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# **The Impact of the Development of Shale Gas in the United States on Europe's Petrochemical Industries**

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## Summary

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The shale gas revolution has led to strong falls in energy prices, reducing significantly the raw material costs of the US petrochemical industry. Between 2008 and 2012, US gas prices fell by two thirds. Ethane comes from natural gas liquids (NGLs) contained in shale gas, and used by the US petrochemical industry as the raw material to make ethylene. Its price fell by 55% between 2008 and 2012. These price cuts are giving the US petrochemical industry a significant competitive advantage, and profits are exploding. The United States has become the region in the world with the second lowest energy and raw material prices, just after the Middle East.

This renewed competitiveness is leading to the re-birth of American petrochemicals, whereas the sector was stagnating and even experiencing waves of closures in the middle of the 2000s. An estimated \$15 billion is set to be invested in the sector by 2017, generating a 40% increase in ethylene output, the leading petrochemical product. The competitive advantage makes itself felt downstream in the sector. In particular, plastics derived from the transformation of petrochemicals are used in manufacturing in three major consumer industries: packaging, construction and the automotive industry. By 2017, the output capacity of polyethylene, the polymer most used in the production of plastics, should rise by 40%. The economic spillovers of such investments are significant. The American Chemistry Council (ACC) has conducted a study of around one hundred investment projects, identified at the end of March 2013 in the US chemical industry (excluding pharmaceuticals). These projects involved \$72 billion in investment, through to 2020. They will raise the turnover of the chemical industry by \$67 billion (in 2012 dollars), by 2020, and will create 1.2 million jobs during the phase of construction. By 2020, additional earnings of the US economy will run to \$201 billion, with tax revenues of \$14 billion. The ACC estimates that these investments will lead to the United States to become a net exporter of chemicals, thus eliminating the trade deficit due to rising pharmaceutical imports.

In contrast, the European petrochemicals industry is in a delicate position. It is in the grip of sluggish demand in Europe, rising energy costs, ageing plants and production over-capacity. Unlike the US, Europe's petrochemical producers use naphtha from refined oil as a raw material. Between 2008 and 2012, the price of naphtha rose by 19%, and margins for European producers have been falling, as

they can only pass on costs partially to their clients, given the competition of mega petrochemical plants built in the Middle East in the 2000s, and that to come from the United States.

In time, European petrochemical producers will face a wave of competition from products *Made in America*, expected to hit international markets in 2016-17: i.e. the time needed by US producers to complete their investments. This competition will be new: American products will be in direct competition with hi-tech chemicals in which Europe is currently a leader. Europe does not benefit from low energy prices and will lose out in cost competition. It will have trouble resisting US imports that will not be subsidised, but which will simply benefit from the competitive advantage of having low gas prices. European exports also risk facing US competition elsewhere, as American producers will seek to get into high-growth markets too.

Europe's petrochemicals sector thus faces necessary restructuring and rationalization of its production plants. American competition is accelerating the closure of petrochemical sites and the redirection of European petrochemicals towards niche products. To maintain competitiveness, European companies are closing isolated and loss-making sites, and they are integrating production up- and downstream, in order to benefit from synergies and cut costs. They are diversifying their use of raw materials and replacing naphtha. Downstream production is being redirected towards products in which European demand is growing strongly: innovative products, with high value-added and hi-technology, which are European strong points. The redirection is also shifting to products whose costs are less dependent on energy and raw material prices, which is the weak point of Europe's industry, as its energy costs are three times as high as US costs. These products are also more environmentally friendly, meeting the imperatives of sustainable development. This is another strength of Europe's petrochemical industry, which is leading in research in biochemistry and bio-plastics. Lastly, just as they are investing in high-growth regions (in Asia and especially China), and in low energy cost regions (the Middle East), so too Europe's major industrial groups are investing in the United States, in order to benefit from the shale gas bonanza and cheaper production.

## Introduction

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The massive rise of unconventional hydrocarbons, and especially shale gas, in the United States is often looked at only from the energy perspective. But gas is not just used as a fuel to produce energy. Instead, it is also a fundamental raw material in petrochemical industries. What is usually called the revolution in American shale gas thus has major consequences not only in the field of energy, but also industry.

This study aims to measure the industrial impact of shale gas. It focuses specifically on petrochemicals, and in particular on ethylene, for two main reasons. First, ethylene production is energy intensive. Energy costs (as a fuel and raw material) account for about 70% of total production costs. As a result, this is a key sector for observing the impact of the spread in the price of energy between the United States and Europe. Next, the petrochemical sector is an indicator of the good health of industrial production and its future competitiveness. Products fabricated in the petrochemical sector are used in making plastics (and other derivative products), which are subsequently used in nearly all branches of manufacturing industry. The sector is therefore a reliable lead indicator of the good or poor health of a region's economy.

The first part of this study recalls the rise of shale gas output in the United States, and briefly analyses the main impacts on the American gas industry, especially its impact on the price of energy in the US market. The second part of the study analyses the contrasting evolution of energy prices (gas, electricity, ethane and naphtha) in the United States and Europe. It underlines the significant competitive gains the US has achieved, thanks to shale gas. The revival of America's petrochemical sector is examined in the third part of the study, which details numerous investment projects in new ethylene and polyethylene production capacity in the US, since energy prices have started to fall. Part four looks at the impact of this surge in US production on the European petrochemical industry. It also describes the strategies developed by European petrochemical producers to adapt to this situation.



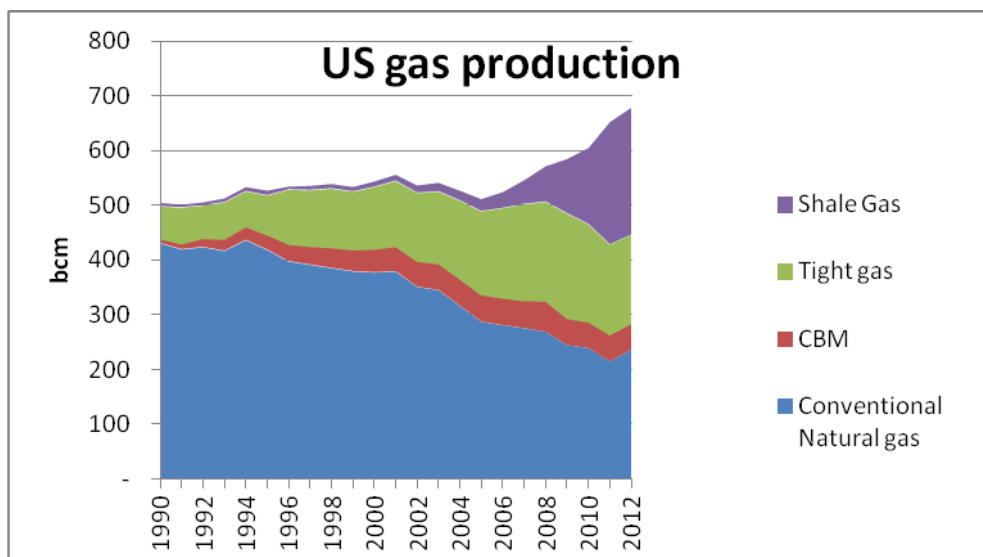
# The Revolution in Shale Gas and Liquids in the United States

## *The United States as the World's Top Gas Producer*

Hydraulic fracturing has allowed the United States to tap non-conventional gas and oil resources, modifying the US energy scene radically.

Just as **gas production in the United States was falling, it then experienced a 24% rise between 2007 and 2012** (Figure 1). This rise has been due to the production of shale gas, which today accounts for 34% of US gas output. In 2012, shale gas output rose to 230 billion cubic meters (Gm<sup>3</sup>), more than five times its 2007 level.

**Figure 1. Gas Production in the United States, 1990-2012**



Source: US Energy Information Administration (EIA)

Since 2009, the United States has become the world's largest gas producer, ahead of Russia.

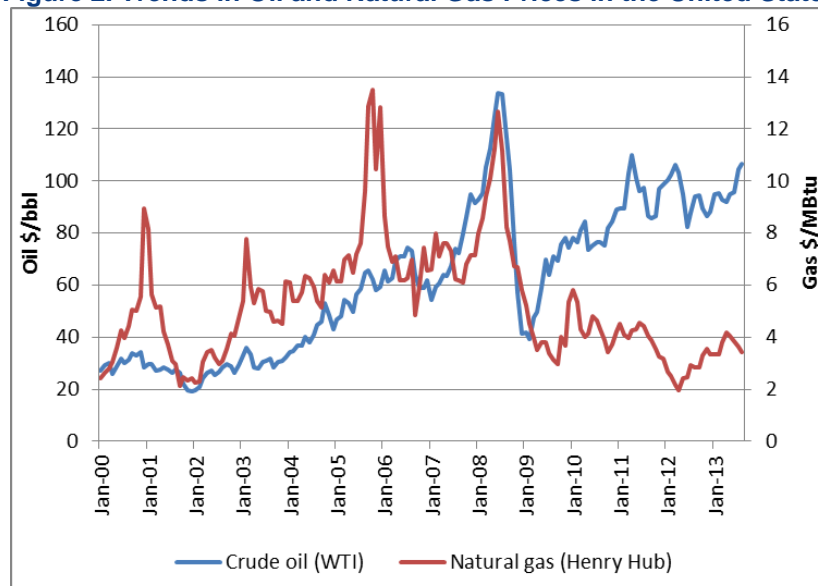


## Rising Gas Supplies have Led to Strong Price Falls

The term “shale gas revolution” better applies to the consequences for gas supplies on the US market and hence the world market for gas, rather than for the technology of hydraulic fracturing. The latter has in fact long been known and used in the oil industry. The strong rise in gas production has indeed led to a fall in prices and the decoupling of the price of gas from oil. This contrasts to way gas prices in the United States, as in Europe, rose strongly during the 2000s, being directly linked to the price of oil.

Figure 2 shows the evolution of gas prices in the United States (Henry Hub spot prices), as well as the trend of American crude oil prices (WTI), since 2000. In the middle of the decade, US output was declining, and the country was envisaging rising imports of liquefied natural gas (LNG) to complement its own supplies. In 2007, the US FERC (Federal Energy Regulation Commission) identified no less than 43 projects for importing LNG. Gas prices were peaking: \$12.7 per million British thermal units (MBtu) in June 2008, with an annual average price of \$9 that year. Since 2009, prices have fallen, first as a result of the financial crisis and more recently with the development of shale gas. In 2012, the price stood at \$2.75 per MBtu on average, even falling to less than \$2 in April that year. Since this low point, American prices have risen to about \$4 per MBtu (\$3.43 in August 2013). Despite this rise, prices remain very low: equivalent to \$24 per barrel of oil, and clearly below the prices levels in the other large regional markets (see Part II).

**Figure 2. Trends in Oil and Natural Gas Prices in the United States**



Source: World Bank

The abundance of supply and low domestic gas prices are leading US gas producers to look to international markets, and especially lucrative Asian and European markets. About 20 LNG export projects have been put forward, and two have been approved: Sabine Pass in Louisiana and Freeport in Texas, with a total export capacity of 36 Gm<sup>3</sup>. The first shipments are expected to occur in 2015-2016. Operators of two other projects, Cove Point in Maryland and Cameron in Texas, have signed long term contracts and should also begin exporting by the end of the decade, bringing total exports to nearly 60 Gm<sup>3</sup>. From being a net importer (the US imported 42 Gm<sup>3</sup> net in 2012), the **United States could become a net exporter of gas by 2020**, thanks to LNG exports.

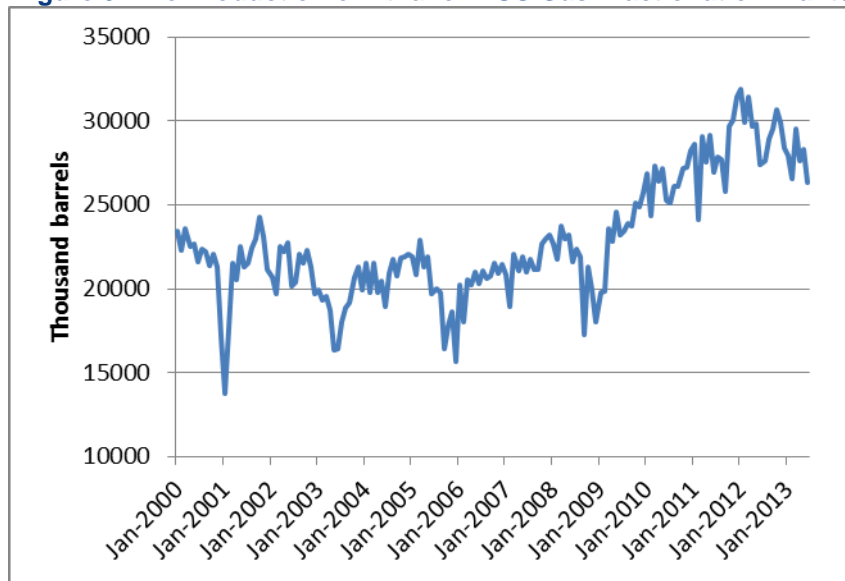
### ***The Production of Gas is Accompanied by Greater Output of Natural Gas Liquids (NGLs)***

The very low price of gas does not cover production costs in a significant number of shale gas basins. The breakeven price is hard to estimate as it depends on nearly every play. But it is reckoned to be around \$4 to \$5 per MBtu by most companies. However, this level is tending to fall, given significant cost reductions in the industry (especially due to the application of “clusters and gas hubs” which allow producers to achieve important synergies and savings).

**Falling prices have encouraged producers to target basins rich in gas liquids (Marcellus and Eagle Ford), which offer better returns than methane. Accordingly, the production of natural gas liquids (NGLs), which is linked to shale gas, is also rising strongly** (Figure 3). Ethane output reached 355 million barrels (Mb) in 2012, an increase of 38% on 2008, linked to the rapid rise of wet gas production. Gas fractionation plants are proliferating in the United States. They allow methane (distributed through networks) to be separated from liquids which are used in petrochemicals, industry and the residential/commercial sector. Ethane (C<sub>2</sub>) is used almost exclusively by the petrochemical industry to produce ethylene. Propane (C<sub>3</sub>) can also be used as a raw material in petrochemicals to produce propylene and ethylene. But it can also be widely used in the residential sector for heating needs and in transport. Butane (C<sub>4</sub>) is another raw material in petrochemicals and is also used in refineries in which it is mixed with natural gasoline. Propane and butane are liquefied petroleum gas (LPG). Pentanes + (C<sub>5</sub>+) are also used as raw materials in the chemical industry, but they have other uses too: for example, as diluting agents for the extraction and transport of heavy oils in Canada.<sup>1</sup>

<sup>1</sup> EIA (2013a), Annual Energy Outlook 2013, EIA/DOE, Washington, DC, April-May 2013.

