Cost & Capital

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Natural Gas Impact on Resin

Category Sourcing Guide

- **The ratio of Crude Oil to natural gas price has increased up to 800% in three years.** Historical crude oil to natural gas price relationships averaged 5-8x and are now trending up to 30x affecting the traditional balance of these two feedstocks for resin production.
- **Material design choices made today will affect the cost competitiveness of plastic components.** ABS resin will enter a period of tight supply due to the bottlenecking of Butadiene as production shifts to natural gas cracking from crude oil based sources.
- **Historical cost models based on crude oil will become obsolete.** As the sources of supply shift away from crude oil based sources, pricing models for polypropylene and other major products will need to be updated to reflect the changing cost structure of the resin suppliers.

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Cost and Capital Partners *is a management consulting firm that works with companies to improve cost and capital efficiency. Our client base includes Fortune 1000 companies from the industrial, automotive, electronics, hospitality, process, consumer goods, transportation and white goods industries. We work with clients to improve results and enhance visibility for strategy development. Supplier engagement is a core focus ranging from direct supplier negotiations to market and financial viability assessments. In addition to working with clients to execute sourcing initiatives, we also deliver sourcing training that enables organizations to increase their level of professionalism in supplier engagement.*

The Cost and Capital Partners approach to category strategy development is a data focused review of the underlying economics. This report is based on an assessment of recent industry developments in the shale gas and chemical industries. Cost models for ABS, PP and PE were developed by combining activity based costing methodologies with the changing supply and demand landscape of the input materials.

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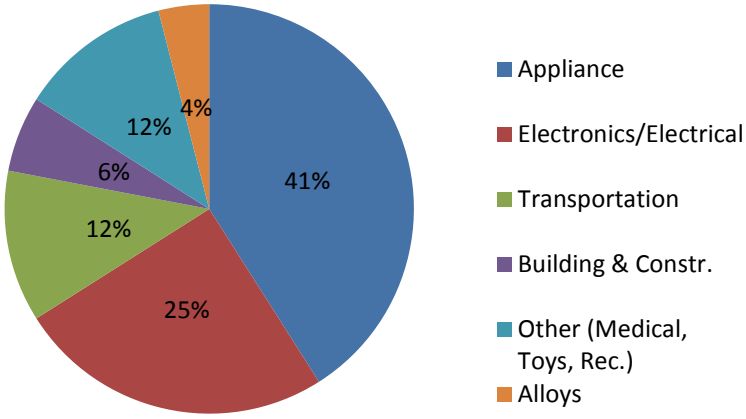
Introduction

The natural gas boom in the United States created by advances in low cost horizontal drilling combined with hydraulic fracturing or "fracking" methods has altered traditional economics for the energy and chemical industries. US natural gas prices have dropped by up to 50% while crude oil prices have risen in the past 3 years. This glut of natural gas has led to a doubling of the crude to natural gas ratio from 13.75 to 28.45 as of February 2013. The implications of the flood of cheap natural gas and the widening spread when compared to crude oil are clear. Refiners are changing their feedstock from crude-derived naphtha, towards natural gas, for the production of ethylene. According to Platts, over the past few years, US cracking moved from a historical mix of 70% ethane and 30% naphtha-based feedstock to 87% ethane and 13% naphtha and is expected to continue this pattern until a split of 95% ethane and 5% naphtha cracking is reached. While this will lower the cost of plastics that are direct ethylene derivatives, such as polyethylene, it will have a negative impact on resins that rely on by-products of naphtha cracking (e.g. acrylonitrile butadiene styrene, or ABS, and polypropylene). To compensate for this impact, some companies, including Dow Chemical, are working to take advantage of abundant US propane by developing on-purpose polypropylene cracking facilities. The development of these facilities will further strengthen the bias towards polypropylene and polyethylene and away from ABS.

As can be seen in Figure 1, the Appliance, Electronics and Transportation industries are the largest worldwide users of ABS and will be most affected by increased ABS pricing. Sourcing managers in these areas should immediately work to understand their current resin exposure and the possibility of material substitutions. A clear understanding of material substitution opportunities will allow the sourcing department to work with product design to demonstrate the value of an aggressive value engineering campaign. Where materials cannot be substituted, long term agreements should be examined to guarantee future supply, and negotiate long term formula based pricing for the ABS components.

