

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 ($\approx 90\%$ of PMA market)
 - 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

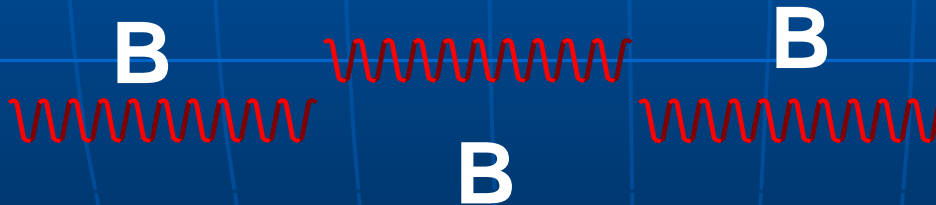


POLY-STYRENE

- Polystyrene is hard and brittle



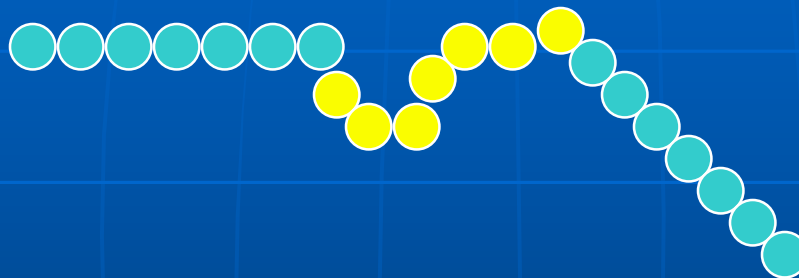
Rubber
band



POLY-BUTADIENE

- Commonly co-polymerized with butadiene

SB and SBS



**Block
Copolymer
(SB & SBS)**

● Butadiene

● Styrene

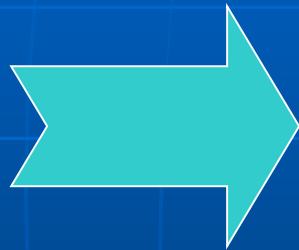
Why is SBS Currently in Short Supply?



