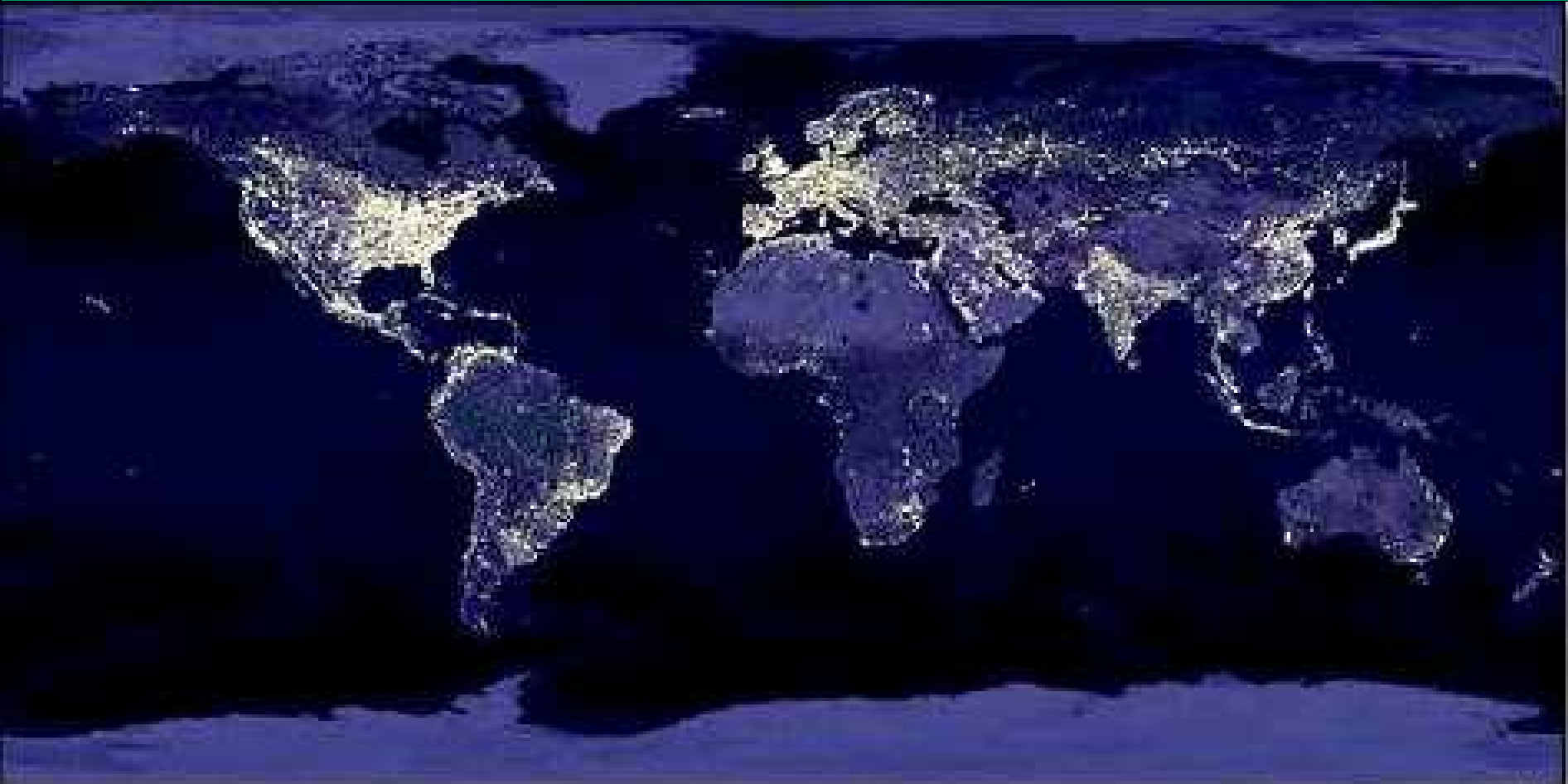


Course: Oil and Gas Infrastructure – April 7, 2009

Instructor: David J Borns, djborns@sandia.gov

SAND2009-3281P

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NASA

Course: Oil and Gas Infrastructure – April 7, 2009

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Today's Content

Nation's Oil and Gas Infrastructure

- Overview and History
- Oil Infrastructure
 - Oil Supply – drilling rigs, production well, gathering lines 40,000 miles
 - Interstate Pipeline Capacity – 55000
 - Refined Petroleum Product Pipelines – 95,000 miles
 - Oil Storage Facilities
 - Oil Tanker Vessels
 - Refineries
- Natural Gas Infrastructure
 - Natural Gas Supply – drilling rigs, production well, gathering lines for delivery to interstate pipelines 20,000 miles
 - Interstate Pipeline Capacity – 278,000
 - Intrastate Pipeline Capacity - 1.8 million
 - Natural Gas Storage Facilities
 - LNG Tanker Vessels
- Trends and Issues

Course: Oil and Gas Infrastructure – April 7, 2009

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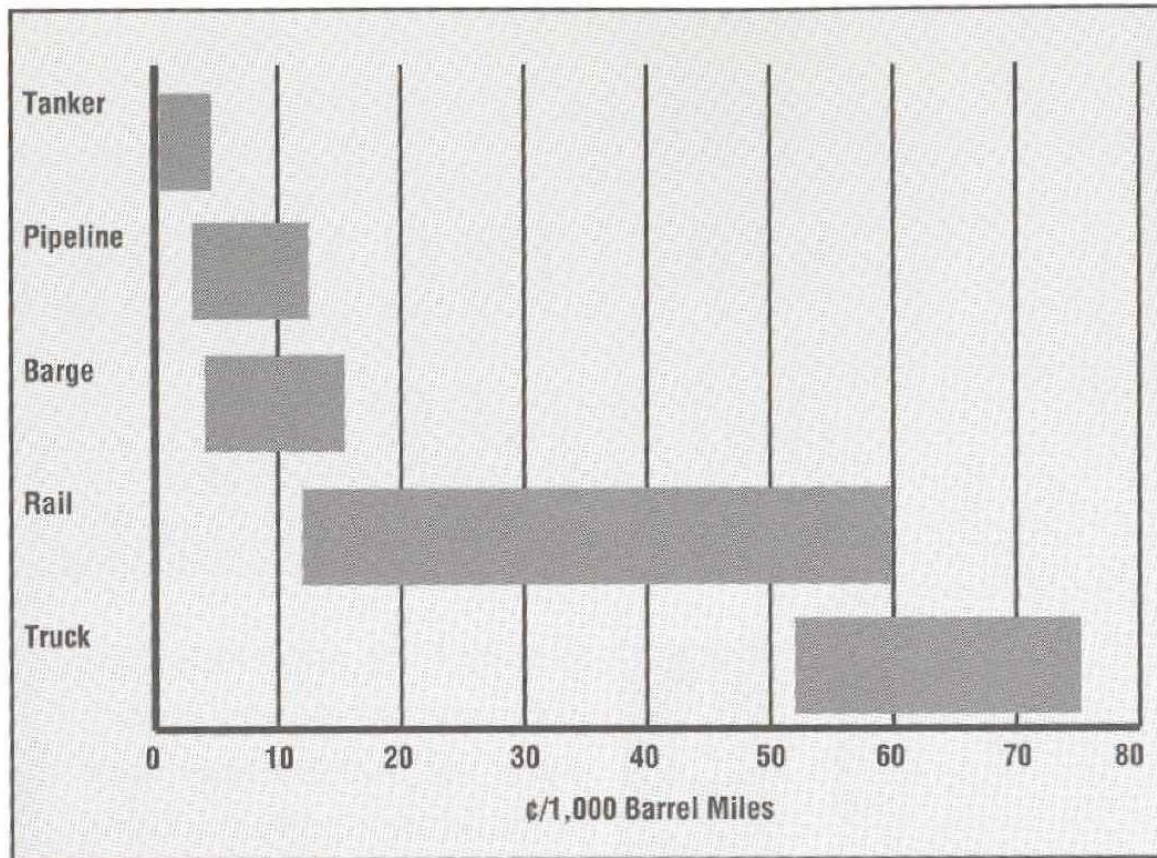


Fig. 1-1. Petroleum transportation costs.