Figure 1: **World ABS Demand**



Source: IHS

This paper will review the shale gas impact on resins, specifically polypropylene, ABS and polyethylene. Cost & Capital Partners has developed cost models that take into account the change in refinery feedstock bias as well as capital investments coming on line that will affect the traditional pricing mixes of common resins.

Natural Gas Developments

US Natural Gas Feedstock

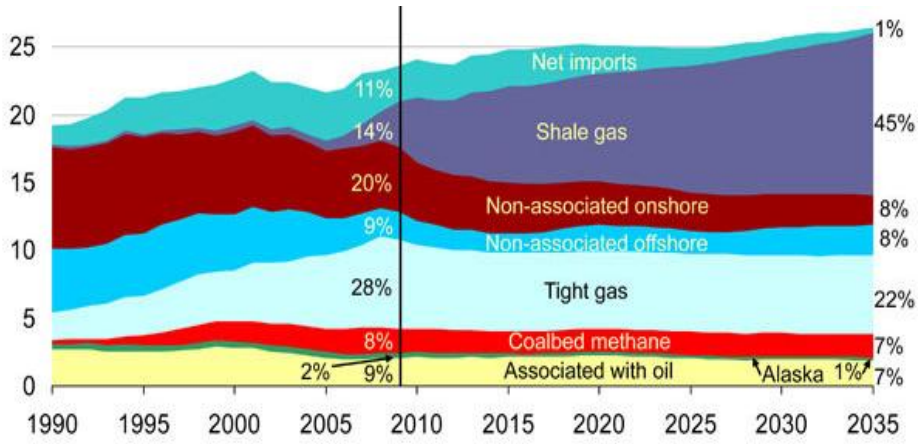
Expansive shale plays, illustrated in Figure 2, exist throughout the US and are being aggressively developed in Pennsylvania, Texas, Oklahoma and North Dakota. This development is a result of a change in drilling and fracking techniques in the US. These developments have given the US a head start relative to the rest of the world in the race towards monetizing shale reserves. Shale development has given the US a distinct cost advantage over Europe and Eastern Asia. Only the Middle East currently has lower natural gas pricing. However, unlike the US, the Middle East does not have the extensive industrial infrastructure to fully take advantage of this gas glut.

Figure 2: **US Shale Plays**

Source: EIA

As illustrated in Figure 3, shale gas will account for 45% of the United States' gas production by 2035. This will essentially eliminate the need for imports which previously accounted for 11% of consumption. Shale gas is also typically cheaper to extract than other methods, thus resulting in reduced pricing and increasing its prevalence as a feedstock in the market.

Figure 3: **U.S. Dry Gas Trillion Cubic Feet per Year**

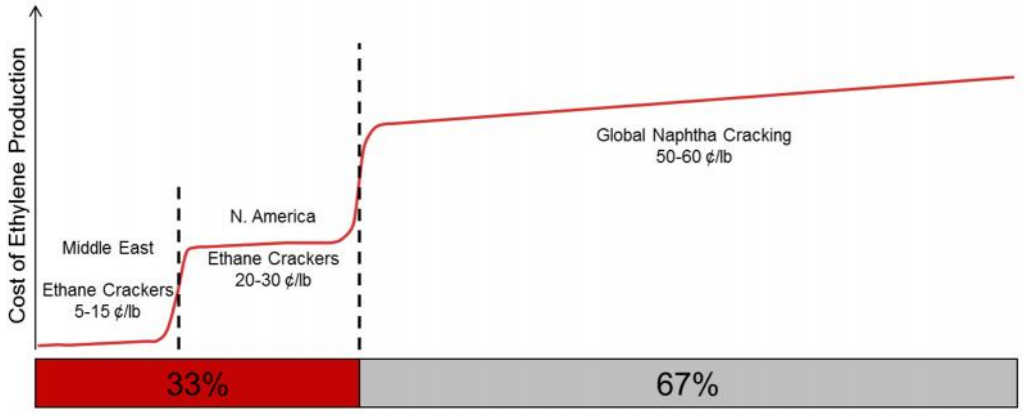


Source: U.S. Energy Information Administration (EIA)

US Natural Gas Advantage

The flood of cheap natural gas as a feedstock has the potential to change the landscape in the chemicals industry. Refineries utilizing natural gas have a pronounced cost advantage over heavy-feed (e.g. crude, naphtha) cracking. As previously mentioned, advances in shale extraction in the US have created a further advantage over natural gas in regions such as Europe and Asia. The cost advantage of natural gas vs. naphtha is highlighted below in Figure 4.

