

Polymer-Modified Asphalt Supply Outlook

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Acknowledgements

- **Polymer Supply Information**
 - **De Witt & Company**
 - **Tom Brewer**

Predominate Modifier



- **Styrene-Butadiene-Styrene (SBS) is most widely used in US and around the world**
 - **Excellent performance – case studies**
 - **Long history of success – since 1970's in Europe**
 - **SBS produce a stable, compatible system easily used in today's construction practices**

Styrenic Polymers (Elastomers)



Disposable
fork

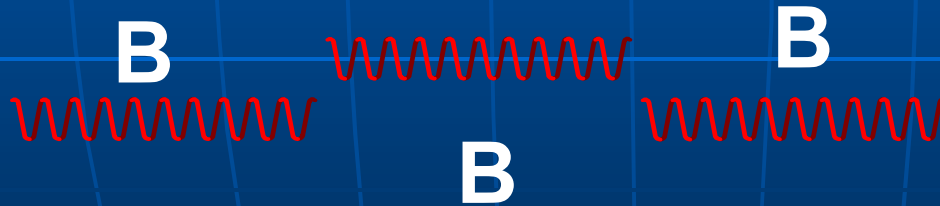


POLY-STYRENE

- Polystyrene is hard and brittle



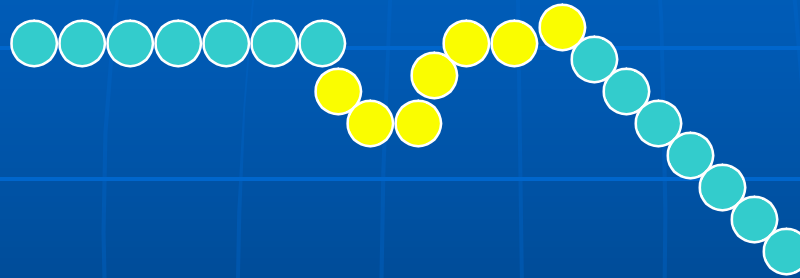
Rubber
band





POLY-BUTADIENE

- Commonly co-polymerized with butadiene

SB and SBS



**Block Copolymer
(SB & SBS)**

-  **Butadiene**
-  **Styrene**

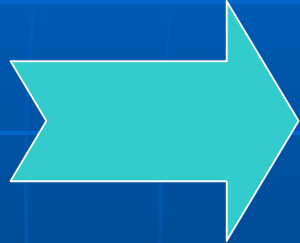
Why is SBS Currently in Short Supply?



- Styrene-Butadiene-Styrene (SBS) polymer capacity is not short
- Shortage of raw materials - Butadiene
- **Ethylene production is the problem**

Why is Ethylene Production the Problem?

Ethylene



- **By-products of Ethylene Production**
 - Styrene
 - Propylene
 - **Butadiene**
 - Isoprene
 - Pentadiene
 - Cyclopentadienes
 - Aromatic Resin Formers
 - Isobutylene
 - Amylenes
 - Hydrogen
 - Benzene

Ethylene & Butadiene Market Comparison



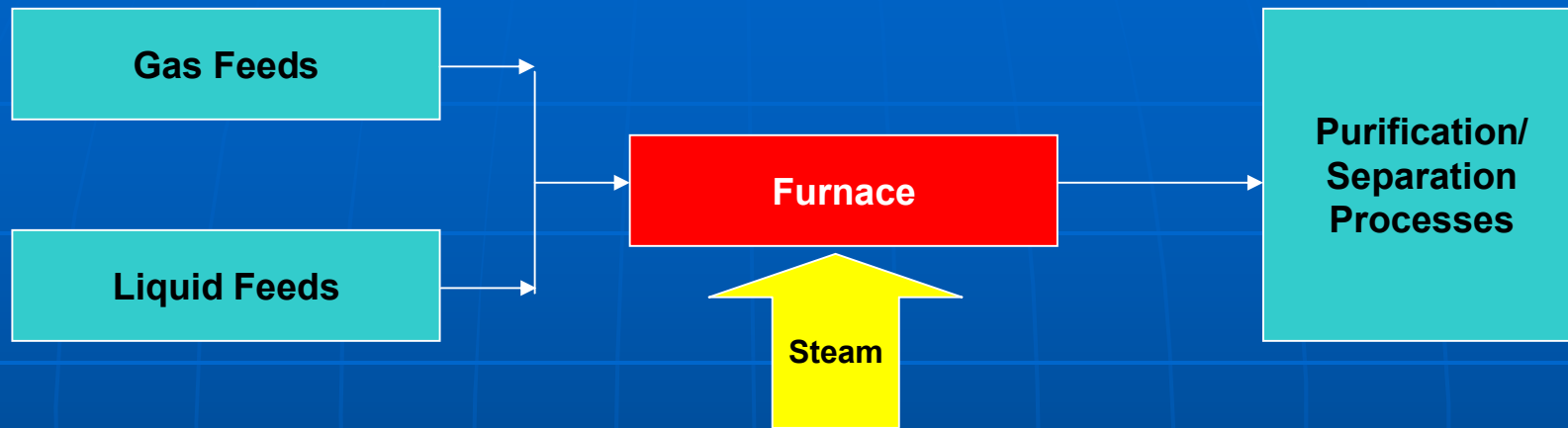
■ Ethylene Market

- 120 million tons per year
- Primary use – packaging materials
 - Plastic wrap
 - Trash bags
 - Milk jugs

