Shale gas
Reshaping the US chemicals industry

October 2012

A current look at the chemicals industry value chain

At a glance

The impact of shale gas on domestic chemical companies has been to decrease the costs of both raw materials and energy.

It is estimated that the US chemicals industry investment in ethylene production, has increased capacity by 33%. As these investments take hold, yielding more supply, the United States could become a major, global, low-cost provider of energy.

Volumes from natural gas separation plants expected to increase more than 40% over the next five years.

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Executive summary

In a recent PwC report on the potential impact of shale gas on US manufacturing, it was stated that by 2025, shale gas could add more than 1 million workers to the US manufacturing industry and allow US manufacturers to lower their raw materials and energy costs by as much as $11.6 billion annually.[1] This potential is based on the United States' abundant supply of shale and the country's technological innovations in mining, which could enable the production of an inexpensive source of energy for the foreseeable future. While shale gas reserves are being explored in many parts of the world, only the United States has been able to commercialize production on a large scale.

For chemical companies, the impact of shale gas has been to decrease the costs of both raw materials and energy. The price of US natural gas has declined from $12.50/MBTU in 2008 to approximately $3.00/MBTU in 2012, and prices are expected to decline further, at least in the short term, as a result of excess inventory.[2] Based on industry reports, we estimate that the US chemicals industry has invested $15 billion in ethylene production, increasing capacity by 33%. As these investments take hold, yielding more supply, the United States could become a major, global, low-cost provider of energy and feedstocks to the chemicals industry.

For manufacturing companies, the initial opportunity has been in supplying products and services to support shale gas expansion. Subsequently, they may be able to take advantage of low-cost chemicals to create plastic-based substitutes for other materials, such as metal, glass, wood, leather, and textiles. For manufactured products with a high chemical content, such as automotive bumpers, plastic sheets and panels, electronic components, and packaging films, lower natural gas prices could provide a strong economic incentive for US manufacturers to reverse offshoring of manufacturing activity and build production facilities in the United States. Longer term, lower energy costs could help revive manufacturing in the United States and positively affect the competitive position of American manufacturing.

1 PwC, "Shale Gas: A renaissance in United States manufacturing?" 2011

2 "US Shale Oil-Gas Production Potential 2: Shale could greatly cut oil imports, if US gas markets are developed," Oil & Gas Journal, Sept. 3, 2012, 96

Introduction

Advances in horizontal drilling and fractionation of shale gas basins in North America are altering the chemicals industry value chain, constituting a potential game-changer that could affect the entire energy industry. Recent technological developments in North American shale gas drilling have the potential to yield 862 trillion cubic feet of technically recoverable shale gas in the United States, as PwC reported in "Shale Gas: A Renaissance in US Manufacturing," published in December 2011.

The actual amount of recoverable shale gas is up for debate, as are the safest and most ecological ways to access the reserves. Nevertheless, it has become clear that the United States has abundant, easy-to-access shale gas reserves, which has resulted in huge investments by upstream industry participants in shale gas drilling, ethane manufacturing assets, natural gas pipelines, processing equipment, and storage and transportation facilities for natural gas liquids.[3]

The shale gas boom could change the competitive landscape for value chain participants. In this analysis, we examine the immediate and longer-term effects on the chemicals industry.

3 BENTEK Energy and Turner, Mason & Company, "The Great NGL Surge!" Nov. 11, 2011

Impact of shale gas on the chemicals industry value chain

A low-cost and abundant fuel and feedstock source

Prices of natural gas in the United States have dropped sharply as a result of its availability in shale formations and the technological advancements in horizontal drilling and fractionation techniques to access it.[4] These advancements have boosted efficiency in obtaining natural gas from shale, including formations rich with natural gas liquids (NGLs).