Oil Infrastructure History

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- First discoveries were transported by rail but gathered in whiskey barrels on horse carts
- Teamsters controlled transportation (price of horse wagon transport more than rail transport)
- Pipeline developed to bypass teamsters and eventually the railroads controlled by JD Rockefeller



- Trunklines expanded in the early 1880

Oil Infrastructure History

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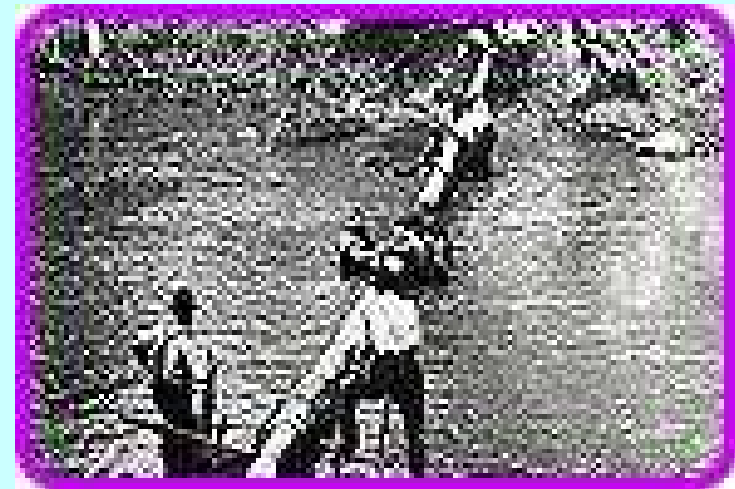
- Baku to Black Sea (Samuel eventually Shell and Rothschild's) to compete with Rockefeller for European markets established in the 1890's the basic oil transport infrastructure and routes that exist today



Oil Infrastructure History

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- WWI pipeline traverse nation
- 1920 pipelines mileage over 115,000 miles
- Coastal tankers disrupted during WWII led to rapid expansion in pipeline transport
- 1970-1977 Trans Alaskan Pipeline System (TAPS)
- 1970-1990 Specialty pipes
 - one mile deep under ocean
 - transport of supercritical CO₂ for EOR
 - natural gas liquids
 - specialty chemicals



Early National Pipeline Infrastructure

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By the early 1920's
a national pipeline
System emerges



A SKETCH MAP SHOWING THE ELABORATE OIL PIPE-LINE SYSTEM WHICH FORMS A NETWORK BENEATH THE SURFACE OF THE EASTERN HALF OF THE UNITED STATES

North American Liquid Pipeline Infrastructure



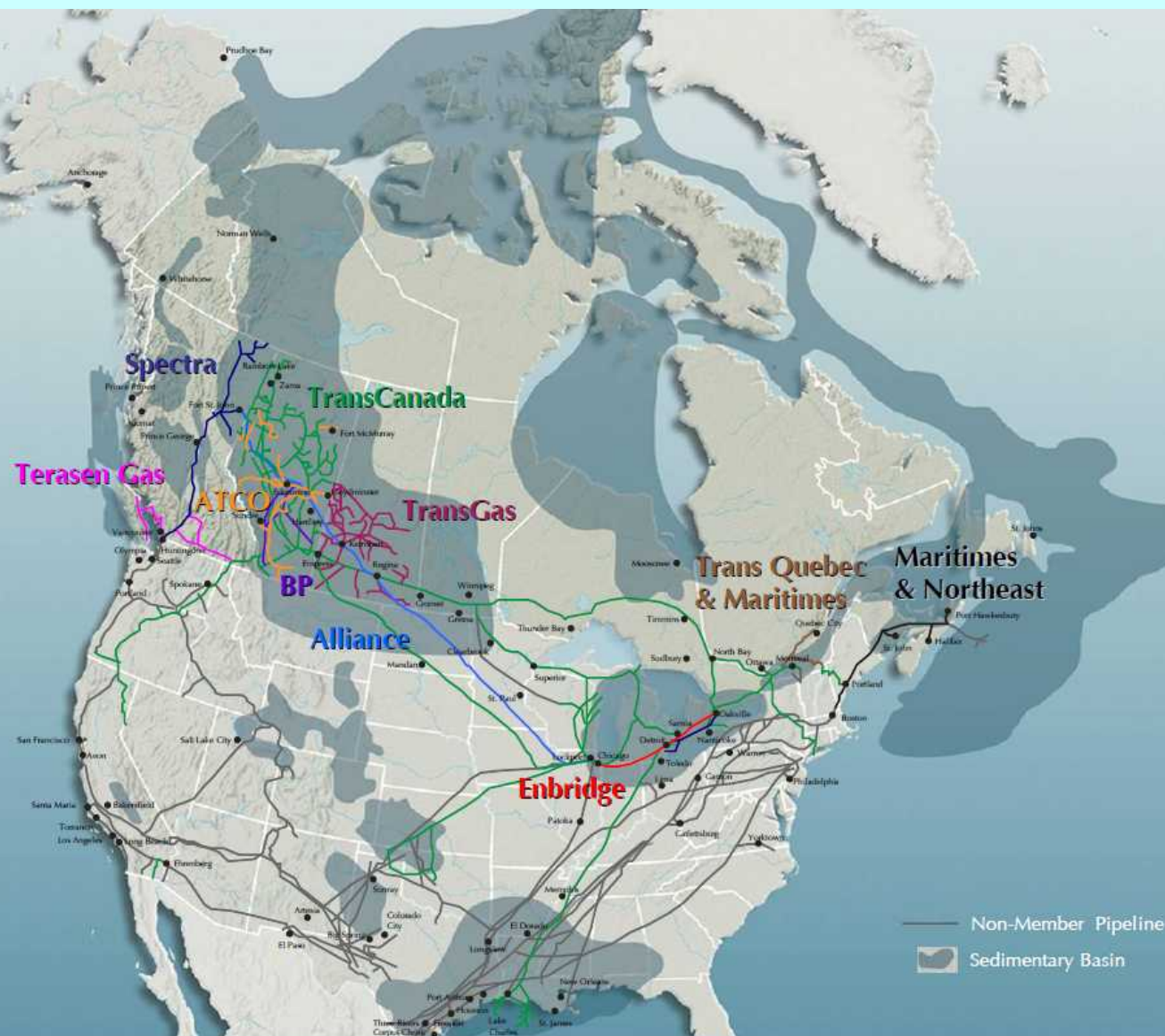
July 2008



Canadian Energy
Pipeline Association
Association canadienne
de pipelines d'énergie