■ Butadiene Market

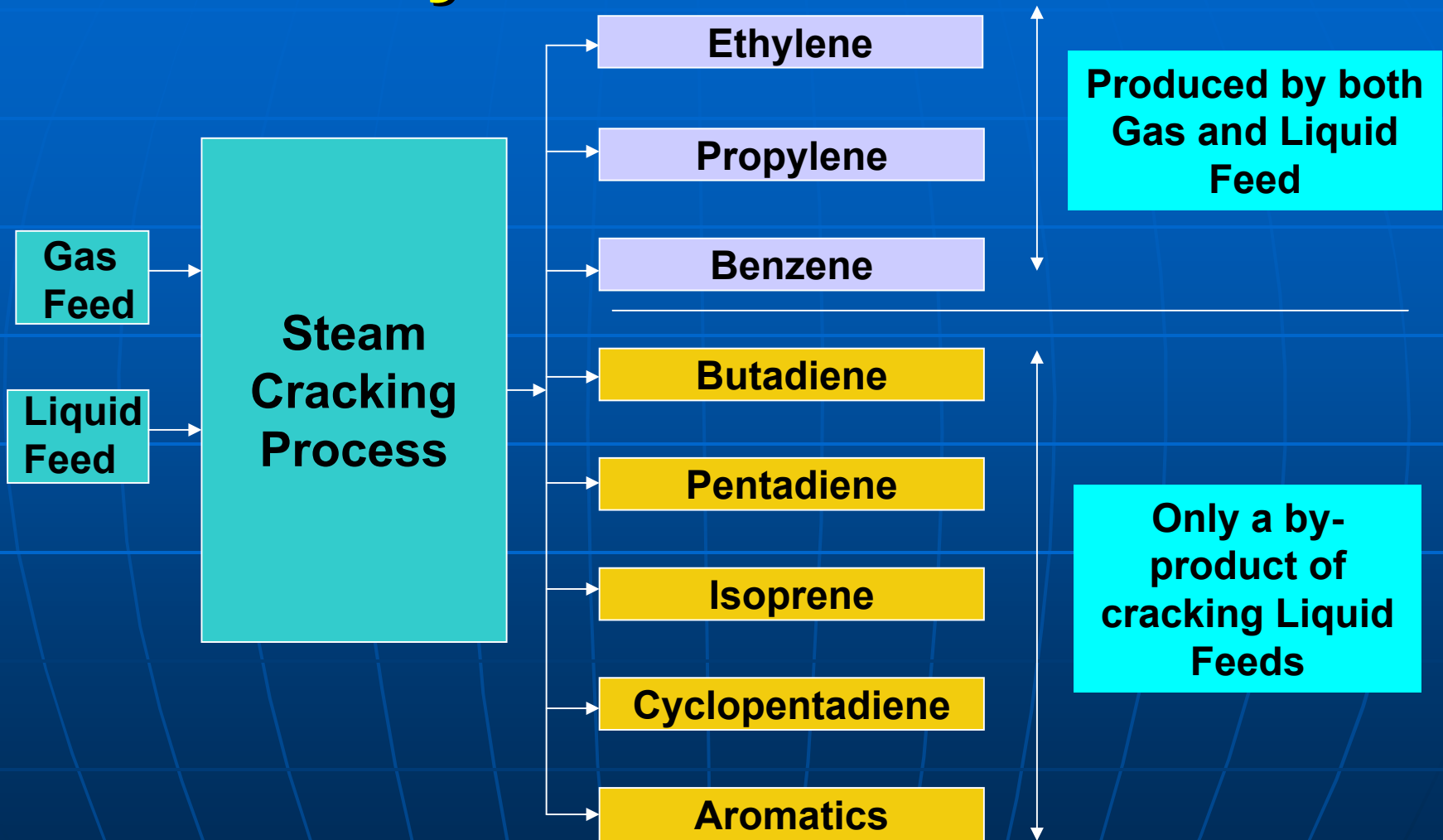
- 14 million tons per year
- Primary use – tires (70%)
- Multiple other automotive and durable good uses
- SBS polymer for asphalt (6%)

How Is Ethylene Made?



