March 13, 2015

Summary of Findings

Introduction

Liquefied petroleum gas (LPG) refers to propane and butane that is recovered from the natural gas or oil stream at natural gas processing plants and refineries, respectively. In practice, the acronym LPG can be used to describe propane, butane, or a mixture of the two products. In the energy industry, some of the statistical data available for LPG supply and demand does not delineate between propane and butane, particularly for export markets. Although many US terminals export both propane and butane, the Portland Propane Terminal will export propane exclusively.

Propane is a versatile fuel with diverse uses and global dependence. It is fairly easy to transport and therefore is a valuable energy source for many countries in Asia and Latin America. As a result, the global community is adopting LPG for heating and cooking needs, which is allowing for displacement of dirtier, solid biofuels (e.g., wood). This study discusses how individuals in international markets could benefit from propane exports from the Portland Propane Terminal.

What is propane? How is it used?

Propane is a fuel which is often used for cooking and home heating (commonly referred to as residential and commercial use). Barbeque grills may be fueled by propane tanks and rural homes and businesses rely on nearby propane tanks to fuel their furnaces and stoves. Propane is also used in agriculture. Corn farmers use propane to power heaters to dry their harvest and prepare the corn for storage, allowing them to prevent molding and spoilage of valuable crops. In addition to using propane for residential and commercial uses, motor vehicles can be designed to operate on propane instead of gasoline. Many commercial vehicle fleets, including Portland's school buses, have been converted over to propane to reduce emissions. Propane is also used in the US manufacturing sector to produce many of the plastic goods used in our everyday lives, including medical supplies and household goods like water bottles and reusable bags. It is even used to create many car parts, including siding.

US/Canada Propane Supply and Demand

In the US and Canada, propane supply is expected to continue to grow over the next 10 years and reach 2.1 million barrels per day (MMb/d) in 2025. There are two main end uses for propane in the US and Canada: industrial, which includes manufacturing, and residential and commercial. Bentek expects industrial demand to grow to approximately 505 Mb/d in 2020 and hold steady at that level. Residential and commercial demand is also expected to remain fairly flat at approximately 520 Mb/d. Therefore, in total, the US and Canada will consume only 1.0 MMb/d of propane domestically in 2025, resulting in a marine export opportunity for facilities like the Portland Propane Terminal.

US Propane Exports

Propane exports from the United States are nothing new. The US has been an exporter of propane since the Energy Information Administration (EIA) began tracking this information in 1981. Between 2000 and 2008, US exports of propane averaged 57 Mb/d. Since 2008, US exports of propane have risen significantly. Through November 2014, the US exported 487 Mb/d of propane, eight times more than it did in between 2000 and 2008. This level of exports places the US among the top propane exporting countries globally.

Today, there are five operating LPG export terminals in the US with approximately 722 thousand barrels per day of loading capacity available. Most of this capacity is located in Texas, which is also the primary trading hub for propane in the US. In addition to the existing terminals, four expansions projects and three new-build terminals are planned, which would add about 620 Mb/d of additional export capacity.

The Portland Propane terminal will have an export capacity of about 37 Mb/d. To put this number in perspective, this capacity equates to only 5% of the existing capacity along the Gulf Coast, which is the major propane export region in the US.
Due to its location on the West Coast, the Portland Propane Terminal has a significant advantage for transport to Asia as compared to terminals on the Gulf Coast and East Coast. A one-way trip from Portland to Japan is about 12 days, compared to transport times of about 27 days from the Gulf Coast to Japan through the Panama Canal and 44 days from the Gulf Coast to Japan around Africa's Cape of Good Hope.

Asian LPG Market

In 2012, four of the top six LPG importing countries in the world were located in Asia: Japan, India, South Korea and China. Therefore, this study focused on the Asian market, defined as: Japan, South Korea, China, India and Indonesia, to determine their appetite for US propane. Based on data from the International Energy Agency (IEA), all five countries are net importers of LPG and present the Portland Propane Terminal with opportunities to supply growing markets with propane.

Japan
In 2012, Japan consumed approximately 520 Mb/d of LPG, compared to domestic production of approximately 125 Mb/d. Primary demand sources for LPG in Japan are residential/commercial (39% of total LPG demand) and industrial (29%). Additional uses include electricity, transportation and blending into liquefied natural gas (LNG) to increase its heating value.

South Korea
South Korea consumed approximately 250 Mb/d 2012 versus production of 75 Mb/d. The largest demand sector for LPG in South Korea is transportation (47% of total demand). Additional uses are industrial (23%), residential/commercial (20%) and blending into natural gas to increase heating value (10%).

China
China's LPG in 2012 demand was 760 Mb/d in 2012 slightly below the country's domestic production of LPG of 675 Mb/d. The primary demand source for LPG is residential/commercial (78% of total LPG demand), followed by industrial (13%). Transportation (3%) and other (6%) are minor sources of demand.

India
In 2012, India consumed approximately 500 Mb/d of LPG, an increase of nearly 50% over 2005 demand. During the same time period, India produced approximately 300 Mb/d of LPG. The primary demand source for LPG is residential/commercial (94%). Industrial (1%), transportation (1%) and other (4%) are all minor sources of demand.

Indonesia
Indonesia's domestic production of LPG of 80 Mb/d in 2012 was only sufficient to meet half of the country's LPG demand of 160 Mb/d. Indonesia's LPG demand has experienced dramatic growth since 2005, rising 400%. The primary demand source for LPG is residential/commercial (99%). Industrial (1%) is a minor source of demand.

In total, the five Asian markets investigated in this study consumed 2.19 MMb/d of LPG in 2012, an increase of 23% over the levels consumed in 2005. The largest market in 2012 was China, consuming nearly 760 Mb/d of LPG, followed by Japan

(521 Mb/d), India (496 Mb/d), South Korea (259 Mb/d) and Indonesia (160 Mb/d). The fastest growing markets were Indonesia and India, showing growth of 407% and 49%, respectively, between 2005 and 2012. In terms of demand use, residential/commercial was the largest sector across all countries, representing 67% of total LPG consumption in 2012. The next largest sector was industrial at 14%, followed by transportation (8%), natural gas blending (5%), other (3%) and electricity (2%). In 2012, the Asian markets studied produced 1.27 MMb/d of LPG, satisfying only 57% of the countries' total demand. The remaining 925 Mb/d of LPG demand required imports. In the future, a portion of these imports could be met by supply from the Portland Propane Terminal.

Benefits of LPG

Use of solid biofuels, such as those used extensively in China and India, presents a significant health hazard to the indigenous populations. The World Health Organization estimated that in 2012, 4.3 million deaths were directly related to indoor air pollution. Household air pollution deaths were highest in Southeast Asia (1.7 million per year) and the Western Pacific (1.6 million per year), areas that would be served by the Portland Propane Terminal. Propane exports from Portland have the potential to displace use of solid fuels and greatly improve household air quality.

India Case Study

Since 2005, solid biofuels have represented over 80% of total fuel consumption for residential and commercial needs in India. Refined products, including LPG, represent the second largest component for residential/commercial demand at 13 to 14%, with coal and natural gas comprising about 5%. Significant opportunity to displace solid biofuel exists in India, particularly with LPG, given the ease of transport and storage. A shift toward LPG usage in place of solid biofuels offers the opportunity to improve the quality of life in India by reducing emissions from dirtier fuel sources.

China Case Study

China has also shown that displacement of solid biofuel is possible. Use of solid biofuels has trended down from 72% in 2000 to 59% in 2012. In particular, cleaner burning refined products (which includes propane) and natural gas have taken share from solid fuels. In China, the actual demand for oil products, including LPG, and natural gas have both risen by approximately 20 million tonnes of oil equivalent. These products have grown more quickly than coal, a dirtier fuel source. LPG produces about 33% less pounds of carbon dioxide per heating value (MMBtu) when burned than coal.

Conclusions

Propane serves as a good transition fuel for countries with limited infrastructure for natural gas and electricity. Specifically, it is relatively easy to store and transport, making it a good fuel source for remote locations. Additionally, propane burns more cleanly than more primitive solid biofuel sources which are commonly used in such locations, which could in turn lead to better living conditions in developing markets. Bentek expects that residential use of propane can displace biofuels in these markets. This displacement would favorably impact the lives and improve the health of many people in developing countries.

Specifically, the Portland Propane Terminal is strategically positioned to supply propane given its proximity to Asian markets. Its geographic proximity will allow it to serve key Asian propane markets more easily than export terminals along the US Gulf Coast or the US East Coast. Bentek estimates that the travel time from Portland to Japan at 12 days, a 44% shorter travel time than a ship traveling from the US Gulf Coast.

Beyond consumption of propane for heating and cooking in Asia, the use of propane for industrial applications also offers benefits for both Asian manufacturers and global consumers. Many of the products manufactured using propane are ultimately returned to the Port of Portland for distribution to US consumers.

About Bentek Energy

Bentek Energy is a natural gas and oil analytics and forecasting unit of Platts, a leading global provider of energy and commodities information. The Company focuses on the following sectors within the energy industry: natural gas, liquefied natural gas (LNG), crude oil, natural gas liquids (ethane, propane, butanes and natural gasoline), power, including renewable power sources and infrastructure related to these markets.

Pembina Portland Propane Export Terminal

Overview of Propane Market Demand and End Uses

March 13, 2015

Bentek Energy is a leader in energy market fundamentals

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Bentek's clients span the industry

40% Majors, producers, marketers, industrials

22% Pipelines, utilities, midstream

33% Financial entities and Hedge Funds

5% Government, associations, consultants

Bentek is a data-driven, analytical company specialized in energy

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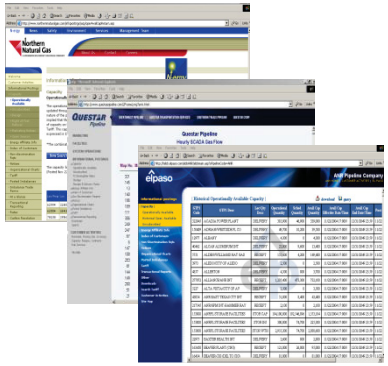
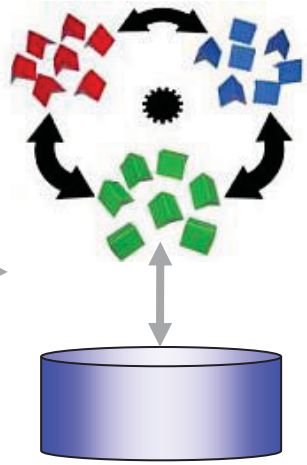
Collect Data → **Organize and Process** → **Analyze and Interpret** → **Deliver**





What Bentek does:

Bentek provides transparency, actionable intelligence, and key market insights to the market

Unbiased view

What Bentek does NOT do:

Move gas, buy gas, store gas invest, hedge, drill, manage assets

The BENTEK Approach

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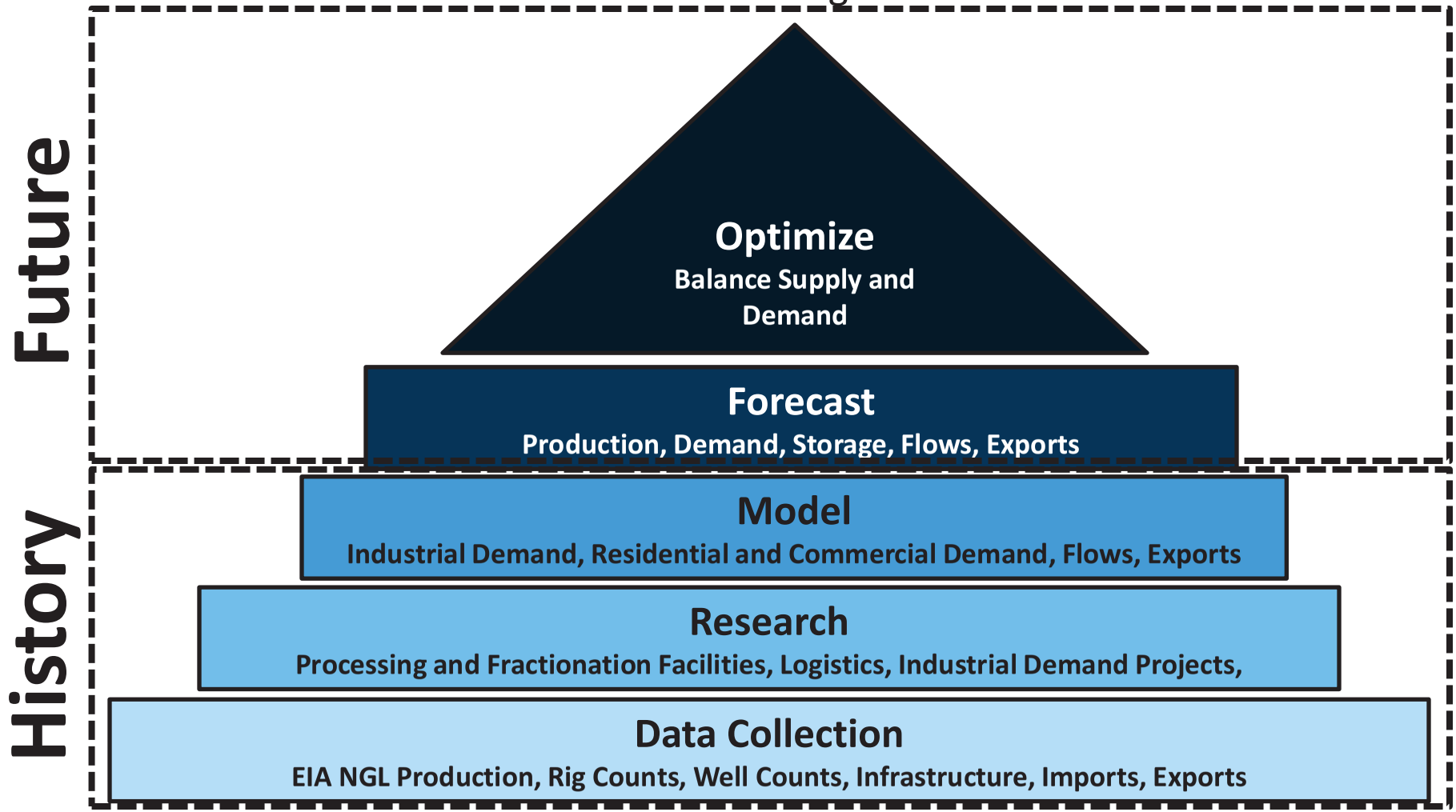
Bentek collects, organizes and analyzes data in the energy industry to develop key market insights



Note: Graphic Above Is Not inclusive of All Data, Research and Model Performed By Bentek.

Overview on global uses for Liquefied Petroleum Gas (LPG)

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Propane is a versatile fuel with diverse uses and global dependence

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- Liquid petroleum gas (LPG) is used colloquially to refer to propane
- By definition LPG is a mixture propane and butane
- Propane is produced from natural gas processing plants and refineries
- Major uses of propane include:

Medical Supplies

Household Goods

Crop Drying

Manufacturing

Cooking and Home Heating

Transportation

Outlook on the North American Propane Market

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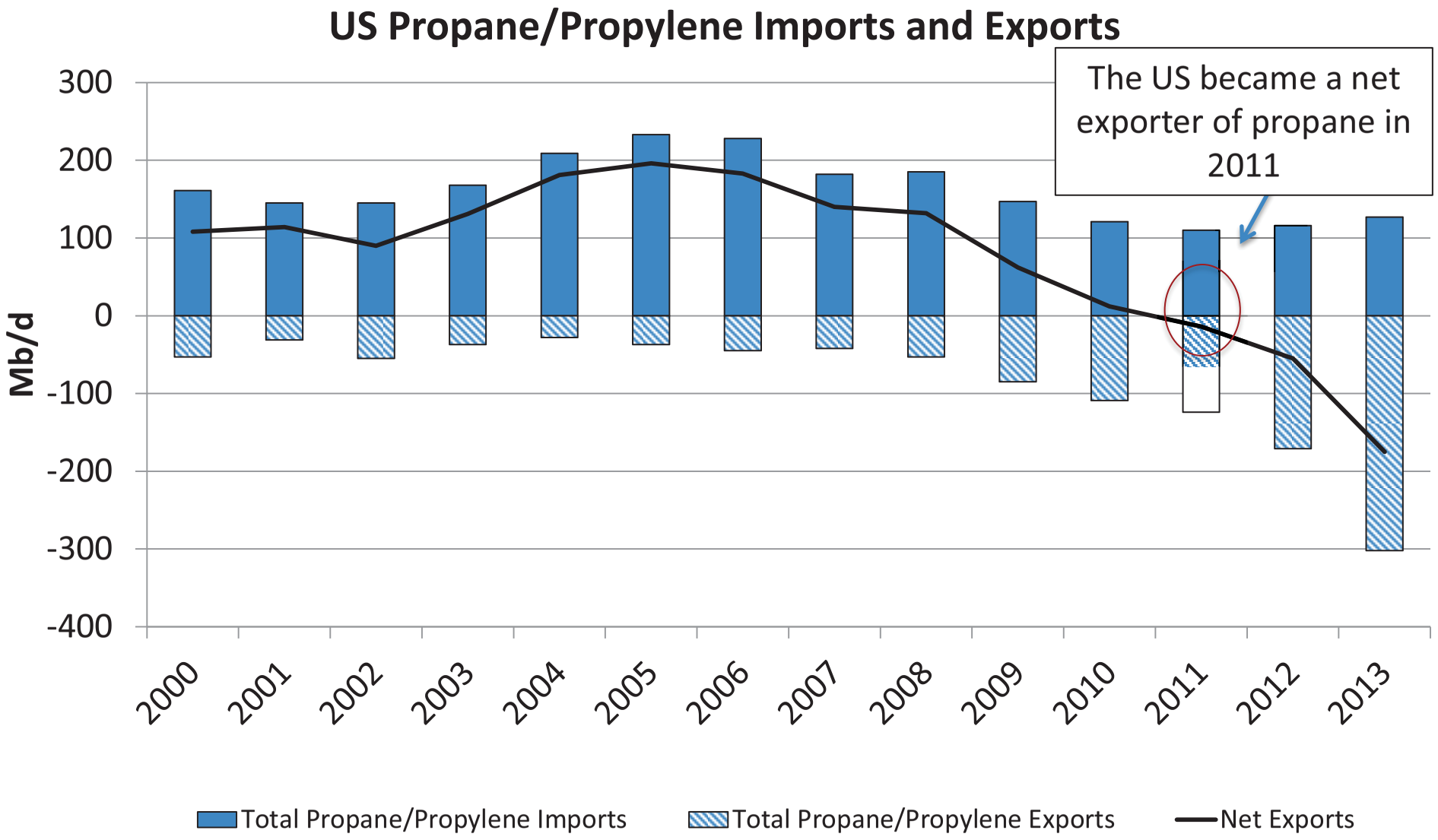
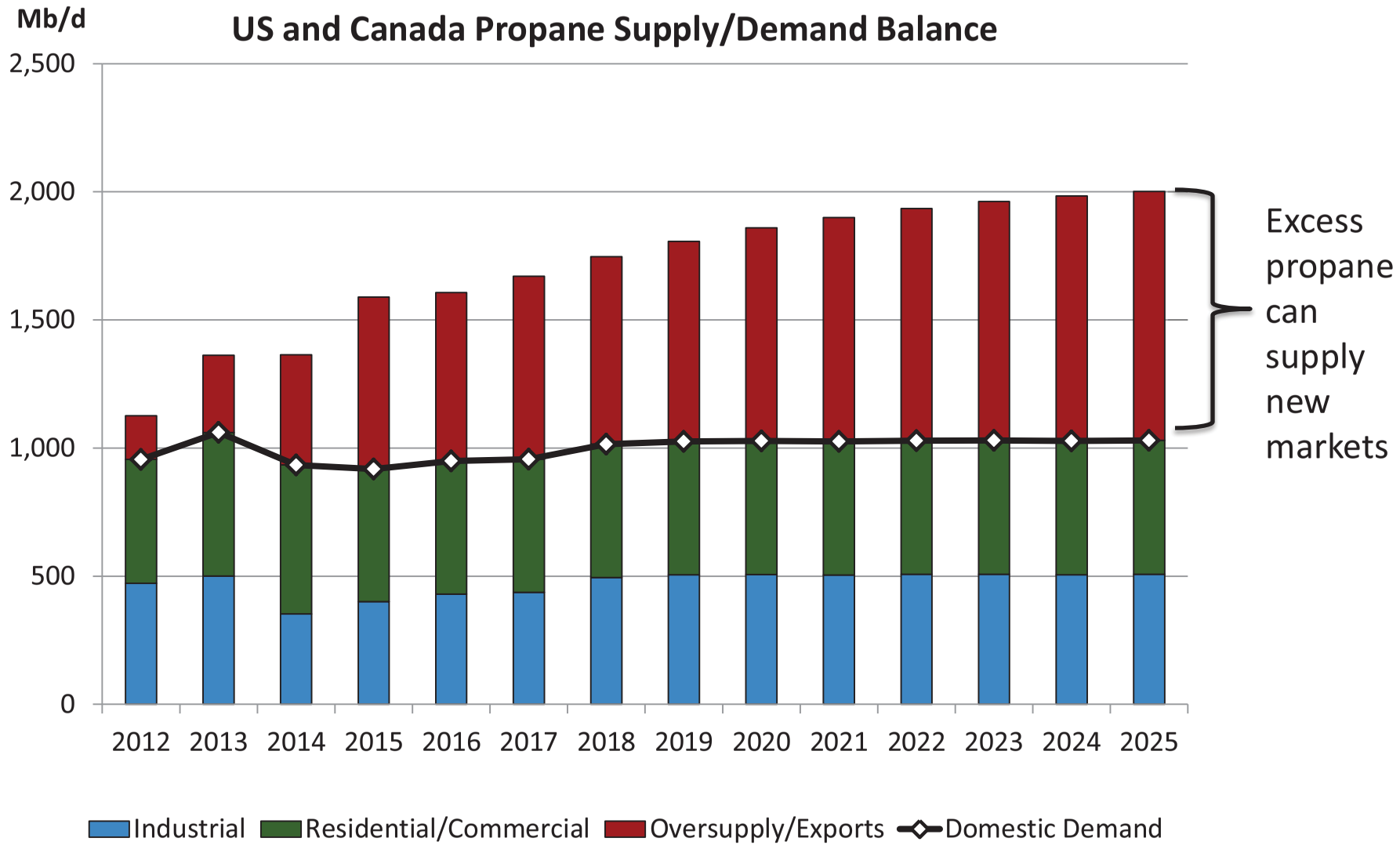
US Propane Exports are Nothing New



