Wood Based Lignin Co Products
An overview

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An Overview

- Historical
- Lignin Markets
- Commercial and Scientific Lignins
- Observations & Future

Wood based co-products… It Depends

Entity	Product	Co-Product
Landowner	Timber	Recreation, Watershed
Lumber Mill	Lumber	Chips, Hog Fuel, Steam, Electricity
Furniture Mill	Furniture	Sawdust, Steam, Electricity
Plywood Mill	Plywood	Chips, Poles, Hog Fuel, Steam, Electricity
Pellet Mill	Fuel Pellets	Bedding, Soil Amendments
Pulp Mill – Sulfite	Pulp, Paper	Alcohol, Lignin, Steam, Electricity
Pulp Mill – Kraft	Pulp, Paper	Turpines, Tall Oil, Lignin, Steam, Electricity
Wood and Wood Residuals	Benefits Society	Renewable, Low Carbon

Georgia Pacific - Bellingham, WA

GP Bellingham History

- Originally operated by Puget Sound Pulp & Timber (PSP&T)
  - Bellingham mill built in 1917 on apple box and other lumber debris
- $Ca(HSO_3)_2$ pulping process
- World War II & synthetic rubber
- Ethanol from waste wood sugars (1946)
- Butadiene route / ethanol not required
- PSP&T purchased ethanol plant & started lignin business
  - 1946-2001 6,000,000 gallon/year, 190 and 200 proof
  - 1948-2001 240,00 tons/year, lignin co-products
- PSP&T acquired & operated by Georgia Pacific 1965-2001
- Bellingham Pulp & Chemical closed in 2001

NW Lignin Co-Product Producers

- Rayonier – Hoquiam, WA
  - Vanillin
  - Lignin
- Marathon Corp – Lebanon, OR
  - Lignin
- Boise Cascade - Salem, OR
  - Yeast
- Georgia Pacific Corp – Bellingham, WA
  - Alcohol 190^{o} & 200^{o}, 6MM g/yr
  - Lignin, 240,000 t/yr

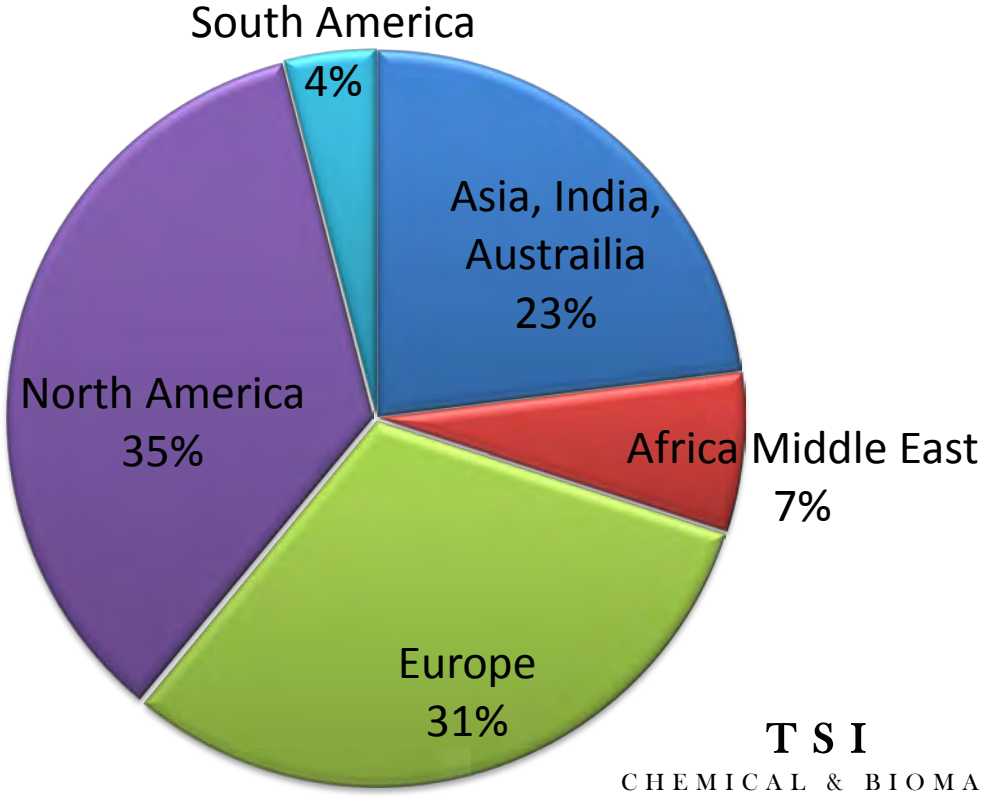
<u>GP Bellingham Lignin Products</u>

- Oil well mud additives
- Concrete and gypsum dispersants and conditioners
- Emulsifiers/dispersants, carbon black, textile dye & Pigments, wax & oils
- Plant nutrition, micro nutrients
- Road stabilization, compaction & dust
- Pelletizing – Animal Feed, wood mineral pelletizing
- Dust collection
- Mining – Floatation aids
- Refraction Clays Binder
- Phenolic Resins – plywood industry