- **Basic ethylene production technology is called a steam cracking process**
 - Process heats feed up to 1700 degrees, then injects steam that cracks the molecules
 - Cracker unit cost \$2 billion
- **Choice between gas feeds like ethane, propane and butane and liquid feeds like naphtha and gas oils.**
- **Output is a mixture of ethylene and other products**
- **Requires a downstream purification processes to separate products**

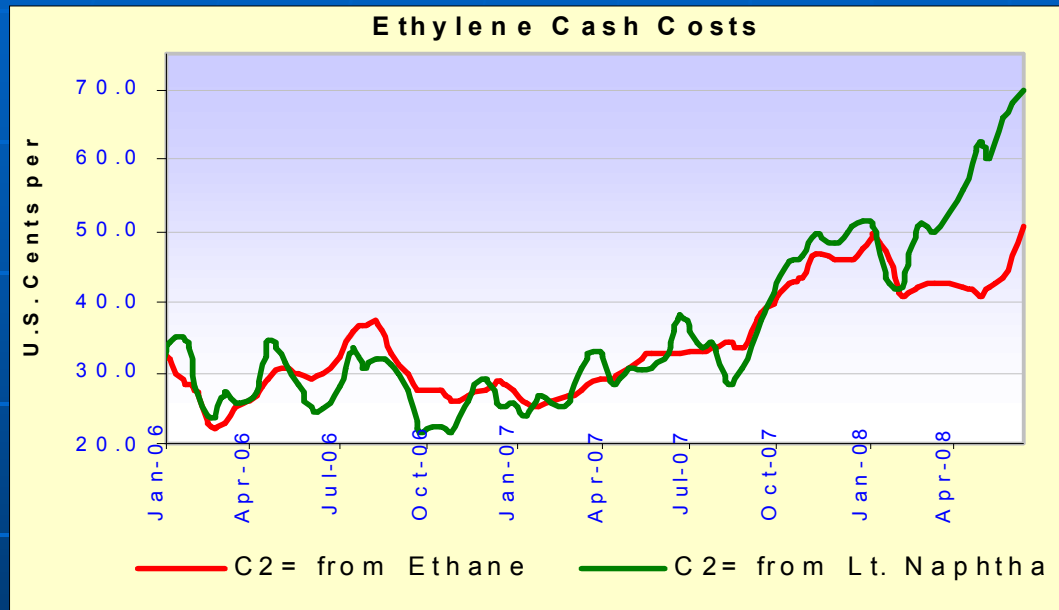
What's Important to Know About Ethylene Production



Choosing Feeds to Produce Ethylene

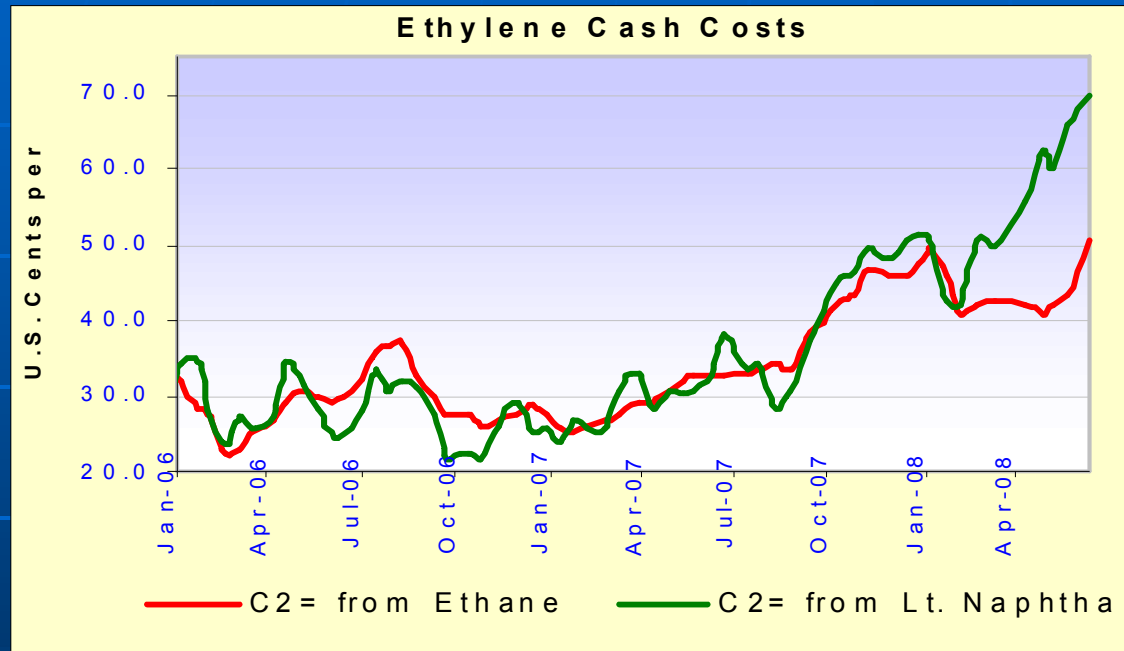
- Each producer runs an economic model
- Feed availability and costs for the producer at their location
 - Yield of each feed – varies considerably
 - Demand for each product
 - Alternatives to buy versus make that product
- Ethylene and propylene are the prime products
 - Evaluate netback of all products
 - Liquid feeds generally produce 15:1 ethylene to butadiene
 - Economic impact of butadiene is not large
 - Based on the conditions producers set a feed slate for the “Cracker”
 - Butadiene shortage is not a primary consideration for feed slate

