



Houston – London – Singapore - Dubai

Polypropylene Market Study

Prepared for

**Alberta Economic Development
Williams Energy
Alberta Industrial Heartland Association**

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Executive Summary

Executive Summary - Markets

- North America, W. Europe, and NE Asia are the largest and most mature consuming regions (excluding China) for polypropylene. SE Asia, the Indian sub-continent, the Former Soviet Union, and Africa/Mid-East will represent the regions with the highest rate of growth through 2009
- Overall polypropylene demand is forecast to grow globally at a rate of approximately 5.8% in the 2004-2009 timeframe
- North American PP operating rates are forecast to decline after a peak in the 2005/2006 time period as capacity additions are expected to exceed demand growth
- U.S. operating rates are forecast to moderate after 2005 as additional capacity comes on-stream
- Injection molding is the largest end use for PP in the United States, followed by PP fibers and film/sheet
- Imports into Canada are expected to continue to supply a major portion of Canadian demand until 2008 when additional capacity is expected on-stream

Executive Summary - Markets

- Operating rates are forecast to fall in NE Asia as imports fill the gap between flattening production levels and strong demand growth. Large new capacity on-stream, especially in the Middle East, to be absorbed.
- The Japanese PP business is forecast to remain status-quo with a mature demand profile and no planned capacity increases.
- South Korea will experience a slight decline in operating rates even without any planned capacity expansion due to a decline in export
- Operating rates in Taiwan are expected to decline as new capacity comes on-stream in 2004-2005

Executive Summary - Trade

- In North America, the U.S. will remain the second largest exporter of PP in 2008 since it has adequate propylene supply. A change will occur in Mexico due to the start-up of new capacity, which will change its trade position slightly to being a less significant net importer. Canada is also expected to add capacity and net imports shrink significantly by 2008.
- From 2004 to 2009, West Europe will experience a decrease in exports of about 650,000 metric tons, and its imports will more than double in the same period, bringing the region to a net import position by 2008.
- The Middle East region was a net importer in 2003; however, due to a capacity increase of about 4.2 million tons (mostly in Saudi Arabia and Iran) during the forecast period (2004-2009), net exports will surge to around 3.0 million tons in 2009. Saudi Arabia will replace S. Korea in 2008 as the world's largest exporter of PP.
- Due to large increases in PP demand, China will remain the largest importer by far of PP through the forecast period, with its imports accounting for over 40 percent of total global trade in 2008.
- Southeast Asia's trade position will change in 2005 from net exporter to net importer of over 200,000 metric tons in 2008

Executive Summary – Target Markets

- NE Asia and the United States represent the most likely target markets for the polypropylene plant in Alberta
- Imports into NE Asia are approximately 3,600 thousand metric tons in 2004, and are expected to increase to nearly 5,000 thousand metric tons for the study period.
- Imports into the United States are approximately 230 thousand metric tons in 2004 and are expected to remain above 200 thousand metric tons for the study period.
- The specific end-use profile for the target markets will dictate the grades and technology to be employed for pp production
- Approximately 70% of the US market is based on homopolymer
- However, approximately 60% of the Japanese market is based on random and block copolymers
- A freight equilibrium line for transporting PP by rail car from Edmonton versus U.S. Gulf Coast runs approximately from southern California to the eastern edge of the E. North Central region of the United States
- It is estimated that approximately 25-30 percent of the U.S. market could be served competitively on a logistics basis versus the producers located on the U.S. Gulf Coast
- An alternative to producing PP in Alberta is to move propylene from Edmonton to the USGC, and then convert to PP for the U.S. market. On this basis, an advantage of approximately 3.0 – 3.5 cents per pound will exist when serving the markets along the parity line from Alberta

Study Objectives

Objectives

- Alberta Economic Development and private sector partners are studying the economic feasibility of producing polypropylene in the Province of Alberta.
- The purpose of this study is to identify and quantify polypropylene markets that can be accessed from an Edmonton area location at logistics costs lower than from the U.S. Gulf Coast.
- This study will be used as background to promote investment in polypropylene production in Alberta among firms considered most likely to find this to be an attractive opportunity.

Scope

Study Scope

- Identify probable markets for Alberta-produced polypropylene and current suppliers to those markets that would compete with the Alberta-produced polypropylene. Both North American and Asian producers will be considered.
- Identify the necessity or desirability of being able to produce homopolymers, random copolymers and impact copolymers
- Evaluate the economic reach of rail delivery systems to U.S. markets, including analysis of the rail freight rates from Alberta compared to the U.S.G.C to selected destinations.

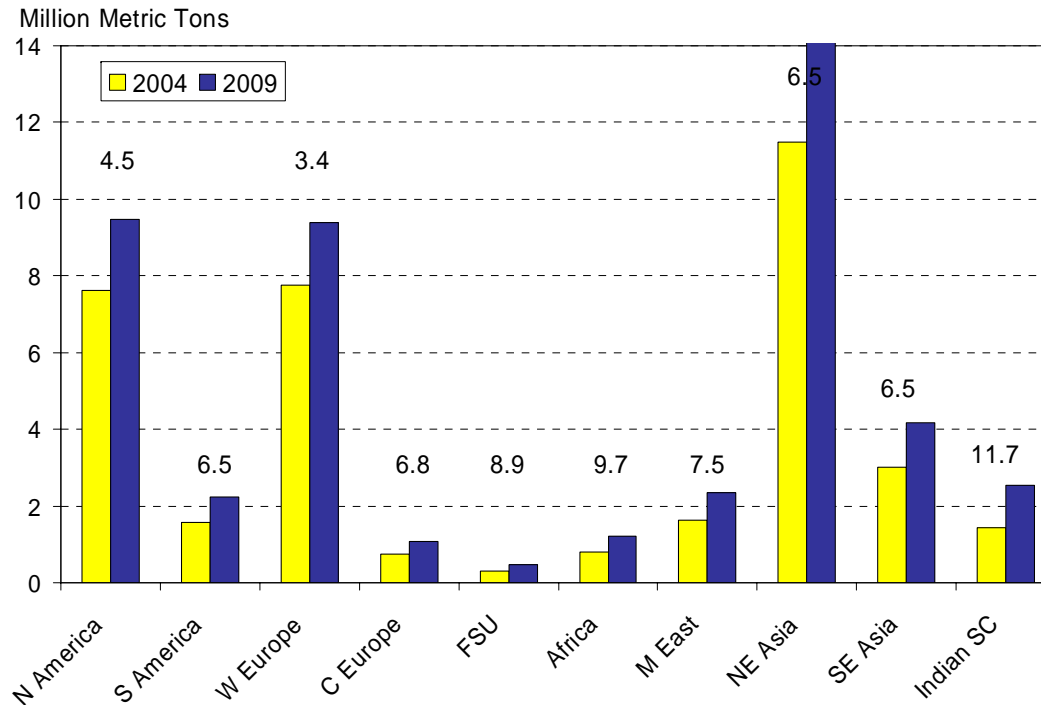
Polypropylene Market Overview

Recent Developments

- Over 1.0 billion pounds of PP capacity was permanently shut down in North America in the 2001-2003 period.
- This has helped elevate operating rates.
- PP operating rates moved higher in 2004 approaching 95 percent.
- Injection molding is the largest market for PP.
- PP exports will continue to grow through 2008, and then are expected to dip in 2009 as new world capacity comes on-stream.
- PP will flow from Canada to the U.S. and from the U.S. into Mexico under the NAFTA trade agreement. As Mexico becomes more self-sufficient, their imports will decrease.

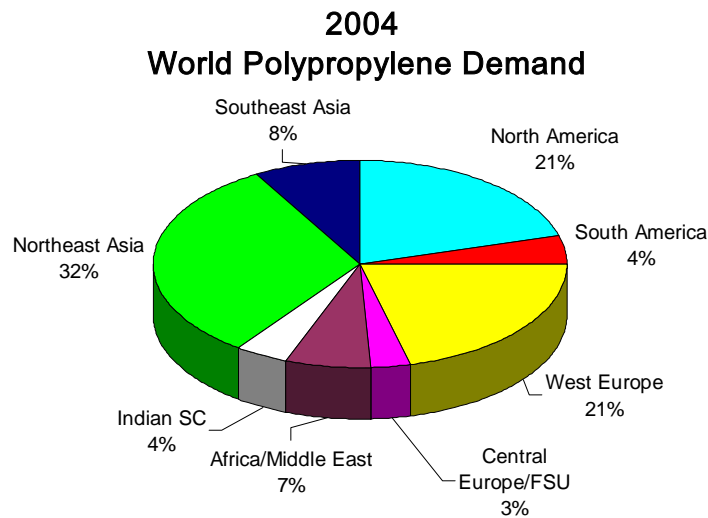
Global PP Demand Forecast

World PP Demand Growth By Region
2004 versus 2009



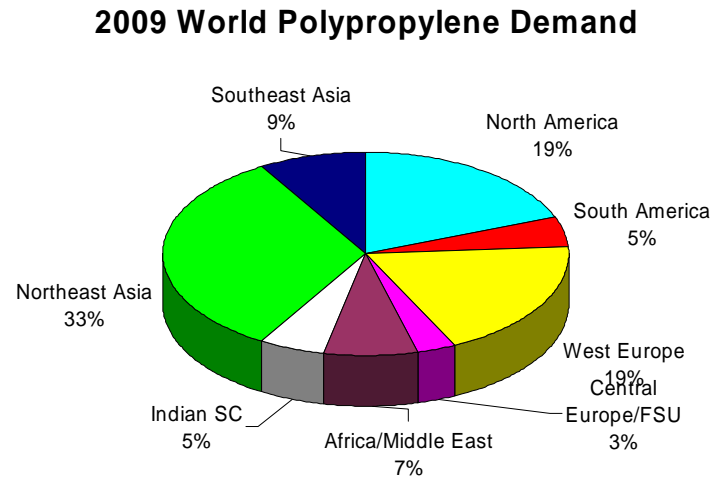
North America, W. Europe, and NE Asia are the largest and most mature consuming regions. SE Asia, the Indian sub-continent, the Former Soviet Union and Africa/Mid-East will represent the regions with the highest rate of growth through 2009.