Source: EIA, Bentek

Increased propane production creates marine export opportunity for Portland



Source: Bentek *Market Call: North American NGLs 1Q2015*

Propane flows to marine export terminals from key supply areas

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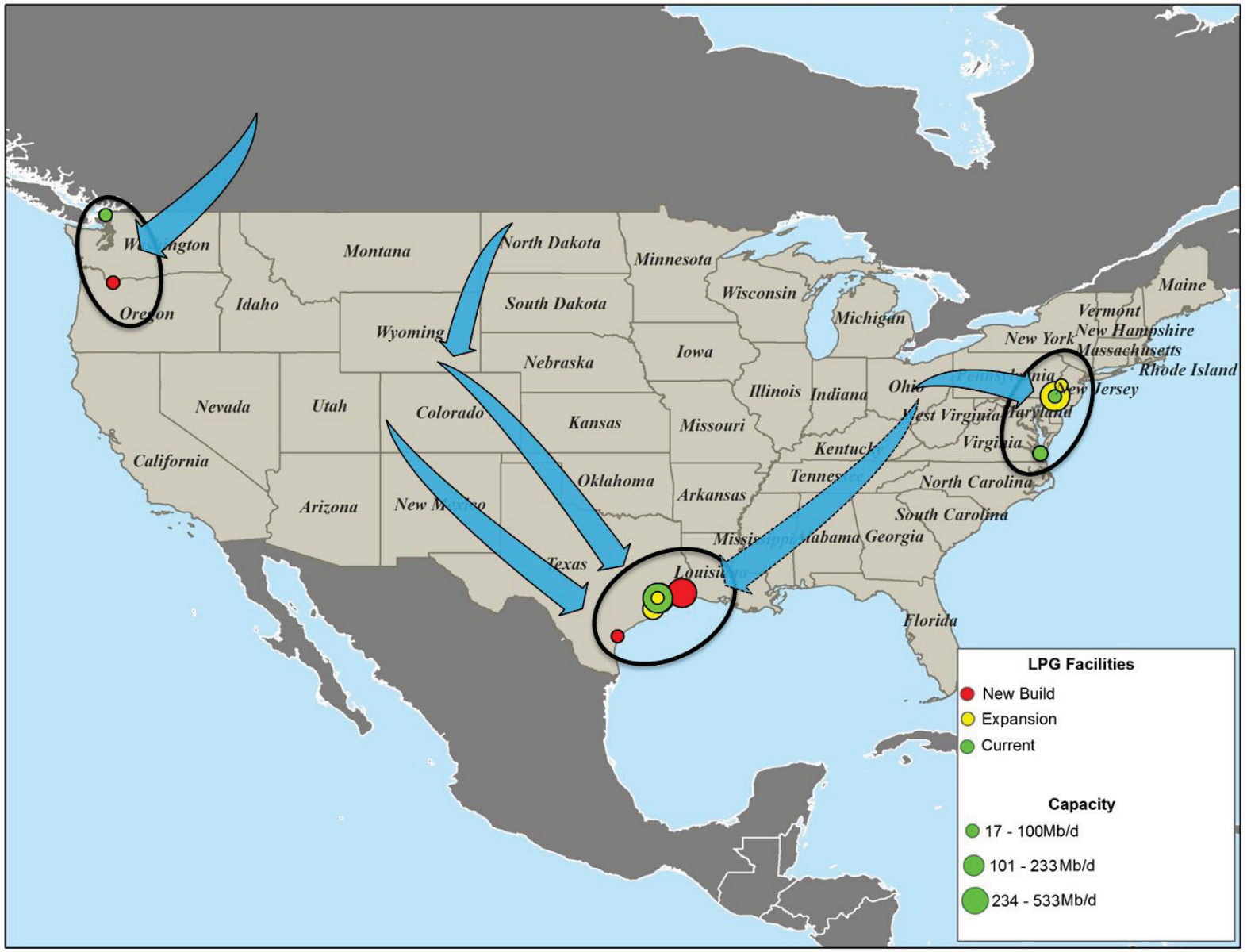


Export terminal capacity is focused along US Gulf Coast

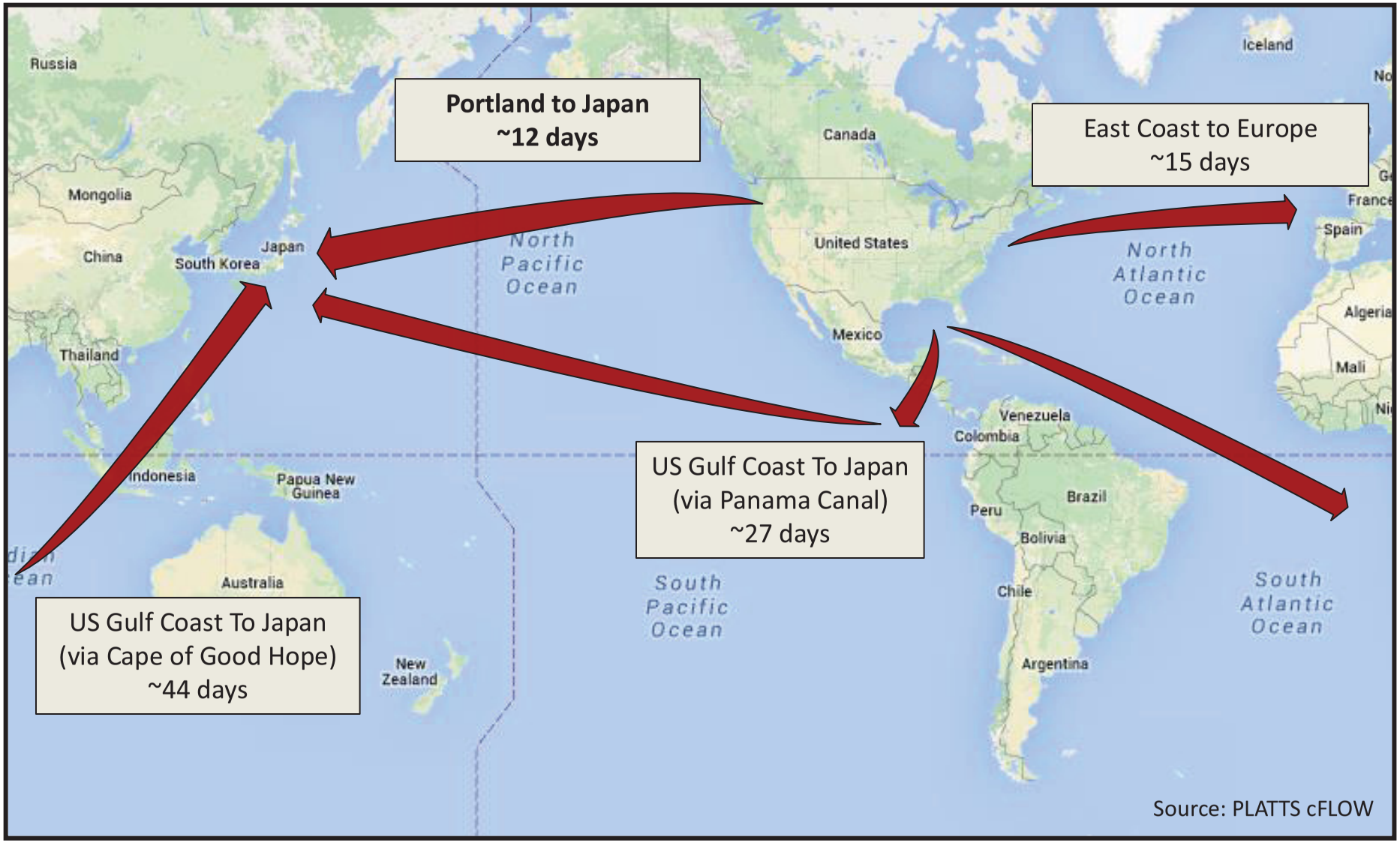
Company	Project Name	State	Capacity (Mb/d)	Expected ISD*
Existing LPG Export Terminals			**722**	
Enterprise	Enterprise	TX	250	—
Targa	Galena Park	TX	217	—
Sunoco Logistics	Marcus Hook	PA	17	—
DCP Midstream	Chesapeake	VA	8	—
Sunoco Logistics	Mariner South	TX	200	—
Petrogas	Ferndale	WA	30	—
Brownfield Expansions			**483**	
Enterprise	Enterprise Expansion II	TX	50	2015
Enterprise	Enterprise Expansion III	TX	233	2015
Sunoco Logistics	Marcus Hook Expansion I	PA	~40	2014
Sunoco Logistics	Marcus Hook Expansion II	PA	~160	2016
Greenfield -- New Builds			**137**	
Occidental Chemical	Ingleside	TX	100	2015
Pembina	Portland Propane Terminal	OR	37	2018
EnLink Midstream	EnLink	LA	NA	NA
Repurpose			**147**	
Phillips 66	Freeport LPG	TX	147	2016
Kinder Morgan	Fairless Hills	PA	NA	2017
Targa	Patriot	TX	NA	NA

LPG Ship

Portland Propane Terminal capacity is only 5% of existing LPG export capacity

Source: Bentek *NGL Facilities Databank,* company reports
**ISD refers to in-service date for the terminal.*
NA= Not available

Portland has significant location advantage for transport to Asia



Global LPG Market Fundamentals

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Increased US LPG exports headed to Latin America, Europe and Asia

