INTRODUCTION

This paper is intended to provide some longer range perspective on chemical raw material supply in N. America. When this paper was conceived the global chemical industry was facing some of the biggest changes in history of the business. These changes had real implications on long-term N. American chemical supply. No global economic recession was envisioned at that point. Now with the overlay of this global economic downturn the changes are much more significant and will definitely affect how one acquires chemical raw materials in the coming years.

I know at this point everyone has a sufficient supply of raw materials at reasonable prices. Also, that your current focus is more on when sales will return and how you can cut costs to survive until it does. I believe that many of you are either too comfortable about chemical raw material supply or consumed trying to survive. It may surprise you to know that for some raw materials, if only half the demand would come back today, there would be some real shortages in the US market. This is before we see big changes that are about to hit US chemicals in the next one-to-two years. So I encouraging each of you not to get too comfortable with the current supply situation, but start now to look at longer-term supply strategies to survive these changes.

This paper will look closely at ethylene production. One might ask the question why ethylene? The reason is simple; either ethylene or the byproducts of ethylene production constitute a majority of the products used in the PSA industry. Therefore, ethylene is the well-spring for most products you buy, but it is two to three steps up the supply chain.

One only has to look at 2008 chemical supply to know the importance of ethylene. Several polymers, SBS, SIS and C5 aliphatic tackifiers were in short supply in 2008, but when you examine the supply chain, the shortage was not due to polymer or monomer purification capacity, but rather due to byproduct supply from ethylene production.

WHAT’S IMPORTANT TO KNOW ABOUT ETHYLENE

Ethylene is produced through a steam cracking process. This process takes a liquid or gas feed and through a furnace, raises the temperature up to over 1500 degrees Fahrenheit. At which time, the process injects steam into the hot feed stream. This injection acts to crack the molecules, where they hopefully crack and/or reform to produce only ethylene. Fortunately for us, and unfortunately for the steam cracker operators, they produce other products called byproducts. Or if they want to charge a higher price, they call them co-products.

One can see why you often hear an ethylene unit being called a “Cracker”, as it refers to the steam “cracking” process.

These Crackers typically feed a liquid or gas. The liquids can be various naphthas or gas oils from refineries or gases separate from natural gas or refinery/chemical waste gas streams. What is important
to know is that naphthas produce many of the byproducts that are important to the PSA industry, whereas gases typically produce very little.

The terminology used for products from ethylene is relatively simple. There are byproducts and derivatives. Examples of these are shown below:

<table>
<thead>
<tr>
<th>Derivatives:</th>
<th>Ethylene  =&gt; Polyethylene</th>
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</thead>
<tbody>
<tr>
<td>Byproducts:</td>
<td>Crude C5’s =&gt; Isoprene =&gt; SIS</td>
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<tr>
<td></td>
<td>=&gt; Piperylenes =&gt; C5 Aliphatic tackifiers</td>
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Over the years, the crackers were built specifically for only one type feed; either they cracked liquids or gases, and had no flexibility. Around the 1980s, gases became so advantaged that many liquid crackers in the US were reconfigured to be flexible crackers. These flexible crackers could take advantage of times when gas feeds were lower cost than liquids. Feeding gas to liquid cracker wasn’t as efficient as feeding gases through a gas cracker, but it captured a large part of the incentives. One might think of using a liquid cracker to crack gases as cracking nuts with a sledge hammer.

So when you hear that the “crackers” are going light, then it means they are moving away from liquid feeds to gas feeds.

The extent of flexing to gas feeds varies by producer, and it is never 100%, but in the range of 10-50%. Some producers have made strategic decisions not to be flexible. Last year was one of the most volatile cracking slate years, where gases had a significant cost advantaged over liquids. In fact, one ethylene producer really got burned by not being flexible. The monthly losses for this non-flexible cracker were rumored to be $6-10 million/month. I am sure that this company’s new strategy is “light is right”.

Although cracking slate financially impacted this one producer, I think the derivative supply implications of a cracking slate that can change 10-30% are very significant. And that is the reason this is an important parameter to understand and track.