CEPA Members - Liquid Pipelines

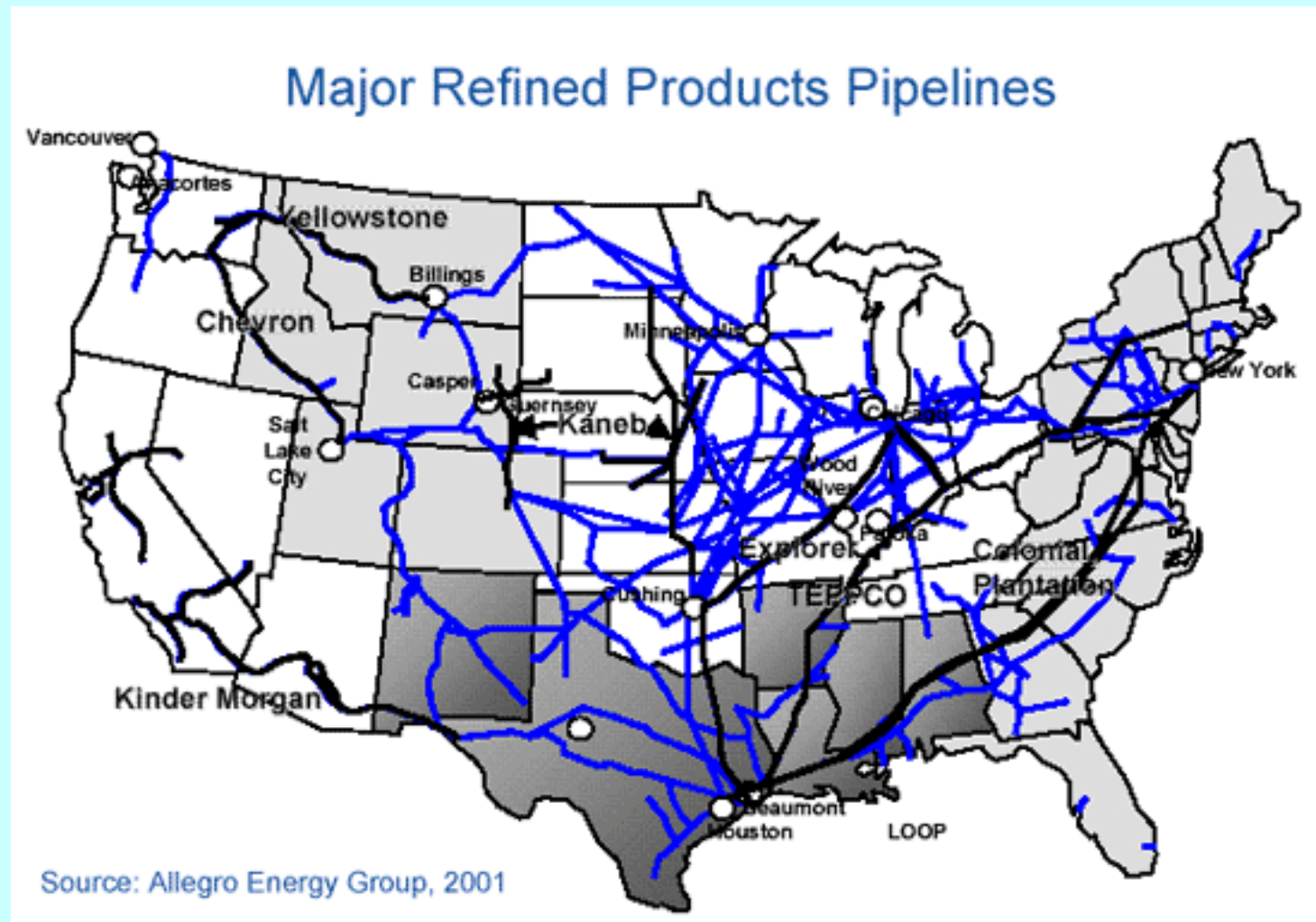
North American Natural Gas Pipeline Infrastructure



July 2008

Refined Product Pipelines

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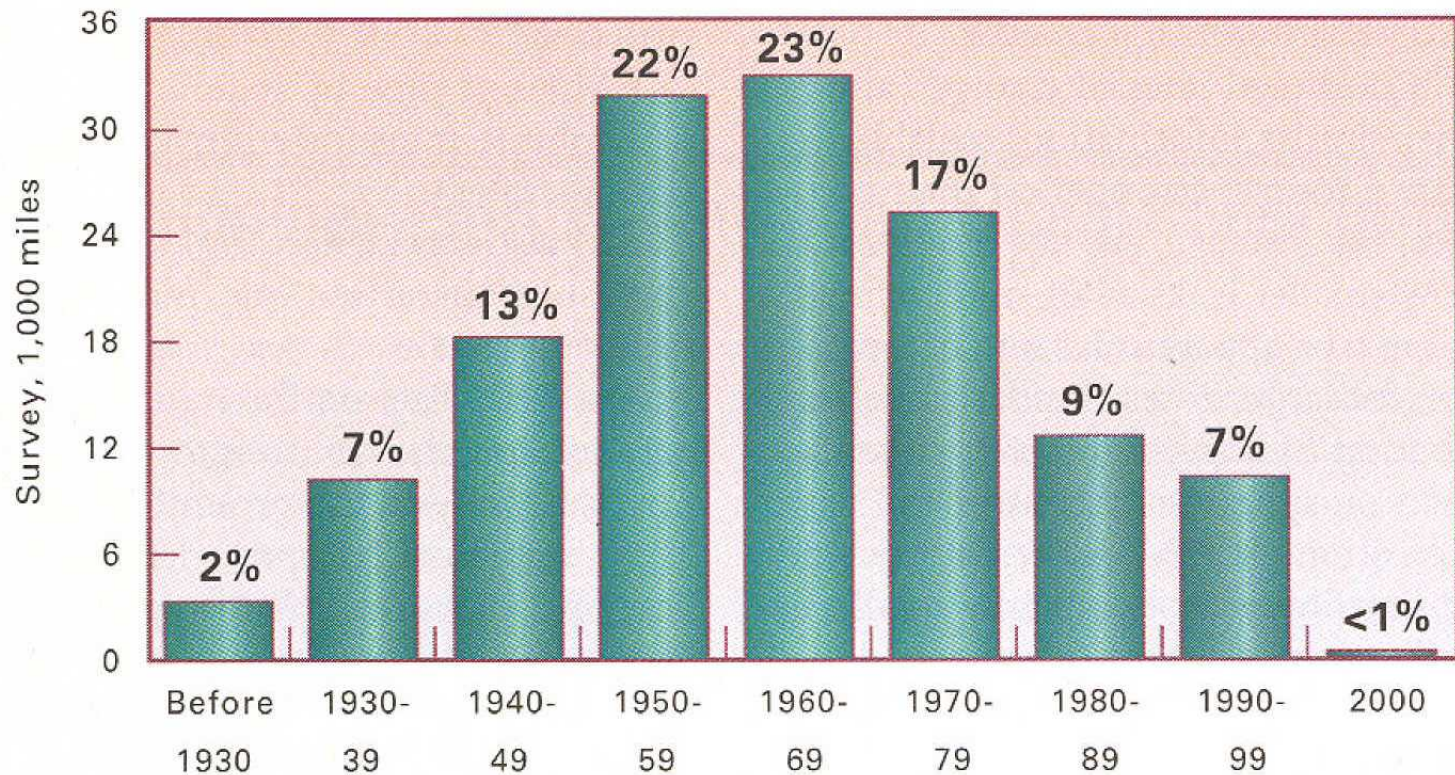