Before natural gas can be transported efficiently and sold commercially, its impurities must be extracted. The by-products of this extraction process, known as NGLs, include hydrocarbons such as ethane, butane, and propane, which are valued as raw materials in the petrochemical markets. With the increase in natural gas production comes an increase in NGL production, with volumes from natural gas separation plants expected to increase more than 40% over the next five years, reaching more than 3.1 MMBD in 2016.[5]

The chemicals industry value chain

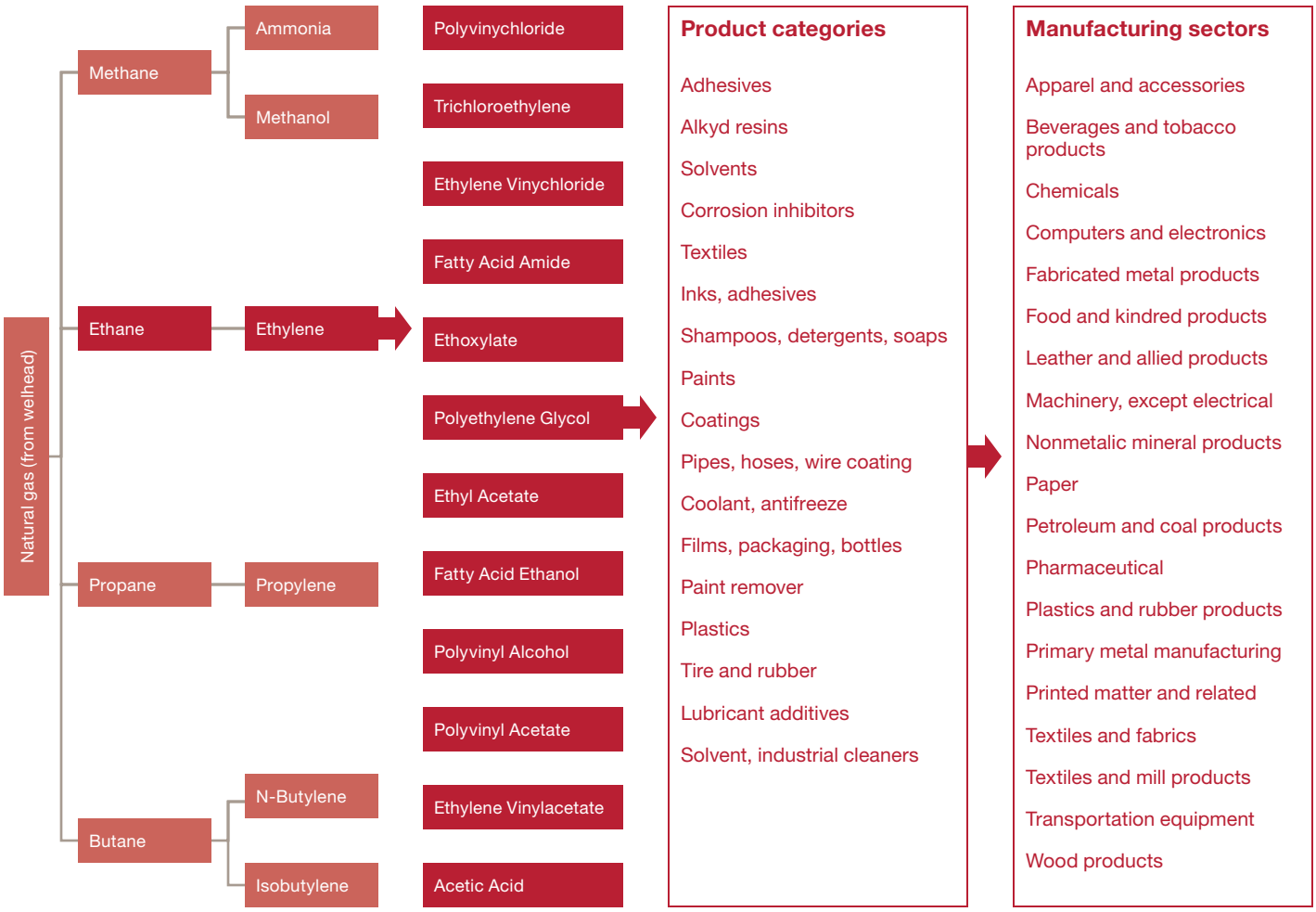
The NGL from shale gas production is used by the chemicals industry to produce a variety of derivatives and products that ultimately become raw materials for multiple manufacturing sectors, as depicted in Figure 1, which features the ethane chain.

