Innovest
STRATEGIC VALUE ADVISORS

Overview of the Chemicals Industry

Overview for Coming Clean

March 2007

Report prepared by: Innovest Strategic Value Advisors, Inc., a New York-based investment research firm with more than ten years of investment research experience and a dedicated chemicals sector team.

KEY ISSUES

"Lost businesss" in the US

Currently the US remains the major production center for the industry. However over the past five years companies have begun moving operations to Asia, India and the Middle East and will continue to do so for the forseeable future.

REACH

While Innovest has developed a comprehensive analytical approach to determine individual company exposure to the regulation, the bottom line is that most large cap firms are not expected to experience dramatic affects.

Commodity Firms: Business As Usual

Commodity chemicals production remains a marginal business meaning that innovation is limited and negative externalities associated with production continue to be an issue. Meanwhile more specialized firms in the Diversified and Specialty segments of the industry are turning to new technological capabilities that may yield safer synthesis and better chemistry over the long term.

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1 Executive Summary

The global chemical industry has sales estimated at $2.5 trillion dollars and the sector is experiencing an unprecedented period of mergers and positive earnings reports. That stated, new issues such as energy security, changing consumer preferences and the forces of globalization create new challenges for the global chemicals sector. This report outlines many of these industry driving forces so that NGOs can better understand how to strategize around them.

The economic climate for the sector is tepid in the nearterm but there are positives. The industry generates 2% of the United States GDP but is rapidly expanding overseas. Declines in housing starts and a potential overall slump in the economy are predicted to cause a slight reduction in demand but not an abrupt downturn. Chemical sector end markets such as textiles, packaging and electronics and other goods are experiencing growth giving new life to many companies in the chemical sector.

To date, the United States continues to dominate global chemicals production by volume. Given this, it is relevant to note that the newly elected Democratic majority in Congress is looking into a variety of initiatives from greenhouse gas emissions control to chemical site security regulation.

However it is increasingly obvious that the migration of production capacity overseas is resulting in a loss of chemicals production activity in the US. In 2004 the industry lost approximately US $47 million and about $53 million worth of production in 2005. The largest losses by end market appear to be in chemicals for the textiles, electronics and mining sectors[1].The emphasis in our analysis is on China as it currently represents the most important impetus for overseas migration of chemicals production deals although new production is also moving to India and the Middle East.

This has implications for companies and for the way that the externalities of chemicals production are perceived and dealt with globally. The current operating climate is rapidly changing for chemicals production in China. Innovest tracks how this changes the operating expense outlook in the region. However, for the NGO community. it is the age old concern that regulation and enforcement remain less rigorous in many parts of the world where chemicals production is slated to increase. The reality on the ground is never what is portrayed in corporate responsibility

[1] US Department of Commerce, American Chemistry Council. “Guide to the Business of Chemistry 2006”. Pg 72.

disclosure. The recent airing of "China from the Inside" on US public television provides visual evidence of this[2].

Raw material prices are undoubtedly one of the most critical driving forces for the sector and largely determine where new production arises. Preliminary Innovest analysis shows a potential underestimation of global natural gas supply. This has grave implications for chemicals producers unless new energy resources can be accessed by the sector. Calls are being made for greater funding of coal gasification projects. Additionally, pending regulatory scenarios in the US may have a de facto affect on the price of energy drawn from the grid. The chemicals sector will invariably be the first hit by such changes.

Finally, product portfolios are rapidly changing to adjust to new demand scenarios. Companies, desperate for new marketing platforms are recognizing for the first time that green product design principals may help top and bottom line growth. More importantly, the sector is already in full swing in the race to meet demand for alternative and renewable energy technologies. We project that these trends will gradually change the face of the chemicals sector, particularly as new technologies at the quantum scale enable increasingly cleaner modes of production and which may yield fundamentally safer products over the very long-term.

Within this context NGOs can plan their interactions with the sector to speed change. Ultimately, the research process for this report yielded two important observations for activists targeting the chemicals industry. First, while many of the large specialized companies are introducing new technological capabilities that promise to change the future of chemical synthesis for the better, the old line Commodity companies continue to produce the same basic chemicals using dated production options designed to get product to market in the least expensive and in a rapid manner. The externalities associated with this group of companies may continue to be a focus for NGOs.

Secondly, as companies increasingly turn to high performance catalysis, renewable energy technology, white biotech and other next generation technological platforms, there appears to be a distinction between new chemistry and old chemistry. the challenge for NGOs is to target old chemistries and identify the companies making them. If viable alternatives are available, the market for such products will eventually drop out.

The final section of the report is an overview of key environmental and social issues that Innovest feels are pertinent to the performance of companies in the sector.

[2] http://www.pbs.org/kqed/chinainside/

2 The Chemical Industry

Definitions & Categories

With its essential role in other sectors, it is not surprising that the chemical sector is a vast, complex industry. Companies that produce chemicals are intricately tied to one another as suppliers and consumers, and are dependent upon other industries, as well as global economic trends.

FIGURE 1 US Business of Chemistry Flow Chart 2005 (billions)

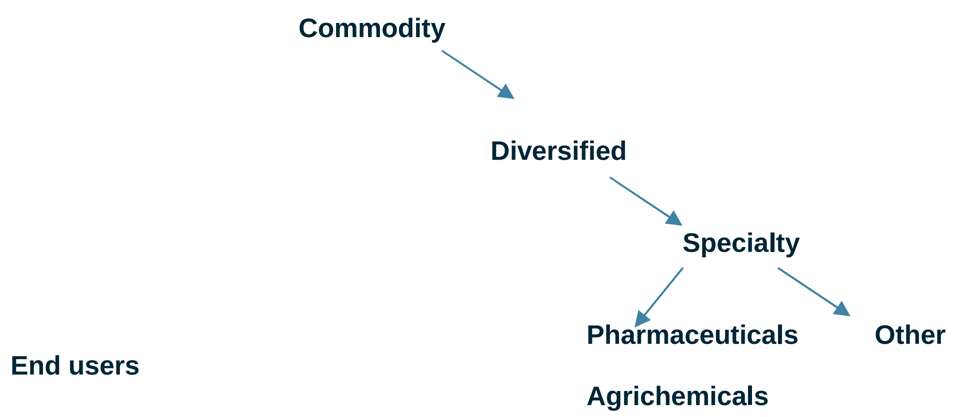
Source: Bureau of Economic Analysis, American Chemistry Council (ACC) analysis

The main raw materials of the chemical industry are fossil fuel, water, air, salt, limestone, sulfur, and other specialized raw materials. The industry converts these materials into products; a chief characteristic of the industry is that its products almost always require further processing before reaching end users.

Given the complexity of the industry, there are several ways in which the industry is commonly broken down into sub-sectors and categories. These categories, however, are not necessarily fixed. Furthermore, major chemical-intensive segments such as pharmaceuticals and agrichemicals are sometimes considered sub-sectors of the industry and sometimes categorized as distinct end-market sectors. In the financial community, it is typically noted whether pharmaceutical data is included in analysis.

[For the purpose of this report, pharmaceuticals and agri-chemicals are considered separate end-market sectors, unless otherwise noted.]

FIGURE 2 Chemical Sector Value Chain



Source: Innovest

On a basic level, a distinction is made according to the types of chemicals produced. Major categories include organic chemicals and inorganic chemicals, as well as commodity, diversified, and specialty chemicals.

ORGANIC CHEMICALS

Simply defined, organic chemicals contain carbon. More than 90% of all known compounds are organic, and include chemicals found in animal and plant life. Organic chemicals are mostly derived from substances such as petroleum, coal, and natural gas. Examples of organic chemicals include benzene, ethylene, formaldehyde, phthalate plasticizers, urea, vinyl acetate, and vinyl chloride.

The organic chemical industry is highly diverse and includes thousands of individual chemicals and compounds. Companies take a few basic raw chemicals and combine and transform them into new substances that are, in turn, valuable to other industries. Organic chemicals are essential ingredients in plastics, synthetic fibers, rubber, adhesives, inks, dyes, explosives, and fertilizers.

Petroleum-based chemicals (petrochemicals) account for a large majority of organic chemicals. Approximately 95% of organic chemicals are derived from petroleum or natural gas[3]. These chemicals are produced by transforming petroleum or natural gas into more useful petrochemical "building blocks" (such as benzene, toluene, xylene, ethylene, and propylene) and then into tens of thousands of intermediate chemicals. Petrochemical Derivatives is a $102 Billion Business in the US according the American Chemistry Council.

For petrochemicals, there are several methods of separating, or ‘cracking’ the large hydrocarbon chains found in fossil fuels. Natural gas is processed to produce methane and natural gas liquids (NGLs), and petroleum is refined to produce a variety of products including naphtha and NGLs. Naphtha and NGLs and processed in large vessels or ‘crackers’, which are heated and pressurized to crack the hydrocarbon chains into smaller ones. These smaller hydrocarbons are the petrochemical feedstocks used to make other chemical products.

Ethylene is the largest petrochemical product by volume, and is used in the production of plastic, rubber, fibers, detergents, solvents, and anesthetics. Issues associated with petrochemicals manufacture include: high intensity energy use, petrochemical processes involve volatile processes, petroleum based plastics are less optimal from a raw material sustainability perspective, and some petrochemicals fall into toxicity classifications such as benzene.

Major companies include BASF, Dow Chemical, Du Pont, ExxonMobil Chemical Company, Royal Dutch/Shell Group

INORGANIC CHEMICALS

Inorganic chemicals do not contain carbon-carbon bonds, (Though some inorganic compounds may contain carbon, they lack carbon-carbon bonds). Inorganic compounds are generally derived from metal and non-metallic minerals. Examples of inorganic chemicals include acids, metals, and gases; nitrates, fluoride, metals, silicones, silanes, and borates; aluminum sulfate, ammonia, chlorine, caustic soda, hydrochloric acid, hydrogen peroxide, nitric acid, sodium chlorate, and sulfuric acid.

The inorganic chemical industry deals with inanimate material and processes to create chemicals and gases that are often referred to as ‘basic chemicals’. The industry's products are used as basic chemicals for industrial processes (i.e., acids, alkalies, salts, oxidizing agents, industrial gases, and halogens); chemical products to be used in manufacturing products (i.e., pigments, dry colors, and alkali metals); and

[3] United States Environmental Protection Agency. EPA Sector Notebook. Organic Chemicals. 1996. page 5-9

finished products for ultimate consumption (i.e., mineral fertilizers, glass, and construction materials).

The largest use of inorganic chemicals is as processing aids in the manufacture of chemical and nonchemical products. Consequently, inorganic chemicals often do not appear in the final products.[4] Inorganic chemicals account for nearly a quarter of total global sales. Most inorganic chemicals are used as building blocks for other compounds and products; the industry is therefore closely tied to business cycles of other manufacturing industries, as well as the state of the global economy.

Analysis: While organic chemicals also have their place in the Toxic Release Inventory, a focus of Innovest research has been on the inorganic sector, namely the chlor-alkali segment. See section 3 Products for further information.

Major companies include Dow, EI Dupont de Nemours, Degussa, Celanese, FMC, L'Air Liquide, BOC Group.

MARKET BASED CATEGORIES

Chemicals, and the companies that produce them, are also categorized according to the market segments they serve. . These are the categories used by the financial community and also by Innovest. This allows for company comparison across an array of factors. While these definitions have to be somewhat loose, these categories at least allow for some uniformity within groupings. For example, it is more rational to compare absolute toxic release information for companies that have relatively similar industrial processes.

Commodity Chemicals

The commodity chemicals market includes companies that manufacture basic chemicals in large volumes. These include plastics, synthetic fibers, films, certain paints and pigments, explosives, and petrochemicals. There is no product differentiation within the sector; products are sold for their composition.

The global commodity market is valued at approximately $908 billion, and is considered a mature industry. The leading revenue source is the plastics and synthetic rubber sector, followed by the petrochemical sector. Regionally, the largest global commodity market is in Asia-Pacific, which generates approximately 33% of

[4] EPA Sector Notebook. Office of Compliance Sector Notebook Project. Profile of the Inorganic Chemicals Industry.. Office of Compliance Enforcement and Assurance. United Stated Environmental Protection Agency. September 1995. Page 5.

global value. Europe follows at 31%, and the US at 22% of global market segmentation.

The commodities market is highly fragmented. The leading companies, Dow Chemical and BASF, account for less than 5% of the total market each. Other industry leaders include Bayer, Dupont, and Akzo Nobel. More than 85% of the market share, however, is accounted for by a mix of other companies. A full environmental and social rating accompanies each company on the following list. Contact Heather Langsner at hlangsner@innovestgroup.com for further information.

Commodity Firms Innovest Ratings Universe

3405-TO	Kuraray Company Limited
3401-TO	Teijin Limited
3407-TO	Asahi Kasei Corp.
CZZ-FF	Celanese AG
NCX	Nova Corp.
3404-TO	Mitsubishi Rayon Company Limited
3402-TO	Toray Industries Inc
4183-TO	Mitsui Chemicals
4061-TO	Denki Kagaku Kogyo KK
4042-TO	Tosoh Corporation
4010-TO	Mitsubishi Chemical Corporation
4118-TO	Kaneka Corporation
SOLB-BT	Solvay
LYO-N	Lyondell Chemical Co.
MGT-FF	MG Technologies AG

Financial considerations for the commodity market include high energy costs, rising feedstock (raw material) costs, and the global economic situation. Intangible value considerations include operational risks such as worker protection, the environmental impact of energy use, and site security.

End user markets include other basic chemicals, specialties, and other chemical products; manufactured goods such as textiles, automobiles, appliances, and furniture; and pulp and paper processing, oil refining, aluminum processing, and other manufacturing processes. Markets also include some non-manufacturing industries.

In 2005, US shipments of commodity chemicals was valued at $198,500 million [almost $2 billion].

Breakdown of Commodity Chemicals

INORGANIC CHEMICALS

Chlor-Alkalies

Industrial Gases

Other Inorganic Chemicals

BULK PETROCHEMICALS & INTERMEDIATES

Olefins:

Ethylene

Propylene

Butadiene

Aromatics:

Benzene

Toluene

Xylenes

Methanol

PETROCHEMICAL DERIVATIVES & OTHER INDUSTRIAL CHEMICALS

Plastic Resins

Synthetic Rubber

Synthetic Fibers

Other Basic Chemicals:

Carbon Black

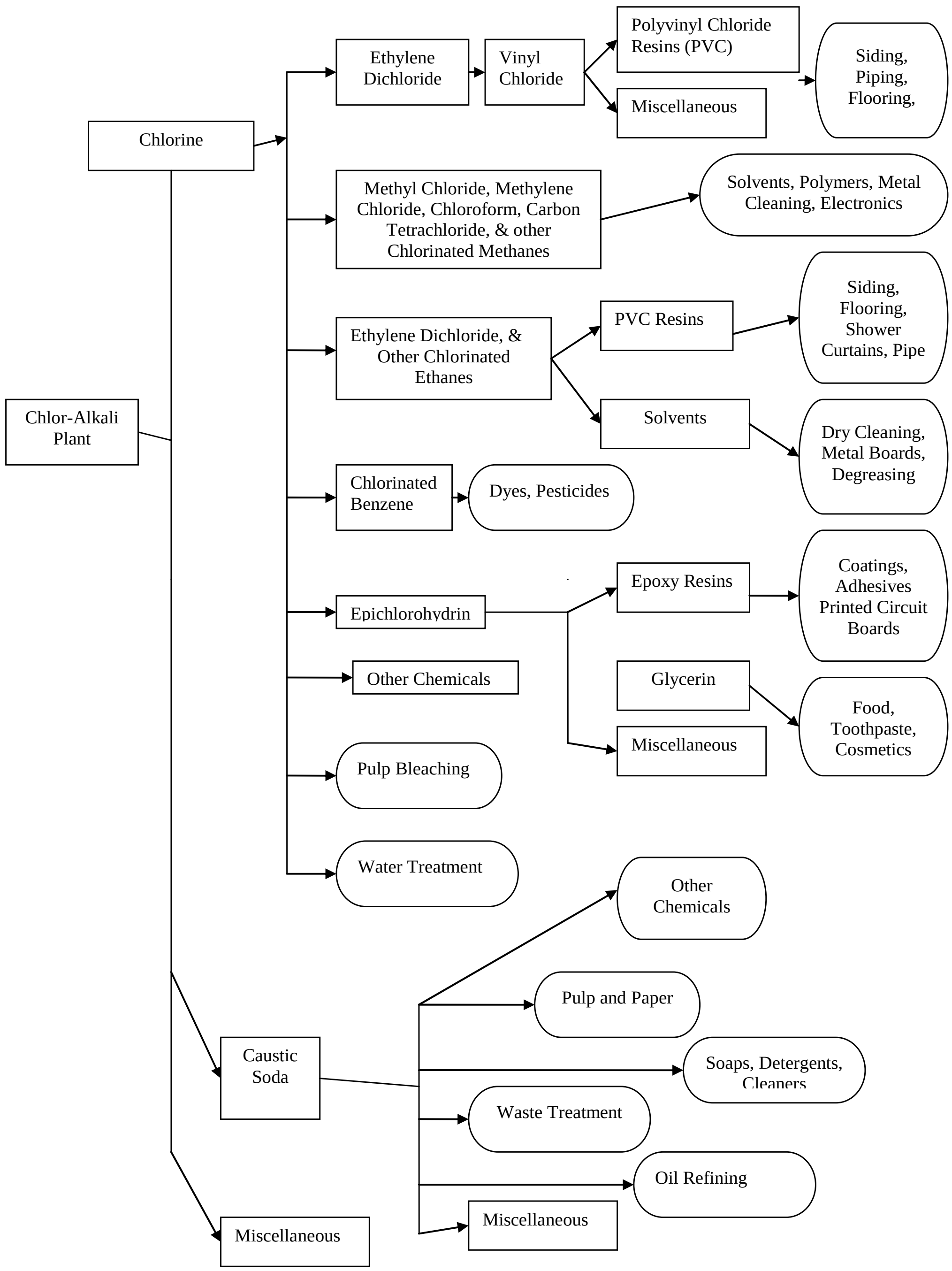
Colorants

Wood Chemicals

Printing ink

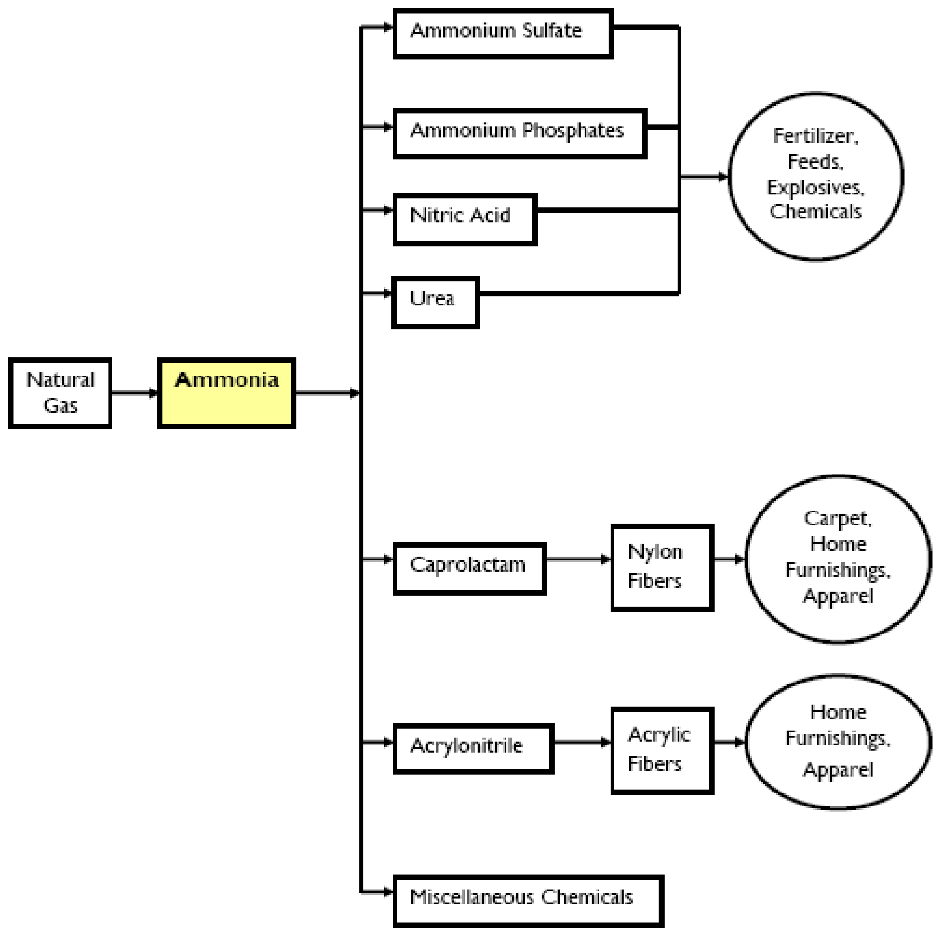
Key Chemical Chains in Commodities/Basic Chemicals Production

FIGURE 3 Chlor-Alkali Chain



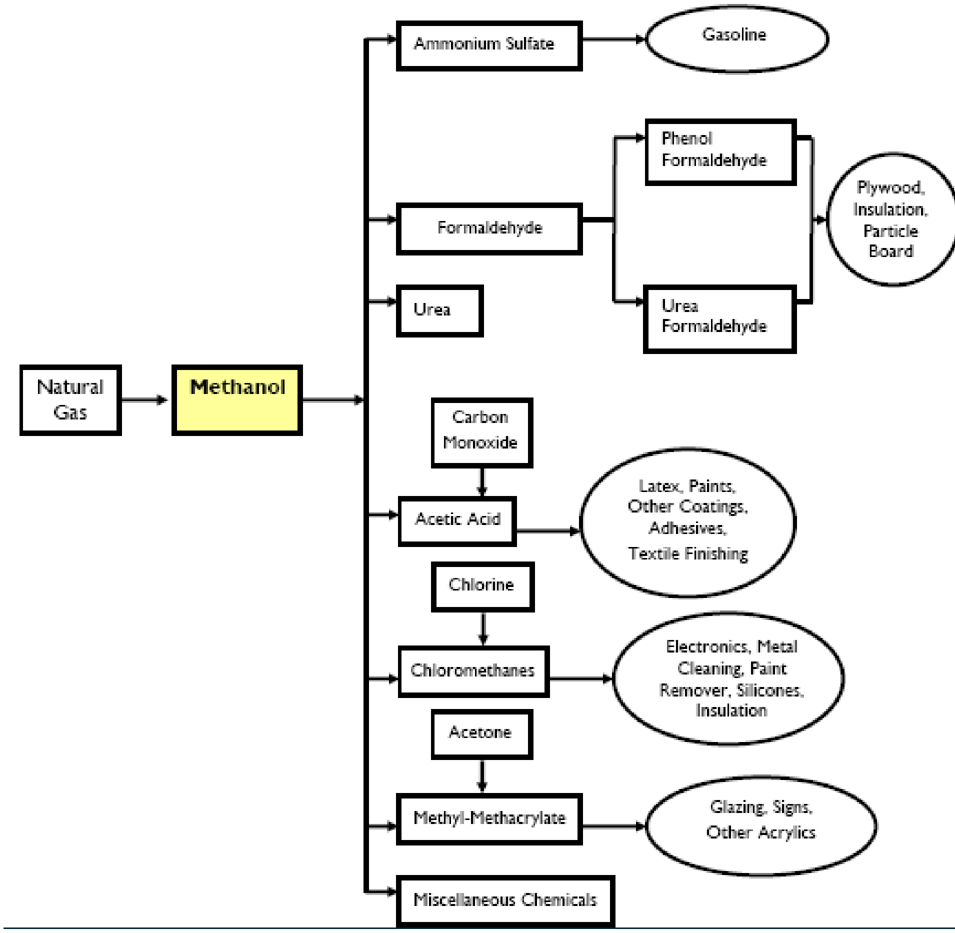
Source: American Chemistry Council

FIGURE 4 Ammonia Chain



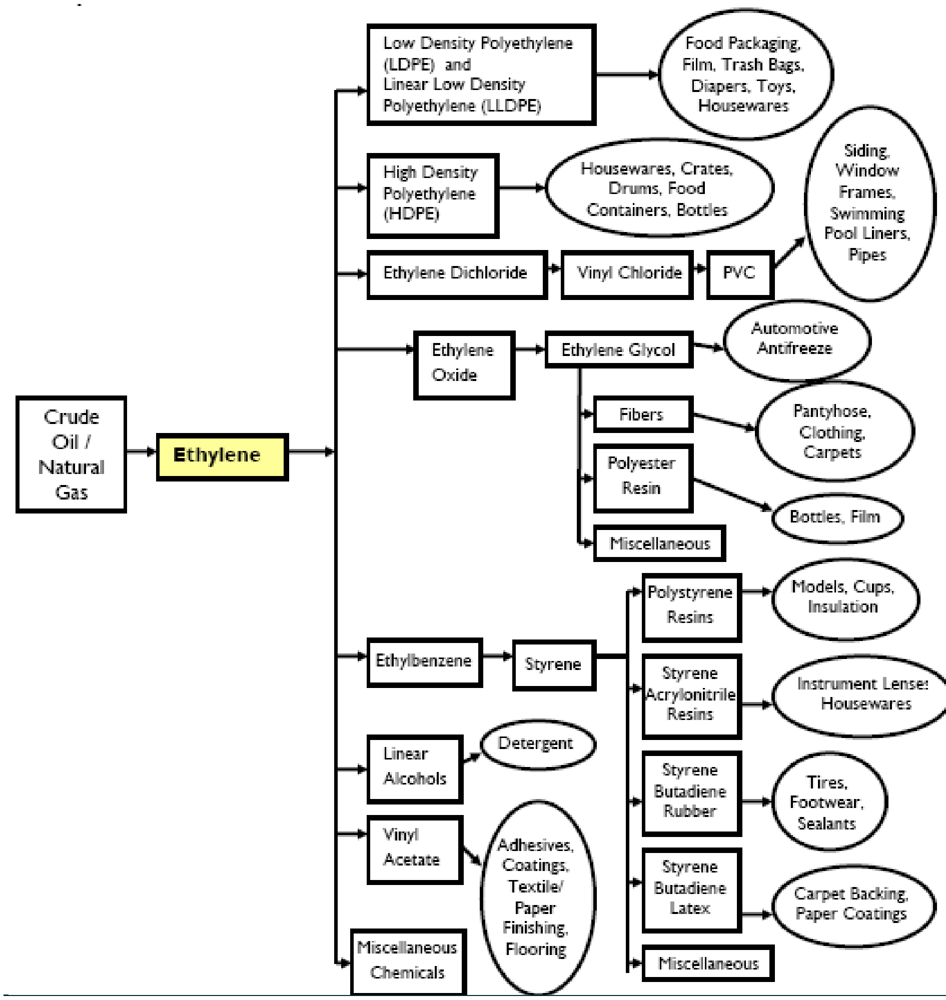
Source: American Chemistry Council

FIGURE 5 Methanol Chain



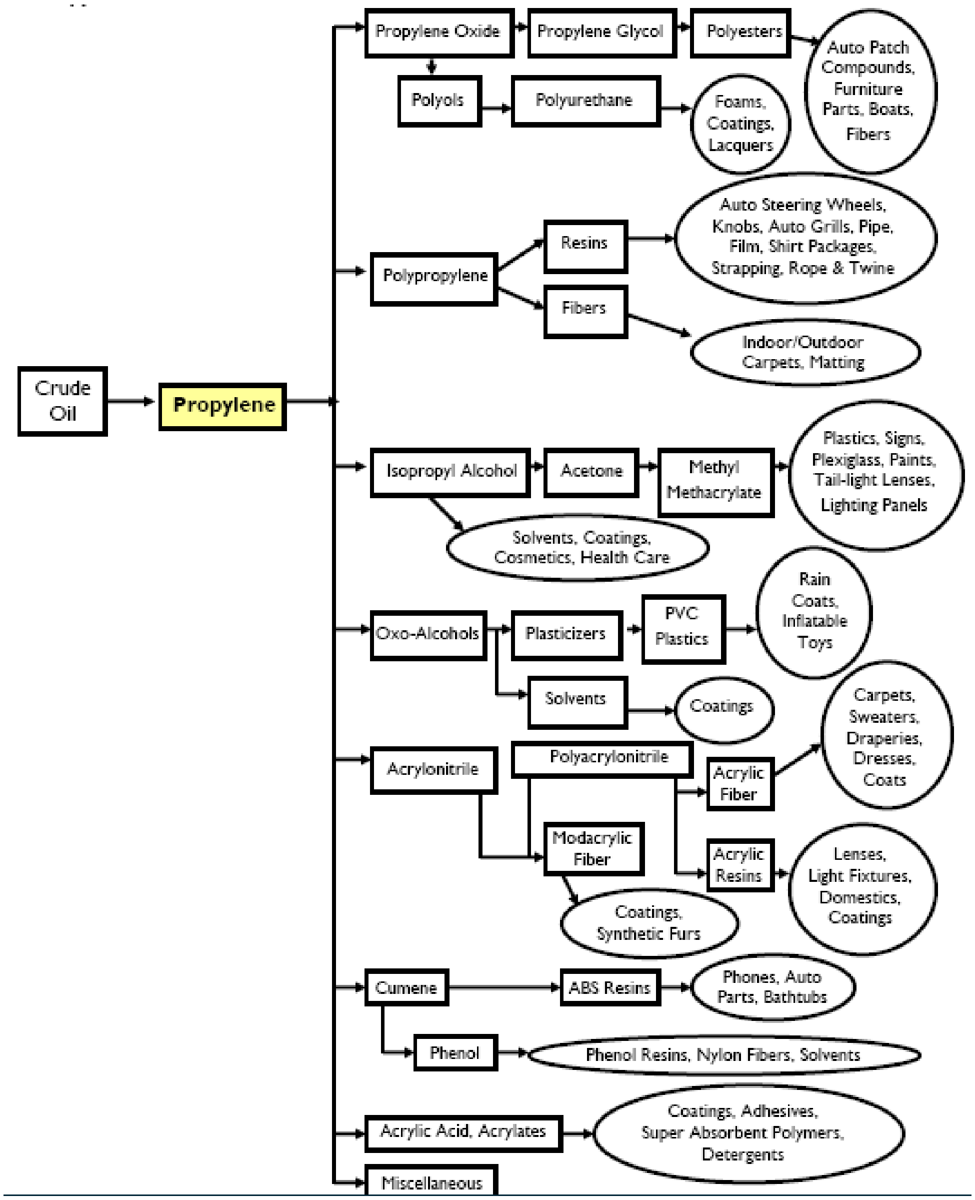
Source: American Chemistry Council

FIGURE 6 Ethylene Chain (Ethylene is the most important basic chemical)