**Figure 3. The Production of Ethane in US Gas Fractionation Plants**



Source : EIA

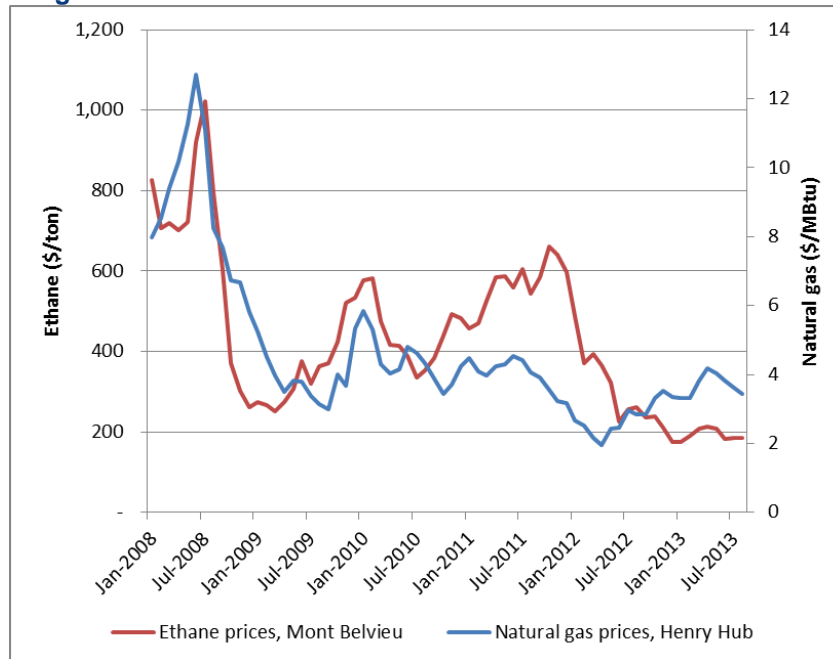
The production of propane has followed similar trends, to the point that the United States has become a net exporter of this gas.

The availability of NGLs has revolutionised the US petrochemical industry. Ethane is used as the basis for producing ethylene, which is one of the major intermediate products used in making plastics. Its increasing availability is driving a revival of the US petrochemicals sector based on cheap, abundant ethane.

## ***The Falling Price of Ethane***

**The strong rise in ethane production has led to sharp price falls in the US.** Having peaked at 93 cents per gallon in 2008 (\$663/t), prices fell by 55%, to 41 cents per gallon in 2012 (\$296/t). During the first six months of 2013 prices collapsed a further 45% with respect to the same period in 2012, down to 27 cents per gallon (\$197/t). The price of ethane, which followed the price of American gas, has decoupled since mid-2012, given the availability of ethane which the market cannot absorb. The numerous petrochemical projects using ethane that have been announced in the US require about three years of construction, and will not come into operation before 2016-17. In the meantime, as new outlets are not yet available, the low price has encouraged some producers to leave NGLs in gas (a practice described as “ethane rejection”). As a result, ethane production fell by 9% during the first four months of 2013. In the shorter term, some projects are being put into place to rebalance the market, including exports from the Marcellus basin to Canada, and liquefaction projects to export ethane to Europe.

**Figure 4. Prices of Ethane and Natural Gas in the United States**



Source : Platt's, EIA

Even though future production of NGLs and especially ethane is hard to evaluate, as it is strongly dependent on the relative price of gas and NGLs, most experts expect a significant rise in output to between 3 million and 3.2 million barrels per day (Mb/d), by 2015/16, compared to 2.4Mb/d in 2013.<sup>2</sup> This would constitute a 30% rise. The Energy Information Administration (EIA) expects output of 3Mb/d to 3.7Mb/d by 2017, depending on the energy scenarios used.<sup>3</sup> Such developments require significant investments in transport infrastructures and gas fractionation, as well as in the transport of NGLs. Presently, fractionation capacities are limited to 2.8Mb/d, but 1.4Mb/d of new capacity is set to be built in 2013-14.

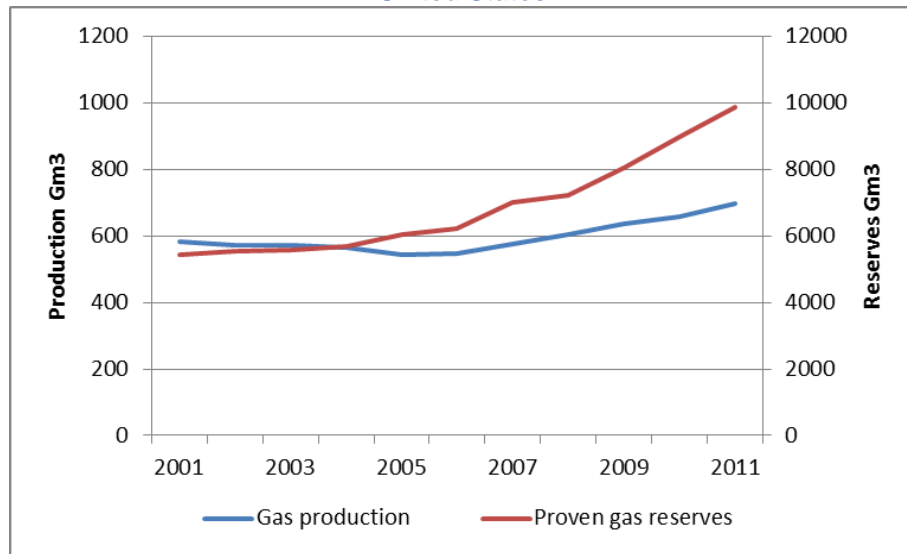
<sup>2</sup> Platt's (2012), The North American Gas Value Chain: Developments and Opportunities, Platt's special report, September 2012.

<sup>3</sup> EIA (2013a), op.cit.

## ***America's Gas Resources are Substantial and the Contribution of Shale Gas to Total Gas Output is Likely to Increase***

Proven gas reserves in the United States were estimated by the EIA to be 9,877 Gm<sup>3</sup>, on 31<sup>st</sup> December 2011.<sup>4</sup> They include 3,627 Gm<sup>3</sup> of proven reserves of shale gas. Despite the rise in gas output over the last five years, proven reserves have continued to grow, mainly due to better knowledge of the potential of shale gas.

**Figure 5. The Evolution of Natural Gas Reserves and Production in the United States**



Source : EIA

Gas resources are enormous: as of 31<sup>st</sup> December 2011 they are estimated at 69,000 Gm<sup>3</sup>, of which 19,000 Gm<sup>3</sup> of shale gas.<sup>5</sup>

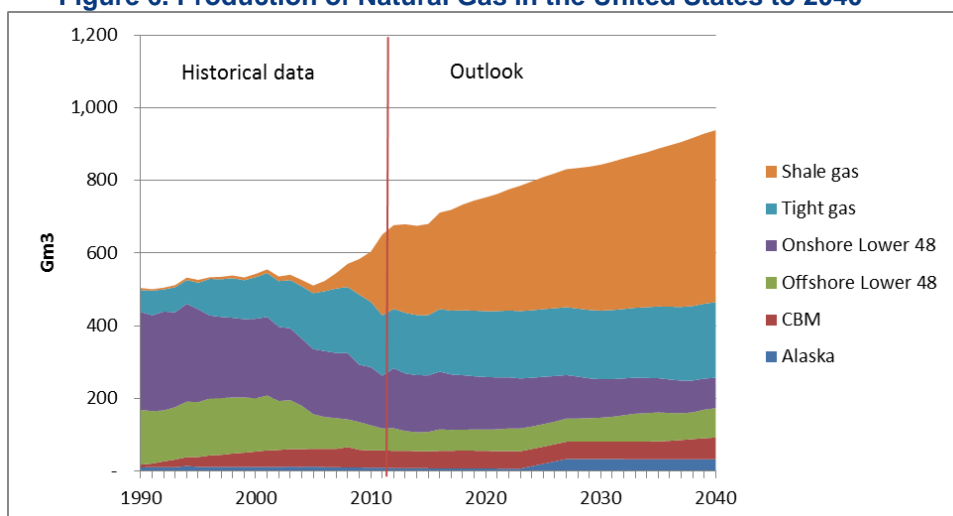
This huge potential makes it possible to envisage the continued growth of American gas production. The EIA estimates that output could rise by 1.3%/year on average between 2011 and 2040, reaching 940 Gm<sup>3</sup> by then: i.e. a 44% increase on 2011.<sup>6</sup>

<sup>4</sup> EIA (2013b), U.S. Crude Oil and Natural Gas Proved Reserves, EIA/DOE, Washington DC, 1 August 2013.

<sup>5</sup> EIA (2013c), Shale oil and shale gas resources are globally abundant, Today in energy, EIA/DOE, Washington DC, 10 June 2013.

<sup>6</sup> EIA (2013a), op. cit.

**Figure 6. Production of Natural Gas in the United States to 2040**



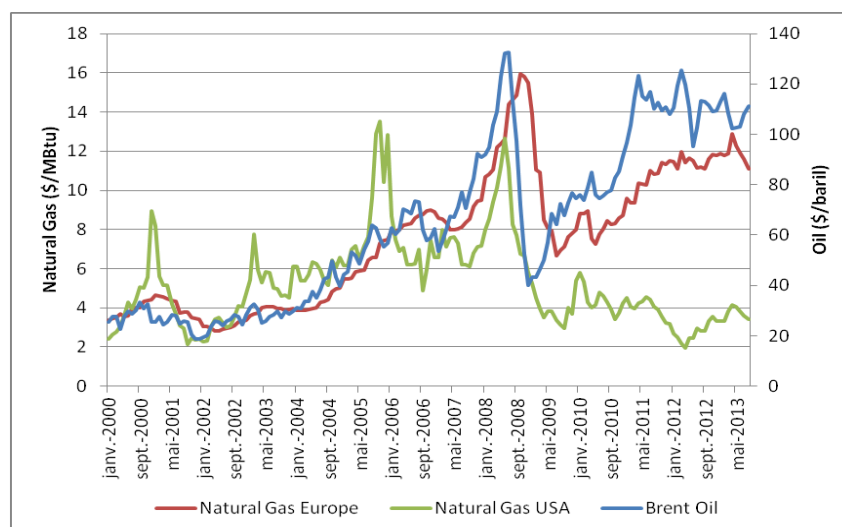
Source: EIA

## Energy Prices: a Competitive Advantage for the United States

### *European Industry Pays Three Times as Much for Gas as US Industry*

The strong growth of gas supplies in the United States has led to a fall in the price of gas on the spot market and the decoupling of gas prices from oil. This evolution has allowed the United States to become more competitive *vis-à-vis* Europe, where the gas price is still largely indexed on oil prices, and is three to four times as high as in the US. Figure 7 compares spot market prices in the US with the price of imported gas in Europe. In 2012, the price of natural gas in Europe was on average \$11.47 per MBtu, whereas it was only \$2.75 per MBtu in the USA (\$11.12 and \$3.43 respectively in August 2013). The price of imported gas in Europe was thus four times as high as American prices (compared to 2.7 times as high for 2009-2013).

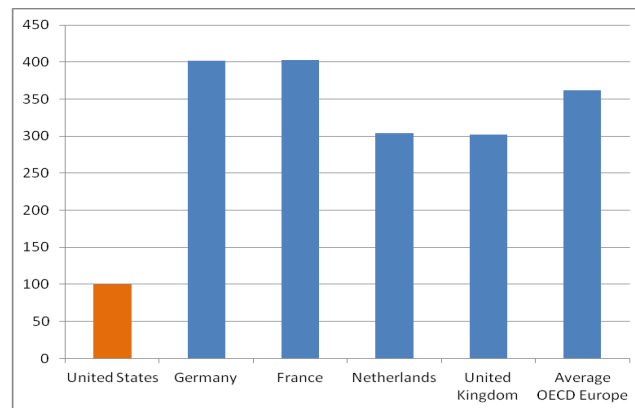
**Figure 7. The Price of Natural Gas in the USA and in Europe, and the Price of Crude Oil**



Source : World Bank, EIA

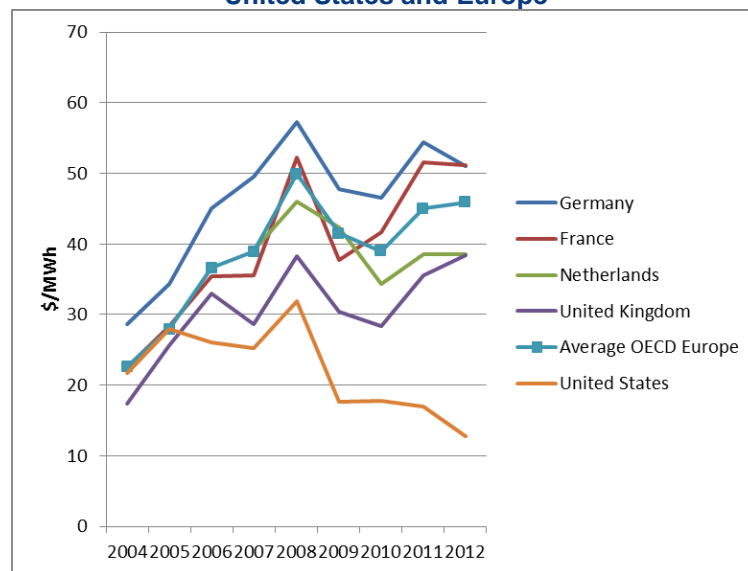
These trends have led to prices for European industry which are at least three times as high as prices for US industry (Figure 8), and this difference has widened in the last two years (Figure 9), weakening the position of European industry with respect to the US. The situation is especially delicate for industries that are energy intensive consumers and which are exposed to international competition, such as chemicals, fertilisers, and steel, etc.

**Figure 8. Average Price of Gas for Industry in the United States and Europe (average 2012; indexed prices: the United States = 100)**



Source : International Energy Agency (IEA) (2013)<sup>7</sup>

**Figure 9. Recent Trends in the Price of Gas Delivered to Industry in the United States and Europe**



Source : IEA (2013)

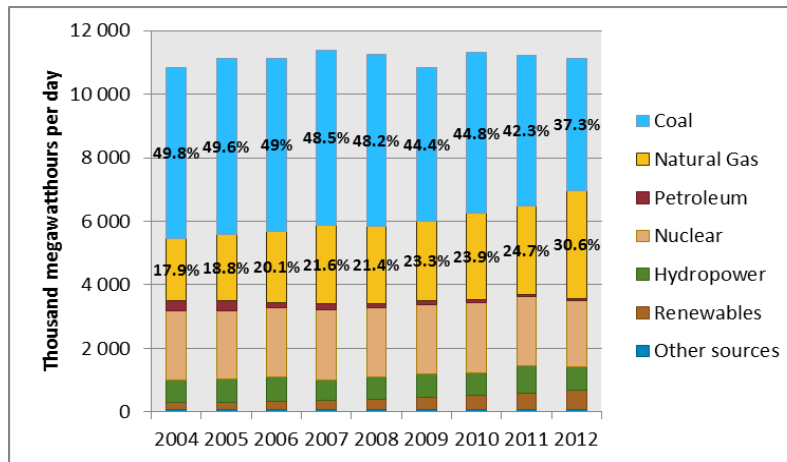
<sup>7</sup> IEA (2013), Energy prices and taxes, 2013, second quarter, IEA/OCDE, Paris.