Global PP Demand by Region



2004 Total Demand = 38.6 Million Metric Tons

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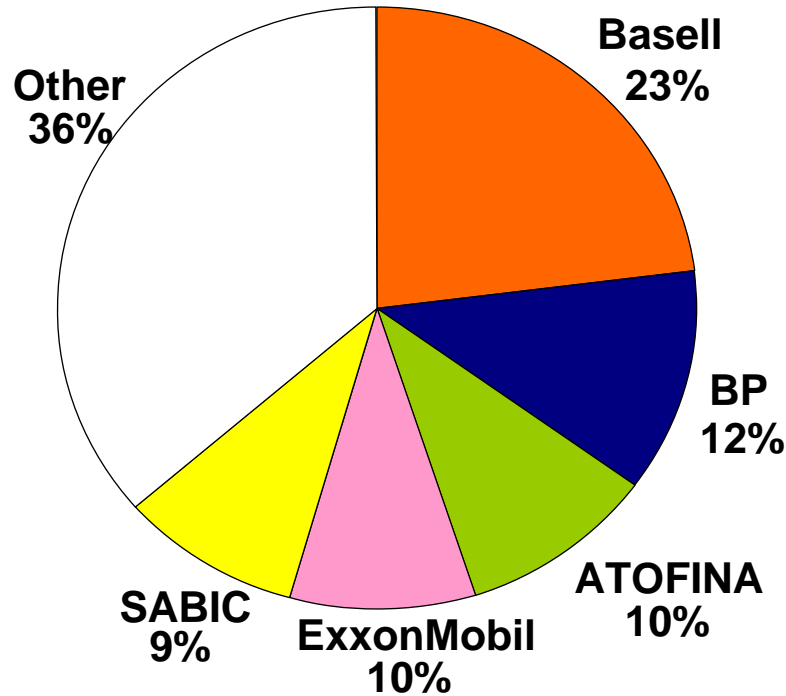


2009 Total Demand = 51.3 Million Metric Tons

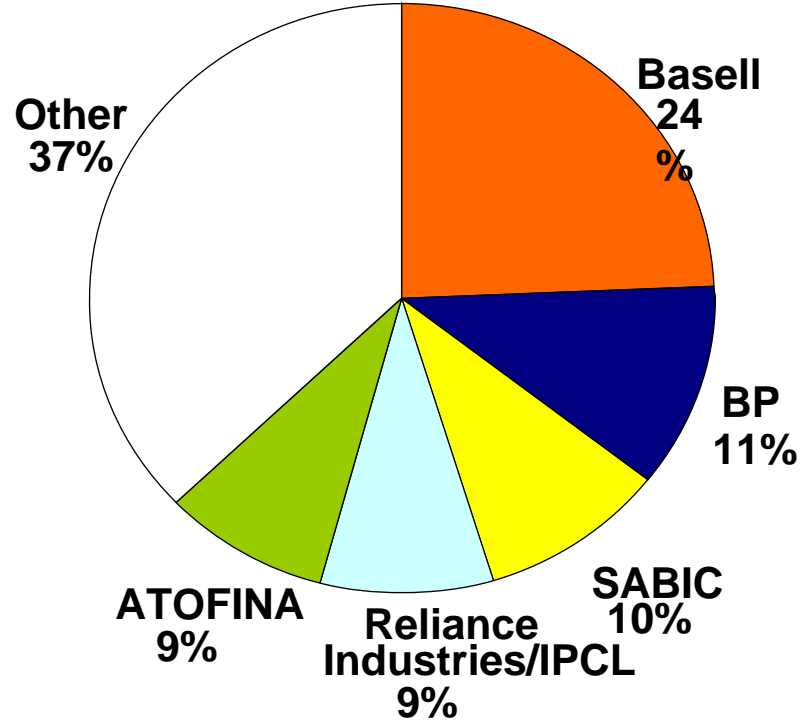
Overall polypropylene demand is forecast to grow globally at a rate of approximately 5.8% in the 2004-2009 timeframe

World Top Polypropylene Producers/Marketers

2004



2008



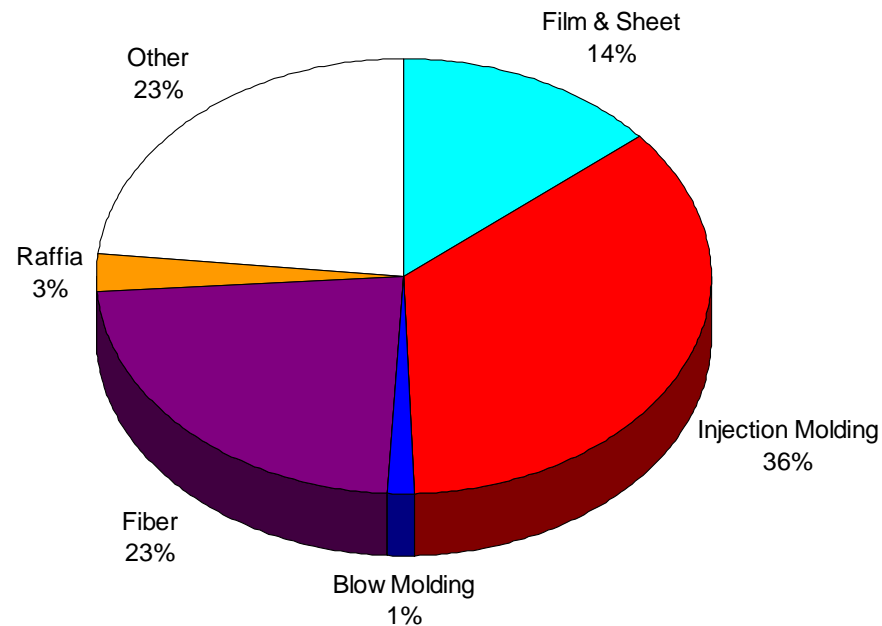
Capacity = 41.3 Million Metric Tons Capacity = 49.6 Million Metric Tons

The five largest polypropylene producers represent nearly two-thirds of global polypropylene capacity



N. America PP End-Use Profile

North America
2004 Polypropylene Demand by End Use

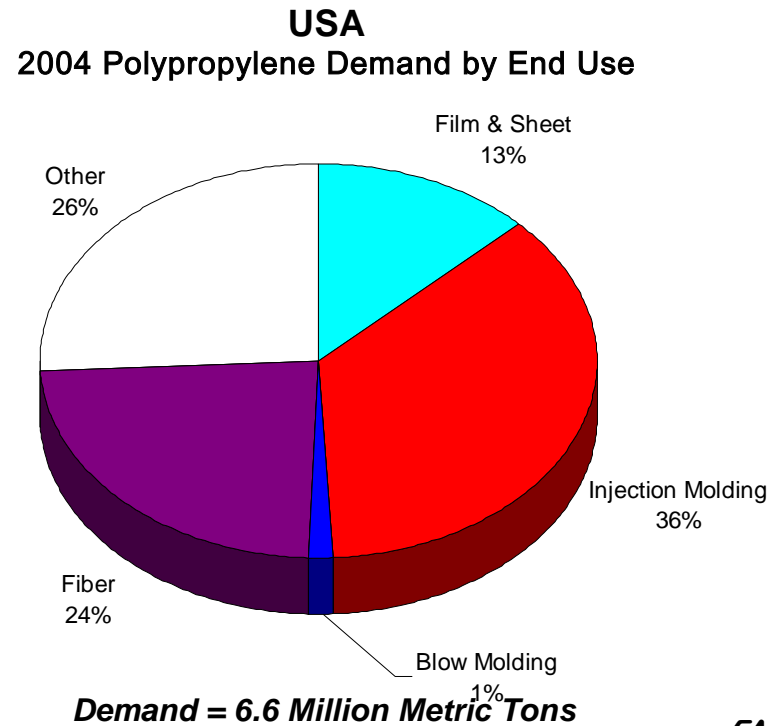


Demand = 7.9 Million Metric Tons

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**Injection molding and PP fibers are the largest end-use applications
in North America**

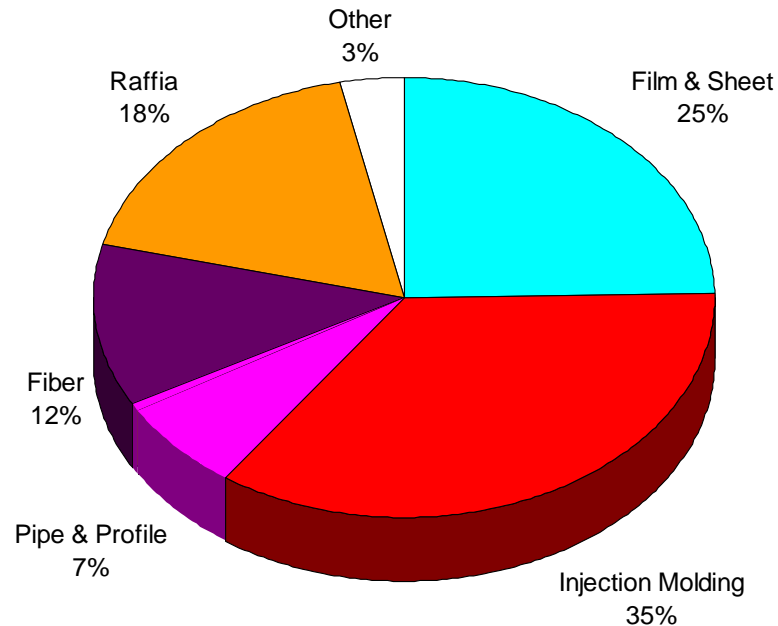
U.S. PP End-Use Profile



Injection molding is the largest end use for PP in the United States, followed by PP fibers and film/sheet