Figure 4: **Global Capacity Cost Curve**

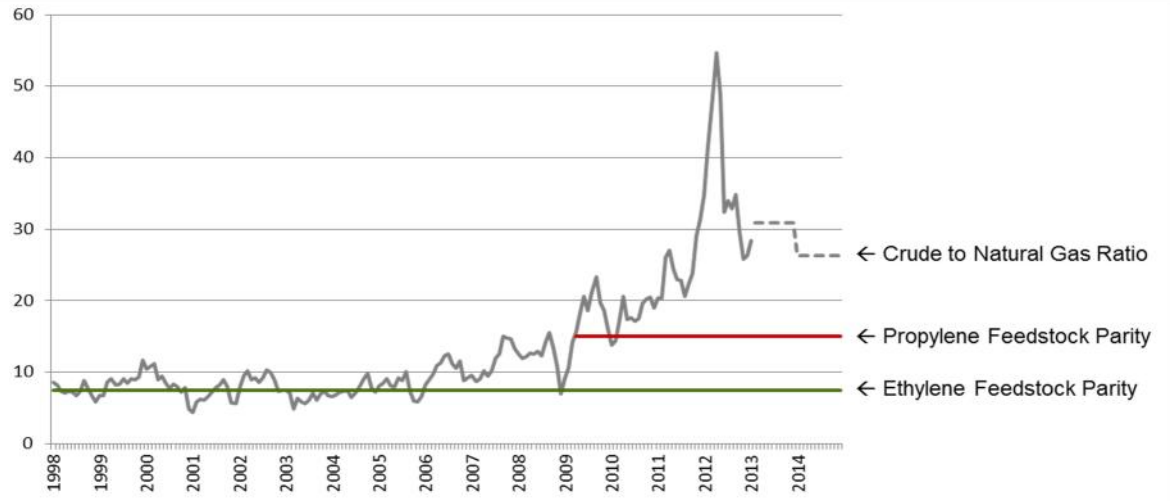


Source: Tim Roberts, LyondellBasell: Ethylene – Good Today, Better Tomorrow – A Year Later, CMAI

The natural gas feedstock advantage directly affects the production cost of ethylene, the most widely produced organic compound on earth, and its downstream products.

To take advantage of the large natural gas to crude oil spread illustrated below in Figure 5, refineries are currently being built in the US to crack natural gas instead of naphtha. With the exception of a Shell facility in Western Pennsylvania, the majority of these refineries are planned to be built near the Texas and Louisiana Gulf Coast. Additionally, on-purpose propylene refineries are being developed to take advantage of lower feedstock prices and to make up for the fact that reduced naphtha cracking will result in less propylene being created as a secondary. As natural gas crackers and on-purpose propylene capacity is added, downward pressure will be applied to ethylene and propylene pricing. Other secondaries of naphtha cracking such as butadiene (a key input for ABS) will suffer due to reduced production and limited planned on-purpose capacity.