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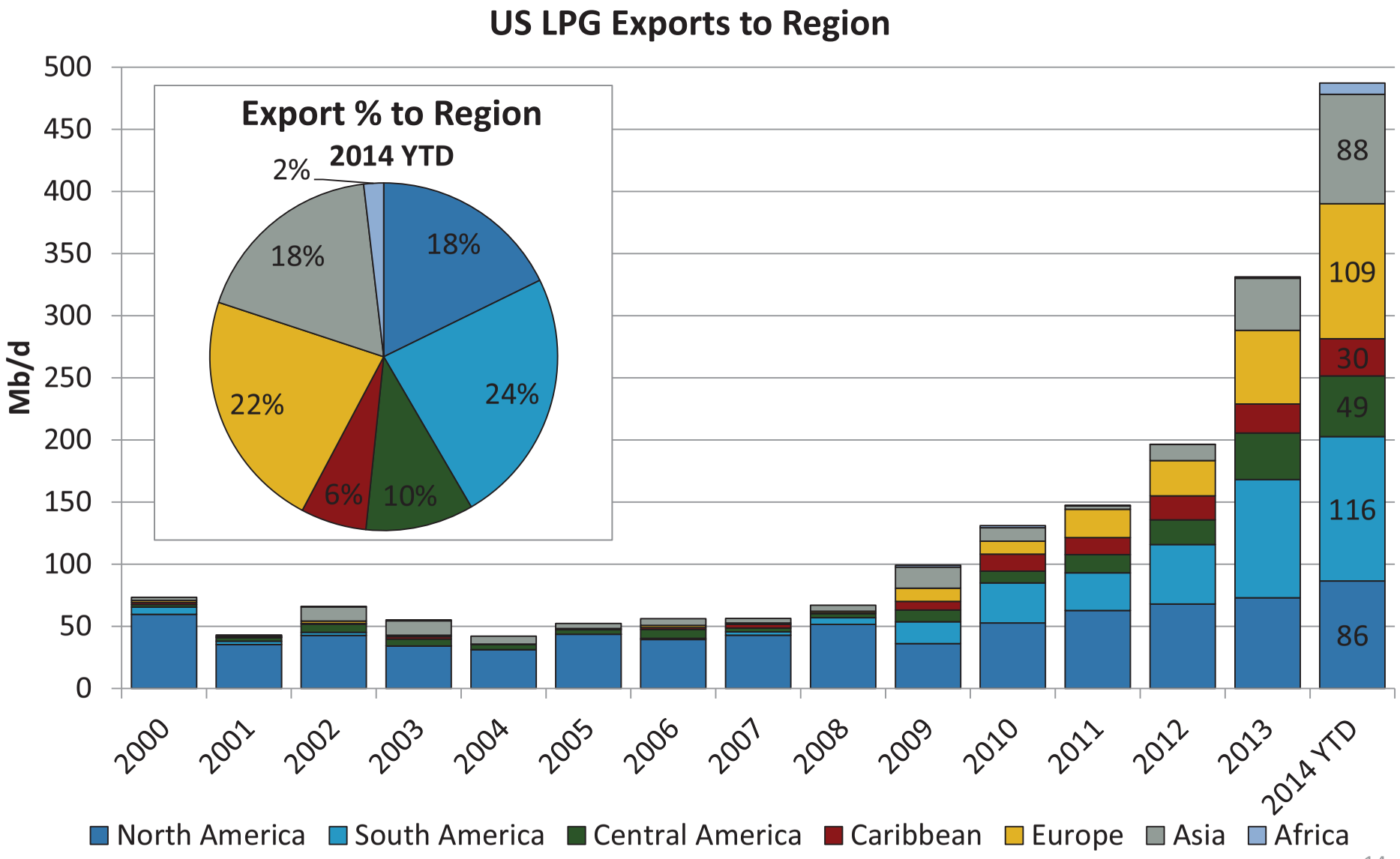
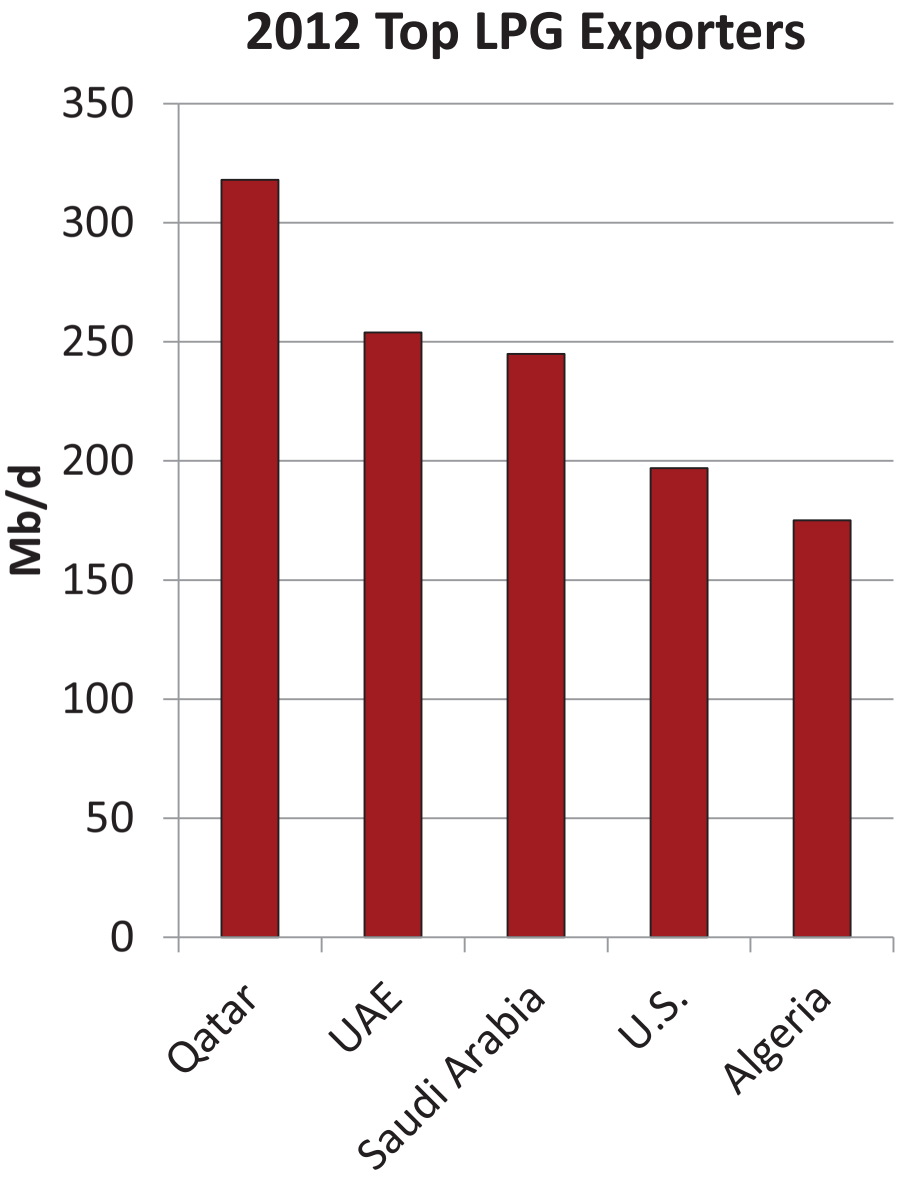
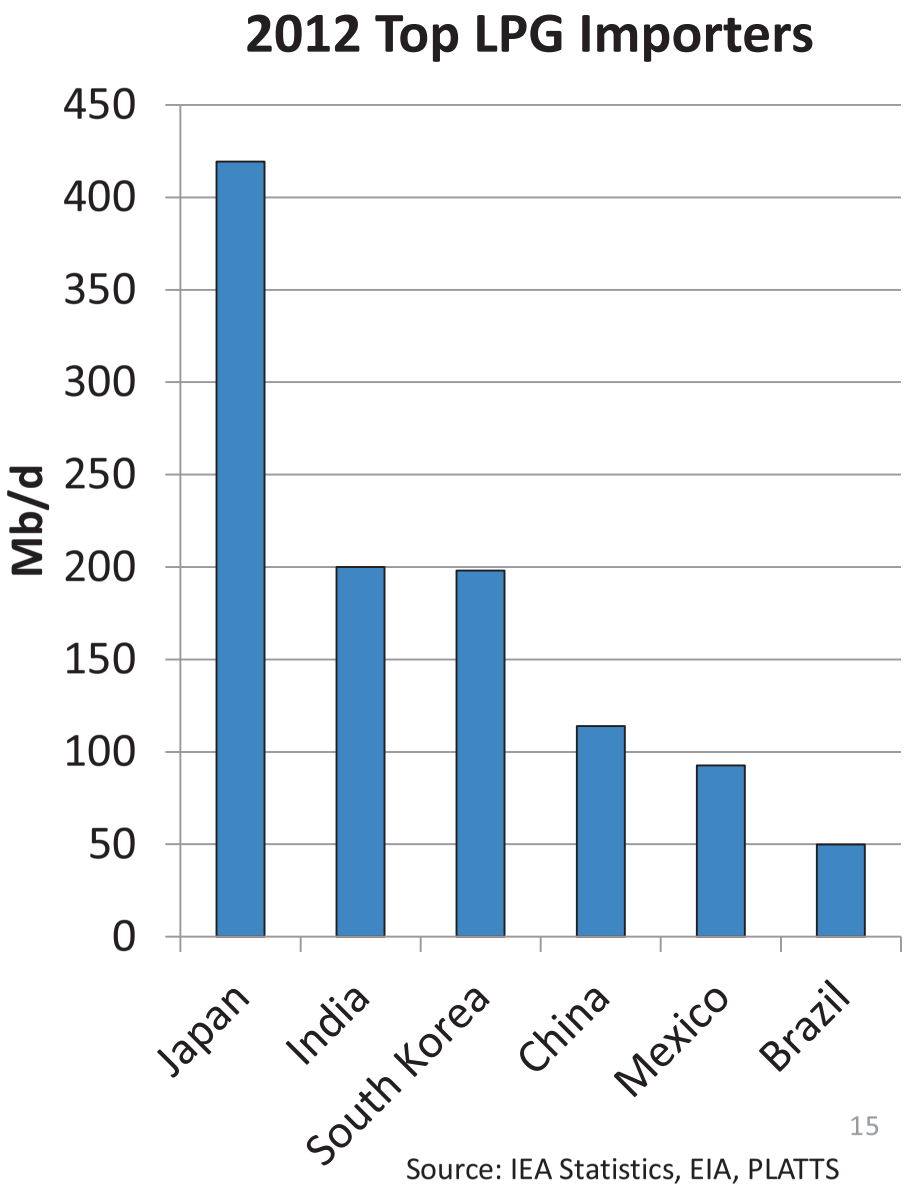