World Consumption
(Lignosulfonate)

Region	Million Tons (Metric)
Asia, India, Australia	250-320
Africa Middle East	70-90
Europe	350-400
North America	400-450
South America	50-70
Totals	**1120-1330**

TSI Market Analysis 2001-2004



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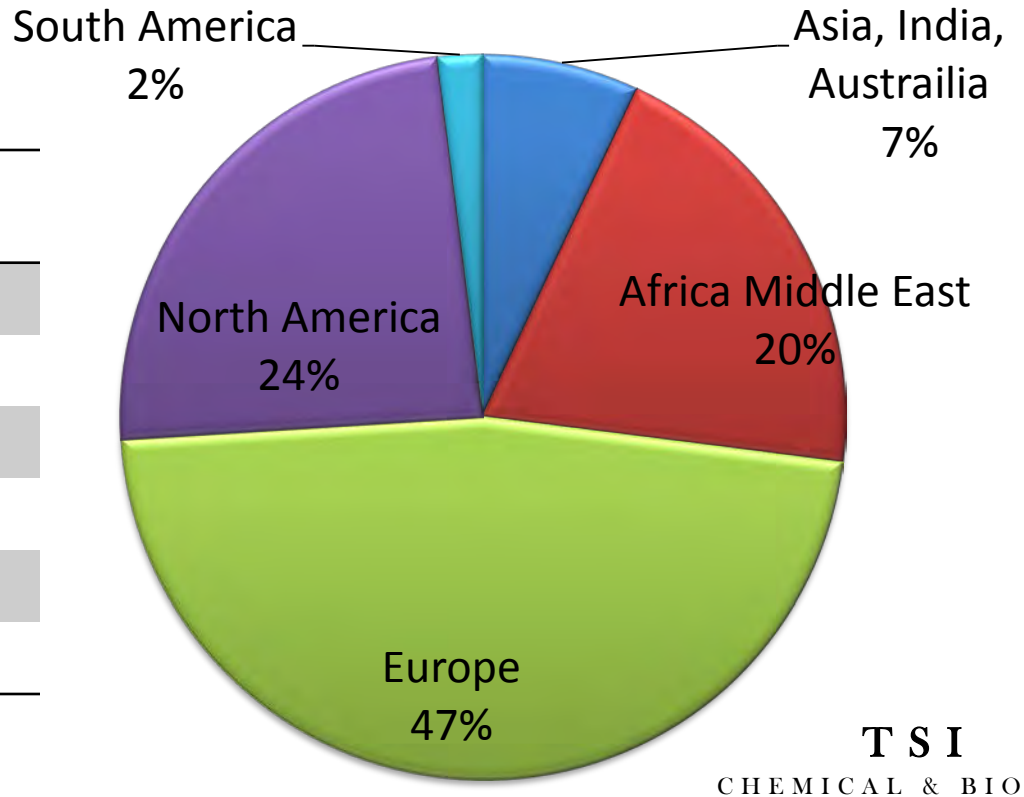
World Production
(Lignosulfonate)

Region	Million Tons (Metric)
Asia, India, Australia	50-100
Africa Middle East	165-200
Europe	400-500
North America	200-270
South America	20-40
Totals	**835-1110**