As the chemicals industry ramps up its ethylene capacity and corresponding downstream ethylene derivative products, the impacts could flow through the value chain into other manufacturing sectors and, ultimately, to finished products. Our analysis will use the ethane chain to highlight these potential changes.

4 "Petrochemicals," Chemical Week, March 27, 2011

5 BENTEK Energy and Turner, Mason & Company, "The Great NGL Surge!" Nov. 11, 2011

Figure 1: Shale gas through the ethane chain into manufactured products



Sources: PwC and TopLine Analytics

Figure 2: Economic cost model of natural gas to ethane-ethylene

			US		
		Saudi	Recent	Historical	Asia
Raw material costs					
Natural gas costs	$/MMBTU	0.75	3	12.5	
Crude oil costs	$/BBL				100
Equivalent	$/ton	483	148	615	964
Ratio for 1 ton of ethylene		1	1.29	1.29	2.98
Ethane feedstock costs	$/ton	483	190	793	2874
Catalyst + other	$/ton	0	2	2	2
	$/ton	483	192	795	2876
Other costs					
By-product credits	$/ton	276	153	431	1565
Utilities	$/ton	149	109	454	235
Direct costs	$/ton	99	167	167	172
Total ethylene cost	$/ton	455	316	985	1717
Typical ethylene margin	2.50%				
Transfer price for ethylene	**$/ton**	**466**	**323**	**1009**	**1760**

Change in US natural gas cost

US is lowest-cost ethylene producer

Sources: CMAI, TopLine Analytics, and Alembic analysis, 2012

Note: The timing for Saudi Arabia and Asia is based on 2011 pricing for feedstock material. Their pricing has remained constant over the period of this analysis.

Ethane to ethylene: a major first step in the chemicals industry value chain

The extracted raw materials are used to produce a variety of products in the chemicals industry. In the case of ethane, it is converted to ethylene and then a range of downstream products. Ethylene is the most significant single chemical in terms of volume and value.

Cost economics of ethane and ethylene

The availability of natural gas as a low-cost energy source has resulted in lower-cost ethane and ethylene.[6] While we can assume that natural gas pricing will fluctuate over the next several years because of various market conditions, figures 2, 3, and 4 use the price of $3.00 MMBTU for natural gas, based on the NYMEX 2012 price of $2.58 and Trading Charts futures forecasts of $5.90 for April 2015 prices.[7] [8] This natural gas price will affect the price of ethylene, which is expected to decline from a little less than $1,000 per ton to a little more than $300 per ton, as indicated in Figure 2.

6 "Petrochemicals," Chemical Week, March 27, 2011

7 "Natural Gas Summary," US Energy Information Administration, July 31, 2012, Web

8 "Natural Gas Futures Prices," Tradingcharts.com, Aug. 1, 2012, Web

Figure 3: Ethane to ethylene cost economics

				US		
			Saudi	Recent	Historical	Asia
Natural gas costs	$/MMBTU		0.75	3	12.5	
Crude oil costs	$/BBL					100
Ethylene cost	$/ton		466	323	1009	1760
Ratio for 1 ton of HDPE	$/ton		1.025	1.025	1.025	1.025
Ethylene cost	$/ton		478	332	1035	1804
Utilities	$/ton		31	12	48	31
Direct cost	$/ton		51	51	51	51
Other costs	$/ton		132	132	132	132
Total costs	**$/ton**		**692**	**526**	**1266**	**2018**
Typical polyethylene margin	$/ton	3.00%				
Potential HDPE selling price	**$/ton**		**713**	**542**	**1304**	**2079**

US natural gas costs reduced by 4.2x

Polyethylene price reduced by 2.4x

Sources: CMAI, TopLine Analytics, and Alembic analysis, 2012

Note: The timing for Saudi Arabia and Asia is based on 2011 pricing for feedstock material. Their pricing has remained constant over the period of this analysis.