## European Industry also Pays Twice as Much for its Electricity

America's competitive advantage also stretches to the electricity market. **Indeed, falls in the price of gas have led to a rise in the consumption of gas by electricity producers in the US. This has been at the cost of domestic coal**, which was more expensive than natural gas in 2012. Thus, while coal still generated half of US electricity in 2007, its share fell to 37% in 2012. As for gas, its share was 22% in 2007, and rose to 31% in 2012.

**Figure 10. The Production of Electricity in the United States by Primary Fuels**



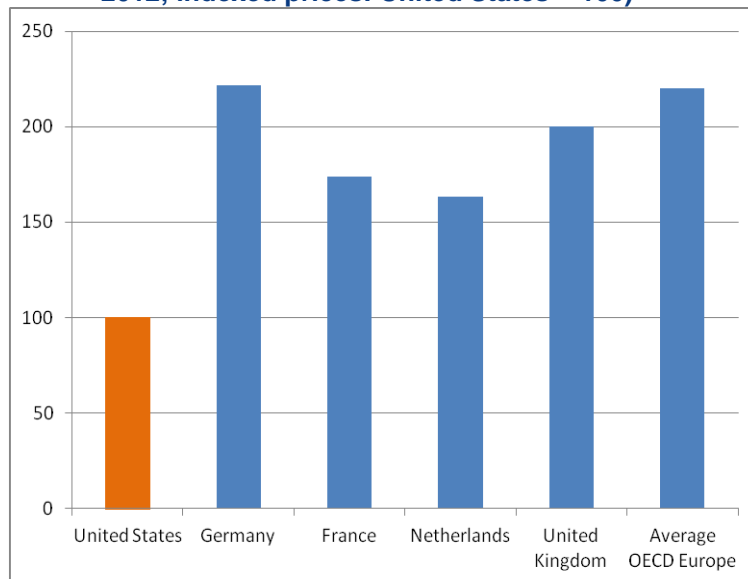
Source : EIA

**The price of natural gas has made it possible to limit the rise of prices of electricity sold to American industry, over the last five years, and even to cut prices since 2012.** In the second quarter of 2013, the price of electricity stood at \$65.2 per MWh, down 2.7% on 2012.

In Europe, the reverse has occurred as the price of electricity is strongly influenced by European environmental policies (subsidies for renewables and CO<sub>2</sub> quotas). The collapse of prices for CO<sub>2</sub> quotas has weakened the CO<sub>2</sub> constraint in the short term. But discussions in progress on the future of the ETS have also led to increasing uncertainty about future prices.

Figure 11 shows that **in 2012 electricity prices in the United States were on average 2.2 times lower than prices faced by European industry.**

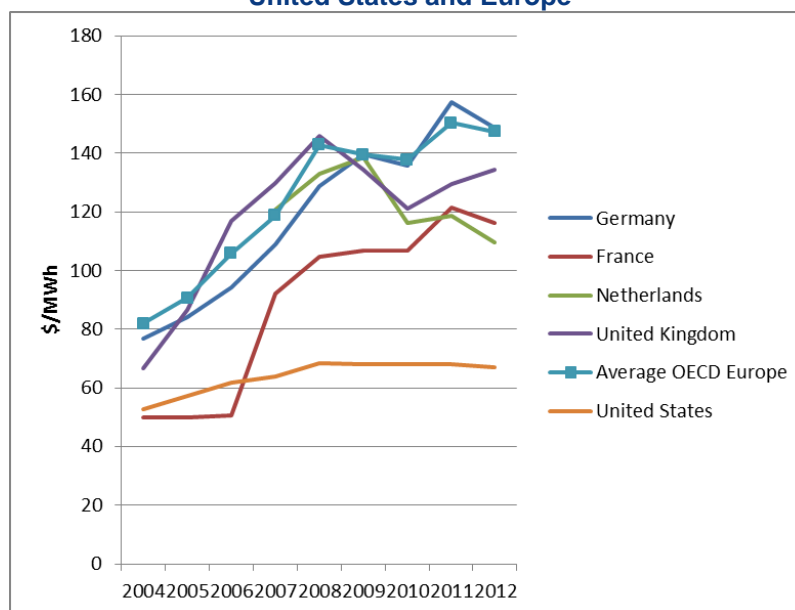
**Figure 11. Electricity Prices for US and European Industries (average 2012; indexed prices: United States = 100)**



Source : IEA (2013)

The recent falls in wholesale prices on the European market is largely insufficient to remove the US competitive advantage (Figure 12).

**Figure 12. Recent Trends in the Electricity Price for Industry in the United States and Europe**



Source : IEA (2013)

## ***European Petrochemical Producers Pay Three Times as Much for their Raw Materials as American Firms***

The fall in ethane prices in the United States is a real bonanza for the US petrochemical industry which uses ethane mainly as a raw material in producing ethylene, an olefin used in making a very large number of polymers or plastics.<sup>8</sup> Ethylene is produced in steam crackers that “crack” (i.e. separate molecules) ethane derived from natural gas. Alternatively, it can be made from oil fractions (mainly naphtha) obtained during refining. **Petrochemical processes require a lot of energy.** A typical steam cracker uses between 16 and 19 GJ/tonnes for cracked outputs using ethane, and between 14 and 17 GJ/tonne using naphtha.<sup>9</sup> The petrochemical sector therefore depends strongly on the availability and prices of processed raw materials (natural gas or crude oil).

For reasons linked to the availability of raw materials, the US petrochemical sector (and that in the Middle East) mainly uses ethane from gas. In contrast, the European (as well as Asian) industry uses primarily naphtha, a petroleum fraction obtained from oil refining. As indicated in Part I, **the price of ethane in the United States (although very volatile during the period) fell by 55% between 2008 and 2012, to attain \$296/t on average in 2012.**<sup>10</sup> The fall in ethane prices contrasts with the rise in naphtha prices in Western Europe. **There, the price of naphtha, which is linked to the oil price, rose by 19% during the same period,** to reach \$936/t in 2012.

### **Box 1. Price Volatility**

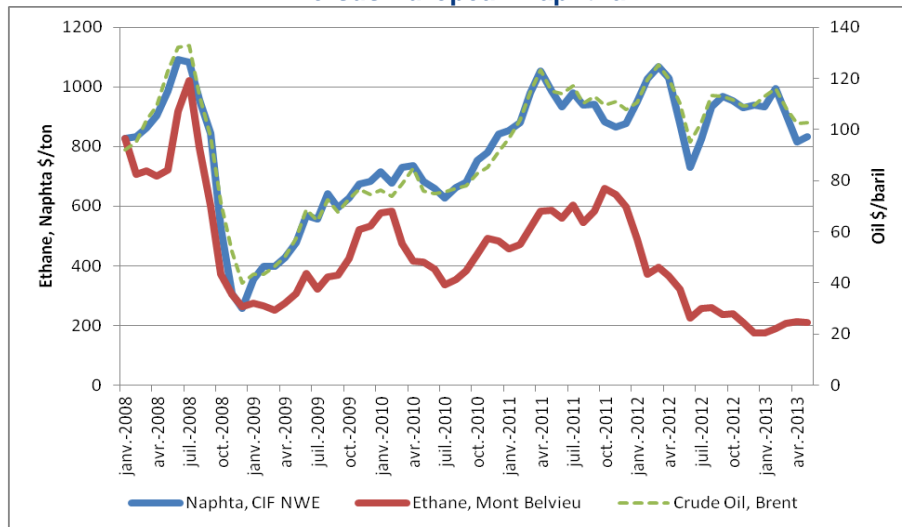
The analysis of America’s competitive advantage with respect to Europe is based on price levels in 2012 and their evolution over the last five years. Energy prices are very volatile, and the price spreads mentioned vary a lot from one year to another, or even one week to the next, mainly as a function of crude oil prices. The results of the analysis thus differ significantly from one year to the next. However, the trend observed for the last five years still holds during the first months of 2013, even though the prices of oil and hence naphtha, as well as that of ethylene have fallen. US ethylene producers continue to benefit from very comfortable margins.

<sup>8</sup> See Annexes 1 and 2.

<sup>9</sup> Naphtha crackers use the best available technology, which reduces energy consumption to 11-14 GJ/tonne of cracked output. Source: Ren T. et al. (2009), Energy efficiency and innovative emerging technologies for olefin production, Faculty of Chemistry, Utrecht University, The Netherlands.

<sup>10</sup> See Figure 4, p. 9.

**Figure 13. Prices of Raw Materials for Petrochemicals: US Ethane versus European Naphtha**

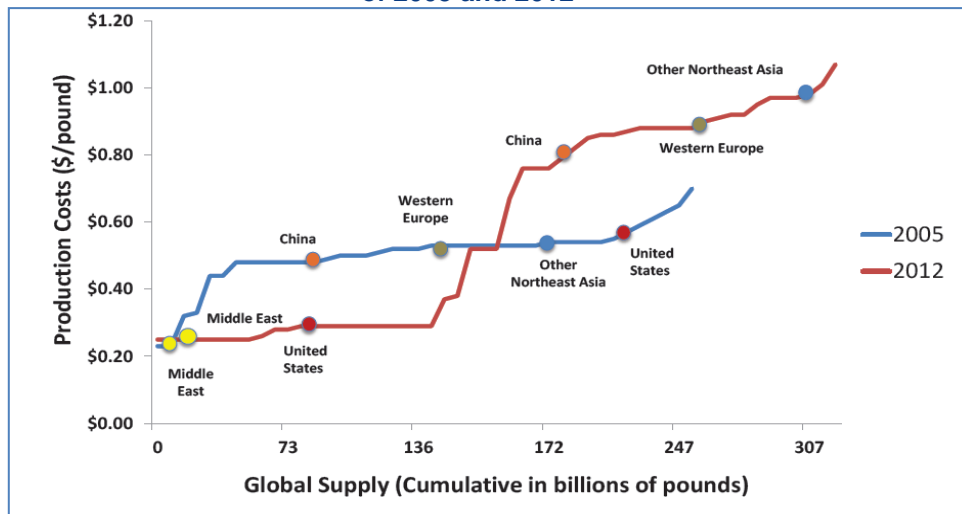


Source : Platt's, EIA, Fedex.

This strong disparity in raw material prices leads to significant production cost differences of ethylene between the two processes (using naphtha or ethane), given the strong energy intensity of ethylene.

Figure 14 shows that **in 2012 production costs in the United States were a third of those in Europe**. It also shows that the fall in the price of gas and NGLs in the United States has allowed American producers to regain competitiveness compared to other regions in the world. **In 2005, costs in the US were similar to those in Europe**. But from 2005 to 2012, the costs of producing ethylene were halved and **the United States is now a low-cost producer, thanks to shale gas**.

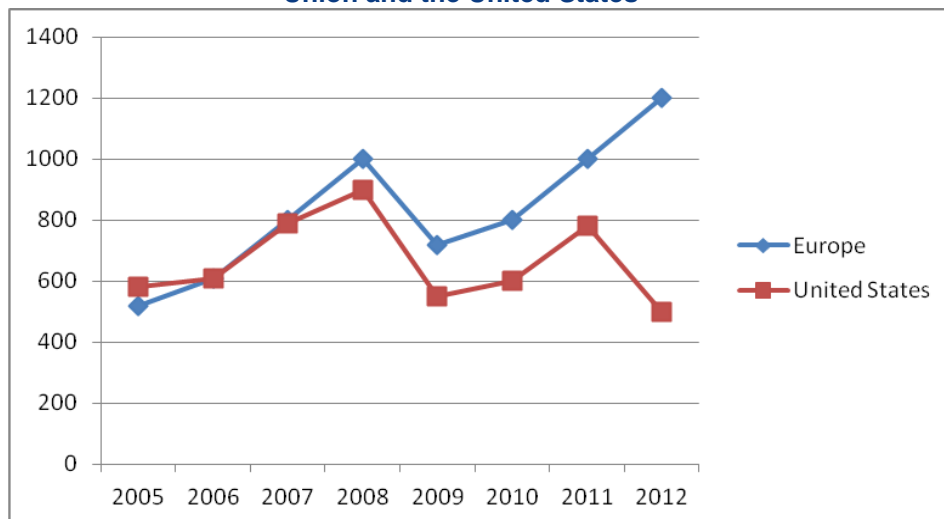
**Figure 14. Ethylene Production Costs Across the World: A Comparison of 2005 and 2012**



Source: ACC (2013)<sup>11</sup> (note: 1 kg = 2.2046 lb)

For Europe, this disadvantage runs to several billion euros per year. The European Chemical Industry Council (or CEFIC) estimated that in 2012 the cost of producing one tonne of ethylene in Europe was \$700/t higher than in the United States.<sup>12</sup> For the European market as a whole, which produces about 20 million tonnes of ethylene each year, this differential amounts to \$14 billion (or €11 billion) per year.

**Figure 15. Comparison of Cash Costs for Ethylene in the European Union and the United States**



Source: CEFIC

<sup>12</sup> CEFIC (2013), The implications of the shale gas revolution for the European chemical industry, Cefic Position Paper, Brussels, 15 March 2013.

# The Revival of the US Petrochemicals Industry

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America's competitive advantage strongly encourages petrochemical companies to invest in the US. Petrochemicals is a sector which is very highly energy intensive and hence benefits most from the shale gas revolution. Not only are companies in the US witnessing their profit margins take off compared to their competitors, but a number of mega-projects have also been announced that raise production capacity in ethylene and polyethylene. As a result, it is possible to talk of a **“reshoring” to the US of the petrochemical industry**.

## *Shale Gas is Transforming Petrochemicals in the United States*

Following strong growth in the 1990s, when the US petrochemical and plastics industries experienced 5% growth per year, the economic slowdown in 2000-2001 combined with a strong rise in energy prices led to a brutal end in growth. Rising gas prices in the US during the 2000s actually weakened the country's competitive position. This led to the shutdown of petrochemical plants and their offshoring to countries with very low raw material costs. The crisis in 2008-2009 led to further output falls, so that by the end of the decade the US petrochemicals industry looked sure to decline. But, the rapid development of ethane production and falling prices are radically changing the situation.