TSI Market Analysis 2001-2004



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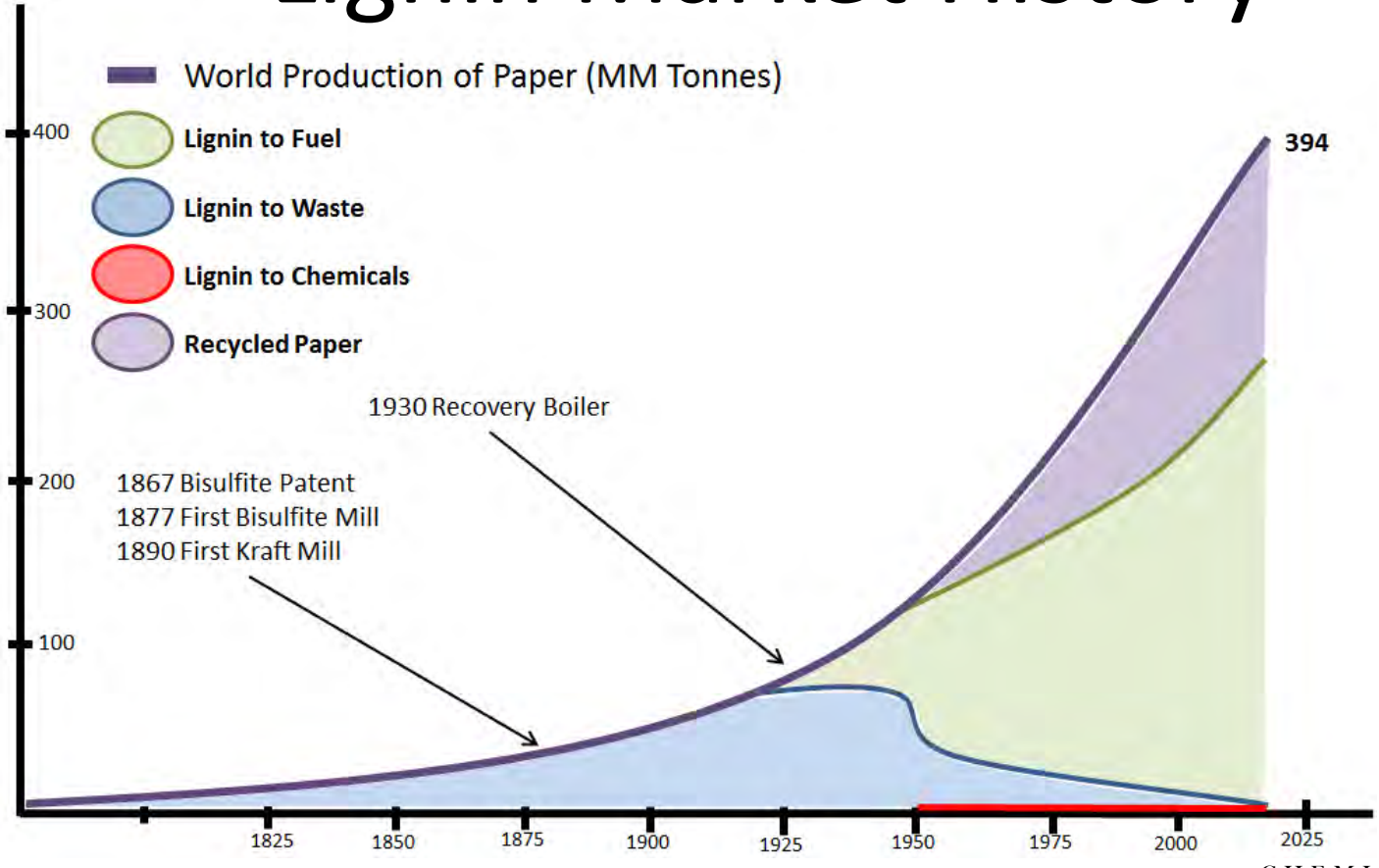
Lignin Market History



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The Lignin Market

- Unusual Lignin Market
  - Potentially 200-300 million ton/yr commercial lignin available
  - Lignin Market 1.3 million ton/yr – Sulfite Lignin
  - Sulfite Mills are old technology and are closing

- Conclusion:
  - Potentially very large supply of lignin available
  - Customers are worried about supply

Commercial and Scientific

Commercial Lignin

- By product of paper industry – many components
- Softwood Sulfite Example
  - Lignosulfonate 50-60%
  - Hexose & Pentose 15-25%
  - Sugar Acids & Residuals 10-14%
  - Resin & Extractives 2-4%
  - Ash 8-12%

Scientific Lignin

- Laboratory produced pure lignin

What's the issue

- Separation of lignin from commercial lignin is difficult
- Source species
- Residuals
- Science needs to deal with purification issues

Observations

- Wood to sugar, bio-chemicals, or bio-fuels
  - Protection of cellulose fiber not required
  - 150 years of paper tradition not required
- Lignin is the issue
  - Paper industry fuel
  - Bio-fuel industry is not economically viable without valuable co-product
  - Scientific GMO to reduce lignin… society may reject
- Current Commercial Lignin
  - Potential large supply
  - Sulfite closures → shortage of sulfite lignin → customer change use
  - Fuel will predominate
- Paper & Bio-products combination & synergy
  - Paper better economics than sugar
  - Part to paper, part to sugar & other

Future

- Utilize new sciences (bio) to extract chemicals from existing paper wastes
- Utilize new sciences (bio) to extract chemicals from wood
- Co-mingle paper production with bio-refinery science to benefit both