Figure 4: Economic cost model of ethylene glycol

				US		
			Saudi	Recent	Historical	Asia
Natural gas costs	$/MMBTU		0.75	3	12.5	
Crude oil costs	$/BBL					100
Ethylene cost	$/ton		466	323	1009	1760
Amount for 1 ton of HDPE			0.66	0.66	0.66	0.66
Ethylene cost			308	213	666	1162
Utilities			150	56	234	150
Direct cost			31	31	31	31
Other costs			35	35	35	35
Total costs			**524**	**336**	**967**	**1378**
Typical ethylene glycol margin		3.00%				
Potential ethylene glycol price	**$/ton**		**540**	**346**	**996**	**1419**

US natural gas costs reduced by 4.2x

Ethylene glycol price reduced by 2.9x

Sources: CMAI, TopLine Analytics, and Alembic analysis, 2012

Note: The timing for Saudi Arabia and Asia is based on 2011 pricing for feedstock material. Their pricing has remained constant over the period of this analysis.

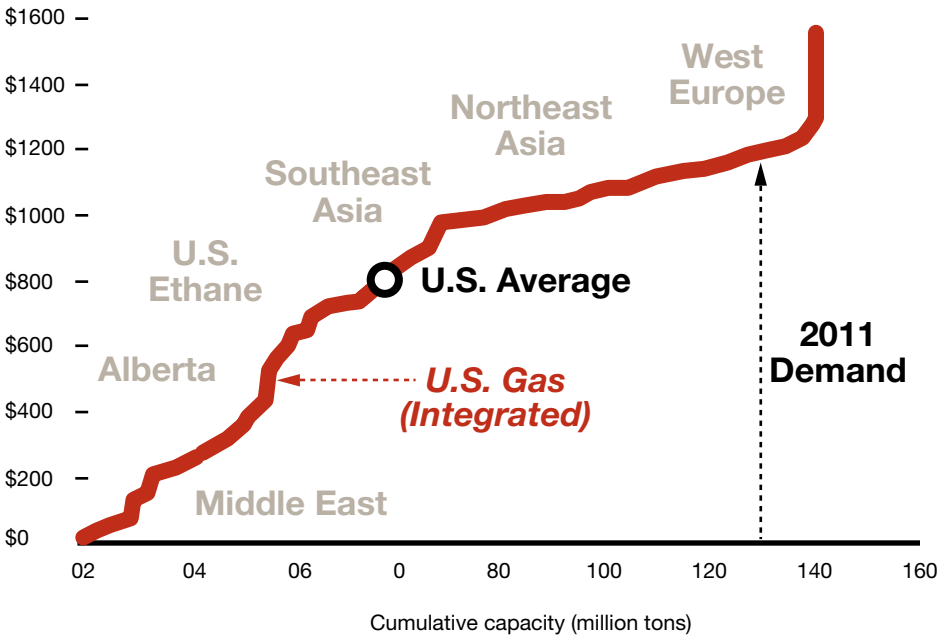
Cost economics of ethylene to high-density polyethylene

Polyethylene, the No. 1 plastic by volume and value, is produced by converting ethylene into long-chain polymers. The cost of polyethylene production in North America could decline, similar to the cost of ethylene and natural gas (see Figure 3). Based on our assumed price of $3.00 MMBTU for natural gas, the price of polyethylene from US sources is potentially 2.4 times less than the historical cost.

Cost economics of ethylene glycol

The downstream effect for another high-volume ethylene derivative, ethylene glycol, shows the same potential for cost reductions, as seen in Figure 4.