NE Asia PP End-Use Profile

Northeast Asia
2004 Polypropylene Demand by End Use

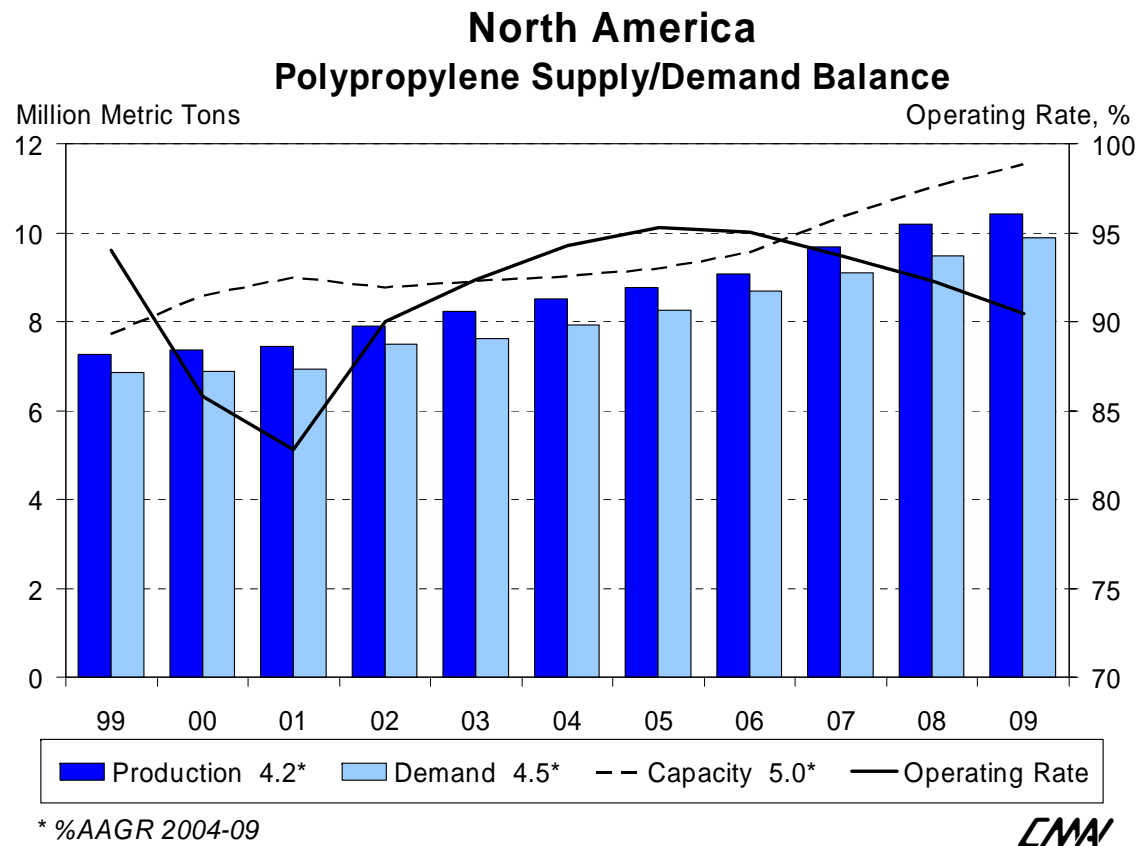


Demand = 12.3 Million Metric Tons

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Injection molding and film/sheet are the largest end-use applications for PP in NE Asia

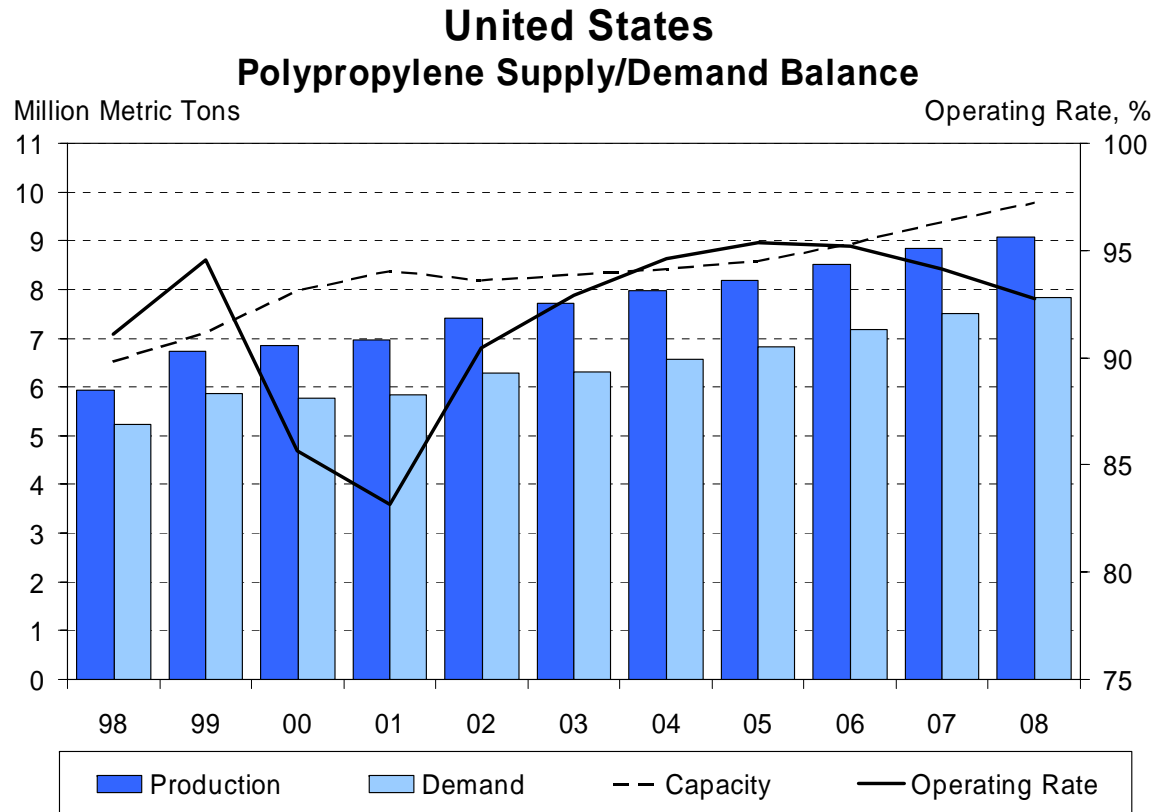
North American PP S/D Forecast



Operating rates are forecast to decline as capacity additions are expected to exceed demand growth

Analysis for the period 1998 – 2015 is presented in the Appendix

United States PP S/D Forecast



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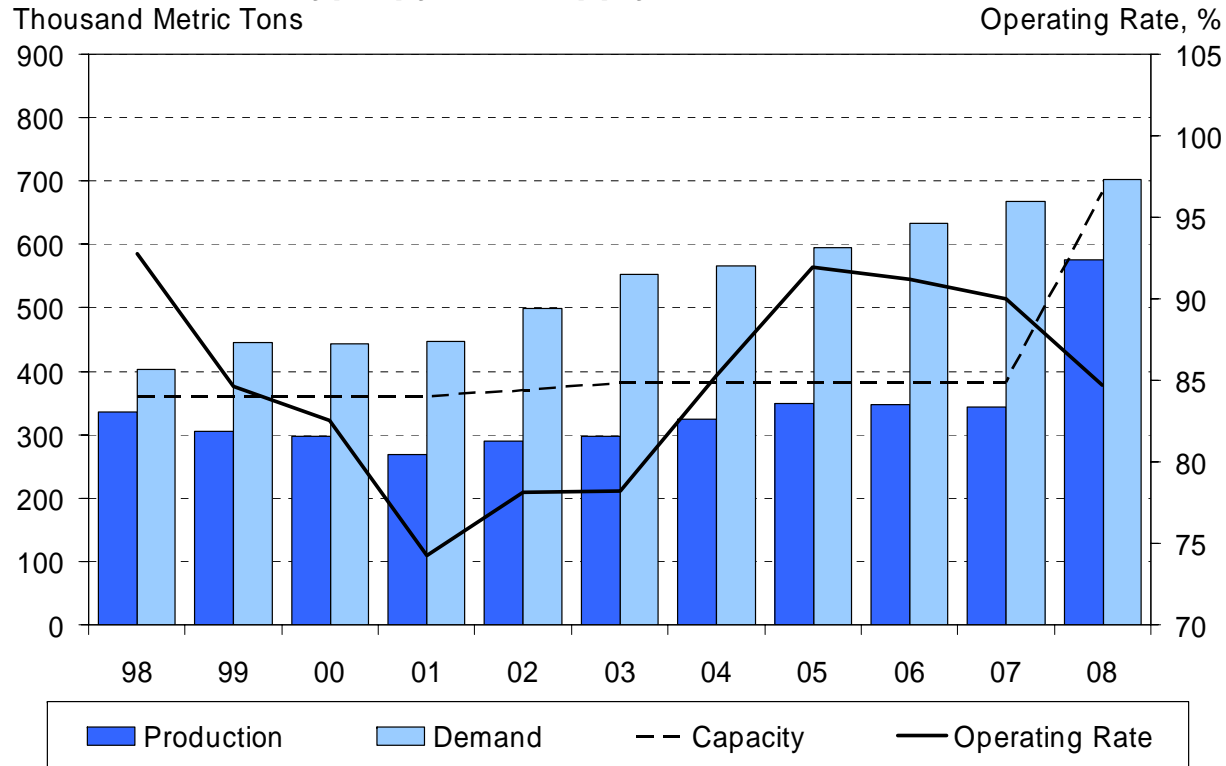
U.S. operating rates are forecast to moderate after 2005 as additional capacity comes on-stream

