately 150 MMBbl of Gulf Coast products.

An additional 20 MMBblwould also be lost to the Southeast states due to Colonial Pipeline downtime.

Area Affected	Category 1	Category 2	Category 3
Gulf Coast Product Shortfall (MBbl)	11	89	150
Southeast Product Shortfall (MBbl)	2	13	20

3. Hurricane Landfall – East New Orleans, LA

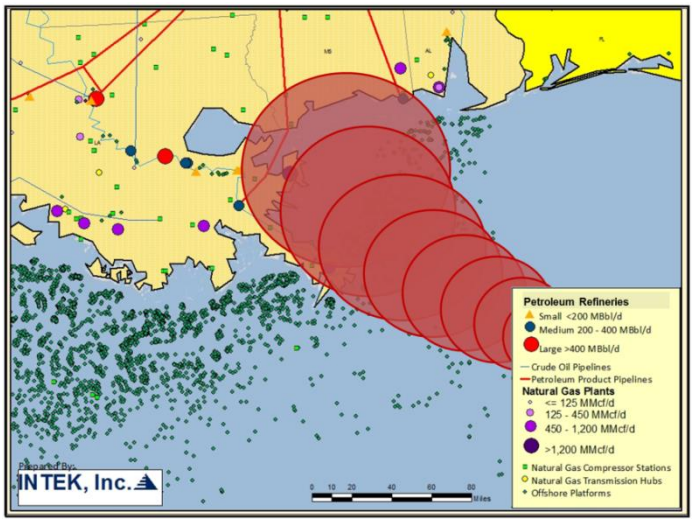
As a result of lessons learned from Hurricane Katrina, Eastern Gulf Coast landfalls may result in up to 92 percent shut in of oil and gas production in the Gulf of Mexico. As with all Gulf Coast hurricanes, areas experiencing landfall will suffer wind damage, flooding, storm surge, and power outages resulting in suspended operations of ports, pipelines, terminals, and refineries. Even though the potentially affected refining capacity is significantly less than the Texas cases, the New Orleans area plays a major role in product distribution to Southeast states, namely through Colonial and Plantation pipeline deliveries as well as inter-coastal barge movements to the Florida Gulf Coast.

Crude and Product Infrastructure Outages

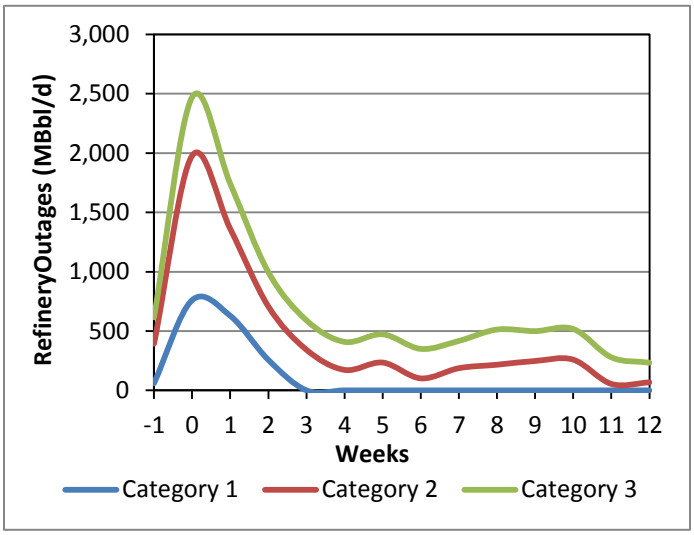
- **Crude Pipelines**: Ho-Ho, Capline, North Louisiana System
- **Refineries**: 3 - 15
  Capacity (MBbl/d): 668 - 2,895
- **Petroleum Terminals**: 4 - 60
  Capacity (MMBbl): 0.5 - 64
- **Product Pipelines**: Colonial, Plantation
- **SPR Sites:** Bayou Choctaw
  Total Inventory (MMBbl): 73

Natural Gas Infrastructure Outages

- **Processing Plants**: 2 - 31
  Capacity (MMcf/d): 2,950 - 10,152
- **Compressor Stations**: 6 - 82
- **Transmission Hubs**: 0 - 5
  Capacity (MMcf/d): 0 - 3,180



At landfall, New Orleans area refineries may experience outages anywhere from 750 to 2,500 MBbl/d depending on the severity of the storm. A Category 3 hurricane passing through the Southeastern Louisiana coast has potential to take down 2.5 MMBbl/d of refining capacity. In this case, outages from a Category 1 storm may fully recover by Week 3. More severe damage from Category 2 and 3 hurricanes will extend an initial recovery between Weeks 4 and 5. Full recovery for more significant damage may take 12 or more weeks after landfall.



Product losses to the Gulf Coast are substantially lower compared to previous scenarios, ranging anywhere from 12 to 71 million barrels. As mentioned previously, Southeastern states are largely reliant on product movements from the Louisiana Gulf Coast. In the worst case, Southeastern states will lose 18 MMBbl of products over the 14 week model period.

Area Affected	Category 1	Category 2	Category 3
Gulf Coast Product Shortfall (MBbl)	12	44	71
Southeast Product Shortfall (MBbl)	2	10	18

Hurricane Stress Test Analysis Summary

All hurricane stress tests highlight several vulnerabilities to Gulf Coast oil and gas production and major TS&D infrastructure. In each case, judging from prior storms, it can be expected that no less than 90 percent of GOM oil and gas production will be indefinitely shut in. Major infrastructure outages were also summarized for both oil and gas sectors, however refinery outages and subsequent product shortfalls present more challenging issues towards Gulf Coast hurricane resiliency.

The results from each scenario in Table 32 below highlight the dependency of Southeastern states on Gulf Coast refining and product pipeline distribution.

The Colonial and Plantation pipelines are two critical Southeast lifelines in the U.S. product TS&D infrastructure. Modeling results suggest that any hurricane-related outage to Gulf Coast oil production and refining will lead to local and inter-PADD product shortfalls. The magnitude and duration of the outages and shortfalls will also increase with more severe landfalls.

Table 32: Fuels Supply Impacts of Hurricane Cases Analyzed

	Affected Refinery Capacity (MBbl/d)	Gulf Coast Product Loss (MMBbl)	Southeast Pipelines Affected	Southeast Product Loss (MMBbl)
Galveston Bay	2,091 - 4,543	10 - 168	Colonial	1 - 17
Port Arthur	2,205 - 4,623	11 - 150	Colonial	2 - 20
New Orleans	668 - 2,895	12 - 71	Colonial, Plantation	2 - 18

The Houston-Texas City and Port Arthur regions are in close proximity to each other, and highly interconnected through inter-coastal waterways, marine facilities, major on and offshore pipelines, and terminals. Each area represents about 25 percent of Gulf Coast refining capacity.

In each Category 3 hurricane case however, despite an independent Texas Gulf Coast landfall, up to 50 percent of Gulf Coast refining capacity went offline. Even though each region represents roughly 25 percent of Gulf Coast capacity, the overall effect of production shut-ins, port and marine facility closures, and pipeline and terminal closures will indirectly impact the unaffected region, thus exacerbating cumulative refinery outages.