Model Output



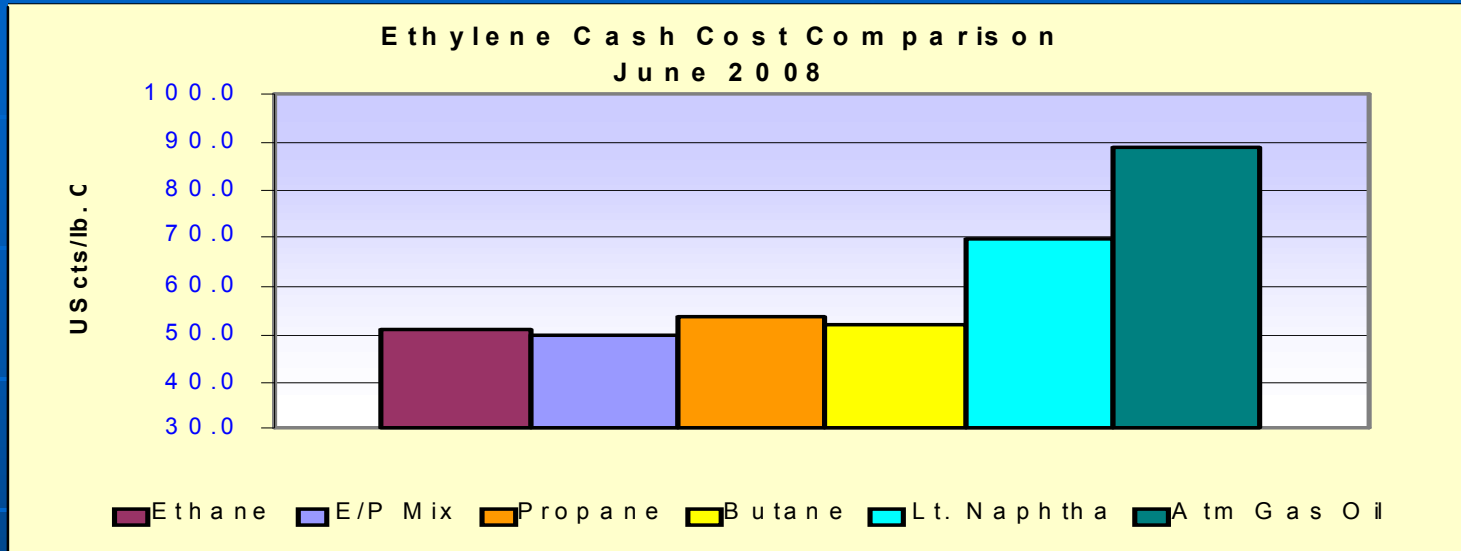
- Liquids are always in the slate due to the facilities being built to be liquid crackers
- Crackers modified in the 80's to be flexible
- Flexibility depends on producer, but varies from ~10% to ~50%
- Producing 3-5 million pounds a day a few pennies makes a big difference

What's Changed



- **Structural change - natural gas producers installed facilities to separate ethane**
 - Ethane higher value than natural gas
- **Ethane prices didn't increase with the crude oil run-up**
- **Economic incentive to run more ethane feed**