Pipelines: Issues of Age

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PPTS MILEAGE BY DECADE OF CONSTRUCTION*

Fig. 2



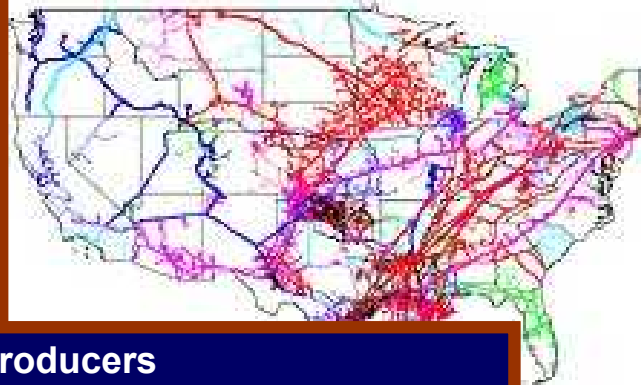
*Decade-of-construction data from Pipeline Performance Tracking System updated May 29, 2001.

Gas Infrastructure: Large, Complex

Gas Production



25 major producers
8,000 independent producers
272,500 gas wells
Some production 100 miles offshore

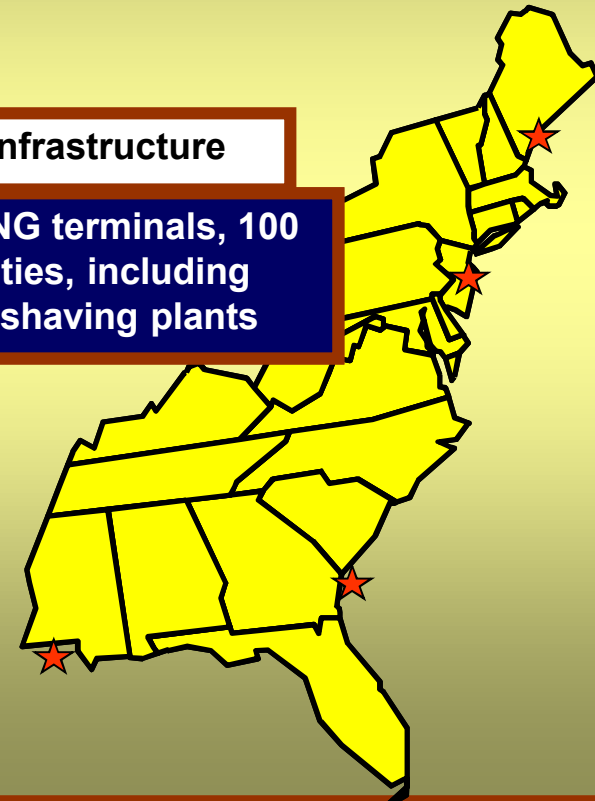


Gas Delivery

Transmission Lines: 298,000 miles
Gathering lines: 200,000 miles
Distribution lines: 1,000,000 miles
High consequence areas: 28,900 miles

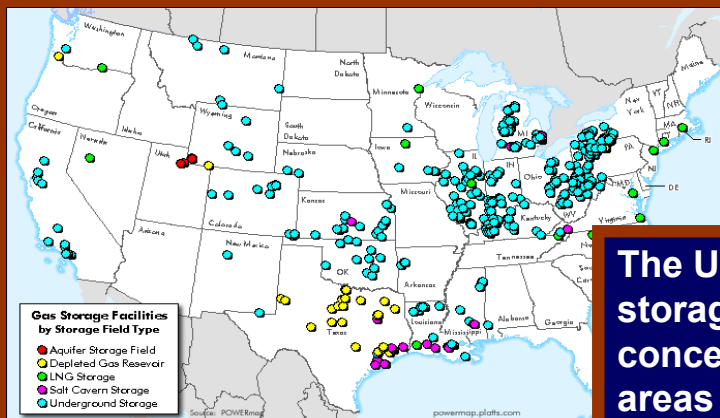
LNG Infrastructure

★ Four LNG terminals, 100 LNG facilities, including peak and shaving plants



Gas Storage

The US has 410 underground storage facilities, which are concentrated in highly populated areas of the Midwest



Detailed histories for the period by energy sector

• *Natural Gas*

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Natural Gas (Attraction)

- *Burns clean without soot and sulfur unlike coal*
- *Also does not have same environmental impacts of coal extraction*
- *Dominantly domestic production relative to oil*

Natural Gas (History)

• *Early Days*

- *First gas company established in Baltimore 1816, using synthetic gas from coal*
- *Similar companies were established in other cities in the next two decades*
- *Primarily for street lighting*
- *Household uses such as cooking did not arise until the late 19th century*
- *Competition of cheap oil based kerosene and electric arc lighting*
- *Manufactured gas lost its market to natural gas found primarily in south and southwest and then west and Midwest*
- *It remained a local fuel with pipelines within 150 miles usually within one state*

• *Major Transition*

- *After WWII it became economic to build long distance pipelines*
- *Natural gas evolved as a nationwide supplier*
- *Residential and commercial and industrial*

Detailed histories for the period by energy sector

• *Natural Gas*

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- *History of Natural Gas Political Stalemate*
- *Natural gas while it remained a local fuel was regulated by the state as public utility*
- • *As pipelines started to cross state boundaries regulation by individual states became impossible*
 - *Natural Gas Act of 1938 created a new federal agency Federal Power Commission with authority to ensure prices are just and reasonable (Act was unfortunately ambiguous on who regulates the well head price)*
 - *FPC becomes FERC when DOE formed*
- • *In 1954, the Supreme Court decided the landmark case, Phillips Petroleum Co. vs. Wisconsin, that FPC should regulate wellhead price to protect consumer*
 - *FPC interpreted that this ruling only applied to interstate gas*
 - *Congress set out to overturn the ruling*
 - *In 1956, House and Senate voted to deregulate wellhead price*
 - *Eisenhower favored deregulation*
 - *However Senator Francis Case, who favored the bill, found that a lobbyist left 25 \$100 bills to be given to him. Eisenhower vetoes bill blaming the arrogant gas lobby*

Detailed histories for the period by energy sector

• *Natural Gas*

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The Thirty-Year War

“When the Carter Administration brought its energy legislation to the Hill, it stumble into one of the great religious wars in American politics. The war over government regulation of natural gas prices goes back a full generation. The administration’s talk about energy waste, their econometric models, and deeply entrenched positions of the warring camps” congressional staff member in 1978