The New Orleans case was unique in that, despite and overall decline in refinery outages from previous cases, Southeastern states experienced product shortfalls in the same magnitude as both Texas cases. Unaffected Texas refineries could theoretically produce products to supply the Southeast; however a New Orleans landfall disrupts both the Colonial and Plantation pipelines, thus barring any potential relief from unaffected refineries in Houston and Port Arthur. Additionally, products moving by vessel from New Orleans refineries to Florida and East Coast PADD I will not be available with coastal TS&D infrastructure outages, not to mention any incurred.

Gulf of Mexico Oil and Natural Gas Production

Approximately 1 Bcf/d of natural gas production and 1 MMBbl/d of crude oil production will be shut down in the Gulf of Mexico for a period of 6-10 days depending on the strength and path of a Gulf Coast hurricane. With stronger Category 2 and 3 hurricanes, oil and gas production recovery periods could be as much as two to three weeks in order to repair damage to platforms, pipelines, natural gas plants, compression stations, and pump stations, that may result from flooding or storm force winds.

Options to Mitigate

1. Provided that TS&D infrastructure is back online, unaffected SPR sites could supply oil to coastal refiners in PADD IB, III, and V to mitigate production shut-ins and product shortfalls from the Gulf Coast . (SPR refinery relief will not be effective to mitigate Southeast product shortfalls unless Colonial and Plantation pipelines are operational.)
2. PADD IB and Pacific Northwest refineries could also increase supply from Canada or North Dakota, but are constrained by local offloading capabilities.

Resiliency Options

- Study the need for additional dedicated product reserves to address hurricane-related product shortfalls from the Gulf Coast (PADD III) to all areas of PADD I.

VIII. Regional Resiliency Options

A. Introduction

The major threats to crude and petroleum products supply are hurricanes in PADDs I and III, earthquakes in PADD V, and disruptions of critical pipeline and marine transportation infrastructure, interruptions of imports from foreign suppliers, and deliberate acts in all PADDs. Industry and government both have important roles in hardening crude oil TS&D infrastructure to prevent or reduce impacts, improving preparedness to reduce the size and duration of supply disruptions, and maintaining and assuring the deliverability of back-up oil and refined product supplies to meet industry and end-user needs until a disruption can be curtailed.

Even though there is extensive redundancy and resiliency in the nation's natural gas TS&D infrastructure, both natural disasters and other intentional acts can threaten natural gas supply and deliverability. Further, increased domestic gas production and growing demand for gas for power generation and other uses is changing gas transmission flows, infrastructure, and regional supply resiliency. Aging gas distribution infrastructure also poses safety issues and resiliency challenges, as evidenced by the 2010 San Bruno, CA pipeline explosion, recovery from which has taken over four years.

The following options are suggested by the foregoing assessment of infrastructure vulnerabilities and resiliency.

B. Reduce Impacts of Choke Points on Crude and Product Supplies

It is clearly evident from this study that stocks of crude oil or refined products are needed in several markets to mitigate supply shortages that may be caused by interruptions of crude oil supply to refineries or interruptions of refining, transportation, storage, or distribution infrastructure. This is need is particularly evident in PADD I (East Coast) and in PADD V (West Coast).

1. Assure Timely West Coast Access to Crude Oil and Refined Products

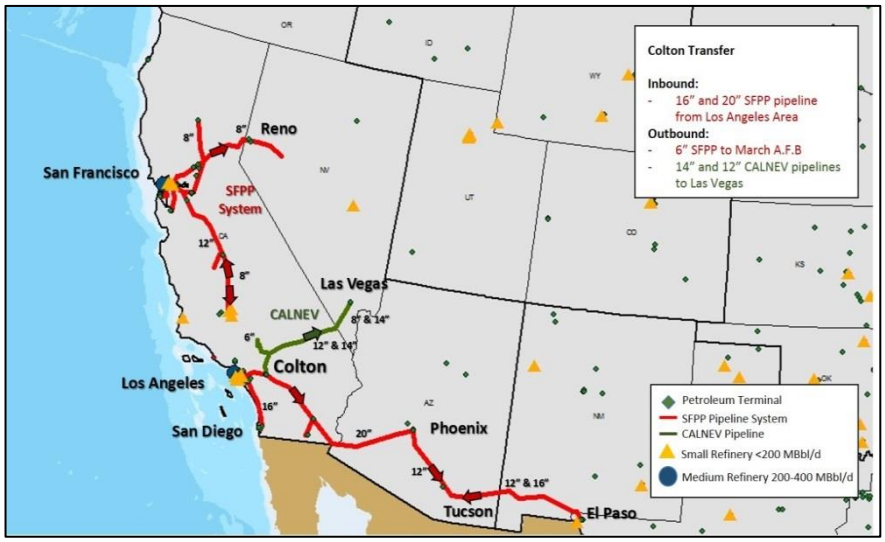
PADD V is highly susceptible to earthquakes, but less so to tsunamis and other natural disasters. PADD V depends on crude oil imports from South America and the Middle East for more than one-third of its refinery demand, much of which travels through the Panama Canal to reach West Coast ports. (Alaska and Hawaii refineries partially supply those self-contained markets). Most of PADD V refined products demand is met by local refineries.

The northern states of Washington and Oregon can rely on alternative sources of crude and refined products from Canada in the event of a supply disruption. However, the California markets of San Francisco and Los Angeles are far less resilient. Further, Reno, NV depends on product pipelines from the San Francisco area, and Phoenix, AZ and Las Vegas, NV depend on products supplied by pipelines from Southern California. Numerous major airports, nine air force bases, and several naval bases rely on Southern California refiners and imports for fuels, posing strategic resiliency concerns (Figure 22).

The major concern in PADD V is that there are few alternative sources of oil or refined products to meet major market demands in the event of a major earthquake or other supply disruption.

Consequently, resilience depends on stocks in storage being sufficient to meet market requirements until disrupted infrastructure can be restored.

Figure 22: PADD V Crude Oil and Product Movements and Dependency



Source: INTEK Inc. and RFRS, 2014

Terminals at Colton, CA store products for shipment from southern California to the Phoenix and Las Vegas areas and critical military facilities. While a major supply disruption could be offset by SPR crude shipments (non-ULCC) via the Panama Canal to Southern California refineries, it could take as much as 21 days for SPR crude to reach California refineries, via this route. Current regional product storage (about 10 days) is insufficient to mitigate a significant interruption of supply to critical markets and military bases in California, Arizona, and Nevada.