- 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



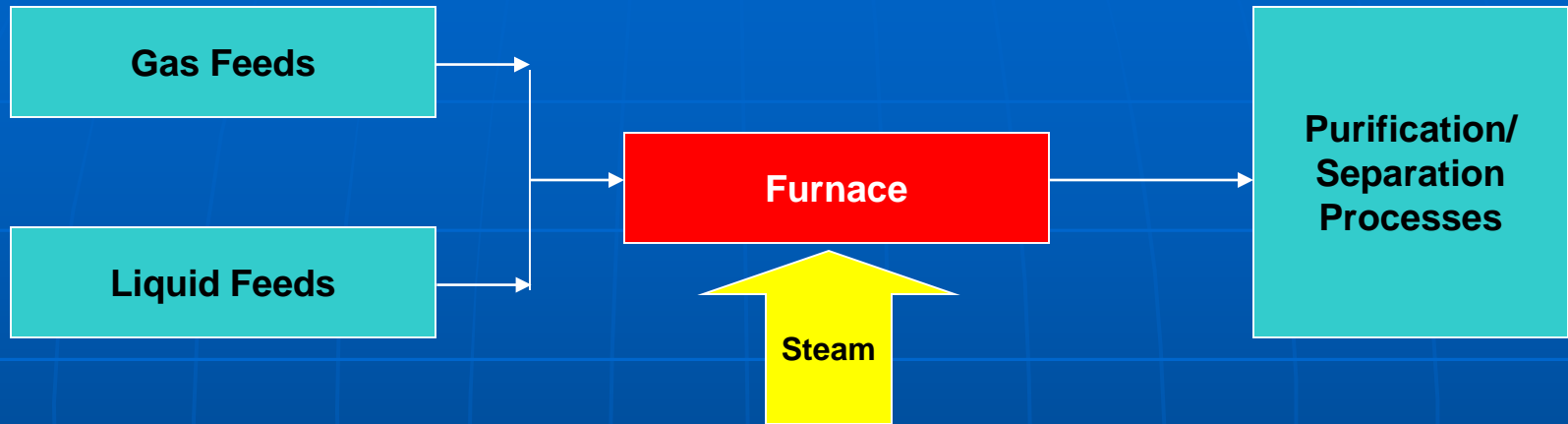
■ Ethylene Market

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

■ Butadiene Market

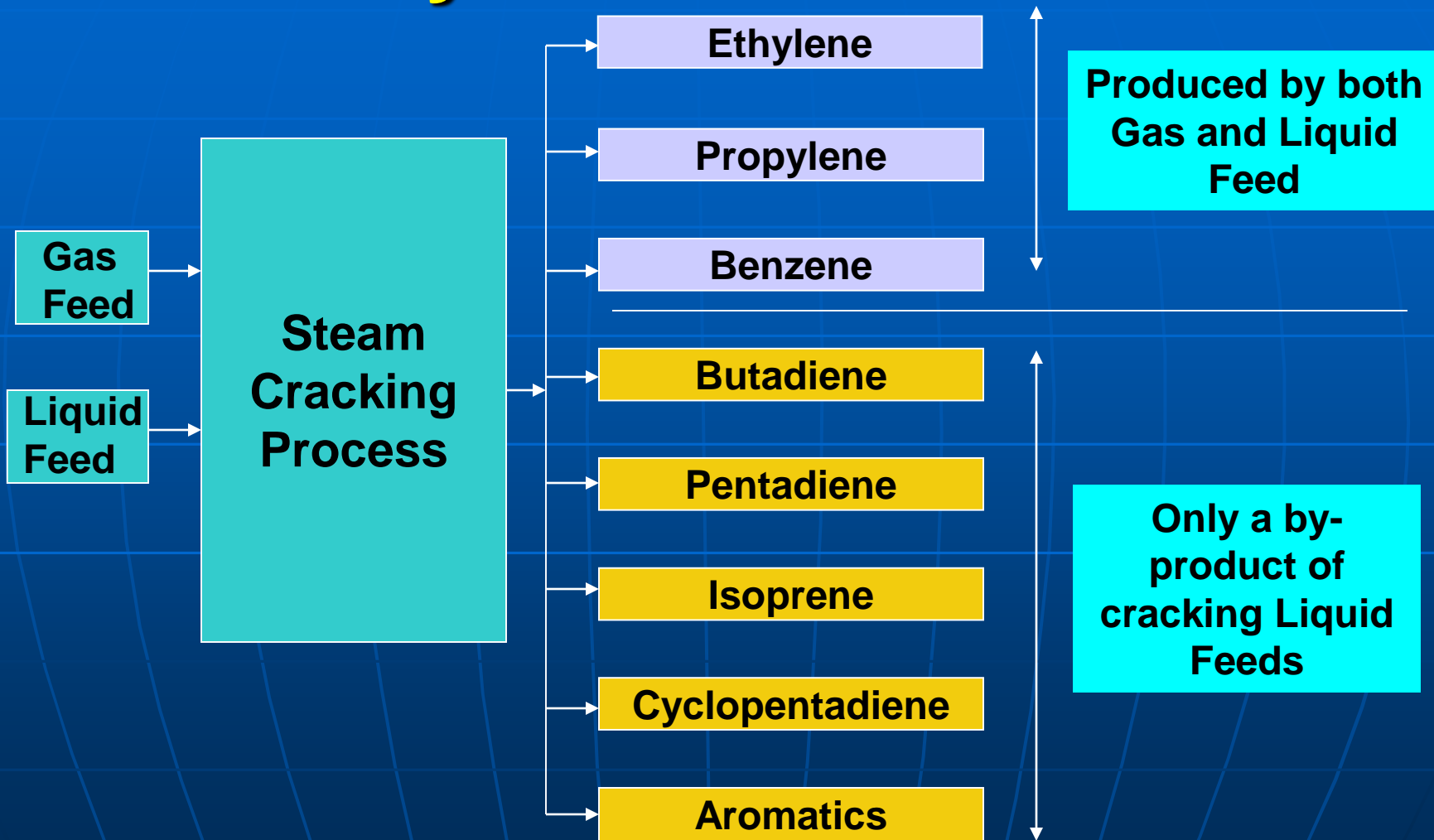
- 14 million tons per year
- Primary use – tires (70%)
- Multiple other automotive and durable good uses
- SBS polymer for asphalt (6%)

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**

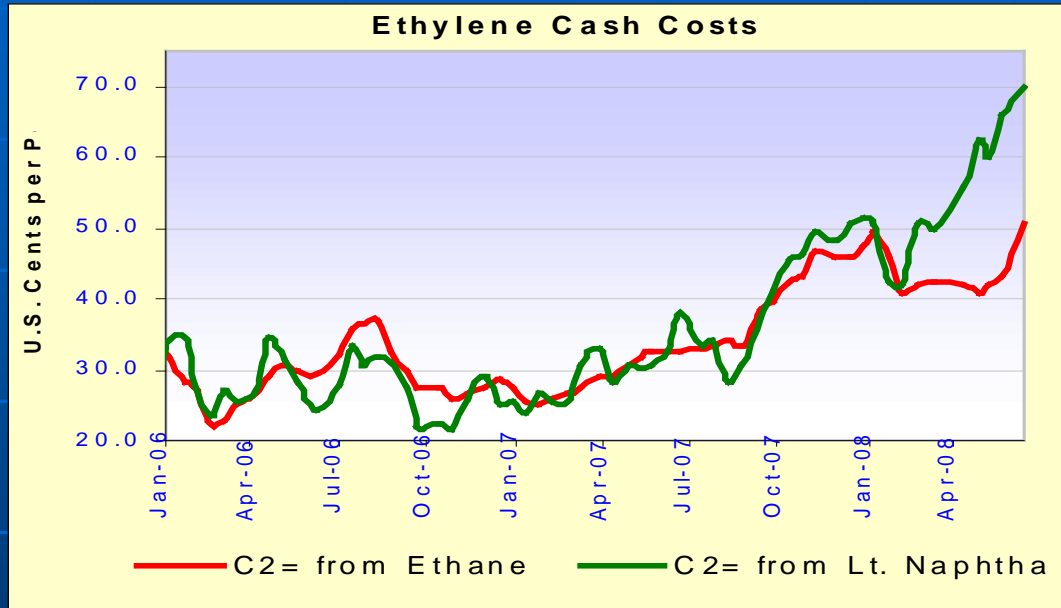
What's Important to Know About Ethylene Production