•Natural gas pricing posses a overwhelmingly difficult political issues objective conflict of interest among several groups and regions

- 2/3 of gas was under federal price controls*
- Two markets interstate and interstate*
- Fundamental problem whether price is based on market or cost of production*
- Natural gas production peaked in 1973 and dropped 12% by 1978 at 20tcf in 1970’s*

Liquefied Natural Gas Tankers

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LNG

- 20% of US natural gas by 2020 (6 million Tcf)
- Large Safety and Security Issues
- Issues of current urban settings
- Future trend for offshore terminals

Water Transport Tankers



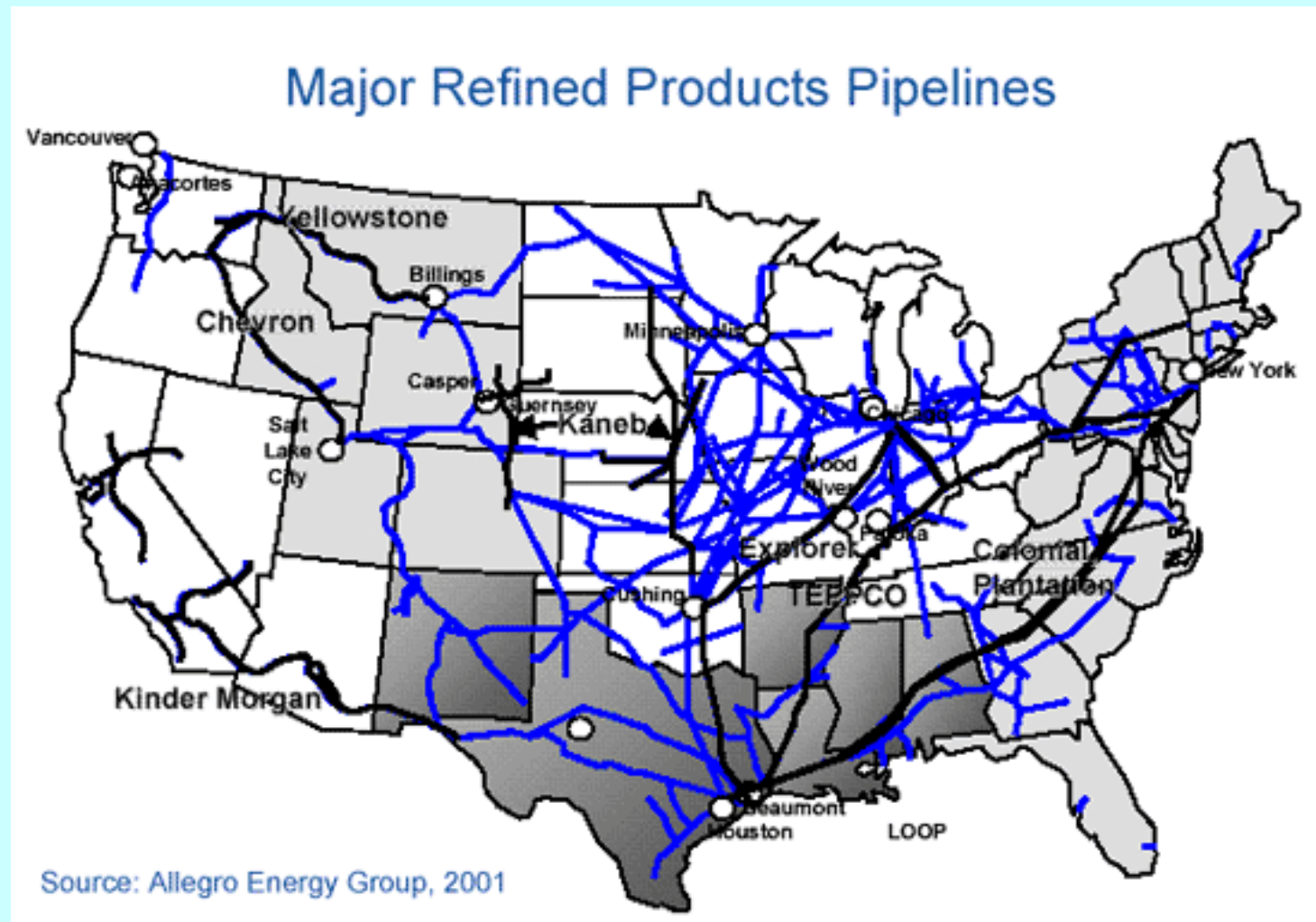
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Oil tanker size categories

AFRA Scale		Flexible market scale			
Class	Size in DWT	Class	Size in DWT	New price [41] 1	Used price [42] 1
General Purpose tanker	10,000 - 24,999	Product tanker	10,000 - 60,000	\$43M	\$42.5M
Medium Range tanker	25,000 - 44,999	Panamax	60,000 - 80,000		
LR1 (Large Range 1)	45,000 - 79,999	Aframax	80,000 - 120,000	\$58M	\$60.7M
LR2 (Large Range 2)	80,000 - 159,999	Suezmax	120,000 - 200,000		
VLCC (Very Large Crude Carrier)	160,000 - 319,999	VLCC	200,000 - 320,000	\$120M	\$116M
ULCC (Ultra Large Crude Carrier)	320,000 - 549,999	ULCC	320,000 - 550,000		