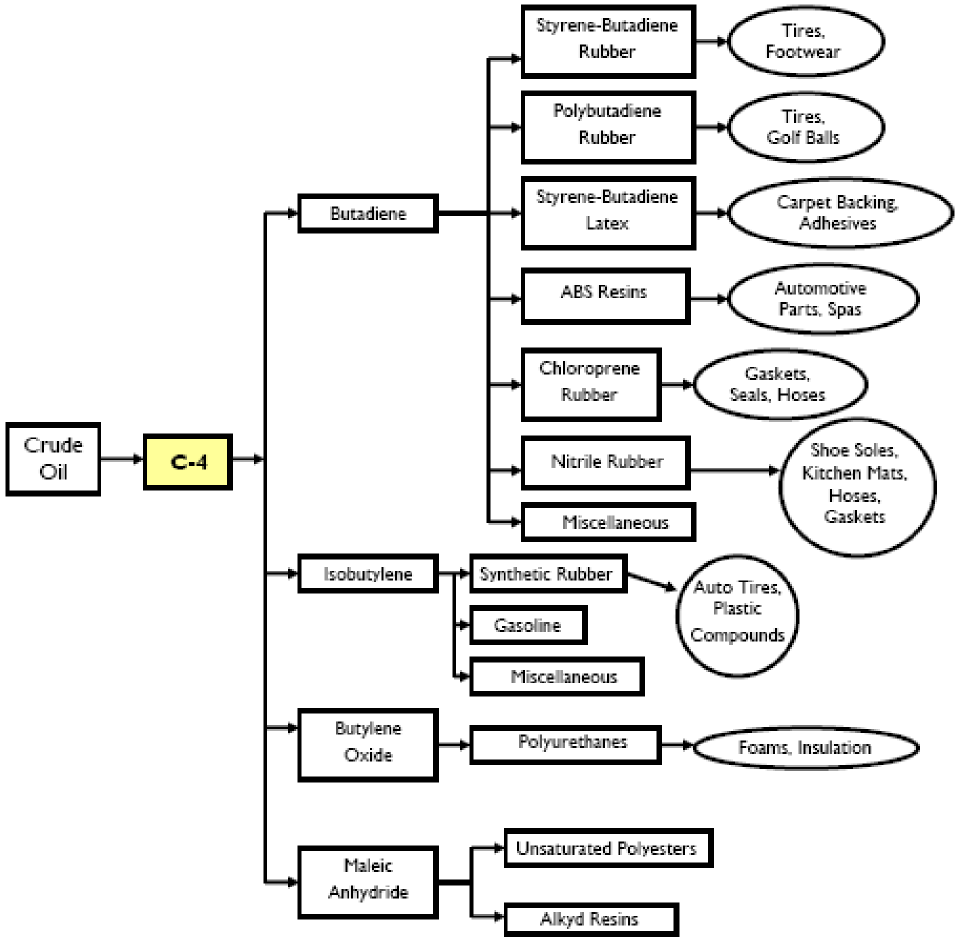
Source: American Chemistry Council

FIGURE 7 Propylene Chain



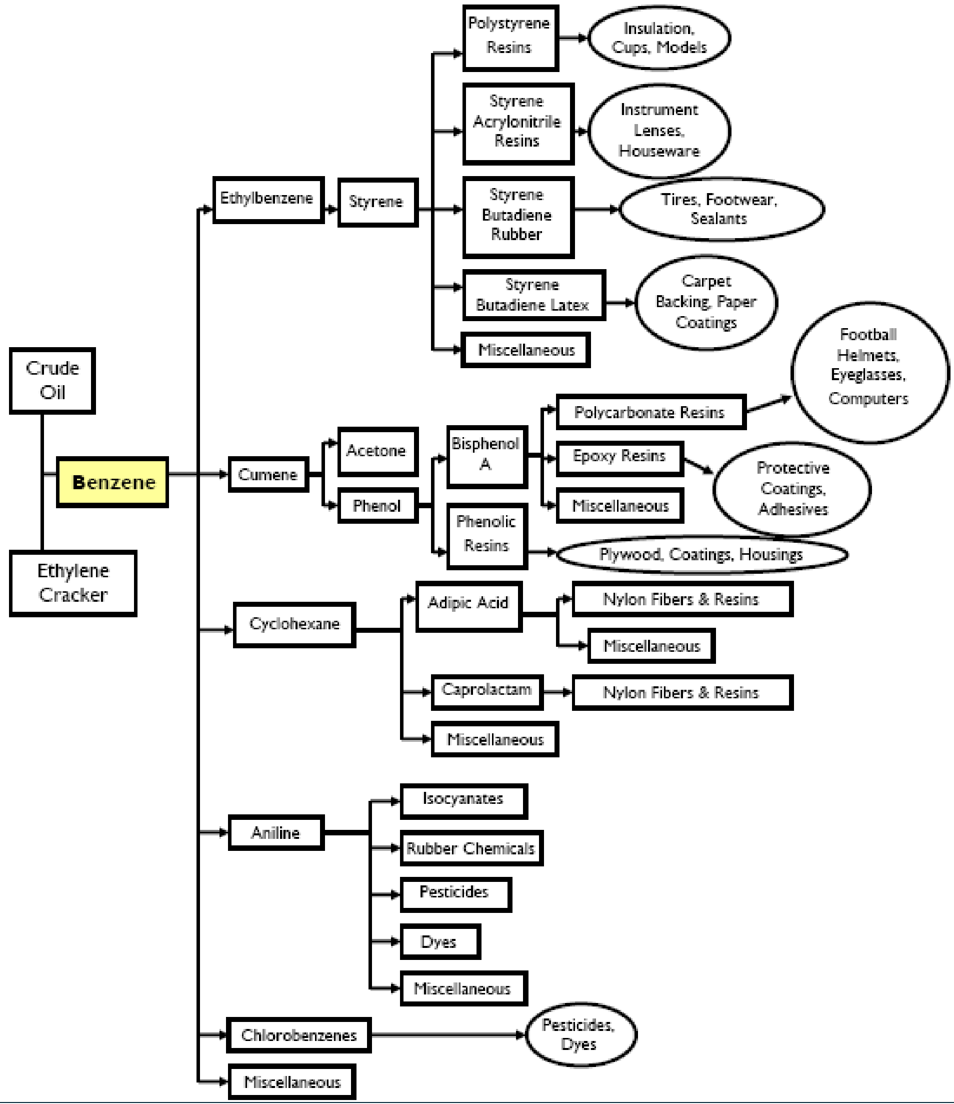
Source: American Chemistry Council

FIGURE 8 C-4 Chain



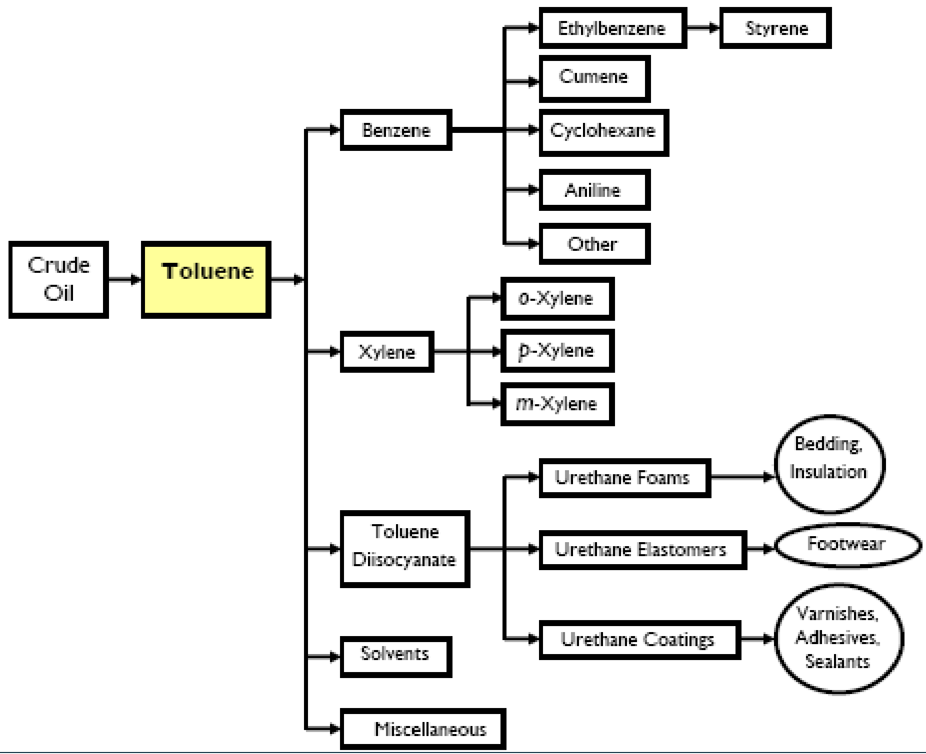
Source: American Chemistry Council

FIGURE 9 Benzene Chain



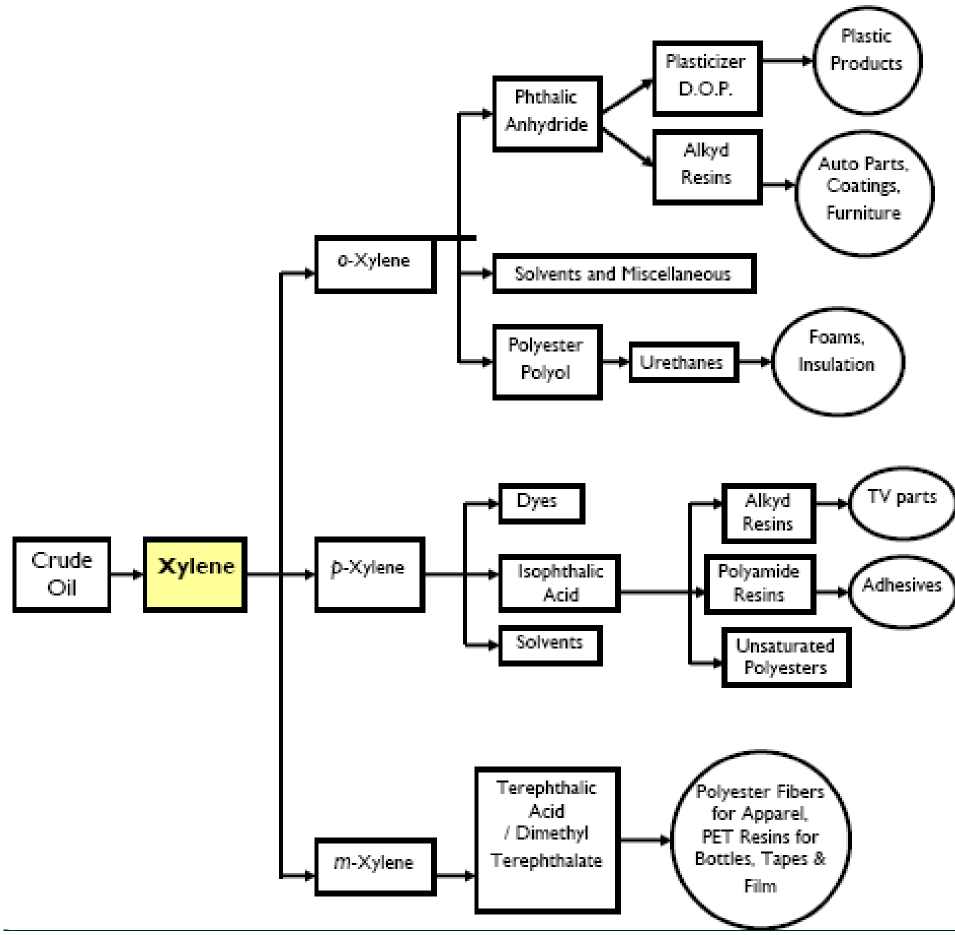
Source: American Chemistry Council

FIGURE 10 Toluene Chain



Source: American Chemistry Council

FIGURE 11 Xylene Chain



Source: American Chemistry Council

Diversified Chemicals

The diversified chemicals market is comprised of companies that produce a diverse range of chemical products. These companies are characterized by a conglomerate business model, and are highly impacted by economic market cycles. Vertical integration is common throughout the group. The lead source of revenue in this sector is base chemicals.

Leading companies include BASF, Dow, Bayer, Du Pont, and Akzo Nobel.

Intangible value issues include operational risks such as worker protection, energy use, and site security. Other sustainability issues, such as environmental regulations and product liability, are emerging as relevant to long-term valuation.

The list of Diversified Chemicals Companies differs depending on the index in question and in all cases the full list is very long. The graphic below is a list of large capitalization Diversified companies rated by Innovest. Each company in the list is backed by a full environmental and social rating. For further information please contact Heather Langsner at hlangsner@innovestgroup.com for copies of profiles.

Diversified Firms Innovest Ratings Universe

BAS-FF	BASF
BAY-FF	Bayer
4208-TO	UBE Industries
AKZA-AE	Akzo Nobel
4005-TO	Sumitomo Chemical Company Limited
4021-TO	Nissan Chemical Industries Limited
4004-TO	Showa Denko KK
DOW	Dow Chemicals Company
DD	Du Pont El De Nemours
PPG	PPG Industries Inc
4182-TO	Mitsubishi Gas Chemical Company Inc
ORI-AU	Orica Limited
EMN	Eastman Chemicals Company
HUN-N	Huntsman Corp.
4188-TO	Mitsubishi Chemical Holdings Corp.
EC	Engelhard Corp.
DGX-FF	Degussa AG
FMC	FMC
HPC	Hercules Inc
4028-TO	Ishihara Sangyo Limited
SIK-EB	SIKA Finanz

Specialty Chemicals

The specialty chemicals market is characterized by high value-added, low volume chemical production. These chemicals are used in a wide variety of products, including fine chemicals, additives, advanced polymers, adhesives, sealants and specialty paints, pigments, and coatings.

The global specialty chemicals market generated total revenues of $577.2 billion in 2005. The leading revenue source for the market is the sale of chemicals for paints and inks, followed by fine chemicals. Europe is the largest specialty chemicals market, generating approximately 35% of global market revenue. Asia-Pacific is an important contributor to the specialty market, and is expected to grow in the future.

The specialty market is extremely fragmented. Consolidation of companies has been a major trend, and is expected to continue. Leading companies include Ciba, Rohm & Haas, Clariant, Shin-Etsu, though together they account for just 5% of global sales.

Within the specialty chemical sector, a company's strength is largely based upon intellectual property and R&D capabilities. Development of new products is crucial, and a constantly updated portfolio of patents is important for maintaining high prices.

Similar to the commodity sector, the specialty sector is affected by high costs of energy and feedstock. Intangible value issues include heightened emphasis on research, customer migration to alternative products, and the impact of regulations on products.

In addition to these market oriented distinctions, the chemical industry is comprised of several major sub-sectors. [In this report, these categories are noted when necessary.]

Subsectors and Other Distinctions

Petrochemicals: Petrochemicals are derived from crude oil, crude products, or natural gas. Petrochemicals are used in the manufacture of numerous products such as synthetic rubber, synthetic fibers (e.g., nylon and polyester), plastics, fertilizers, paints, detergents, and pesticides. It is the basis for most organic chemistry.

Pharmaceuticals: Pharmaceuticals are generally considered a sub-sector of the chemical industry. Information and statistics on the chemical industry may or may not include the pharmaceutical sector, though it tends to be demarcated as a separate category.

Bio-based Chemicals: Bio-based chemicals are products, other than food and feed, that are derived from biomass feedstock. These include green chemicals, renewable plastics, natural fibers, and natural structural materials. Many of these products can replace products and materials traditionally derived from petrochemicals.

Agricultural Chemicals: Total agricultural chemicals sales reached $26,923 million in 2005 and conventional crop protection chemicals reached $12,242 million in 2005. Global shipments of agrichemicals totaled 131.2 billion in 2005. A full environmental and social rating accompanies each company on the following list. Contact Heather Langsner at hlangsner@innovestgroup.com for further information.

Specialty Firms Innovest Ratings Universe

NZYM'B-KO	Novozymes
GIVN-EB	Givaudan N
ECL	Ecolab Inc
4217-TO	Hitachi Chemical Company Limited
ROH	Rohm & Haas Company
CIBN-EB	Ciba Specialty Chemicals
6988-TO	Nitto Denko Corp.
BOC-LN	BOC Group PLC
AI-FR	Air Liquide R
PX	Praxair Inc
APD	Air Products & Chemicals Inc
CLN-EB	Clariant
BVIT-LN	British Vita PLC
ICI-LN	Imperial Chemical Industries PLC
LONN1-EB	Lonza Group
DSM-AE	DSM NV
4202-TO	Daicel Chemical Industries Limited
4631-TO	Dainippon Ink & Chemicals
POT-T	Potash Sask Inc
AGU-T	Agrium Inc
4613-TO	KANSAI PAINT CO
4185-TO	JSR Corp.
YAR-OS	YARA INTERNATIONAL
4205-TO	NIPPON ZEON CO
SIAL	Sigma Aldrich Corp.
4063-TO	Shin-Etsu Chemical Company Limited
IFF	International Flavours & Fragrances
SYNN-EB	Syngenta AG
4091-TO	TAIYO NIPPON SANSO CORP
MON	Monsanto Company
CEM	Chemtura Chemical
MX-T	Methanex
4043-TO	TOKUYAMA CORP
ARJ	Arch Chemicals Inc
CRDA-LN	Croda International PLC
ELM-LN	Elementis
GRA	Grace WR & Company Del
SDF-FF	K+S AG
4272-TO	Nippon Kayaku Company Limited

4114-TO	Nippon Shokubai Company Limited
4203-TO	Sumitomo Bakelite Company Limited
YULC-LN	Yule Catto & Company PLC

There are various international categories and codes to track economic and industry data. Relevant codes for the chemical sector include:

FIGURE 12 International Classification Codes

	Classification System	Industry Code	Sub-sectors
North America	North America Industry Classification System (NAICS)	NAICS 325 – Chemical Manufacturing	NAICS 3251 – 3259
European Union	Classification of Economic Activities in the European Community (NACE)	NACE 24 – Manufacture of Chemicals and Chemical Products	NAICS 24.1 – 24.7
UN	International Standard Industrial Classification of all Economic Activities (ISIC)	ISIC Division 20 – Manufacture of Chemicals and Chemical products	ISIC Group* 201 – 203

Source: Innovest. *Note: these categories are from the latest version of ISIC (ISIC Rev. 4), a revised structure approved by the UN Statistical Commission in 2006.

FIGURE 13 US Industrial Production according to chemical type (index where 2002 = 100)

	2000	2001	2002	2003	2004	2005
Industrial Production (index where 2002=100)						
Total Business of Chemistry	96.0	94.3	100.0	99.7	102.8	102.5
Basic Chemicals	105.5	95.0	100.0	98.1	103.5	96.7
Inorganics	95.7	91.7	100.0	98.7	100.7	99.0
Alkalies and Chlorine	76.5	64.4	100.0	105.8	111.3	106.9
Industrial Gases	84.6	83.6	100.0	106.0	107.9	104.5
Inorganic Pigments	92.9	86.1	100.0	99.0	106.0	100.1
Acids	98.6	101.6	100.0	100.8	102.6	99.5
Other Inorganics	106.2	112.0	100.0	96.3	98.8	102.1
Petrochemicals & Derivatives	109.2	96.2	100.0	97.8	104.5	95.9
Organics	110.3	95.1	100.0	98.4	105.8	95.2
Synthetic Materials	108.0	97.5	100.0	97.2	102.9	96.8
Plastic Resins	105.6	94.5	100.0	96.1	102.2	95.9
Synthetic Rubber	105.1	95.4	100.0	94.9	100.8	95.1
Man-Made Fibers	109.5	89.0	100.1	104.3	112.3	99.9
Agricultural Chemicals	120.0	111.5	100.0	103.1	106.3	102.5

Fertilizers	98.1	88.4	100.0	94.0	97.0	93.7
Crop Protection	110.3	102.6	100.0	110.1	113.4	118.3
Specialties	110.0	99.5	100.0	99.8	104.8	107.9
Coatings	101.0	98.8	100.0	96.4	101.3	102.9
Other Specialties	113.5	99.8	100.0	101.2	106.1	109.8
Pharmaceuticals	87.3	93.9	100.0	102.2	105.0	106.0
Consumer Products	87.8	89.5	100.0	94.6	93.2	98.9
Addenda						
Chemicals, excluding Pharmaceuticals	102.3	94.6	100.0	97.9	101.2	100.0
Basic & Specialty Chemicals	106.8	96.4	100.0	98.6	103.9	100.1
Adhesives & Sealants	109.6	107.6	100.0	105.2	122.3	124.5

Source: US Federal Reserve Board and ACC analysis. Notes: A measure of volume as calculated by ACC

NOTES ON SECTOR DEFINITIONS

The act of defining the sector in order to prioritize organizational efforts presents a complex challenge. We offer here a few informal parameters to aid in rationalizing a focus.

1. **Both organic and inorganic chemicals are present on the US toxic release inventory. While those with little familiarity with chemistry might be inclined to associate a higher level of toxicity to inorganic chemistry, this would be incorrect. Note that benzene and polycyclical aromatic hydrycarbons are organic chemicals that have ecotoxicological risks associated with them.**
2. **Even relatively benign chemicals/materials in large amounts present risk**
3. **Volume of production is not necessarily a useful indicator. Increasingly, regulatory and activist entities have begun to concentrate on more esoteric chemicals. For example not all the chemicals listed on the OSPAR priority roster are high volume production items: http://www.ospar.org/eng/html/welcome.html.**
4. **Nanomaterials should be regarded as entirely new substances which do not interact with the environment according to macro scale physics. Nanoengineered particles have a higher surface to mass ratio. Hence volume is most certainly not the primary consideration in evaluating potential ecotoxicity issues for engineered nanomolecular structures. Particle size, chemical composition, and surface functionality are more pertinent aspects to consider.**

3 Global Market and Production

Global production of chemicals has increased from 1 million tons in 1930 to 400 million tons in 2005. There are approximately 100,000 types of chemicals produced today[5] with 10,000 of them marketed in volumes greater than ten tons. The US is currently the top producer, producing 70,000 different chemical substances and generating $550 billion a year[6].

Global production is highly concentrated geographically, with the EU, US, Japan, and China accounting for three quarters of global production. An estimated 30% of chemical production is traded across borders. Because of the diversity of products, many countries are both significant importers and exporters.