Option:

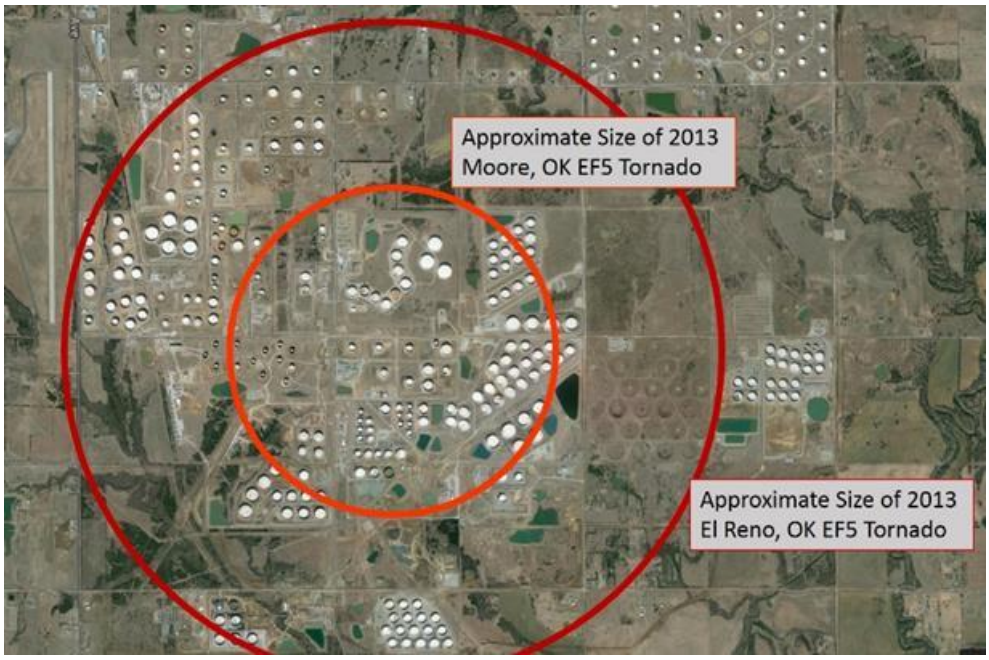
West Coast Reserve Study: DOE EPSA and OPR could evaluate and assess the potential advisability, costs and benefits of a West Coast Reserve. The detailed assessment would determine the optimal composition (crude, products or both), capacity and size(s), location(s), configuration, and specifications of the fuels or refinery feedstocks to be stored, and the potential costs and benefits of a potential West Coast Reserve. Most likely, the reserve would need to be at a centrally located site, in southern California, outside of the fault areas, and have sufficient stocks to provide up to 10 days of supply. Resiliency would be improved by having product system connect to the CALNEV system to serve Las Vegas, and connect to the SFPP systems to serve Phoenix, AZ and Reno, NV while serving other refiners, metropolitan areas, product distribution systems, and strategic infrastructure.

2. Assure Crude Oil Distribution From Cushing, OK Market Hub

The crude oil market hub at Cushing, OK is a major interconnection point for crude oil pipelines supplying refineries in PADDs II and III. More than 20 pipeline systems converge at Cushing, moving crude from the southwest and Mid-Continent, to refiners in PADD II and PADD III. Cushing has more than 80 million barrels of crude oil storage capacity in above ground tanks that are susceptible to tornados that are common to the region.

A major tornado centering on Cushing, or other destructive event, could destroy some or all of the storage infrastructure and crude oil stocks, interrupt electric power to transportation, storage and distribution systems, and interrupt critical crude oil supply system connectivity, seriously affecting refineries and markets throughout much of the nation (Figure 23).

Figure 23: A Large EF5 Tornado Superimposed on Cushing Tank Farm



Source: INTEK/Google Earth, 2014

While little can be done to prevent tornados, infrastructure hardening and disaster preparedness can reduce the connectivity impacts and potential supply loss associated with a disaster at Cushing.

Option:

Cushing Oil Hub Strategy: DOE could work with industry and DHS and state and local agencies to prepare and implement a plan to improve infrastructure hardening, tornado resistance, disruption response, back-up power systems, protect pipeline and storage systems and stocks, and improve oil supply resilience in the event of a major tornado, fire, or other disruptive event at the Cushing hub. A detailed and practiced plan should also provide for effective industry government and industry cooperation.

3. Assure Supply of Refined Products to the North East

PADD I alone accounts for 32 percent of U.S. fuels demand. Of this, 52 percent is consumed in Sub-PADDs IA and IB, which include the major cities of Boston, New York, Philadelphia, Pittsburgh, Baltimore, and Washington, DC. More than 70 percent of this demand is supplied from PADD III refiners or imports.

The Sub-PADD IA New England states include Connecticut, Rhode Island, Massachusetts, New Hampshire, Vermont, and Maine. These states are subject to long, harsh winters, coastal storms and hurricanes, coastal flooding, sudden and intense squalls, and derechos.

Because New England lacks indigenous fuels production, its fuels are largely supplied by other regions as well as by foreign imports. The region relies on its ports, marine terminals, rail, and highway systems to receive and distribute fuels, and is highly reliant on the fuels supply and infrastructure of Sub-PADD IB, Sub-PADD IC, and PADD III (Figure 24).

Sub-PADD IB is also susceptible to hurricanes, winter weather, coastal flooding, and derechos, which can impact critical TS&D infrastructure. Any disruption of Linden, NJ or New York Harbor infrastructure, system interconnections, or associated power or communication systems could disrupt the distribution of fuel stocks, largely by barge and tanker, to terminals in New England.

Figure 24: New York Harbor Area and Regional Terminals (SPR 2013)

The Linden, New Jersey and New York Harbor areas in PADD IB, including the Colonial and Buckeye systems, and the Arthur Kill and Kill Van Kull waterways, and all of the marine and storage terminals that serve them, were shut down and severely damaged by storm surge, rainfall, and associated flooding, and power loss during and after Hurricane Sandy, curtailing product movements to the northeast.

Post-Hurricane Sandy, the Department of Energy has developed a 1 MMBbl Northeast Refined Petroleum Product Reserve (NERRPPR) , in addition to the 1 MMBbl Northeast Home Heating Oil Reserve (NEHHOR). The State of New York has also subsequently established a 3 million gallon (71,500 barrels) gasoline reserve near Manhattan on Long Island.

While laudable, the combined stocks in these new reserves are still insufficient to satisfy the 1.3 MMBbl/d fuels demand of the northeast region for more than a few days in the event of a significant interruption caused by a hurricane or other event. Further, while the sites for these reserves were carefully selected, they too could be susceptible to interruption, depending on the path and intensity of a hurricane and its storm surge.

Option:

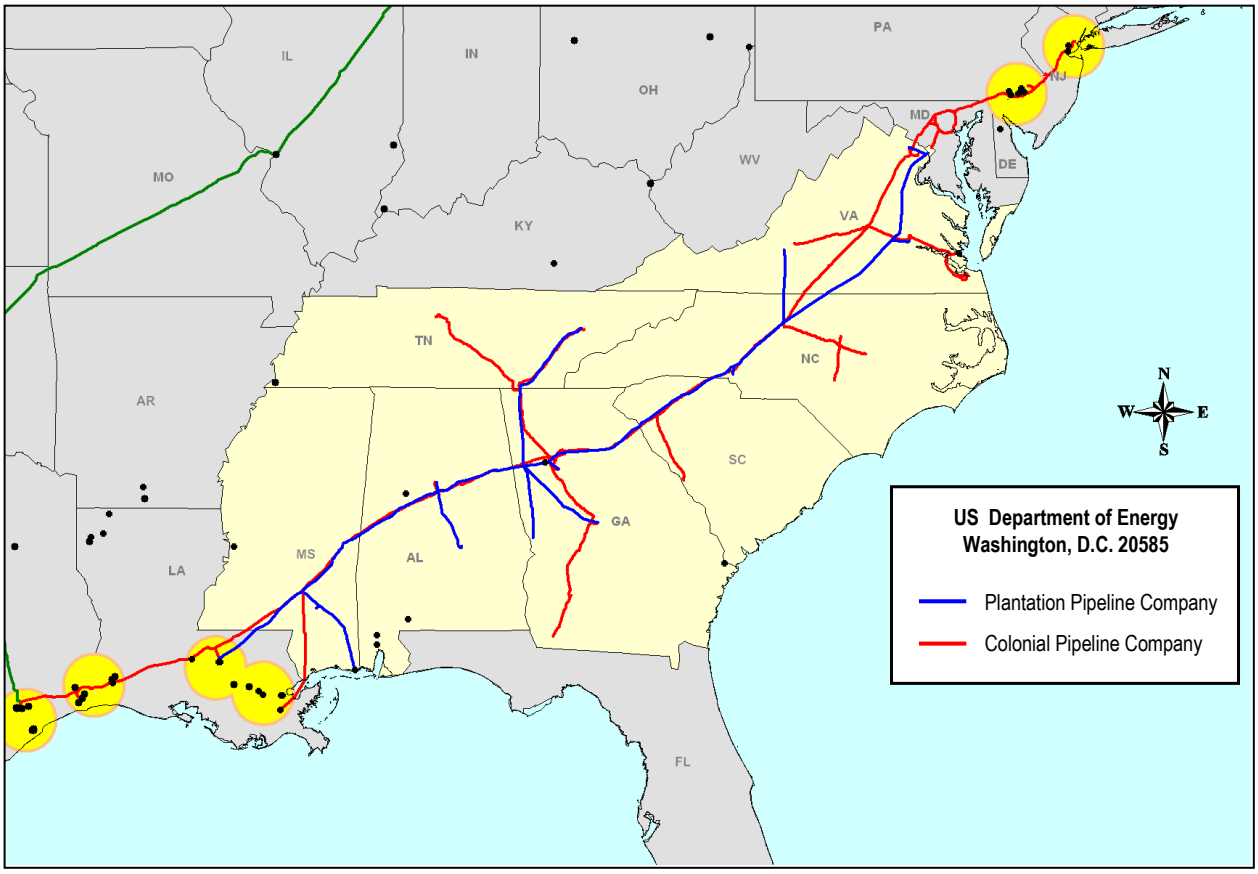
North East Regional Refined Petroleum Product Reserve Expansion Assessment: A detailed assessment could be conducted by DOE EPSA and the DOE Office of Petroleum Reserves (OPR) to determine the size(s), location(s), configuration, composition and quality of stocks to be stored, and the potential costs and benefits of an expanded Northeast Regional Refined Petroleum Products

Reserve (NERRPPR). Such an expansion would serve the high demand areas from Washington, DC to the north and improve resiliency to meet up to 10 days of PADD IA and PADD IB demand. Stocks stored could include all liquid fuels, including motor gasoline, ULSD, and aviation fuels, to be determined by the assessment.

4. Assure Supply of Refined Products to the South East Region

The southeastern states (Sub-PADD IC) have no refining capacity and are nearly totally reliant on refined products that are supplied from PADD III by two pipelines, Colonial and Plantation (Figure 25). The region's resiliency is limited to receiving products through coastal ports by seaborne vessels from PADD III or foreign sources. A major hurricane or other disruptive event in PADD III could interrupt fuels supply to the Southeast for as much as 14 days or more.

Figure 25: Southeast Regional Dependency on PADD III and Product Pipelines (SPR 2011)



Following the hurricanes of 2005 and 2009, the DOE Office of Policy and DOE OPR undertook a detailed study of the vulnerability of the Southeast which examined options for a refined products reserve in the Southeast. The 2011 RPPR Study for the Southeast study considered various sizes, locations and configurations of a Southeast reserve.

Options:

South East Refined Petroleum Product Reserve Plan: DOE EPSA and the DOE OPR s could update and implement a plan for storage and distribution of refined products sufficient to meet needs of Sub-PADD IC and other markets in event of supply interruptions from PADD III to improve resiliency to up to 10 days of demand. OPR should update the assessment of costs and benefits to reflect current supply, demand, infrastructure, and market conditions.

C. Harden Existing Refining, Transport, and Storage Infrastructure

Since the recent Gulf Coast and East Coast hurricanes, industry has made extensive efforts to identify vulnerabilities and harden infrastructure to reduce the magnitude and duration of infrastructure damage and associated supply disruptions. Much of this effort is ongoing, but more hardening and facility maintenance work needs to be done by industry and by state and federal government agencies responsible for coastal and inland waterways, ports, terminals, locks and dams, and other critical infrastructure including the Strategic Petroleum Reserve. The following options should be considered:

Options:

On-Site Power: Incentivize industry to incorporate on-site power generation or co-location of generation facilities and refinery sites to reduce risk of refinery power loss in the event of hurricane or other disruption.

Pumps and Electrical Equipment: Encourage industry to adopt and implement risk assessment and standards for elevating or relocating critical refinery and terminal system controls and water-sensitive electrical equipment, wrapping and relocating electric pump motors, and constructing permanent or temporary floodwalls, at refineries and terminals that may be vulnerable to flooding and salt-water damage. Convene industry participants to share best practices.

Storage Tanks: Encourage industry to conduct risk assessments and adopt and implement standards and procedures for minimizing impacts to storage tanks at refineries and product terminals, including allowing water drainage from diked areas, anchoring tanks in flood-vulnerable areas, ensuring sufficient tank fill prior to expected weather events (to preclude tank movement by wind or water surge), and installing tank girders to reinforce structural integrity and protect against wind damage.

Ports and Waterways: Accelerate essential but deferred maintenance of critical waterways and government-owned and maintained infrastructure, including dredging of ship channels, strengthening of signals and controls, and maintenance, repair and upgrading of lock systems, such as those that control the flow of crude and products along the Mississippi River and other major coastal and inland waterways.

Strategic Petroleum Reserve (SPR): It is critical that the SPR maintain the ability to address severe global oil supply disruptions and carry out U.S. obligations under the International Energy Program. To address the vulnerabilities and infrastructure changes discussed in this report, along with recent recommendations of the DOE Inspector General, the SPR should review its above-ground facilities, storage capacity, composition (crude oil vs. refined products), and the location of stocks in the

context of evolving oil market risk. The SPR must also take steps to adapt to changing North American petroleum flows and unprecedented supply logistics. Specifically, the SPR should:

- **SPR Strategic Review:** SPR should prepare a long-term strategic review which addresses vulnerabilities to U.S. oil supply, SPR requirements and release authorities, and engineering considerations such as maintenance and upgrades to above ground site facilities and cavern integrity.
- **SPR Distribution Assessment:** SPR should perform a comprehensive assessment of SPR distribution capability in response to a congested crude oil distribution system and reduced import demand. Recommendations may include building new pipeline connections to commercial marine terminals or building dedicated SPR docks.
- **SPR Optimization Plan:** SPR should develop and implement a plan to optimize the SPR to meet new drawdown, storage, and distribution requirements.
- The SPR has estimated that to maintain its capacity, deliverability and drawdown readiness for the next 30 years,~$5-6 billion will be needed to maintain, upgrade, and expand SPR capabilities.