## **Substantial Margins Due to Low Ethane Prices**

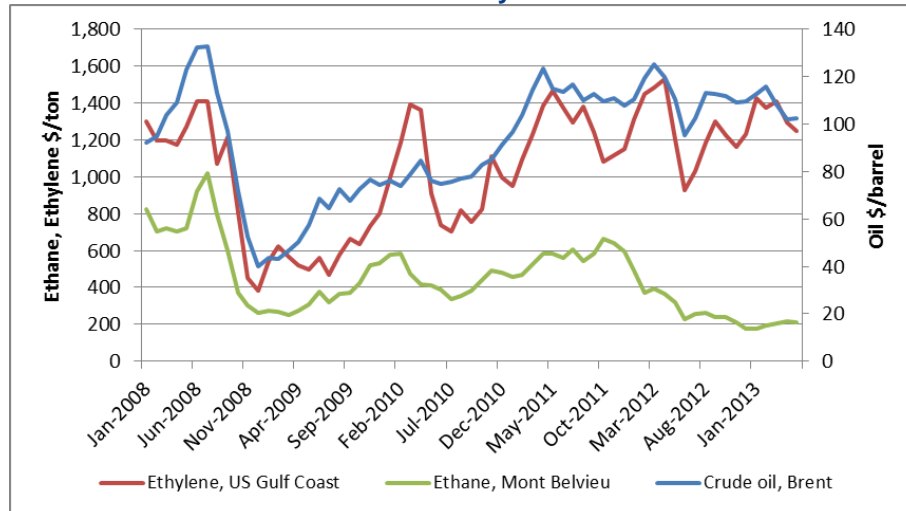
**While ethane prices have fallen strongly, ethylene prices have moved upwards.** In 2012, the latter price was \$1,254/t on average, a rise of 17% with respect to 2008 (Figure 16). The price of ethylene is indeed determined by the marginal production cost of the most expensive unit, which leads to demand and supply equilibrium for ethylene worldwide. Figure 14 shows how this is the price of Asian producers who used naphtha as a raw material.<sup>13</sup> The price of ethylene is thus a function of naphtha, and not natural gas. It

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<sup>13</sup> See. p. 23.

therefore changes as a function of crude oil prices. **This gives US producers a second advantage as they see their profit margins surge.**

**Figure 16. The Price of Ethylene in the United States, Compared to Crude Oil and Ethylene Prices**



Source : Platt's, EIA

US petrochemical companies are converting their steam crackers from naphtha to ethane (and propane), derived from shale gas, in order to benefit from profitable margins. While in 2007, ethane was only used as a raw material in the production of 55% of the country's ethylene, by 2012, the share had risen to 71%, and should increase further to 75% in 2013.

By using ethane to make ethylene, US producers can generate extra revenues of \$12 billion, given the prices observed in 2012, compared to production using naphtha.<sup>14</sup>

## Massive Investments in Ethylene Production

**The fall in the price of ethane and its growing availability have led to massive investments in the production of ethylene and its derivatives.** During the last two years, expansion announcements, returns to operations and the construction of new steam crackers fed by ethane have proliferated. **23 projects have been announced in the US since 2011**, as shown in the following table.

<sup>14</sup> This calculation is based on ethylene production in the United States (24Mt in 2012, of which 71% came from ethane).

Table 1. Ethylene Projects in the United States

Operator	Headquarters of operator	Location	Project	Capacity (kt/year of ethylene)	Beginning of operation
BASF-TOTAL Petrochemicals (BTP)	Germany/France	Port Arthur, TX	Conversion to ethane and LPG of the plant built in 2001 and based on naphtha (capacity: 1 Mt/year)	60	2012
Dow Chemical	USA	Hahnville, LA	Restarting	400	2012
Westlake Chemical	USA	Lake Charles, LA	Expansion	110	2013
Ineos	Switzerland	Alvin, TX	De-bottlenecking	120	2013
Westlake Chemical	USA	Calvert City, KY	Conversion to ethane and expansion	80	2014
BASF-TOTAL Petrochemicals (BTP)	Germany/France	Port Arthur, TX	Expansion	150	2014
Williams	USA	Geismar, LA	Expansion	230	2014
Chevron Phillips	USA	Old Ocean, TX	Expansion	90	2014
Dow Chemical	USA	Plaquemine, LA	De-bottlenecking	200	2014-16
Dow Chemical	USA	Freeport, TX	Conversion to ethane/propane	200	2014-16
LyondellBasell	Netherlands	Channelview, TX	Expansion	230	2014-16
LyondellBasell	Netherlands	La Porte, TX	Expansion	390	2014-16
LyondellBasell	Netherlands	Corpus Christi, TX	Expansion	390	2015
Westlake Chemical	USA	Lake Charles, LA	Expansion	110	2015
Aither Chemicals/Bayer	USA/Germany	Charleston, W. VA	New steam cracker	272	2016
Formosa Plastics	Taiwan	Point Comfort, TX	New steam cracker	1200	2016
ExxonMobil Chemical	USA	Baytown, TX	New steam cracker	1500	2016
Chevron Phillips	USA	Baytown, TX	New steam cracker	1500	2017
Dow Chemical	USA	Freeport, TX	New steam cracker	1500	2017
Occidental Chemical/Mexichem	USA/Mexico	Ingleside, TX	New steam cracker	550	2017
Shell Chemical	Netherlands	Monaca, PA	New steam cracker	1000	2017
Sasol	South Africa	Lake Charles, LA	New steam cracker	1400	2017
Appalachian Resins	USA	W. Va	New steam cracker	230	nd
<b>TOTAL</b>				<b>11682</b>	



While the first projects to be built between 2012 and 2015 relate to extensions of existing capacity, the re-opening of moth-balled plants or the conversion of plants using naphtha to ethane and propane, **seven projects relate to new, mega-sized plants (1 to 1.5 Mt of capacity per year). These are nearly all located in the Gulf of Mexico. They are set to enter operation by 2016-17.**

Thus Dow Chemical – the leading US chemical company – has requested permission to build its largest ethylene production plant (1.5 Mt per year) at Freeport, Texas. This investment of \$1.7 billion is part of a \$4 billion programme by Dow, in Texas and Louisiana. (as shown in Box 3). For its part, Exxon Mobil is building a 1.5 Mt/year plant to produce ethylene in Baytown, Texas. The ethylene plant, which could start production as of 2016, will supply two polyethylene plants. Their combined capacity will be 1.3 Mt per year. Chevron Phillips Chemical, a joint venture between Chevron and ConocoPhillips, will build a new ethylene plant and two polyethylene plants near Houston, Texas. It will invest \$5 billion as part of its “US Gulf Coast Petrochemicals Project”. Shell Chemical has announced a similar project for a steam cracker in Pennsylvania, as well as a polyethylene unit. Formosa Plastics, which is headquartered in Taiwan, is planning the construction of an ethylene plant at Point Comfort in Texas, with a capacity of 1 Mt per year. Occidental Chemical and the Mexican firm Mexichem have announced a project to produce 550 kt per year of ethylene at Ingleside, Texas. Lastly, Sasol, the South African company, is planning to invest \$15 billion to \$21 billion in Lake Charles in Louisiana to build a petrochemicals complex (ethylene and derivatives) and two GTL (Gas-to-Liquids) plants.

Two other new projects of more modest size have been announced outside the Gulf of Mexico region. Aither is planning to build a steam cracker with a capacity of 272 kt in West Virginia. Appalachian Resins, a US start-up, is also planning to set up a petrochemicals complex (ethylene and polyethylene), again in West Virginia. These projects, along with that of Shell in Pennsylvania, could mark the development of a new petrochemicals hub in the region, based on gas rich in liquids in the Marcellus basin.

**Petrochemical companies from across the globe have announced their intentions of investing in the United States:** the Saudi company SABIC (one of the world leaders in chemicals), the Brazilian petrochemical firm Braskem, the Indian company Reliance Industries and the Thai firm Indomara. Even Total is studying the possibility of building a new steam cracker in Texas.<sup>15</sup>

<sup>15</sup>Hydrocarbon Processing, 23 May 2013  
<http://www.hydrocarbonprocessing.com/Article/3210025/Total-mulls-new-ethane-team-cracker-in-Texas.html>

If all these projects are completed, then 11.7 Mt of extra capacity in ethylene production will be built in the United States between 2012 and 2017. This represents a 42% increase on current capacity (28.1 Mt at the start of 2013).<sup>16</sup>

Of the nine new plants which have been announced, three are being planned by companies headquartered outside the United States, and two by US firms which are associated with non-US companies. **These projects demonstrate renewed interest by international chemical groups in the United States.**

If all projects go ahead, then the resulting additional capacity will exceed the abilities of the American market to absorb them, even if it experiences increases in demand due to the re-industrialisation of the country and the relocation back to the US of manufacturing industries. **Some of the new projects are thus targeting exports.** The export of ethylene is however very costly due to the high costs of maritime transport for this product (estimated at \$300/t between the United States and Asia). As a result, the export of derivative, high-value products, and especially polymers (notably polyethylene) is preferred.

Most of the new steam crackers which have been announced are associated with polyethylene (PE) units, which should be built by 2017 (see below). About 7 Mt of ethylene will be consumed by these new units. Less than 5 Mt per year of new capacity is destined for export, or more surely will replace American ethylene imports.<sup>17</sup> Until now, the United States has been an importer of ethylene (3.2 Mt were imported in 2012, mainly from Saudi Arabia and Iraq).<sup>18</sup> These imports are set to decline, being replaced by low cost ethylene made locally.

#### Box 2. Uncertainties about the Completion of Projects

The actual completion of petrochemical projects announced in the US does entail a certain number of uncertainties. Their cost (several billions of dollars) could hamper the execution of certain projects. LyondellBassell has preferred to opt for expanding existing capacity. This is faster to do, and involves less capital than building new plant. The first units to be built are indeed those which should benefit the most from American competitive advantage. Obtaining environmental permits could slow down projects, especially those outside the Gulf of Mexico states, the latter benefitting from the long tradition of the oil industry in the region, and strong local acceptance. The availability of properly skilled labour could also constitute a limit. Carrying out such large projects requires having 10,000 workers on site

<sup>16</sup> Oil & Gas Journal (2013), Global ethylene capacity poised for major expansion, OGJ, Volume 111, Issue 7, 1 July 2013.

<sup>17</sup> It takes 1.05 tons of ethylene to produce 1 ton of PE. If extra PE capacity rises by 6.5 Mt, then the US market will absorb 6.83 Mt of ethylene, so that 5 Mt will be available for export.

<sup>18</sup> US International Trade Commission Dataweb (<http://dataweb.usitc.gov>).

during the peak construction period. Were five projects to be undertaken at the same time within the Gulf region, then this would lead to a demand for 50,000 qualified workers. The availability of ethane could also be a major challenge for carrying out projects. The gas industry must indeed develop its capacity to produce wet gas rapidly, along with the related processing and transport infrastructure. There is a real risk that the demand for ethane will exceed supplies, if all the projects are completed. This would lead to rising ethane prices and hence falls in the US competitive advantage. Lastly, the risk of building too much capacity and putting strong downward pressure on the price of products could also end by dampening investments in the industry. US demand for polyethylene is only likely to see moderate growth over the next years, which will oblige producers to look to foreign markets. The latter, however, are already experiencing surplus supplies, which should continue to be the case following the construction of new plants for polyethylene and other derivatives in the Middle East, Asia, as well as in Canada and South America.

## The Competitive Advantage Upstream of the Sector Impacts on Integrated Producers Downstream

The competitive advantage upstream (the production of ethylene) impacts downstream: the production of derivatives of ethylene and especially polyethylene (PE). For integrated producers, the cost of making polyethylene could also fall by a factor of 2.4 with respect to historical costs.<sup>19</sup> This new competitiveness encourages ethylene producers to build new PE plants, downstream from crackers. Such integration helps them achieve comfortable profit margins with respect to the output of ethylene made from naphtha, or with respect to US producers which are not integrated, and which must buy ethylene at market prices.

**Eleven companies have announced their intentions of increasing the capacity of existing plants or building new PE units (Table 2)**, so as to profit from the low cost ethylene they will produce. Even Shell, which sold its polyethylene activities in 2005 to Bassell, is planning to build two units downstream of its cracker in Pennsylvania.

**If all projects are indeed completed, then US PE capacity will rise by about 6.5 Mt per year, by 2017.** This represents an expansion of 42% of present US capacity (15.4 Mt at the start of 2013). In 2012, American production of PE was 14.1 Mt.

The fall in polyethylene production costs could have consequences for numerous industries (construction, packaging, cars, plastics, etc.) which could substitute materials such as metals, glass, wood with low-cost plastics.

<sup>19</sup> PwC (2012), Shale gas Reshaping the US chemicals industry, October 2012.

Table 2. Polyethylene Projects in the United States

Operator	Headquarters of operator	Location	Project	Capacity (kt/year of polyethylene)	Beginning of operation
LyondellBasell	Netherlands	USA	De-bottlenecking	100	2014
Westlake	USA	Lake Charles, LA, Calvert, KY	Expansion	nd	2015
Ineos/Sasol	Switzerland/ South Africa	Lake Charles, LA	New plant (HDPE)	470	2015
Sasol	South Africa	Lake Charles, LA	New plant (LLDPE)	450	2016
LyondellBasell	Netherlands	USA	Expansion of existing capacity	450	2016
ExxonMobil Chemical	USA	Mont Belvieu, TX	New plant (650 kt LLPE, 650 kt HDPE)	1300	2016
Dow Chemical	USA	Freeport, TX	New plant (LLDPE and HDPE)	1200	2017
Formosa Plastics	Taiwan	Point Comfort, TX	New plant (LDPE)	300	2017
Chevron Phillips	USA	Old Ocean, TX	New plant (LLDPE and HDPE)	1000	2017
Shell Chemical	Netherlands	Monaca, PA	New plant (LLDPE and HDPE)	1000	2017
Aither	USA	W. V	New plant	nd	nd
Appalachian Resins	USA	W. V	New plant	230	nd
TOTAL				6500	

While part of additional PE production will be absorbed by the US market, **most will be destined for export**. In 2012, US export sales of PE ran to 3.2 Mt, accounting for 22% of total annual sales. By 2020, some analysts forecast that this share could rise to 40%.

### Box 3. Dow: a Strategy of Relocating to the United States

Dow, the top US chemical company and world leader in the production of ethylene and polyethylene, is following a strategy which is an example of relocation of petrochemical activities back to the United States. Indeed, the firm has announced both the closure of plants throughout the world, and investments of \$4 billion in the US petrochemical sector. In October 2012, Dow announced 2,400 job cuts (i.e. nearly 5% of its global workforce) and the closure of about 20 sites across the world by 2014. In Europe, these concern: a high-density polyethylene plant in Tessenderlo (Belgium), its sodium borohydride activities at Delfzijl (the Netherlands), its plants in Ribaforada (Spain) and at its Formulated Systems division (polyurethanes foams and epoxy solutions Birch Vale, the United Kingdom). In April 2012, Dow had already announced a plan to restructure operations in four sites, involving 900 job cuts, including two sites in Europe in Portugal and Hungary. In March 2013, Dow announced the end of operations in two business units: Polypropylene Licensing and Catalysts, and Plastic Additives, which are no longer considered as strategic by the company.

Dow is not however giving up its strategic development axes in the Middle East. In a joint-venture with Saudi Aramco, Dow is in the process of building a gigantic petrochemicals complex at Al Jubail, involving \$20 billion in investments. It is also pursuing its activities in Europe, where the company generates 30% of its turnover, but on a far more selective basis. Dow is closing down sites making basic products which depend on energy prices and is focusing on high value-added, innovative products which need little energy. Dow is also pursuing its development in high-growth Asian markets.