Refined Product Pipelines

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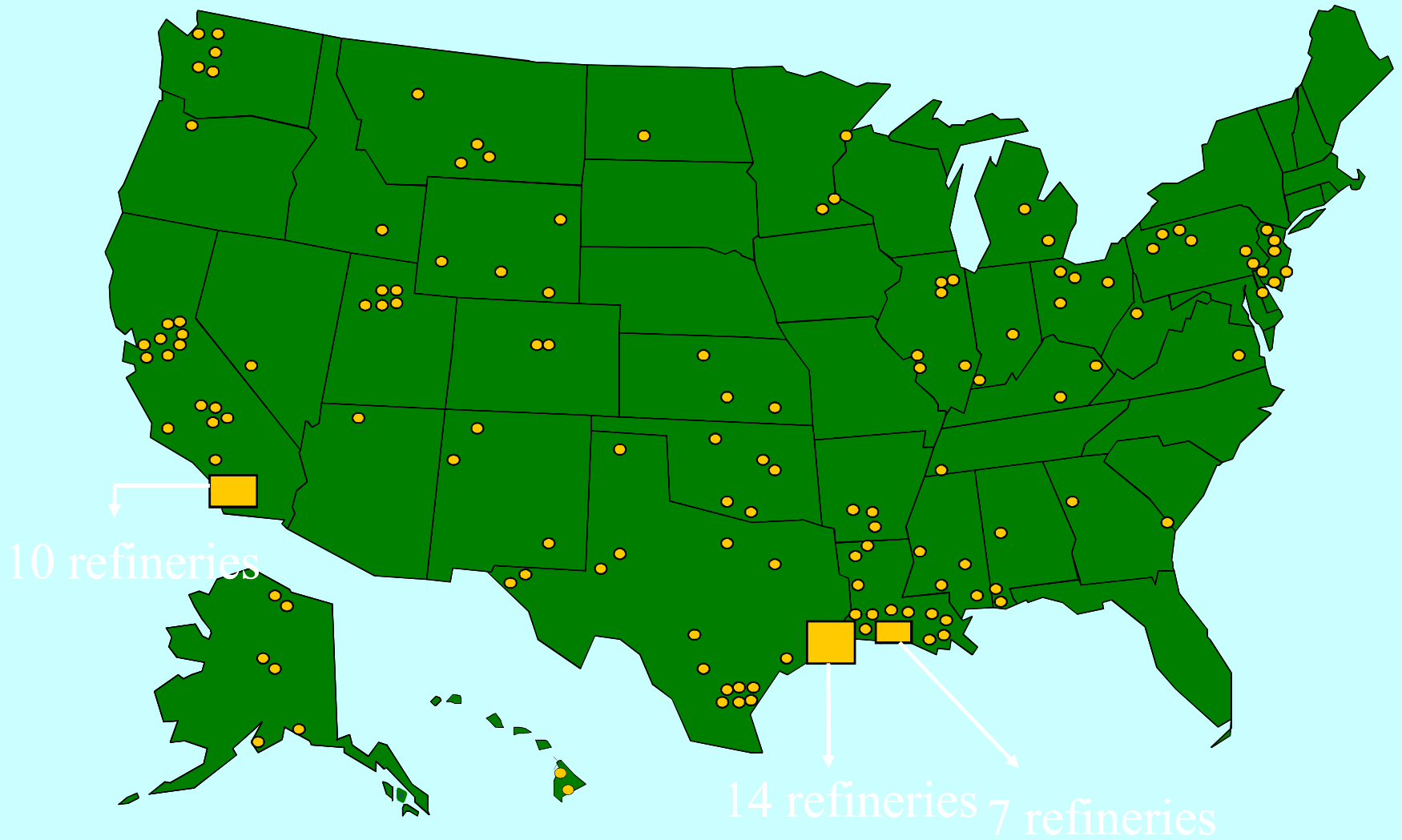


Refineries

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- **Peak in 1981**
- **US refiners began to shut down plants and consolidate cost due operating margins (environmental regulation effects) and feedstock costs**
- **Less than a handful of new refineries since 1976**
- **A new medium size refinery costs \$1 billion dollars**
- **From 301 to 133 refineries**
- **Low at 15 million b/cd (1994) to 16.6 today**
- **Refinery utilization from 70 to 90+%**
- **Refinery size double to average of 125,000 b/cd**
- **Amount of gasoline imported has gone from 4% 1995 to 10%**

Location of U.S. Refineries

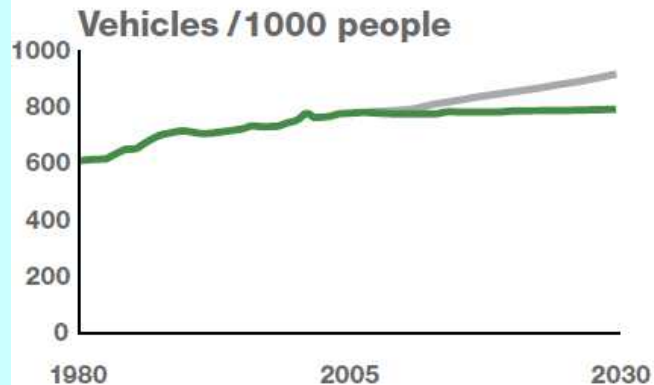
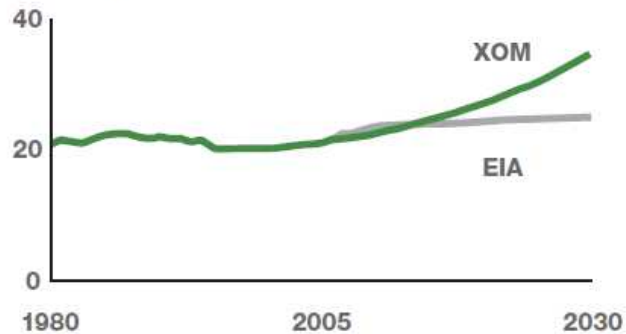


Refineries

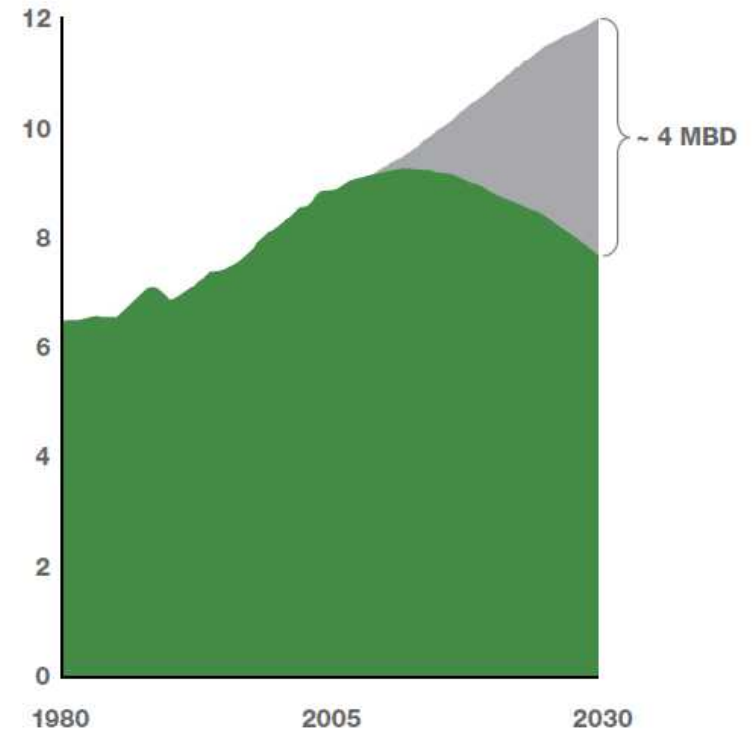
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U.S. Light Duty Vehicles – Comparison with EIA