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Canadian PP S/D Forecast

Canada

Polypropylene Supply/Demand Balance

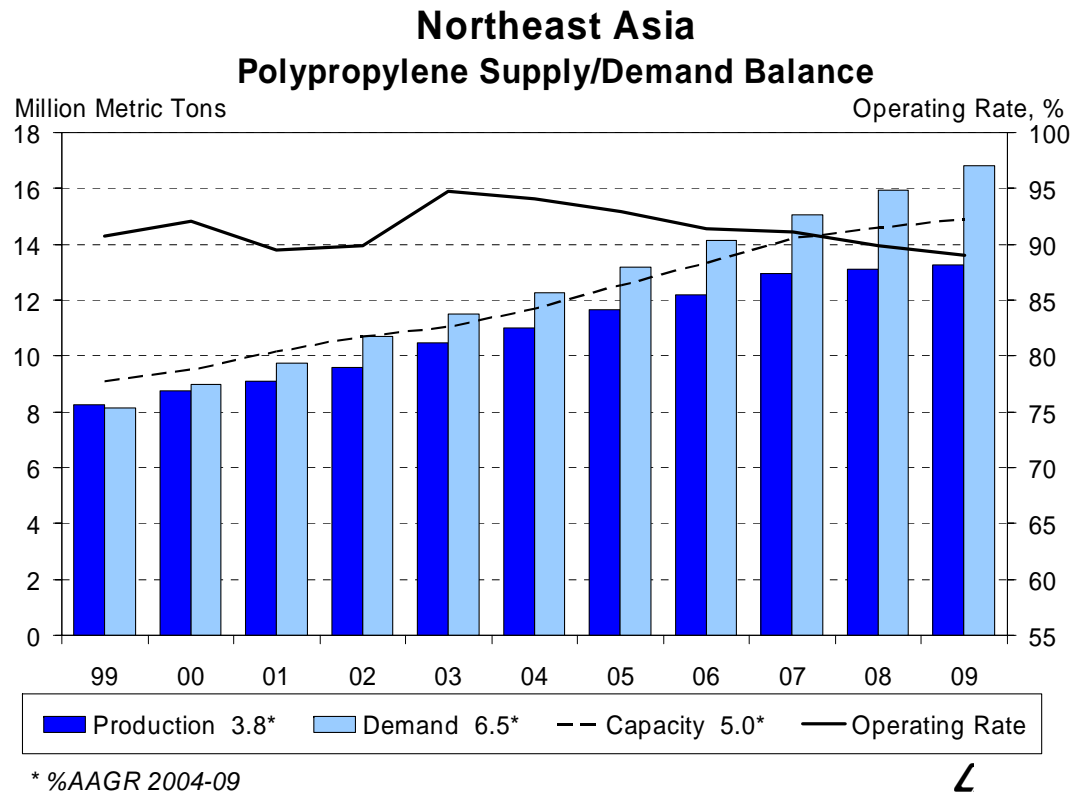


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Imports are expected to continue to supply a major portion of Canadian demand until 2008 when additional capacity comes on-stream

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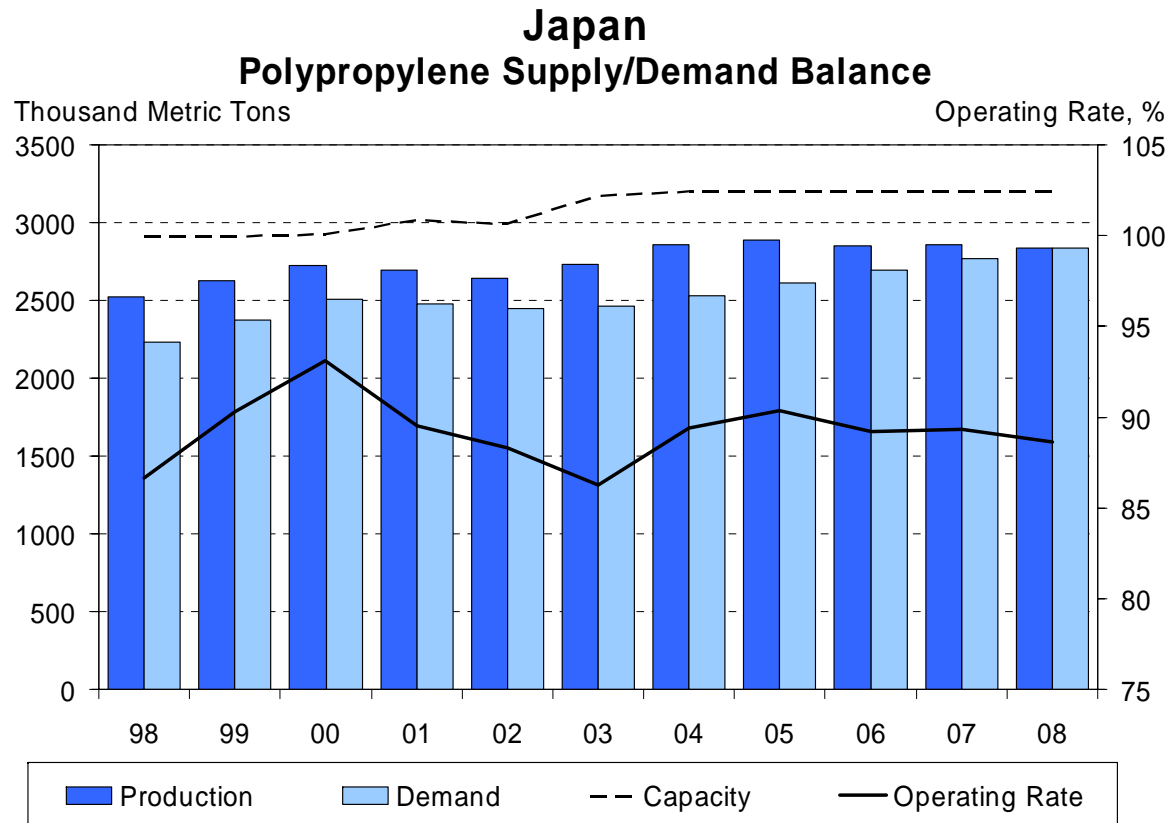
NE Asian PP S/D Forecast



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Japanese PP S/D Forecast

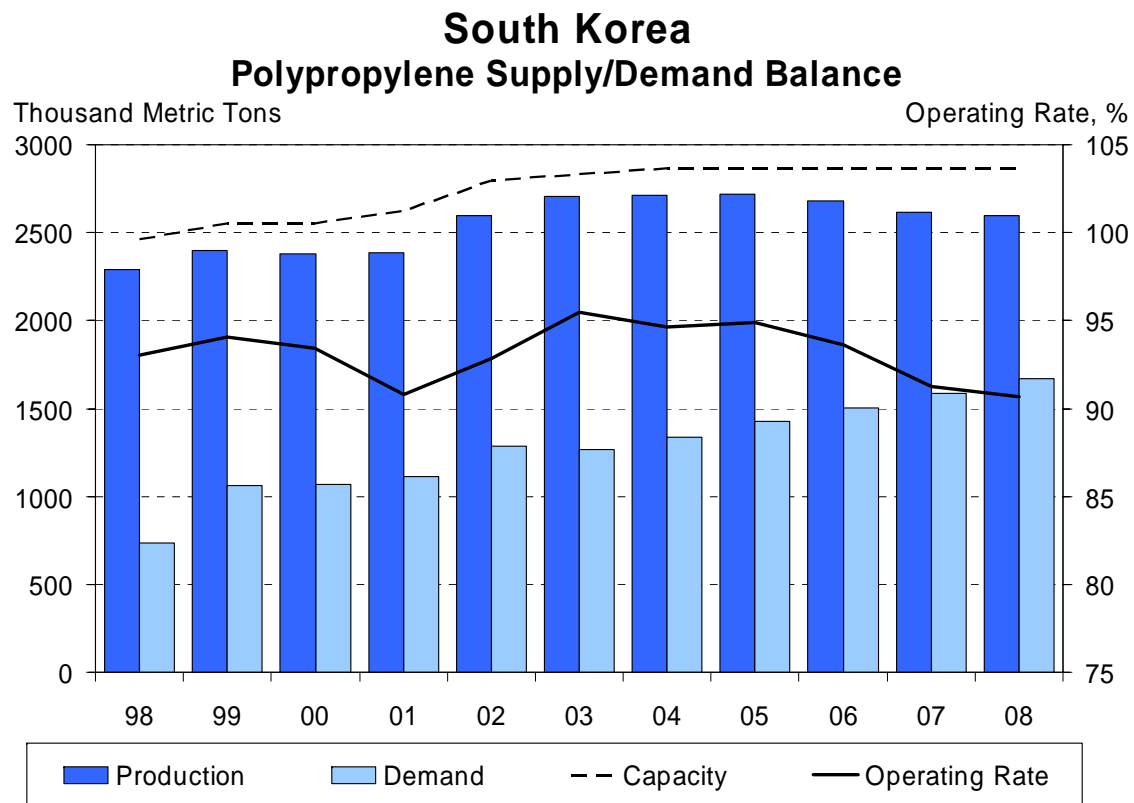


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The Japanese PP business is forecast to remain status-quo with a mature demand profile and no planned capacity increases.

Analysis for the period 1998 – 2015 is presented in the Appendix

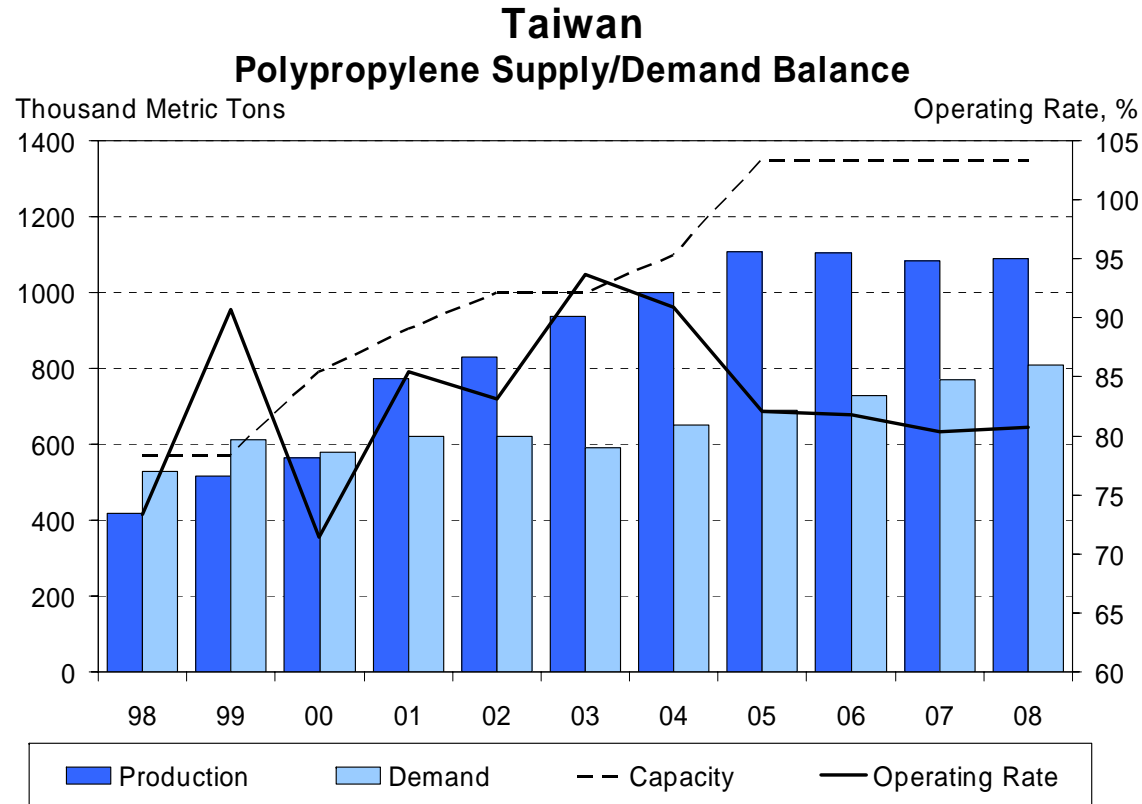
S. Korean PP S/D Forecast



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South Korea will experience a slight decline in operating rates even without any planned capacity expansion due to a decline in exports