FIGURE 14 Global Chemical Sales (billions of dollars) 2005

Global Chemical Sales (billions of dollars)	2005
United States	566.8
Canada	49.3
Mexico	35.5
North America	651.6
Brazil	78.0
Other	90.9
Latin America	168.9
France	107.6
Germany	151.9
Italy	108.6
United Kingdom	89.1
Other Western Europe	233.5
Western Europe	690.7
Russia	39.2
Other Central/Eastern Europe	51.1
Central/Eastern Europe	90.3
Africa & Middle East	107.8
Japan	253.2
China	264.1
India	67.2
Korea	93.0
Other East Asia	123.8
Other Asia/Pacific	50.0
Asia/Pacific	851.3
Total World	**2,560.6**

[5] [5] US Department of Commerce, American Chemistry Council. "Guide to the Business of Chemistry 2006".
[6] ibid

FIGURE 15 Figure 15 Global Chemical Shipments, By Region Origin/Export 2005

Region	($ billion)
North America	**628.7**
United States	558.0
Canada	40.9
Mexico	29.9
Latin America	**144.5**
Brazil	69.5
Puerto Rico	45.0
Other Latin America	30.0
Western Europe	**810.2**
France	120.2
Germany	190.3
Italy	95.4
United Kingdom	96.8
Belgium	48.5
Ireland	43.0
Netherlands	49.8
Spain	53.8
Sweden	18.3
Switzerland	49.5
Other Western Europe	44.6
Central/Eastern Europe	**88.4**
Russia	40.9
Poland	12.7
Other Central & Eastern Europe	34.7
Africa & Middle East	**90.6**
South Africa	13.0
Israel	14.7
Saudi Arabia	13.8
Turkey	16.3
Other	32.7
Asia/Pacific	**798.3**
Japan	269.6
China	222.7
India	68.4
Korea	97.7
Indonesia	14.3
Singapore	18.4
Taiwan	46.0
Other East Asia	29.2
Australia	21.9
Other Asia/Pacific	9.9
Total World Shipments/Value of Output*	**2,560.8**

*Note: Includes pharmaceuticals

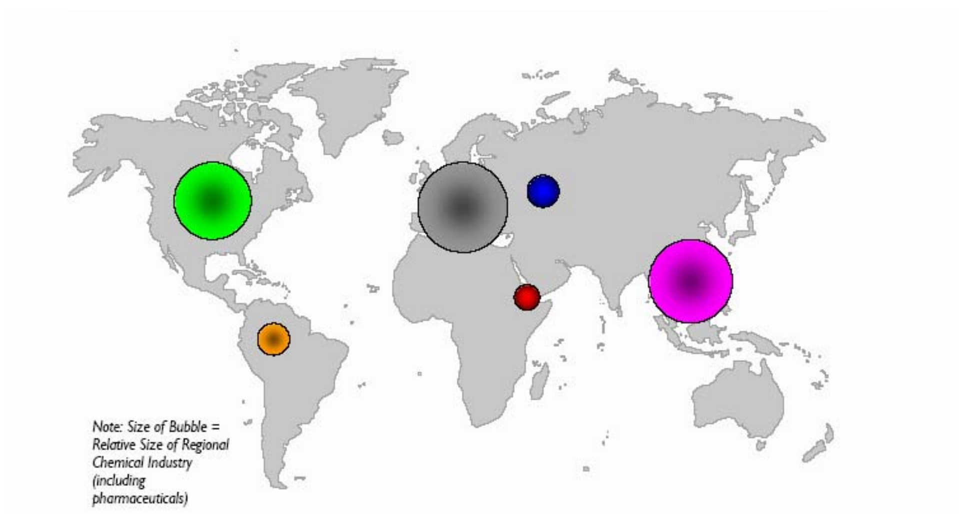
Source: ABIQUIM, ANIQ, CCPA, CEFIC, JCIA, VCI, Bureau of the Census, Eurostat, Statistics Canada, United Nations, American Chemistry Council estimates

FIGURE 16 Global Chemical Shipments by Industry

Product	($ billion)
Industrial Gases	48.9
Inorganics	106.1
Bulk Petrochemicals & Organics	450.7
Polymers, Synthetic Rubber & Man-Made Fibers	387.2
Basic Chemicals	**992.9**
Adhesives & Sealants	32.7
Coatings	111.6
Other Specialties	360.8
Specialties	**505.1**
Pharmaceuticals	**648.4**
Fertilizers	92.4
Crop Protection	38.8
Agricultural Chemicals	**131.2**
Consumer Products	**283.1**
Total World Shipments/Value of Output	**2,560.7**
Excluding Pharmaceuticals	**1,912.3**

Source: ACC estimates

FIGURE 17 Size of Regional Business of Chemistry



Source: The American Chemistry Council

The global market is expected to continue to grow, mainly due to the expansion of the Asia-Pacific region, which could potentially take over the US and Europe as the main centers of production.

Global sales are estimated at $1.7 trillion for chemicals, and $330 billion for pharmaceuticals. Chemical companies around the world, however, are struggling to cope with the current high costs of raw materials and energy.

There are currently 120 chemical plants that cost $1 billion or more under construction; only one of those is being built in the US [7]

[7] Interview, Chemical Markeet Reporter . September 2006.

REGIONAL TRENDS IN CHEMICAL PRODUCTION

Though long-term prospects for the US chemical industry are generally promising, foreign trade and investment have become increasingly important for US companies. Demand for chemicals in Asia, the Middle East, and Latin America continues to grow, and many US chemical companies are building production facilities overseas.

US Trade and Production

The chemical industry is the largest exporter in the US Historically, the industry has maintained trade surpluses, but since the early 2000's the trade balance has been negative. (This includes pharmaceuticals). This trade deficit can be attributed to the rise in energy costs, which reduce the competitiveness of the US industry and a decline in manufacturing in the US, as many producers shift to lower-cost regions such as Asia.

While US chemical exports rose in 2005, partly due to higher selling prices as a result of higher energy costs, imports of chemicals into the US continued to gain. Trade surpluses were maintained for organic chemicals and polymers, but trade deficits existed for specialty chemicals and pharmaceuticals. [S&P]

FIGURE 18 US Direct Investment Abroad (USDIA) and Foreign Direct Investment in the US (FDIUS) in the business of chemistry ($ million)

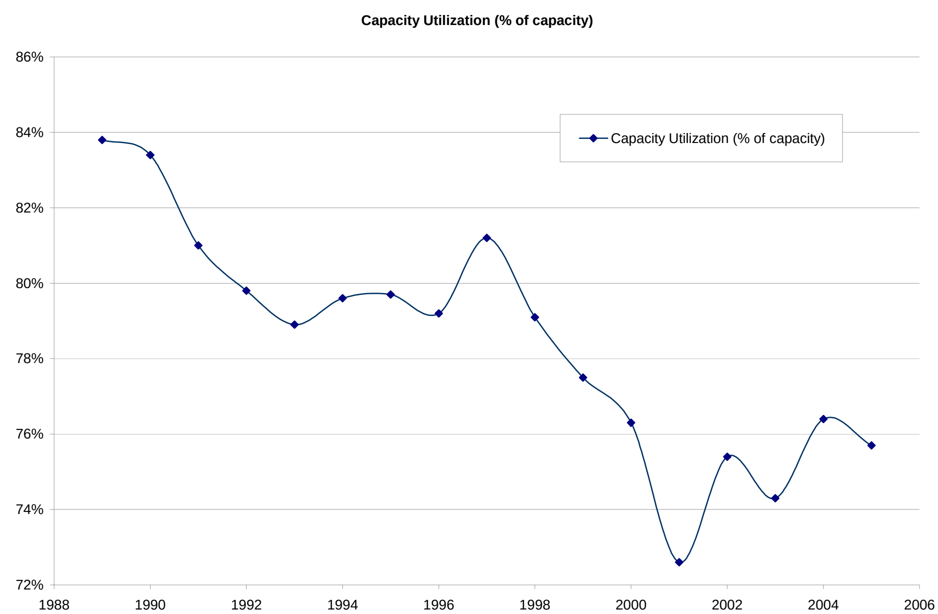
	2000	2001	2002	2003	2004	2005
USDIA	81,727	79,186	82,543	91,435	99,435	109,354
FDIUS	120,413	128,630	123,341	136,466	138,081	151,624

Source: US Bureau of Economic Analysis

Lost Production in the US and other Developed Countries

While the US is still the largest exporter, the region's primacy in chemicals manufacture may be on the wane. High energy prices have caused the manufacture of semi-finished and finished goods to low cost centers such as China. This is resulting in so called "lost manufacturing" by the US Chemical sector. The estimated cumulative opportunity losses (based on trade losses) for the chemical sector over 10 years consist of $188bn in chemical sales, including $50bn in sales from the top seven thermoplastic resins $40bn in capital expenditures in chemicals, including $5bn for new thermoplastics capacity $30bn in chemical research and development expenditures $43bn in US government tax revenue from chemical companies $3bn in charitable contributions from chemical companies and 157,000 chemical industry-related jobs[8].

FIGURE 19 Capacity Utilization in the Business of Chemistry (% of capacity)



Source: Federal Reserve Board

Lost Manufacturing Effect on Petrochemicals: The US organic base chemicals industry is becoming increasingly global, as it is in Europe. More funds are being allocated for overseas expansion in petrochemicals than for domestic output. This is primarily attributable to the movement of commodity industrial consumers of plastics and fibers to regions where the cost of labor is low. Also, Middle East supply points give producers a net cost advantage in serving Asian markets.

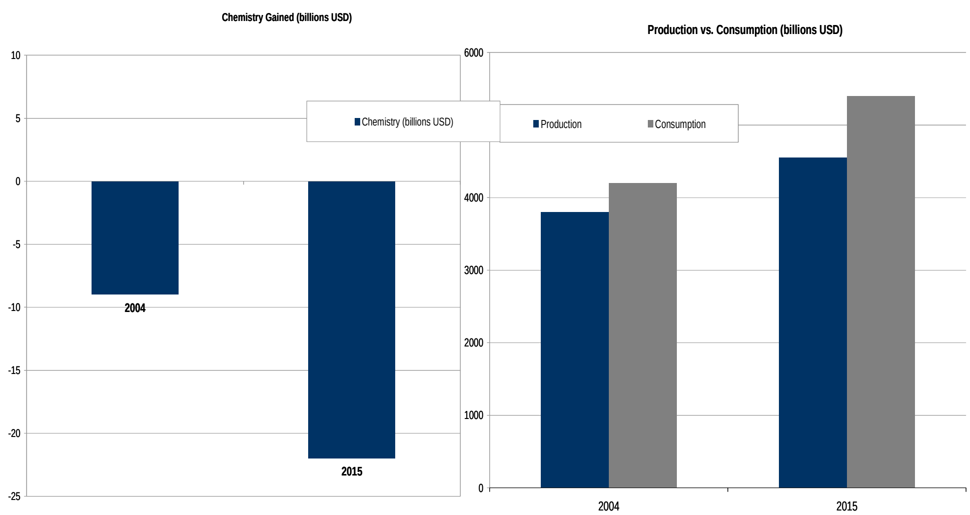
Currently no new ethylene (the most important base organic chemical) plants are scheduled for completion in the continental US. This is in contrast with Europe, where there are a few ethylene expansions planned or in progress in the next two-to-four

[8] American Chemistry Council ACC, Innovest research

years.[9]

By 2015, about 11m tons of the top seven thermoplastics will be imported instead of produced locally.

FIGURE 20 Lost Manufacturing in the United States



Source: Chemical Market Reporter

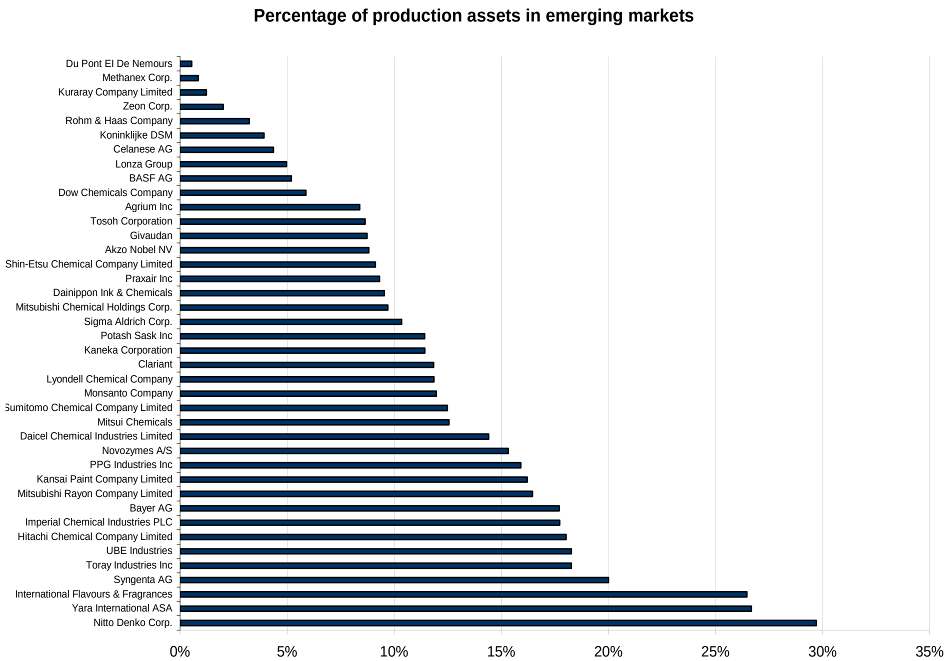
China

Is it all about China and to a lesser extent India?

China led the global growth in chemical demand over the past two years. Western multinationals are currently shifting chemical production to China, and Chinese companies are increasing their capacity to try to meet the demand of the burgeoning Chinese based market for chemicals for production of consumer goods, industrial and agricultural chemicals. The table below reflects the level of production assets for reporting firms in the Innovest analytical set. China represents the majority portion of these assets for most of these firms.

[9] "Lost Manufacturing".Chemical Market Reporter. ICIS Chemical Business America. 6 November 2006.

FIGURE 21 Percentage of Production Assets in Emerging Markets Global Chemicals Sector 2005/06



Source: Innovest, Thomson/FirstCall
Note: Companies do not specifically report China sales in a useable data format

Nevertheless, China is expected to continue to be a major market for chemicals produced by other countries.

In 2005, China became the third largest producer of chemicals, after the US and Japan.

Nevertheless, China is expected to continue to be a major market for chemicals produced by other countries. According to KPMG, "even with a huge amount of new capacity planned for the next 5-10 years, China will continue to be dependent on imports of such bulk goods for the foreseeable future." The American Chemistry Council (ACC) forecasts that over the next 10 years, annual output growth of China's chemical industry will average around 10%.

Leading Chinese chemical companies include Sinopec, PetroChina, Sinochem, China National Offshore Oil Corp. (CNOOC), and China National Chemical Chemical Corp. (ChemChina).

The leaders in the sector, Sinopec and PetroChina, are moving forward to expand their olefins and derivatives capacity. This is expected to double China's ethylene capacity, though China will still continue to import large amounts of ethylene and derivatives. Half of the growth in new ethylene capacity in the next five years will be in the Middle East and one-third will be in Asia, Mansour Al-Kharboush, vice president, shared services, and chairman of Sabic India said at the 8th Indian

Petrochem conference in Mumbai. "By 2010, ethylene production in Iran and the Gulf Cooperation Council (GCC) countries is estimated to account for about 20% of the global capacity," Al-Kharboush said[10].

It is expected that future projects will eventually rely less upon foreign investment.

While several joint ventures in ethylene have been commissioned by multinationals such as Shell, BASF, and BP, it is expected that future projects will eventually rely less upon foreign investment. According to KPMG, production of bulk commodities will be more difficult for foreign companies. However, foreign investment is expected to play a large role in the specialty chemicals sector, since the Chinese government is initiating a new focus on innovation as opposed to industrial production. China appears to be in the midst of a shift in emphasis from manufacturing to innovation. In June 2006, the Chinese government unveiled an ambitious long-term plan to move from a manufacturing economy to an innovation-based one. China is set to boost R&D expenditure to levels comparable to that of the US and Japan. Currently, China devotes only 1.2% of its GDP to R&D spending, and the government has announced its intention to boost that figure to 2% by the end of the decade and 2.5% by 2020. By then, China will be spending $110bn/year on R&D, putting the country at a level comparable to the US and Japan. According to an executive summary conducted by the Economist Intelligence Unit, an increasing number of companies are viewing the Chinese Government's active support for R&D as China 's greatest asset. In addition to government support, the low-cost environment and skilled researchers are what make China an R&D destination for multinationals. However, despite these incentives intellectual property concerns persist. China has yet to tackle the copycat culture and develops its financial system, two major obstacles that may hinder the shift.

While we state that China will continue to be an importer of chemicals, Innovest analysis shows that production of certain chemicals is already at capacity in China and there is even overcapacity in some regions for specific items such as PVC and related products. The Chinese government has begun implementing a quota system in certain regions.

To counter the high costs of oil and gas, steps have been taken to develop chemicals from coal – China’s cheapest and most abundant natural resource. The government is encouraging the development of new technologies to make this a cleaner, more energy efficient process.

Examples of current global investment in China:

» **GE Plastics signed a deal (summer 2006) with PetroChina to create a world-scale polycarbonate (PC) resin manufacturing joint venture.**

[10] Chemical Market Reporter News Brief, 16 November 2006

» **DuPont reports double-digit growth in China and plans to continue investment. According DuPont's head of China operations, "China is our number one focus in the world for investment."**

» **Degussa recently opened a polyesters and colorant plant at the Shangai Chemical Industry Park.**

Key issues for global chemical companies working in China

NEW ENVIRONMENTAL REGULATIONS

The mad rush to China may not be a winning proposition for all companies, and in fact, is turning out to be more costly than expected. Several firms are now facing increased operating costs due to new regulatory developments taking place in China, which is laying the foundation for increased environmental oversight for domestic and foreign-owned firms. This is resulting in regional energy use and production targets, and other grand initiatives. Several companies are already feeling the increased intensity. For example, the commodity firm Mitsui was among the first targets of dioxin-related cleanup in China.

PVC

In order to head off energy use and environmental issues, in June 2006, the Chinese State Environment Protection Administration (SEPA) proposed that the Inner Mongolia province should cut its targets of PVC production to 5 million tons per each. Targets were also set for coal and energy generation. There is the potential for this to impact other regions, considering that the Chinese government has committed to invest more than $85 billion to improve the environment by promoting clean energy sources.

WATER TREATMENT

With approximately 90% of China's cities and 75% of its lakes suffering from some degree of water pollution, a multitude of chemical companies are flocking to provide water treatment chemicals and services in various forms. Market driving forces include the recently issued governmental five-year plan, which aims to have 60% sewage treatment in bigger cities by 2010. Additionally, the 2008 Olympic Games in Beijing and the 2010 Shanghai World Expo pose as pressing incentives to improve environmental conditions in China. Chinese demand for water treatment products is currently expected to increase by about 14% per year. Large players in China's water treatment market include Dow and Ciba Specialty Chemicals. Dow recently expanded into the market with its acquisition of Zhejiang Omex Environmental Engineering (OEE), a company which has provided design engineering and installation for high-purity water facilities throughout China since 1995.

India

India is borrowing the special economic zone (SEZ) concept from China in order to boost business in areas such as oil refining, petrochemicals and textiles. Gujarat, in the west, has been one of the most active areas in attracting foreign and local companies. It claims to have 68% of the country's petroleum, chemical and pharmaceutical production, 21% of India's chemical output, and the highest share in polymer production[11].

Public interest groups and other organizations are concerned about the sovereignty of the SEZ model. Business World recently reported that buried in the SEZ Act of 2005 is a stipulation that zones are exempt from any central government act or other regulations. Plus, industries in SEZs are under no obligation to conduct environmental-impact assessments, or hold environmental public hearings.

Middle East

According to Innovest sources, the Middle East is slowly emerging as a chemical production leader because of competitively priced feedstock, and its close proximity to growth markets such as India and China. Most of the production is petrochemicals. For example, in 2005, the UAE's petrochemical industry grew to account for 6% of the total GCC production.Among GCC countries, Saudi Arabia accounted for 76% of the total regional petrochemical production, followed by Qatar (11%), Kuwait (6%) the UAE (6%), and Bahrain (1%)[12].

At a recent industry conference leading analysts urged chemicals producers in the region to begin developing beyond basic petrochemicals production. More complex chemistries are needed in order to serve nearby markets. ICIS Chemicals Business America states that approximately 75% of petrochemical companies in Dubai were engaged in manufacturing other chemicals, which include pesticides, agrochemical products, paints, varnishes, pharmaceuticals, medicinal chemicals, detergent and cosmetics this year[13].

[11] Kovac, Matt. “View from India” News and Analysis. Chemical Market Reporter. 6 November 2006.
[12] Anuradha Rao.”Petchems dominate Middle East investment”. *ICIS Chemical Business America* . 18 December, 2006
[13] Anuradha Rao.”Petchems dominate Middle East investment”. *ICIS Chemical Business America* . 18 December, 2006

Organic chemicals that are manufactured in, or imported into, the United States in amounts equal to or exceeding 10,000 pounds per year are subject to reporting under the TSCA IUR. Reporting is required every four years.

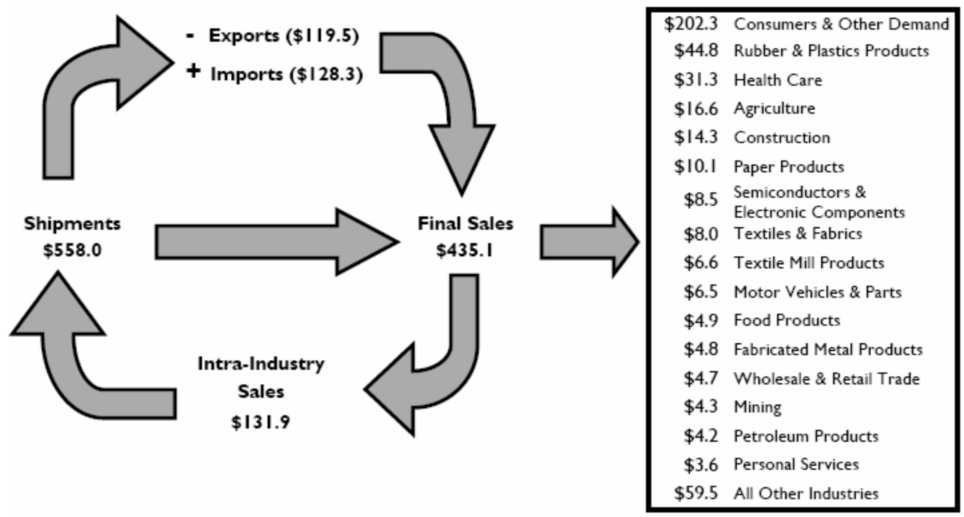
The HPV Challenge Program Chemical List consists of all the HPV chemicals reported during the 1990 IUR reporting year. Inorganic chemicals and polymers, except in special circumstances, were not subject to the IUR reporting requirements, although a number were reported in error. The HPV Challenge Program Chemical List contains about 2,800 chemicals.

PROFITS

Profits: Where does the chemical industry make the most money? Which products have the highest profit margins? Where do they see high profit growth?

Chemicals and pharmaceuticals are fundamental to the all manufacturing industries. A breakdown of the US chemical business illustrates the range of industries to which the chemical sector provides its products.

FIGURE 22 US Business of Chemistry, 2005 ($ billions)



Source: US Census Bureau data and American Chemistry Council (ACC) analysis

Specialty chemicals, including pharmaceuticals, are the most profitable segment of the industry. Commodity pricing is also a factor in evaluating high profit centers.

FIGURE 23 Global Chemicals Market Segmentation: % Share by Value, 2004

Category	% Share
Base Chemicals	39%
Pharmaceuticals	26%
Specialty & Fine Chemicals	23%
Consumer Chemicals	12%

Source: Datamonitor

The rise in prices was a key factor driving increases in the value of shipments for 2005. The rise in shipments translated into an increase in company sales in most cases, and this, in addition to cost-cutting at many companies, led to higher earnings and profitability.

MANUFACTURING

Industrial customers are major users of chemicals, and the strength of the manufacturing sector has a significant impact on the chemical sector. About half of the output of the chemical industry goes to US manufacturing companies, to be used as raw material in production processes. According to S&P, the long-term shift of production companies from the US to lower-cost regions such as Asia will continue to negatively impact the US chemical industry.

CONSTRUCTION

The residential construction market is a major consumer of chemicals. The construction industry is responsible for 3.4% of all chemical purchases in the US, making it the fourth largest consumer of the US business of chemistry. Chemicals comprise approximately 17% of all materials used in new construction. Home construction and buying consumes synthetic materials such as pipes and siding, manufactured from plastics. Construction stimulates demand for appliances, carpeting, furniture, and paints – also produced from chemicals. The strength of the construction industry directly impacts the strength of the chemical industry.

AUTOMOBILES

Car manufacturing consumes a significant amount of chemical products in the form of plastics, rubber, fibers, and paint. Every automobile contains over $2,000 worth of chemical processing and products. Most of the major Diversified chemical firms serve the automotive sector in the areas of specialized coatings and plastics. In the case of firms like Akzo Nobel and DuPont, the automotive sector is the primary client for those divisions.

FORCES FOR CHANGE IN THE INDUSTRY:

Forces for change in the industry. Trends in the chemical industry include consolidation, production shifting away from the US, Europe, and Japan to other regions, increasing prices for feedstocks, increasing regulation, and growing demand for green chemicals.

What are the significant forces shaping the chemical industry today and how can they be harnessed to move the industry to green chemistry?

Energy

The price of crude oil and particularly natural gas have always represented a material concern for the sector but last year's volatility pushed the envelope for several of the companies covered in this analysis. Elevated energy prices have contributed to layoffs and diminished profits. High energy prices not only increase the cost of operation but generally slow down economies. This issue is so critical, that the CEOs of several of the major players in the industry were collectively imploring the Bush Administration to adopt an Energy Policy last year that would allow sector leaders to provide investors with some assurances about the future profit potential of chemicals production. Moreover, the companies themselves are increasingly aware of the importance of developing environmentally sound capacity to deal with energy price fluctuations over the long-term.

In the US, the chemical industry accounts for almost 7% of total energy use. Major energy sources are petroleum and natural gas, and about 50% of total energy consumption goes to raw material use. According to the ACC, in 2005 the US chemical industry spent $63 billion on fuel, energy, and feedstock (up from $51 billion in 2004).

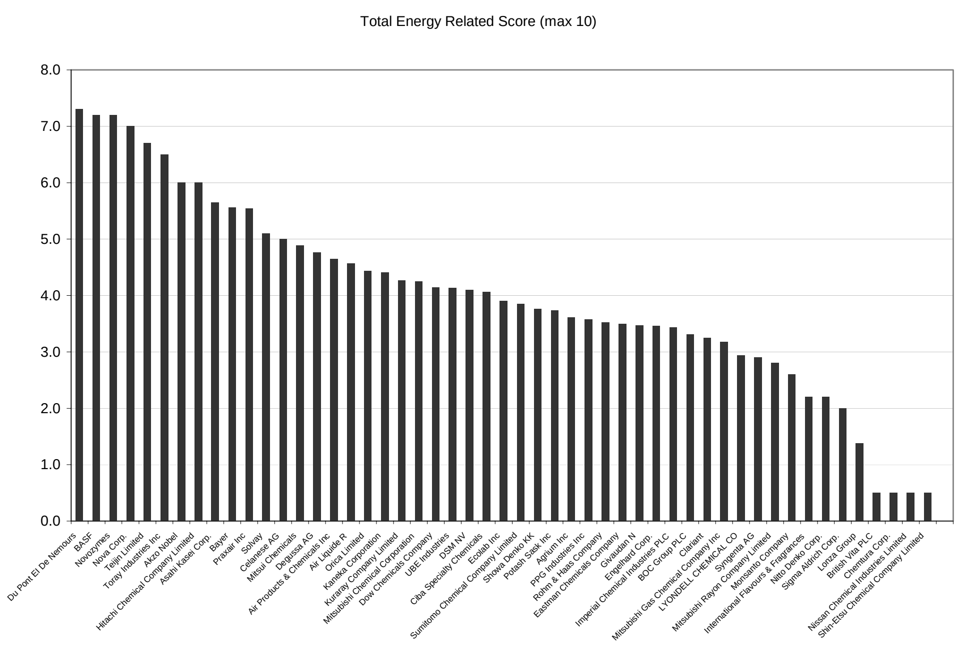
In Europe, members of the European Chemical Industry Council account for approximately 12% of all EU energy demand. Over the past decade energy use for the chemical sector as a unit of production has been steadily increasing; however, the carbon intensity of energy use is generally declining.