New Vehicle Fuel Economy
Miles per Gallon



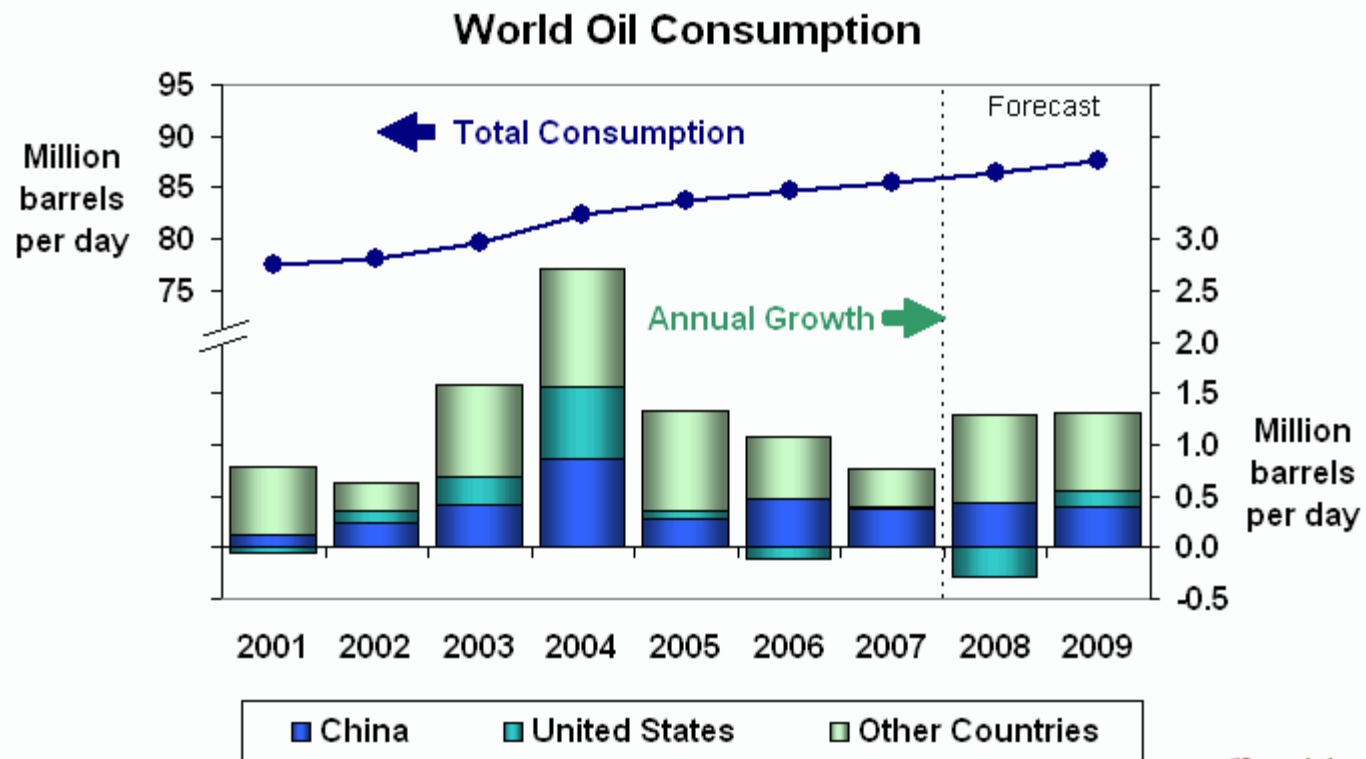
Light Duty Fuels Demand
MBD



Key measures of the U.S. light duty vehicle fleet, and the fuel demand outlook to 2030, are provided above.

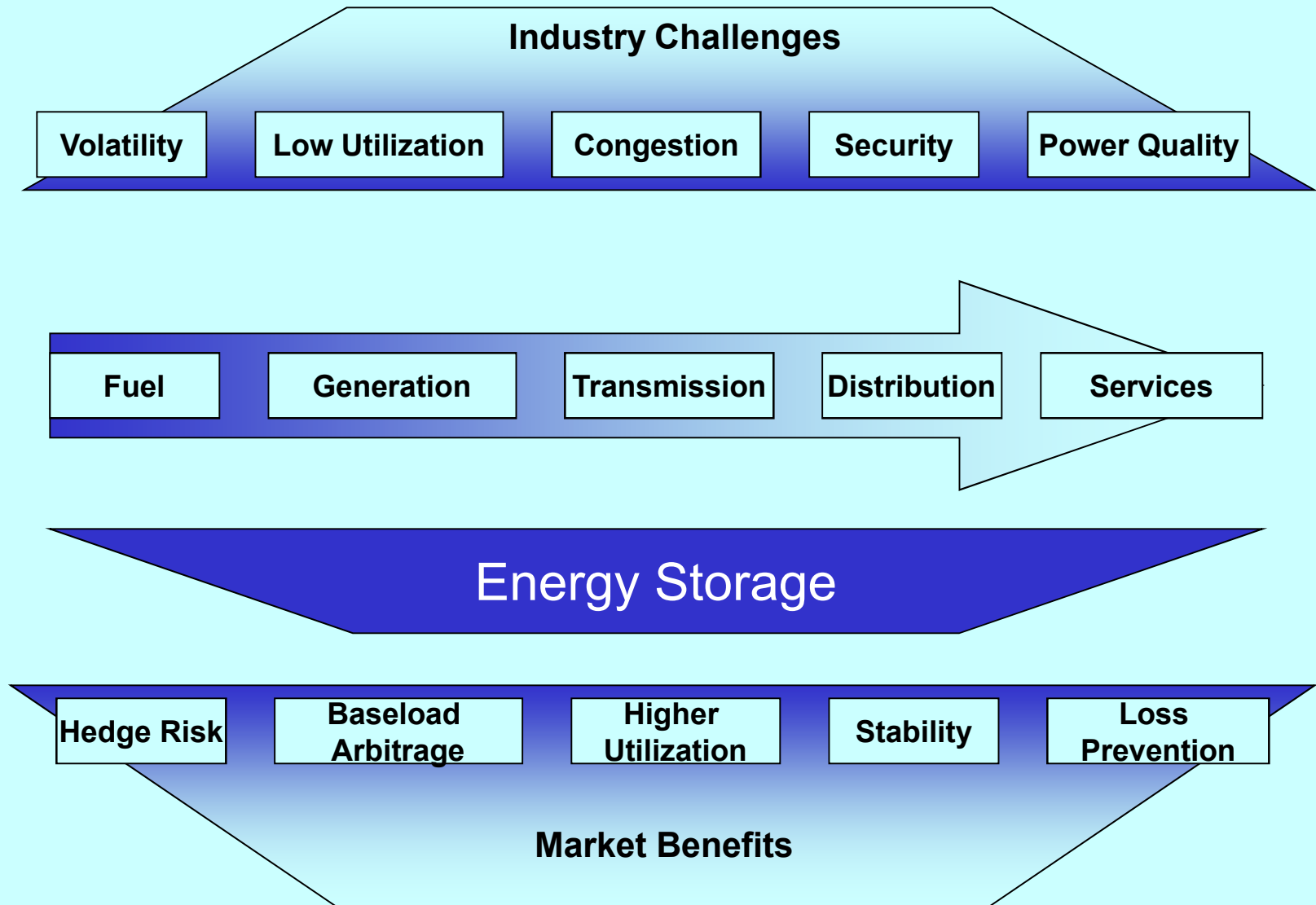
World Oil Consumption

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Short-Term Energy Outlook, June 2008