Figure 5: 2012 global ethylene cash cost by site



Source: Gary Adams, "Leveraging a Fractured Future," presentation, IHS, Feb. 9, 2012

Shift in global dynamics

According to the World Bank's Pink Sheet,[9] the prices of natural gas in 2008 in Europe, $11.42/MBTU, Japan, $16.00/MBTU, and the United States, $12.50/MBTU, were in the same ballpark; however, that was before the shale gas boom in the United States, which made the US price more competitive in the global marketplace. This dynamic, and the relatively high price of oil at $80 to $100 per barrel, has the potential to give the US chemicals industry a significant competitive advantage globally. Whether this advantage is realized depends on a number of factors, including the domestic tolerance for hydraulic fracturing and its waste products, as well as the political and economic ramifications of exporting liquefied natural gas (LNG).[10]

The ethane chain in the Middle East, Europe, and Asia

While oil and gas companies in the United States are exploiting shale gas technologies and reducing their natural gas and NGL costs, other regions are not as favored. The Middle East ethane production chain is predominantly centered in Saudi Arabia, which has leveraged its historically low-cost raw material sources to become a global petrochemicals powerhouse. However, its newer ethylene production facilities rely on an ethane-butane mix, which yields higher-priced ethylene and other feedstock chemicals. These factors are serving to reduce the country's historic competitive advantage. Figure 5 illustrates the global cash cost per site.

9 Development Prospects Group. "Commodity Price Data," The World Bank, May 3, 2012, Web

10 Michael Levi, "The Case for Natural Gas Exports," *The New York Times*, Aug. 16, 2012

Europe, and to a lesser extent Asia, have a more limited supply of ethane. Most of their ethylene capacity is produced from naphtha, an intermediate refined form of crude oil, which is more expensive than the Middle East ethane-butane mix and the US shale gas ethane. For upstream participants, these realities could demand new strategies in managing global supply and demand, balance of trade, pricing policies, and supply chain economics for ethylene and the corresponding downstream derivatives. Armed with the lower-priced shale gas economics, the United States could find itself among the low-cost ethylene and derivatives producers. Over time, one impact could be a favorable shift in the US balance of trade as ethylene capacity comes on line.[11] Several multinational oil and gas companies are investing in building the infrastructure to export LNG. In addition, companies are in the early stages of negotiating long-term supply agreements with foreign entities for LNG.

As these developments unfold, there could be other changes. The East Coast or Pacific Coast could emerge a hub for export, based on the location of shale gas reserves and production facilities. And with low US ethane prices linked to natural gas, some might explore the option of using NGL tankers and infrastructure to ship ethane.

11 "America's New Energy Reality," *The New York Times*, June 9, 2012

Impact on chemicals industry segments

The United States is already a net exporter of ethylene derivatives, and the volume is expected to increase significantly. Together with low-cost Middle East producers, the chemicals industry may see some economic disruption in other regions that use crude oil to produce those products. This may cause the shutdown of less lucrative assets and lead to the imposition of trade barriers by some countries in an attempt to protect local production.

Major oil and gas companies and upstream commodity industry participants are already acting on plans to take advantage of shale gas opportunities. Some are negotiating mergers, acquisitions, and divestitures; analyzing their portfolios, pricing policies, and supply chains; and conducting customer service analyses.[12] They are considering whether to restart mothballed assets, invest in greenfield projects, form strategic alliances, and expand and upgrade existing assets. For many of these companies, today's focus is on execution of large capital projects, identification of engineering and construction resources, and establishment of strategic sourcing agreements with NGL providers, exporting options, and material logistics. With low-cost and abundant ethylene, coupled with a slowdown in the growth of domestic demand, US companies are looking abroad for expansion opportunities.[13] Some companies have clearly stated this intention and are making multibillion-dollar investments in building new plants to increase capacity.[14] Recently, both Dow Chemical[15] and Chevron Phillips Chemical[16] announced plans to build ethylene production plants in Texas.