Source: EIA Note: North America includes Canada and Mexico

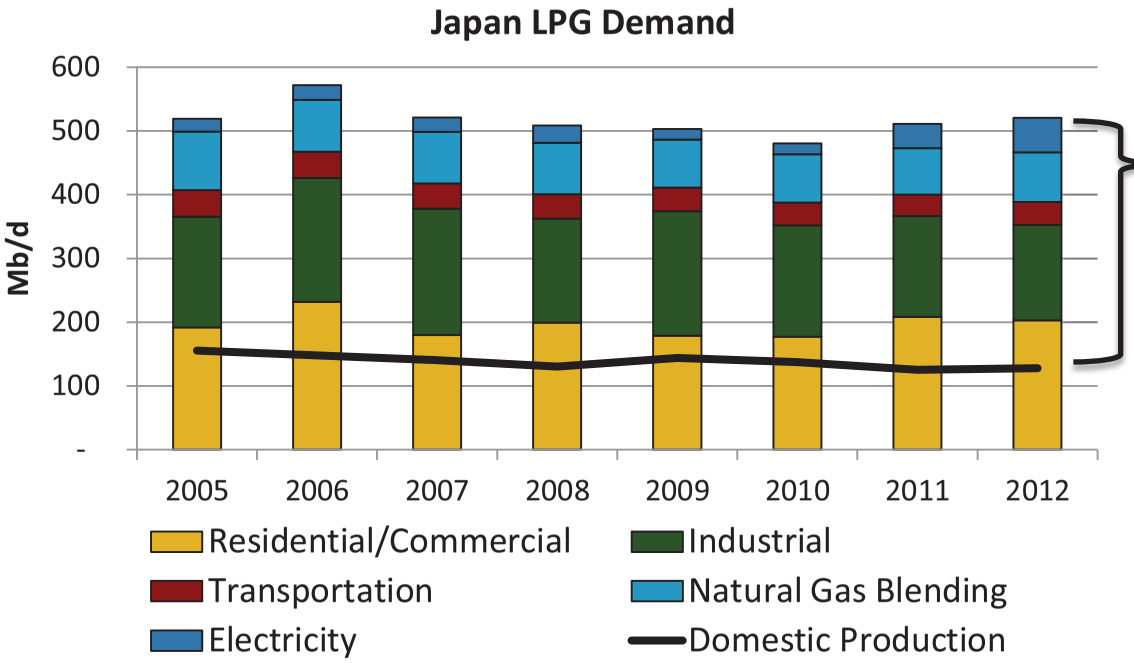
Major LPG importers and exporters



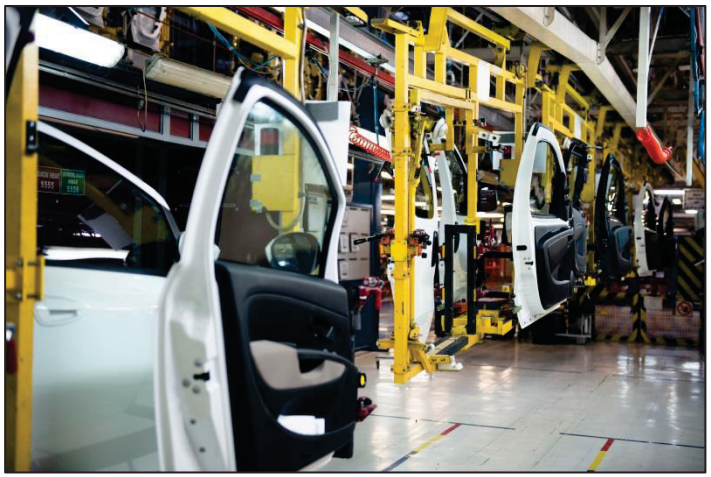


Source: IEA Statistics, EIA, PLATTS

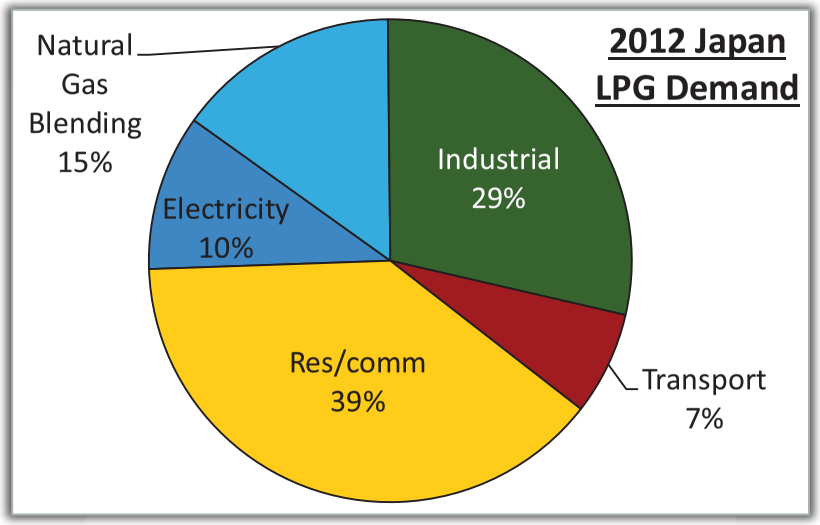
Japan has diverse uses for LPG



Total demand exceeds domestic production; Japan is a net importer of LPG



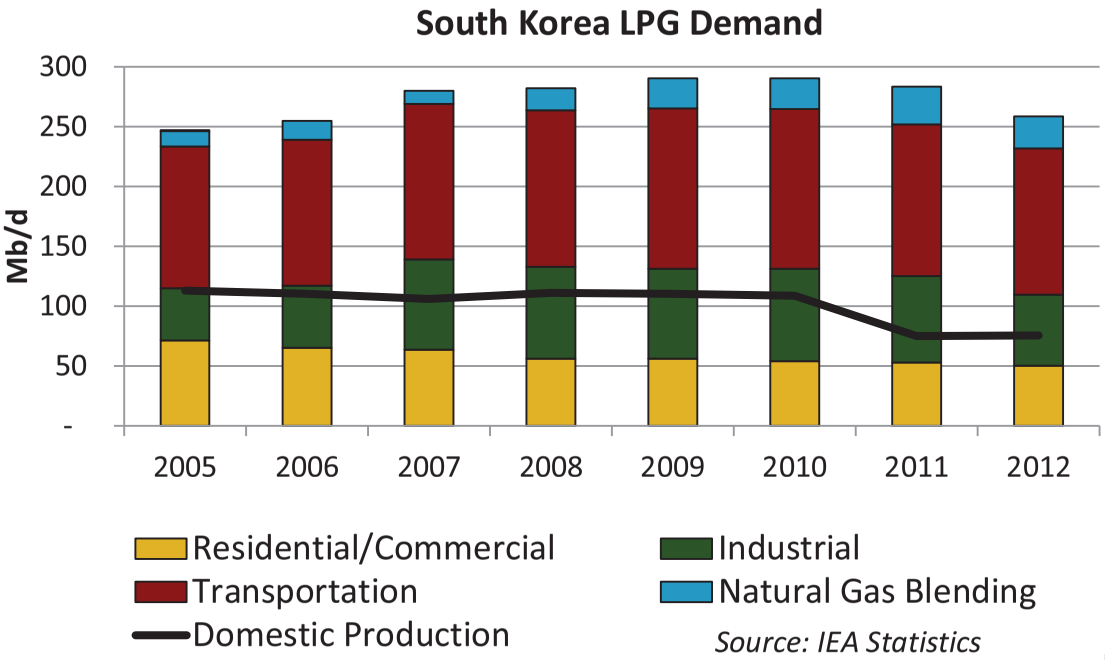
Automotive manufacturing plant



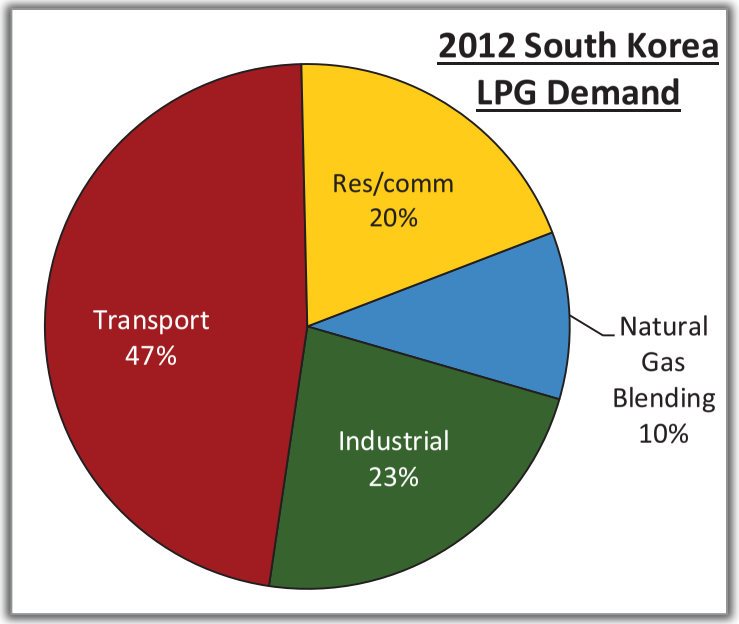
Source: IEA Statistics

- Japan requires LPG from other countries to satisfy demand, exports from North America provide an opportunity to diversify supply
- One main use in industrial sector is to produce plastic for manufactured goods (e.g., for use in car parts)

South Korea uses LPG primarily as a motor vehicle fuel ("Autogas")



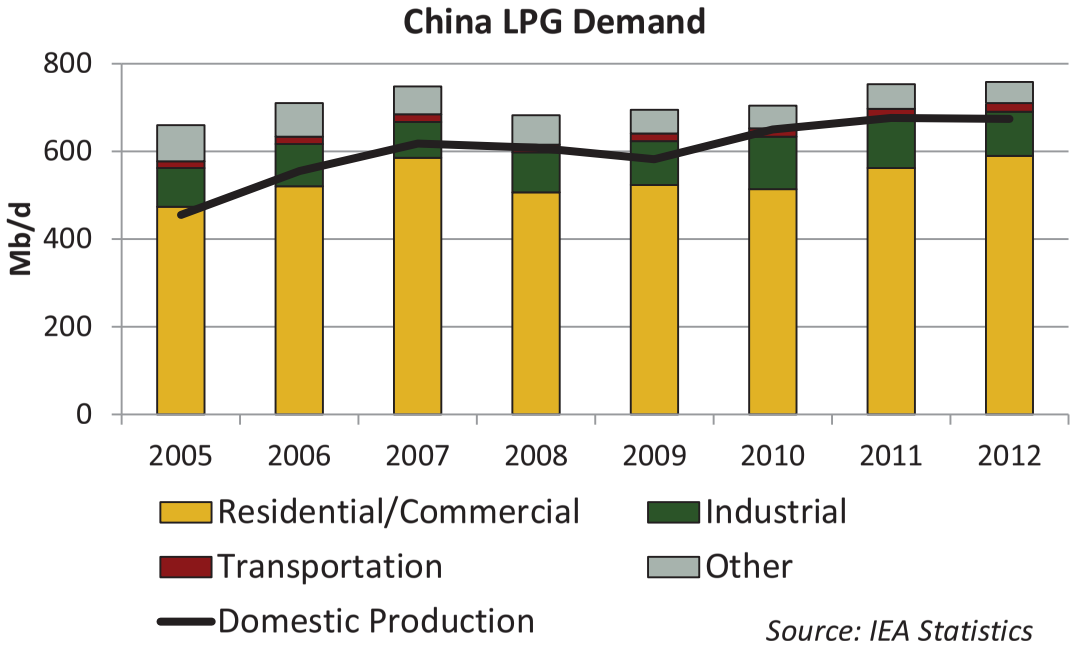
Source: IEA Statistics



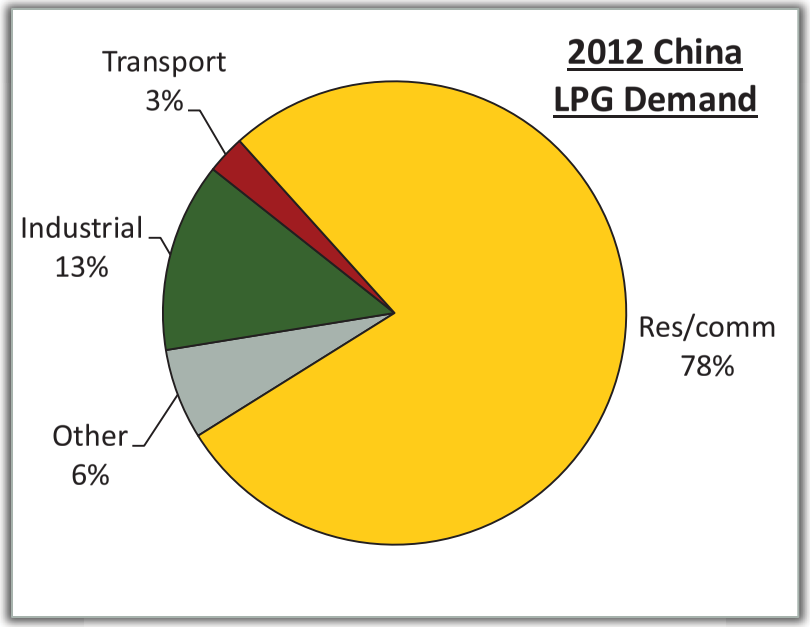
- South Korea also requires LPG from other countries to satisfy demand, exports from North America provide an opportunity to diversify supply
- 13% of South Korea's total vehicle fleet runs on LPG, as Autogas has been highly supported by the Korean government (World LP Gas Association)