An ethylene feed slate is developed by using sophisticated models that take into account the producer’s specific situation, like availability of various feeds at their location, derivative and byproduct demand and margin contribution of each product. All this data is loaded into a model to calculate the cash costs of producing ethylene by various feeds.

Changing cracking slate is very difficult and typically changes are made weekly to slowly move slate to its ultimate destination. Changing a cracking slate is like turning a big ship, it’s not done quickly.

As I mentioned, the US was the first region to make a change to flexibility on feeds to liquid crackers. The reason they were the first do this is the established liquid cracking capacity and more importantly, access to cheap natural gas streams. Now after 20 years, other established ethylene producing regions like Europe, Japan and parts of Asia, moving to flexible cracking. For those of us that are dependent on byproducts from liquid cracking this is not a good global trend, regardless of the region.

At this point, you are armed with sufficient ethylene knowledge to understand the future trends and implications.
The Overlay of the Global Economic Downturn

The global economy crashed during the fourth quarter of 2008. It was a frenzied crazy quarter with chemical producers stuck with high priced inventory, demand crashing and falling prices. This forced a massive destocking of inventories, as producers feared being stuck with high priced inventories or a high level of inventory. Both of which are fatal errors, particularly at year-end, where a product managers scorecard is examined in detail.

The chaos just got worse as the quarter progressed, each time demand decreased, production was reduced to hit the new lower inventory target. This situation was exacerbated by shortages earlier in the year that forced some buyers to hoard material, which caused an even higher level of destocking to hit year end inventory targets. These inventory targets were under additional pressure at cash-strapped companies. By December production units had to be shutdown if they had any chance of hitting their year-end inventory targets. Many of these units stayed down into the first quarter.

Towards the end of the fourth quarter, some Asian chemical producers, in desperation, rushed into the Western World markets attempting to move product at incremental pricing to cover some costs; a better alternative then shutting down. The Asians were shocked when they couldn’t sell any product, even with a significant discount. Buyers sheepishly told them they couldn’t afford to buy the material. Buyers either didn’t have the demand or cash to buy the material. So these Asian producers went back home and shut down their units, much like the US chemical producers.

So the fourth quarter was a mess. Less product was sold at lower prices from higher cost inventory. Therefore the financial results for most chemical businesses across the supply chain were a disaster.

Now with all this destocking during the fourth quarter, the expectation for the first quarter was a massive restocking followed by some level of demand recovery. Neither really happened, which appears to have put a permanent dent in chemical demand that’s not going to get repaired any time soon.

This permanent dent in demand can be the catalyst for a continuing decline of the US chemical industry. Looking at ethylene, this dent or decrease appears to be about a 10% decrease; not insignificant. As ethylene is the heart of the chemical industry a 10% decrease in demand/operating rates will have a major impact on profitability and potentially a longer-term impact on industry structure.

Putting ethylene aside, the decline in demand for other chemical products varied considerably based on markets served. The variation in demand decrease is considerable and ranged between 10-60%. Products that primarily relate to the housing market declined earlier and deeper than most market segments. Another segment which took a major demand hit was the tire/auto industry, which was down almost 60%. While industries like packaging or disposable diapers, the drop was less severe and came later in the year; down 10-20%.

Just as the demand decrease varied with market segments, so will the timing of the recovery. For instance, we would not expect new housing to recover for 2 years with 12 months of inventory on the market today. Similarly, tires and automotive sales may take 1-2 years. Whereas, the packaging and adhesives markets, may only take six months to recover. My point is that demand recovery will not be uniform. Not being uniform will positively and negatively affect supply of certain chemicals.
A positive example of this would be isoprene to make SIS or polyisoprene. Tire demand will take more time to recover, thus freeing up isoprene to make SIS for adhesives, which will recover sooner. You could draw a similar conclusion about butadiene and butadiene based rubbers like SBS.