Choosing Feeds to Produce Ethylene

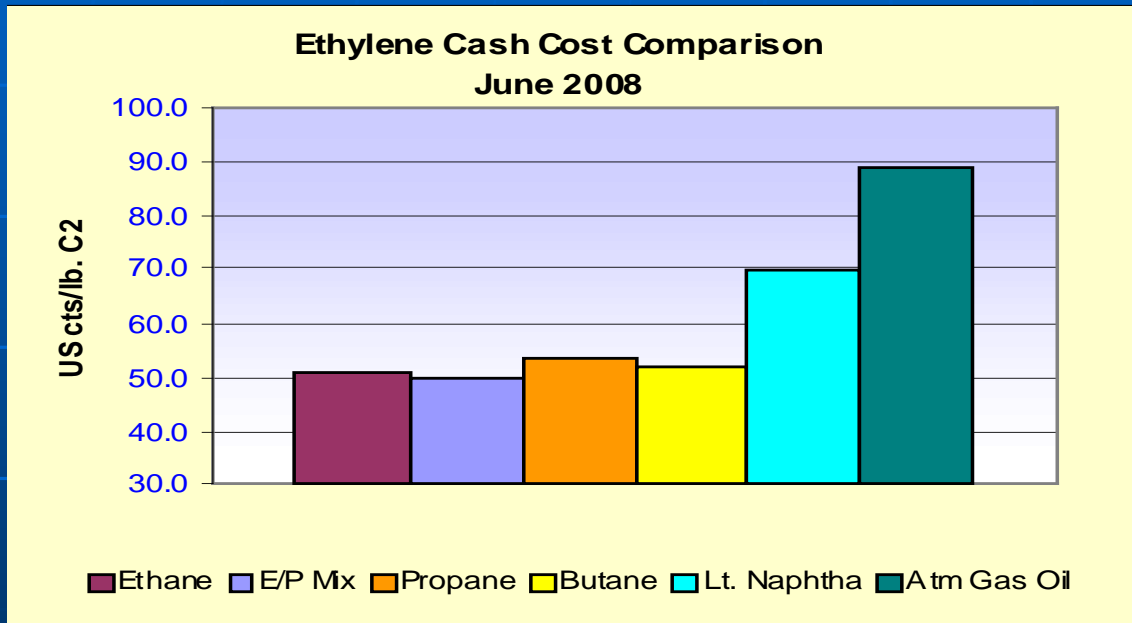
- Each producer runs an economic model
- Feed availability and costs for the producer at their location
 - Yield of each feed – varies considerably
 - Demand for each product
 - Alternatives to buy versus make that product
- Ethylene and propylene are the prime products
 - Evaluate netback of all products
 - 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



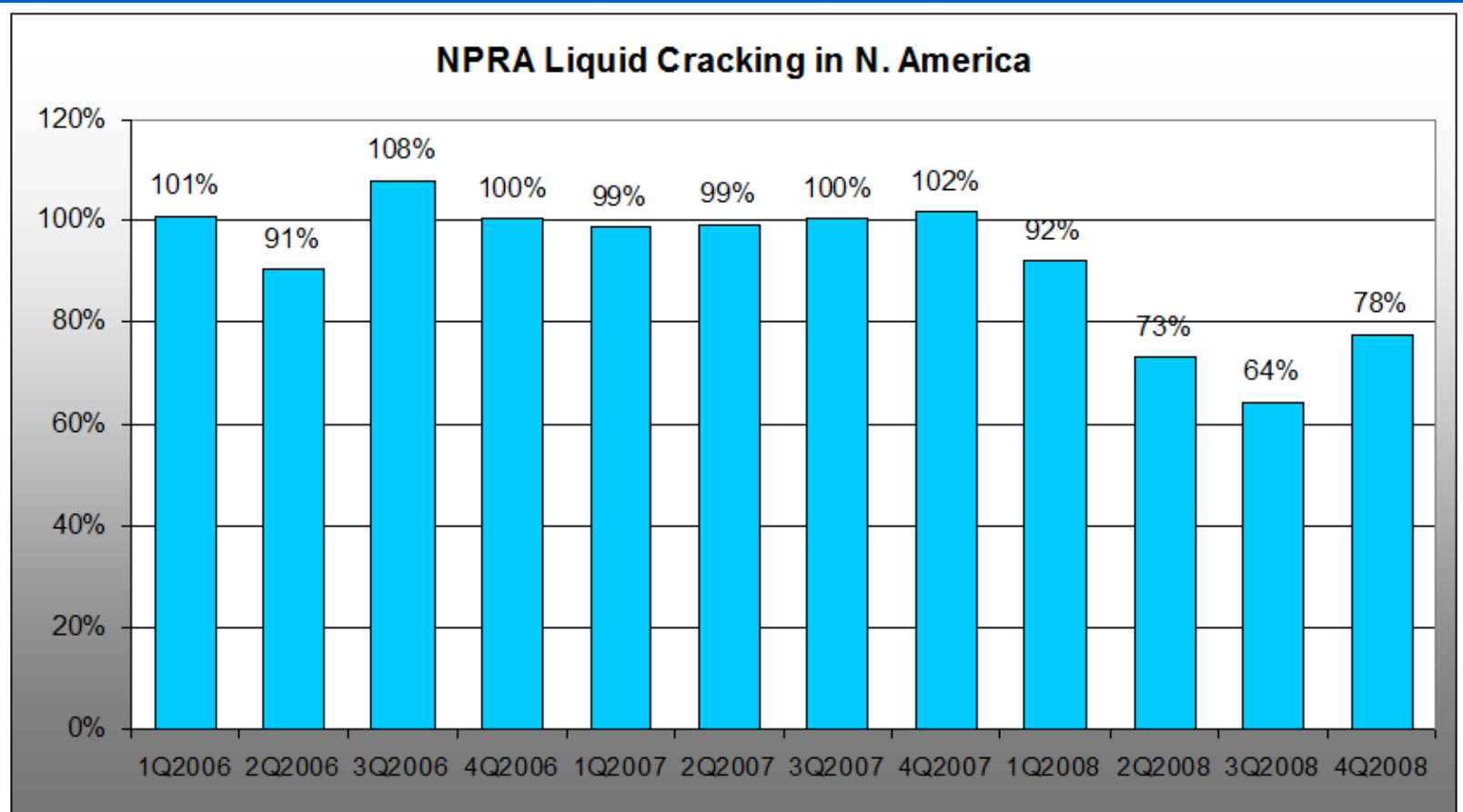
- Liquids are always in the slate due to the facilities being built to be liquid crackers
- Crackers modified in the 80's to be flexible
- Flexibility depends on producer, but varies from ~10% to ~50%
- Producing 3-5 million pounds a day a few pennies makes a big difference