Autogas fueling station

China diversifies use for LPG as its economy grows



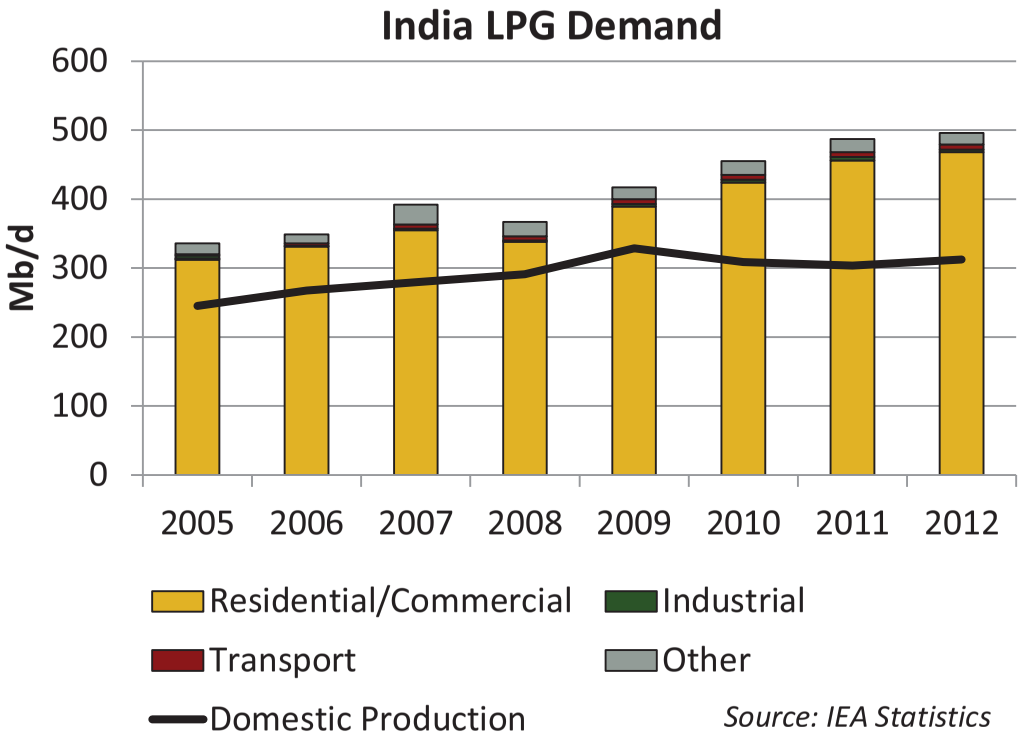
Source: IEA Statistics



- China primarily uses LPG in the residential/commercial sector
- Demand for LPG is anticipated to grow in the industrial sector in China, as new industrial complexes are constructed to produce feedstock materials for plastics

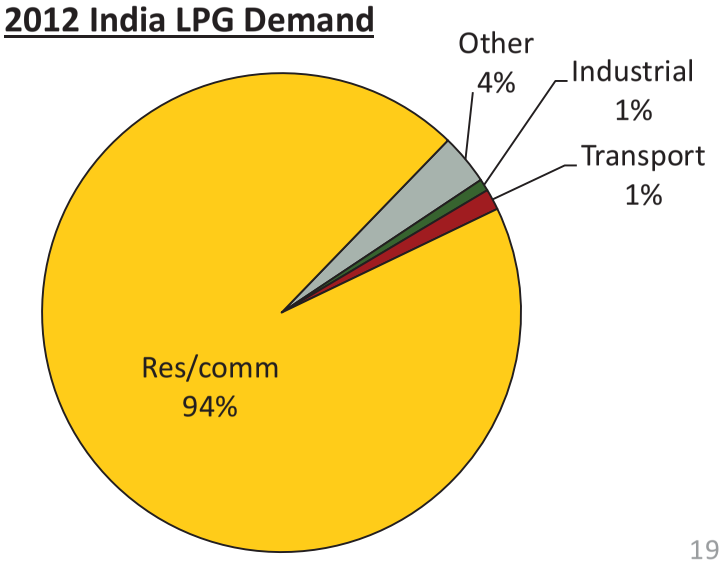
Worker in Chinese textile factory

India uses LPG primarily to heat homes and cook food



Source: IEA Statistics

Man prepares food in India

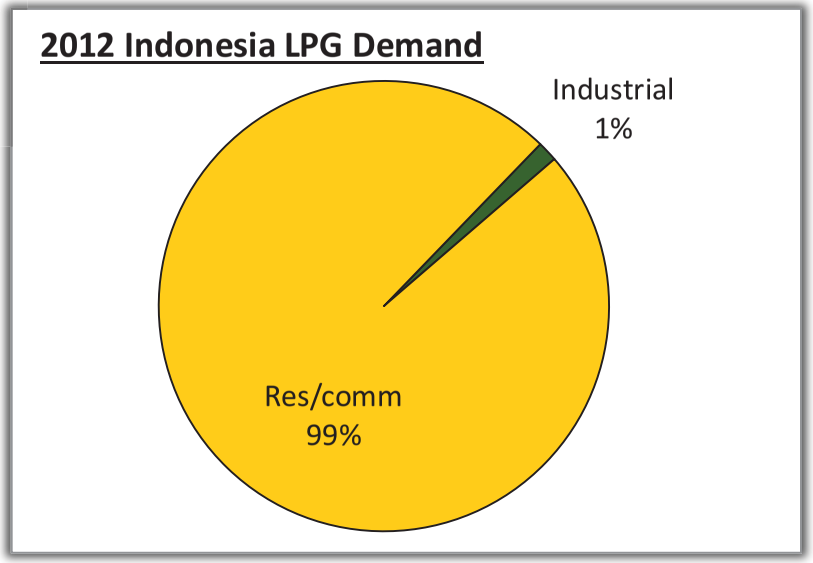


- 94% of LPG use in India is in the residential/commercial sector
- LPG is a bridge fuel for people who traditionally use biomass (e.g. wood, charcoal, dung) for cooking and heating

Indonesia's demand for LPG is growing

Indonesia has become a net importer of LPG

Source: IEA Statistics



Jakarta

- Indonesia was previously a net exporter of LPG, but that has changed over the past few years as domestic demand has outpaced supply
- Similar to India, Indonesia uses LPG predominantly in the residential/commercial sector, for cooking and heating

Local LPG production insufficient to meet demand

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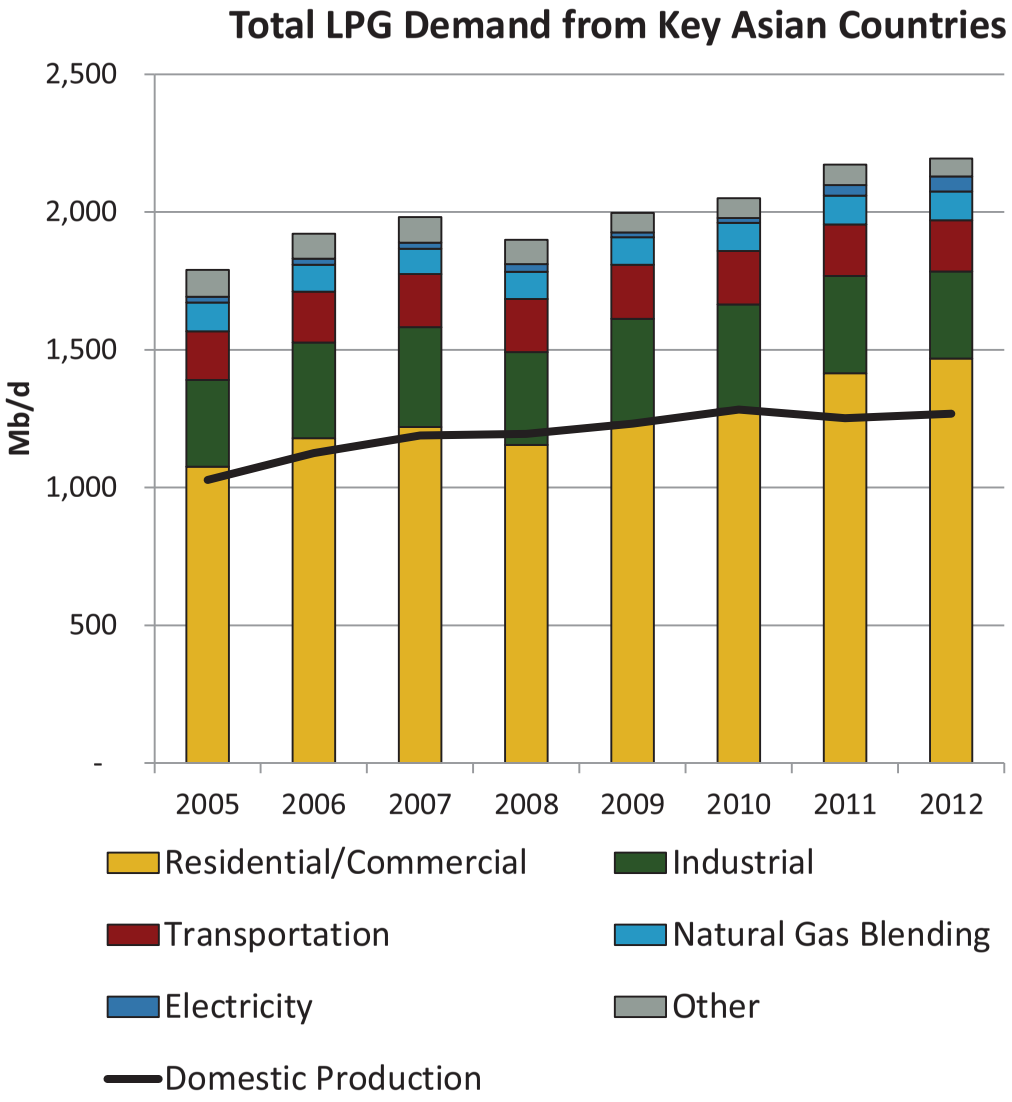
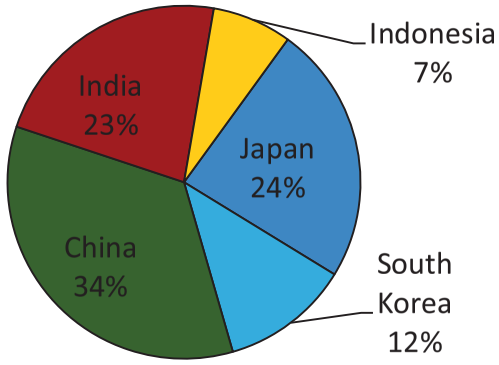
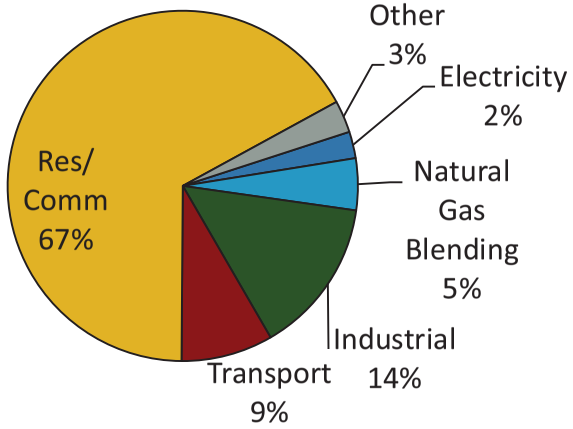


2012 Total LPG Demand by Country



China and Japan represent nearly 60% of total LPG demand for these five nations

2012 Total LPG Demand by Source



Residential/commercial demand represented 67% of total demand in 2012

Despite growing res/comm demand for propane, developing countries are still dependent on solid biofuels