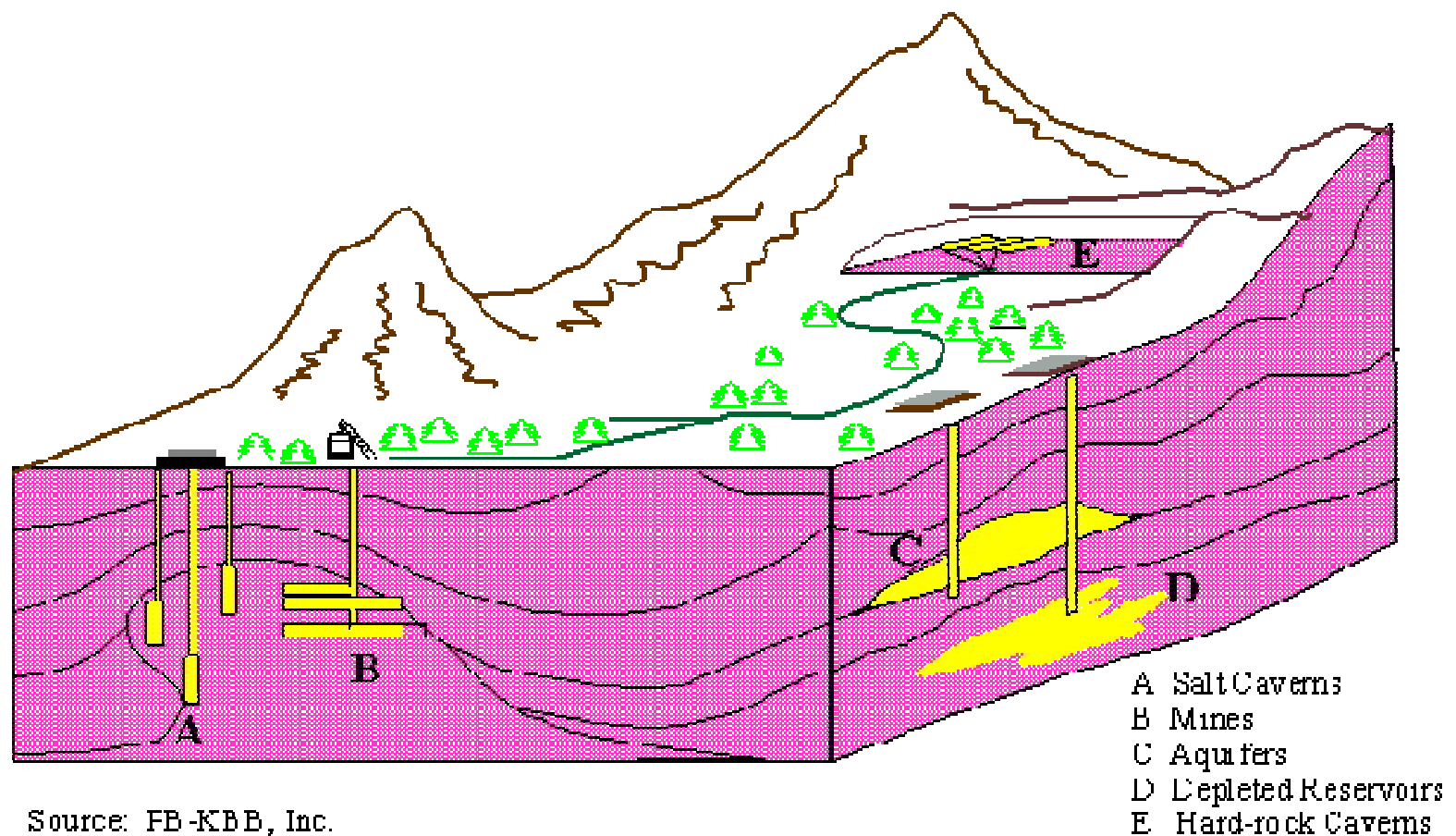
Storage: Oil and Natural Gas



Storage: Oil and Natural Gas

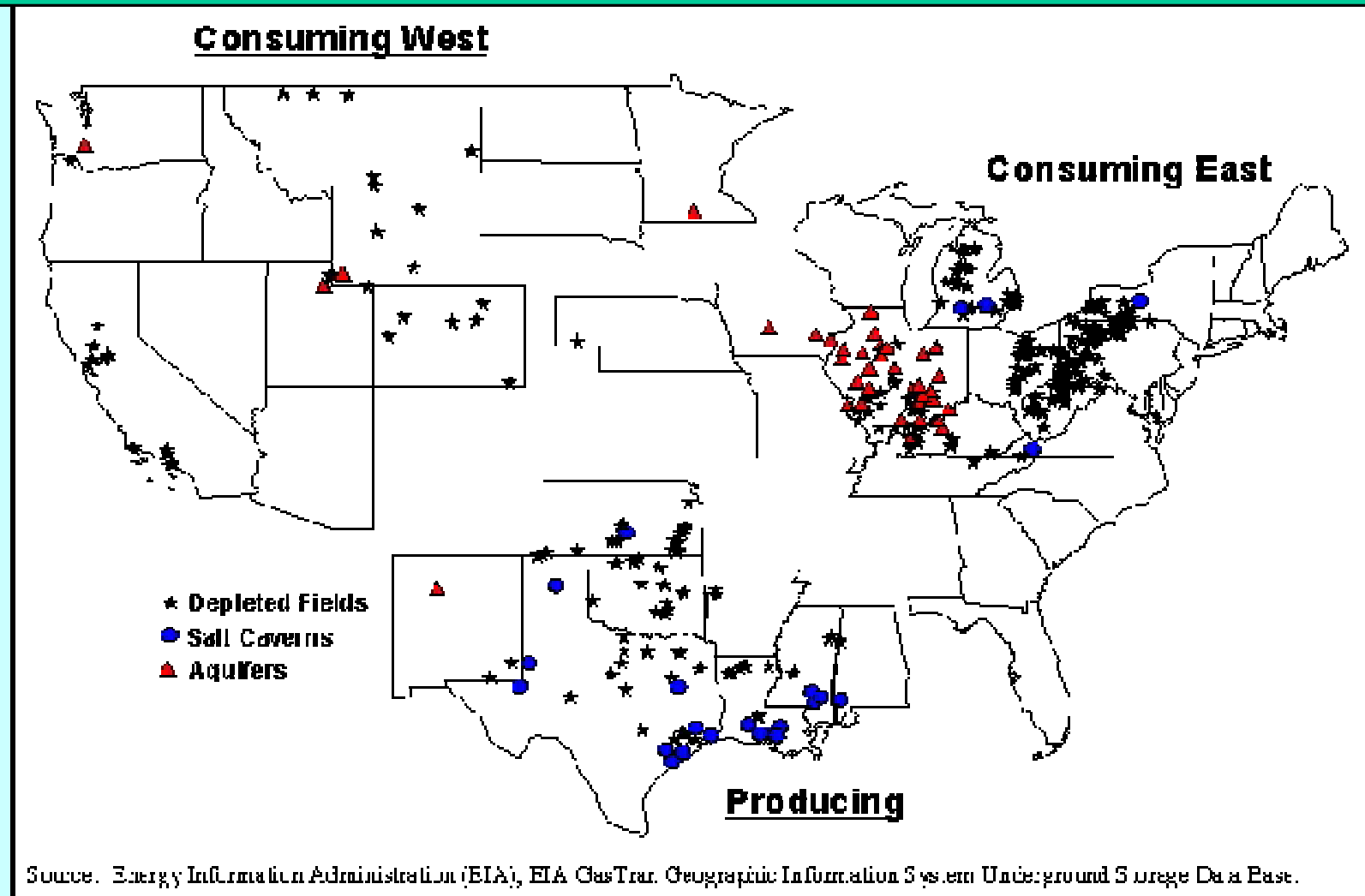
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Figure 1. Types of Underground Natural Gas Storage Facilities



Storage: Oil and Natural Gas

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