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**

Feed Slate Change in 2008

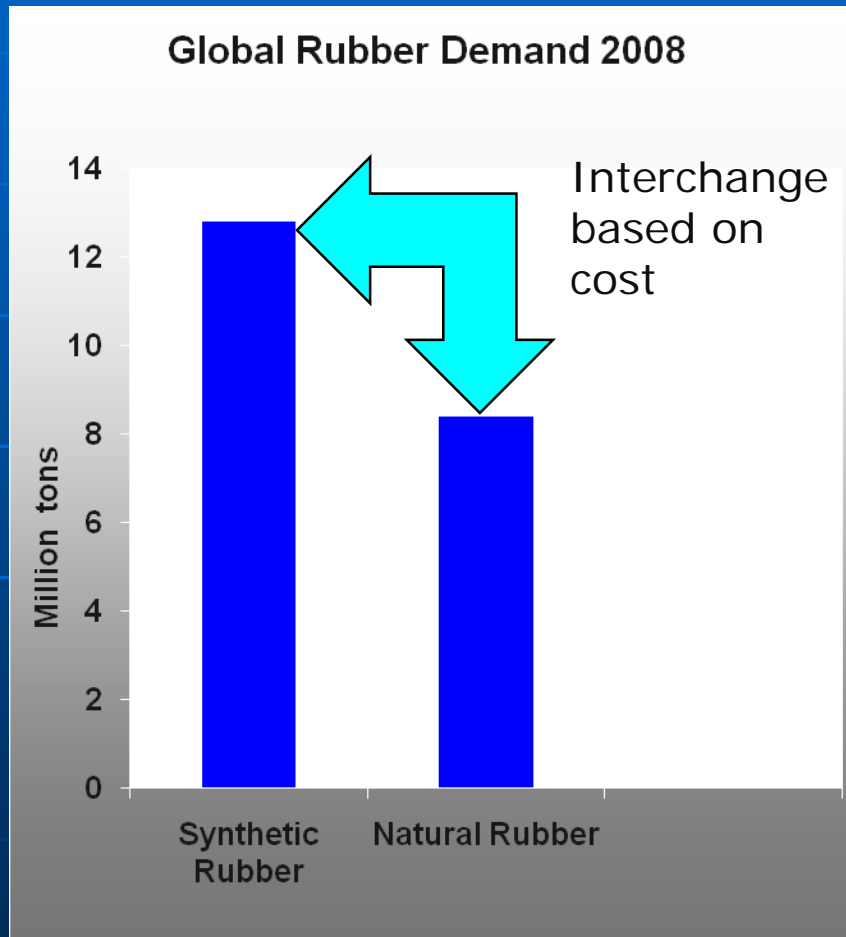


2008 Liquid Cracking Down 23% vs. 2007/6

Ethylene General Trends

- Little to no capacity additions in Western World
- 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
- 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