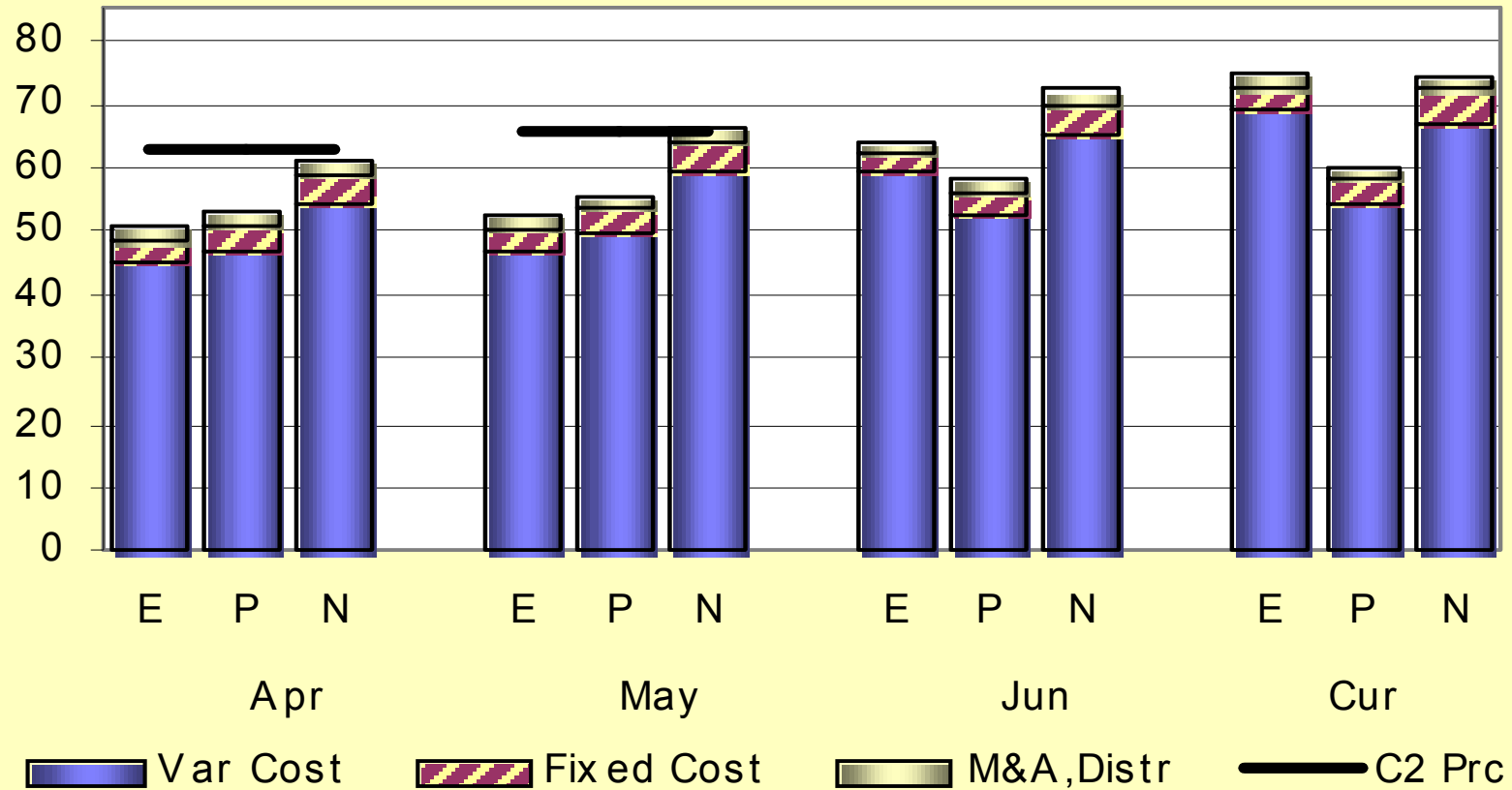
What's Changed



- DeWitt estimates that the 1Q cracking slate went 10% lighter vs 2007 starting in February
- 2Q2008 slate has moved even lighter; possibly another 10-20%
- Incentives so great that teams of engineers are working on putting more gas into the cracking slate on a crash basis