The International Energy Agency estimates that energy related costs may represent approximately 7-15% of net income for a given chemical company depending on the specific nature of its operations or in some special cases, accounting for up to 85% of production costs.

Energy use per unit of production was on the rise for most companies in the sector. The American Chemistry Council predicts that feedstock unit costs and other energy costs will remain at high levels through 2007. Companies face a 12.4% increase in feedstock costs and operating energy costs will increase by 24.9%. Dow's energy efficiency target for 2005 was the reduction of 290 trillion BTUs – equivalent to California's annual residential electricity use. DuPont has estimated its fuel savings at more than $2 billion since 1990 due to conservation and improved product yield. Twenty percent of Showa Denko's energy mix is derived from hydroelectric power. In general, many of the chemical companies we track are having difficulty meeting their annual energy use reduction targets and haven't been meeting them for several years.

Companies typically rely on hedging and fuel switching in order to adjust for volatility. These are near-term strategies for managing exposure to energy risk in the sector. We wanted to know whether companies find it economically efficient to plan for longer term scenarios given a certain intensity of process. We selected 17 companies that we categorized as having high energy intensity ratings. They all responded that they do indeed find it necessary to plan for the long term which is why some of them invest in on-sight co-generation for example. Approximately 9 companies include renewable energy technology into their long-term energy risk management strategies. Japanese firms typically apply more quantitative rigor in demonstrating to shareholders the value from investing in process enhancements. For example, Toray states that it reduced energy costs by ¥658 million ($5.7m USD) in 2004. Hitachi saved ¥290 million ($2.5m USD) in 2005.

FIGURE 24 Energy Performance of Select Companies, 2005



Note: (Score 10= good performance). Scores are an aggregate of quantitative and qualitative factors including energy related greenhouse gas emissions normalized by sales among other measures. Source: Innovest

Globalization

World trade is an important element of globalization. Historically, many of the industrialized developed nations have maintained trade surpluses in chemicals.

Western Europe is by far the largest exporting block; Japan maintains a modest surplus as well. Asia-Pacific runs a large deficit in chemistry trade, and has been traditionally followed by Latin America, Africa, and Central & Eastern Europe. A major development over the last five years has been the erosion of North America's trade surplus to what is now the third largest deficit position among regions. According to S&P, world trade in chemicals (exports and imports among countries) grew more than twice as fast as global output during the 1990s. More than a 1/3 of total global production is currently traded internationally.

In the US, chemical sales are expected to grow about the same rate of the domestic GDP. Foreign trade and investment are becoming increasingly important for the US industry as demand from chemical markets outside the US and Europe grows, particularly in Asia.

Many US and European companies are investing in building new production sites closer to the growing emerging markets. In 2004, the US chemical industry invested about $10 billion abroad (about double the level of ten years earlier). In addition, many of the industry's US-based custumers are moving their operations overseas where costs of production are lower.

Elevated feedstock prices and rapid growth of Asian markets have caused many companies to expand production to China, Malaysia, Singapore and other low-cost locations. This has implications for a variety of atypical operational and business factors that can impact performance. For example, a tightening of environmental regulations coming online in China may increase production costs in a market previously considered facile on such requirements.

US companies have recently invested in, or are seriously considering, joint-ventures throughout the world. Major projects include:

- **Dow - Kuwait, Oman, Malaysia, Thailand**
- **Exxon Mobil - Singapore, China, Qatar**
- **Chevron Phillips Chemical - China, Qatar, Saudi Arabia, China, Singapore**

Consolidation

Sector experts are saying that the increase in mergers that began in 2006 is likely to continue in 2007. Apparently the sector is undergoing its third major surge in M&A activity similar to those in the late 1980s and in the late 1990s. Moreover this season may produce a record number of transactions . Hedge funds seem to be driving a lot of the activity. The positive outlook for the economy may be the reason that so many deals are going forward. Single digit growth for most of these companies means that mergers and acquisitions are often the only way to improve those numbers.

Examples of mergers (and divestments include) BASF, Ashland, Eastman, Chemtura and others.

Innovation

Much has recently been made about the correlation between sales and innovation for major industrial sectors, particularly the chemicals sector. Cleantech and green chemistry appear to be the new buzzwords in innovation for the sector. At least 12 out of 17 Diversified firms, approximately 10 Specialty firms and 9 of the Commodities companies are apparently launching cleantech/green chemistry strategies or are at least stating interest. Innovest finds that the build up in interest has been generating over the past few years but seems to have picked up momentum in 2005.

Estimated global sales of renewable-based/biotech-based chemicals in 2005 are $98 billion or 7% of global chemical sales. Biofuels take off with Ag/Chemical and Biotech players scrambling to take advantage of $3 billion worth of US Federal funding for research for bio-energy related R&D and commercialization.

Significant initial investments

Regardless of whether its biofuels or alternative plasticizers, there is not always first mover advantage associated with this type of innovation and investments are considerable.

Profit Potential

- **Analysts at Mckinsey and Company place chemicals based on renewable feedstock or manufactured via fermentation or enzymatic processes at 10% of the total global chemical sales valued at $159 billion by 2010.**
- **The market for environmental catalysts is projected to grow from $4.2 billion in 2004 to $9.1 billion in 2009.**
- **DuPont expects to add $6 billion to company sales by 2015 based on cleantech and green chemistry innovations.**

For further information about the profit and investment prospects of these new technology platforms, please see Innovest's 2006 Diversified Chemicals Sector Report. Please Contact Heather Langsner at hlangsner@innovestgroup.com to acquire a copy of the report.

Investment Dollars

Innovest has been informing investors for several years that chemical product liability is likely to be a driver of event risk for investors going forward. Lyondell (LYO: NYSE) and DuPont (DD: NYSE) are useful examples. Interestingly, this has been a record-breaking year for shareholder resolutions pertaining to toxics in products. The movement has culminated this May in a joint statement by seventeen investing organizations collectively representing more than $22 billion in assets under management.

The initiative calls for other investors to join with them in supporting shareholder resolutions seeking better disclosure regarding capital at risk pertaining to toxics in products. Note that the Carbon Disclosure Project started three years ago at a similarly low level and now represents $31 trillion in assets under management. The Investor Environmental Health Network (IEHN) also wants companies to explain the opportunities for moving to safer alternatives. Innovest is the only investment research firm that currently identifies chemical product risk prior to incident. Conventional analysis does not consider this in valuation.

Innovation

What sectors drive innovation in the chemical industry? e.g., pharmaceutical industry? What other sectors?

Major areas of R&D interest, as well as technological developments achieving rapid diffusion in recent years include:

- **Biotechnology in chemical production • New materials for construction applications**
- **Metallocene & other single-site catalysis • Advanced composites• New inorganic chemistry • Other specialty polymers**
- **Powder coatings, radiation-cured coatings,**
- **and water-based coatings**
- **New fibers (polymethylene terephthlate,**
- **corn-based, etc.)**
- **Sustainable chemistry • “Smart” plastics and fibers**
- **New solvent cleaning technologies • Chemicals and materials for microelectronics**
- **Combinatorial technology (molecular modeling,**
- **integration of artificial intelligence, etc.)**
- **Advanced materials for high-perform**
- **Nanomaterials • Bioprocesses & biocatalysts**
- **Direct oxidation of alkanes • Electro-optic & conductive polymers**

Patents

FIGURE 25 Patents Granted by Segment and Nation

Patents Granted	1995	1996	1997	1998	1999	2000	2001	2002	2003
Total Patents Granted (All Technologies)	101,419	109,645	111,984	147,518	153,486	157,494	166,037	167,333	169,028
	13.4%	13.4%	15.3%	13.9%	13.6%	12.3%	12.6%	12.5%	11.3%
Total Business of Chemistry	13,563	14,645	17,188	20,507	20,829	19,434	20,871	20,945	19,089
By Business Segment									
Pharmaceuticals	3,011	3,773	5,284	6,476	6,658	6,085	6,666	6,514	6,013
Chemicals, excluding Pharmaceuticals	10,552	10,872	11,904	14,031	14,171	13,349	14,205	14,431	13,076
Agricultural Chemicals	1,861	2,156	2,759	2,885	3,008	2,880	3,103	3,168	2,857
Consumer Products	718	747	858	1,081	1,237	1,025	1,111	1,207	1,073
Basis Chemicals & Specialties	7,973	7,969	8,287	10,065	9,926	9,444	9,991	10,056	9,146
Basic Chemicals	6,546	6,399	6,792	8,277	8,075	7,609	8,195	8,413	7,356
Inorganic Chemicals	896	849	813	1,015	1,064	1,041	1,006	1,021	1,053
Bulk Petrochemicals & Organic Intermediates	4,230	4,187	4,551	5,698	5,632	5,041	5,343	5,637	4,652
Polymers, Synthetic Rubber & Man-Made Fibers	1,420	1,363	1,428	1,564	1,379	1,527	1,846	1,755	1,651
Specialties	1,427	1,570	1,495	1,788	1,851	1,835	1,796	1,643	1,790
Coatings	548	548	507	592	681	595	606	606	591
Other Specialties	879	1,022	988	1,196	1,170	1,240	1,190	1,037	1,199
By Nation									
United States	7,076	8,006	9,633	11,287	11,552	10,578	11,056	11,161	10,171
Japan	2,268	2,196	2,312	2,834	2,692	2,533	2,837	2,723	2,436
Germany	1,428	1,437	1,581	1,854	1,771	1,789	1,968	1,959	1,792
France	594	609	767	897	902	844	952	929	860
United Kingdom	550	522	696	879	883	876	901	839	738
Canada	226	275	323	446	504	471	497	504	424
Italy	257	278	292	317	319	316	309	310	275
South Korea	83	98	99	130	175	186	215	241	266
Netherlands	107	110	152	230	227	230	242	234	240
Switzerland	264	272	297	291	311	254	307	299	233
Belgium/Luxembourg	111	139	168	213	216	199	220	264	200
India	20	18	28	56	75	86	118	175	200
Sweden	76	93	124	135	161	144	166	178	181
Israel	52	84	81	112	122	114	111	155	171
Denmark	69	72	117	159	185	166	180	139	170

Australia	58	62	86	132	135	105	154	137	102
Taiwan	36	49	55	65	94	79	112	112	95
Other	324	374	432	535	599	543	638	698	630

Source: US Patent and Trademark Office

FIGURE 26 Basic and Specialty Chemical Revenues from New Products (as % of Revenues) ESTIMATED

	1994	1999	2002	2003	2004	2005
All	13%	20%	13%	11%	14%	13%
Basic	12%	15%	13%	3%	16%	14%
Specialty	15%	23%	15%	15%	17%	13%
Small	10%	15%	11%	10%	15%	31%
Mid	13%	17%	22%	11%	17%	13%
Large	13%	20%	11%	16%	16%	14%

Source: ACC

4 The Corporations

The following is a list of overarching themes that stand out as being pertinent to an understanding of individual chemical companies and the sector in general.

Marginal business

The most inherent and fundamental characteristic to understand about the industry is the extremely tight margins within which these companies operate. This stems from two factors:

- **Downward price pressure**: **Even producers of the more esoteric small batch specialty products eventually must face the fact that they will experience increasingly tight markets as competition expands. The extent of this issue is extreme to the extent that price fixing has become rampant throughout the industry.**
- **Raw material price increases**: **Price volatility can have dramatic affects within a given quarter.**

Equity stakeholders dominate

The chemicals sector is largely financed through equity as opposed to other forms of corporate financing. As such, the combination of tight markets and volatility in the price of key industrial inputs means that companies are often announcing a round of **cost cutbacks in order to meet quarterly share price projections**. As discussed later in this report, capital upgrade expenditures are often at the top of the list for rapid cutbacks. Our analysis reveals a potential connection between delayed capital expenditures and facility integrity and safety problems. For further information on this topic please see our report on The Implications of Enterprise Risk for the Chemical Sector 2007. Please contact Heather Langsner at hlangsner@innovestgroup.com for a copy of the report.

Complex footprint

There are far more chemical companies than are typically assumed. In addition to major companies such as BASF, Dow, and DuPont, there are thousands of small and medium-sized companies operating privately around the world. Moreover, the large capitalization firms may have joint venture holdings with multiple small players. Sometimes the level of ownership is quite small. This may dictate the level and quality of enterprise risk management for these smaller entities. In the event of an incident, the relatively small holding by the large cap parent might serve as an easy excuse to avoid liability.

Cyclical business

The performance of the aggregated chemicals sector is largely tied to general economic cycles. Further, specific products are inherently tied to the fluctuations of specific markets such as automotive, housing, etc. Changes occurring in those sectors have a large effect on product formulation and product sales.

Declines in housing starts and a potential overall slump in the economy are predicted to cause merely a slight reduction in demand as opposed to an abrupt downturn. Expansions are lasting longer and GDP is only expected to drop to 2.6% this year before returning to 3.4% again in 2008 according to top industry economists. End markets such as textiles, packaging and electronics and other goods are experiencing growth. However, note our projections regarding the reduction in demand for PVC applications in the 2006 Chemicals Sector Report. Many of our Diversified chemicals firms are reporting favorable earnings this quarter and in Dupont's case, there is reason to believe that management is purposefully being overly cautious about its 2007 1Q estimates.

Who are the major global producers of chemicals by volume/profit?

In the past five years, the chemical sector has been dominated by three companies: Dow, BASF, and Dupont. In 2006, three major oil companies reached the top rankings.

FIGURE 27 Global Top 50 Chemical Companies, 2006

Rank 2005	Rank 2004	Company	Chemical Sales [$M], 2005	Chemical Sales as % of Total Sales	Headquarters Country
1	1	Dow Chemical	$46,307	100%	US
2	2	BASF	43,682	82	Germany
3	4	Royal Dutch/Shell	34,996	11	UK/Netherlands
4	5	Exxon Mobil	31,186	12	US
5	6	Total	27,794	16	France
6	3	DuPont	25,330	90	US
7	9	China Petroleum & Chemical	21,121	21	China
8	8	Bayer	20,654	61	Germany
9	7	BP	20,627	8	UK
10	11	Sabic	18,947	91	Saudi Arabia
11	13	Formosa Plastics	18,747	59	Taiwan
12	--	Lyondell Chemical	18,606	100	US
13	10	Mitsubishi Chemical	17,945	82	Japan
14	12	Degussa	14,630	100	Germany
15	16	Mitsui Chemicals	13,372	100	Japan
16	15	Huntsman Corp.	12,962	100	US

17	32	Ineos Group	12,400	100	UK
18	14	Akzo Nobel	11,758	73	Netherlands
19	19	Sumitomo Chemical	11,458	81	Japan
20	17	Air Liquide	11,388	88	France
21	20	Toray Industries	11,297	87	Japan
22	24	Chevron Phillips	10,707	100	US
23	18	ICI	10,583	100	UK
24	--	Basell	10,582	100	Netherlands
25	25	Shin-Etsu Chemical	10,244	100	Japan
26	21	DSM	10,202	100	Netherlands
27	23	Dainippon Ink & Chemicals	9,126	100	Japan
28	27	Lanxess	8,901	100	Germany
29	30	BOC	8,385	100	UK
30	28	PPG Industries	7,964	78	US
31	29	Asahi Kasei	7,927	58	Japan
32	40	Solvay	7,833	74	Belgium
33	34	ENI	7,787	9	Italy
34	31	Air Products	7,743	95	US
35	35	Praxair	7,656	100	US
36	42	Yara	7,168	100	Norway
37	41	Rohm and Haas	7,064	88	US
38	36	Eastman Chemical	7,059	100	US
39	37	Reliance Industries	6,718	36	India
40	26	General Electric	6,606	4	US
41	33	Clariant	6,566	100	Switzerland
42	39	Sasol	6,547	60	South Africa
43	38	Rhodia	6,330	100	France
44	43	Syngenta	6,307	78	Switzerland
45	49	Celanese	6,070	100	US
46	45	Borealis	5,992	100	Denmark
47	46	Ciba Specialties	5,955	100	Switzerland
48	48	Nova Chemicals	5,617	100	Canada
49	47	Teijin	5,516	65	Japan
50	42	LG Chem	5,468	75	South Korea

Source: C&EN, July 2006

What percent of total global production is manufactured by these companies?

The 15 leading chemical companies worldwide account for less than 20 % of global sales [and often operate in very different markets such as pharmaceuticals, petrochemicals, and basic and consumer chemicals]. Small and medium-sized enterprises, which may produce a single product at a single factory, are common. In the EU, for example, there are approximately 31,000 chemical enterprises, 96% of them with fewer than 250 employees.

Small & Medium Companies

The chemical industry is more than just large, publicly-owned corporations. These companies frequently have many subsidiaries. Unlike the major corporations with substantial environmental commitments and corporate responsibility agendas, many of the small companies are privately-owned or the large cap companies only retain a small percentage of ownership. It is very difficult to determine to what extant these small companies, and their own suppliers and subsidiaries, are fulfilling environmental commitments and conforming to regulations. The following is an example of how complex these companies can be. This is a list of joint venture projects and subsidiaries in Dupont's holding:

Example: DuPont – Select Subsidiaries

Antec International
Antec International Ltd
Belco Technologies Corporation
Butachimie
Carrs Paints
Chemfirst Inc
Chemfirst Inc
Crosfield Electronics Ltd
Du Pont
Du Pont (Australia) Ltd
Du Pont (U.K.) Ltd
Du Pont China Limited
Du Pont Coordination Center Nv
Du Pont Dai Nippon Engineering Corp
Du Pont De Nemours (Nederland) B.V.
Du Pont De Nemours Deutschland Gmbh
Du Pont De Nemours France Sas
Du Pont De Nemours International Sa
Du Pont De Nemours Italiana Srl
Du Pont De Nemours(Belgium) Bvba
Du Pont Elastomers L.P.
Du Pont Foreign Sales Corporation
Du Pont Iberica S.L.
Du Pont México S.A. De C.V.
Du Pont Performance Coatings - Tintas E Vernizes S.A.
Du Pont-MBK-Alliance Co
Du Pont-MGC Co Ltd
Du Pont-MRC Co Ltd
Du Pont-Toray Co Ltd
Du Pont-Toray Pte Ltd
Dupont Agrosoluciones
DuPont Automotive
Dupont Automotive Systems Servic Nv
Dupont Bvco B.V.
Dupont Canada Inc
Dupont Coatings S.A.S.
Dupont Danmark Aps
Dupont De Colombia S.A.
Dupont Displays Inc
Dupont Do Brasil S/A.
Dupont Dow Elastomers Gmbh
DuPont Dow Elastomers LLC
Dupont Ekc Technology
Dupont Electronic Polymers L.P.
Dupont Far Eastern Co Ltd
Dupont Healthcare Services Ltd
Dupont Holographics Inc
Dupont K.K.
Dupont Merck Pharmaceuticals Inc
Dupont Mrc Dry Film
Dupont Nlco B.V.
Dupont Performance Coatings (U.K.) Ltd
Dupont Performance Coatings Austria Gmbh
Dupont Performance Coatings Iberica S.L.
Dupont Performance Elastomers B.V.
Dupont Performance Elastomers Japan K.K.
Dupont Performance Elastomers K.K.
Dupont Performance Elastomers Pte. Ltd.
Dupont Performance Elastomers Sa
Dupont Polymer Powders Switzerland Sàrl
Dupont Powder Coating France Sas
Dupont Powder Coatings Andina S.A.
Dupont Powder Coatings De México S.A. De C.V.
Dupont Powder Coatings Iberica S.L.
Dupont Powder Coatings U K Ltd
Dupont Powder Coatings USA, Inc
Dupont Red Lion (Beijing) Coatings Co. Ltd.
Dupont Technologies
Dupont Teijin Advanced Papers (Asia) Ltd
Dupont Teijin Advanced Papers (Japan) Ltd
Dupont Turkiye Kimyasal Urunler Sanayi Ve Ticaret A S
Dupont Vespel Parts & Shapes Inc.
Dupont-Asahi Flash Spun Products Co Ltd
Dupont-Kansai Automotive Coatings Co
Dupont-Mitsui Fluorochemicals Co Ltd

E I Dupont India Private Limited
E.I. Du Pont Canada Company
Ekc Technology Ltd
First Chemical Corporation
Granirex Inc
Green Meadow Ltd
Griffin Europe Ltd
Griffin Llc Valdosta Georgia (De)
Hitachi Chemical Dupont Microsystems Llc
Hitachi Kasei Dupont Microsystems Kk
I D A C
Imarx Pharmaceutical Corp
Invista (U.K.) Superior Holdings Ltd
Jet Oil
Krystal Holographics International Inc
Liqui-Box Canada Inc
Liqui-Box Corporation
Liqui-Box International Inc.
Neptune Environmental Technologies Inc
New England Nuclear Corp
Nordisk Alkali Biokemi
Pioneer Argentina S.A.
Pioneer Hi - Bred Seeds Agro S.R.L.
Pioneer Hi - Bred Sementes De Portugal S.A.
ServiceDivisionGmbh
Pioneer Hi Bred International Inc
Pioneer Hi Bred Italia Sementi Srl
Pioneer Hi Bred Italia Servizi Agronomici Srl
Pioneer Hi-Bred Italia Srl
Pioneer Hi-Bred Japan Co. Ltd.
Pioneer Hi-Bred Limited
Pioneer Hi-Bred Northern Europe
Pioneer Hi-Bred Production Ltd
Pioneer Hi-Bred Services Gmbh
Pioneer Hi-Bred Spain S.L.
Pioneer Overseas Corporation
Protein Technologies International Gmbh
Semillas Pioner Chile Limitada
Sentinel Transportation Co Llc
Solae do Brasil Holdings SA
Spies Hecker Gmbh
Spies Hecker Gmbh
Standox Gmbh
Stonetech Professional Inc
Teijin Du Pont Films Inc
Teodur B.V.
Thapar Du Pont
Uniax Corp (Santa Barbara, Ca)

Source: Factiva

In addition to the difficulty of accessing public information regarding these smaller companies, there are challenges in holding larger companies accountable for the environmental performance and regulation offenses of their subsidiaries.

Which of the chemical companies are making green chemicals? Bio-based chemicals? Using bio-based process chemistry?

Green chemistry is the design and implementation of processes and products that minimize or eliminate the use and generation of hazardous substances which may have an adverse effect on the environment and on human health.

Clean Tech Development, Capturing Future Value

Cleantech investments reached $1 billion in Q3 2006 according the Cleantech Venture Network, an 8-10 percent increase in investments over the previous year[14]. At that rate, we expect that clean tech could

[14] Matt Marshall. Mercury News. Feburary 15, 2004. http://www.siliconvalley.com/mld/mercurynews/business/7959849.htm. Visited 12/20/06.

actually become an investment category in the same manner as biotech. Some big chemical and industrial companies have spotted this trend and we are seeing significant increases in investment in everything from materials for high efficiency photovoltaic and fuel cells to water purification membranes and sustainable agriculture.

Most of the firms in our chemicals ratings universe are slow to aggregate information for investors regarding their strategic efforts to increase revenues through green and sustainable product design. However DuPont has made concrete commitments in this regard. BASF, Dow, Akzo Nobel and several others are also making similar commitments.

For example Dupont has committed:

- Environmentally Smart Market Opportunities from R&D Efforts: By 2015, DuPont will double investment in R&D programs with direct, quantifiable environmental benefits for our customers and consumers along our value chains.
- Products that Reduce Greenhouse Gas Emissions: By 2015, DuPont will grow annual revenues by at least $2 billion from products that create energy efficiency and/or significant greenhouse gas emissions reductions for our customers. The company estimates these products will contribute at least 40 million tonnes of additional CO2 equivalent reductions by our customers and consumers.
- Revenues from Non-Depletable Resources: By 2015, DuPont will nearly double revenues from non-depletable resources to at least $8 billion.

In general companies typically respond that green chemistry is an inherent aspect of all R&D because this kind of research promotes a chemistry that makes syntheses safer and more efficient. However it is important to distinguish between the handful of green chemistry offerings that are recognized each year by the Presidential Green Chemistry Awards process and the overall fundamental shift to new technological capacities that is taking place at certain companies.

For example, BASF has developed an alternative plasticizer called Hexamol Dinch® to replace conventional phthalates in toys. This would be an example of an isolated innovation that would be a candidate for recognition by the Green Chemistry Awards. However on a larger scale, BASF and others are launching new technological capacities that will enable fundamentally safer synthesis over the long run. The companies growth platform for the next several years is based on five growth clusters: plant biotech, white biotechnology, nanotechnology, raw material switch out and renewable energy technology

We find that green chemistry and environmental product/process design is becoming a critical aspect of competitive value as the markets for fuel cells, water treatment and more benign solvents heat up. In light of this, we tried to assess strategic positioning with regard to new business development in this area.

Legislators are getting in the game. By a wide bipartisan majority, the US House of Representatives has approved HR3970, the "Green Chemistry Research and Development Act of 2004." The Bill would provide for the implementation of a federal interagency green chemistry research and development program and green chemistry grant programs. The legislation authorizes the National Science Foundation to spend $7 million in fiscal year 2005, $7.5 million in fiscal year 2006 and $8 million in fiscal year 2008. In addition, approximately $20 million will be divided among the National Institute for Standards and Technology, the Environmental Protection Agency and the Department of Energy. The bill has been sent for approval by the Senate.

The challenge is to evaluate respective offerings to determine the most viable green R&D portfolios within this competitive set of companies. In the United States, some companies in the sector have been recent recipients of the prestigious Presidential Green Chemistry Competition Awards. For example, **DuPont** received the award in the category of alternative solvents/reaction conditions in 2003 for its work on bio-based polymers. Full-scale production using bio-based feedstock should begin in a few years and is expected to have a wide variety of market applications.

Elevated energy prices have caused a surge in the prices for conventional polymers. In light of this, it is possible that the pricing of polylactic acid biopolymers or PLA may become more competitive. Bio-based plastics are being developed by several companies in this sector; however, we note that Cargill has just purchased **Dow**'s interest in its 50/50 joint venture with NatureWorks LLC. Dow pulled out due to the low returns associated with the product, however, the incentive to remain invested is likely low considering the company's heavily vested interest in and profit prospects related to polyvinyl chloride product lines. Investors may note that PVC ingredients and final products are a focal point for future restriction, regulation, and market rejection across several markets. For further information on this issue, please refer to Innovest's investment analysis on Dow and the Dow Report (available on the website at www.innovestgroup.com).