In the United States, there has been an about-turn in its policy. While Dow shutdown some of its steam crackers at the end of the 2000s, the company has announced investments of \$4 billion in the Gulf of Mexico, in order to profit as much as possible from the opportunities linked to the abundance of shale gas in the United States. Its investment plan aims at consolidating its leadership in the market for ethylene derivatives and for propylene. They also mark its relocation of production of basic products to the USA, with the announcement of a \$1.7 billion investment in a new ethylene cracker at Freeport, Texas, whose front-end engineering design (FEED) has been assigned to Technip. The investment plan has been developed in stages and is far more exhaustive. It follows the central strategy of Dow on refocusing on producing high-technology chemicals with high margins.

Upstream, apart from the steam ethane cracker which should produce 1.5 million tonnes of ethylene per year, the plan includes the re-opening of closed steam cracker and the conversion to ethane of crackers at Plaquemine in Louisiana and at Freeport in Texas. The plan also includes the construction of a propylene unit making 750 kt per year, at Freeport.

Dow has signed an agreement with Range Resources Corporation to supply ethane and propane from the Eagle Ford and Marcellus basins.

In March 2013, Dow announced the next stages of its investment plan with the construction in Freeport of four new units downstream of its ethylene and propylene units. These four plants aim at producing high-performance plastics for fast growth markets, such as packaging, cars, hygiene and medicine, telecommunications and transport. They will all be supplied by Dow's future petrochemical capacities, which will come into operation in Freeport, as of 2017.

Given all these investments, Dow is relocating its main chemical activities back to the United States.

Table 3. Dow's Petrochemical Projects in the Gulf of Mexico

Location	Project	State of project
Hahnville, LA	Restarting of steam cracker of 400 000 t/year	Finalised in December 2012
Plaquemine, LA	De-bottlenecking/ethane flexibility	Scheduled for 2014, in progress
Freeport, TX	Conversion to ethane/propane of the existing steam cracker	Scheduled for 2016, in progress
Freeport, TX	Steam cracker based on ethane of 1.5 Mt/year ethylene	Scheduled for 2017, FEED contracted to Technip
Freeport, TX	Propylene complex of 750 000 t/year	Scheduled for 2015, work in progress
Freeport, TX	Ethylene-propylene-dien metallocene (EPDM) monomer plant	Scheduled for 2017
Freeport, TX	Plant to produce elastomers with high melt flow	Scheduled for 2017
Freeport, TX	Improved polyethylene unit	Scheduled for 2017
Freeport, TX	Plant of low-density specialised polyethylene	Scheduled for 2017

## *Macroeconomic Spillovers of the Surge in US Petrochemicals*

The United States is in the process of gaining a competitive advantage with respect to other regions in the world, thanks to its access to low-priced energy. This re-found competitiveness is benefitting foremost energy-intensive industries, which use energy both as a fuel and as a raw material, such as petrochemicals and chemicals. They will be the big beneficiaries of the shale gas revolution in the years ahead.

The upstream competitive advantage of the sector will impact the whole production chain, leading to greater competitiveness of derivative products ranging from major, basic chemicals through to plastics and finished products using plastic materials. The sectors that are most affected include organic chemistry, resins, fertilizers, refining and metals such as steel. These sectors will experience both stronger demand in the United States, as higher GDP generates higher US demand, and greater exports due to the competitive advantage created by lower energy prices in the US.



Two recent reports have calculated the impact of the development of shale gas on the chemical industry, in terms of jobs, value added and tax earnings. Their results are not directly comparable, as they use different methodologies. But both studies, whose main results are presented below, indicated strong growth in investment in the US chemical industry and significant economic spillovers in terms of jobs, value added and tax revenues.

**The American Chemistry Council (ACC) has conducted a study of about 100 investment projects identified at the end of March 2013, in the US chemical industry.<sup>20</sup> Their total investment is set to run to \$72 billion by 2020.<sup>21</sup>** These investments only take into account investments which have been announced as a result of the competitive advantage of shale gas. In 2012, for example, spending in the US chemical industry (excluding pharmaceutical products) ran to \$31.8 billion, of which \$3.2 billion were attributable to the shale gas effect. The ACC study looks at the impact of these investments on jobs, the creation of value added, tax revenues and international trade. The large majority of these projects relate to the production of ethylene and its derivatives (polyethylene, PVC, etc.), ammonia, methanol, propylene and chlorine. These projects will allow an increase in production capacity of petrochemicals, plastic resins, fertilisers and other chemicals of 60 Mt per year. Most are geared towards export markets and half the projects are being developed by non-US companies.

**The ACC believes that these projects will increase the turnover of the chemical industry by \$67 billion (in 2012 dollars) by 2020 and by \$265 billion over the period 2012-2020.** The additional production in 2020 would create 46,000 jobs in chemicals and a total of **537,000 that are direct, indirect and induced.** Additional revenue for the US economy (direct, indirect and induced) should amount to \$201 billion in 2020. Investment could create 1.2 million jobs during the phase of construction projects (2010-2020). The tax revenues related to these investments are estimated by the ACC to be \$20 billion during the investment period, and then \$14 billion in 2020.

The ACC believes that with these investments, the United States will become a net exporter of chemicals (pharmaceuticals included). This should allow elimination of the trade deficit in the chemical industry due to increasing imports of pharmaceutical products. **In 2012, the trade balance for the chemical industry turned positive (\$800 million), and this situation is expected to improve significantly: according to the ACC the surplus in the trade balance of chemicals is expected to reach \$46 billion by**

<sup>20</sup> ACC (2013), op. cit.

<sup>21</sup> At the end of September 2013, the ACC database included 117 projects, worth a total investment of \$80 billion.

2020, thanks to the increase in exports of chemicals, and reduced imports of pharmaceutical products.

**A second report, published by IHS<sup>22</sup> on the revival of manufacturing industry in the United States, highlights the relocation of petrochemical industries** which had been set up offshore during the past decade in favour of countries with low energy costs (the Middle East), or where there was strong growth in demand and low labour costs (Asia and China in particular).<sup>23</sup> The report, published in September 2013, examines the value chain of unconventional hydrocarbons and assesses their economic contribution from the upstream to downstream chemicals.<sup>24</sup> In 2012, the value chain of unconventional hydrocarbons contributed \$283 billion to US GDP, and generated nearly \$75 billion in tax revenues at the federal and local level. It also supported 2.1 million jobs. IHS estimates that by 2020 these contributions will reach 3.3 million for jobs, more than \$125 billion in tax revenue, and more than \$468 billion contributing annually to GDP. The investment needed midstream and downstream and in the chemical industry is estimated by IHS to be nearly \$346 billion, over the period 2012-2025

**About \$129 billion should be invested in the chemical industry to build capacity of 89 Mt by 2025. Investments in chemicals are expected to generate \$505 billion in revenues over the period 2012-2025.** Four sectors should benefit especially from these investments: ethylene, propylene, methanol and ammonia. Ethylene and polyethylene are the main products to benefit from American's new competitiveness. Production capacity could increase by 30 Mt, by 2025.

The development of unconventional gas has created 53,000 jobs in the chemical industry up to 2012. According to IHS, the figure could reach 319,000 in 2025. Value added to GDP was \$6.8 billion in 2012, and is forecast to reach \$51 billion in 2025. Over the period 2012-2025, \$115 billion in tax revenue should be paid to the federal and local governments.

**Like the ACC, IHS has highlighted the impact of these developments on the US trade balance of chemicals.** IHS recalls that the US chemical industry contributed 13% of exports, worth \$198 billion in 2012. Production of chemicals is expected to increase by 5% per year between 2013 and 2020 in the IHS baseline scenario. A

<sup>22</sup> IHS is an American consulting firm with an international reputation. It works mainly on energy issues.

<sup>23</sup> IHS (2013), *America's New Energy Future: The Unconventional Oil and Gas revolution and the US Economy*. Volume 3: A manufacturing renaissance, September 2013.

<sup>24</sup> The chemicals taken into account by the IHS study are those which transform natural gas and NGLs into basic products. They include basic petrochemical products, their derivatives, ammonia, methanol, chlorine, etc, all of which are highly energy intensive.



large share of this production will be for export, as growth in US demand is expected to remain modest. Polyethylene exports could reach 8 Mt in 2025. In the longer term, a larger share would be consumed in the United States thanks to the relocation of manufacturing industries back to America. **The impact on the trade balance of chemicals should be reinforced by on-site production of finished products with high value added, which the United States imports today.**

# A Further Threat to European Petrochemicals

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## *The State of European Petrochemicals since the Financial Crisis*

Petrochemicals are a key sector of the European economy. According to the CEFIC, the sector's turnover reached € 121 billion,<sup>25</sup> or 25% of the turnover of the European chemical industry, excluding pharmaceuticals.<sup>26</sup> But the industry is in crisis.<sup>27</sup> **European manufacturers are caught in the grip of sluggish demand and rising energy prices.** They face increasing international competition, eroded competitiveness and structural production overcapacity.

### Falling Demand

**European demand for ethylene**, having collapsed in 2008/2009, picked up in 2010, but since then it has again been on a downward trend. In 2012, it was only 19.2 Mt, compared to 22 Mt in 2007, a decrease of 14%, as shown in Figure 17. Of the three major sectors consuming plastics derived from ethylene (packaging, construction and the automotive industry), only the packaging sector has weathered the crisis in the euro area. While global demand for plastics is doing well, with growth of 2.9% in 2012 (288 Mt), it fell in Europe, with a decline of 3.2% in 2012 to 45.5 Mt.<sup>28</sup>

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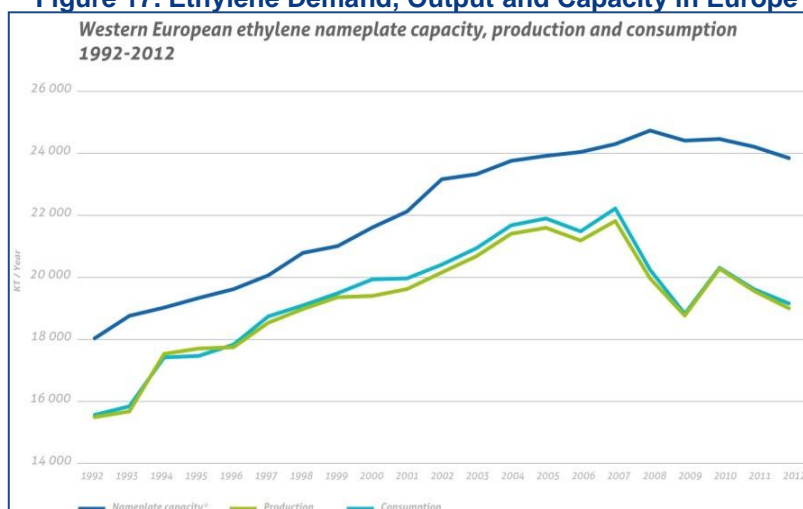
<sup>25</sup> CEFIC (2012), Facts and Figures 2012, Brussels, December 2012.

<sup>26</sup> See Annex 3.

<sup>27</sup> Care needs to be taken not to confuse the petrochemical sector in Europe and European actors, which are diversified global groups that have their headquarters in Europe or in other regions of the world (the United States and Saudi Arabia). These actors are present in all growth zones of the petrochemicals industry (the Middle East for raw materials as feedstocks and Asia in terms of demand). Most of them have announced investment plans in the US based on shale gas.

<sup>28</sup> usinenouvelle.com, *Matières plastiques : un marché mondial en pleine mutation*, 29 May 2013.

**Figure 17. Ethylene Demand, Output and Capacity in Europe**



Source: Association of Petrochemical Producers in Europe (APPE)<sup>29</sup>

## The Rising Prices of Energy Raw Materials

The European petrochemical companies also face **higher prices for their raw materials**. Indeed, petrochemical plants produce their ethylene and other compounds mainly from naphtha, derived from refining oil. In 2012, naphtha and condensate provided European steam crackers with 75% of their inputs, compared to only 12.5 % for ethane, propane and butane, with diesel providing the rest. European petrochemical producers thus face a major disadvantage compared to US firms using ethane as feedstock, and compared to the mega petrochemical complexes in the Middle East, which are also fed by ethane from local fields of natural gas. The European industry is heavily penalised by higher naphtha prices, which track the price of crude oil. Faced with growing competition from the Middle East and future competition from the United States, European petrochemical companies can only partially pass on price increases to their polymer-producing customers. As a result, their profitability is weakening and **their margins are eroding**.

**Table 4. The Annual Price Rises of Naphtha and Ethylene**

	2009	2010	2011	2012
<b>Naphtha</b>	<b>34%</b>	<b>43%</b>	<b>24%</b>	<b>9%</b>
<b>Ethylene</b>	<b>30%</b>	<b>29%</b>	<b>20%</b>	<b>9%</b>

Source: Euler Hermes, 2013<sup>30</sup>

<sup>29</sup> <http://www.petrochemistry.eu/about-petrochemistry/facts-and-figures.html>

<sup>30</sup> Euler Hermes Economic Research (2013), Crisis in the European petrochemical industry?, 19 May 2013.

## Excessive and Ageing Capacity

This bleak situation has already led European petrochemical firms to close or mothball steam crackers in Western Europe in recent years. Shell has reduced its production in Wesseling and in Heide in Germany, and ExxonMobil has done the same in Fawley, England. Total for its part reduced its production capacity by 20% between 2007 and 2011.

But production capacity remains excessive. Production capacity of ethylene amounted to 23.8 Mt in late 2012 compared to output of only 19 Mt. The utilisation rate has fallen below 80% (79.7% in 2012 and 76% for the six first months of 2013). These very low levels, compared to petrochemical plants running at over 88 % on average over the past twenty years, no longer ensure the profitability of sites.

**Table 5. Capacity Utilisation of Ethylene Production in Europe**

	2008	2009	2010	2011	2012
<b>Capacity (kt)</b>	<b>24,774</b>	<b>24,441</b>	<b>24,463</b>	<b>24,212</b>	<b>23,847</b>
<b>Production (kt)</b>	<b>19,968</b>	<b>18,768</b>	<b>20,280</b>	<b>19,559</b>	<b>19,003</b>
<b>Utilisation rate (%)</b>	<b>80.6%</b>	<b>76.8%</b>	<b>82.9%</b>	<b>80.8%</b>	<b>79.7%</b>

Source: APPE

European steam crackers are also older, which leads to higher maintenance costs than those of their competitors. Indeed no steam crackers have been built in Europe since the mid-1990s: **90% of current capacity is more than thirty years old**. European steam crackers are also smaller than recent plants, and therefore do not benefit from the economies of scale achieved by mega- projects built in the Middle East or under construction in the United States. The situation is difficult for isolated petrochemical sites that cannot benefit from possible synergies which integration with a refinery permits. As a result, they have higher costs of production.