Global Rubber Perspective

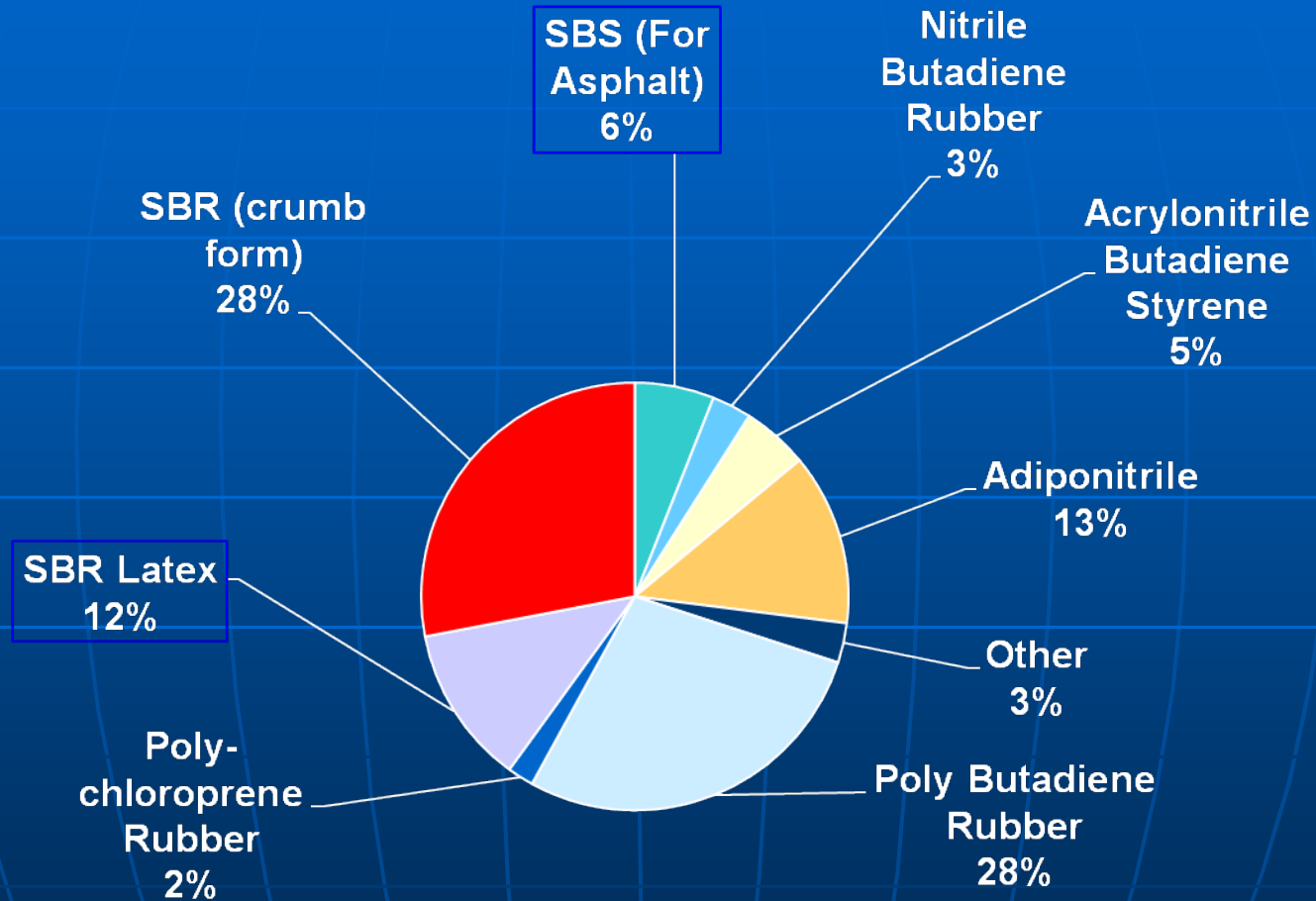


- Global rubber demand in 2008 is 21.4 million tons, or 47 billion pounds
- Tires are the major consumer of synthetic and natural rubber
- Butadiene is a major component in most synthetic rubber: SBR, PBR, SBS, etc
- Decreased tire demand will significantly improve butadiene supply

July 2008 - Butadiene (Bd) Supply

- Globally tight due to lighter cracking and higher demand
 - 2008 Bd supply estimated at 75% 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

North American Butadiene Consumption



July 2008 - 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

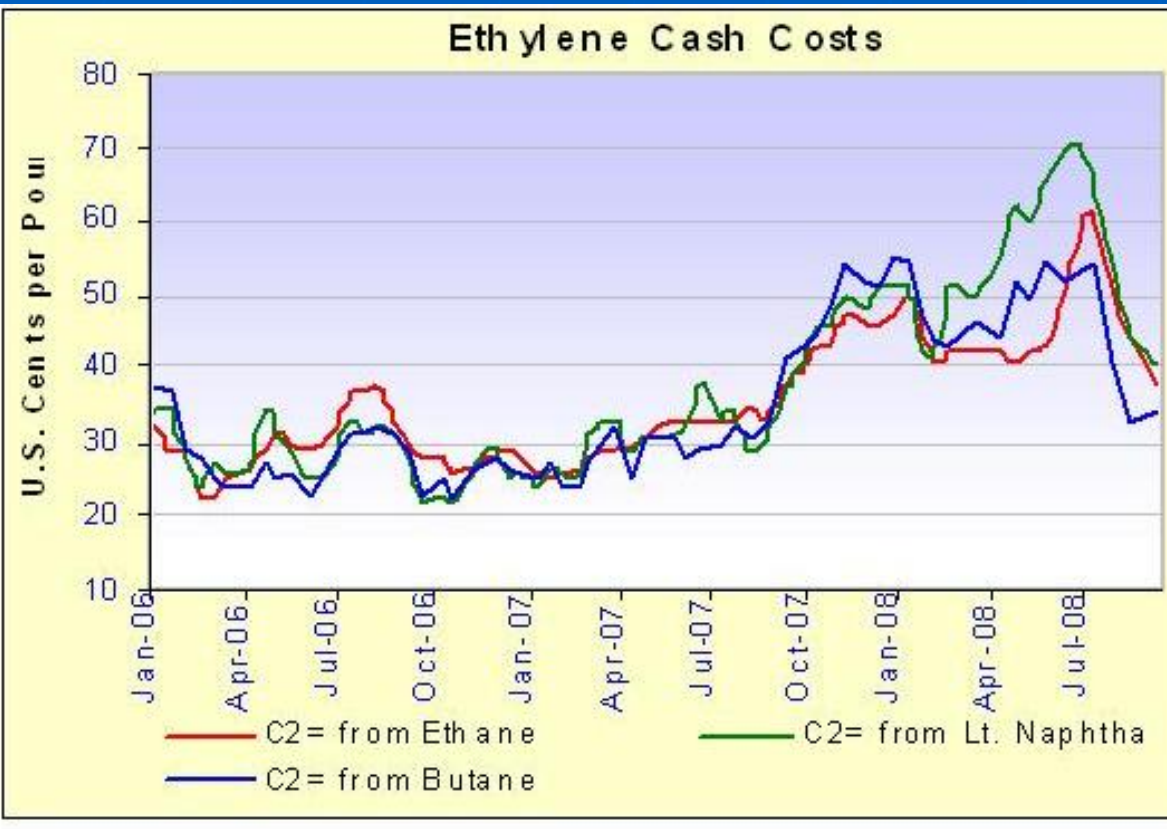
- Higher natural rubber prices driving consumers to synthetic rubbers based on Bd
- Lighter cracking
 - Higher naphtha prices
 - Structural change in US ethane market
- Low cost gas-based ethylene capacity coming on-stream in Middle East.