Figure 5: **Ratio of Crude Oil to Natural Gas Price**

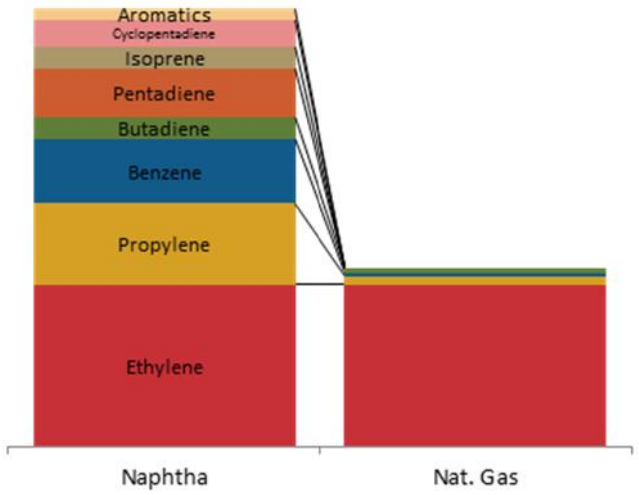


Source: EIA, Cost & Capital Partners Analysis

Impact on Plastics

As seen below in Figure 6, various secondaries result from cracking naphtha. With the move towards more cost effective natural gas based cracking, the production of these secondaries will become less prominent and will ultimately result in higher prices for their respective resins. This is of particular concern for buyers of resins such as ABS and Polypropylene. The amount of butadiene, a key input for ABS, created from natural gas cracking is negligible and will not likely be replaced by on-purpose production. On the other hand, while propylene is produced as a secondary at far lower levels when cracking natural gas vs. naphtha, refineries are currently being developed to specifically create propylene. These are referred to as "On-Purpose" Propylene refineries. These refineries are expected to lessen the effects of a move from naphtha-based cracking to natural gas cracking on resins such as polypropylene.

Figure 6: **Production of Secondaries (Naphtha vs. Natural Gas)**

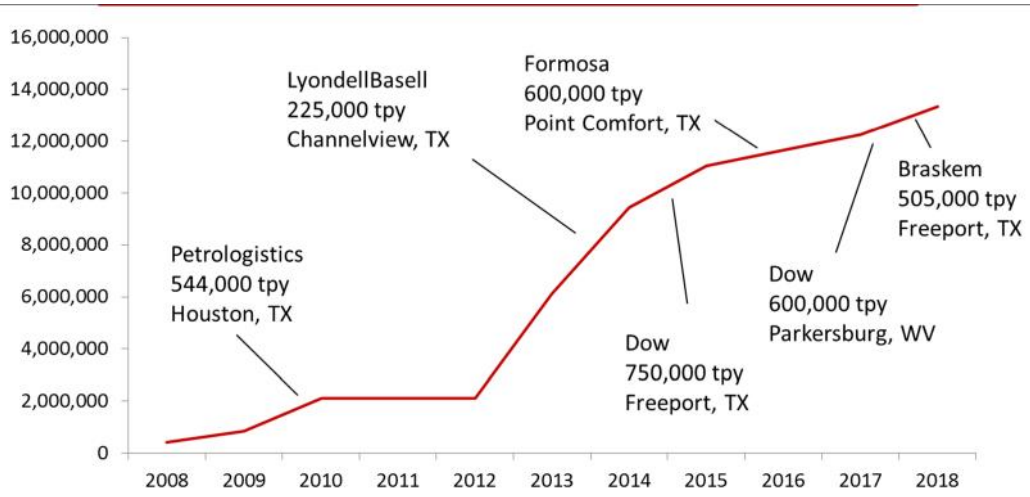


Source: Cost & Capital Partners Analysis

On-purpose reactors are called that since they force the carbons to align in a three carbon formation. They achieve this by adding heat to Propane to strip off a pair of Hydrogen atoms and create propylene from propane. These reactors historically have not been economical since the propylene cracked from Naphtha was usually cheaper than forcing the creation of propylene. But, with the sustained spread between natural gas and crude oil prices, on-purpose reactors are now more cost effective than relying on the cracking of naphtha.

On-purpose propylene facilities will rely on propane extracted from shale gas. Due to the abundance of resources extracted from shale, the spread between propane and propylene will be attractive enough to support year-round facilities. The spread between propylene and ethylene will increase as natural gas cracking becomes more prevalent. This combination of factors is encouraging several chemical companies to invest in propane-based on-purpose reactors in the United States, Middle East and in China

Figure 7: **Global Propylene "On-Purpose" Reactor Development Capacity Additions (tons per year) – Planned US Facilities are highlighted**