We surveyed this group of companies for the percent of R&D specifically dedicated to green chemistry efforts. Only a few companies were able to provide a rough sales number associated with green chemistry products. In the case of **Engelhard (recently purchased by BASF)**, the company's core business strategy is inherently focused on the unique capacity of advanced catalysis science to resolve the inefficiencies of production. Engelhard's focus on materials science yields more benign products and processes for application in coatings, personal care products, combustion and other industrial processes. In terms of competitive positioning, investors may note that Engelhard's Rightfit™ Organic Pigments received the 2004 Green Chemistry Award in the category of safer chemicals.

The field of electrochemistry includes a wide range of different charge-transfer phenomena. These areas include (but are not limited to): photosynthesis, battery chemistry, ion-selective electrodes, coulometry, and many biochemical processes.

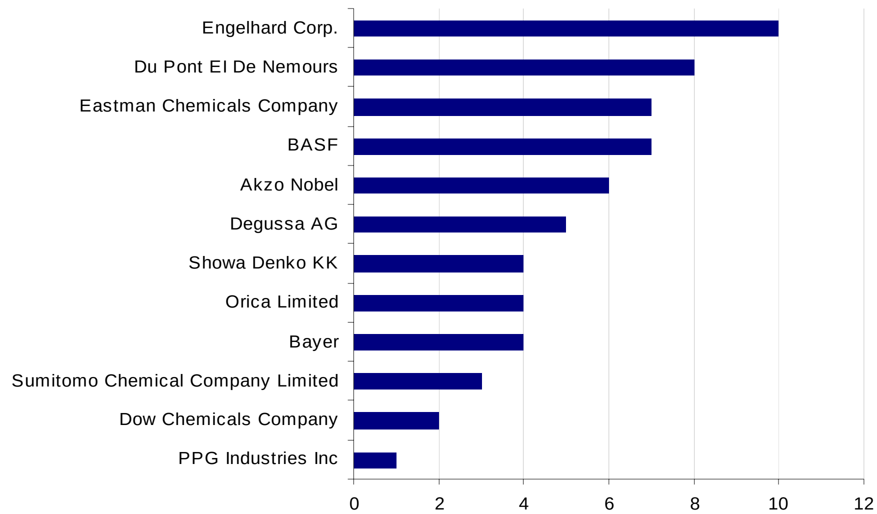
Beyond green chemistry, **BASF**'s Verbund concept combines corporate functions with social interests in product development and makes material use more intelligent and more transparent. According to BASF, Verbund is the transition from a resource efficient chemistry to a resource conscious chemistry. This philosophy is illustrated by examples from electrochemistry, a core technology of BASF. Selective processes with low energy demand, recycling techniques, water saving technologies are discussed. Electrochemistry is also needed in a future solar hydrogen society.

Verbund's broad and integrated approach makes it difficult to specifically pin down revenues associated with innovative environmental technologies. However, the company has developed a new label for products that have been evaluated by an Eco-Efficiency Analysis. BASF is also looking to plant biotech, biocatalysis and advancements in nanotechnology to enhance its sustainable and green product portfolios. Finally, the company recently established a lateral R&D start-up called Future Business (BFB) GmbH in 2001. BFB develops new business areas on the basis of BASFs sustainability principles.

The Japanese firms offer up long lists of relevant products so it is important to remain focused on the following considerations in order to verify some of these claims:

- **Is the product really environmentally efficient or is the company providing faulty guidance? Certain Japanese chemical firms indicate to investors that polyvinyl chloride has many resource and energy efficiency properties. Any resource and energy efficiency advantages that may be associated with PVC plastic are virtually overshadowed by PVC's toxicity profile throughout the lifecycle of the product. See Innovest's guidance on PVC in the Commodity and Specialty Chemicals Sector Reports.**
- **Meets a pressing environmental load reduction requirement (energy, emissions, etc),**
- **Addresses an environmental specification (such as low VOCs)**
- **Which resolves some environmental problem (plant based plastics or non-PBT pesticide)**
- **Improves an existing environmental technology (lighter, smaller, cheaper photovoltaic cells)**
- **Expected market uptake/demand**

FIGURE 28 Scores for Environmental Products Strategy and Development



See Appendix D8

Chemical companies typically claim that all R&D activity is inherently green chemistry because normal safety procedures would automatically insure a benign result. This is a vast oversimplification by our understanding. Most green chemistry projects are only designated as such because they follow the 12 principles of green chemistry specifically. The twelve principles are as follows:

The Twelve Principles of Green Chemistry:

1.Prevention: It is better to prevent waste than to treat or clean up waste after it has been created.

2.Atom Economy: Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product.

3.Less Hazardous Chemical Syntheses: Wherever practicable, synthetic methods should be designed to use and generate substances that possess little or no toxicity to human health and the environment.

4.Designing Safer Chemicals: Chemical products should be designed to affect their desired function while minimizing their toxicity.

5.Safer Solvents and Auxiliaries: The use of auxiliary substances (e.g., solvents, separation agents, etc.) should be made unnecessary wherever possible and innocuous when used.

6.Design for Energy Efficiency: Energy requirements of chemical processes should be recognized for their environmental and economic impacts and should be minimized. If possible, synthetic methods should be conducted at ambient temperature and pressure.

7.Use of Renewable Feedstocks: A raw material or feedstock should be renewable rather than depleting whenever technically and economically practicable.

8.Reduce Derivatives: Unnecessary derivatization (use of blocking groups, protection/ deprotection, temporary modification of physical/chemical processes) should be minimized or avoided if possible, because such steps require additional reagents and can generate waste.

9. Catalysis: Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.

10.Design for Degradation: Chemical products should be designed so that at the end of their function they break down into innocuous degradation products and do not persist in the environment.

11.Real-time analysis for Pollution Prevention: Analytical methodologies need to be further developed to allow for real-time, in-process monitoring and control prior to the formation of hazardous substances.

12. Inherently Safer Chemistry for Accident Prevention: Substances and the form of a substance used in a chemical process should be chosen to minimize the potential for chemical accidents, including releases, explosions, and fires.

According to our research, if green chemistry projects (projects that follow the 12 principles) are underway, they are isolated and not integrated into a wider R&D strategy.

Some companies excel in different ways promoting green chemistry. Some companies are known for having a high number of projects underway such as DuPont while others like BASF are more known for a better conceptual understanding of what it means to integrate green chemistry principles throughout the business through use of life cycle analysis and other techniques.

Green Chemistry: What are the major green chemical (and bio-based) markets – e.g., cleaners, solvents, etc. – and their market trends?

It takes time for bio-based and green chemistry products to make their way through the pipeline. However, Innovest has been tracking the R&D pipelines of key players since 2002. Hence, we have developed a sense of which firms are on the cusp of the movement and poised to make profit. This focus allowed us to make correct calls in two cases: **Engelhard (recently purchased by BASF) and BASF AG (BF: NYSE)**.

INNOVEST PICKS FOR COMPANIES CAPITALIZING ON GREEN CHEMISTRY R&D

Genecor International, Cargill, DuPont, BASF, Novozymes, and Toray. To a lesser degree, DSM and Degussa. Novozymes has been working on its enzyme manufacturing process for ethanol a bit longer and seems to be the better bet so far relative to Genecor. Novozymes is also making progress in reducing cap-ex on the technology.

Plant based technology issues

It is becoming increasingly clear that plant based technologies have drawbacks from both from a geopolitical and sustainability perspective. Petroleum giant Shell has lately been pointing to the ethical consideration of clearing more forest territory for fuel crops as opposed to crops for food. Moreover, the same trade dynamics that affect crude oil apply equally to renewable fuels. Experts are beginning to ask: "Would a nearby ethanol supplier be any more reliable than Venezuela?" We continue to factor these concepts into our valuation of bio-fuel investment options.

The following is our overview of key areas of research that are relevant to the development of environmentally beneficial technologies over the long-term.

Biobased Plastic

Bioplastics are picking up steam this year with major investments by DuPont and BASF on the supply side and Wal-Mart and Toyota on the demand side. Bio-based plastic alternatives and alternative plastic additives reduce petroleum dependence and environmental footprint but also offer opportunity for product differentiation and the generation of higher valued revenue streams throughout the entire plastics value chain. The landscape as we see it today:

- **BASF forecasts that the world market for biodegradable plastics will grow more than 20% a year, and Kozaburo Tsukishima, general manager of Toyota's biotechnology and sustainable forestation division, expects 20% of the world's plastic to be bioplastic by 2020.**
- **Increased petroleum costs caused price hikes between 30% and 80% for conventional food packaging plastic last year allowing some bioplastics to reach full price competitiveness.**
- **The number of companies getting into production is increasing. We count approximately 15 to date, not all of which are included in this analysis[15].**
- **The most important application for bioplastics currently is in the packaging sector, where these materials can fulfill the requirements of the EU Directive on Packaging and Packaging Waste.**
- **Toyota is pouring capital into its bioplastics division, aiming to capture 4 trillion yen, roughly two-thirds, of the world market for bioplastic by 2020. 4 trillion yen is approximately one-fourth of Toyota's revenue for FY2003.**
- **Wal-Mart and subsidiary Sam's Club has begun to specify bioplastic for some of its food packaging, which shows mainstream market acceptance and price-competitiveness.**

FIGURE 29 Application by Industry Segment

Application	Notes
Appliance	
Building & Construction	
Consumer Products	strong potential for application of bio alternatives/ already in progress
Electrical & Electronic	already bioPLA prototypes in development
Industrial	
Medical	strong potential for application of bio alternatives
Packaging & Food Service	strong potential for application of bio alternatives/already in progress
Transportation	Toyota is in first stages of development

Source: Innovest

15 Innovest research 2006. Contact analyst for data analysis.

FIGURE 30 Companies in the Plastics Value Chain

Company	Product/Segment	Percentage of Sales
BASF	Plastics	28%
Ciba	Plastics Additives	26%
Chemtura Chemical	Polymer products (plastics and plastic additives)	30%
Rohm and Haas	plastic additives and monomers	23%
Shin-Etsu	PVC	56%
Daicel	Plastics	44%
Danippon	Plastics	14%
JSR	Plastics	20%
Tokuyama	Plastics	exact % not disclosed
Bayer	Plastics	36%
Celanese	VC monomer	exact % not disclosed
Dow	Plastics	25%
Degussa	Specialty Polymers	13%
DuPont	Polymers	25%
Eastman	Plastics	10%
Kaneka	Plastics	29%
Mitsubishi Chemical Corporation	Plastic Resins	43%
Orica	PVC Resins	22%
PPG Industries	VC Monomer	21%
Showa Denko	Plastics	34%
Solvay	Plastics	28%
Sumitomo	Plastics	32%
Teijin	Plastics	24%
Toray	Plastics	23%
Tosoh	VC Monomer	60%
Asahi Kasei	Plastics	4%
Denki Kagaku Kogyo KK	Plastics	exact % not disclosed
Mitsubishi Rayon Company Limited	Plastic Modifiers, Plastic Optical Fibers	42%
Mitsui	Plastics	
UBE	Plastics	29%
Nissan Chemical Industries	Vinyl Chloride Stabilizer	exact % not disclosed

Source: Innovest

Current Status of PLA players:

After detailed review of the relative positioning among the various PLA companies, we find that there is little room for apples to apples comparison at this time. PLA (polylactic acid) is a raw material alternative to petroleum-based plastic resin. It is derived from glucose extracted from agricultural crops such as corn or potatoes and is fully biodegradable and compostable. Companies like DuPont and Cargill manufacture PLA in the United States and there are several Japanese firms that manufacture PLA now.

» Toray (3402-TO**) is involved in the development of intermediary materials after sourcing the inputs from NatureWorks (Cargill). The company anticipates that the pricing differential between conventional and PLA is shrinking. The company's enhancements to improve the mechanical properties of PLA seem to be the most developed among the various companies in the space. The company's nanotechnology additives for PLA are of particular interest and of**

course of particular concern from an EHS perspective for us. The company assures us that they are working on that aspect.

- DuPont **is selling under the name Sorona® a polyester family based on 1-3-propanediol, which is made out of corn sugar by a fermentation process. The products are attributed mainly to applications in fibers, filaments and engineering components.**
- BASF **commercial products Ecoflex® and Ecovio® serve the market for biodegradable/compostable applications especially in flexible film applications and are therefore not really in competition with the DuPont. In 2006 BASF is increasing its capacity for Ecoflex® from 8.000 to 14.000 metric tons per year. Additionally the company is bringing a new product called Ecovio® on the market. For the time being BASF is at its production capacity limit. BASF's Ecovio® product is the first BASF biodegradable plastic to be made with renewable materials and will launch in January. The Global Market for biodegradable Plastics (without loose fill; BASF estimations):**
  - **Approximately 40.000 metric tons in 2005**
  - **Approximately 160.000 metric tons in 2010**
- Asahi Kasei **(3407-TO) has ready product on the market but the company is not strongly promoting its capabilities in this area yet.**
- Mitsui **(4183-TO)** and Dainippon Ink **(4631-TO) currently have product but also do not emphasize its PLA activities. However the Japanese firms are producing the raw material so we expect that they will begin to see profit in this segment over the next 3 years.**

Ethanol and Bio-fuels

In our view, **industrial biotech** represents the future of the chemical industry's contribution to renewable energy sources. Companies like **Monsanto (NYSE: MON)** are placing their bets on the near term demand for corn-based ethanol due to the current status of regulation in the United States. However, over the long term as prices and advances in enzyme mediated processes narrow the gap; we feel Genecore International and **Novozymes (NZYM'B-KO)** will lead the way in producing bio-fuels.

Research Developments

Capital expenditure and technical barriers have limited investment prospects in the development of biofuels such as ethanol. However recent advancements have led to biofuels becoming a more viable investment option. There are currently two possible tracks for ethanol production: corn-based production and enzyme mediated cellulose. GMO corn supplier **Monsanto (NYSE: MON)** is currently the favorite in the former.

However we currently hold the position that enzyme mediated processes will eventually overtake this initial track. Enzyme technology for ethanol production offers several benefits over Monsanto's method:

- More sustainable feedstock**: Any organic by-product (husks, hulls, etc) can be used. This bypasses concerns about using food sources and arable land for fuel production.**
- Reduced Cap-ex**: Novozymes is currently working to reduce capital investments and appears to be making progress. Whereas cap-ex was considered to be prohibitive, the gap is narrowing rapidly. The company has recently announced that it has achieved a 30-fold reduction in costs for the enzyme process.**
- Corn processes are not efficient**: The energy used to process ethanol from corn is so significant that ethanol is currently not considered an environmentally efficient option. Given the small net-energy gain resulting from corn-based ethanol, we expect a rapid market shift to enzyme mediated cellulose-based ethanol as research advances.**

OUR PICK Novozymes, rated AAA by Innovest, which recently concluded a four-year research project that achieved a 30-fold reduction in the cost of enzymes used to make cellulosic ethanol.

Novozymes has implemented a rigorous R&D program to overcome the hurdles associated with biofuel production. Moreover the company's R&D emphasis is evident by the number of new products and products in the pipeline. As of June 2006, 25% of Novozymes total products were on the market while the remaining 75% were in trial phase. In a benchmarking of over 35 companies, Novozymes ranked first in sector for R&D expenditures which comprised 12.6% of net sales in 2005. Currently we feel more secure with Novozymes over Genecore but we continue to monitor the competition between the two entities for ethanol production.

Within Innovest's universe, the following companies are currently involved in the development of **enzyme technology** for biofuels:

Company	Business Segment	Percentage of Sales
Novozymes	Technical Enzymes	59.4%
DSM	Life Science Products	15.6%
Lonza	Synthesis/Biotech	36.4%
Sigma Aldrich	Biotech	20.8%

Source: Innovest

Demand Drivers

Biofuel demand escalated due to high energy prices and low energy security in 2005, which created a need for stable pricing and reliable feedstock supply.

Governmental support as indicated by the many recent legislative developments:

» **The Renewable Fuel Standard (RFS) of the US 2005 Energy Bill requires that 7.5 billion gallons of biofuels be utilized by 2012. As a result, Federal programs authorized by the Energy Policy Act of 2005 are designed to support R&D for biomass ethanol production, support private investment in biorefinery construction to make ethanol and other commodity chemicals, and provide monetary incentives for quick adoption of cellulosic ethanol for fuels. Since the bill was signed into law, approximately USD 3 billion for bioenergy projects, R&D and commercialization was authorized.**

» **The Japanese Environment Ministry recently passed legislation making it mandatory for all new cars to run a blend of 10% ethanol starting in 2010.**

» **In July 2006, the Canadian Renewable Fuels Association announced a comprehensive plan to implement the federal government’s commitment to require 5% renewable content in Canadian gasoline and diesel fuel. Among other incentives, the plan offers tax credits for ethanol and biodiesel producers.**

» **In March 2006, the European Commission released the “EU Strategy for Biofuels”, an initiative targeting a significant increase in the capacity and production of biofuels in the EU.**

» **In late July 2006, the Indonesian Ministry of Industry proposed a ban on the export of sugar cane molasses, a raw material of ethanol, to support the development of biofuels. Currently, Indonesia's ethanol output is approximately 170,000 kiloliters per annum, of which 27,000 tons are exported.**

Increasing Competition

The enactment of various regulatory programs encourages the use of bio-fuels. An increasing number of companies are moving into the market for ethanol. Virgin Group recently established a subsidiary, Virgin Fuels, to invest in alternative fuels, including cellulosic ethanol. In 2005 Bill Gates committed to an investment of $84 million in

Pacific Ethanol of Fresno. As a result, many companies have accelerated R&D efforts to remain competitive in this rapidly-evolving market.

The DuPont/BP Alliance

DuPont recently partnered with BP to produce Biobutanol. Initially, the fuel will be produced using sugar beet as the feedstock. In the future, the companies have stated plans to use corn, wheat, and sugar cane. Further into the future the partnership intends to revert to enzyme-based processes that will use biomass/cellulosic feedstocks from fast growing “energy crops” such as grasses, or “agricultural byproducts” such as straw and corn stalks.

Biodiesel vs. Biofuels

An increasing number of our sources are talking about biodiesel as the more viable alternative to ethanol mostly because only a small amount of ethanol can be blended into conventional gasoline. Biodiesel on the other hand can be developed from any organic material and can run at 100% concentration in a diesel engine. One company, Imperium Renewables, is building a 100 million gallon-per-year plant in Washington stated at a cost of $40 million. Note that biodiesel prices are not contingent on the price of crude like ethanol[16]

Environmental Catalysts

The market for environmental catalysts is projected to grow from **$4.2 billion in 2004 to $9.1 billion in 2009**. Current leaders in this field include BASF (through its acquisition of Engelhard), Johnson Matthey, and Umicore. With increasingly stringent environmental regulation, the auto-catalyst market in particular currently comprises 40% of the environmental catalyst market**. For further information please refer to company profiles.**

[16] Chemical Market Reporter 22, May 2006

Companies in Innovest's universe involved in environmental catalyst production:

Company	Environmental Catalyst Application
Toray	Automotive emission-control systems, fuel cell catalysts
BASF	Automotive emission-control systems, fuel cell catalysts
Nova Chemicals	Catalysts to lower the amount of energy required for olefins manufacturing
Mitsui	Currently researching catalysts to produce benzene from natural gas
Lonza Group	Bio-catalysts to replace chemical intermediaries in manufacturing processes
Yara International	Catalysis technology that helps to reduce GHGS in production of fertilizers. Nitrous oxide catalyst that decreases nitrous oxide emissions at the company's existing nitric acid plants AdBlue, an operating fluid for diesel-powered freight trucks that uses selective catalytic conversion to improve emissions
Rohm and Haas	Bio-catalyst stabilizers
Air Products and Chemicals	Specialized catalysts and surfactants that replace ozone-depleting chemicals.

REACH

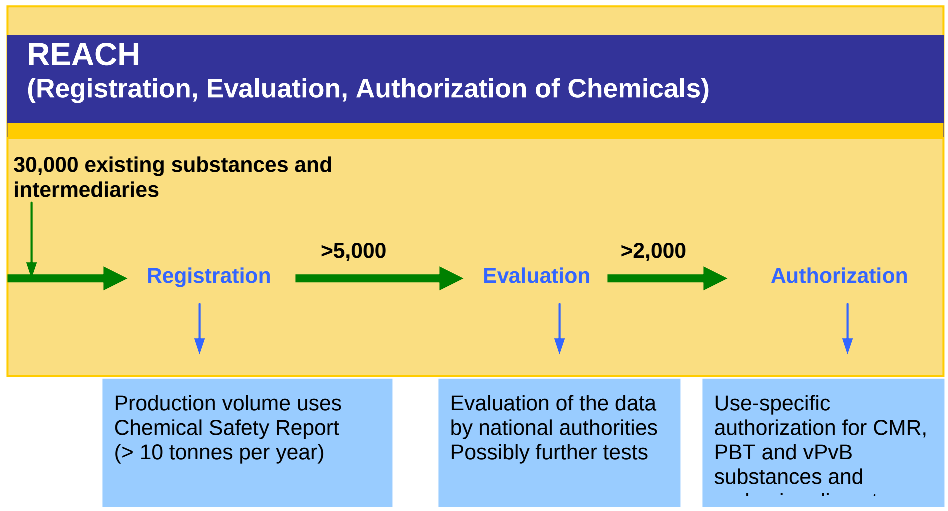
The European Union is in the process of overhauling its chemicals policy. The new policy currently under development known as REACH (Registration Evaluation and Authorization of Chemicals) is due to enter into effect by 2006. The policy objectives of REACH are:

» **Streamline and increase the effectiveness of existing policy,**

» **Improve the health and safety of EU citizens, and**

» **Promote future progress toward sustainable development.**

FIGURE 31 REACH Registration Process



Source: BASF AG

Registration

Approximately 30,000 existing substances and all future new substances that are manufactured or imported in a volume of more than 1 ton per year in the EU must be registered with a central Agency. It is industry's task to obtain and assess the necessary data about the substances and exposure. The volume thresholds apply to each individual manufacturer or importer.

Evaluation

In the evaluation, the relevant national authorities can check the dossiers that are submitted for the registration of each substance. This is compulsory in the case of annual volumes of > 100 tons. The authorities are also allowed to carry out a more detailed check of specific substances, if they believe that a risk is to be expected due to the structure of the substance or the total European tonnage.

Authorization

CMR[17], **PBT**[18] and **vPvB**[19] substances as well as **endocrine disruptors**[20] are subject to an authorization procedure. This means that such substances may only be used

[17] carcinogenic, mutagenic, causing harm to reproductive systems in animal studies or humans
[18] persistent, bioaccumulative and toxic
[19] very persistent, very bioaccumulative
[20] substances that affect the hormone system

for authorized applications. The registrant must provide evidence for each use that the risk emanating from the substance is controlled by technical or organizational measures.

Chemical Safety Report

A Chemical Safety Report must be compiled for substances of > 10 t/a. This contains physicochemical, toxicological and eco-toxicological data, risk assessments for all uses and measures for risk management.

What are Target Substances in Our Analysis?

The following is a simplified list of chemical groups that we look for in our analysis of companies. For this particular set of companies, we identified companies that make substances under 1, 2, 4, 7, and 8. When data was available, we attempted to assess relative reliance on use of these substances and possible market exposure.

1. Dioxins: by-products of PVC plastics manufacture, bleaching and incineration
2. Furans: by-products of plastics manufacture, industrial bleaches and incineration
3. Metals: lead, mercury, arsenic, cadmium
4. Organochlorines: insecticides, DDT, chlordane
5. Organophosphates: insecticides, chlorpyrifos, malathion
6. Pthalates: plasticizers (additives that make plastics softer, more pliable)
7. Volatile and Semi-volatile Organic Compounds: solvents, xylene, ethyl benzene, benzene

"Although the draft was improved compared to the first version from May 2003 it is nonetheless not practicable. The costs and the expected negative economic effects are enormous; industry's competitiveness is significantly harmed. Current studies have reconfirmed this serious situation. Therefore, the present legislative proposal is still a cause of great concern."

BASF website 2004

This issue is so contentious that Representative Henry Waxman (D-CA) issued a report last year asserting that the Bush Administration, in cooperation with the US chemical industry, has worked to undermine the development of REACH. There is much speculation about the negative implications of REACH for the global industry. A major US concern involves the effect of REACH on transatlantic trade. REACH would apply to a majority of US exports to the European Union – **valued at $551 billion in 2005**. (Source: ACC Business of Chem).

In a 2005 study, KPMG studied the potential risk of REACH on 152 substances and found no important substances to be vulnerable. Direct costs of implementation, furthermore, are expected to be spread throughout the supply chain. According to the European Commission, the commodities sector will bear higher costs than the specialty sector.

Chemicals Categorized as being of "Very High Concern" will have to be registered, evaluated, and authorized before they could be marketed. This includes:

- Carcinogens, mutagens, and reprotoxins which are either known or very likely to be toxic to humans

- Chemicals that are persistent and very bioaccumulative in humans and wildlife for which toxicity data are still unavailable

- Chemicals that can become widely disseminated in the environment, and which are persistent, bioaccumulative, and toxic particularly

A 2006 review of 102 European chemical companies found that 40% were hardly aware of the implications of REACH, and that those who were aware were making limited preparations.

It is far more difficult to determine potential company-specific outcomes. Business model is a significant determinant of relative exposure. For example, the more vertically integrated a company is, the greater the chances that the company is handling a variety of regulated or designated "focus" chemicals.

BASF is the only company that discloses production capacity data for major substance categories such as chlorine. It is even more difficult to pinpoint sales numbers associated with such profitable but highly regulated substances as chorpyrifos (made by **DuPont and Dow**) or brominated flame retardants (Great Lakes). This inhibits our ability to make projections about the potential financial impact of future product-specific regulations. In light of this, we relied on data from Chemical Market Reporter to extrapolate a rough estimate of market positioning in certain product segments.

A few of the larger companies have complained to the press about broad affects to the industry, portraying a grim picture of subsequent job losses and financial affects associated with REACH. During the comment period, **Akzo Nobel** estimated that approximately 30 to 40 percent of intermediaries used by its coatings division could be phased out, but these companies simultaneously downplay the issue in official financial disclosure.

Conservatively, we expect that REACH will have the most significant impact on small and medium-sized enterprises. The large-cap firms covered in this competitive set of 12 relatively large-cap firms are generally considered to have greater resources to deal with such changes (with a few noteworthy exceptions). Specialty chemical manufacturers are also likely to experience greater impacts due to concerns in that REACH may have implications for intellectual property protection and because specialty revenues are derived from the production of new chemicals that would invariably trigger the evaluation phase of REACH resulting in costly delays in commercialization. Finally, we have begun to evaluate potential impacts on downstream users of chemicals throughout the value chain. Note that REACH will be mentioned throughout several Innovest industry sector reports. Among the key sectors affected would be textiles, pharmaceuticals, electronics and automobiles.

Asset management firms are beginning to question companies regarding their efforts to prepare for REACH. London-based Insight Investments recently surveyed 17 firms including BOC Group, ICI, Yule Catto Plc, Victrex Plc, **BASF AG** and **Bayer**.