D. Improve System Resiliency for Liquids and Natural Gas

A variety of actions can be taken by industry and government to improve the resiliency of refining, product transport, and storage systems to restore operations more quickly after a disruptive event. Of critical importance is the rapid restoration of electric power to operate critical TS&D infrastructure.

Options:

Priority Restoration for Fuels TS&D Infrastructure: Establish regulations and practices to prioritize restoration of electric power to critical fuels TS&D infrastructure, where there is a national impact if infrastructure is out of service.

Back-Up Power (Terminals and Pipelines): Incentivize industry to establish and implement standards and take action to provide back-up power and facilitate rapid restoration of electrical service to crude and product terminals and pumping stations along crude oil and refined product pipeline systems, where there is a national interest for additional resiliency, including pre-wiring facilities to receive back up power from private or government supplied portable generation equipment.

Back Up Power (Terminals and Retailers): Incentivize refined products distributors and retailers to acquire and maintain back-up generators to enable truck filling at terminals and sustain operations at retail fuel stations

Spare Parts & Equipment: Encourage refineries, terminals, and pipelines to identify likely needs and sources of critical spare parts and equipment that could expedite restoration of operations following a disruption, and determine the cost-effectiveness of acquiring and maintaining local stores.

Preparedness Training: Encourage industry to define, adopt, and implement standards and practices for emergency preparedness and response, including drills and exercises, to ensure preparedness for natural disasters or other disruptive events.

E. Improve Natural Gas Transmission and Distribution Systems

With the shale gas revolution taking place in the east, increased shale gas production in other regions, and increased volumes of associated gas being produced along with tight oil in the Bakken, Woodford, and Permian basins, among others, the dependencies, infrastructure, and vulnerabilities of the nation's gas transportation, storage and distribution system are changing. With abundant, low-cost domestic sources of natural gas available, natural gas demand is projected to increase rapidly. This is particularly true in PADD I, where demand in the southeast states (PADD IC and PADD III) is projected to increase Industry and government are presented with an opportunity to work together to ensure that production growth, infrastructure development, and associated development are facilitated.

The major vulnerabilities of the natural gas transportation, supply, and distribution systems are:

- Declining, but still significant, reliance on gas supplies from the hurricane-vulnerable Gulf of Mexico,
- Vulnerability of compressor stations, interconnect points, and city gates to natural disasters and other threats and disruptions, and
- The relative age, condition, and efficiency of local distribution infrastructure.

Transmission

The nation's gas transmission system was built with excess capacity to transport greater volumes of gas in the future as warranted by demand growth and production. Adding more compressions stations to the system will increase deliverability. The primary concerns are the directionality of the transmission as new production in PADD IB backs out production from other regions, conversion of LNG import facilities to export facilities, and addition of capacity to serve potential new markets for power generation and commercial and residential use in the northeast and other areas of PADD I currently served by coal or nuclear-fired generation.

Storage

A major vulnerability is the inability of the gas storage and transmission to withdraw at high rates and sustain that rate for extended periods that may be required during peak load periods caused by excessive heat or abnormal periods of cold weather. Increased use of natural gas by the electric power generation sector will require the addition of more high-deliverability storage. This will entail the development of new storage reservoirs and improvement of technical capabilities to extract gas from storage at higher rates sustained for longer periods, without damaging the storage reservoirs.

Distribution

System leaks from aging pipelines, compressor stations, and aging distribution pipeline represent not only an economic loss of gas supply, but also undesirable methane emissions into the Earth's atmosphere.

The federal government and the natural gas industry have a long and productive history of cooperation, technology transfer, and voluntary programs to reduce methane emissions. New initiatives can augment these programs to further improve system efficiency, integrity, and resiliency.

Options:

Encourage TS&D Expansion: Encourage industry to install more gas transmission, high-deliverability storage, and efficient delivery and distribution infrastructure in New England to serve rising gas-fired power generation demand, particularly during peak load periods, as well as growing transportation, commercial, and residential demand.

Encourage and Incentivize New High Deliverability Storage: Increased use of natural gas by the electric power generation sector will require the addition of more high-deliverability storage. This will entail the development of new storage reservoirs and improvement of technical capabilities to extract gas from storage at higher rates sustained for longer periods, without damaging the storage reservoirs.

Initiative to Modernize Natural Gas Transmission and Distribution Infrastructure: DOE and DOT should develop and implement a plan, in close cooperation with industry and the states, to modernize the aging gas distribution system infrastructure, detect and reduce methane leaks and emissions, and improve system efficiency. This plan could include:

- **Efficiency standards for natural gas compressors** to reduce gas consumption and emissions.
- **Economic incentives for technology demonstration and implementation**, such as new FERC provisions to allow cost recovery by industry for infrastructure improvement investments, and loan guarantees to spur commercialization of innovative technologies for methane emission reduction in the TS&D system
- **Cost shared research, development, and demonstration (RD&D)** to develop new and more efficient technologies for sensors, controls, engines, and materials; emissions reduction in gas exploration and production systems (including reducing gas flaring); and leak detection and measurement systems.
- **Facilitation of continued collaborative and cooperative** efforts and partnerships with industry, states, regulators, consumers and other stakeholders, and
- **Effective information sharing,** including development and communication of industry best practices that can improve system efficiency and reduce methane emissions and leakages.

Estimation of Costs and Benefits: DOE should work with industry to estimate the costs and benefits of natural gas TS&D system modernization.

F. Assure Adequate Propane Stocks in Northeast and Other Regions

Options:

Conduct a Propane Supply Options Study. Sub-PADD IC, New England, is entirely dependent on other regions for supplies of propane. To ensure that adequate supplies of propane are available to

meet consumer demand during peak heating season, DOE should conduct an assessment of the circumstances that led to propane supply shortages and price spikes during the 2014 peak season in Sub-PADD 1A and other areas, and evaluate options to avoid a recurrence of the conditions that limited propane supply. The study should evaluate the costs and benefits of establishing minimum requirements for propane stocks in storage in key demand regions prior to commencement of annual peak demand periods; making demonstration of sufficient stocks in storage a pre-requisite prior to approval of propane exports to foreign markets; and authorizing Jones Act waivers to facilitate the rapid supply of propane stocks from PADD III in the event of a propane supply shortfall or disruption.

G. Adopt Policy and Regulatory Measures to Facilitate Resiliency

A variety of policy actions can help enable private industry, federal and state agencies, and consumers to prepare for and respond to natural disasters and other events that may disrupt the nation's fuels supply system. These options include review or modification of existing laws and policies that constrain: rapid industry or government response to fuel supply emergencies, allowances for waivers of regulatory provisions during times of emergency, effective coordination between government and industry, and improved communications with impacted consumers.

Options:

Review State Anti-Gouging Laws: Encourage States to review and consider amendment of anti-gouging laws in order to allow fuels distributors and retailers to recover the full cost of emergency fuel acquired to sustain the supply during disruption.