Taiwanese PP S/D Forecast



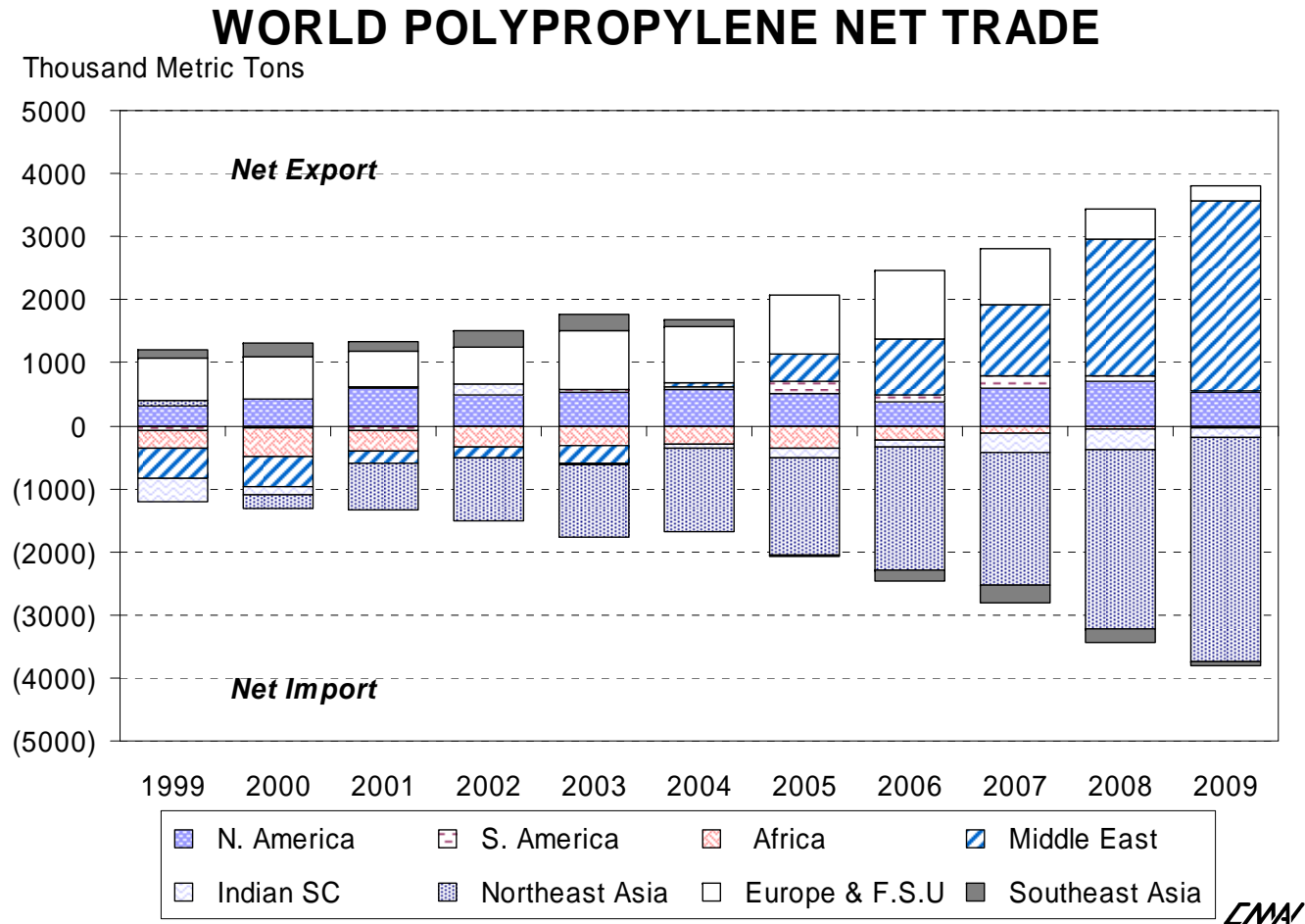
CMAI

Operating rates in Taiwan are expected to decline as new capacity comes on-stream in 2004-2005

PP Trade Issues

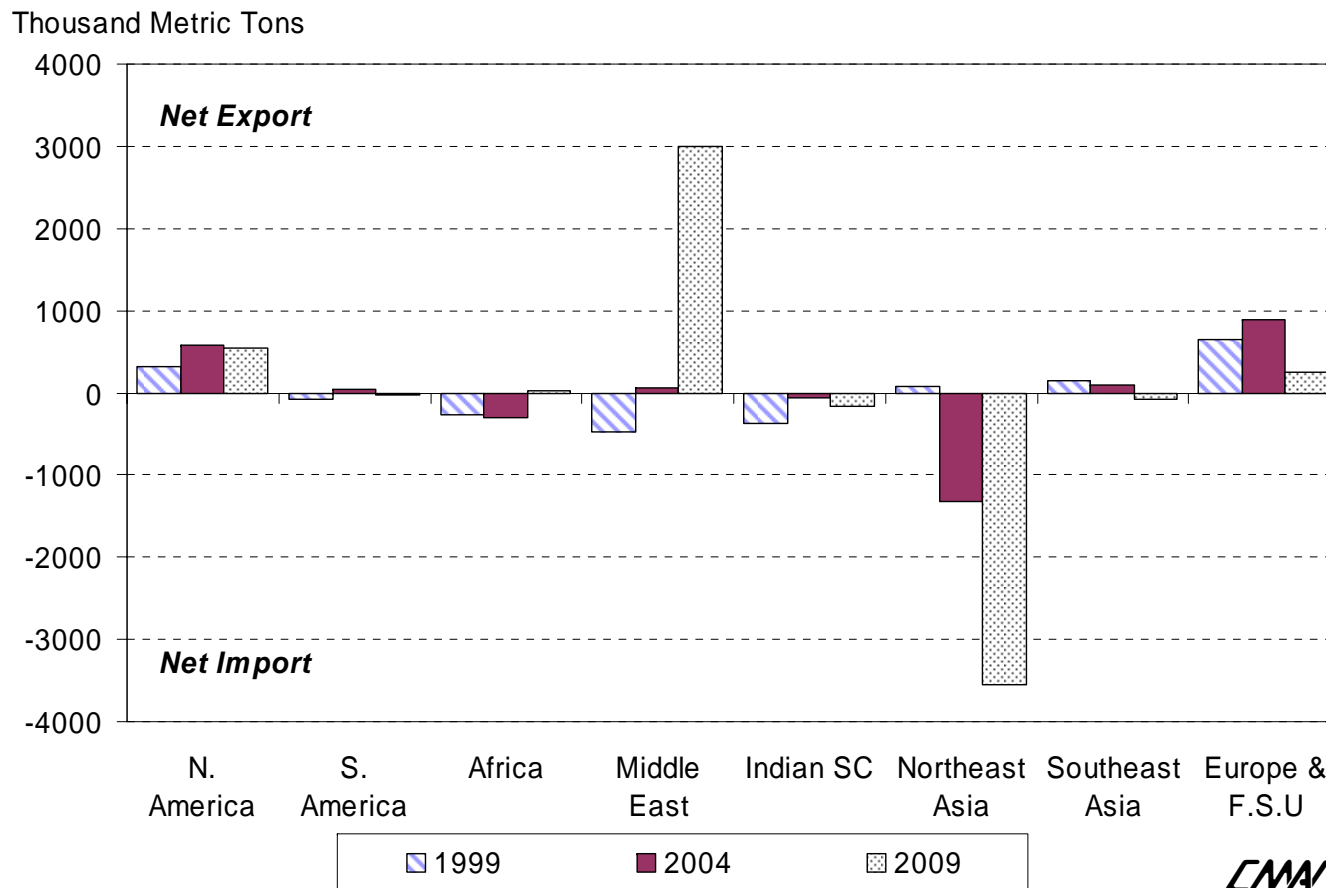
- In North America, the U.S. will remain the second largest exporter of PP in 2008 since it has adequate propylene supply. A change will occur in Mexico due to the start-up of new capacity, which will change its trade position slightly to being a less significant net importer. Canada also adds capacity and net imports shrink significantly by 2008.
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- Southeast Asia's trade position will change in 2005 from net exporter to net importer of over 200,000 metric tons in 2008.

Global Trade in PP Will Grow Significantly in the 2005-2009 period



The Middle-East and NE Asia Will Impact Regional Net Trade in PP

PP NET TRADE BY REGION



PP Product Grades and Types

Polypropylene Property & Applications Profile

- The principal characteristics of polypropylene that have contributed to its rapid growth and acceptance are:
 - Relatively high stiffness, low specific gravity (0.900-0.906 g/cc) high tensile strength (especially when oriented), good clarity, stress crack resistance, chemical resistance and relatively high heat deflection temperature.
 - Mechanical strength properties, when filled or reinforced sufficient to compete with more costly engineering plastics in many applications.
 - Good injection molding characteristics.
 - Ability to be drawn and oriented, which is the basis for the production of polypropylene fibers and oriented film.