Factors considered in this analysis included:

» **Relative exposure based on sales to and volume of production in Europe**
» **Nature of major exports to Europe (Chemical Market Reporter)**

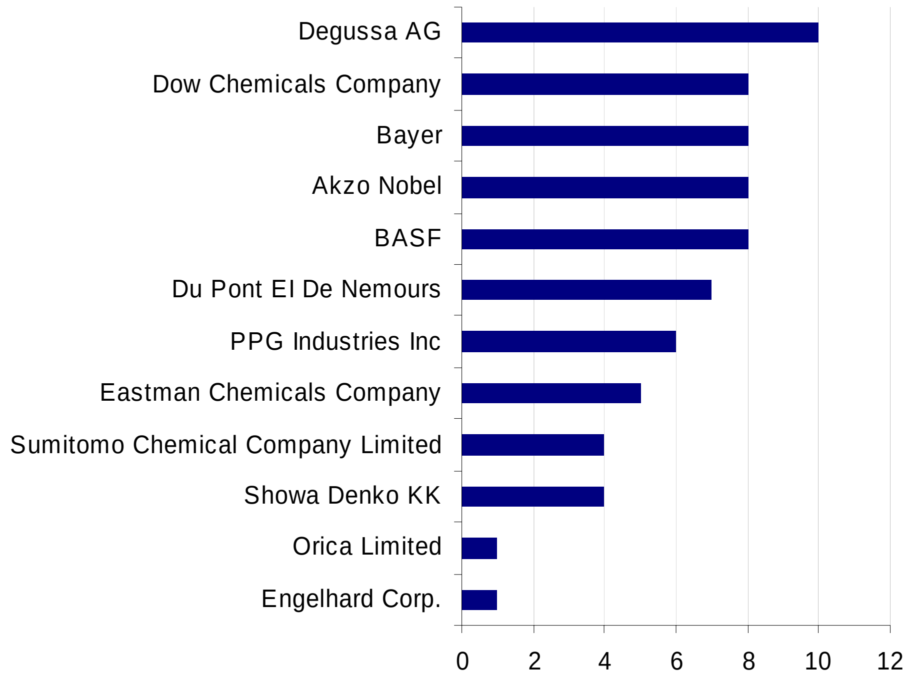
- **Significant market share in “high concern” chemicals**
- **Company profile: market capitalization, product focus, business model**

Scores were adjusted for:

- **Strategy to apprise the investment community of the impending effects**
- **Extent of commitment to voluntary existing chemicals testing programs**

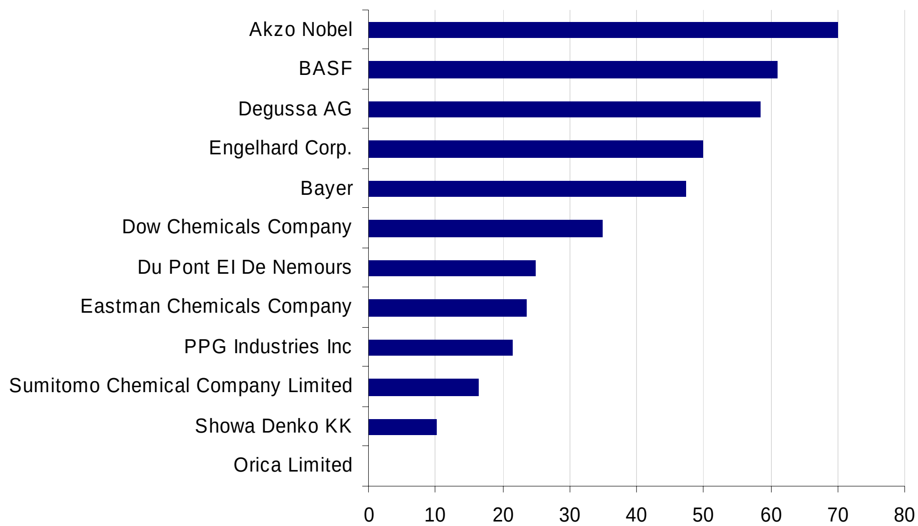
Note that cooperative agreements have been made between Europe and Japan to reduce the cost of chemicals certification and we detect intent to incorporate some of the general principals of new European chemicals policy into the Japanese Chemicals Substances Control Law (JCSCL). The Japan Business Council in Europe, which represents 31 downstream users of chemicals (we suspect this means diversified and specialty manufacturers involved in new chemicals innovation), specifies a detailed list of reasons why REACH could be potentially harmful to Europe-Japanese trade relations in the chemicals sector. Two firms in this group trade on the Tokyo exchange.

FIGURE 32 European sales as a Percent of Total Revenues in 2004



Source: Worldscope. Data.See Appendix D9.

FIGURE 33 Estimated Exposure to REACH



10=elevated exposure, 0=minimal exposure relative to sector competitors. Degussa AG may be more exposed due to the fact that the company is essentially a conglomerate of specialty manufacturing companies. Specialty firms cannot rely on pre-existing chemical data and may lose competitive edge due to lengthy product certification procedures. Investors may note that some analysis has been dedicated to the possibility that REACH will enhance the competitiveness of European firms. Those companies that adapt more readily and find ways to innovate more benign substances (that require less testing) eventually show themselves as leaner and more creative amidst new challenges. See Appendix D10.

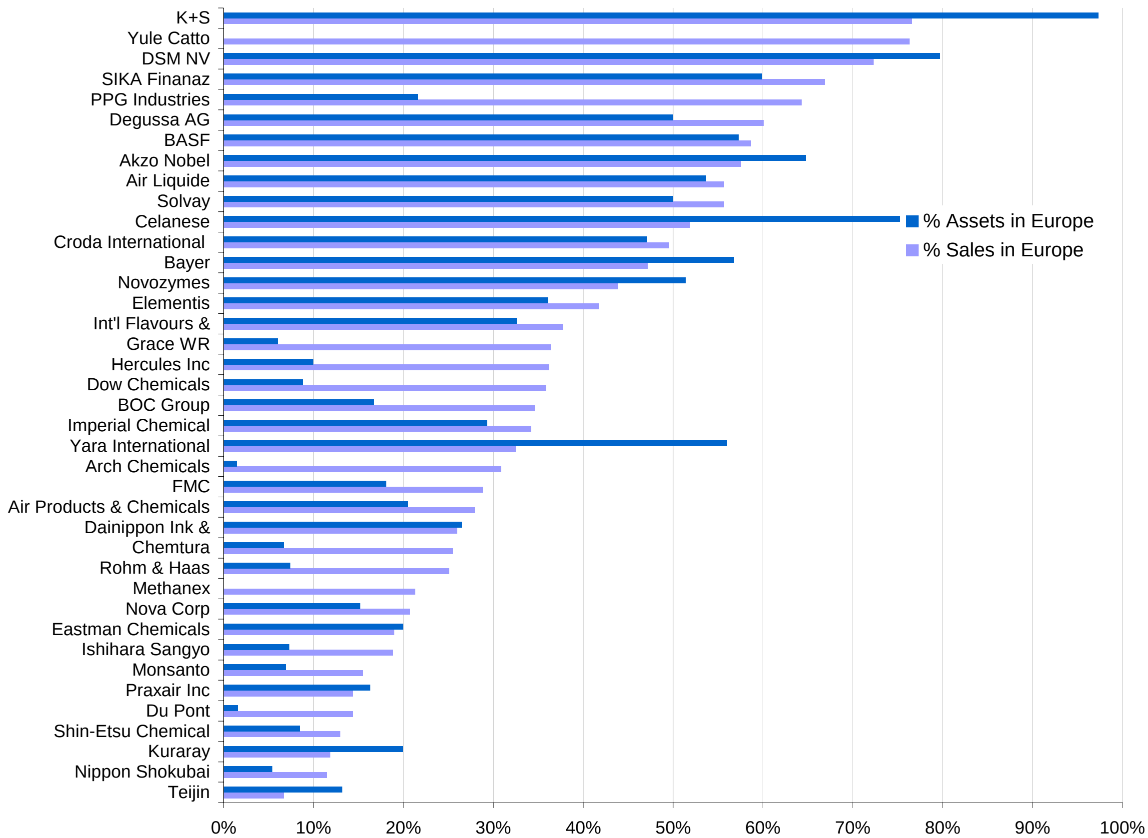
Analysis of REACH

Starting in 2004 we began our analysis of the competitive concerns associated with REACH noting that transatlantic trade could be affected. Readers who require background on this issue should refer to our previous sector reports. As part of our annual review process, we interview more than 60 companies to identify risk and exposure. The analysis breaks down into four parts:

Basic exposure

This first line of analysis provides a general sense of what percentage of revenues could be affected by the regulation.

FIGURE 34 Basic analysis of European sales and production assets in Europe



Source: Innovest

HPV

We go beyond this basic assessment by evaluating correlated indicators such as company performance in submitting complete chemical toxicity reports on time to the OECD's High Product Volume (HPV) voluntary program. We feel this is an interesting proxy for company ability to respond to the reporting challenges presented by REACH. This analysis is incorporated into an overall score for market and product risk **see sub-scores provided in the beginning of the report**.

Product review

Innovest already conducts a comprehensive review of potential product risk for each company in our chemicals universe. Then we apply this analysis to an estimation of product groups that are likely to trigger the "authorization" phase of REACH. This allows us to identify intermediates used in production and end products that might be phased out in the Authorization stage.

- **Most companies are so diverse that a specific hit to one intermediary may be of minimal relevance. However, in volume, certain companies may experience enough change that routing process re-planning may be necessary. Companies are only just beginning to make cost estimates of related process changes.**
- **Since 2002 our research has only uncovered material impacts (changes that could affect stock prices within a given 1 or 2 quarter period) for certain small and mid cap companies. These companies are not in our ratings universe at this time. That stated, a few large capitalization firms in our ratings universe may be seriously impacted and in some cases, have made it to our “watch list”. These are large cap firms who may experience event related affects based on a regulatory ruling pertaining to an intermediary critical to a key segment or product line.**
- **The relative importance of the intermediary in question and the timing of the ruling are focal points in the analysis. Dates for phase in of REACH are now widely known:**

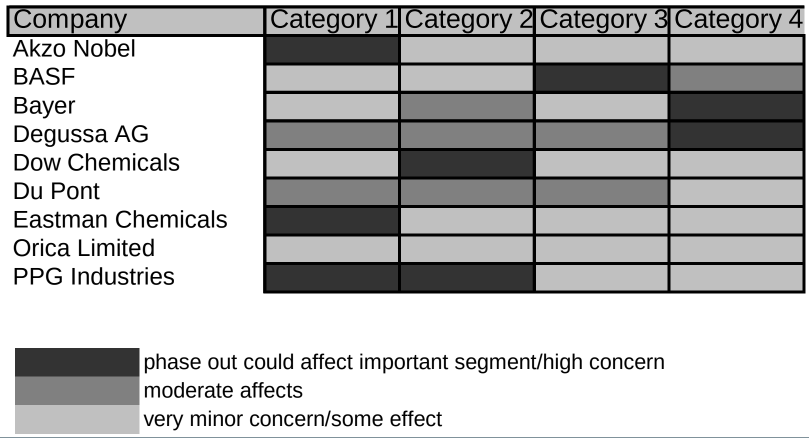
2007	Inception
2008	Registration of new Substances
2010-2020	Registration of substances in quantities exceeding 1
2013	volumes exceeding 100 tons
2018	volumes exceeding 1 ton

We track handling and usage of the three categories of the “Chemicals of Very High Concern” that would trigger the “Authorization”. This is scheduled to enter into effect starting in 2010. In this phase chemicals of concern will go through the process. It is during this period that phase-out or restriction is most likely to occur.

We have created a scoring system to allow us to categorize level of impact and classify companies by subjectivity to the Authorization phase. In many cases all categories are relevant. However when one factor is particularly evident, this dominates the score. The categories are as follows:

1. **Large number of intermediaries relevant to a single business unit/market segment**
2. **Key intermediary necessary for high revenue product**
3. **Broad impacts across all holdings**
4. **Broad Intellectual Property and Time to Market Concerns**

FIGURE 35 Sample Analysis REACH Product Survey



Source: Innovest

This work allows us to prioritize follow up meetings with companies on a yearly basis. We are looking more closely at companies like **Akzo Nobel, Degussa, PPG and Dow** in the Diversified Chemicals group. In Specialty and Commodity we are monitoring **Chemtura, Rohm & Haas, Shin Etsu, Kaneka and Solvay** among a few others. However this research only uncovered material impacts for mid-cap and small cap companies that are not currently included in our ratings universe.

Company interviews

Companies then have an opportunity to provide further information. In many instances, we find companies attempting to capitalize on REACH by developing alternative chemicals to replace those that are likely to be early candidates for restriction or phase-out. Over time this type of activity could represent a potential source of breakthrough revenue. Akzo Nobel’s alternative coating used in the shipping industry was the sole reason that the company met its earnings projections for the coatings division in 2003.Which chemical companies drive policy for the others?

5 End Users

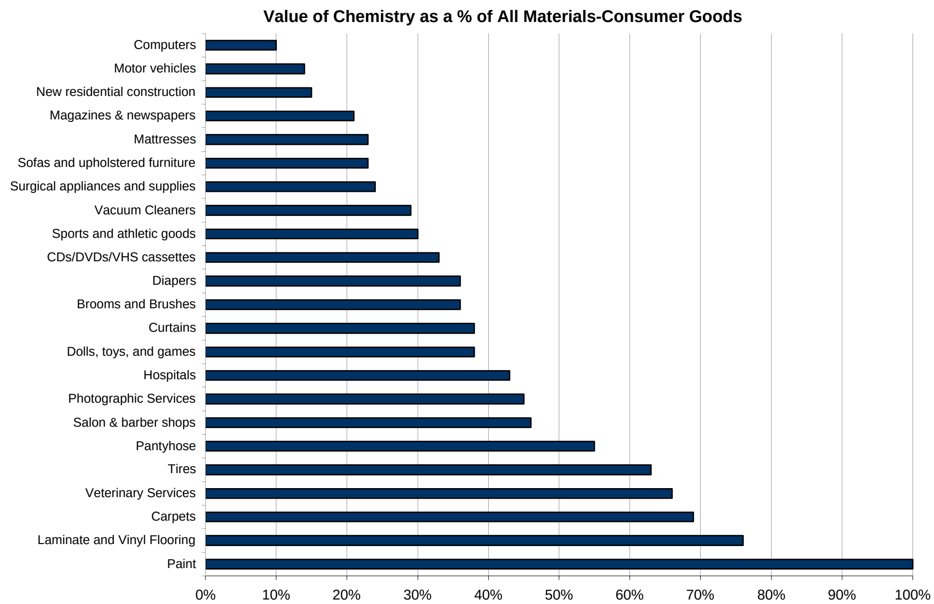
What are the major end uses for chemicals – e.g., pharmaceuticals, pesticides, plastics, etc.? What percent of the chemical market do they represent in monetary value and volume?

FIGURE 36 US Chemistry Sales by Industry (million $)

	2000	2001	2002	2003	2004	2005
Agriculture	16,769	14,008	14,706	16,001	16,121	16,622
Mining	3,074	2,776	2,809	3,582	3,924	4,295
Construction	11,174	11,303	12,048	12,622	13,108	14,258
Food Products	4,281	4,331	4,426	4,434	4,673	4,881
Textiles & Fabrics	8,538	8,815	8,663	8,466	8,537	7,957
Textile Mill Products	6,251	5,976	6,044	6,207	6,457	6,627
Wood Products	1,369	1,247	1,352	1,410	1,494	1,509
Furniture	1,083	971	959	971	995	1,084
Paper Products	10,652	8,440	8,791	9,347	9,772	10,145
Printing	3,029	3,266	3,283	3,125	2,994	2,871
Petroleum Products	3,024	3,062	3,446	3,604	3,782	4,170
Business of Chemistry	92,135	96,964	101,724	109,477	121,719	131,947
Plastics & Rubber Products	37,572	38,587	39,121	40,539	41,843	44,811
Nonmetallic Mineral Products	3,623	3,496	3,358	3,267	3,296	3,633
Primary Metals	2,763	2,454	2,588	2,493	2,673	2,897
Fabricated Metal Products	4,550	4,626	4,587	4,280	4,597	4,844

Sources: ACC analysis based on Bureau of the Census, Bureau of Economic Analysis, and Bureau of Labor Statistics

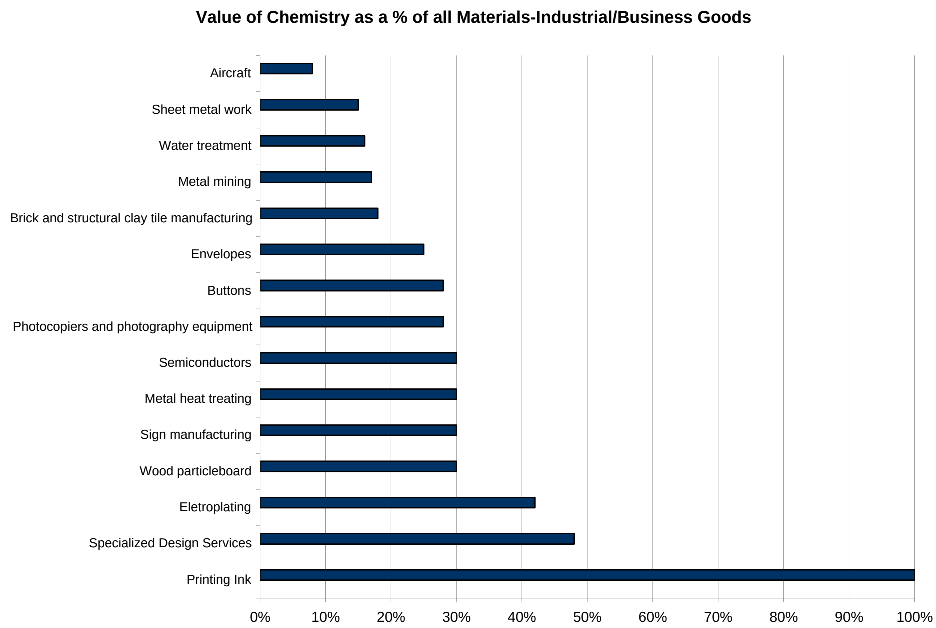
FIGURE 37 Value of Chemistry as a % of All Materials-Consumer Goods



Source: Bureau of the Census and Moore Economics analysis

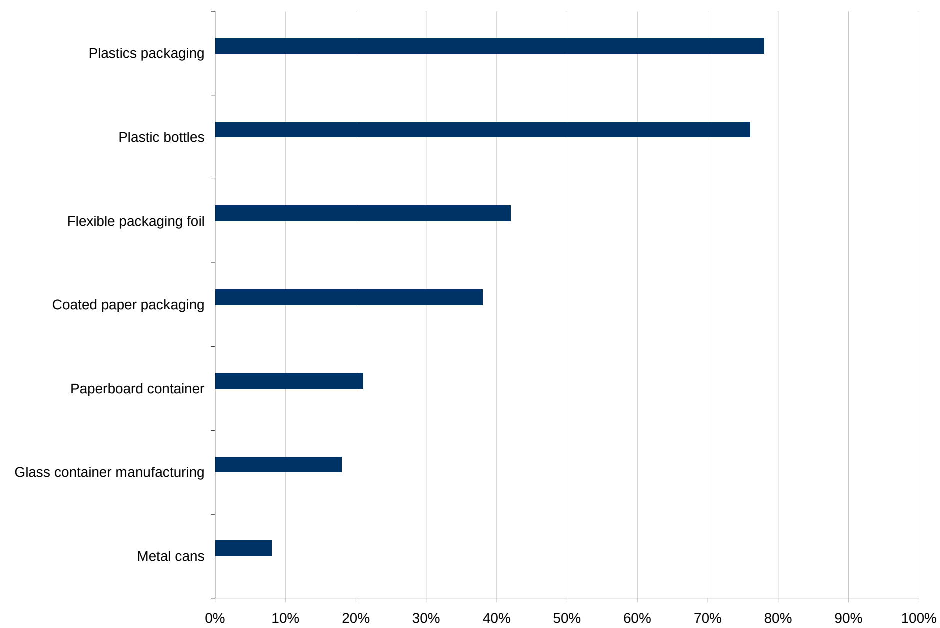
Who are the major producers of chemicals into each sector? What are their core chemicals?

FIGURE 38 Value of Chemistry as a % of All Materials-Industrial/Business Goods



Source: Bureau of the Census and Moore Economics analysis

FIGURE 39 ChemFactors for Packaging (Value of Chemistry as a % of All Materials)



Source: Bureau of the Census and Moore Economics analysis

What percentage of the chemical industry is dedicated to plastics?
How does this break down according to different polymers?

Commodity Chemicals

Bulk petrochemicals are building blocks for a myriad of petrochemical derivatives. Bulk petrochemicals include Olefins (Ethylene, Propylene, Butadiene), Aromatics (Benzene, Toluene, Xylenes), and Methanol. More than 90% of organic chemistry is derived from these seven petrochemicals.

FIGURE 40 US Bulk Petrochemical production, 2005

Bulk Petrochemical	millions of pounds
Olefins	
Ethylene	52,810
Propylene	33,470
Butadiene	4,495
Aromatics	
Benzene	15,050
Toluene	8,575
Xylenes	9,260
Methanol	5,150

Source: American Chemistry Council

Organic (or petrochemical) intermediates represent the next step in the conversion of bulk petrochemicals. Organic intermediates are used in downstream derivatives such as plastic resins, synthetic rubber, man-made fibers, surfactants, dyes and pigments, ink, and others. Over 70% of petrochemicals end up as plastic resins, synthetic rubber, or synthetic fibers.

In the US, bulk petrochemicals and organic intermediates are a $65 billion business. They serve other chemical manufacturers as well as end users such as the automotive, building and construction, consumer and institutional, electrical/electronic, furniture, and packaging markets.

FIGURE 41 Petrochemical Derivatives and Other Industrial Chemicals – US Business Value and Major Industrial End Markets

Petrochemical Derivatives & Industrial Chemicals	US Business Value ($ billion), 2005	Major Industrial End Markets
Plastic Resins	$66	Packaging, building & construction, consumer, electrical/electronics, furniture, appliances, ink & coatings
Synthetic Fibers	$7	Apparel, furnishing, automotive, construction, industrial
Synthetic Rubber	$6.5	Automotive, construction, consumer, other industries
Colorants	$6.2	Textile, paper, plastic
Inks	$4.5	Packaging, greeting card, photocopying, newspapers, book, other printing
Other Industrial Chemicals	$12	Miscellaneous

Source: ACC

Plastic Resins

Plastic Resins are the largest product segment for bulk petrochemicals. They are derived from ethylene, vinyl chloride, styrene, and propylene. Plastic resins include commodity thermoplastics, thermosets, engineering resins, and thermoplastic elastomers.

FIGURE 42 US Plastic resins – production, value, end users

Plastic Resins	US Production (millions of pounds), 2005	US Business Value ($ billion)	End Users
Thermoplastics	84,541	$49	Packaging, building & construction, consumer & institutional, electrical/electronics, furniture, automotive
Thermosets	8,657	$10	Building & construction (primary), furniture, appliances, transportation, adhesives, electrical/electronics, ink & coatings
Engineering plastics	3,777	$7	Automotive, electrical/electronic, consumer, appliances

Source: ACC

Synthetic fibers

Cellulosic fibers are made from wood pulp and raw materials from trees and plants, and include acetate and rayon. Polymeric fibers are derived from petrochemicals, and include acrylic, nylon, polyester, and polyolefins.

FIGURE 43 US Synthetic Fiber production

Synthetic Fibers	US Production (millions of pounds), 2004
Cellulosic Fiber	130
Acrylic Fiber	135
Nylon Fiber	2,575
Polyester Fiber	2,975
Other Synthetic Fibers	3,305

Source: ACC

Specialty Chemicals

In the US, specialty chemicals generated $116 billion in shipments in 2005. Many specialty markets are fragmented and serve a variety of manufacturing industries, as well as non-manufacturing industries such as oil recovery, construction or electric utilities.

FIGURE 44 US Shipments of Specialty Chemicals:

US Shipments, 2005	$ million
Specialties:	
Total Specialties	116,381
Adhesives and Sealants	8,769
Catalysts	2,478
Coatings	23,902
Cosmetic Additives	971
Electronic Chemicals	7,791
Fine Chemicals	19,602
Flavors & Fragrances	3,553
Food Additives	4,787
Functional Fluid & Lubricant Additives	2,131
Industrial & Institutional Cleaning Chemicals	7,794
Oilfield Chemicals	2,502
Paper Additives	951
Plastic Additives	4,068
Plastics Compounding	8,561
Rubber Processing Chemicals	509
Water Management Chemicals	3,496
Other Specialties **	14,516

Source: US Bureau of the Census, ACC analysis

SPECIALTY CHEMICAL END USER MARKETS:

Adhesives & Sealants include epoxy, hot melt, glues, rubber, caulk, joint, and other sealing compounds. They serve major markets such as automotive, building and construction, non-wovens, office supplies, and packaging.

Catalysts are precious metals and other specialty metals that serve major markets such as oil refining, chemical processing, and automotive emission controls.

Coatings include alkaloid, enamel, latex, oil-based, powder, and other coatings. Coatings are mainly used in stains, varnishes, lacquers, removers, and thinners, and serve major markets such as building and construction and other general industrial, packaging, and transportation markets.

Cosmetic additives are used in cosmetics, bath and shower products, perfume, skin care, sun care, toiletries, and other personal care markets.

Electronic Chemicals are essential to the manufacture of semiconductors, printed circuit boards, and other electronic components used in computers, mobile and other telecommunications equipment, automotive and medical devices.

Fine Chemicals are undifferentiated intermediate, medicinal and aroma chemicals produced in low volumes, serving major markets such as pharmaceuticals, crop protection, dyes, flavors and fragrances, food, and electronics.

Flavor & Fragrances are used to impart flavor and fragrance in finished food and personal care products, and serve major markets such as foods, beverages, cosmetics, toiletries and other personal care products.

Food Additives are used to impart flavor and other properties in finished food products as well as facilitate food and beverage processing plants, and serve major markets such as baked goods, confections, frozen foods, dairy products, soft drinks and beer, and other food and beverage processing.

Functional Fuel and Lubricant Additives are added to lubricating oils to impart special properties and to fuel to enhance combustion and/or reduce emissions of pollutants.

Institutional and Industrial Cleaners are used to clean and sanitize surfaces, equipment and other applications in food and beverage processing plants, restaurants, schools, hospitals, lodging, laundries, and other institutional settings. It serves major markets such as food service, hospitality, health care, educational institutions, and food processing.

Oilfield Chemicals are used to enhance oil recovery and production.

Paper Additives are used to facilitate paper manufacture or to enhance the properties of the final paper product.

Plastic Additives are added to plastic resin to aid or facilitate processing of the plastic resin or to enhance, extend or modify the final properties of plastic product. It serves major markets such as the plastic processing industry and ultimately light vehicles, building & construction, electronics, and consumer products, and others.

Plastic Compounding is the physical mixing of resins with performance enhancing additives to produce a compounded plastic mixture that is either less expensive, or has more favorable physical aesthetic properties, than the base resin alone. The compounded resin product is marketed to plastic processors who manufacture a wide variety of plastic products for construction, automotive, and other applications. Major markets include the plastic processing industry and ultimately light vehicles, building & construction, electronics and consumer products, and others.

