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Abstract

This article studies the likely impact of unconventional gas developments in the U.S. on EU competitiveness. We find, first of all, little evidence for a prosperous unconventional gas development in Europe. Second, the U.S. boom has already a strong impact on both world and European energy markets. In particular, lower U.S. gas and coal prices have changed relative energy prices both at home and abroad. Finally, competitiveness impacts in some (sub)sectors will be considerable. These impacts are not only related to production based on gas use as a feedstock but also on the 'byproducts' from unconventional gas production, such as ethylene, propane and butane. However, several indirect impacts, such as lower coal import prices, may soften the adverse competitiveness impact in the EU.

JEL-Code: L710, O520, Q310, Q410, Q430.

Keywords: shale gas, hydrocarbon resources, energy demand and supply, non-renewable resources, competitiveness impacts, European Union.

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1. Introduction

Currently most of the global supply of technically recoverable natural gas comes from conventional sources. For quite some time reserves were thought to be limited and restricted. Some argued that such restriction inevitably would induce a period of peak oil and gas (Hubbert, 1962). It was not a question whether, only when this would happen. The rapid rise in fossil fuel prices in the first decade of the new millennium suggests we would already face this period (Blackmon, 2013). How different is the discussion today. The recent boom in unconventional fossil fuels, such as shale gas and oil relegated such ideas to the background.[2] Indeed, this boom illustrates an old lesson: higher fossil fuel prices also stimulate supply side investments and technological change in the fossil fuel industries, which, in turn, is likely to lead to the discovery of new reserves (Odell, 1994). And this is precisely what the recent multiple upward adjustments of the potential supply of both conventional and unconventional gas illustrates (IEA, 2012a).

Known reserves of unconventional sources can be mainly found in Asia-Pacific (such as China) and North America. Production from these unconventional sources in North America has exploded the last decade and is now responsible for the new fossil fuel resource boom. Along with this production, U.S. gas prices collapsed which, in turn, created new comparative advantages for some industries and greatly reduced the cost of U.S. climate policy (see also Krupnick et al, 2013). For some observers this U.S. bonanza would also provide a promising future for Europe. Such a future is particularly attractive in view of current concerns about strategic dependency from Russian gas too.

[2] Shale gas is, like tight gas and coalbed methane, often referred to as an unconventional gas (JRC, 2012). Although the chemical content of unconventional and conventional gas is similar (namely methane), the sources and involved production methods are different. Tight gas is found in formations similar to conventional gas sources, but with lower permeability. Coalbed methane is natural gas contained in coalbeds, originally extracted from coal mines to make them safer, but nowadays also from non-mineable coalbeds. Shale gas is contained within rock formations, known as shale. These rock formations are characterized by its very low permeability and low porosity. The depth can range from near surface to several thousands of meters.

Whether and to what extent Europe could benefit from its own boom of unconventional gas production is still an open question, however. At the moment it is very uncertain how large the actual unconventional reserves are, and also whether companies will be allowed to even explore them in Europe, let alone exploit them (European Commission, 2014). Less uncertain is the major impact of the North American unconventional fossil fuel boom on the European economy in the short and medium term. The growing gap between gas prices in the different world regions has already raised competitiveness concerns within the EU industry, in particular if not similar unconventional gas exploitation with associated gas price reduction within Europe might become true. Competitiveness concerns not only apply to the gas sector as such because incidence effects matter too. Although some argue both macroeconomic as well as sectoral impacts would be limited in the long run (e.g. Spencer et al., 2014; ICF, 2014), our analysis shows that impacts in some (sub)sectors will be considerable, in particular for impacts related to the 'byproducts' of unconventional gas production, such as ethylene, propane and butane.

We analyze the likely impact of unconventional gas developments on EU competitiveness in the short and long run.[3] For this purpose the paper reviews first of all the literature and brings together facts and trends in both conventional and unconventional gas production and prices as well as in other related energy markets in Europe and other world regions. Next we discuss recent and potential developments in unconventional gas exploitation, in particular in the U.S. and Europe. Using these insights we explore where the unconventional gas revolution has a likely impact at the European economy and we provide a

[3] We do not analyze whether a European unconventional gas boom would physically be possible at all. This question is beyond our expertise. We also do not discuss the linkage between the unconventional fossil fuel boom and the environment. Serious concerns exist about the impact on, for instance, local drinking water conditions, climate change emissions through methane leakages (flaring and venting), and local disturbances of the environment (e.g. Olmstead et al., 2013; IEA, 2012b). Finally, we do not answer the question whether Europe should facilitate unconventional gas exploration or not from a social welfare perspective.

first impression of the potential impact on the European electricity production as well as on other European industries.