Polypropylene Grade Characteristics

- Polypropylene products are broadly characterized by main parameters:
 - Homopolymer/Copolymer
 - Molecular Weight Distribution (MWD)
 - Melt Flow Index (MFI)

PP Homopolymer

- Polypropylene homopolymer has high stiffness, good clarity, low density (0.900 - 0.906 grams per cubic centimeter), chemical resistance, and relatively high temperature resistance.
- However, the homopolymer has poor impact resistance, especially at low temperature.
- Polypropylene copolymers are produced to improve properties for certain applications.

PP Random Copolymers

- Random copolymers have ethylene molecules inserted randomly between the propylene molecules in the polymer chain.
- Random copolymers have higher impact resistance, higher clarity and more flexibility than homopolymers.
- The ethylene content is typically two to four percent by weight.
- Random copolymers are generally produced in the same process configuration as the homopolymers.

PP Block (Impact) Copolymers

- Block copolymers (sometimes referred to as impact copolymers) are composed of a string of propylene molecules, periodically interrupted by strings of ethylene-propylene copolymer or polyethylene.
 - Polymer has better impact strength at lower temperatures and higher melting points than random copolymer.
 - In order to produce block copolymers, a second reactor is required in the process.
 - Non-reactor produced impact copolymers have been made by compounding a homopolymer polypropylene with an EPDM or EP rubber (homopolymer “alloys”).

Polypropylene Molecular Weight Distribution

- The Molecular Weight Distribution (MWD) for polypropylene is expressed as either “Narrow” or “Broad”
 - **Narrow MWD**: the majority of the PP polymer chains have approximately the same chain length, or molecular weight
 - **Broad MWD**: the PP polymer chains vary significantly in chain length, or molecular weight
- The Molecular Weight Distribution is important in selecting products suitable for a particular application, e.g., injection molding. This is due to improved processing characteristics for the fabrication operation, as well for the properties of the finished product

Polypropylene Melt Flow Index

- The Melt Flow Index (MFI) for polypropylene is expressed as a range of flow rates, which are inversely proportional to the molecular weight of the resin.
 - **Low MFI**: indicates a high molecular weight resin which is useful in processing applications where the strength of the resin in the melt phase is important, e.g., blow molding.
 - **Medium MFI**: indicates an intermediate molecular weight which is useful in applications where a balance of melt strength and high through-put is important in processing operations such as film production.
 - **High MFI**: indicates a low molecular weight resin which is useful in achieving high throughputs in the processing applications such as fiber spinning and injection molding.
- The Melt Flow Index is important in selecting products suitable for a particular processing application, e.g., blow molding. This is primarily due to improved processing characteristics for the fabrication operation, and less of a factor for the properties of the finished product.

PP Application/Grade Profile

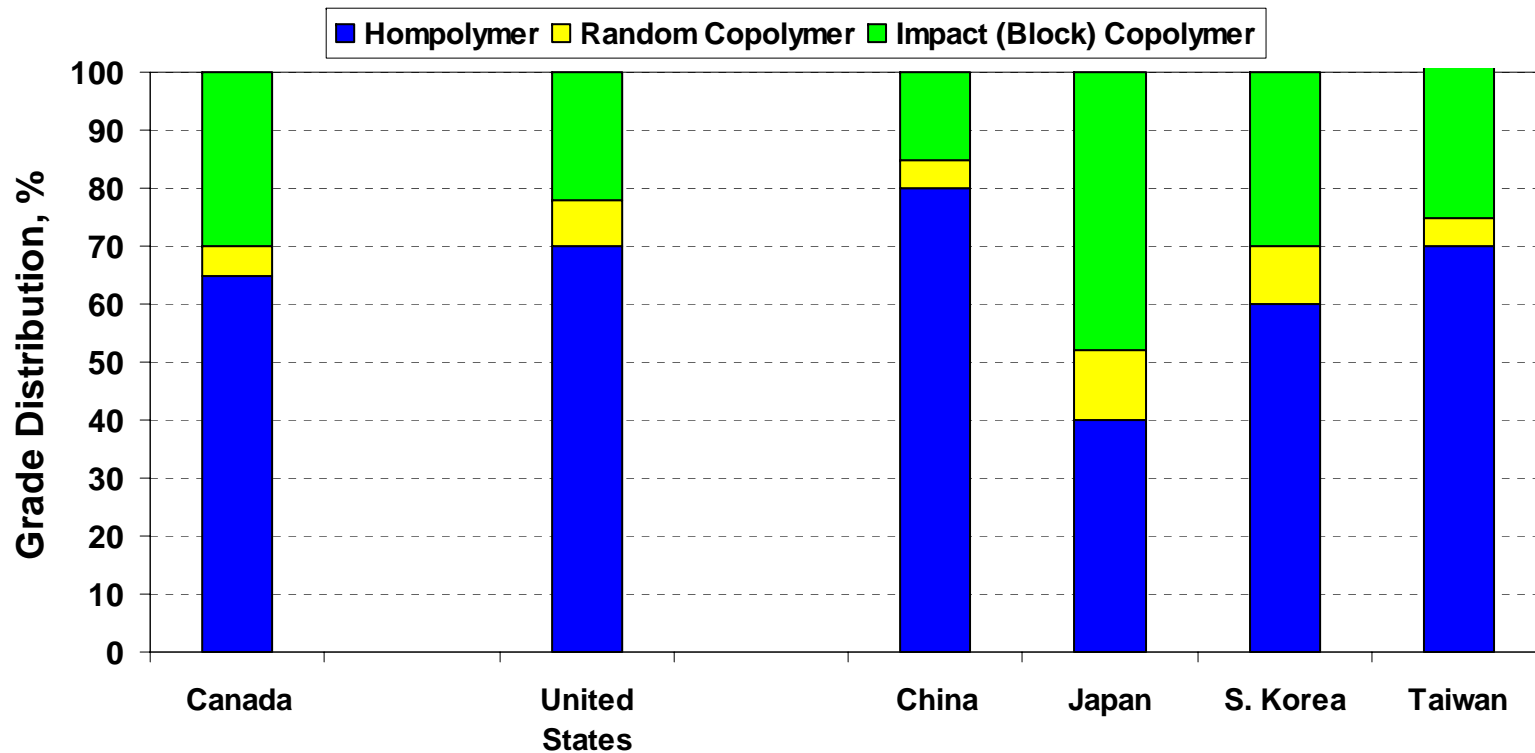
- The three main property parameters on which PP resins are characterized provide an overview of the application-specific profile for PP's main end-use application profile.

	<u>Homopolymer</u>	<u>MWD</u>	<u>MFI</u>
Injection Molding	H, IC	Broad	High
Sheet	H, RC, IC	Narrow	Low
Film	H, RC	Narrow	Intermediate
Blow Molding	H, RC	Broad	Low
Fiber	H	Broad	High
Raffia	H	Broad	High

H = Homopolymer
 RC = Random Copolymer
 IC = Impact (Block) Copolymer

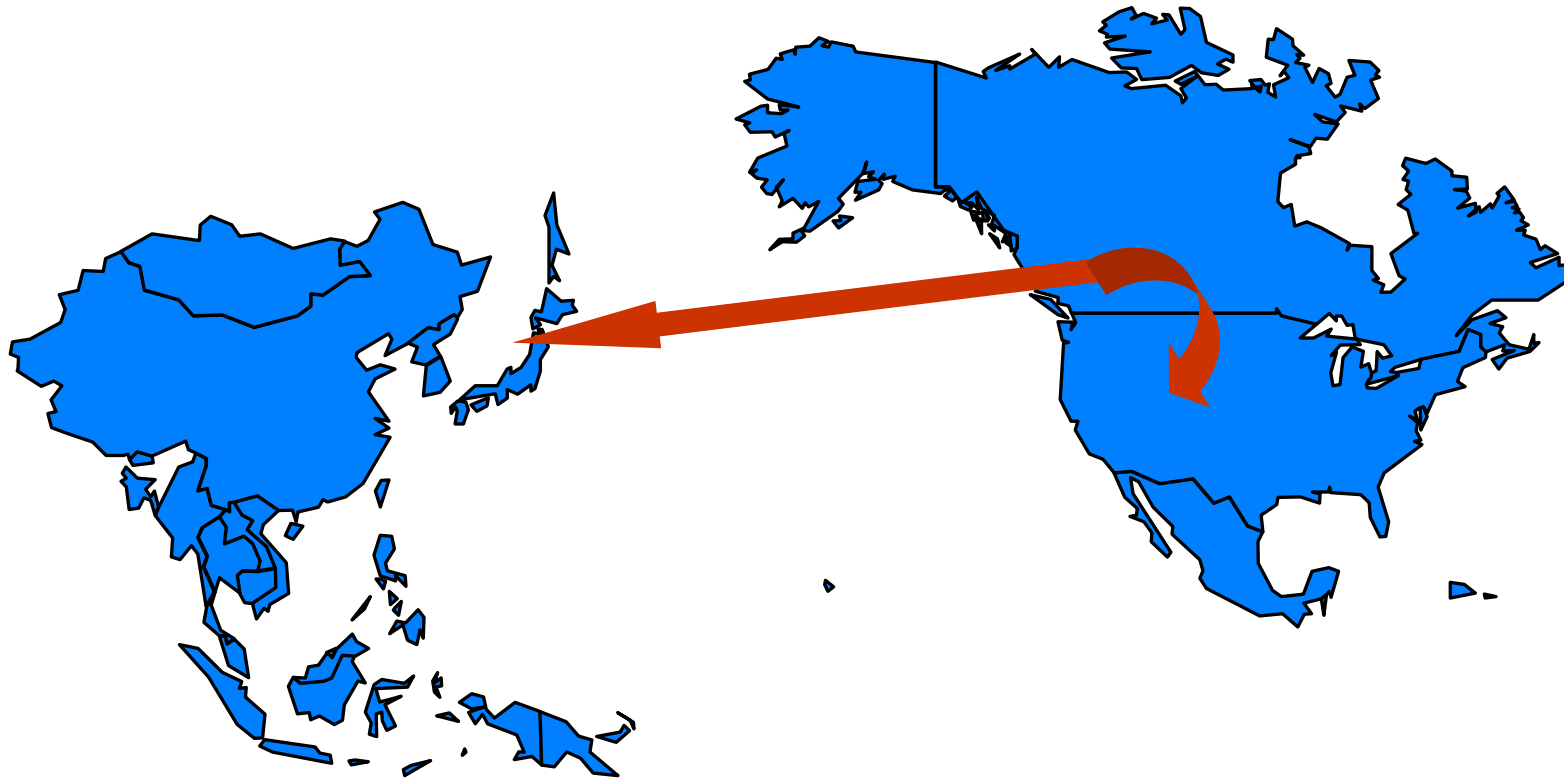
The Specific End-Use Profile for the Target Markets Will Dictate the Grades and Technology to be Employed for PP Production