Rubber Processing Chemicals are used to facilitate processing or to improve the properties of the final rubber product. They serve the tire and rubber products industry.

Water Management Chemicals are used in the treatment of cooling and boiler water to prevent the buildup of scale and corrosion and also to prevent disease in drinking water. It serves major markets such as paper mills, chemical plants, oil refineries, and electric utilities.

Key product lines

Ethylene

An organic chemical, ethylene is the simplest alkene (olefin or vinyl compound), and is produced via steam cracking. Ethylene is crucial in industry, and is the largest volume petrochemical produced. The US, Western Europe, and Japan account for 58% of global demand for ethylene.

Crude oil and natural gas are refined to produce ethylene, a primary output, which is then used as a building block for other chemical processes. Demand for plastics accounts for about three-quarters of final ethylene demand. It is also used in the manufacture of antifreeze, synthetic fibers and rubbers, solvents, and detergents. Major producers of ethylene include Dow, ExxonMobil, Chevron Phillips Chemical Co., and Lyondell.

In the US, ethylene production was 52,810 millions of pounds in 2005. Eleven firms control 50% of the market. [S&P]. In 2005, production of ethylene was severely hindered due to the hurricanes on the gulf coast, which impacted oil and gas refineries, as well as plastics plants in the area.

FIGURE 45 Largest North American Ethylene Producers, 2004

Company	Capacity (MM lbs/year)
Equistar	11,375
Dow Chemical (including U. Carbide)	10,915
ExxonMobil	8,600
Chevron Phillips Chemical	7,600
Shell	5,500
Formosa Plastics	3,400
BP Chemicals	2,900
Huntsman	2,830
Westlake Petrochemical	2,650
BASF/Fina	2,100
Eastman Chemical	1,500
BASF/GE/Williams	1,250
DuPont	1,200
Sasol North America	900
Sunoco	300
Javelina	175

Source : Chemical Market Reporter

FIGURE 46 Global demand for ethylene

	billion pounds
2004	54.17
2005	53.8
2009	60.55 (projected)

Source: Chemical Market Reporter

Analysts expect demand for ethylene to grow in China, and the capacity of plants in the Middle East to double over the next ten years. In the long run, ethylene-derivative exports to Asia are expected to erode as China expands its petrochemical capacity and the Middle East accelerates its flow of exports to the region. Furthermore, imports of ethylene-based plastic products from Asia, particularly China, are expected to capture an increasing share of the US domestic market.

In the US, about 70% of ethylene is derived from natural gas and associated liquids. In Europe, a majority of ethylene is produced from petroleum derivatives such as naphtha or gas oil. The rising cost of natural gas prices is a crucial concern for ethylene producer, especially in the US

Chlor-alkali Sector

The chlor-alkali industry produces mainly chlorine, caustic soda (sodium hydroxide), soda ash (sodium carbonate), sodium bicarbonate, potassium hydroxide, and potassium carbonate. In 1992, chlorine and caustic soda production accounted for about 80 percent of the chlor-alkali industry's value of shipments and, in terms of weight, were the eighth and ninth largest chemicals produced in the US, respectively. Chlorine and caustic soda are co-products produced in about equal amounts primarily through the electrolysis of salt (brine).4 The majority of domestic chlorine production (70 percent) is used in the manufacturing of organic chemicals including: vinyl chloride monomer, ethylene dichloride, glycerine, glycols, chlorinated solvents, and chlorinated methanes. Vinyl chloride, which is used in the production of polyvinyl chloride (PVC) and many other organic chemicals, accounts for about 38 percent of the total domestic chlorine production. The pulp and paper industry consumes approximately 15 percent of US chlorine production, and about eight percent is used in the manufacturing of other inorganic chemicals. Other major uses are disinfection treatment of water, and the production of hypochlorites. More than two-thirds of all chlorine is consumed in the same manufacturing plant in the production of chemical intermediates.5 The largest users of caustic soda are the organic chemicals industry (30 percent) and the inorganic chemicals industry (20 percent). The primary uses of caustic soda are in industrial processes, neutralization, and off-gas scrubbing; as a catalyst; and in the production of alumina, propylene oxide, polycarbonate resin, epoxies, synthetic fibers, soaps, detergents, rayon, and cellophane. The pulp and paper industry uses about 20 percent of total domestic caustic soda production for pulping wood chips, and other processes. Caustic soda is also used in the production of soaps and cleaning products, and in the petroleum and natural gas extraction industry as a drilling fluid.6

Polyvinyl Chloride (PVC)

Global polyvinyl chloride (PVC) demand is forecast to grow about 4% per year through 2009. However, there is the potential for increasing elasticity in the market for consumer-facing applications of PVC, particularly as the quality of alternative products improve. Demand for **non-construction** related applications of PVC is affected by the following issues:

EUROPEAN POLICY:

Vinyl Chloride monomer will be covered by expected European REACH regulations. Europe represents 19% of the global demand for PVC products.

CUSTOMER MIGRATION IN KEY MARKET SEGMENTS:

2005 was an important year for PVC phase-outs by major name brands. While the outlook for construction applications of PVC remains strong, the following developments point to a growing product perception problem that could impact the other major aspects of PVC demand - namely packaging and non-construction related applications:

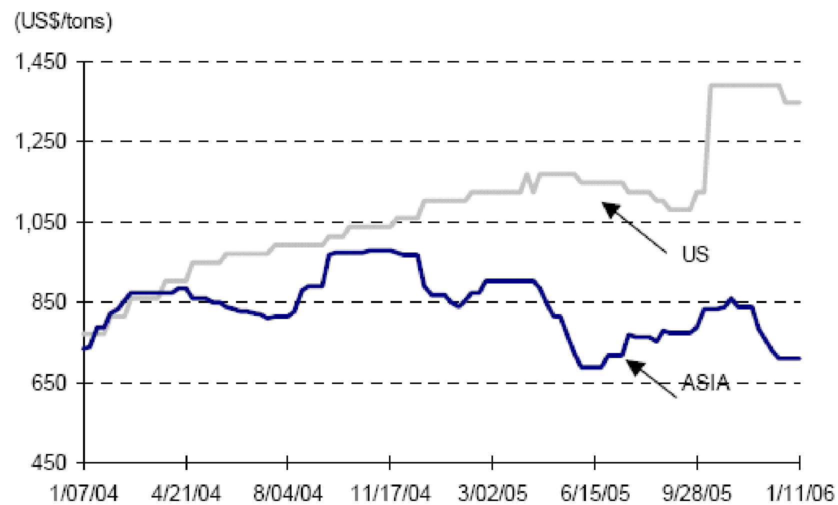
- **Wal-Mart, Intel, Dell, Hewlett Packard, Firestone Building Products, cities of New York and San Francisco, a majority of the Hospital and Healthcare market are in the process, or have initiated phase-out of PVC.**
- **Chinese manufacturers report that the government has been cracking down on property speculation. This could potentially lead to a slowdown in the building of new units. PVC overcapacity in China, could in turn, affect the long-term PVC market**
- **Petroleum prices may drive up resins prices, potentially affecting sales of siding (approximately 15% of construction demand), windows (~6.5%), profiles (~3.6%) and flooring (~3.2%). Sales of these items have been down.**

FIGURE 47 Select companies that serve the PVC Value Chain

Company	Product/Segment	Percentage of Sales
BASF	Plastics	28%
Ciba	Plastics Additives	26%
Chemtura Chemical	Polymer products (plastics and plastic additives)	30%
Rohm and Haas	plastic additives and monomers	23%
Shin-Etsu	PVC	56%
Daicel	Plastics	44%
Danippon	Plastics	14%
JSR	Plastics	20%
Tokuyama	Plastics	exact % not disclosed
Bayer	Plastics	36%
Celanese	VC monomer	exact % not disclosed
Dow	Plastics	25%
Degussa	Specialty Polymers	13%
DuPont	Polymers	25%
Eastman	Plastics	10%
Kaneka	Plastics	29%
Mitsubishi Chemical Corporation	Plastic Resins	43%
Orica	PVC Resins	22%
PPG Industries	VC Monomer	21%
Showa Denko	Plastics	34%
Solvay	Plastics	28%
Sumitomo	Plastics	32%
Teijin	Plastics	24%
Toray	Plastics	23%
Tosoh	VC Monomer	60%
Asahi Kasei	Plastics	4%
Denki Kagaku Kogyo KK	Plastics	exact % not disclosed
Mitsubishi Rayon Company Limited	Plastic Modifiers, Plastic Optical Fibers	42%
Mitsui	Plastics	
UBE	Plastics	29%
Nissan Chemical Industries	Vinyl Chloride Stabilizer	exact % not disclosed

Source: Innovest

FIGURE 48 PVC price per ton in Asia and the US



PVC PRICE PER TON IN ASIA AND THE US

It is possible that the new emphasis on sustainable development in China will lead to innovation and design specifications that will eventually bypass PVC. Alternatives to PVC siding, flooring and window casing include aluminum, polyolefin and polyethylene, and ceramics. Price differentials on these options are dropping, and given the emphasis on green building, costs may not be seen as prohibitive. China's State Environment Protection Administration (SEPA) is proposing that Inner Mongolia in northern China cut its PVC production targets by half in order to conserve resources and minimize environmental impacts to the region. This may become a trend across several high production regions.

Environmental Overview

The following chart shows that the chemicals sector ranks just after Petroleum refining in terms of expenditures on plant upgrade per employee. Innovest is conducting a more in-depth accounting review of this issue.

FIGURE 49 Net property, Plant & Equipment per Employee by US Industry ($ thousand)

Petroleum	$350
Business of Chemistry	$200
Paper & Allied Products	$145
Primary Metals	$98
Motor Vehicles	$80
Food & Kindred Products	$60
Stone, Clay & Glass Products	$55
Aircraft & Parts	$53
Electronic & Electrical Equipment	$53
Industrial Machinery & Equipment	$35
Instruments & Related Products	$34
Rubber & Plastic Products	$33
Textile Mills	$32
Printing & Publishing	$30
Fabricated Metals	$28
Other Transportation	$25
Furniture	$22
Other Manufacturing	$22
Lumber & Wood Products	$22
Apparel & Other	$18
Total Manufacturing	**$55**

Source: US Bureau of the Census, US Bureau of Labor Statistics, ACC analysis

FIGURE 50 Motivation for Capitol Investment in the US Business of Chemistry (% of total spending)

	2000	2001	2002	2003	2004	2005
Expand Capacity for Existing Products	30.9%	25.4%	9.2%	14.9%	21.7%	29.5%
Capacity for New Products	9.5%	7.1%	16.9%	6.0%	10.2%	8.8%
Replace Existing Plant & Equipment	25.3%	27.5%	36.0%	36.5%	29.2%	29.7%
Improving Operating Efficiencies	11.7%	13.2%	15.7%	12.6%	9.6%	8.7%
Energy Savings	3.2%	2.9%	3.1%	4.0%	3.5%	3.4%
Health & Safety	5.8%	6.2%	6.3%	7.2%	6.3%	7.0%
Environmental Protection	7.2%	8.0%	9.1%	9.1%	7.6%	7.4%
Other	6.4%	9.7%	3.7%	9.7%	11.9%	5.5%
Total Capital Investment	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Source: ACC Business of Chemistry

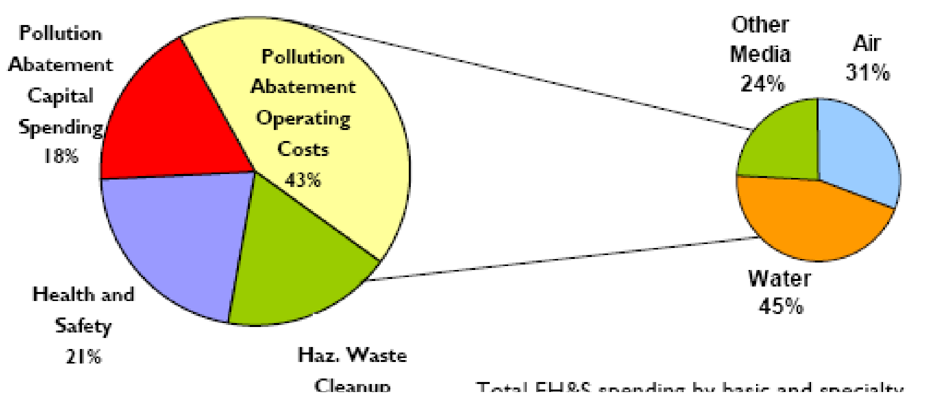
FIGURE 51 US Basic and Specialty Chemical Producers' EH&S Spending

	2000	2001	2002	2003	2004	2005
EHS Spending (million $)	10,186	9,780	9,759	9,912	10,008	10,217
As a % of Shipments	3.9%	4.1%	3.9%	3.7%	3.4%	3.2%

Source: ACC

Since 1970s, there has been an increase in gross annual operating costs (such as depreciation, labor, material and supplies, services, etc.) for pollution abatement and control at manufacturing facilities. In 2005, $4.4 billion of these expenditures accounted for 43% of the total EH&S spending. In addition to end-of-pipe type pollution abatement activities, chemistry companies also spent about $1.8 billion on Superfund and other hazardous waste site remediation.

FIGURE 52 EH&S Spending by Basic & Specialty Chemical Producers by Type of Spending



Source: Responsible Care

Innovest Suggestions for NGO Focus

CLIMATE CHANGE

According to the World Resources Institute, the chemical industry is the second largest energy-consuming manufacturing sector in the world, and accounts for almost 5% of global greenhouse gas (GHG) emissions. GHG emissions attributed to the industry are a result of the direct production and use of chemicals. This includes the on-site manufacturer emissions from fossil fuel combustion; indirect emissions from electricity consumed during the manufacturing process; and the release of emissions from various industrial processes. In some cases, emissions may result more from the use of a chemical than from its production (e.g., HFCs).

In the UK, the Chemicals Industry Association (CIA) forged the Climate Change Agreement with the government in 2000/1. The current target is to improve energy efficiency by 14% by 2010. In exchange, companies receive an 80% reduction on the tax of business use of energy. Companies can also purchase emission allowances from the UK Emissions Trading Scheme. In the US, members of the American Chemistry Council have committed to an 18% reduction in GHG by 2012.

Carbon remains a commonly overlooked cost and liability factor for the sector considering the continual intensification of carbon regulation in various markets. In Europe, the chemical sector is excluded from Phase I of the Kyoto Protocol. However, this means only that emissions and releases directly related to production, either routine or fugitive, are eliminated from regulation. Emissions resulting from grid use or on-site power generation are technically still relevant to the sector. Moreover, it is likely that the sector will be included in Phase II of the Kyoto Protocol.

Generally, companies follow regional or industry-driven initiatives to reduce energy use and carbon releases. Companies may also set internal energy efficiency targets; however, many companies have not met either industry or internal targets. Some companies such as DuPont and BASF are engaged in projects to introduce wind and fuel cells technology into production; however the sector has been generally slow, relative to other sectors, in increasing the use of renewable and alternative energy resources as a percentage of overall energy mix. There are a number of new initiatives at state and federal levels in the US, Japan and the European Union to improve the uptake of these options.

Efforts to establish carbon dioxide rules for the auto industry in the US could force the EPA to regulate greenhouse gases in general. This has the potential to result in a major change in the operating environment for the chemical industry. A long-running suit brought by 12 states now before the United States Supreme Court seeks to regulate and set limits for the CO_2 content of automotive emissions. Industry experts are claiming that a ruling in favor of the plaintiffs, would establish that the EPA has the authority under the Clean Air Act to regulate CO_2 emissions. Such a precedent could have wider implications for the chemicals sector according to many companies in our analytical set. Already there is discussion of the utility sector immediately switching to natural gas in the wake of a hypothetical ruling for the plaintiffs. That alone would have extreme implications for the cost of energy for chemicals manufacturers.

EMERGING MARKETS

Rapid growth has lead to a surge of investment in emerging markets by the majority of companies in the analytical set. Economic growth in India and China has fundamental implications all three sub-segments Commodity, Diversified and Specialty Chemicals.

Concurrently, the Chinese State Environment Protection Administration (SEPA) is laying the foundation for increased environmental oversight for domestic and foreign-owned firms. The 2008 Olympic Games in Beijing and the 2010 Shanghai World Expo pose as pressing incentives to improve environmental conditions in China.

Beijing authorities are pushing to curtail air pollution in preparation for the 2008 Olympics and a recently issued governmental five-year plan asserts to have 60% sewage treatment in bigger cities by 2010.

Examples of China's paradigm shift include a June 2006 proposal by China's State Environment Protection Administration (SEPA) to cut PVC production targets by half in order to conserve resources and minimize environmental impacts of the Inner Mongolia Province in Northern China. We understand that this may become a trend across several high production regions. Additionally, in June 2006, China's top environmental protection official pledged to block construction projects

that fail to pass stringent environmental impact assessments. Environmental protection officials had evaluated 55,000 construction projects in the last two years, and had denied approval of 1,190 projects, with investments totaling USD 20.96 billion for failing to meet environmental protection standards.

HEALTH & SAFETY

Perhaps the most visible environmental issue for the industry is the impact of chemicals on human health and safety. Through the prevalence of manufactured chemicals in modern life, people are exposed – sometimes unwittingly – to countless substances that originate in the chemical industry supply chain. A crucial element in health and safety issues is the long-term effect of chemical exposure: whether the industry and regulatory policy should be responsible for as-of-yet unproven or suspected effects, or whether chemicals should continue to be used if, so far, there is no demonstrable harm to humans.

Body Burden

Body burden is the amount of harmful substances present in a person's body.

Biomonitoring is the scientific technique for assessing human exposures to natural and synthetic compounds in the environment. Through the analysis of human tissues and fluids (such as blood, urine, breast milk, and hair), data can be collected to identify trends in chemical exposure and links to related diseases.

Chemicals have been recognized, or suspected to be associated with many health concerns including: cancer; disruption of the reproductive, endocrine, cardiovascular, and immune systems; endocrine toxicity, kidney toxicity, musculoskeletal toxicity, respiratory toxicity, neurotoxicity, disruption to development, and skin toxicity, among others

Recent media attention has covered body burden issues as they relate to exposure from consumer products, the food supply, occupational exposures, and other sources.   Chemicals that have been found widely in biomonitioring include perflourinated chemicals, chlorinated organics, some metals,and other PBT's.

A number of major NGOs have campaigns devoted to raising awareness of body burden issues, conducting biomonitoring studies, and advocating for regulatory change.

According to the North American Pollutant Releases and Transfers report, known or suspected carcinogens comprised 11 % of total releases on- and off-site of all matched chemicals in 2003. Chemicals linked to birth defects and other developmental or reproductive harm accounted for 8 % of total releases on- and off-site.

Worker Health

Similar to other manufacturing sectors, worker health and safety issues are prime concerns for chemical companies. Within the sector, however, there is the added risk of the materials being produced and their direct impact on worker's health. Though an issue throughout the industry, worker health is a primary concern for companies within the commodities sector (the specialty sector is more focused on R&D and is less likely to expose a large number of employees to large batches of chemicals).

Industrial hygienists track the issues related to worker health, including on-site injuries and worker illness. According to the ACC, the incidence of worker illness and injury in the US chemical industry has declined 60% since 1990.

It is not always clear, however, how contract labor and subsidiary companies fit into the data, and whether worker safety at tertiary subsidiaries are tracked and attributed to the larger holding company.

TOXIC WASTE

Within the industry, the term ‘emissions’ refers not only to air emissions that affect climate change, but to waste emissions to land and water, as well. According to S&P, the industry has been forced to incur considerable costs to comply with tighter regulations regarding toxic waste.

In North America, toxic waste is monitored and measured by the Canadian-based Commission of Environmental Cooperation (CEC). The CEC analyses data from the US Toxics Release Inventory (TRI) and the Canadian National Pollutant Release Inventory (NPRI) and publishes a report that analyzes all manufacturing industries, including chemicals. It includes specific data on known or suspected carcinogens and on chemicals that are linked to birth defects and other developmental harm (California Proposition 65 Chemicals).

In 2003, the chemical industry reported the second largest total release and transfers from all manufacturing industries. Methanol, nitric acid and nitrate compounds were the largest releases, primarily as off-site transfers.

FIGURE 53 Chemical Industry releases and transfers

On-site releases	197,423,453 kg
Off-site releases	23,009,892 kg
Total reported releases on- & off-site	220,433,345 kg
Transfers to recycling	78,940,651 kg
Other transfers for further management	316,921,945 kg
Total reported amounts of releases & transfers	616,295,941 kg
NPRI as % of North American Total	5%
TRI as % of North American Total	95%
Major chemicals reported*	Methanol (transfers to energy recovery and to treatment) Nitric acid and nitrate compounds (transfers to sewage, underground injection) Toluene Xylenes (transfers to energy recovery) Manganese and compounds (land)

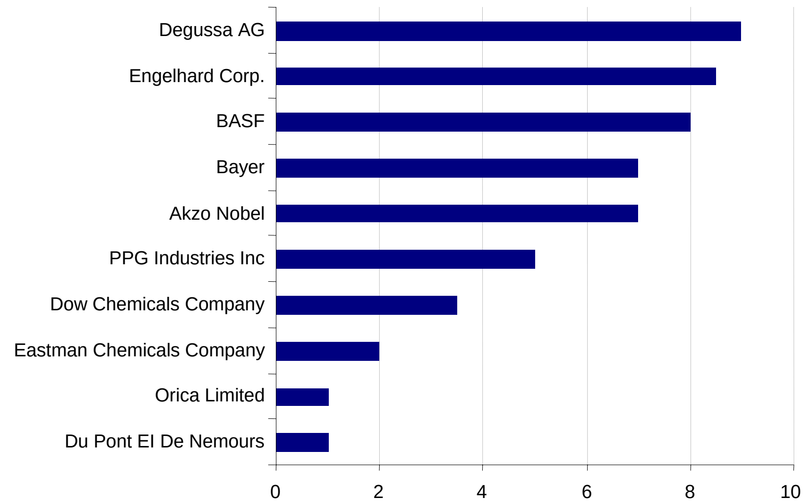
*(Chemicals accounting for more than 50% of total reported amounts)

Source: Commission for Environmental Cooperation, Taking Stock 2003 North American Pollutant Releases and Transfers

Risk Screening Environmental Indicators (RSEI):

The EPA has recently issued data to the public that combines environmental release statistics (using the Toxic Release Inventory) and demographic and geological information, called Risk Screening Environmental Indicator (RSEI). RSEI is commonly used as a screening tool to compare toxic chemicals released to the environment from industrial sources. While this information is new and not yet fully parsed, a project at the Political Economy Research Institute (PERI) at the University of Massachusetts at Amherst has correlated entries with Dun & Bradstreet company identifiers, and has aggregated RSEI scores to develop The Toxic 100. Released in May 2006, this list identifies the top air polluters among corporations that appear in the “Fortune 500,” “Forbes 500,” and “Standard & Poor's 500” lists of the country's largest firms. Currently, PERI is completing an additional iteration of the Toxic 100, and a full corporate list of toxicity rating. This analysis might be of use in framing environmental justice claims.

FIGURE 54 The following is a ranking of the sector by RSEI score:



In a benchmarking of RSEI scores for Diversified Chemical companies in Innovest's universe, DuPont ranked worst-in-sector. This is indicative of both DuPont toxic releases and the size of the affected population, relative to sector peers.

New regulations may stimulate an increase in disposal costs and may limit disposal options. Companies try to respond by altering routing procedures to minimize the toxicity of certain waste streams. In some cases, it may be possible to achieve zero emissions. Zero waste means zero disposal costs – a particularly important issue in Japan where tightening landfill regulations are resulting in higher fines and other regulatory action.

Given the limited profit margin of many of these companies, the reserve accounts they set aside for environmental clean up obligations are sometimes notable. Risk adverse companies may set aside greater amounts and may have taken a very cautious approach to projected environmental liabilities available under the Generally Accepted Accounting Principals (GAAP). Others in this sector may be under-reserved depending on the circumstances.

SITE SECURITY ISSUES

Site security at chemical plants and facilities has been raised as a serious security concern. In the US, a Responsible Care Security Code has been developed to address facility, cyber, and transportation security. The code is mandatory for ACC members and has four basic components for facilities:

- **Prioritize facilities**
- **Assess vulnerabilities via methodologies developed by credible third parties**
- **Implement security enhancements**
- **Verify physical enhancements**

According to ACC, members have fulfilled their code obligations at all 2,040 facilities, and have invested more than $2 billion on security since the 9/11 terrorist attack.

A bill attached to the 2007 US Homeland Security funding bill ($38.4 billion) that was recently passed deals with chemical facility security, though it gives the Secretary of Homeland Security discretion in determining which chemical factories “present high levels of security risk”. Of the 15,000 chemical facilities in the US, the Department of Homeland Security (DHS) has identified 4,000 as dangerous facilities, and has focused attention on 272 facilities. Thousands of chemical facilities are exempt, and there are no deadlines for plants to submit security plans, or for the DHS to approve or disapprove security plans. Furthermore, there are no criteria for choosing ‘high risk’ plants. The NGO community, focused on risk and toxic reduction, has cited much criticism of the new bill including:

- **The lack of any specific "security measures" including site repairs, safer technologies, etc.**
- **The exemption of thousands of chemical plants that the DHS does not consider high risk. Although the DHS initially identified more than 4,000 dangerous facilities, they have focused on as few as 272 facilities.**
- **3,000 drinking water and wastewater facilities are exempt.**
- **Chemical plants are not given a deadline to submit security plans or deadlines by which DHS must approve or disapprove security plans.**
- **The criteria defining a high-risk plant is not identified.**
- **It fails to clarify the right of states to to set stronger security standards than the federal government as New Jersey has.**

PRODUCT LIABILITY AND REGULATION

Chemical product liability is likely to be a significant driver of volatility over the next several years.

Benzene

For example, there are a growing number of lawsuits in the industry regarding worker exposure to benzene. Manufacturers of benzene that may be liable to such claims are **Air Products and Chemicals Inc., Clariant AG, Lonza Group AG, Rohm & Haas Company, BASF, and Degussa AG. There is an anticipated 5-10 year timeframe for serious liabilities to surface.**

Dioxins

Another important example is dioxins. Of all the various chemical substances that could create liability, dioxins and dioxin-like compounds may represent a first order of risk. Several dioxin-related community lawsuits are in progress or have been settled out of court in both the US and Japan. There is some indication of growing public attention around the issue of dioxins and other persistent substances. New tests are being funded by the EPA and other entities to track dioxins in the bloodstream (particularly in children) and to determine the link between these substances and many suspected health effects.