July 2008

Ethylene Cash Costs, c/lb



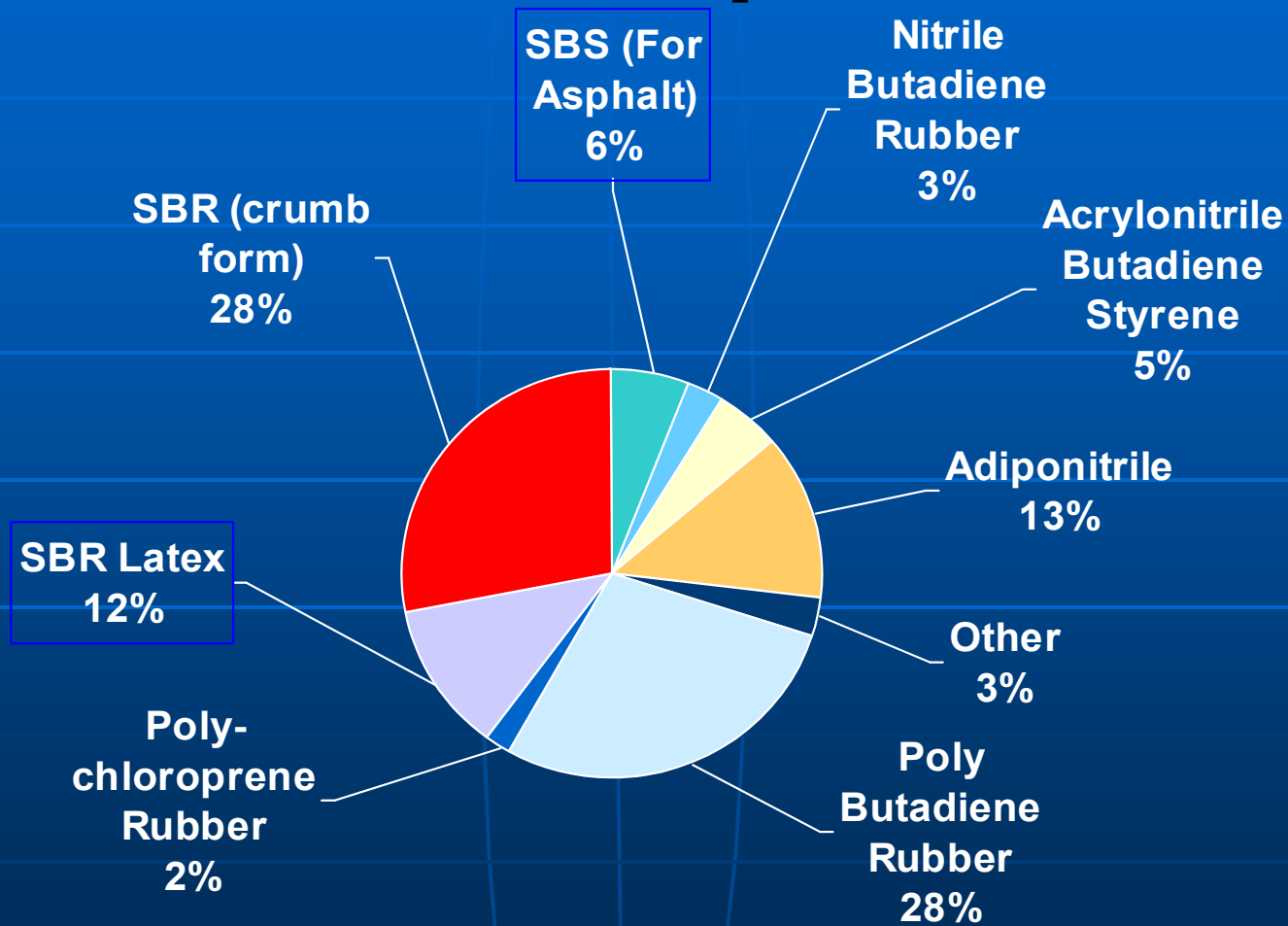
Ethylene General Trends

- **Significant ethylene capacity additions in Middle East and Asia**
 - Most of the Middle East is gas cracking
 - Most of Asia is liquid or naphtha cracking
- **Little to no capacity additions in Western World**
- **New trend for ethylene units outside of US to be more flexible to be able to run more gas feeds**
 - Historically have been naphtha crackers
- **Expect more flexible cracking; hence, more variable Butadiene supply**

Butadiene (Bd) Supply

- **Globally tight due to lighter cracking and higher demand**
 - 2008 Bd supply estimated at 75-85% of 2007
- **New Bd and ethylene capacity due on-stream in Asia**
- **Expected capacity utilization to be lower than 90% for the foreseeable future**
- **Regional differences**
 - US crude Bd supply tight due to light cracking in first half
 - US has excess purification capacity and buys crude Bd from Europe to fill capacity
 - Europe tight on supply due to somewhat lighter cracking; thus, less crude Bd to export to US
 - New Asian capacity needs to catch-up with demand

North American Butadiene Consumption



What Factors Will Influence Supply?

Positive

- **New capacity**
- **Bd pricing itself out of some applications**
- **High gas prices:**
 - **Less driving mean fewer replacement tires**
 - **Smaller vehicles/smaller new car tires**
- **Slowing economy; less growth**

Negative

- **Higher natural rubber prices driving consumers to synthetic rubbers based on Bd**
- **Lighter cracking**
 - **Higher naphtha prices**
 - **Structural change in US ethane market**
- **Low cost gas-based ethylene capacity coming on-stream in Middle East.**