Now with global recession in full bloom and biting at our backsides, it is interesting to read information from all the economists. Some of their points like a recession have always followed a peak in oil prices in the last 50 years, or that a recession was overdue as the consumer was spending 105% of GDP for the last five years. I am sure many of us would have preferred to have known these facts six months ago. Maybe we were too busy spending to hear the message.

Some economists refer to the ‘90s decade as the dot.com boom period and now the 2000s as the Visa decade, where we out-spent our income by 5% per year for 6-7 years. The credit boom was 3 times larger than that of the S&L crisis in the late 1980s. Analyzing historic data suggests that it will take 2 years for this credit excess to fully unwind.

Regarding the economic recovery there are predictions that the recession will end late 2009 and growth will return in 2010. There is alternate scenario by the IMF, they call the “great recession” where there isn’t a recovery until 2011. Further, there is a 40% chance of this happening, which seems quite high.

I’ve digressed a bit from chemicals, but the point is that there is the potential for this recession to last longer than we’d like. The good news here is that there is time work some of the chemical supply issues.

**Long Term Ethylene Supply**

Now with everything you know now about chemicals and the economy, let’s get into the meat of the presentation ethylene. Before the global economic recession the ethylene industry was facing its biggest change in the history of the business. This change was to rollout over the period 2008-2013. Now with the overlay the global recession the implications are even bigger.

Going back several years the ethylene derivative businesses were booming. Global growth was in the range of 4-5%. Western World growth was lower but solid, while Asia was experiencing almost double digit growth. This growth rate meant that you needed 4-5 world scale ethylene and downstream derivative units built each year.

Each region looked at this demand growth and made decisions to participate in this growth or not. Obviously, Asia opted in, but US and Europe determined they couldn’t compete on an export basis. The Middle East saw this as an opportunity and planned to participate in this growth in Asia.

The Middle East had a unique problem that turned out to be an opportunity. They had a surplus of gas as a byproduct of crude oil production that was valued at almost zero cost. Having zero raw material cost, they could make land ethylene derivatives, like polyethylene, anywhere in the world and have a minimum 10 cent/lb advantage. This is huge; it is like a 20-25% cost advantage over existing producers.

So the Middle East embarked on a series of expansions that would position that region as a major producer of ethylene. Their capacity position by 2012 is estimated to be almost 25% of the global ethylene capacity. With a relatively small demand in the region, this positions them as a major exporter of ethylene/ethylene derivatives.
Remember that these new crackers are feeding gas so there are very few byproducts. That will be important later.

A decision to invest in an ethylene unit or cracker is not trivial. A world scale ethylene unit plus downstream derivative facilities costs over a billion dollars.

As all these new units were announced in Asia and the Middle East, engineering firms, fabricator shops and construction firms filled up with work. The demand for all these services was so great that the costs to build these units doubled in price. In spite of these higher costs, most all of the projects went ahead. There were a few schedule slips, but this was due to availability of resources rather than costs.

The initial plans called for about 50 million tons being added globally in five years to an industry that had 110-120 million tons of capacity. Ninety-five percent of this capacity was to be added in Asia and the Middle East, with the remainder in other developing regions like S. America and Eastern Europe. No capacity was planned for the US and Europe.

Over the period 2006-2007, the global growth rate slowed, and especially in the high growth region Asia. This along with limited project resources tended to slow the projects by 1-2 years, but most all of them were still going ahead.

It was probably at this time that the industry seemed to recognize that there was more capacity being built than demand. Further, that this large volume of advantaged capacity in the Middle East would not only be exported to Asia, but to other regions like the US and Europe.

The US had grown its export business to almost 12%, so most figured that the first business that they would lose would be exports; recognizing the domestic market wouldn’t be far behind.

Most ethylene experts made very conservative projections with slightly declining production and lower operating rates for US ethylene operations. Back then these projections did not bode well for adhesive producers, who were growing their demand for byproducts of ethylene production.

The US ethylene producers did two things to prepare for the advent of new low cost products from the Middle East. The two things were fortification and rationalization of their businesses. Fortification took the form of finding lower cost refinery waste streams to crack to close some of the competitive gap with the Middle East production. Rationalization went after small older units that were uncompetitive; like Dow’s Canadian facility and Eastman’s small crackers at Longview, Texas.