POLYPROPYLENE GRADES BY GEOGRAPHIC REGION



Geographic Target Markets

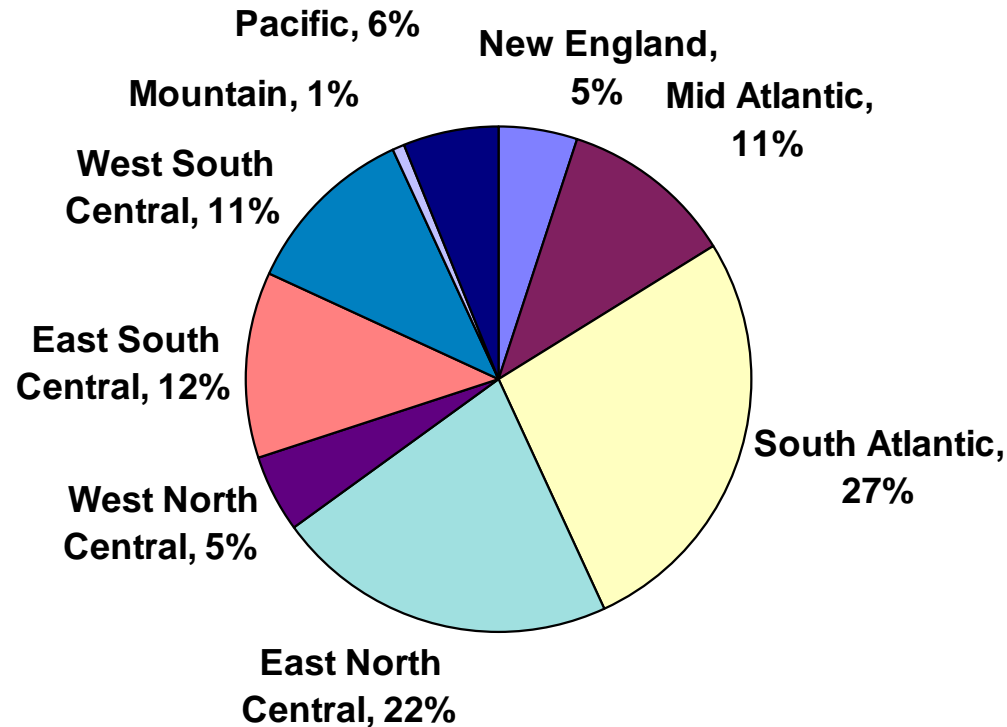
Likely Target Markets



NE Asia and the United States represent the most likely target markets for the polypropylene plant in Alberta

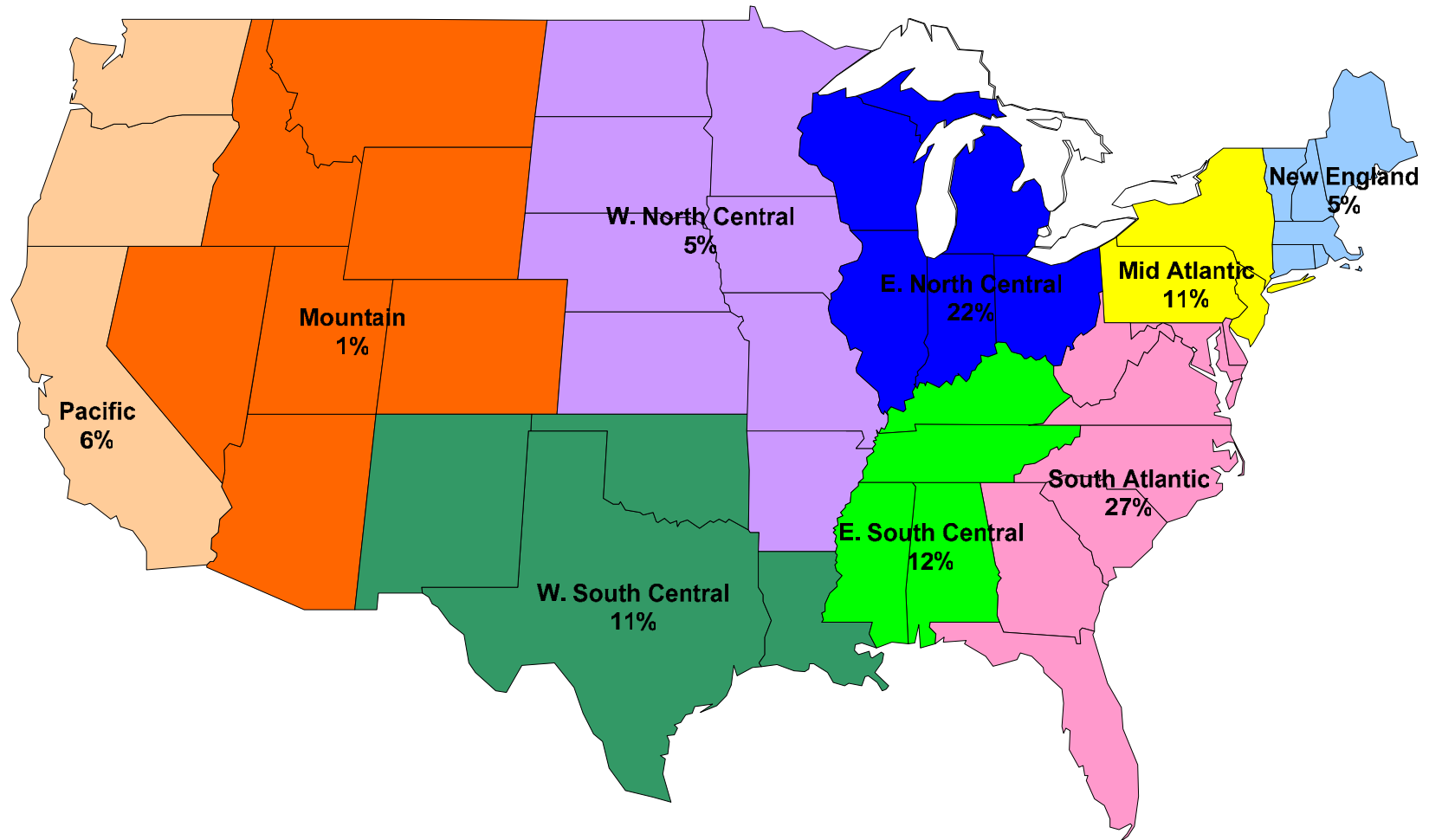
U.S. Market Logistics

U.S. Market Geographic Distribution



Approximately three fourths of the demand for PP in the United States is concentrated in the East and Midwest regions

U.S. Market Geographic Distribution



Transportation Costs From U.S. Gulf Coast

U.S. Cents per Pound	
From:	Houston
To:	
Albuquerque	1.8
Buffalo	4.4
Chicago	2.0
Denver	1.8
Des Moines	2.0
Detroit	4.0
Kansas City	2.5
Los Angeles	4.4
Milwaukee	1.5
Minneapolis	1.5
Ohio	4.1
Phoenix	2.4
San Francisco	4.7
Seattle	4.0



Basis: Shipper-Owned Covered
Hopper Cars; 200,000 Lbs Max.