Shell Chemicals recently said it will build an ethane cracker in Monaca, Pennsylvania.[17] This decision to build in the Northeast, rather than along the Gulf Coast, could have significant ramifications and affect planning for other gas companies. Some questions to be considered include the following:

- Can the Northeast region support another ethane cracker?
- Will Ohio, West Virginia, or Pennsylvania become a new natural gas and NGL hub like Mont Belvieu, Texas?
- Could a Northeast region hub shift the industry economics for these commodities?
- What existing pipelines can be reversed, and where should new ones be constructed?
- Will oil and gas explorers continue drilling in the Northeast region, or will they shift drilling assets to other liquid-rich regions, such as the Bakken basin?
- Which state legislatures are likely to ban or limit hydraulic fracturing for environmental reasons, as New York has done?[18]
- How might state regulations and tax policies affect drilling procedures, decisions, and profitability?

12 "Dow Sees U.S. Ethylene Advantage Widening," Chemical Week, April 30, 2012, Web

13 "ESAI: Shale development to boost US ethylene exports," Oil & Gas Journal, Aug. 6, 2012, Web

14 Emily Pickrell, "New Chevron Phillips plant boosts Texas as chemical hub," Fuel Fix, June 14, 2012, Web

15 "Dow to Build New Ethylene Production Plant at Dow Texas Operations," The Dow Chemical Company, April 19, 2012, Web

16 Emily Pickrell, "New Chevron Phillips plant boosts Texas as chemical hub," Fuel Fix, June 14, 2012, Web

17 "US Appalachian petrochemical project," Shell Chemicals, Aug. 1, 2012, Web

18 Mary Esch, "New York Fracking Ban: Cuomo's Energy Proposal Polarizes Supporters and Opponents," Huffington Post, June 13, 2012, Web

Further downstream, specialty chemical entities are starting to feel the effects of natural gas and NGL prices on their business models. As manufacturers replace petroleum-based raw materials with products based on ethylene, their cost structure will change significantly, as will supply and demand for certain products.

A case in point is butadiene, a petroleum-based chemical used in the manufacture of rubber tires. While butadiene prices are subject to short-term supply and demand considerations, over the longer term, the price of butadiene is expected to rise because of the shift to cost-advantaged natural gas liquids as feedstock to ethylene plants.[19] This pattern is likely to be repeated for other petroleum-based raw materials, many of which are used in building, construction, adhesives, paint, coatings, plastics, packaging, and carpeting.

As the commercial distribution of ethane and ethane-based raw materials increases, it could trigger new innovations and investment in new technologies. Research and development initiatives leveraging ethylene-based chemistries that replace petroleum-based products may predominate. Companies might also look for longer-term sourcing relationships and partnerships with raw material suppliers to help with developing new products.

In the United States, ethylene derivative supply is expected to greatly outstrip demand, driving down pricing.

Lower pricing could help US manufacturers competitively. Certain manufacturers of products with high ethylene content, such as downstream specialty chemical manufacturers, packaging manufacturers, and plastic bottle producers, could have a big advantage. New markets and products may open up. Ethylene-based chemicals may also replace other chemicals where technically possible. As these changes occur, companies may want to carefully manage the supply chain and their innovation portfolio. They may also want to create strategic alliances through mergers and acquisitions to supplement their efforts.

In a similar manner, greater emphasis on commercial activities in such areas as product portfolio management, innovation, pricing policies, logistics, and cost reduction will be essential to maintain global competitive positions. The chemicals industry's traditional response—finding new substitutes—will advance on two fronts.

The first will be to find a substitute in the cost-advantaged ethylene chain. The second will be to produce these products with new technologies in a purposeful manner as opposed to a by-product production process, as in the case of propane dehydrogenation to propylene. And advances in technology often draw new competitors as well. This is likely to be magnified as competitors seek technologies to produce a single molecule as opposed to previous technologies that produced a wide range of molecules, requiring steps that added to production costs and increased time to market.

Finally, with lower-cost ethylene derivatives, a redirection of research and development initiatives centered on leveraging ethylene-based chemistries warrants consideration.