As luck would have it, two other events improved US competitiveness. Ethanol in gasoline formulation freed up butane, a low cost gas, as cracking feed. Second, natural gas supplies improved with new horizontal drilling and advanced recovery techniques. Further, natural gas operators realized that fractionating out ethane from natural gas gave them better margins. As ethane is a preferred gas feed for crackers.

Recognize that all these steps helped improve US ethylene competitiveness, but didn’t fully close the gap with zero feed cost, ethylene produced in the Middle East.

In 2008, there was a step change in installed ethane supply, due to new natural gas separation facilities being installed. This change significantly affected the US cracking slate starting around mid-February.
and continuing most of the year. To understand the extent of this change, we examined NPRA data on liquid feeds, which is real data submitted by ethylene producers. It showed that relative to 2006/2007, which were fairly typical cracking slate years, that the US liquid cracking in 2008 was down 24%. This shift caused major shortages of byproducts from ethylene like isoprene, piperylene and butadiene.

Also in 2008, some of this new Middle East low cost ethylene capacity came on stream. The ethylene came on stream first before the downstream derivative facilities (polyethylene), so the new Middle East producer needed to move this ethylene to market. First, let me mention that ethylene is a gas and difficult to ship. A Thai ethylene producer bought the ethylene, at a price that was below his production costs. This happened a couple times in 2008. The takeaway is that this ethylene was so cost advantaged that an existing producer cut his production rates to buy this material – A sign of things to come.

Now your understanding of the ethylene situation is current up until the global economic recession that we just encountered during the fourth quarter of 2008:

- There has been a lot of preparation in terms of fortification and rationalization.
- Some structural changes in feed supply that has, and will continue to have a major affect on byproduct supply.
- Some early signs of how advantaged the new Middle East capacity is, but no real impact yet.

Now let’s overlay the global economic recession and see the impact on global ethylene supply. The chart below shows DeWitt’s current global ethylene assessment. There are two things worth noting: First, the major dent in production/demand in 2008, which takes several years to recover from; Second that the 50 million tons of additional capacity is now spread over 6-7 years rather than 5 years. Also, some of the expected 2008 capacity will now spill over into 2009.

Included in the capacity increases are 6 M tons of new Middle East capacity coming on stream in 2008 and 2009. The planned 2008 capacity additions came on-stream so late in 2008 that they didn’t affect the market. Therefore, most of the impact of the new Middle East capacity will be felt in 2009.
Now let’s look at the N. American ethylene supply/demand outlook, which is shown in the chart below. Capacity gradually decreases to some point. Also, production continually decreases over the period until 2012, reflecting less export business. Certainly, this forecast is a bit conservative and the production could be less if there are more Middle East imports.

Ethylene experts at DeWitt believe that operating rates in the mid-to-high 70% range are not sustainable. In this range, it is felt that there is the potential for further rationalization. Some think an operating rate of 85% range is more likely. To hit this target capacity would have to be reduced by 8-10%.

This rationalization would take down older smaller units without solid upstream feedstock or downstream business integration. These units would more than likely be liquid crackers with little-to-no flexibility to crack gas feeds.

In the case shown in the graph above, the ethylene production decrease is minus 14% from 2007 through 2012. I reference 2007, as it was the last year in which byproduct supply from ethylene was adequate.

We mentioned earlier that cracking slate went light in 2008 by 25%. The trend to lighter cracking over this period is expected to continue, driven by ethylene producers trying to get more competitive. This lighter cracking will be funded by motor gasoline reformulation, finding lower cost waste streams in refineries, and structural changes in natural gas supply. So just like the ethylene operating rate curve, we expect the cracking slate to bank the 25% reduction in 2008 and move lighter over the forecast period shown. The decrease is expected to 1-2% per year, but it could be higher; especially, if you look at the large financial losses by some of the producers who weren’t feed flexible. Even one ethylene producer went bankrupt with one of the causes being lack of feed flexibility on cracking.