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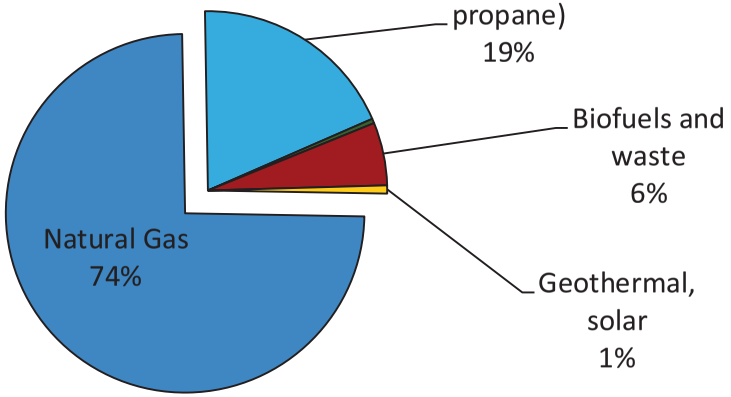
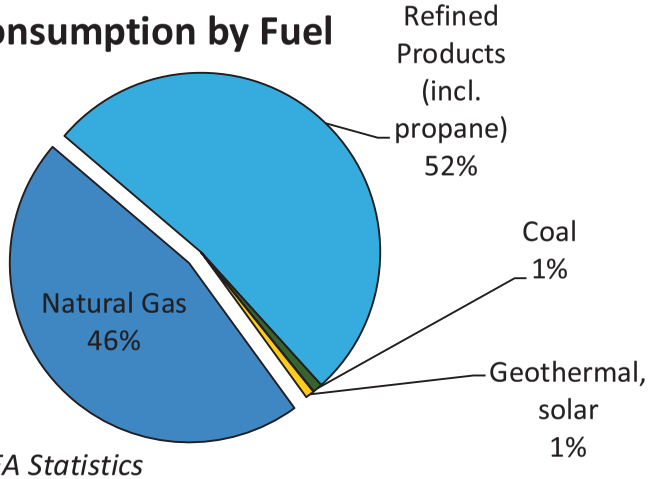
Developed countries like **US** and **Japan** primarily use fuels like **natural gas & propane** for residential use

2012 US Res/Comm Consumption by Fuel



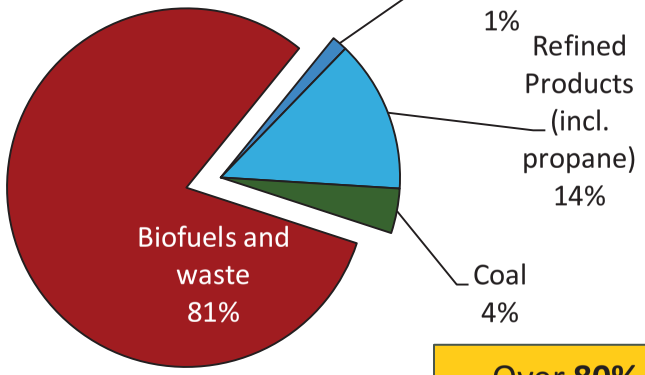
2012 Japan Res/Comm Consumption by Fuel



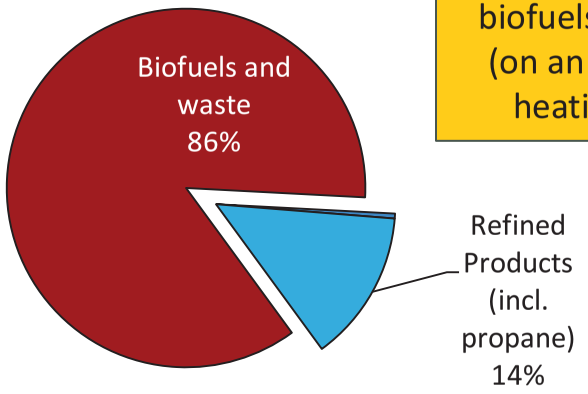
Source: IEA Statistics

Emerging economies like **India** and **Indonesia** rely heavily on **solid biofuels** for residential use

2012 India Res/Comm Consumption by Fuel



2012 Indonesia Res/Comm Consumption by Fuel



Over **80%** of fuel consumed for res/comm use in India and Indonesia is biofuels and waste (on an equivalent heating value)

Key Takeaways Regarding Propane Usage

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	Developed Country (Japan)	Developing Country (India)

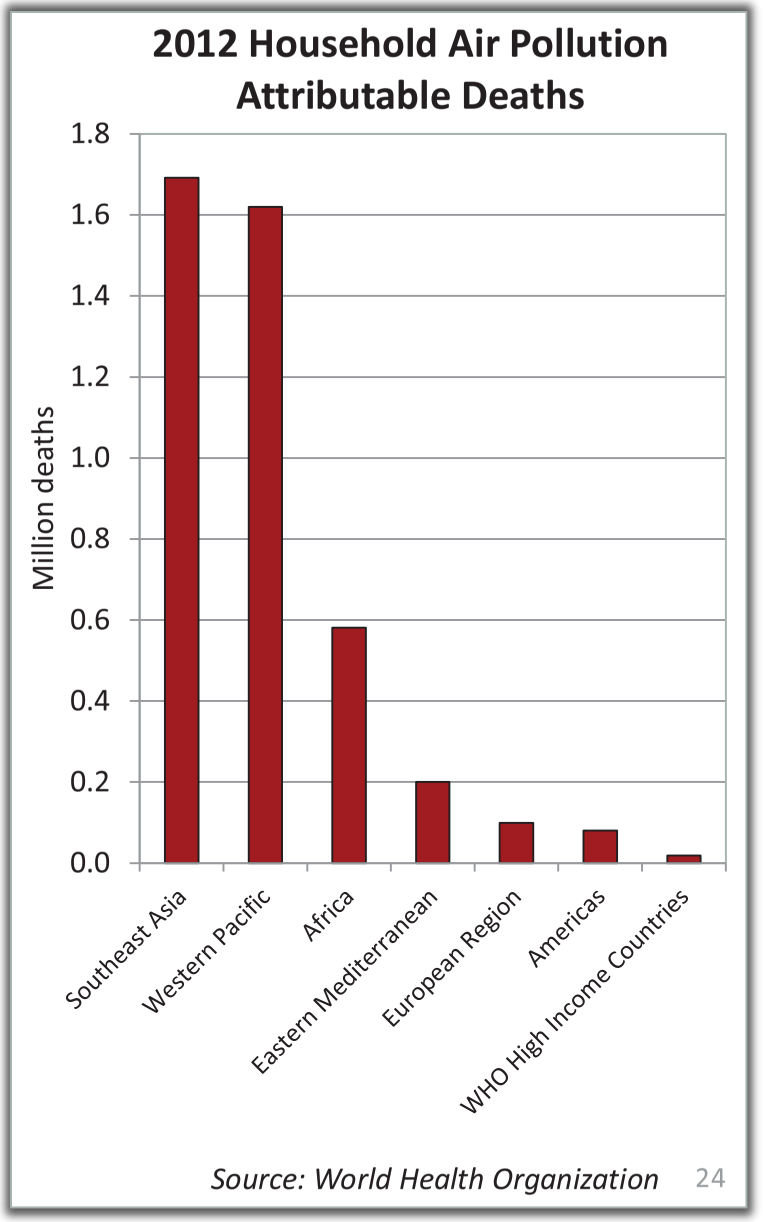
Use of propane	• Diverse
	  • Transportation
	  • Industrial
	  • Manufacturing
	  • Residential/ commercial
		• Concentrated
		  • Residential/ commercial
		  • Limited industrial applications

Fuel substitutes	• Natural gas • Refined products	• Solid biofuels
Opportunity for propane to displace "dirty" fuels	• Moderate- developed countries rely less on coal and solid biofuels	• Large- burning wood emits nearly 50% more CO_2 per MMBtu

Indoor air pollution from solid biofuels is a serious health hazard

- Household air pollution created from burning solid fuels (wood, grasses, dung) creates health hazards in developing countries
- These fuels produce high levels of smoke and pollution inside the home, which can lead to respiratory conditions, lung cancer, heart disease, stroke and cataracts
- WHO attributes **4.3 million deaths** in 2012 to household air pollution, with most in occurring in Southeast Asia

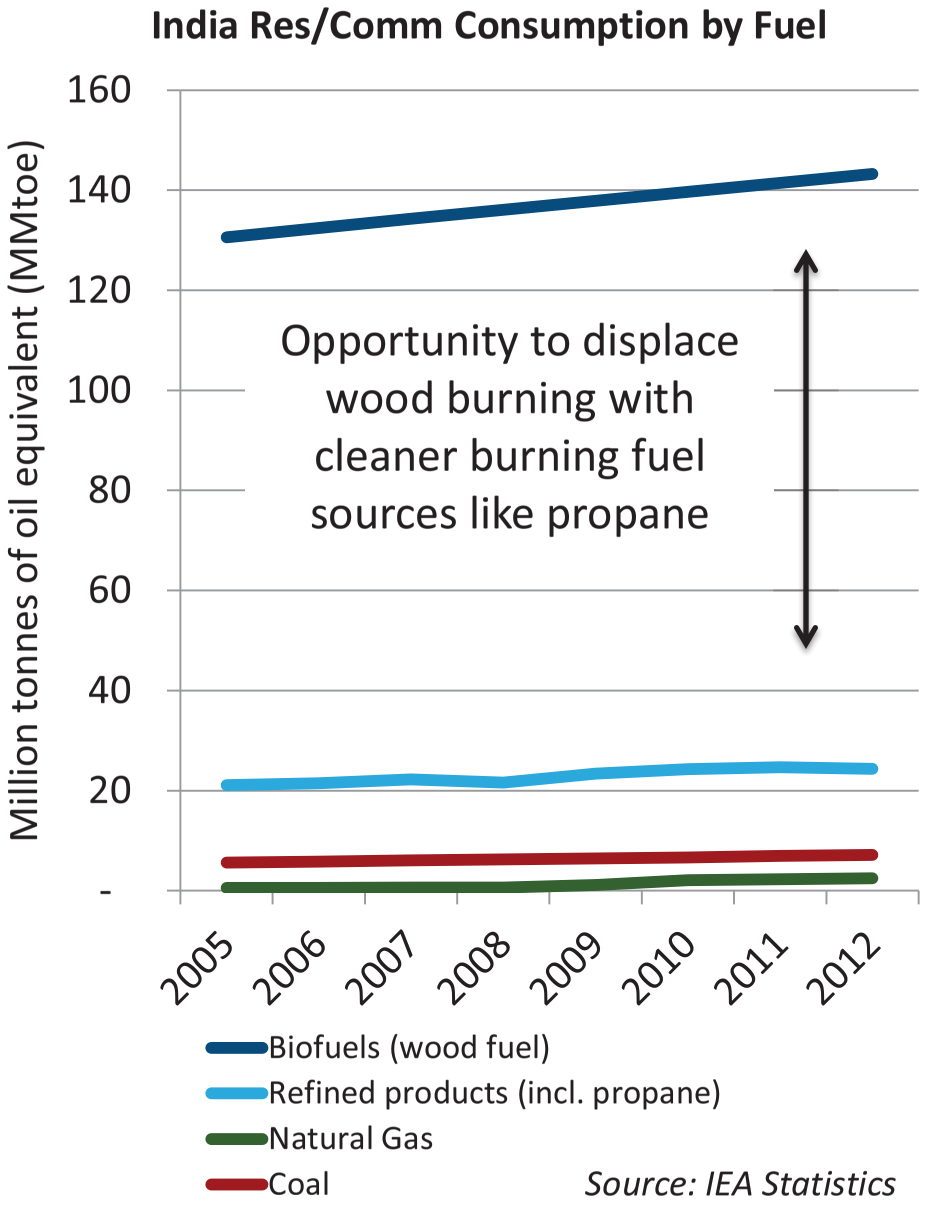
Indian woman tending wood-burning stove



Propane allows developing countries to improve standard of living

- India overwhelmingly consumes solid biofuels (e.g., wood) for household needs relative to other fuel sources (over 80% on equivalent energy basis)
- Propane provides a good transition fuel, as it is easy to transport in cylinders or tankers and store in rural areas (pipeline infrastructure not required, unlike natural gas)