Another factor increasing costs is the position of Europe in terms of environmental protection, particularly with the implementation of REACH and ETS regulations. In the absence of global regulation of CO<sub>2</sub> emissions, Europe is an exception with a consequent additional costs for European industry *vis-à-vis* its international competitors.

## ***The Impact of Shale Gas on Europe's Petrochemicals Industry***

### **The Accelerated Closure of Sites**

**The expansion of US production is aggravating the crisis and accelerating site closures.** Experts estimate that there is still about 15% of overcapacity in ethylene production in Europe.<sup>31</sup> **Small steam crackers with a capacity of less than 400 kilotonnes (kt) face structural deficits and are the first to be affected.** They exist in France and Italy primarily, but also in the UK and some sites in Germany.

Total has announced the closure of its steam cracker at Carling, and in the context of the modernisation of its site at Antwerp is closing one of the smallest crackers there too. In Italy, Versalis, the chemical subsidiary of ENI, has closed the steam cracker at Porto Torres, and will reduce the capacity of the plant at Priolo by 300 kt. It could also close the Porto Marghera site. INEOS, which operates two steam crackers at Grangemouth in the UK, is considering the closure of the smaller unit.

It is possible to observe the displacement of ethylene production capacity to follow demand (Asia), or access to raw materials (the Middle East and now the United States).

**Further downstream, large intermediate producers of plastics are not being spared from transformation either.** The closures of European steam crackers is also leading to the shutdown of old PE and non-specialized plants, which no longer correspond to European demand and which also face increased competition from plants in the Middle East and in the future from the United States.

The first announcements of site closures were made by US companies (Dow and Dupont), which are refocusing their activities on the US petrochemicals industry. In October 2012, Dow Chemical announced the closure of twenty sites across the world and 2,400 job cuts, or nearly 5% of its global workforce by 2014. The sites affected in Europe include the high density polyethylene (HDPE) plant in Tessenderlo (190 kt) in Belgium, which was closed in late 2012.

In April 2013, the Saudi company SABIC announced a cut of more than a thousand jobs in Europe. This decision comes after a

<sup>31</sup> Les Echos, L'essor des gaz de schiste américains menace la pétrochimie européenne, 8 March 2013.

comprehensive review of its operations and activities in its current European industrial organisation, which it largely inherited from the acquisitions of DSM Petrochemicals in 2002, and the takeover of GE Plastics in 2007. Although the plan has not been set out in detail, the specialised trade press has mentioned the olefins, aromatics and polyolefins complex in Teeside (the UK), and the one in Geleen, the Netherlands.<sup>32</sup>

Major European players are also closing their oldest and least specialised units and are replacing them with more innovative production lines, responding to the evolution of European demand.

Austria's Borealis has announced the closure by the end of 2014 of its HDPE production in Burghausen in Germany (175 kt), to focus on the production of polypropylene. LyondellBasell will close its HDPE plant in Wesseling (100 kt) in Germany in the third quarter of 2013 and is enhancing its production of butadiene on the site. In 2014, Total will close its oldest plant of PE in Antwerp (70 kt) in Belgium, and replace it with other PE plants intended to produce a new range of innovative polymers. The plant in Carling in France will be closed and replaced by products targeting growth markets of hydrocarbon resins and polymers. Versalis will close its LLDPE (linear low density polyethylene) plant in Priolo (150 kt) in Italy, and build a new manufacturing plant for resins on the site. The production of ethylene and PE at the Porto Torres (Sardinia) has been stopped and the site will now host a biochemical complex of 350 kt. INEOS, which envisaged the sale of two of its HDPE units that are not integrated with a steam cracker – Rosigno in Italy and Sarralbe in France – has finally decided to keep them. These units account for 37% of the company's PE production capacity. But INEOS is ending the production of C4 LLDPE resins, and is transforming its unit in Cologne in Germany into a LLDPE metallocene unit.

To this long list of closures and job losses in the European chemicals industry, it is possible to add the failure of Kem One in France and the recent announcement by the German company Lanxess of 1,000 job cuts, along with the sale of its units across the world: Brunsbüttel and Dormagen in Germany, Wantzenau near Strasbourg in France, Kallo in Belgium, Bushy Park in the United States, Jhagadia in India, and Nantong in China.

## Opportunities in Butadiene

**The increasing use of ethane in the United States does not have only negative consequences for European petrochemicals.** It also leads to a significant reduction in the production of co-products derived from the cracking of naphtha,

<sup>32</sup> Info Chimie, Coup de sabre de Sabic en Europe, 22 April 2013.

especially propylene and butadiene. The propylene and butadiene yield from pure naphtha feedstock is 13% and 4-5%, respectively, while it is only 1-2% for propylene and 1 % for butadiene with an ethane feedstock. **The replacement of naphtha by ethane in the United States has led to a reduction in the annual propylene production of 2.7 Mt (i.e. by 50%) since 2005. Butadiene production has decreased by between 300 kt and 400 kt, or by about 20 %. These reductions have led to shortages in both markets and have pushed up the price of propylene and butadiene, price increases that have benefited European refiners using naphtha as a feedstock.** On the propylene market, the shortage of supply in the United States has led American companies to build so-called "on-purpose units". Five projects for producing propylene from propane, via dehydrogenation processes are currently underway across the Atlantic.

On the butadiene market, used by the automotive industry for the manufacture of tires, the cost of dedicated plants is very high. Technology has yet to make progress for new dedicated plants to be built. **The rising price of butadiene is encouraging European refiners to increase their production.** In 2013, LyondellBassell increased the capacity of its butadiene unit in Wesseling in Germany from 170 kt to 238 kt. BASF has built a new 155 kt plant in Antwerp, which should start operating in 2014. Versalis plans to build a unit of 100 kt in Dunkirk, by 2016. MOL is also planning a new unit in Tiszaújváros, in Hungary by 2015.

However, the prices of butadiene and propylene are very volatile and reflect not only supply shortages, but also changes in demand. Thus, the price of butadiene, having peaked in 2011 at around \$4,500 per tonne, has subsequently fallen by 70 % due to the declines in demand at such price levels.

## European Trade in Chemical Products: Higher Imports of Polyethylene and Ethylene

**The increase of production capacity of ethylene and its derivatives in the United States will lead to fierce competition among exporters, with Europe possibly paying the price eventually.** The global market is indeed facing overcapacity. Global ethylene production capacity reached 143 Mt as of 1<sup>st</sup> January 2013, while world production reached 130 Mt.<sup>33</sup> The situation is similar for polyethylene.

Global demand for PE is growing strongly, boosted by demand from emerging Asian and Latin America countries. The global market was estimated at 78 Mt in 2012, and could be around

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<sup>33</sup> Oil & Gas Journal (2013), op.cit.

100 Mt in 2017 (Europe is set to participate only marginally in this growth). But this increase is insufficient to absorb new capacity: apart from the projects in the United States, the Middle East and Asia are now expanding their capacities too. China, the largest importer of PE (8 Mt in 2012) has announced its willingness to be self-sufficient and has launched an ambitious program to produce olefins and its derivatives from coal (CTO, or coal-to-olefins). In the short/medium term, China should remain a major importer, but imports will decline and competition between exporting countries is set to strengthen.

**These developments could cause a radical change in the international trade of PE. In recent years, European chemical firms have faced competition from countries in the Middle East,** which have built a very strong industry in a few years. In 2004, this region accounted for 10% of the global production capacity of polyethylene. By 2014, it should represent 18% of capacity, with the building of giant complexes in Saudi Arabia and Abu Dhabi. Already in 2012, Europe consumed 13 million tonnes of polyethylene and imported 2.5 Mt, mainly from the Middle East, while its production capacity is 17 Mt.<sup>34</sup> **To withstand this competition, European chemical producers are turning towards specialty plastics. But in this high-tech niche, the United States is generating new competition,** because it has real skills in processing and is considering producing innovative plastics too (see Box 3).

Currently, the Middle East is the leading provider of PE to Asia (and to a lesser extent to Europe), while the United States is the supplier of South America. The pressures exerted by new US capacity could lead the Middle East to turn increasingly to Europe to sell its surplus production. Low cost polymers *Made in America* could also be exported to Europe if the United States fails to sell its production to South America and Asia. Europe, whose production costs are higher than those of the Middle East and the United States, would be in a difficult position to curb imports.

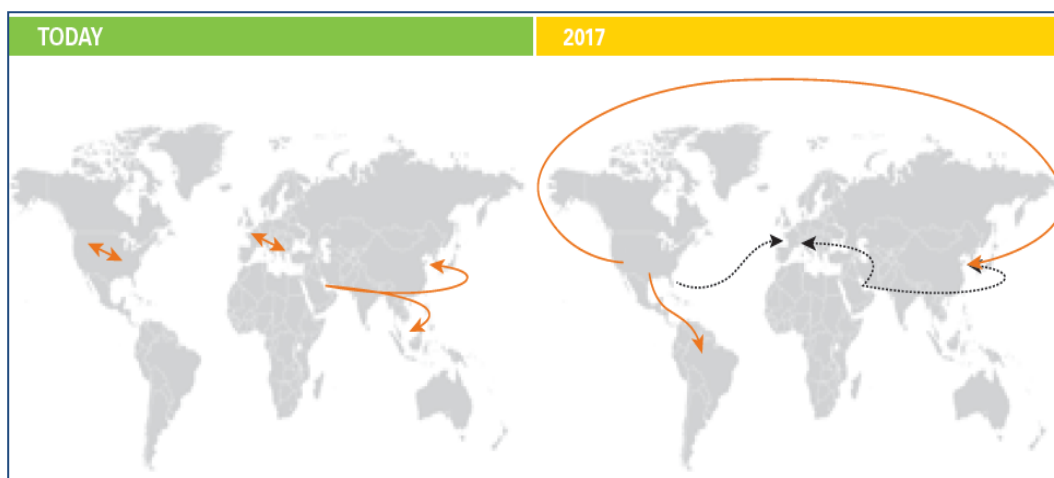
**US ethylene exports (and those of the Middle East) to Europe should also develop,** given the competitive advantage of US ethylene compared to that produced in Europe. These imports will affect non-integrated sites. INEOS, in particular, has invested \$80 million in a terminal for ethylene storage in Antwerp. The terminal has been operational since late 2012, and has a capacity of 1 Mt per year. It allows the company to import ethylene from diverse international sources (the Middle East and the United States). The terminal received its first shipment of American ethylene in February 2013. It is connected to INEOS sites near Antwerp and to its European sites through the pipeline linking Antwerp to Cologne.

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<sup>34</sup> Les Echos, 8 March 2013, op.cit.



**Figure 18. International Trade in Petrochemical Products:  
Greater Competition**



Source: KPMG (2013)<sup>35</sup>

## Imports of American Ethane

**Europe will also become an importer of US ethane.** INEOS is the first company to have signed a long term contract (15 years) with the American company Range Resources-Appalachia LLC to import ethane from the Marcellus basin, from 2015. The project involves the importation of 70,000 b/d of ethane. This ethane is for the steam cracker at Rafnes which INEOS operates in Norway. These imports are not easy from a logistical point of view. INEOS has signed a contract with the shipping company Evergas which will build and operate new vessels dedicated to the transportation of ethane. INEOS also plans to import ethane for its steam cracker at Grangemouth in the UK.

Other companies have also indicated their interest in the imports of raw materials from the United States. Versalis said it was studying ethane imports from the US for its cracker at Brindisi in Italy, which can easily substitute ethane for naphtha. The company also said it was studying such imports for its Dunkirk unit.

## The Strategies of European Actors

The European market may be sluggish and suffering a loss of competitiveness in relation to the Middle East and now the United States. However, it remains an attractive market in terms of size and the per capita consumption of finished products derived from petrochemicals. Although consumption should not increase

<sup>35</sup> KPMG (2013), Strategic realignment in the global chemical industry, Reaction, Chemical Magazine, 11th Edition, KPMG International.

significantly in Europe, consumers are demanding ever-more sophisticated products which offer high margins. European operators are well established in the region – some for nearly a century – and have many advantages in meeting such new demand provided they are competitive. To cope with international competition and remain competitive, European operators are restructuring their plants and adapting their strategies. They are pursuing five main approaches.

### **(1) Cost reductions**

The most radical way is *the closure of sites*, which is necessary to reduce the European overcapacity and restore margins.

Cost reduction is also achieved by the *integration of refining and cracking* to maximize the synergies between the two activities. An example of this integration is the modernization of Total's Antwerp platform that will allow the cracker to use gases recovered from refining as raw materials. At its site in Normandy, Total has integrated the refinery at Le Havre with the petrochemical complex at Gonfreville. This allows the refinery to use the hydrogen produced by the petrochemical complex. Energy synergies (fuels, steam, etc.) are also used to enhance the energy efficiency of the two sites.

The *diversification of raw materials* and replacement of naphtha by other sources also reduce costs. In general, petrochemical producers adapt their steam crackers so they can accept diverse sources of raw materials (naphtha, LPG and ethane), while optimising their supply sources, via the importation of ethane and propane rather than naphtha. This diversification also extends to renewable raw materials through the transformation of biomass into products used directly by chemical and polymer producers. Such *biochemistry* allows manufacturers to shift away from fossil fuels, to limit emissions of greenhouse gases and to produce environmentally friendly products, for which demand is growing in Europe. Versalis, for example, is involved in the conversion of a petrochemical site in Porto Torres (Sardinia), which eventually will become a complex for bio-monomers and bio-polymers.

Petrochemical companies are also aiming *to reduce the energy* intensity of production, by modernising their steam crackers. Total invested €250 million in 2011 to modernize its petrochemical plant at Gonfreville, and improve its energy efficiency.

### **(2) Integrating through to the end client and the development of chemical clusters**

European petrochemical companies are also developing chemical clusters, which are integrating their activities upstream and downstream, through to end consumers further down the production chain. This integration enables them to develop synergies between their various activities, to benefit from economies of scale and retain their customers. A downstream client, for example, can use gases

recovered when making upstream products. BASF was the first company to develop the concept of "*Verbund*" (or combination), which allows it to develop synergies between its various activities and benefit from economies of scale and significant cost reductions. The company estimates that globally its concept of "*Verbund*" allowed it to save €1 billion in 2012, to reduce its energy consumption by 1.5 Mtoe, and cut CO<sub>2</sub> emissions by 3.4 Mt.

This strategy allows European chemical producers to increase their competitiveness and reduce their energy cost disadvantage. It also allows them to get closer to their customers and better meet the latter's demands, which is an advantage over foreign producers.

### **(3) Repositioning in innovative and differentiated niche products with high value added**

European manufacturers also seek to redeploy production towards niche products with higher value added, that are less intensive in energy and raw materials, and which emit less CO<sub>2</sub> (green chemicals, bio-chemicals). They are developing innovative products and seek to differentiate themselves from competitors which are more advantaged through cheap energy. European companies are reducing their activities linked with basic petrochemicals and shifting their production to products that are less subject to cyclical business.