So let’s see if we can put together all these projections. Remember these projections are all relative to 2007 and cover the period through 2012. 2007 was chosen as a base year, as it was a year with normal demand and “historically” normal ethylene production; if ethylene could ever be considered normal is a real moving target.
- Decline in ethylene production – minus 14%
- Potential rationalization of capacity – potentially minus 8-10%
- Lighter cracking slate – minus 28-30%

So, if you just add these numbers, one gets a reduction that is over 50%. Fortunately, they are all not additive, the lighter cracking has most of the ethylene decline in it. So the maximum potential reduction is more like 40% relative to 2007.

This number is quite large, but assumes most of this reduction comes at the expense of liquid cracking. I don’t believe you can assume these changes to be all reductions in liquid cracking, but 80-90% may not be a bad estimate. So that leaves you with roughly a 30-35% change in ethylene byproduct production.

If these forecasts come to pass and adhesive demand returns, then there is going to be some supply issues on ethylene byproducts. Many feel that the byproduct supply will get tight in 2011. This should be a confluence of a rebounding economy and the full impact of new Middle East ethylene capacity.

There is the potential that some individual products may be short before 2011, but will affect markets that rebound faster than ethylene. Some products that go into adhesives are potential candidates.

Before we move on, let’s take a look globally for those of you that operate globally businesses. Global ethylene in established production regions, like Europe and Japan are going to face the very same issues outlined above.

1. Demand decrease due to the recession
2. Low cost Middle Eastern imports
3. Rationalization and fortification

The only issue that will be different for these regions is lighter cracking. Yes, there will be some use of low cost refinery waste gas streams as feed, more use of butane and LPG, but they don’t have the sources of low cost gas, like the US or Middle East.

So the change in these regions will be less than in the US, but nonetheless, it will have an impact on supply; especially if you consider that between US, Europe, and Japan, that they purify a majority of the world’s ethylene byproducts and convert them into polymers.

Before we get into options, let me digress on new chemical capacity. As a person who has spent his life looking at project economics, there are some simple things that drive projects

1. Fill rate
2. Break even point
3. Prices/Margins
4. Capital costs

Most chemical plants break even above a 60% capacity utilization; some as high as 70-80%. For anyone that has done any project economics you know you have to be profitable by year two, which implies an amazing fill rate, and it has to continue to experience high growth for the next five years. The Asians accomplish this by importing to the point local demand is sufficient to fill the new plant on start-up. So
that makes the economics easy. Or can you be like the Middle Eastern projects with a significant feed/margin advantage that drives their fill rate and/or margins.

So the takeaway from this is that building new byproduct purification or polymerization units with GDP or GDP plus 1-2% growth, and current prices is a non-starter, unless your situation is like the Asians or the Middle East producers.

The implications are that the Western World, including Japan will not invest to recover more byproducts as supply tightens. In general the opportunities for supply will be in Asia or the Middle East.

The timing on when any byproduct will go short will depend by specific markets and the rate of recovery for those markets. For instance, below we’ve shown 3 market segments with what we judge are significantly different recovery timing:

- Housing markets are not expected to recover for 2-3 years,
- Tire industry might be 1-2 years
- Adhesives industry 6-12 months

As the housing market takes longer, this will help the supply of certain tackifier resins. As the tire industry takes longer, this will help the supply of certain synthetic rubbers. My point is that the rate and pace of some market segments will give you time to work your specific long term supply issue(s).

The answers will not be easy or simple. Some of the easier answers imply higher costs. The more challenging solutions, which will be more difficult to implement, could improve your competitive position and improve profitability

As I stated at the beginning the chemical industry is about to face the biggest change in its history. The positive thing about the recession is that it gives you 1-2 years to develop options. So I think it’s important for each you to look up your supply chain, and not just one step up the chain, assess your specific situation and develop a supply strategy that is robust enough to survive the changes coming in the chemical industry.
The Changing World of Raw Materials

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