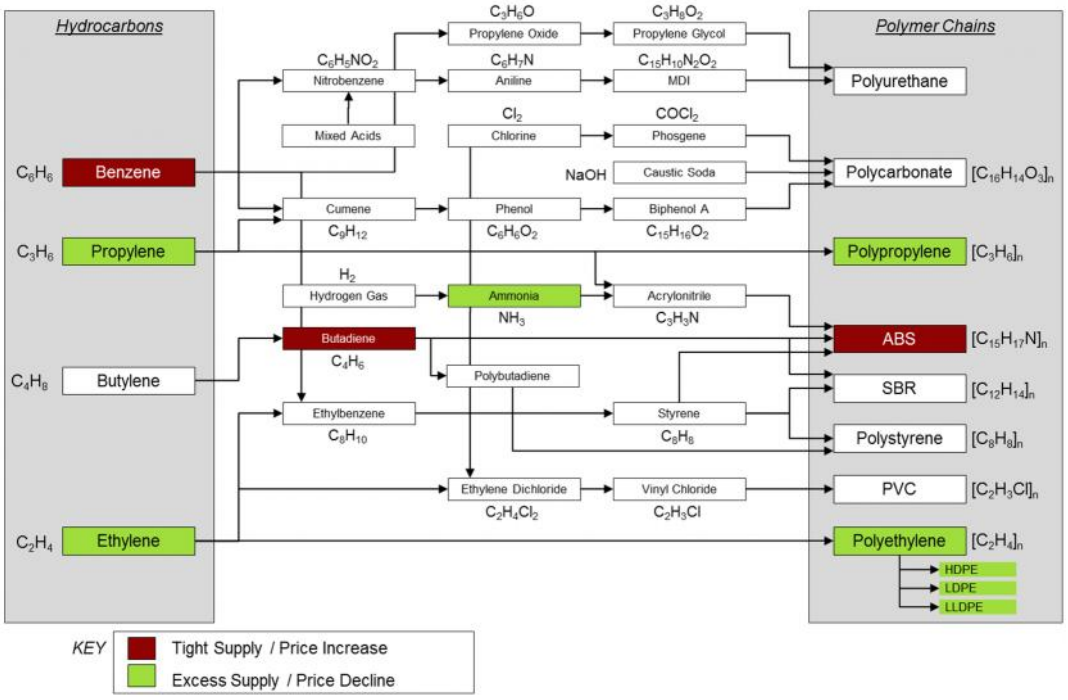


Source: ICIS, Cost & Capital Partners Analysis

where the government is looking to reduce polypropylene imports. The various US based on-purpose reactors illustrated in Figure 7, along with many others worldwide, are expected to account for 30% of total global propylene production by 2018. This production will help to moderate supply constraints for propylene and subsequent resins such as polypropylene.

Figure 8 details the pricing pressures that will develop if current trends persist. Particularly, polypropylene and polyethylene will see pricing stabilize or decrease while ABS will experience price increases. This is due to the game changing effects of abundant natural gas in the US and other parts of the world. The pricing pressure chart (Figure 8) helps to illustrate where buyers of resins should focus their investigations. Long term contracts with resin suppliers should be reviewed in the case of polypropylene and polyethylene while materials utilizing ABS should be reviewed for potential substitution opportunities.