July 2008 - Tire Demand Data



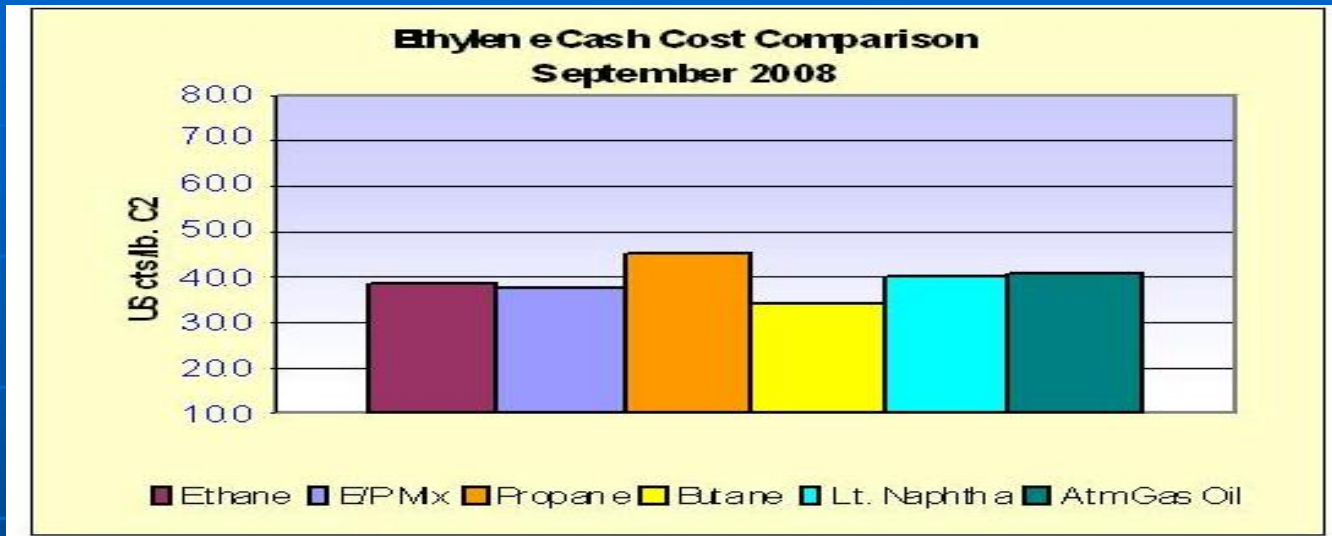
- **New Tire Demand**
 - June vehicle production down 8% and falling
 - Vehicle production skewed towards smaller vehicles
 - Tire demand could be down over 12%
- **Replacement Tires**
 - Higher gas prices are reducing miles driven
 - Expect reduced tire demand over time
 - May take 3-6 months to play out.

October 2008



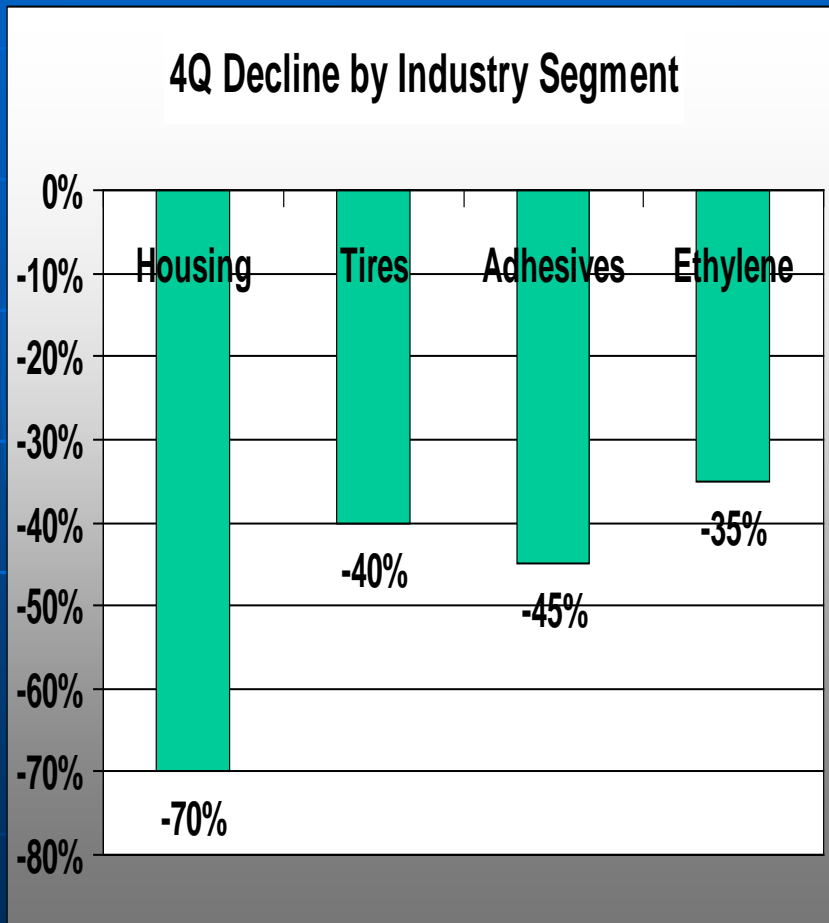
- Spread between gas and liquid feeds now down to \$.05
- Demand is shrinking – tire demand is down
 - Asian market price drop of \$0.10- \$0.15 per lb

October 2008



- Tire Demand is 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
 - Should be adequate SBS supply in 2009