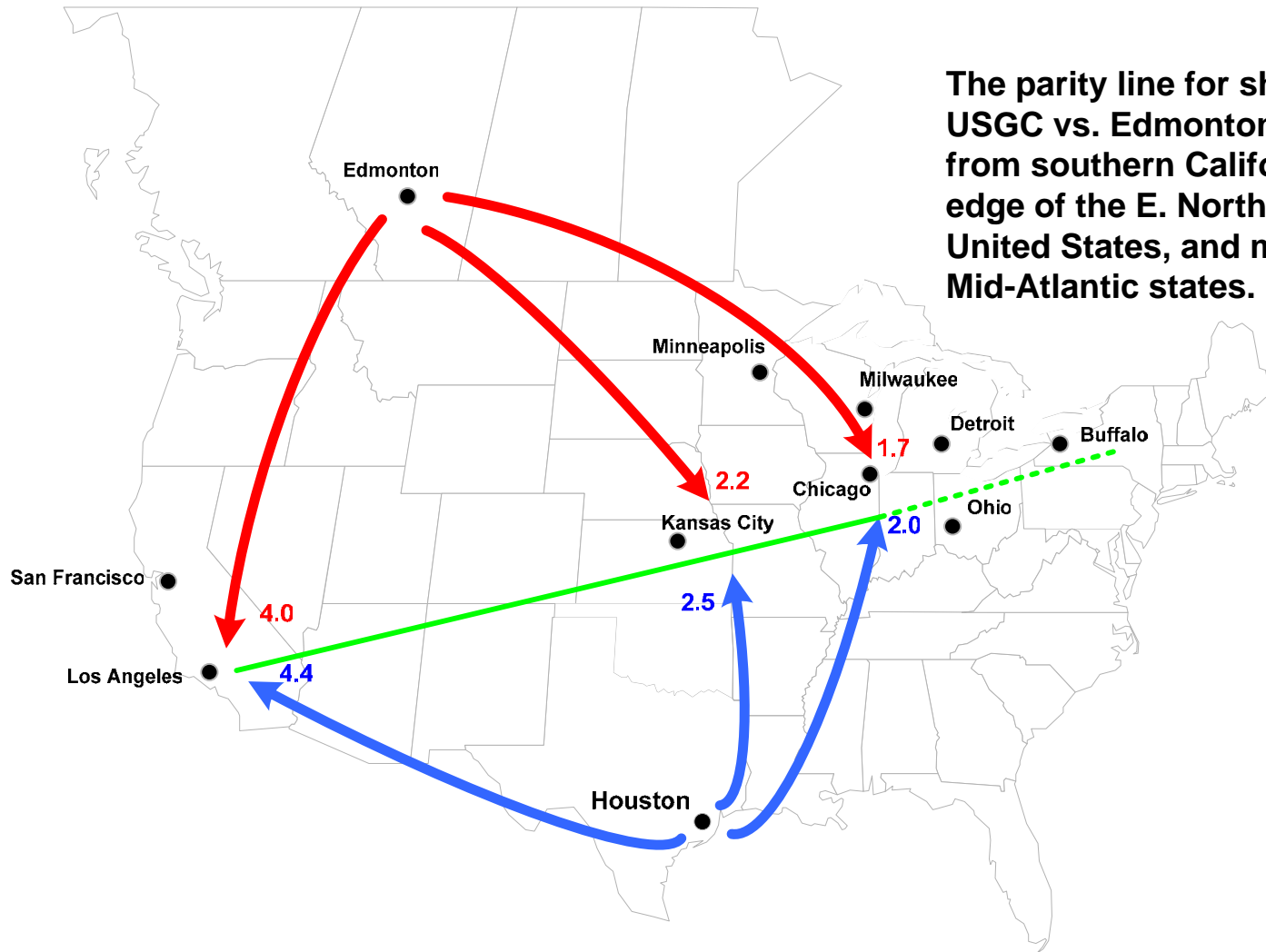
Transportation Costs From Edmonton, AB

To:	U.S. Cents per Pound
From: <u>Edmonton</u>	
Buffalo	2.2
Chicago	1.7
Detriot	1.8
Kansas City	2.2
Los Angeles	4.0
Minneapolis	1.3
Ohio	2.3
San Francisco	3.7
Milwaukee	1.9



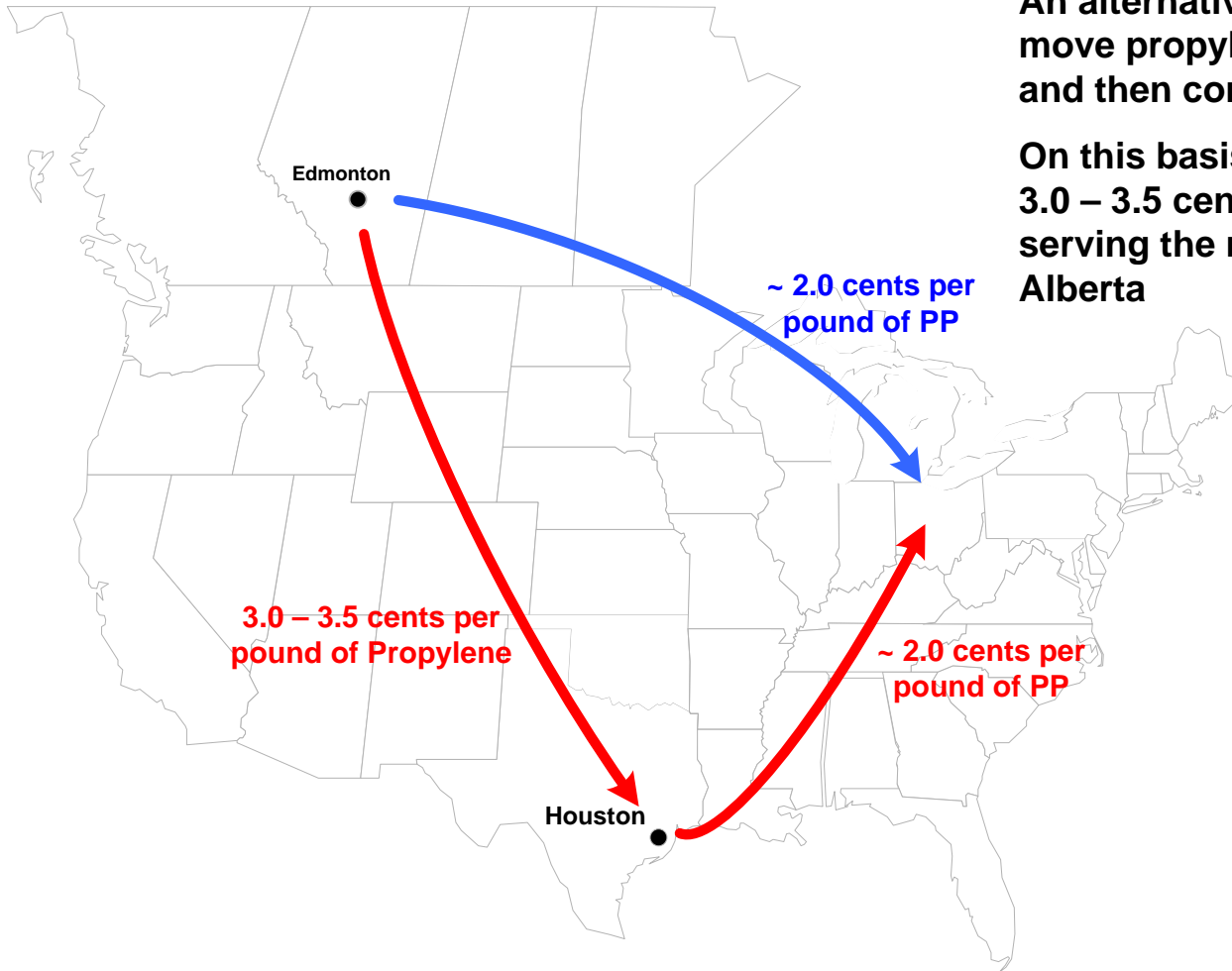
Basis: Shipper-Owned Covered Hopper Cars; 200,000 Lbs Max.

Transportation Costs Comparison Edmonton vs. Houston



The parity line for shipping costs from USGC vs. Edmonton runs approximately from southern California to the eastern edge of the E. North Central region of the United States, and may extend into the Mid-Atlantic states.

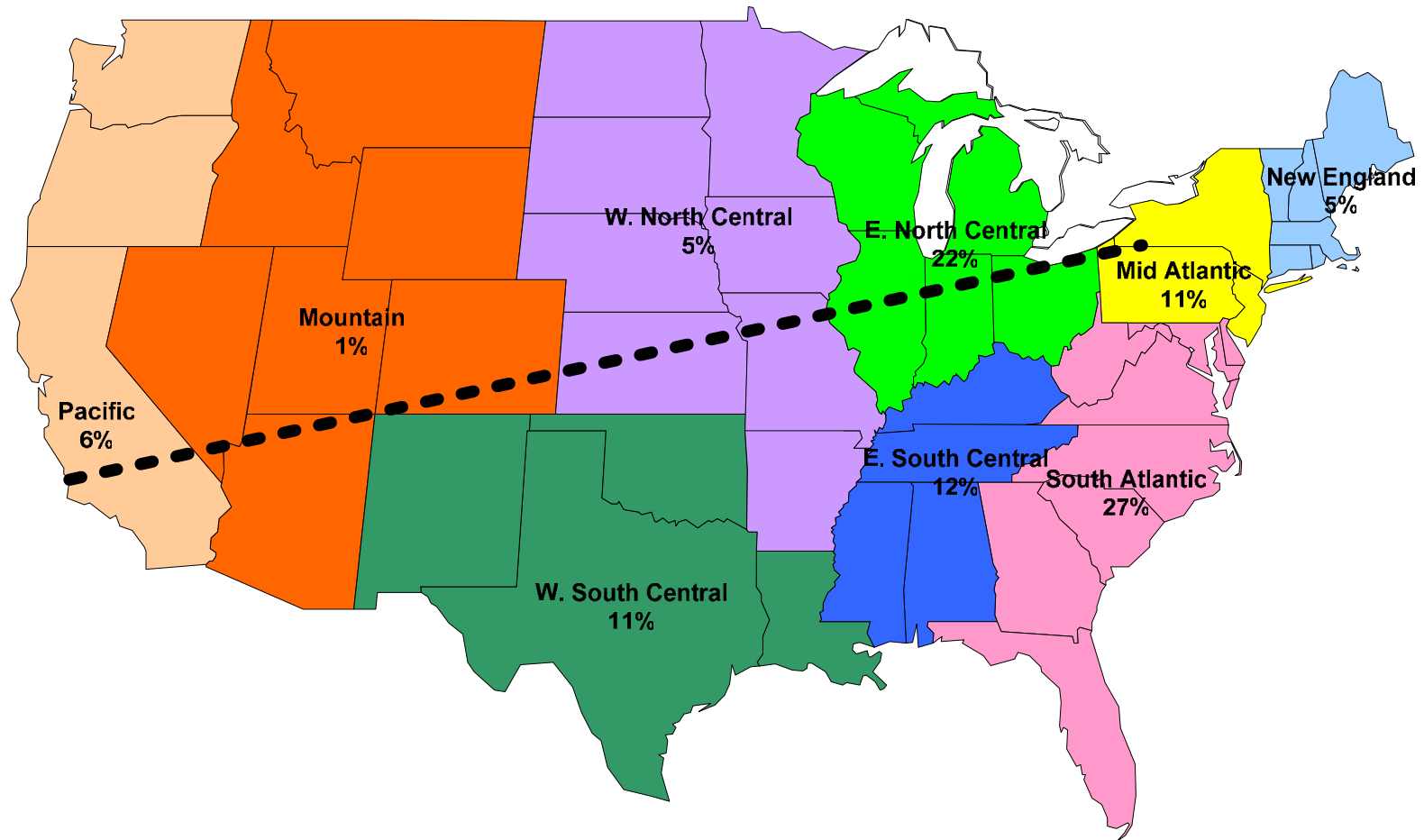
Alberta Propylene vs. Polypropylene Logistics



An alternative to producing PP in Alberta is to move propylene from Edmonton to the USGC, and then convert to PP for the U.S. market.

On this basis, an advantage of approximately 3.0 – 3.5 cents per pound will exist when serving the markets along the parity line from Alberta

U.S. Market Geographic Distribution



Approximately 25-30 percent of the U.S. market could be served competitively on a logistics basis versus the producers located on the U.S. Gulf Coast.