Figure 8: **Pricing Pressure Chart**



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Polypropylene Impact

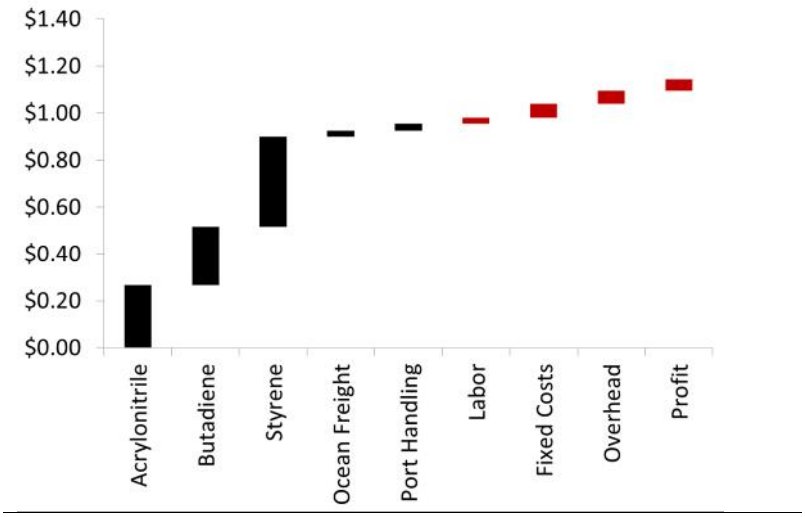
Even though polypropylene will likely not experience constraints to the same extreme as ABS, it will still experience pricing pressure due to reduced naphtha-based cracking. Propylene, the key monomer for polypropylene is a major byproduct of Naphtha-based cracking. Due to the extreme spread in oil vs. natural gas, refineries are increasingly moving away from naphtha-based cracking and towards natural gas cracking. The negative impact on polypropylene is that natural gas yields negligible amounts of propylene for the same amount of ethylene. According to ICIS, US crackers' propylene production has fallen by 2.4 million tonnes or 42% between 2005 and 2012. Due to the expected continued demand for polypropylene, interest in "on-purpose" propylene production from the dehydrogenation of propane to propylene is on the rise. As previously stated, these facilities are expected to account for 30% of propylene production by 2018. The fact that on-purpose propylene facilities are currently being prioritized over other on-purpose facilities for other monomers, such as butadiene, will increase polypropylene's advantage over ABS. Over time, these facilities should help to reduce some of the recent extreme pricing pressure on polypropylene. Additionally, the on-purpose facilities will mainly utilize propane as a feedstock, thus starting a decoupling of the relationship of crude oil to propylene. Typically, propane accounts for 80% of the cost of propylene created at on-purpose facilities. An alternate manner of forecasting polypropylene pricing is to keep in mind that $0.01 impact on propylene essentially equates to $0.01 impact in polypropylene. Thus, the ramp-up in on-purpose propylene facilities will be critical in muting the shift away from naphtha-based cracking. This will be especially true in regions with cheaper sources of natural gas (e.g. Middle East and North America).

It is important to note that even with on-purpose reactors, polypropylene will still trade at a long-term premium to alternatives such as HDPE, PVC and PS. Buyers must keep these factors in mind and remember that historical resin formula pricing will become dis-associated with actual cost if not updated and managed with the supply base.

ABS Impact

As refineries shift from naphtha to natural gas, butadiene sources will continue to tighten. As can be seen in the adjacent chart, butadiene currently accounts for approximately 22% of ABS pricing. This percentage will augment in the coming years as butadiene prices rise. Butadiene will become the limiting bottleneck in ABS supply and pricing. As polypropylene supply benefits from the addition of the on-purpose reactors, the ABS price premium relative to polypropylene will also increase. Butadiene will become scare as polypropylene becomes more available.

Figure 9: **ABS Cost Walk – February 2013 ($/lb)**



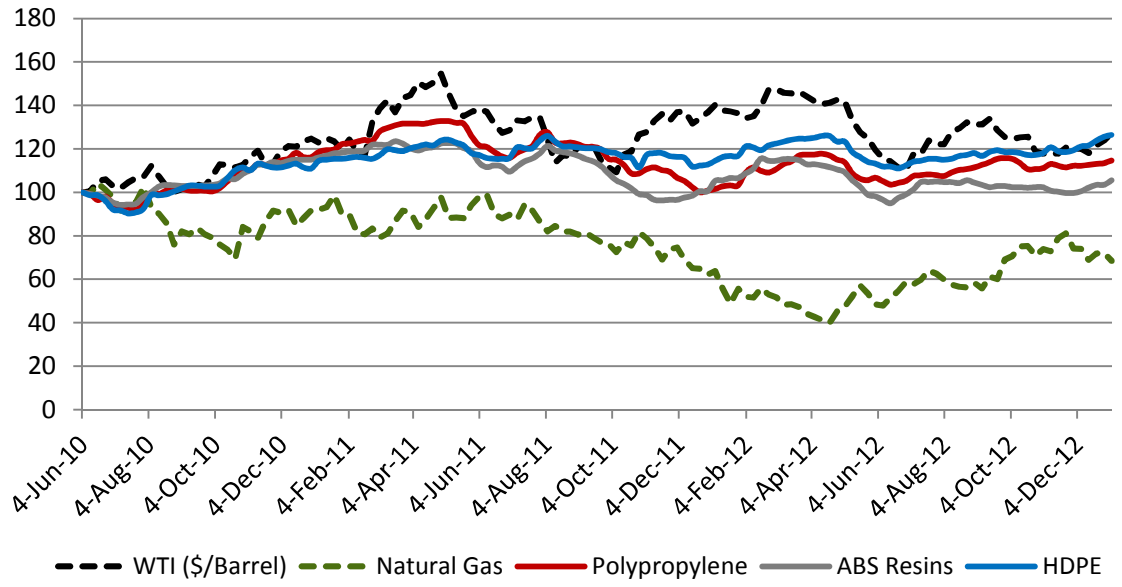
Source: IHS

Buyers of ABS must account for the potential impact of price escalations and examine alternative materials. Several alternatives are discussed below in the Material Substitution Opportunities section.