19 "TPC Group Reports Second Quarter 2012 Financial Results," TPC Group, Aug. 2, 2012, Web

The 'wave of change' beyond the chemicals industry

If the changes brought about by shale gas take hold in the chemicals industry, they will create a need for specialty steels, reactors, separation columns, pipes, compressors, pumps, valves, fittings, control systems, storage tanks, and other chemical processing equipment, as well as the services of engineering and construction firms.

Given the law of supply and demand, increases in ethylene-based capacity could yield a decline in chemicals pricing. Since chemicals are used in an estimated 90% of all manufactured products, lower chemicals prices could bring about a reduction in costs for US manufacturers. Another possible outcome is that chemical products will increasingly become a substitute for more expensive materials, such as metals, glass, wood, leather, and textiles.

Partial substitution could occur in complex manufactured products. For example, while today automobiles have a 20% chemical content, that percentage could rise as some manufacturers reengineer parts to increase chemical content, thereby decreasing weight and costs.

It is also possible that lower energy costs could bring some manufacturing back to the United States.[20] Dow Chemical's decision to build an ethylene plant in Texas is in part based on the competitive advantage low-cost, natural gas-based feedstocks brings to the production of certain products, such as plastics, performance materials, and advanced materials.[21] Likely targets will be relatively simple products such as toothpaste tubes, disposable medical syringes, or pens that can be produced on high-speed lines with robotics, requiring little labor. In the electronic device industry, we are seeing the manufacturing of more demanding products, such as touch-sensitive screens, higher-strength films, mobility devices, and miniaturized components, return to the United States.[22] Additionally, supplying US customers with US products simplifies the long and costly supply chain.

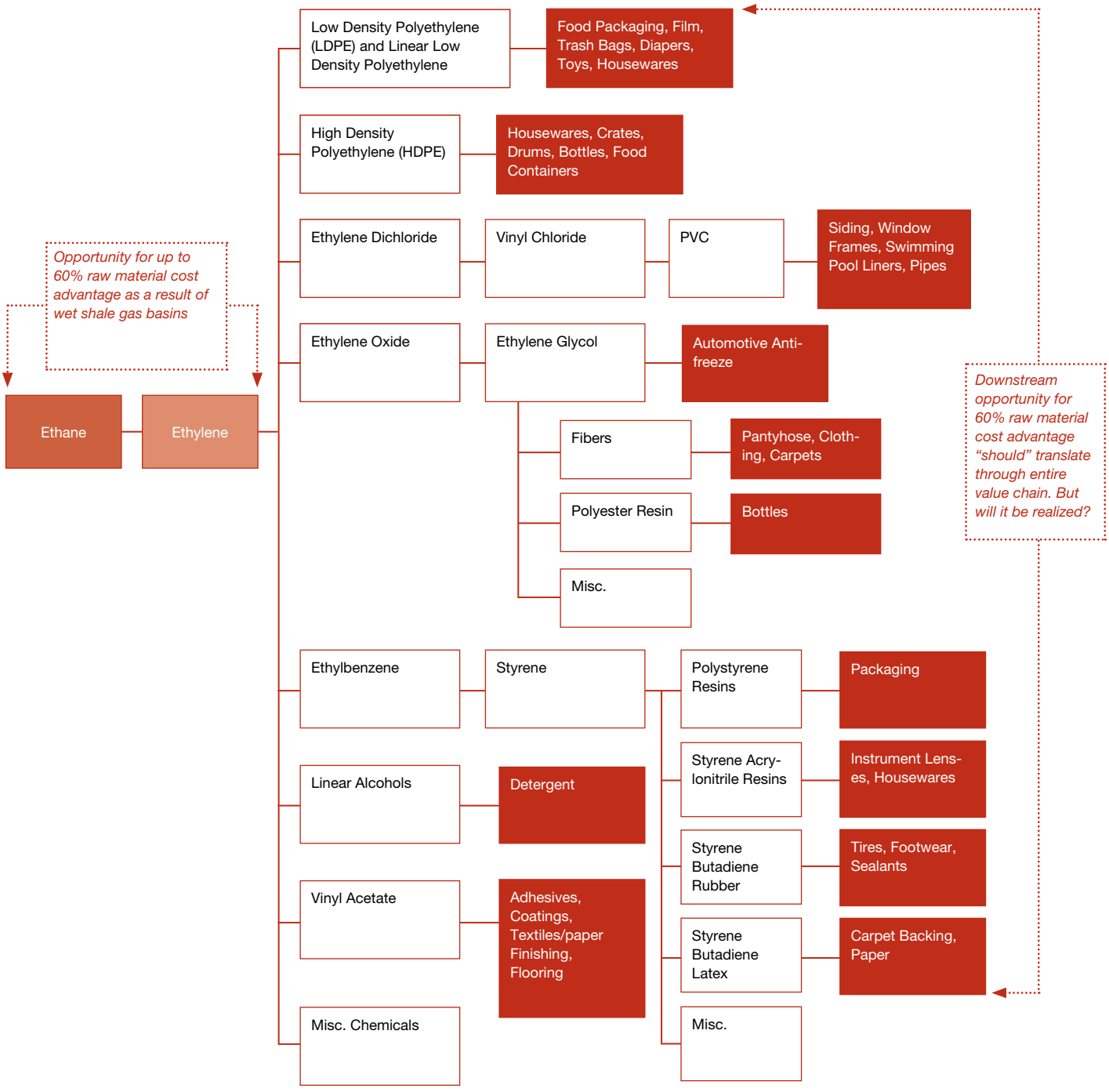
All of these scenarios present challenges and opportunities for manufacturing companies. We have seen the changes in natural gas prices and how those changes flow through the chemicals industry. Figure 6 illustrates the potential ethane impact on manufacturing. Whether these opportunities are realized will depend on how downstream manufacturers will be positioned to capture the cost-saving opportunities. Successful manufacturing companies are already reexamining their strategies, product innovation portfolio, supply chain planning, and other areas. Some of the changes they face might be as dramatic as the events now unfolding in the chemicals industry.