Thus, while closing unprofitable, old and inadequate PE plants no longer suited to European markets, petrochemical firms are investing in the production of resins and elastomers incorporating more technology, and thus meeting the needs of growing markets. Car production is one such growing market for innovative products which make vehicles lighter so they use less energy. Insulating plastics are another booming market in Europe, as are bio-plastics.

#### **Box 4. Repositioning in high value added products: the case of Carling**

In parallel to the closure of the Carling cracker, Total has announced the repositioning of the site on markets further downstream, such as the manufacture of certain plastics and additives with high value added, like hydrocarbon resins. Such products have applications in high growth markets, like touch screens or vehicles, and require much lower proportions of raw materials than does ethylene (10 to 15 % of product prices). The group has also announced the production of thermoplastics (newly used polymers by car manufacturers as an alternative to steel to make lighter vehicles and hence reduce fuel consumption). Total will also strengthen the capacity of the Carling site in polystyrene and modernise the polyethylene production unit in order to provide advanced plastics for the medical market and that of electric cables. Total plans to invest €160 million in 2016, to adapt this petrochemical platform and restore its competitiveness.

#### **(4) Innovation and sustainable development**

Innovation, high technology and know-how of European industry are at the heart of these strategies. They are leading to the production of polymers and plastics from renewable sources (e.g., bio-ethanol and polylactic acid), to more efficient processes in their use of raw materials and energy, and to products with higher value added, aimed at end sectors (lighter vehicles, thickness reduction of packaging, better insulation of buildings, etc.). European petrochemical firms are thus positioning themselves at the forefront of sustainable development, and providing solutions to their end customers looking for products that respect the environment.

#### **(5) Investment in growth regions**

European operators are increasing their presence in high growth markets (Asia, Latin America) and regions with low production costs (the Middle East and now the USA). Emerging Asian countries are at the heart of their development strategies, given the strong growth in demand in the region. Moreover, during the past two years, like US petrochemical producers, they are reinvesting in the United States in steam crackers using ethane from shale gas.

## Conclusion

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**The US competitive advantage linked to the development of shale gas is an additional threat to the European petrochemical industry, already subject to strong international competition, especially producers in the Middle East.** The loss of competitiveness by European industry and weak demand limit the room for manoeuvre of European firms operating upstream in the sector.

The impact is felt on production. There is no longer any investment in Europe in base chemicals, apart from investment in the re-conversion and modernisation of production plants. This does not create jobs. In the United States, in contrast, investments in new plants are exploding.

Eventually, the effect on the trade balance of ethylene and polyethylene could be significant. Europe will not have the means to defend its industry, as ***Made in America* petrochemicals will not be subsidised, but simply will benefit from the competitive advantage associated with the shale gas revolution in the United States.** This development comes at a time when the European Union and the United States are negotiating a free trade agreement. This should facilitate the trade of chemicals between the two areas and help save €1.5 billion per year in tariffs.<sup>36</sup> But will it not provide additional incentives to import US petrochemicals?

The realisation of this threat, however, is subject to many uncertainties, beyond the very sensitive nature of the petrochemical industry to business cycles in the global and regional economies.

**The largest uncertainty relates to the evolution of energy prices, and particularly the relative prices of natural gas and oil.** The competitive advantage of the United States is based on the differential between naphtha prices in Europe and ethane prices in the United States. It seems unlikely that the price of naphtha, linked to oil, could fall for a prolonged time. The evolution of ethane prices seems more uncertain. The sharp drop in prices since mid-2012 is related to the abundance of ethane supply versus demand. This could backfire if the gas industry is not able to expand quickly its production

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<sup>36</sup> CEFIC, <http://www.cefic.org/newsroom/2013/EU-US-trade-deal-will-create-jobs-growth/>

of wet gas and the necessary processing and transportation infrastructure. Tensions in the market for ethane would cause prices to rise and reduce the competitive advantage of US petrochemicals producers. The uncertainty also relates to the level of gas prices in the United States, which influences the production and price of ethane. US gas demand is expected to grow rapidly, both to supply domestic demand (especially power plants, but also related to fertiliser and methanol projects, and over the longer term to transport), as well as LNG export projects. LNG export projects, in particular, are seen as a threat by most US chemical companies which fear that this massive additional demand will increase gas prices and reduce their competitive advantage. **The price of gas in the US is expected to increase from its current level**, first as new shale gas resources more difficult to produce are developed. Moreover, regulation at the state level could be enhanced, leading to increased costs for US producers of shale gas. In fact, the US Environmental Protection Agency (EPA) is currently studying the environmental impact of the production of shale gas, in particular its impact on the water. It should report its findings in 2014.

If there is a consensus on the future increase in gas prices in the United States compared to their current levels, major uncertainties concern the level of such increases. The EIA expects a rise in gas prices from 2015 onwards.<sup>37</sup> But it is set to be modest (+2.4% per year on average over the period 2012-2040), in the baseline scenario: prices increase to \$4.13 per MBtu in 2020, and to \$7.83 per MBtu in 2040 (in 2011 dollars). This allows gas to maintain its advantage over oil. However, the advantage is reduced relative to current levels, as oil prices increase less quickly than gas.

**Uncertainty also relates to the development of shale gas outside North America.** The estimate of technically recoverable resources in other countries of the world amounts to 186,000 Gm<sup>3</sup> (EIA, 2013).<sup>38</sup> Their exploitation under responsible environmental conditions could change the situation and allow other regions of the world to access abundant energy. The question is crucial in Europe, whose dependence *vis-à-vis* gas imports is growing as conventional gas reserves face inexorable decline, and this despite the current decline in consumption. These imports amounted to 306 Gm<sup>3</sup> in 2012 for the EU-28, and generated a bill of nearly €100 billion. Europe has substantial resources of shale gas: 13,000 Gm<sup>3</sup>, according to the latest estimates by the EIA.<sup>39</sup> If they are certified and developed, they would enable the region to limit its dependence on gas *vis-à-vis* its external suppliers and limit the upward pressure on gas prices.

<sup>37</sup> EIA (2013a), op.cit.

<sup>38</sup> EIA (2013d), Technically recoverable shale oil and shale gas resources: an assessment of 137 shale formations in 41 countries outside the United States, EIA/DOE, Washington DC, June 2013

<sup>39</sup> EIA (2013d), op. cit.

**China remains a major unknown factor**, in the role it could play in the international trade of petrochemical products and the development of its own shale gas. By following a policy of self-sufficiency and reducing its imports of petrochemicals, China will exacerbate competition between exporters and is likely to change the flows of current trade. Moreover, China has the world's largest resources of shale gas (32,000 Gm<sup>3</sup>) and is engaged in a programme to develop these resources.<sup>40</sup> If China achieves its ambitions and produces substantial levels of shale gas, the international gas market could lose its most dynamic outlet, with inevitable consequences for the international gas trade and prices.

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<sup>40</sup> EIA (2013d), op. cit.

## Annex 1: Petrochemicals – Technical Aspects

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**As a sub-sector of organic chemistry**, the petrochemical industry transforms fossil fuels (oil, natural gas, coal) and biomass into major petrochemical intermediates. These are themselves used for the production of multiple finished products.<sup>41</sup>

The main raw materials used in petrochemicals are **naphtha** or gas oil (petroleum fractions), **ethane** (e.g., ex-natural gas) and LPG (propane and butane from the refining or natural gas liquids).

Schematically, the petrochemical industry develops major intermediate products using two processes:

- **Steam cracking**. At high temperatures and in the presence of steam, the long molecules contained in the naphtha and ethane are broken down into smaller chains: **olefins**, such as ethylene (C2), propylene (C3), butenes and butadiene (C4);
- The **catalytic reforming** which only processes naphtha to produce major **aromatic** intermediates such as benzene, toluene and xylenes (BTX ).

The olefins and aromatics are in turn raw materials, called major intermediates, which after processing (polymerisation, organic synthesis, etc.), yield polymers (resins, fibres, elastomers) and finished products that can be used directly by the end user or other industries (industrial plastics, pharmaceuticals, cosmetics, electronics, aerospace and textiles).

**Ethylene is the flagship product of the petrochemical industry**. With more than 130 Mt produced annually worldwide, it is the basis of all global petrochemicals. It serves as a basis for the manufacture of intermediate products (polyethylene fibres and other organic chemicals) that are found in most manufactured products and are consumed in the packaging industries, the automotive industry, construction and a variety of industrial markets and consumer goods. Due to the importance of its production and the diversity of its

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<sup>41</sup> IFP Energies nouvelles (2012), Pétrochimie et chimie ex-biomasse, Panorama 2012, Rueil Malmaison.



derivative markets, ethylene is often used as an indicator of the performance of the petrochemical industry as a whole.

Ethylene is produced by steam cracking in increasingly large furnaces (210,000 tonnes per year for the biggest in the world). This generates economies of scale. Ethylene is obtained from:

- **natural gas rich in ethane** (in USA and the Middle East ) by pyrolysis or cracking at high temperatures. In this procedure, the proportion of ethylene in the resulting gas mixture is about 80-84 %.<sup>42</sup>
- **naphtha** (in Europe and Asia) by steam cracking. The proportion of ethylene in the mixture is about 29-34%. Other products obtained are propylene (13-16%), butadiene (4-5 %), and aromatics, C4+ (10-16%).<sup>43</sup>

The main companies producing ethylene are SABIC, Dow Chemical, Exxon Mobil Chemical, Royal Dutch Shell, Sinopec and Total. Technip is a world leader in the design of plants to produce ethylene, all the way from conception to construction and commissioning.

**Polymerisation converts olefins into very long carbon chains: polymers or plastics.**<sup>44</sup> There are three main groups:

- polyethylene, a plastic produced by the polymerisation of ethylene. It is intended primarily for packaging, the automotive and food industries, as well as cables and pipelines;
- polypropylene, plastic produced by the polymerisation of propylene. It is intended primarily for the automotive, packaging, and household appliance industries, electrical appliances, fibres and hygiene products;
- polystyrene, plastic produced by the polymerisation of styrene (ethylene + benzene). It is used primarily for packaging, insulation and refrigeration.

Polyethylene represents 55-60% of the total use of ethylene. Other products include: vinyl chloride, ethylbenzene, ethylene oxide and ethanol (see Annex 2).

**The petrochemical economy is highly dependent on the availability and price of the raw materials it processes (natural gas and crude oil).** Decisions to invest in petrochemicals are strongly influenced by the cost of raw materials. They are also influenced by the growth in demand of major petrochemical intermediates (olefins and aromatics), which is itself linked to the demand for finished products and thus economic activity, population

<sup>42</sup> Ren T (2009), op cit

<sup>43</sup> Ren T (2009), op cit

<sup>44</sup> Total, <http://total.com/fr/energies-savoir-faire/petrole-gaz/raffinage-petrochimie/metiers>

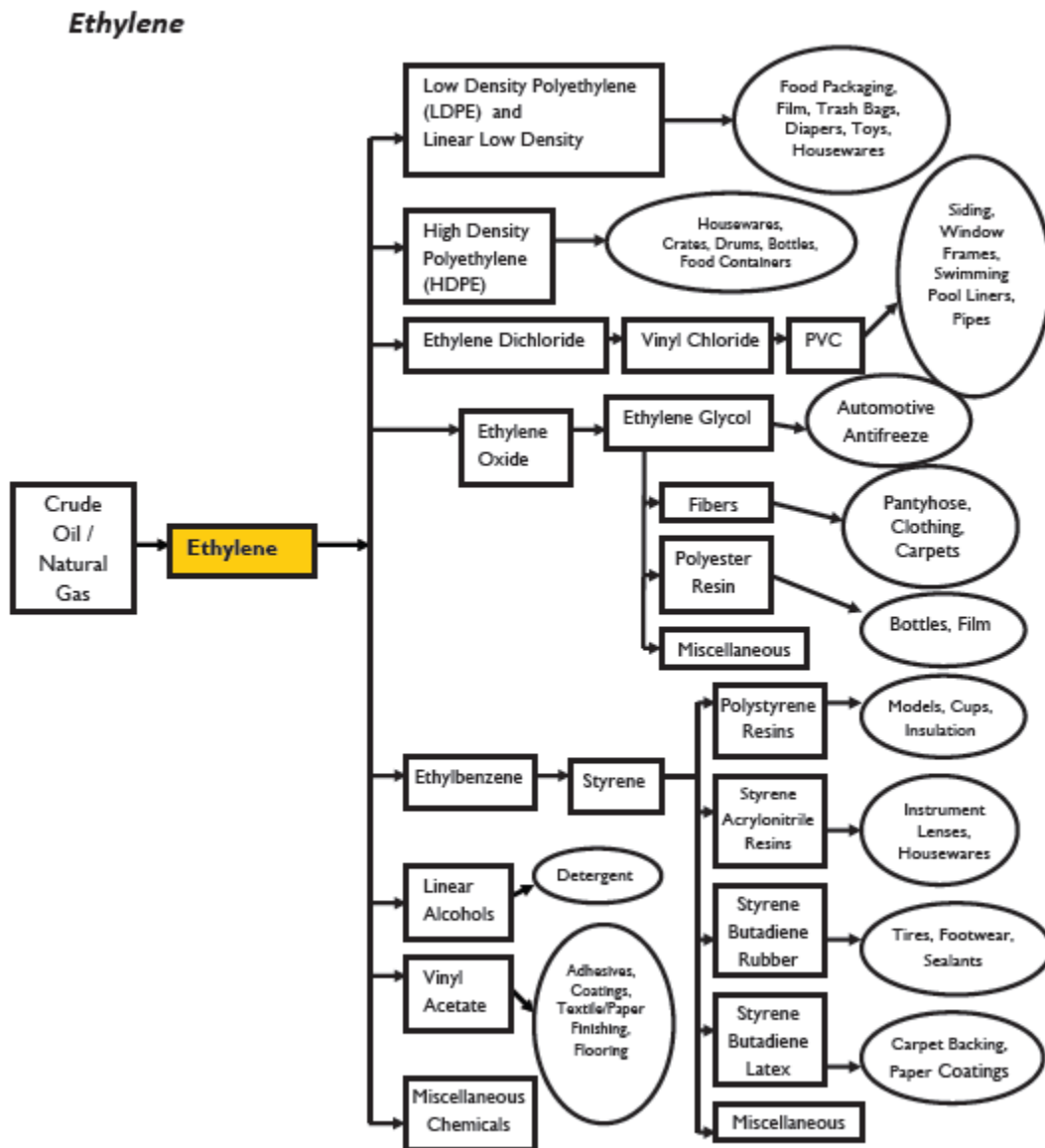
growth and the rise of per capita living standards. **These factors explain the main trends observed in the global petrochemicals industry over the past decade**, including:

- strong growth in demand and capacity in emerging markets, particularly in Asia and China;
- the explosion of capacity in the Middle East, which has low raw material prices, based on the availability of natural gas (at \$0.75 per MMBtu in the case of Saudi Arabia);
- the rationalisation of production facilities in developed countries, the United States and Europe in particular. These are mature markets, which over the past decade have been confronted with the sharp rise in price of raw energy. Shale gas has changed the situation in the United States.