Propane is transported in cylinders



LPG produces less CO_2 than coal or wood

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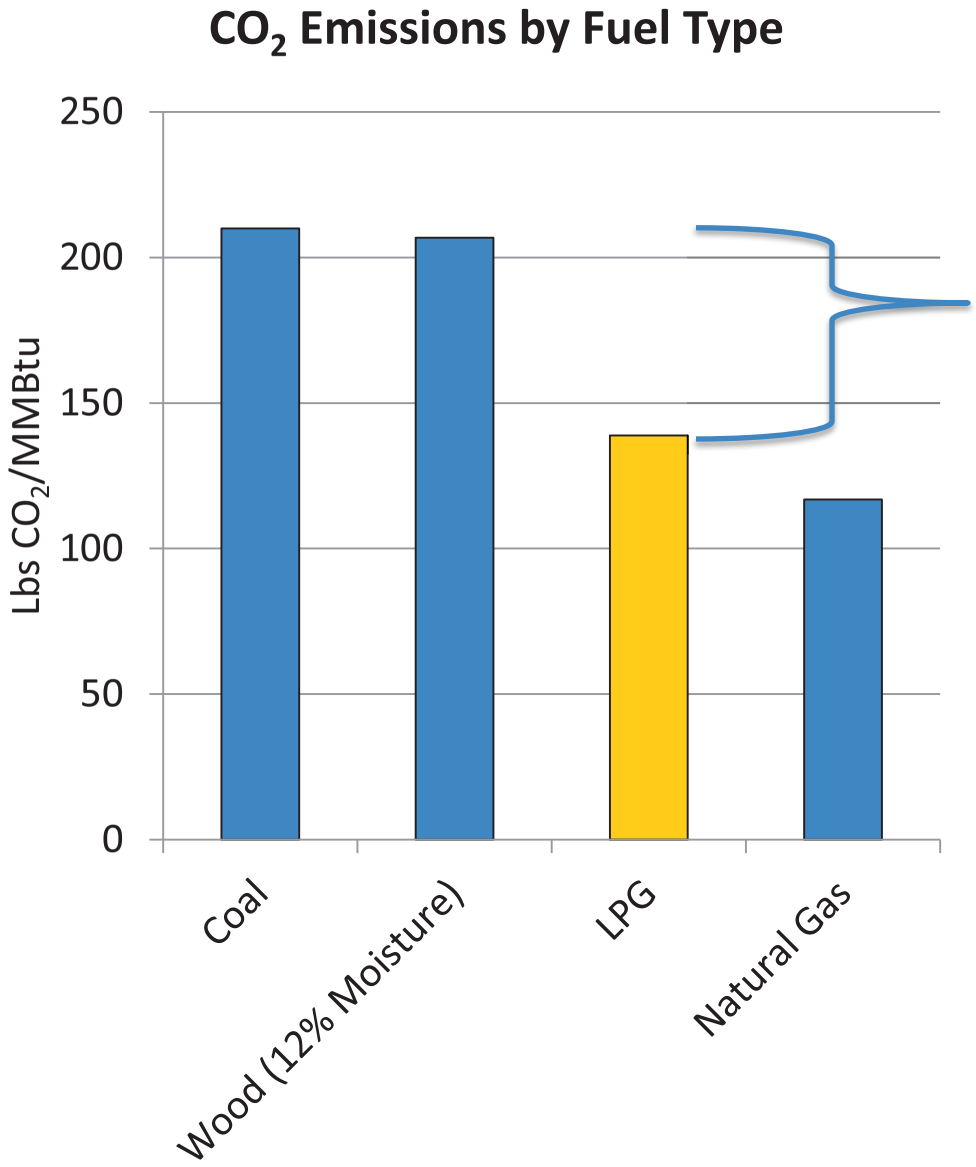
BENTEK Energy a unit of PLATTS



33% less lbs CO_2/MMBtu emitted when burning LPG instead of coal or wood

Source: EIA, The Climate Registry

China has displaced burning solid biofuels in res/comm sector over time

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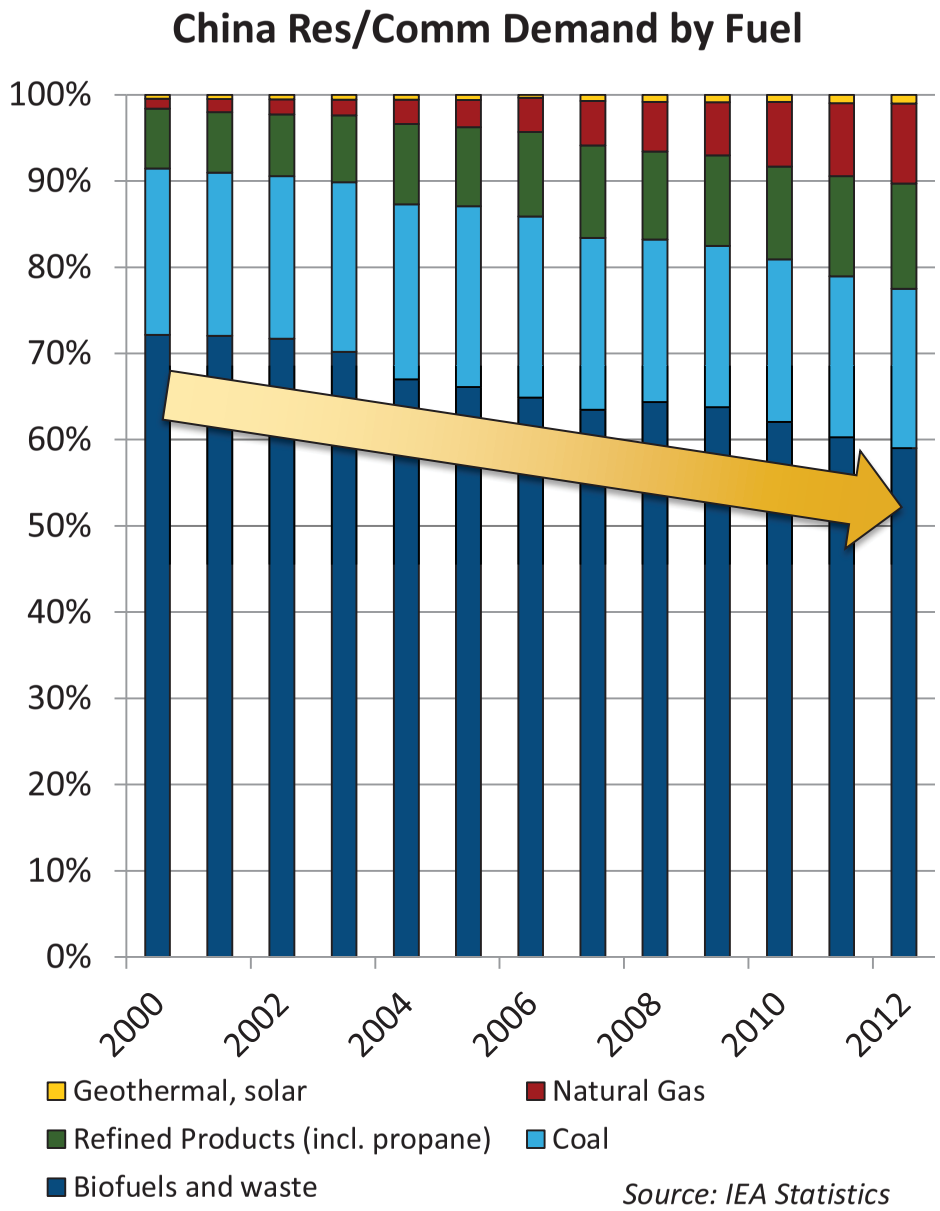
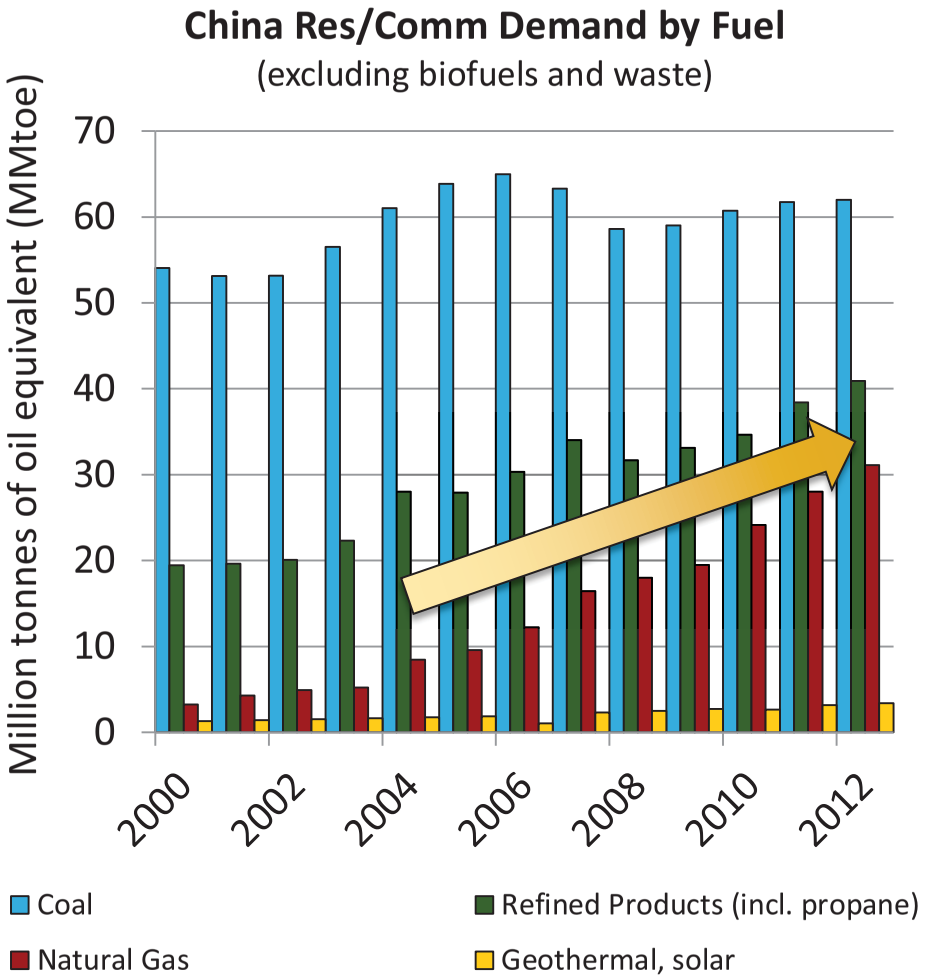


Source: IEA Statistics



Solid biofuel is being displaced by refined products (including propane) and natural gas in the res/comm sector in China

Conclusions

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- Propane serves as a good transition fuel for countries with limited infrastructure for natural gas and electricity
- The North American propane surplus creates the opportunity to export this cleaner-burning fuel to new markets in Asia
- The Portland Propane Terminal is strategically positioned to supply propane given its proximity to Asian markets
  - Residential use of propane can displace biofuels, favorably impacting the lives and improving the health of many people in developing countries
  - Industrial use of propane to manufacture consumer goods benefits both Asian producers and global consumers

Portland propane exports will benefit the global community

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Used for cooking and heating in developing nations.

Propane shipped to Asia.

Used in Manufacturing.

Many finished goods we use everyday are derived from propane.