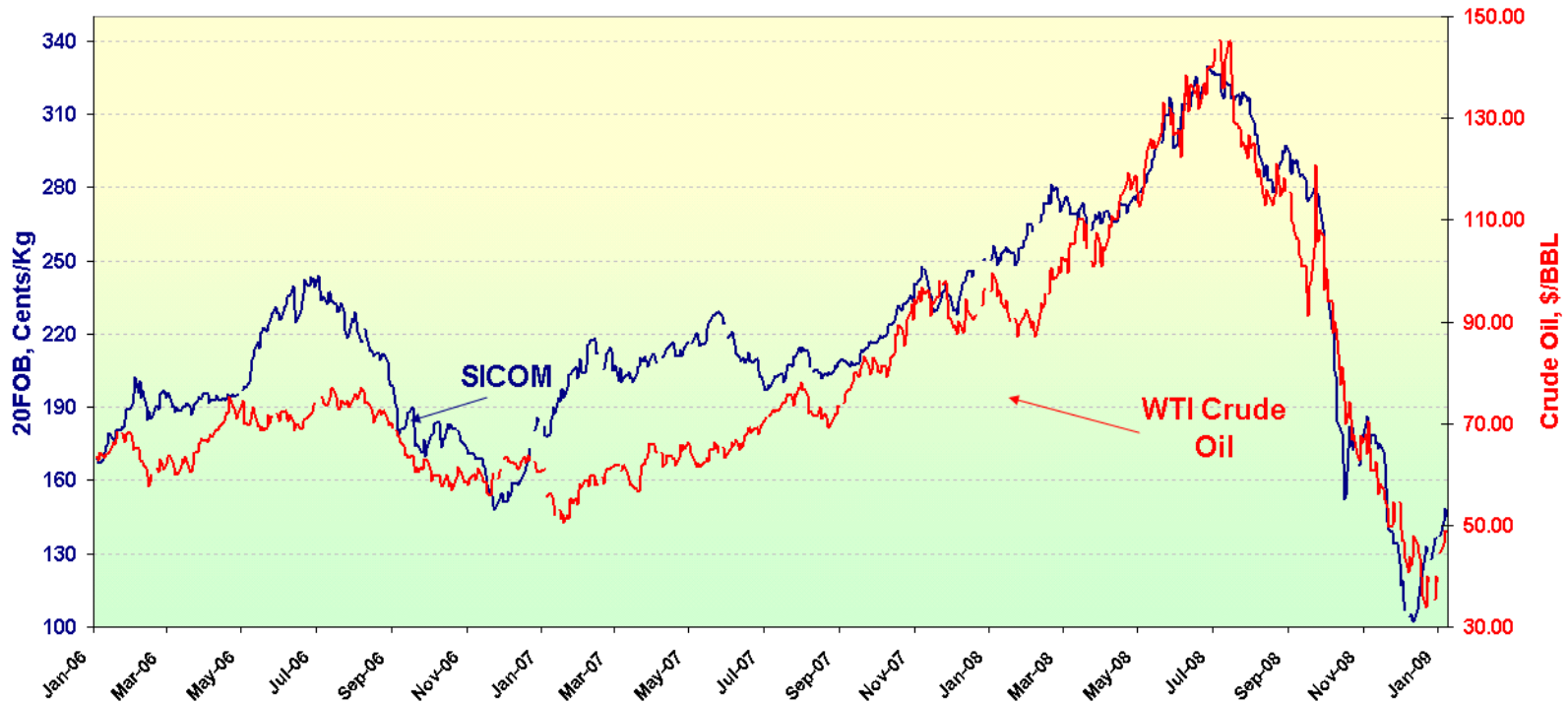
4Q 2008 Economic Decline – Makes Bd Supply Longer



- Economy progressively shut down during the fourth quarter
- Housing industry started years before
- Tire industry was the first 4Q casualty
- Adhesive industry followed quickly behind tires
- Followed by general chemicals/Ethylene
- The sequence helped increase Bd supply

Low Natural Rubber Prices Push Out Synthetic

SICOM Natural Rubber and NYMEX WTI (Prompt Month)



February 2009 - Outlook

- **Expect demand to be lower than 2008 across all market segments**
 - Ethylene is expected to be 10-20% lower than 2008
 - Tire demand expected to be 20% lower than 2008
- **Butadiene supply should be adequate in 2009.**
- **AMAP was correct!!!**

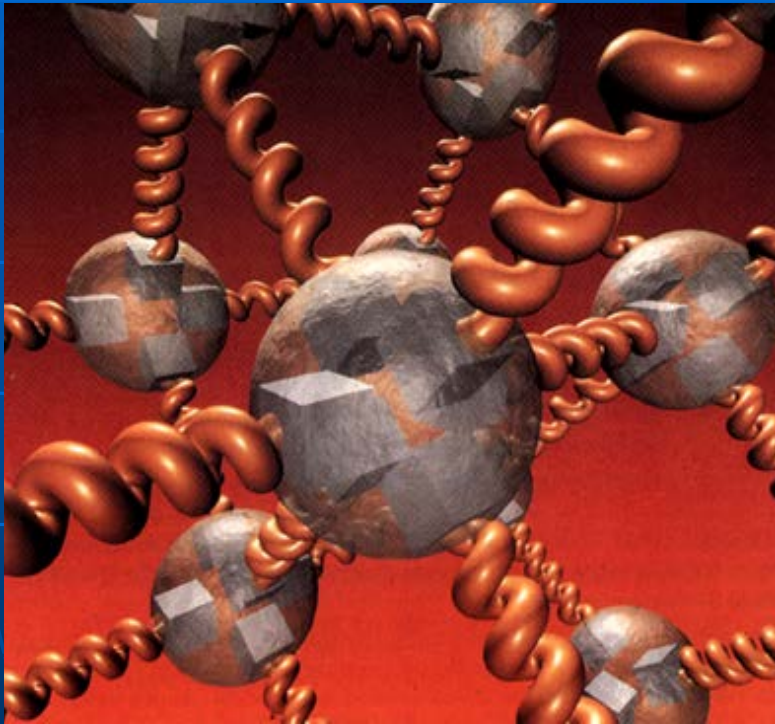
2010 Outlook

- Expect demand to remain at a reduced level across all market segments in 2010
- US economy not expected to have a robust recovery
 - Tire demand expected to remain low
 - Paving demand expected to be flat
- **Butadiene supply should be adequate in 2010.**