Review Jones Act: Review the continued efficacy of the Jones Act and consider amendment or modification, as may be appropriate, to facilitate waivers of provisions requiring fuels transported between U.S. ports to be transported only by U.S. flagged waterborne vessels and carriers. Jones Act restrictions can limit the number and size of vessels available to transport crude and fuels during emergencies and prolong loading times when larger Jones Act vessels are not available.

Encourage Safe Transport of Crude by Rail: Industry should improve the safety, reliability, and capacity of the rail network to transport crude oil to existing and planned local and other refineries. DOE and DOT should work with industry to expedite industry transition to the new DOT 111 standards for rail cars transporting volatile crude oil. Double-hulled rail cars and more stable designs may reduce the incidence of accidents, derailments, and spills and facilitate supply resiliency.

Review Crude Oil Exports: Increasing light oil production from North Dakota and Texas and heavy oil imports from Canada have reduced foreign imports and caused pipeline reversals as crude competes for pipeline capacity. Gulf Coast refineries are designed for heavy oil. DOE, in cooperation with the Department of Commerce, should evaluate the potential costs and benefits of allowing the international trading of crude oil and condensates. This review could consider simplifying procedures for exports or swaps of various crude types during supply disruptions. As part of this effort, the government could also clarify the circumstances by which condensate may be considered a refined product eligible for export.

H. Risk Assessment, Option Prioritization, and Evaluation

These options and recommendations were developed based on the analyses conducted for this study as well as various recommendations of other government studies. The costs and benefits of each of these options needs to be evaluated in the context of the risk that is associated with various TS&D vulnerabilities, and other trade-offs.

These options and recommendations should then be prioritized by the government, considering their risk-weighted costs and benefits. It is further recommended that these options and recommendations be shared with the affected states, industry organizations, and other stakeholders to provide an opportunity for stakeholder input and participation and potential refinement and improvement of the options.

Appendix III - 1

Summary of Key Provisions of State Energy Assurance and Emergency Operations Plans Related to Fuels Supply and Infrastructure

PADD	Sub PADD	State	Energy Assurance Plan	Emergency, ESF-12, or Other Plans	Plan Highlights
I	A	Connecticut	http://www.ct.gov/deep/lib/deep/energy/arra/eap/ct_eap_final_draft_part_1.pdf		• Natural gas companies must submit a five-year supply outlook to the state • The state relies on a free-market approach to petroleum supply and is actively trying to curb petroleum demand in favor of cheaper and cleaner alternatives.[18]
		Maine	http://www.maine.gov/energy/pdf/Maine_Energy_Assurance_Plan_6_1_11[1].pdf		• The state will encourage any dual-fuel power plants using natural gas to switch to other fuels if available • During an extreme shortage (over 20% reduction), the state will begin allocating heating oil, propane, kerosene, and natural gas through their emergency program.[19]
		Massachusetts		http://www.mass.gov/eopss/docs/mema/cemp/ma-cemp-base-plan-final-december-2013.pdf	• The state does not have a publicly-available EAP. • The state does have an ESF-12 Energy Annex to outline activities during an emergency.[20]
		New Hampshire		http://128.121.25.104:8080/awweb/pdfopener?md=1&did=43260	• The state does not have a publicly-available EAP. • The state does have an ESF-12 Energy Annex to outline activities during an emergency.[21]
		Rhode Island	The state does not have any plans publicly available		
		Vermont		http://vem.vermont.gov/sites/vem/files/Base%20Plan_20131202.pdf	• Vermont does not have a publicly available EAP, but does have an EOP with an ESF-12. • The plan largely focuses on coordination between agencies, monitoring, and information sharing.[22]
	B	Delaware	The state does not have any plans publicly available		
		District of Columbia	http://ddoe.dc.gov/sites/default/files/dc/sites/ddoe/publication/attachments/Energy%20Assurance%20Plan.pdf		• The District Department of Energy's main focus during a shortage will be information gathering and sharing. • The mayor can also issue an array of voluntary and mandatory measures like closing government buildings, setting temperature restrictions, and rationing gasoline.[23]

PADD	Sub PADD	State	Energy Assurance Plan	Emergency, ESF-12, or Other Plans	Plan Highlights
I	B	Maryland	http://energy.maryland.gov/energyassurance/documents/MarylandEnergyAssurancePlan.pdf		• Natural gas utilities must submit annual reports to the state outlining their storage capacity needs. If demand exceeds capacity, the companies can implement contingency plans and interrupt service to selected customers. • In the event of a gas shortage, the state will pursue rationing strategies such as even/odd day purchases.[24]
		New Jersey		http://nj.gov/gorr/resiliency/	• The state does not have a publicly-available EAP. • The state has put forth several measures to address resiliency after Hurricane Sandy. Filling stations along evacuation routes have been given grants for back-up generators to ensure power and access to fuel during an emergency.[25]
		New York	http://www.nyserda.ny.gov/-/media/Files/Publications/Energy-Analysis/2012-Energy-Assurance-Plan.pdf	https://www.nyserda.ny.gov/-/media/Files/Publications/Energy-Analysis/2011-NYS-Energy-Emergency-Plan.pdf;	• In the event of a petroleum shortage, the state can activate their Fuels Set-Aside program. Under the set-aside, all prime suppliers doing business in New York are required to set aside three percent of their monthly available supply to be allocated by the State.[26,27] • In response to Hurricane Sandy, New York announced in October 2013 that it would create a 3 million gallon gasoline reserve on Long Island. This storage equates to approximately one day's supply for the New York City area.[28] • The state has also developed the NY Fuel Initiative which provides free back-up generators to large gas stations along evacuation routes.[29] • The state is also establishing an Upstate Strategic Fuel Reserve of 30,000 barrels of both gasoline and diesel.
		Pennsylvania		http://www.portal.state.pa.us/portal/server.pt/document/1324788/2012_state_eop_-_sept_2012_pdf	• The state does not have a publicly-available EAP. • The state does have an ESF-12 Energy Annex in their Emergency Operations Plan but no information on the function's activities is provided.[30]

PADD	Sub PADD	State	Energy Assurance Plan	Emergency, ESF-12, or Other Plans	Plan Highlights
I	C	Florida	http://www.tbrpc.org/edd/pdfs/Energy_Assurance_InterimReport_March2013.pdf	http://www.tbrpc.org/edd/pdfs/FlEnergyResiliencyReport_Dec2013.pdf; http://www.floridadisaster.org/documents/FEAP_Final_Version_4.25.11.pdf	• Florida is split into five Energy Planning Areas to address each region's differing energy needs, infrastructure, and geography. Florida's main energy concerns are disasters caused by hurricanes and shipping disruption as most of Florida's petroleum products are barged into four ports.[31] • The state offices have considerable experience with the National Response Framework and ESF-12 due to the frequency of hurricanes. • The state plan focuses primarily on protecting infrastructure and developing renewables as strategies for threat mitigation.[32]
		Georgia		http://www.gema.ga.gov/content/atts/prepare/Plans%20and%20Maps/Plan%20Library/GEOP2010.pdf	• The state does not have a publicly-available EAP. • The state does have an ESF-12 Energy Annex, but no details of its operations are given.[33]
		North Carolina	http://www.energync.net/Portals/14/Documents/Publications/12-11-2013%20NC%20Energy%20Assurance%20Plan%20FINAL%20Volumes%201-6.pdf		• The state regulates and sets rules for natural gas curtailment while recognizing its necessity. It also encourages consumers to reduce demand in the event of a shortage. • With hurricanes in mind, the state focuses heavily on pre-event planning to maintain access to petroleum. They advise storing back-up generators along evacuation routes and moving fuel tankers parallel to those routes to allow for constant re-supply.[34]
		South Carolina		http://www.scemd.org/files/Plans/2014%20SC%20EOP%20Publish/_A-6%20%20Basic%20Plan.pdf	• The state does not have a publicly-available EAP. • The state does have an ESF-12 Energy Annex to outline and coordinate activities during an emergency.[35]