Tire Demand Data



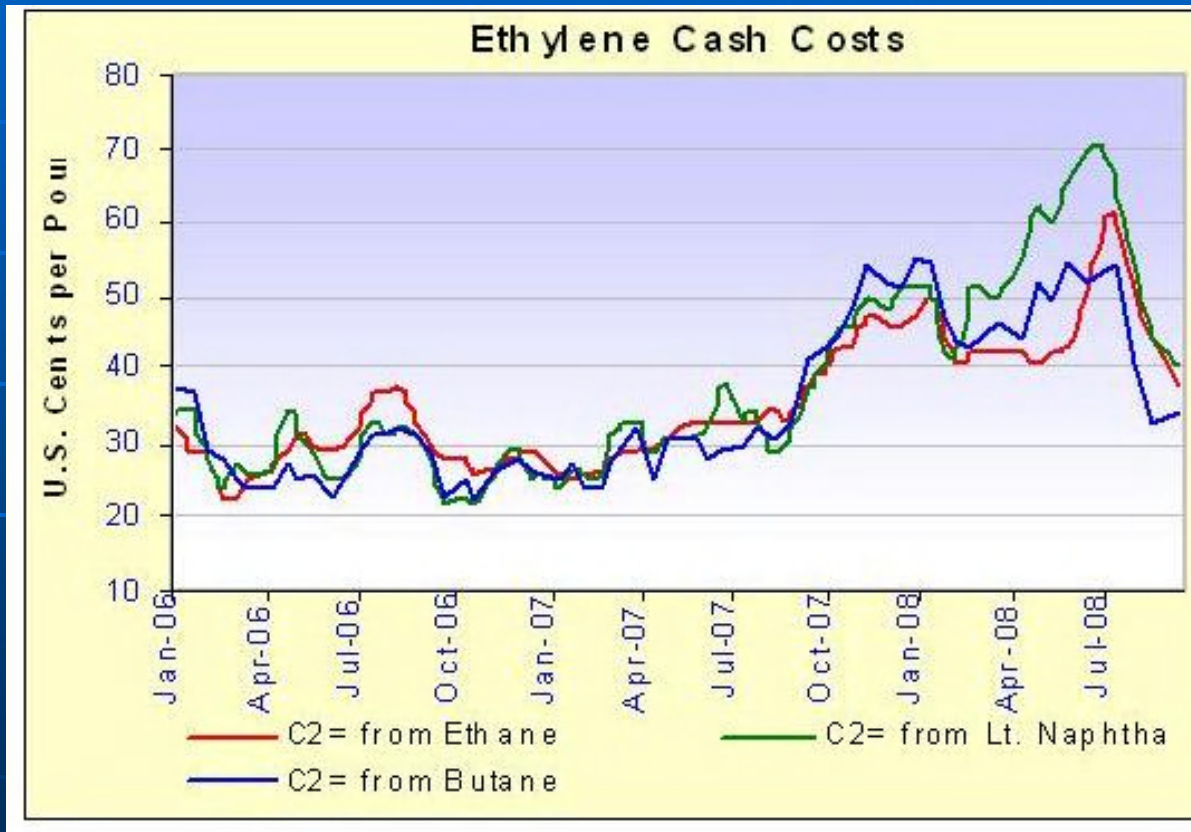
- **New Tire Demand**

- June vehicle production down 8% and falling
- Vehicle production skewed towards smaller vehicles
- Tire demand could be down over 12%

- **Replacement Tires**

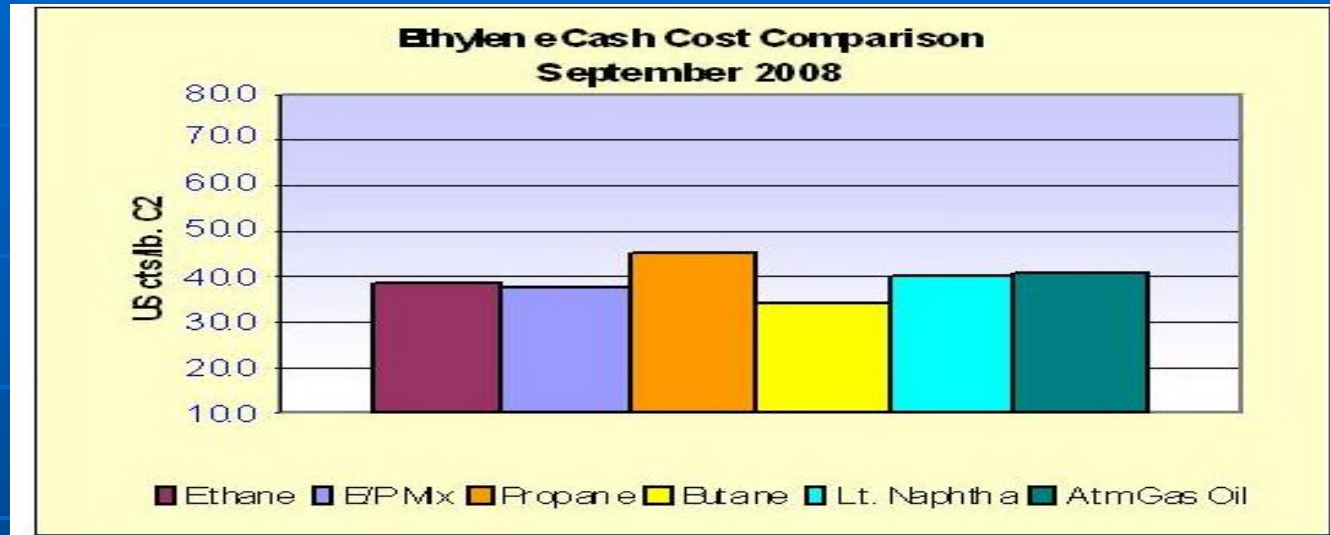
- Higher gas prices are reducing miles driven
- Expect reduced tire demand over time
- May take 3-6 months to play out.

October 2008



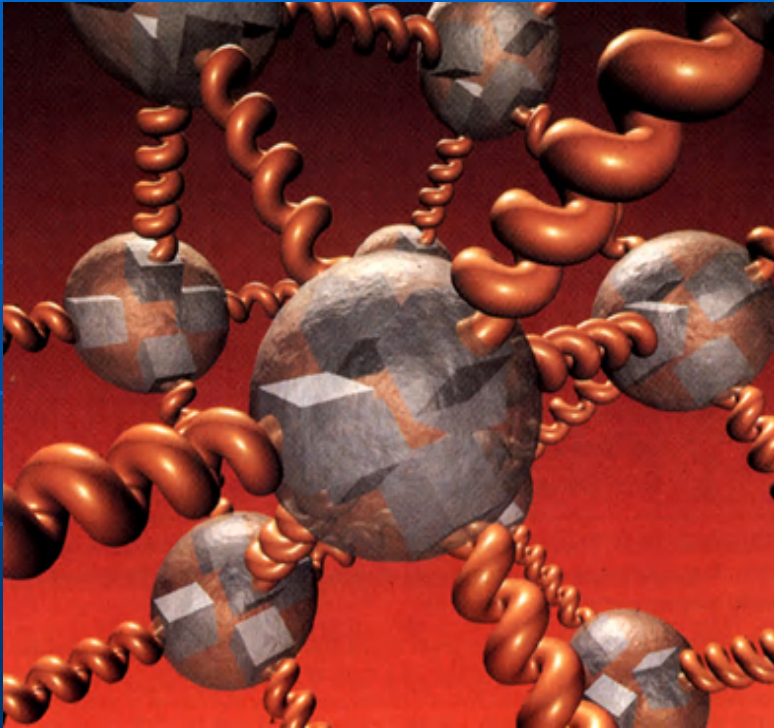
- **Spread between gas and liquid feeds now down to \$.05**
- **Demand is shrinking – tire demand is down**
 - **Asian market price drop of \$0.10- \$0.15 per lb**