Resin Price Developments and Projections

Figure 10 illustrates the change in material and resin pricing over the past three years with June 2010 being the start of the index. Natural gas is clearly the outlier, with its price dropping by nearly 40% since June 2010. This has led to a slight decoupling of HDPE from crude oil since key feedstocks including ethylene can now be generated by much cheaper natural gas. With the exception of the past couple months, ABS and polypropylene have continued to track very closely to crude oil.

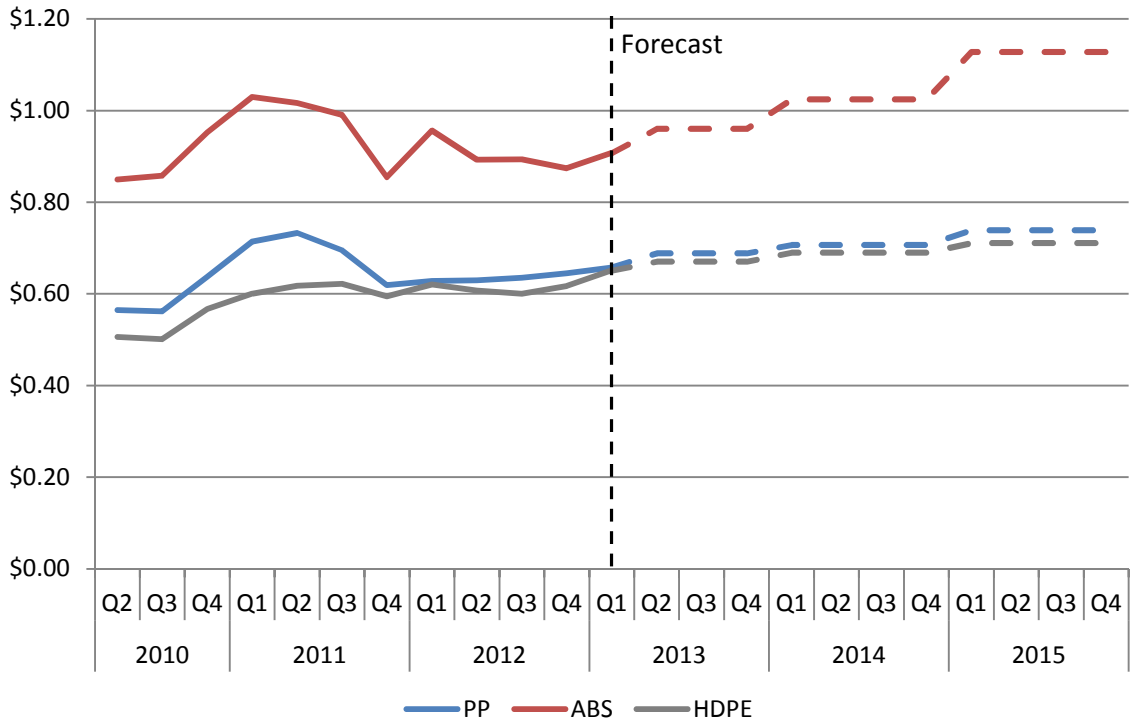
Figure 10: **Resin & Raw Material Index (June 2010 = 100)**



Source: JP Morgan Chemical Reactions, Cost & Capital Partners Analysis

Figure 11 illustrates the pricing developments of polypropylene, ABS and HDPE. ABS currently trades at a $0.30 per pound premium when compared to polypropylene and HDPE. This gap will likely widen as natural gas cracking continues to replace naphtha-based cracking and on-purpose propylene facilities come on line. In the future, based on available supply, the ABS pricing premium should increase to $0.40 per pound. This increase will be a dramatic cost advantage for components designed with polypropylene compared to components designed with ABS.