20 "Petrochemicals," Chemical Week, March 27, 2011

21 David Muir, "Companies Move Manufacturing Jobs Back to America," ABC News, Feb. 22, 2012, Web

22 "Samsung to Invest $4 Billion More on US Chip Plant," Reuters, Aug 21, 2012, Web

Figure 6: Ethane impact on manufacturing industry value chain



Sources: "Shale Gas and New Petrochemicals Investment: Benefits for the Economy, Jobs, and US Manufacturing," American Chemistry Council, March 2012, PwC and TopLine Analytics

Conclusion

The implications of the shale gas boom for any chemical company are varied and complicated. While some companies may already be realizing gains in profitability and shareholder value and creating new opportunities at home and abroad, there is no single model for success. Companies need to consider their individual situation and business options and understand the risks and opportunities being presented by the abundance of shale gas.

Questions that companies should consider include the following:

- Which new energy strategies should the company explore? How can it best take advantage of shale gas availability?
- How should the company allocate investment dollars among the different fuel sources? Where will it get the greatest return in the short and longer term?
- Is the company employing the most effective and efficient sourcing strategies for energy and raw materials?
- Should the company shift R&D and product innovation dollars to capture opportunities presented by the availability of shale gas?
- Will the US chemicals industry economics set off a round of protection among disadvantaged countries?
- What is the company's global versus domestic strategy? What are the tax and transfer pricing implications?
- Which strategies for mergers, acquisitions, and partnerships should the company be considering?
- How will shale gas affect the company's supply chain in terms of cost reductions and risk parameters?
- What are the new and emerging business models for industry value chain participants?
- How quickly will manufacturers' strategic sourcing capabilities ramp up to capture and translate the lower costs of raw materials into their cost structures?
- If consumer prices drop as a result of lower-priced fuel, how will that affect business?
- What new commercial opportunities are emerging, and how should the company price its products?

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