PADD	Sub PADD	State	Energy Assurance Plan	Emergency, ESF-12, or Other Plans	Plan Highlights
I	C	Virginia		http://www.vaemergency.gov/webfm_send/511/COVEOP_2012_ESF_12_Energy.pdf	• The state does not have a publicly-available EAP. • The state does have an ESF-12 Energy Annex as part of its Emergency Operations Plan. In an energy emergency the agencies involved will monitor the situation, set rules for natural gas curtailment, and can implement a variety of voluntary or mandatory measures. It will also coordinate with industry to allocate fuels.[36]
		West Virginia		http://www.dhsem.wv.gov/resources/Documents/WV%20Annex%20V%20-%20Energy%20Resources%20-%20final.pdf	• The state does not have a publicly-available EAP. • The state maintains an Energy Supply Disruption Tracking System and has identified key infrastructure for oil and natural gas delivery. • In the event of a fuel shortage, state agencies will coordinate with industry to obtain essential fuel supplies. The National Guard will oversee bulk fuel delivery.[37]
II	EAST	Kentucky		http://kyem.ky.gov/programs/Documents/The%20Commonwealth%20of%20Kentucky%20Emergency%20Operations%20Plan%208%20August%202011.pdf	• The state does not have a publicly-available EAP. • A draft Emergency Operations Plan does not contain outlines for energy shortages, yet a number of counties in the state have their own plan.[38]
		Michigan	The state does not have any plans publicly available		
		Ohio		http://ema.ohio.gov/EOP_Detail.aspx	• The state does not have a publicly-available EAP. • The state has an Emergency Operations Plan that will be updated in 2014 to cover energy emergencies and establish responsibilities.[39]
	KS/OK	Kansas		http://www.kansastag.gov/AdvHTML_doc_upload/2014%20KRP%20FINAL.pdf	• The state does not have a publicly-available EAP. • The state has an ESF-12 Annex in its Emergency Operations Plan which will provide information-sharing and logistical support. They have the authority to procure fuels from out-of-state.[40]

PADD	Sub PADD	State	Energy Assurance Plan	Emergency, ESF-12, or Other Plans	Plan Highlights
II	KS/OK	Oklahoma	http://www.occeweb.com/pu/PUDVideo/2013%20EAP%20Plan%20FINAL.pdf		• Oklahoma sets forth a variety of demand reduction and supply managing strategies for petroleum, most of which are outlined in the DOE guidelines. Other options include the expansion of public transportation alternatives. None of the measures appear to be mandatory. • The state assumes control of fuel prioritization. • In the event of a natural gas shortage, the state will rely on the companies to restore supply. Curtailments may be necessary, but Oklahoma also encourages more well and storage extraction in times of crisis. Large industrial customers are also encouraged to participate in a gas buy-back program.[41]
	NORTH	Illinois	http://www.erc.uic.edu/assets/pdf/IL_energy_assurance_plan_August2012.pdf		• In the event of an emergency, the state can restrict the sale and consumption of fuel. The state also has contracts with petroleum providers which can be triggered during emergencies to supply fuel. • Illinois also has a large amount of ethanol in storage which can also be used in times of emergency with blend-wall waivers. • The governor's office will ask consumers to reduce consumption of natural gas during times of stress, but curtailments might be necessary if the shortage is severe. Illinois notes that curtailments are extremely rare and will affect businesses first.[42]
		Indiana	The state does not have any plans publicly available		
		Iowa		http://homelandsecurity.iowa.gov/documents/misc/HSEMD_IAEmergencyResponsePlan_OCT2010.pdf	• The state does not have a publicly-available EAP. • The state does have an ESF-12 Energy Annex as part of its Emergency Operations Plan. In an energy emergency the agencies involved will monitor the situation, set rules for natural gas curtailment, and can implement a variety of voluntary or mandatory measures.[43]

PADD	Sub PADD	State	Energy Assurance Plan	Emergency, ESF-12, or Other Plans	Plan Highlights
II	NORTH	Minnesota		https://dps.mn.gov/divisions/hsem/all-hazards-planning/Documents/2013-official-meop-public.pdf; http://mn.gov/commerce/energy/images/MN-Microgrid-WP-FINAL-amended.pdf	• The state does not have a publicly-available EAP. • The state maintains an Annex L to its Emergency Operations Plan which deals exclusively with public utilities. The state agencies' primary goal is to assist localities in restoring natural gas service. • The Minnesota Department of Commerce maintains an EAP which includes a petroleum allocation and set-aside plan.[44]
		Missouri	The state does not have any plans publicly available		
		Nebraska		http://www.nema.ne.gov/pdf/nebraska-seop.pdf	• Nebraska does not have a publicly-available EAP, but does outline emergency energy responses in its Emergency Operations Plan. • The governor can activate the state's Fuels Set-Aside program to allocate fuel resources to essential missions.[45]
		Tennessee	The state does not have any plans publicly available		
		Wisconsin		http://emergencymanagement.wi.gov/planning/WERP/ESF%2012%20Energy.pdf	• The state does not have a publicly-available EAP. • The state maintains an ESF-12 Annex which, when activated, give state agencies the authority to institute mandatory demand reduction measures and to allocate resources based on high-priority needs.[46]
	WEST	North Dakota		http://www.communityservices.nd.gov/uploads/30/EAFall2011ExerciseAfterAction.pdf	• The state does not have a publicly-available EAP. • The state has a Fuels Set-Aside Program that it is actively updating. • The state also is looking at how to best help mitigate disasters affecting neighboring states due to its recent energy abundance.[47]
		South Dakota	The state does not have any plans publicly available		
III	GCLA	Alabama		http://ema.alabama.gov/filelibrary/Alabama_EOP.pdf	• The state does not have a publicly-available EAP. • The state has an ESF-12 Annex that will provide fuel to emergency fuel and power stations as needed.[48]