October 2008



- **Hurricanes Gustav and Ike – temporarily shut down Gulf Coast crackers**
 - Expected Bd price increase of \$0.10 per lb
 - Reduced demand caused spike of only \$0.04 per lb
- **Crackers are back on line, but tire compound plants are not**
- **Tire Demand is way down – Frees up Butadiene for SBS Suppliers**
 - **Result – 100% Bd available to SBS producers for now**
 - **SBS suppliers will be able to build up substantial inventory this winter**

Alternatives to SBS Polymer



- **SBS polymer-modified asphalts are typically cross-linked systems**
 - Contractor friendly
 - Terminal blend supply
 - Do not require agitation
 - Storage stable
 - No major changes to HMA plant operation
 - No major changes to HMA laydown and compaction
- **Alternative modification systems should exhibit similar qualities**

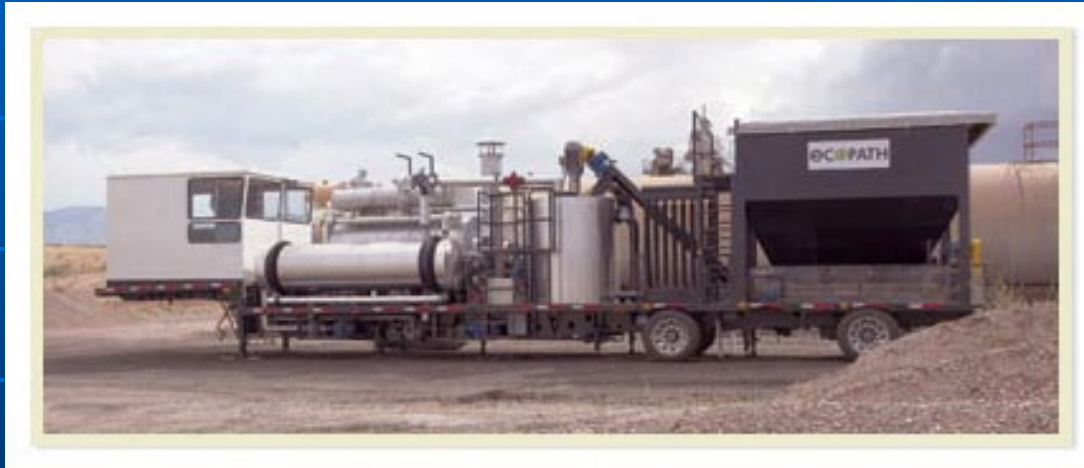
Alternatives to SBS Polymer



- **SBR Latex – butadiene based polymer that is not in short supply at this time**
 - Not storage stable
 - Must be blended at HMA plant
 - Contractor now becomes asphalt modifier and must test and certify product
- **Non- butadiene polymers**
 - Reactive Ethylene Terpolymer (Elvaloy)
 - Ethyl Vinyl Acetate (EVA)
 - Used in warm climates
 - Blended with SBS in cold climates
- **Polyphosphoric Acid (PPA)**
 - An extender, not an alternative
 - Can be blended with SBS to reduce SBS content

Alternatives to SBS Polymer

- **Ground Tire Rubber (GTR) – wet process**



- 15-20% GTR melted and swelled into asphalt
- No cross-linking occurs
- Not storage stable
- Not a terminal blend process
- AR binder cannot be PG graded in a meaningful way
- Recipe specification

Alternatives to SBS Polymer

- **Ground Tire Rubber (GTR) – terminal blend**
 - Typically proprietary process
 - 10-12% GTR added at high temperature and processed with high shear milling
 - Chemical stabilizer added
 - 70% of GTR is non rubber material
 - Carbon black
 - Calcium carbonate
 - Settlement may be an issue
 - SBS is sometimes used to stabilize the system
 - Cannot be PG graded under current DSR test procedures



Alternatives to SBS Polymer

■ Hybrid Binders

- Blend of SBS and GTR
- Cross-linked system
- Storage stable
- Terminal blend system
- Current research sponsored by FL DOT at University of Florida



Alternatives to SBS Polymer



- **'NOTHING' is not an option**

- PG Grading system is based on climate and traffic
- Using the wrong grade will lead to poor performance
- We have enough historical data to prove that PMA does improve pavement performance
- Flexibility and creativity are needed to come up with answers

DON'T SHOOT THE MESSENGER