Flame Retardants

Markets are shifting to halogen-free flame retardants as a result of product safety concerns, availability of safer alternatives, and increasingly stringent EU regulation. Halogenated products remain the leading flame retardants globally. However, in Europe halogen-free alternatives currently comprise more than 70 % of the market. Going forward, we anticipate manufacturers of halogen-free retardants to be at an advantage as regulatory and consumer changes continue. Current producers of flame retardants in the Innovest universe are:

Current producers of flame retardants in the Innovest universe are:

Company	Halogen-based	Halogen alternatives
Clariant AG		X
Nitto Denko Corp	X	
Chemtura	X	
Sigma-Aldrich	X	
BASF		X
Dow		X
Nissan Chemical		X
Celanese AG		X
Mitsubishi Chemical		X
Tosoh Corporation	X	

Source: Innovest

The European Union's RoHS Directive 2002/95/EC required the substitution of various brominated flame retardants (PBDE) in electronics sold starting July 1, 2006, with the exemption of deca-BDEs. However, in June 2006 the European Commission ruled to reverse the exempted status for deca, despite the EU's previous risk assessment findings. Currently, deca is in regulatory limbo with no definite decision having been made. Many companies are choosing a more conservative approach in the meantime, saving them losses that could be incurred if the ban is enforced. The final ruling is expected in early September.

Bisphenol-A

Bisphenol-A is a PBT (persistent, organic and toxic) chemical used in plastics, electronics and other applications. NGOs have begun to build their message on this issue and we count several mainstream press mentions of concern. Bayer was, until recently, one of the two largest producers of Bisphenol-A prior to the spin-off of Lanxess. However, NGOs continue to associate Bayer with this chemical of concern. It is unclear whether the company would incur legal liability in the event of more concerted action by NGOs.

Regulatory Developments

California serves as a broad indicator for developments in product liability. For example California was the first state to enforce a ban on MTBE-blending. In June 2006, San Francisco banned the manufacture, sale, and distribution within the metropolitan area of child care articles and toys containing bisphenol-A and some phthalates for children under three years old. The ban goes into effect on Dec. 1, 2006. San Francisco is the first city in the nation to institute such a ban. A similar measure was introduced in the California legislature this year but failed to pass. Other states such as Massachusetts, Maryland, New Jersey and Connecticut often follow California's lead in fairly rapid succession. A 3-5 year time horizon is not unrealistic for other states to adopt.

Pesticides

A weakening of the conventional pesticide market may impact sales for several companies in our set. Markets are shifting from synthetic to bio-pesticides, driven by biotech advancements that reduce the need for extensive spraying. Citigroup cites a $2 billion reduction in pesticide demand since 1995, a reduction mainly attributed to bioscience. The bio-pesticide industry is projected to increase by 20% per year in the US. Conversely, the synthetic pesticide market is expected to decrease by 3.14%, with bio-pesticides replacing 4.25% of that. Companies potentially affected may include: **Potash, Agrium, Chemtura, Syngenta and the Agrosciences** division of **Dow** face growing pressure in face of further market shift to biopesticides.

Detecting Potential for Product Liability and Regulation

In the US, California serves as an indicator for developments in product liability and imminent regulation. This has been demonstrated with MTBE, as California was the first state to enforce a ban on MTBE-blending. In June 2006, San Francisco banned the use, manufacture, sale, and distribution within the metropolitan area of childcare articles and toys containing bisphenol-A and some phthalates for children under three years old. The ban goes into effect on Dec. 1, 2006. San Francisco is the first city in the nation to institute such a ban. A similar measure was introduced in the California legislature this year, but failed to pass. It is anticipated that similar regulations in other states will take place within a 3-5 year time period.

US Regulation – TRI, HPV Challenge

Important US EPA programs include:

TOXIC RELEASE INVENTORY (TRI)

TRI is a publicly available database containing information on toxic chemical releases and other waste management activities. The current TRI toxic chemical list contains 581 individually listed chemicals and 30 chemical categories.

HIGH PRODUCTION VOLUME (HPV)

According to the General Accounting Office for nearly all chemicals in the US, manufacturers are not legally required to test their products for health effects at any stage of production, marketing, and use. Furthermore, the EPA has not reviewed or gathered data on 12,000 of the 15,000 chemicals produced or imported into the US in annual quantities exceeding 10,000 pounds. Through the HPV voluntary program, manufacturers are submitting screening studies on nearly 3,000 chemicals that people are most likely to be exposed to – those produced or imported into the US in annual quantities exceeding 1,000,000 pounds. According to a GAO study released in 2005, EPA's reviews of new chemicals provide limited assurance that health and environmental risks are identified before the chemicals enter commerce.

HPV chemicals are those which are manufactured in, or imported into, the United States in amounts equal to or greater than one million pounds per year.

The HPV Challenge Program was designed to ensure public access to environmental chemical information. Companies participate in the HPV Challenge program through developing data sets related to specific chemicals. The program currently covers over 2,200 chemicals. [EPA]

In the US, about 3,300 chemicals (excluding polymers) out of approximately 70,000 chemicals in commerce are HPV. Approximately 4.4 to 7.1 trillion pounds of HPV chemicals are produced or imported annually in the US

HPV chemicals are identified through information collected under the Toxic Substances Cotrol Act (TSCA), which gives the EPA broad authority to regulate the manufacture, use, distribution in commerce, and disposal of chemical substances. A major objective is to characterize and evaluate the risks posed by a chemical to humans and the environment before it is introduced into commerce.

The TSCA Chemical Substances Inventory lists commercial substances in commercial use. Chemicals are classified as “existing” or “new”; only “existing” chemicals are listed on the TSCA inventory. Any substance not on the inventory is classified as a “new” chemical. Organic compounds are subject to reporting under the TSCA. Some chemical categories are not included in EPA's HPV list:

- **Polymers**
- **inorganic substances**
- **Microorganisms**
- **Naturally occurring substances**

In addition, several specific categories of chemicals, such as pesticides, food additives, drugs, and cosmetics are excluded.

The TSCA Inventory Update Rule (IUR) requires that companies update the data on listed chemicals every four years.

International Regulation – Stockholm POP

The Stockholm Convention on Persistent Organic Pollutants (POPs) is an international treaty that targets twelve of the most persistent bioaccumulative chemicals. The treaty aims to phase out and eliminate the use of those chemicals. The twelve chemicals include eight pesticides, two types of industrial chemicals, and two chemical families of unintended by-products of the manufacture, use, and/or combustion of chlorine and chlorine-containing materials.

POPs pose a particular health and environmental hazard due to their:

- **Toxicity**
- **Persistence (resisting normal processes that break down contaminants)**
- **Accumulation in the body fat of people, marine mammals, and other animals. They are also passed from mother to fetus.**
- **Ability to travel great distances on wind and water currents.**

POPs can cause nervous system damage, diseases of the immune system, reproductive and developmental disorders, and cancers. All 12 targeted POPs are also endocrine disruptors chemicals.

[The 12 targeted POPs include eight pesticides (aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, mirex, and toxaphene), two types of industrial chemicals (polychlorinated biphenyls or PCBs and hexachlorobenzene), and two chemical families of unintended by-products of the manufacture, use, and/or combustion of chlorine and chlorine-containing materials (dioxins and furans).]

Industry

Responsible Care is a global chemical industry performance initiative. The six categories of the program are:

- **Community Awareness / Emergency Response**
- **Employee Health and Safety at Work**
- **Process Safety**
- **Protection of the Environment / Waste Reduction**
- **Safe Warehousing and Distribution**

NANOTECHNOLOGY

Investments in nanotechnology worldwide increased over eightfold during the period from 1997 to 20051. Experts agree that nanoscience will enable new technologies across a majority of industry sectors going forward.

Early testing reveals that some types of engineered nanoparticles may present risk in terms of human health and eco-toxicity. Experts in the "nano" space are beginning to warn investors that this could result in perception risks that could affect markets for nanomaterials and end-products. Additionally, focus group studies are beginning to show increased awareness and limited trust in government to minimize nanotechnology risk. Whereas, similar studies in previous years have revealed very limited awarness, today the percentages are increasing.

FIGURE 55 Assessment of Risk and Strategic Positioning for 15 Firms Selected for the Innovest Index.

		Product Strategy	Product Risk	Product Stewardship
Altair Nanotechnologies, Inc.	ALTI	Good Strategy/Practices	Moderate Risk/Average Practices	Good Strategy/Practices
ApNano	IPO soon	Good Strategy/Practices	Moderate Risk/Average Practices	Good Strategy/Practices
BASF AG	BAS-FF	Moderate Risk/Average Practices	Product Risk	Good Strategy/Practices
Biosante Pharmaceuticals, Inc.	BPA	Moderate Risk/Average Practices	Product Risk	Moderate Risk/Average Practices
FEI Company	FEIC	Good Strategy/Practices	Not Applicable	Not Applicable
Flamel Technologies S.A.	FLML	Moderate Risk/Average Practices	Moderate Risk/Average Practices	Moderate Risk/Average Practices
General Electric Company	GE	Good Strategy/Practices	Moderate Risk/Average Practices	Moderate Risk/Average Practices
Headwaters, Inc.	HW	Good Strategy/Practices	Product Risk	Moderate Risk/Average Practices
JMAR Technologies, Inc.	JMAR	Good Strategy/Practices	Not Applicable	Not Applicable
Lumera Corporation	LMRA	Moderate Risk/Average Practices	Good Strategy/Practices	Moderate Risk/Average Practices
Nalco Holding Company	NLC	Good Strategy/Practices	Product Risk	Moderate Risk/Average Practices
Plug Power, Inc.	PLUG	Good Strategy/Practices	Good Strategy/Practices	Moderate Risk/Average Practices
Spire Corporation	SPIR	Good Strategy/Practices	Moderate Risk/Average Practices	Moderate Risk/Average Practices
Starpharma Group	SPL	Good Strategy/Practices	Product Risk	Moderate Risk/Average Practices
Veeco Instruments, Inc.	VECO	Good Strategy/Practices	Not Applicable	Not Applicable

Good Strategy/Practices
Moderate Risk/Average Practices
Product Risk
Not Applicable

For monitoring purposes only. Source: Innovest

Nanotechnology Players

LARGE CORPORATIONS

Although estimates differ depending on the definition of nanotechnology, NanoInvestorNews.com shows that there are approximately 200 public companies involved in nanotechnology research and development about 77 of which are large corporations. Several of them have nanoscale particle products on the market or are marketing products enhanced with nanoscale particles. These products typically represent the most simplistic stage of development and are used for the enhancement of existing materials. Nanoparticles that impart reflective and strengthening properties for coatings or which make textiles stain resistant would be examples of this. This group includes large chemical manufacturers like Dow (DOW-NYSE) and DuPont (DD - NYSE). These firms have the resources and capacity to develop techniques to ultimately deliver nanoparticles at commercial production levels.

PURE PLAY

NanoInvestorNews.com lists about 700 private firms. Most of these firms are concentrating on the science and are not close to having a viable product in the near future. Some of them provide information for investors suggesting possible applications for their scientific pursuits. Note that while several companies may be working on the same technology, a firm selected for our index will have been tested for specific traits through our model.

ACADEMIA

University research is an important part of the nanotechnology equation. Several of the venture capital firms and holding companies are working directly with research centers to deliver intellectual property straight to the market. This makes for a complicated risk profile. It is unclear where the accountability for safe nano development would lie in this situation.

Key Issues

PREPARING FOR THE AGE OF NANOTECHNOLOGY

Innovest believes quantum physics is shaping up to be the underlying science behind a significant portion of today's Gross National Product. Estimates of the global market for nanotechnology products stands at approximately $9.4bn in 2005 and $10.5bn in 2006 according to BCC Research. Growth projections vary but general consensus is in the range of $25 billion in the next 4 to 5 years.

HYPE IS DECLINING BUT PRODUCTS CONTINUE TO ENTER THE MARKET

The nano "hype" may be dying down but investment and orders seem to be increasing. Most of this business appears to be in the chemicals sector where nano additives are actually one of the first and still profitable aspects of the market. While higher value added applications in electronics are right around the corner, profit is being realized primarily in personal care, sunscreens, polishing applications and antimicrobial products. Many drug and biomedical applications also are now on the market. Costs are coming down now as well which could lead to even more nano applications in consumer products. As of March 8, 2006, the nanotechnology consumer products inventory contains 212 products or product lines

DUE DILIGENCE

Some particles and processes may represent risk in certain applications This issue is now given more attention relative to previous years. A full day was dedicated to the scientific and legal implications of this issue at the NanoBusiness Alliance conference held in New York this year. However risk remains. Innovest finds that perception issues can be prompted even when the product in question does not actually contain nano particles as in the recent case of a recall in Germany of an industrial cleaning agent.

DRAWING PARALLELS

Industry's experience with synthetic chemicals and genetically modified organisms may provide historic lessons for investors interested in the potential impact that perception issues could have on the advancement of nanotechnology.

2007 WILL BE AN IMPORTANT YEAR

We expect a number of EHS studies to be complete in that year. Moreover, officials in various markets tell us that they have set their sites on that timeframe for establishing a base level of regulation. Adequate funding to ascertain risks is necessary to reduce uncertainty and support the healthy development of nanotechnology markets.

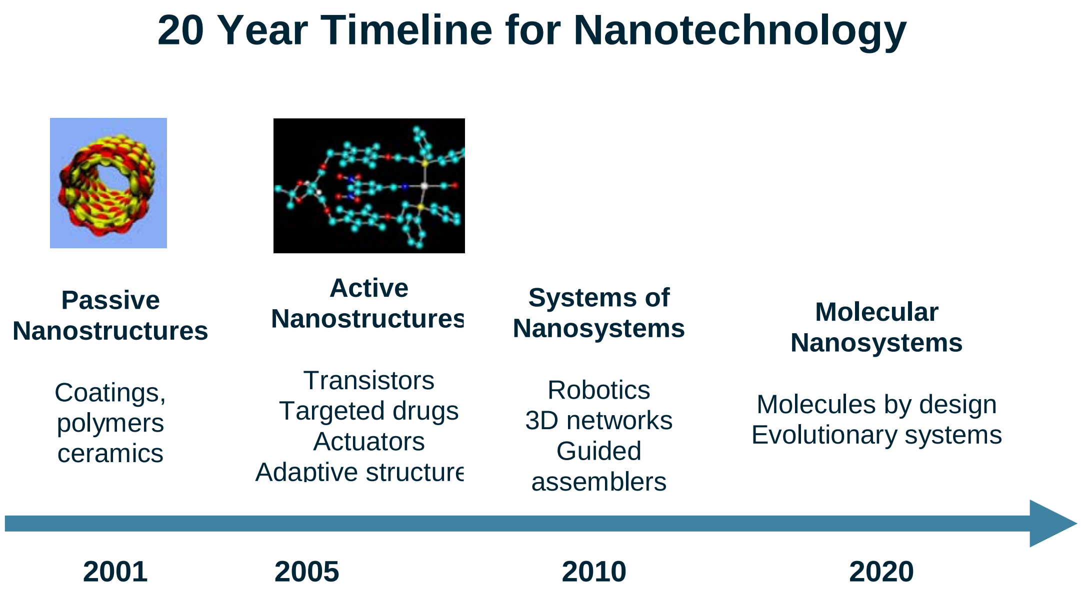
THE RIGHT TECHNOLOGIES, NOW

In August of last year, Innovest's report on the nexus between nanotechnology and cleantech was met with some skepticism. However we maintain that beneficial technology applications are more likely to offset public perception issues should any arise. Moreover it stands to reason that companies would want to focus R&D efforts on rapidly expanding markets. For example, the largest end-user market for nanotechnology in 2005 was environmental remediation at 33% of the total market (BCC Research).

STILL EARLY

The vast majority of companies who claim to be involved in nanoscience or nanotechnology development are still engaged in basic research. The universe of companies will eventually narrow to a few who claim to have product ready for the market. These will be bought by large cap firms or their technology will be licensed. Fewer still will remain who can survive as viable nano pureplay companies. To date the ratio of venture capital to government R&D spending is very low and the number of licensing agreements, IPOs and acquisitions is also low.

FIGURE 56 20 Year Timeline for Technological Development



Source: Michael Roco[21]

NANOMATERIALS IN PRODUCTS

The list of consumer applications containing nano particles of various forms continues to grow. As of March 8, 2006, a nanotechnology consumer products inventory launched by Woodrow Wilson Center for Scholars contains 212 products or product lines. This includes cleaning products, car wax, cosmetics, sunscreens and over the counter medical applications.

Safety Issues

There is a body of technical literature on nanotech safety issues to rely on but the best resource for the layperson is a report released by global insurance giant SwissRe which outlines risks related to inhalation exposure and describes experiments showing particles passing the blood-brain barrier. Early analysis also demonstrates how certain kinds of particles (particularly those with functionalized surfaces) can exacerbate the mobility and bioaccumulative properties of toxins already present in the environment. Fullerenes, quantum dots, carbon nanotubes,

[21] Adapted from Roco, M. National Science Foundation

nanowires and dendrimers are being studied at this time. While Rice University's Center for Biological and Environmental Nanotechnologies has been a central force in identifying these issues and devising technological solutions, it is now commonly recognized that product risk is a possibility that will require the financial community to conduct analysis on a case by case basis.

6 Appendices

Chemicals: What are the top 50-100 chemicals produced (not related to toxicity) and how do they compare to the top 50-100 HPV chemicals?

The list below is derived from the most recent Inventory Update Review (IUR) list (not related to toxicity). The HPV Challenge Program is based on volume, hence High Production Volume.

FIGURE 57 Top 100 Chemicals by Volume

	Top 100 Chemicals - Volume 2002
CASNO	CHEM NAME
6841 0639	Natural gas, dried
64741453	Residues, petroleum, atm. tower
64741566	Residues, petroleum, vacuum
64741486	Natural gas, petroleum, raw liq. mix
8008206	Kerosine, petroleum
64741442	Distillates, petroleum, straight-run middle
64742809	Distillates, petroleum, hydrodesulfurized middle
64741577	Gas oils, petroleum, heavy vacuum
64741544	Naphtha, petroleum, heavy catalytic cracked
8002059	Petroleum
64741599	Distillates, petroleum, light catalytic cracked
64741555	Naphtha, petroleum, light catalytic cracked
64741635	Naphtha, petroleum, light catalytic reformed
74986	Propane
64741420	Naphtha, petroleum, full-range straight-run
64741419	Naphtha, petroleum, heavy straight-run
74828	Methane
64741464	Naphtha, petroleum, light straight-run
64741793	Coke, petroleum
64742810	Kerosine, petroleum, hydrodesulfurized
64742467	Distillates, petroleum, hydrotreated middle
64741680	Naphtha, petroleum, heavy catalytic reformed
64742592	Gas oils, petroleum, hydrotreated vacuum
64741873	Naphtha, petroleum, sweetened
106978	Butane
64742796	Gas oils, petroleum, hydrodesulfurized
68606111	Gasoline, straight-run, topping-plant
68955351	Naphtha, petroleum, catalytic reformed

64741431	Gas oils, petroleum, straight-run
64741588	Gas oils, petroleum, light vacuum
64742865	Gas oils, petroleum, hydrodesulfurized heavy vacuum
74851	Ethane
70592788	Distillates, petroleum, vacuum
64742490	Naphtha, petroleum, hydrotreated light
8052424	Asphalt
68919379	Naphtha, petroleum, full-range reformed
64742489	Naphtha, petroleum, hydrotreated heavy
64741646	Naphtha, petroleum, full-range alkylate
75285	Propane, 2-methyl-
68410004	Distillates, petroleum, crude oil
64741817	Distillates, petroleum, heavy thermal cracked
64741624	Clarified oils, petroleum, catalytic cracked
115071	1-Propene
68476302	Fuel oil, no. 2
68553004	Fuel oil, no. 6
8006142	Natural gas
64741828	Distillates, petroleum, light thermal cracked
68477850	Gases, petroleum, C4-rich
64742730	Naphtha, petroleum, hydrodesulfurized light
74840	Ethane
68308270	Fuel gases, refinery
7782505	Chlorine
64741782	Naphtha, petroleum, heavy hydrocracked
68476346	Fuels, diesel, no. 2
65996772	Coke, coal
64741704	Naphtha, petroleum, isomerization
71432	Benzene
64742821	Naphtha, petroleum, hydrodesulfurized heavy
1634044	Propane, 2-methoxy-2-methyl-
64741862	Distillates, petroleum, sweetened middle
124389	Carbon dioxide
64742478	Distillates, petroleum, hydrotreated light
68476460	Hydrocarbons, C3-11, catalytic cracker distillates
64741691	Naphtha, petroleum, light hydrocracked
68334305	Fuels, diesel
68527195	Hydrocarbons, C1-4, debutanizer fraction
68476335	Fuel oil, residual
68333255	Distillates, petroleum, hydrodesulfurized light catalytic cracked
68915968	Distillates, petroleum, heavy straight-run
64741475	Natural gas condensates, petroleum
64742229	Naphtha, petroleum, chem. neutralized heavy
64741771	Distillates, petroleum, light hydrocracked
68783120	Naphtha, petroleum, unsweetened
68425310	Gasoline, natural gas, natural
64741953	Residual oils, petroleum, solvent deasphalted

68955271	Distillates, petroleum, petroleum residues vacuum
107062	Ethane, 1,2-dichloro-
68915979	Gas oils, petroleum, straight-run, high-boiling
68410979	Distillates, petroleum, light distillate hydrotreating process, low-boiling
57136	Urea
68131759	Gases, petroleum, C3-4
68410059	Distillates, petroleum, straight-run light
68478171	Residues, petroleum, heavy coker gas oil and vacuum gas oil
70592777	Distillates, petroleum, light vacuum
64742387	Distillates, petroleum, clay-treated middle
8030306	Naphtha
64741839	Naphtha, petroleum, heavy thermal cracked
68607307	Residues, petroleum, topping plant, low-sulfur
68475581	Alkanes, C2-3
64741668	Naphtha, petroleum, light alkylate
1330207	Benzene, dimethyl-
64741840	Naphtha, petroleum, solvent-refined light
68527275	Naphtha, petroleum, full-range alkylate, butane-contg.
68783084	Gas oils, petroleum, heavy atmospheric
64741602	Distillates, petroleum, intermediate catalytic cracked
68513020	Naphtha, petroleum, full-range coker
64175	Ethanol
64742876	Gas oils, petroleum, hydrodesulfurized light vacuum
68476506	Hydrocarbons, C.gtoreq.5, C5-6-rich
64741613	Distillates, petroleum, heavy catalytic cracked

Source: Chemical & Engineering News

FIGURE 58 Toxic Chemicals Released in the Largest Quantities

Rank	Chemcial Name	Pounds
1	HYDROCHLORIC ACID	599,122,978
2	ZINC COMPOUNDS	484,974,173
3	ARSENIC (ORGANIC OR INORGANIC COMPOUNDS)	401,207,702
4	LEAD COMPOUNDS	388,912,425
5	COPPER COMPOUNDS	316,678,822
6	NITRATE COMPOUNDS	261,919,824
7	MANGANESE COMPOUNDS	209,518,545
8	BARIUM COMPOUNDS	174,064,093
9	METHANOL	166,274,245
10	AMMONIA	151,805,024
11	SULFURIC ACID	140,501,225
12	HYDROFLUORIC ACID	76,672,698

13	TOLUENE	64,619,053
14	STYRENE	47,670,330
15	N-HEXANE	44,805,346
16	XYLENE (MIXED ISOMERS)	43,243,515
17	VANADIUM COMPOUNDS	41,041,919
18	ZINC	34,259,664
19	CHROMIUM COMPOUNDS	32,349,845
20	CARBON DISULFIDE	29,763,441
21	NICKEL COMPOUNDS	29,126,792
22	METHYL ETHYL KETONE	27,500,022
23	GLYCOL ETHERS	26,023,209
24	ETHYLENE	25,956,320
25	CARBONYL SULFIDE	19,826,827
26	ALUMINUM	19,157,159
27	ACETONITRILE	18,617,452
28	FORMALDEHYDE	18,454,569
29	N-BUTYL ALCOHOL	17,840,589
30	NITRIC ACID	17,723,582
31	CHLORINE	17,297,134
32	LEAD	14,591,436
33	ACETALDEHYDE	13,887,568
34	PROPYLENE	12,451,104
35	ACRYLONITRILE	11,571,505
36	DICHLOROMETHANE	11,393,552
37	ANTIMONY COMPOUNDS	11,256,971
38	CYANIDE COMPOUNDS	9,730,585
39	METHYL ISOBUTYL KETONE	9,623,340
40	MANGANESE	9,288,099
41	CHLORODIFLUOROMETHANE	9,047,749
42	ACRYLAMIDE	8,649,983
43	PHENOL	8,153,965
44	TRICHLOROETHYLENE	8,081,332
45	FORMIC ACID	7,660,746
46	ETHYLBENZENE	7,401,691
47	1,2,4-TRIMETHYLBENZENE	7,348,078
48	1,1-DICHLORO-1-FLUOROETHANE	6,924,280
49	BENZENE	6,744,340
50	ETHYLENE GLYCOL	6,677,248
51	BARIUM	6,273,045
52	COPPER	6,153,131
53	1-CHLORO-1,1-DIFLUOROETHANE	5,852,147
54	COBALT COMPOUNDS	5,423,772
55	ASBESTOS (FRIABLE)	5,396,535
56	ACRYLIC ACID	5,280,197
57	SODIUM NITRITE	5,279,988
58	N-METHYL-2-PYRROLIDONE	5,171,860

59	MERCURY COMPOUNDS	5,044,217
60	CYCLOHEXANE	4,197,653
61	CADMIUM COMPOUNDS	4,171,405
62	VINYL ACETATE	3,635,607
63	CYCLOHEXANOL	3,492,751
64	CHROMIUM	3,466,033
65	METHYL TERT-BUTYL ETHER	3,152,466
66	NAPHTHALENE	3,147,190
67	METHYL METHACRYLATE	2,950,899
68	SELENIUM COMPOUNDS	2,884,136
69	TETRACHLOROETHYLENE	2,626,604
70	HYDROGEN CYANIDE	2,544,009
71	NICKEL	1,999,401
72	1,3-BUTADIENE	1,950,192
73	CRESOL (MIXED ISOMERS)	1,879,565
74	THALLIUM COMPOUNDS	1,847,520
75	ARSENIC	1,788,119
76	CHLOROMETHANE	1,780,210
77	CHLOROFORM	1,537,178
78	TRIETHYLAMINE	1,405,967
79	ANTIMONY	1,367,442
80	SEC-BUTYL ALCOHOL	1,304,585
81	POLYCHLORINATED BIPHENYLS	1,251,837
82	CUMENE	1,248,032
83	MOLYBDENUM TRIOXIDE	1,237,462
84	P-XYLENE	1,235,723
85	VANADIUM	1,221,317
86	PYRIDINE	1,194,138
87	ALUMINUM OXIDE (FIBROUS FORMS)	1,153,609
88	DIISOCYANATES	1,136,005
89	PROPIONALDEHYDE	1,027,570
90	ACETAMIDE	995,179
91	ANILINE	875,867
92	2-CHLOR-1,3-BUTADIENE	874,737
93	CHLOROBENZENE	837,758
94	VINYL CHLORIDE	810,997
95	TERT-BUTYL ALCOHOL	799,434
96	CHLOROETHANE	799,210
97	DICHLOROTETRAFLUOROETHANE (CFC-114)	788,649
98	ACETOPHENONE	782,608
99	POLYCYCLIC AROMATIC COMPOUNDS	779,378
100	O-XYLENE	751,819

Source: Scorecard http://www.scorecard.org