PADD	Sub PADD	State	Energy Assurance Plan	Emergency, ESF-12, or Other Plans	Plan Highlights
III	GCLA	Arkansas	http://www.aoma.org/Arkansas_Energy_Assurance_Plan_FINAL_11-13.pdf		• Natural gas companies are required to submit annual reports for their supply predictions to state offices. During a shortage, standard curtailment policies may be implemented. The state government would largely serve in a support role to the utilities by sharing information and coordinating industry response. • Petroleum shortages will first be tackled with standard voluntary appeals and then mandatory actions such as a gasoline tax and activating the Fuels Set-Aside program is the emergency worsens.[49]
		Louisiana	http://dnr.louisiana.gov/assets/TAD/reports/EnergyAssurancePlan_FINAL_TO_DOE.pdf		• The state will monitor events and report on natural gas shut-in in the Gulf of Mexico during intense storms and hurricanes. They will then coordinate with industry to try to re-establish supply. • Louisiana has also developed complex models to predict fuel demand along evacuation routes to ensure adequate supply in times of emergency. • The state maintains connections to fuel suppliers to ensure fuel for emergency responders.[50]
		Mississippi		http://www.msema.org/wp-content/uploads/2012/07/BasicPlan.pdf	• The state does not have a publicly-available EAP. • The state has an ESF-12 Annex but provides no information on its responsibilities.[51]

PADD	Sub PADD	State	Energy Assurance Plan	Emergency, ESF-12, or Other Plans	Plan Highlights
III	GCTX	Texas	http://www.puc.texas.gov/industry/electric/reports/energy_assurance/Energy_Assurance_Plan-Texas.pdf		• Emergency energy response is part of Texas's much broader emergency planning framework. In the event of a shortage or outage, response and monitoring responsibilities are split between the Public Utility Commission, which oversees electricity issues, and the Railroad Commission, which oversees oil and gas issues. These agencies take on different responsibilities based on a hierarchy of response levels ranging from IV (everything operating normally) to I (emergency conditions). • Texas's EAP outlines a lengthy list of regulations and actions that oil and gas companies must or must not take during an emergency. The Plan further splits these actions into categories based on infrastructure such as underground storage and pipelines.[52]
	WTX/ NM	New Mexico	http://www.emnrd.state.nm.us/ecmd/documents/NMENERGYASSURANCEPLANFINALREPORTJUNE2012.pdf		• Natural gas companies will curtail gas to customers based on their four-tiered priority ranking. First priority are residences, followed by small businesses, followed by large industries without fuel-switching capability, followed by everyone else. • The state has a fuels set-aside program for use in emergencies and also relies on rationing or otherwise restricting the sale of fuels.[53]

PADD	Sub PADD	State	Energy Assurance Plan	Emergency, ESF-12, or Other Plans	Plan Highlights
IV		Colorado	http://cdn.colorado.gov/cs/Satellite?blobcol=urldata&blobheadername1=Content-Disposition&blobheadername2=Content-Type&blobheadervalue1=inline%3B+filename%3D%22Energy+Assurance+Report.pdf%22&blobheadervalue2=application%2Fpdf&blobkey=id&blobtable=MungoBlobs&blobwhere=1251826394416&ssbinary=true		• The state has made several recommendations to prevent or mitigate future fuel shortages. These include the establishment of more storage for both petroleum products and natural gas, a Fuel Set-Aside program for both state and industry, rationing programs, and the installation of back-up generators.[54]
IV		Idaho		http://www.bhs.idaho.gov/Pages/Plans/Documents/Idaho%20Emergency%20Operations%20Plan.pdf	• The state does not have a publicly-available EAP. • The state maintains an ESF-12 Annex which, when activated, give state agencies the authority to curtail gas service.[55]
		Montana	http://deq.mt.gov/Energy/pdf/MTENERGYASSURANCEPLAN-final.pdf		• The state can take several measures during a natural gas shortage, including mandatory reductions in consumption, encouraging a switch to wood as a fuel, and relaxing environmental standards. • In the event of a petroleum shortage, the governor's office can institute a Fuels Set-Aside program which would require all fuel deliveries into the state to reserve a certain percentage for state use.[56]
		Utah		http://publicsafety.utah.gov/emergencymanagement/documents/UtahEOP2013Final.pdf	• The state does not have a publicly-available EAP. • The state maintains an ESF-12 Annex as part of its Emergency Operations Plan which will monitor information and coordinate industry efforts.[57]
		Wyoming		http://wyohomelandsecurity.state.wy.us/library/wyoming%20response%20plan_07.pdf	• The state does not have a publicly-available EAP. • The state maintains an ESF-12 Annex as part of it Response Plan which will monitor information and coordinate industry efforts.[58]

PADD	Sub PADD	State	Energy Assurance Plan	Emergency, ESF-12, or Other Plans	Plan Highlights
V		Alaska		http://www.ak-prepared.com/plans/documents/2013%20Updated%20FINAL%20State%20of%20Alaska%20Emergency%20Operations%20Plan%20January%202011.docx	• The state does not have a publicly-available EAP. • Alaska maintains an ESF-12 Annex as part of its Emergency Operations Plan.[59]
		Arizona		http://www.dem.azdema.gov/preparedness/docs/Basic_Plan.pdf	• The state does not have a publicly-available EAP. • The state maintains an ESF-12 Annex as part of it Response Plan which will monitor information and coordinate industry efforts.[60]
		California	http://www.energy.ca.gov/2014publications/CEC-600-2014-006/CEC-600-2014-006.pdf		• The state government's role, coordinated through the California Energy Commission is to monitor the situation and act as an information hub. If the situation deteriorates then the government can take more direct action like rationing. • California has several statutes authorizing intervention in the event of a crisis. Emergency Order #6 specifically authorizes the government to hold petroleum stocks for emergency vehicles. This order will only be issued in the case of a worsening non-local emergency, otherwise the state has an informal "Fuels Set-Aside" program used to procure needed products for vehicles and services. • The state stresses increased communication and coordination with other PADD V states under the awareness that their oil supply system is self-contained within the PADD. The plan also identifies the state's large dependence on out-of-state natural gas.[61]
		Hawaii	The state does not have any plans publicly available		

PADD	Sub PADD	State	Energy Assurance Plan	Emergency, ESF-12, or Other Plans	Plan Highlights
V		Nevada	http://energy.nv.gov/uploadedFiles/energynvgov/content/PDF-to%20send-EA%20PLAN%20and%20Appendices(1).pdf		• Nevada encourages a standard set of voluntary measures during a shortage. • The state has a Fuels Set-Aside program for longer interruptions and is considering interim measures for periods in between such as establishing emergency clauses in fuel contracts and expanding storage capacity at state terminals.[62]
		Oregon	http://www.oregon.gov/energy/docs/Oregon%20State%20Energy%20Assurance%20Plan%202012.pdf		• Oregon maintains a detailed approach to natural gas shortages, yet all restoration of services will be in the hands of the natural gas companies. The state agencies will serve as information gatherers and public liaisons. • Oregon maintains a three-tiered fuels set aside program and has a detailed set of procedures focusing on both voluntary and mandatory measures to be taken during a crisis. Approximately 5% of all fuel types will be set aside for emergency use.[63]
		Washington	http://www.commerce.wa.gov/Documents/Energy-Emergency-Plan-2013.pdf		• During a natural gas shortage, customers will be encouraged to reduce consumption and switch to other fuels like wood. Power companies relying on natural gas will have the option for a buy-back program. • Washington puts forth a variety of tools to combat energy shortages including demand reduction, supply reservations, and allocation. These measures will move from voluntary to mandatory if the crisis worsens.[64]

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