Figure 11: **Resin Pricing Developments and Forecast**



Source: Deutsche Bank - Trends for Chems, ICIS.com, Cost and Capital Partners Analysis

Material Substitution Opportunities

As pricing gaps continue to increase between ABS and other polymers, buyers and engineering teams will need to assess the existing supply chains and the impact of the bottleneck components. An initial understanding of the annual purchase volume of each type of resin, or components that include the resin is a critical first step. This will help to set a baseline of exposure to ABS, HDPE, polypropylene, etc. Organizations will then be able to study whether it is possible to shift away from materials such as ABS. It is critical for all participants in any such study to keep in mind that material changes should be studied, and business cases developed, with a long term time horizon in mind. Temporary ups and downs may occur in ABS pricing; however it is clear that the shift from naphtha to natural gas-based cracking will be a long term game changer and will likely push ABS to be uncompetitive.

As seen below in Figure 12, reinforced polymer blends (e.g. Polypropylene, HDPE, Nylon, PVC, Polycarbonate) can have similar and sometimes the same performance characteristics as ABS. Common fillers utilized to reinforce non-ABS polymers include: talc, fiberglass, carbon fiber, wollastonite and metal oxy sulfate. The viability of substituting materials will depend on the price differential between ABS, and the competing resin(s), the part's weight, the part's purpose and the production location. In general, the manufacturing process is not necessarily the biggest inhibitor since raw material for injection molded parts can typically be changed by swapping molds. Potential substitution examples include plastic appliance components, automotive parts, electrical casings and various toys. Many of these parts' sub-components can switch from ABS to polypropylene or from polypropylene to HDPE. When shifting between some polymers, the weight of the part may need to be increased to achieve the same performance. This may be viable if the pricing spread between the two examined resins is high enough.

Figure 12: **Material Comparison Matrix**

	Polypropylene	HDPE	ABS	Nylon	PVC	Polycarbonate
Price Trend	↗	→	↑	→	↗	↗
Maximum Temperature	275°F, 135°C	248°F, 120°C	176°F 80°C	210°F, 99°C	158°F, 70°C	250°F, 121°C
Minimum Temperature	32°F, 0°C	-148°F, -100°C	-4°F, -20°C	-94°F, -70°C	-13°F, -25°C	-40°F, -40°C
Autoclavable	Yes	No	No	No	No	Yes
Melting Point	338°F, 170°C	266°F, 130°C	221°F, 105°C	420°F, 216°C	176°F 80°C	300°F 149°C
Tensile Strength	4,500 psi	4,550 psi	4,300 psi	5,800 psi	6,500 psi	10,000 psi
Hardness	R95	SD65	R110	R92	R105	R75
UV Resistance	Poor	Poor	Poor	Good	Good	Good
Specific Gravity	0.90	0.95	1.04	1.13	1.34	1.20

Source: Deutsche Bank - Trends for Chems, Cost & Capital Partners Analysis

Conclusion

The discovery and rapid exploitation of natural gas reserves in the United States has altered resin-related supply chain dynamics. Going forward, feedstocks such as propylene and ethylene will decouple from the increasing price of crude oil. This will happen as a result of refineries' shifting away from naphtha-based cracking towards natural gas. Also, the development of propane-fed on-purpose propylene facilities will help to temper the impact of the shift away from naphtha-based cracking on polypropylene. While these factors have positive implications for resins including polypropylene and polyethylene; a reduction in the feedstock butadiene will negatively impact ABS. Buying organizations should review their supply chain exposure and develop mitigation plans together with their engineering and manufacturing counterparts. Proactive steps taken within the next year can help create a long term competitive advantage over laggards.

Cost & Capital Partners works with clients to help them understand their current level of exposure to shale gas developments. The balance between the impact of crude oil and natural gas on material pricing is undergoing a dramatic shift that will subsequently alter the economic landscape of traditional design materials. Available information related to additional sources of supply will benefit organizations that proactively plan for the market's changes. The economics behind shale gas development affect many downstream products and industries. In addition to resin selection, natural gas will impact the competitive footprint for suppliers of steel, glass, fertilizer, cast products and other energy intensive materials. Prepared organizations will have a long term advantage since responding to material pricing changes is a long lead time initiative that requires the coordination of marketing, design, engineering and manufacturing to align component design to the cost advantaged materials.