2010 Outlook

- If BD demand unexpectedly increases dramatically – supply may be tight (not likely)
- Gas feeds to crackers is less expensive at this time – increasingly lighter feed stock at end of 2009
 - Gas feed currently has cost advantage of 5¢ per pound of ethylene compared to liquid feeds
 - Ethylene production ration to butadiene production is 10 to 1
 - If more BD is required by marketplace, cost of BD must increase by 50¢ per pound to justify switch to liquid feed and offset added cost of 5¢ per pound of ethylene.
- Conclusion - Increase in BD demand will be supplied at a higher cost.

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
- State DOT agencies have developed specifications specifically for SBS systems
- Alternative modification systems may require changes for both DOT agencies and contractors

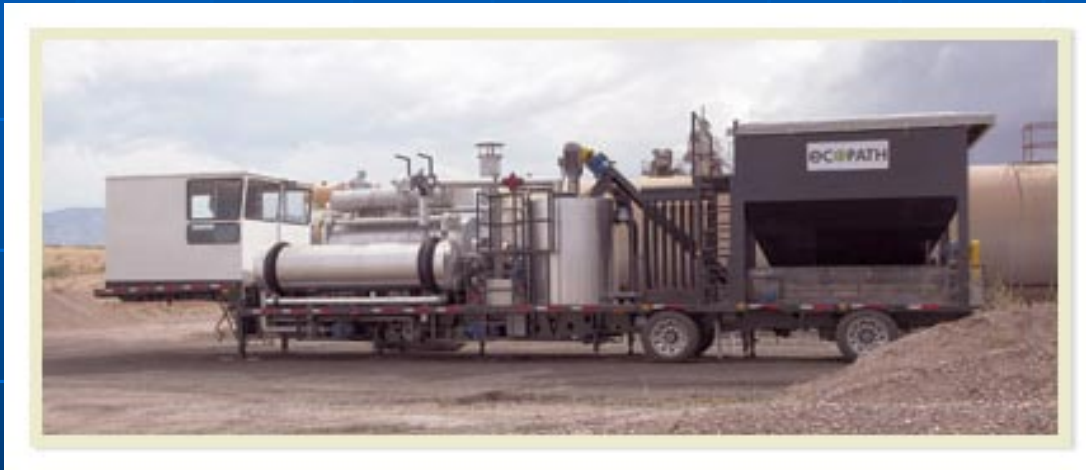
Alternatives to SBS Polymer



- **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**



- 18-22% 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 may be added at high temperature and processed with high shear milling
 - Chemical stabilizer added
 - SBS is sometimes used to stabilize the system
 - GTR contains non-rubber materials
 - Carbon black
 - Calcium carbonate
 - Meeting solubility specification may be an issue
 - Settlement of inert materials in contractors tank may occur
 - Cannot be PG graded under current DSR test procedures

Alternatives to SBS Polymer

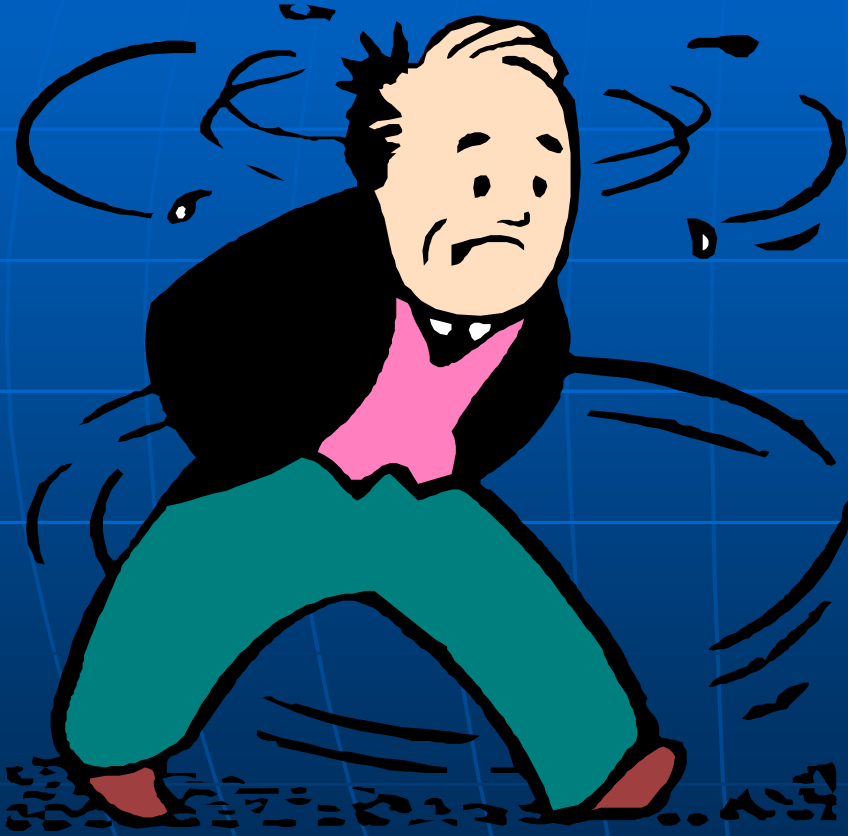


- **Hybrid Binders**
 - Blend of SBS and GTR
 - Cross-linked system
 - Storage stable
 - Terminal blend system
 - Current research sponsored by FL DOT at University of Florida

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



Questions?