In the long term, demand for finished products – and thus petrochemical base products – is significantly higher (4% per year on average) due to economic growth in emerging countries, particularly China.

**Energy is a significant cost in the production of petrochemicals.** For some products, the cost of energy, both raw materials and fuels, can reach 85% of the cost of production. The most energy-intensive products are those for which energy is used both as feedstock and as a fuel: ethylene, butadiene, propylene, ammonia, and methanol.

## Annexe 2: The Ethylene Value Chain

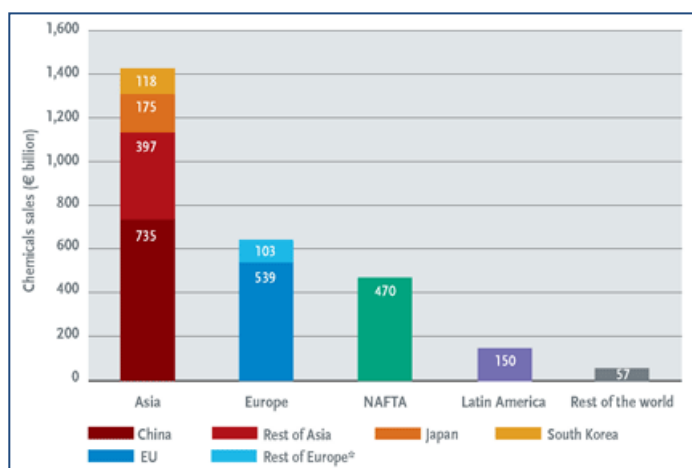


Source: ACC (2013)

## Annex 3: The European Chemical Industry in a Global Context

According to the CEFIC (the European Chemical Industry Council), the turnover of the global chemical industry (excluding pharmaceuticals) amounted to €2,744 billion in 2011 (Figure 19).<sup>45</sup> This was an increase of 11.6% compared to 2010, driven by strong industry growth in emerging countries.<sup>46</sup> China became the world's largest producer, ahead of European Union in 2010, a position it has reinforced since. In 2011, sales in the European Union amounted to €539 billion, and to €422 billion in the United States.<sup>47</sup>

Figure 19: World Production of Chemical Products (a), 2011



Turnover excluding pharmaceutical products. Source: CEFIC.

<sup>45</sup> CEFIC (2012), op.cit.

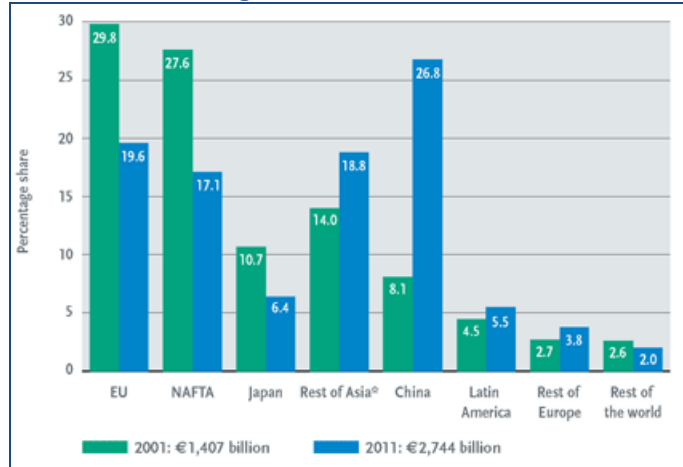
<sup>46</sup> This is the value of sales by the chemical industry. In volume terms, BASF estimates global production of chemical products to have risen by 3.8% in 2011 and by 2.6% in 2012 (Source: BASF (2013a), BASF Report 2012). BASF forecasts a rise in world production of 3.1% in 2013 (source : BASF (2013b), Interim Report, 1st half 2013).

Il s'agit de la valeur des ventes de l'industrie chimique. En données physiques, BASF estime que la production mondiale de produits chimiques s'est accrue de 3,8 % en 2011 et de 2,6 % en 2012 (source ). BASF prévoit une hausse de la production mondiale de 3,1 % en 2013 (source : BASF (2013b), Interim Report, 1st half 2013).

<sup>47</sup> \$587 billion, according to the ACC.

Over the past 10 years, Chinese production has increased rapidly and the share of China in world output is now 27%, compared to only 8% in 2001 (Figure 20). Asia (excluding Japan) now accounts for nearly half of global production.

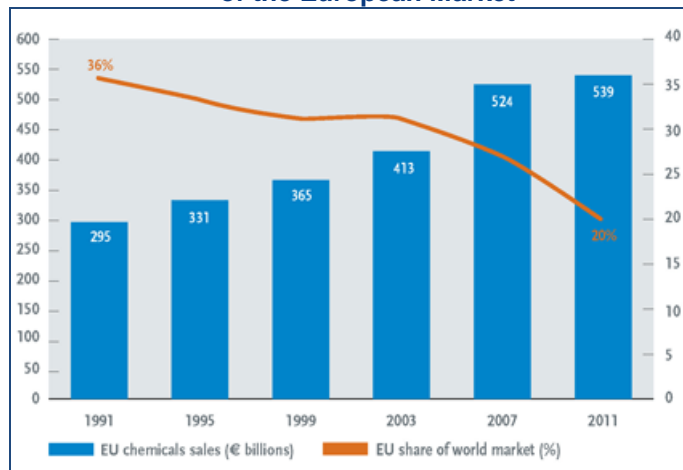
**Figure 20: Change in the Production of Chemical Products by Major Region, from 2001 to 2011**



Source: CEFIC

The growth of production in emerging Asian countries has eroded Europe's market share, despite the latter's continued growth in output over the past twenty years (except in 2009), as shown in the following figure.

**Figure 21: The Evolution of Sales of Chemical Products and the Share of the European Market**



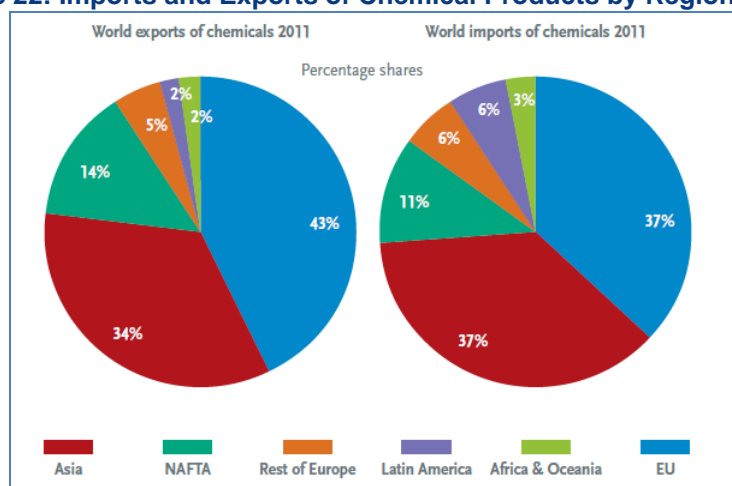
Source: CEFIC

In the future, the global chemical industry will continue to grow, with an average increase of 4 % per annum over from 2013 to 2015, according to BASF.<sup>48</sup> Emerging countries will continue to drive global growth with an average growth rate of 7.8% per year in Asia (excluding Japan). Their output will continue to grow faster than GDP, mainly driven by industrialisation and increases in local consumption, due to the rising living standards of their populations.

The United States should grow at an average rate of 2.3%, thanks to low gas prices. Sales growth in the European Union is set to remain modest, at 1% per year on average for 2013 to 2015.<sup>49</sup>

The chemical industry is actively involved in international trade. Europe is the leading regional exporter and importer of chemicals, with a share of about 40% of world trade (Figure 22). This figure includes intra-European trade, which has grown considerably over the last ten years.

**Figure 22: Imports and Exports of Chemical Products by Region, 2011**



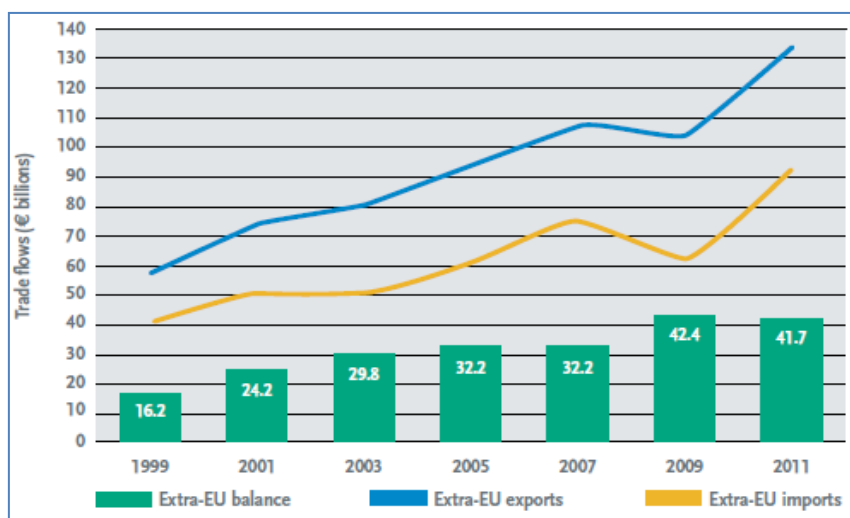
Source : CEFIC

The European chemical industry has a significant trade surplus, running at €42 billion in 2011.

<sup>48</sup> BASF (2013a), volume data and not value figures.

<sup>49</sup> Following a decline of 1.4% in 2012, the CEFIC forecast a further fall in European production in 2013 (-1%), and a modest rise in 2014 (+1.5%).

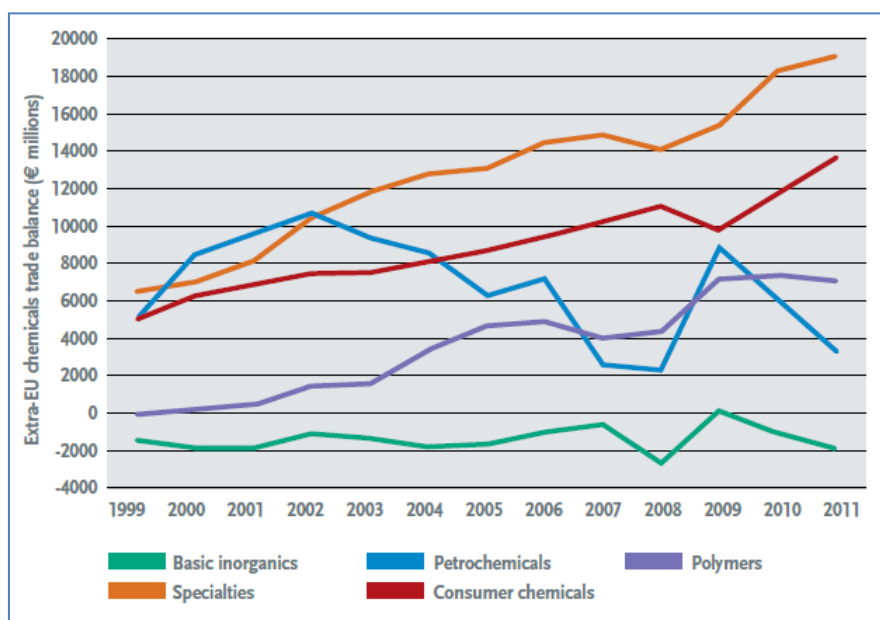
**Figure 23: The Trade Balance of the European Chemical Industry, Extra-EU**



Source : CEFIC

The analysis by major chemical products shows up contrasting across different sectors. While the trade balance of specialty chemicals and consumer chemicals has increased sharply, petrochemicals have been on a downward trend since 2009.

**Figure 24: The Trade Balance in Chemicals by Sector**



Source: CEFIC

## Bibliography

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ACC (American Chemistry Council) (2013), Shale gas, competitiveness and new US chemical industry investment: an analysis based on announced projects, May 2013

Alembic Global Advisors (2013), US chemicals –Overlooked sources of cycle tightness, 24 June 2013

APPE (Association des producteurs pétrochimiques européens) <http://www.petrochemistry.eu/about-petrochemistry/facts-and-figures.html>

BASF (2013a), BASF Report 2012, 2013

BASF (2013b), Interim Report, 1st half 2013, 2013

BCG (The Boston Consulting Group), Behind the American export surge, August 2013

CEFIC (2013), The implications of the shale gas revolution for the European chemical industry, Cefic Position Paper, Brussels, 15 March 2013.

CEFIC (2012), Facts and Figures 2012, Brussels, December 2012

EIA (2013a), Annual Energy Outlook 2013, EIA/DOE, Washington, DC, April-May 2013

EIA (2013b), U.S. Crude Oil and Natural Gas Proved Reserves, EIA/DOE, Washington DC, 1 August 2013

EIA (2013c), Shale oil and shale gas resources are globally abundant, Today in energy, EIA/DOE, Washington DC, 10 June 2013

EIA (2013d), Technically recoverable shale oil and shale gas resources: an assessment of 137 shale formations in 41 countries outside the United States, EIA/DOE, Washington DC, June 2013

Euler Hermes Economic Research (2013), Crisis in the European petrochemical industry?, 19 May 2013

IEA (2013), Energy prices and taxes, 2013, second quarter, IEA/OCDE, Paris.



IFP Energies nouvelles (2012), Pétrochimie et chimie ex-biomasse, Panorama 2012, Rueil Malmaison

IHS (2013), America's New Energy Future: The Unconventional Oil and Gas revolution and the US Economy. Volume 3: A manufacturing renaissance, September 2013

IHS (2013), Energy and the new global industrial landscape: a tectonic shift?, Davos 2013

Info Chimie, Coup de sabre de Sabic en Europe, 22 avril 2013

KPMG (2013), Strategic realignment in the global chemical industry, Reaction, Chemical Magazine, 11th Edition, KPMG International

Les Echos, L'essor des gaz de schiste américains menace la pétrochimie européenne, 8 mars 2013

Oil & Gas Journal (2013), Global ethylene capacity poised for major expansion, OGJ, Volume 111, Issue 7, 1 July 2013

Platts (2013), Time to get cracking, Platts special report: Chemicals, January 2013

Platts (2013), Can shale gas save the naphtha crackers, Platts special report: Chemicals, January 2013

Platt's (2012), The North American Gas Value Chain: Developments and Opportunities, Platt's special report, September 2012

PwC (2012), Shale gas Reshaping the US chemicals industry, October 2012

Ren T. et al. (2009), Energy efficiency and innovative emerging technologies for olefin production, Faculty of Chemistry, Utrecht University, The Netherlands

Roland Berger Strategy Consultants, Global petrochemicals – Who is really benefitting from the growth in the new world?, November 2012

Usine nouvelle.com, Matières plastiques : un marché mondial en pleine mutation, 29 mai 2013