2. The gas market in the EU and global fossil fuel price developments

This section describes the current conventional gas market in the EU in the wider context of global fossil fuel market price developments. We start with recent changes in demand and supply in the EU gas market. Next we take a closer look at the long run developments in gas, coal and oil prices in the major markets of the EU, the U.S. and Japan between 1960 and 2013. Finally, we discuss relative fossil fuel price changes in these regions to better understand which impact the shale gas revolution may have on EU energy markets

2.1 Recent developments in the EU gas market

Within the EU, natural gas is mainly consumed for heating purposes, power production and as industrial feedstock.[4] The overall consumption of natural gas in OECD Europe was 618 billion cubic meters (bcm) in 2011, roughly 15% of the global consumption (IEA, 2014). Almost forty percent of natural gas is used for heating purposes by residents and commercial and public services. While demand by power companies increased for a long time, it is declining since 2009, but still consists of more than 25% of the natural gas consumption in OECD Europe. The IEA expects demand to rise slowly again after 2013, due to improving prices in favour of gas (compared to coal), but recovery to pre-crisis levels is not projected before 2018 (IEA, 2013a).

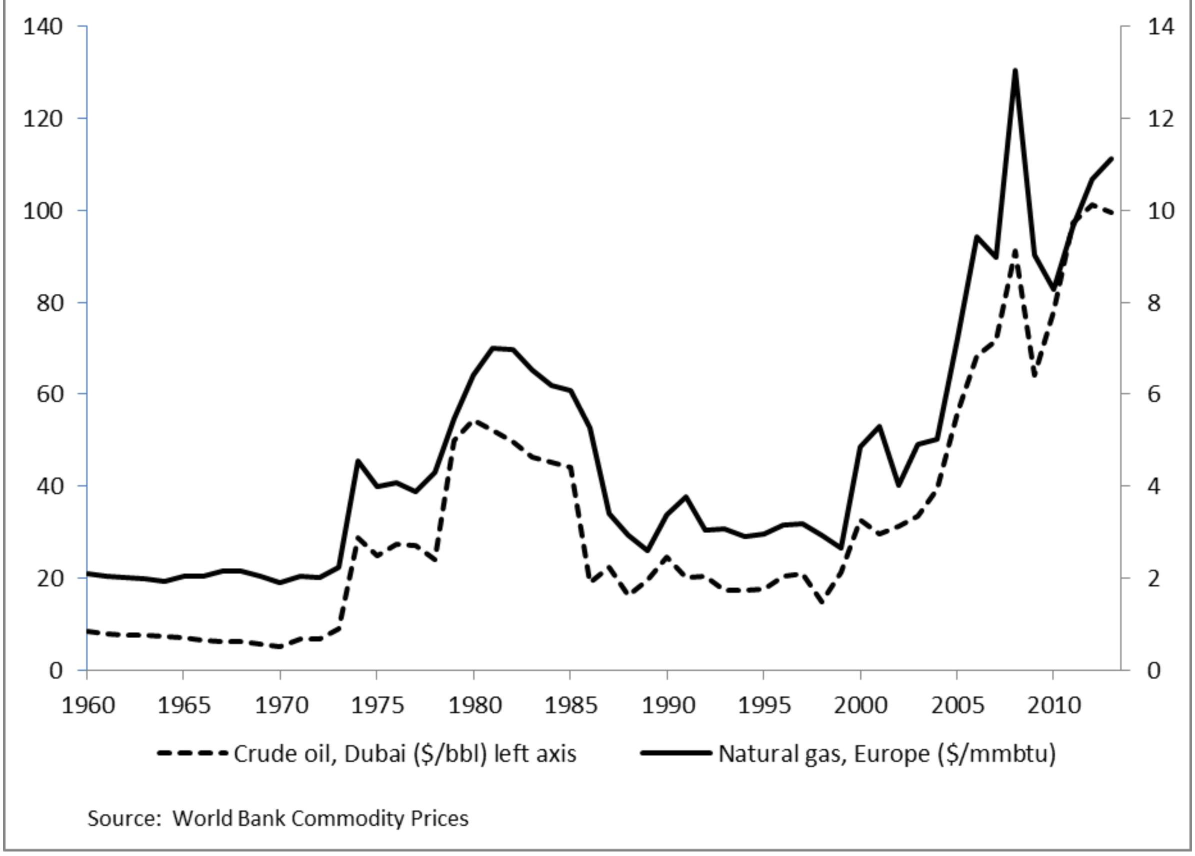
On the supply side, gas is only produced from conventional sources in Europe. Production is concentrated mainly in Norway, the U.K. and the Netherlands.[5] The trend in natural gas production within OECD Europe is clearly downwards because U.K. production is

[4] See Vollebergh et al (2014) for a more extensive description of the background of the European gas market and price developments.
[5] Not surprisingly, export is mainly restricted to the gas producing countries, in particular Netherlands and UK.

falling rapidly in the last decade, while the production in Norway and the Netherlands fluctuate around a constant level. Long term projections indicate further decline of domestic gas production in the U.K.. For instance, the IEA expects production to fall with over 50% between 2010 and 2030 (assuming a 20 bcm increase of unconventional gas production within Europe) (IEA, 2012a).

The overall import share of final gas consumption in OECD Europe was 46% in 2011 (IEA, 2014). This share is expected to increase to in order to compensate for declining domestic production within OECD Europe in the next decades. Imports supplied to OECD Europeusing pipeline infrastructure are from the Russian Federation (130 bcm in 2011) and Algeria (49 bcm in 2011). Liquid National Gas (LNG) is imported from Qatar. New supply may be provided by the international LNG market, with newcomers such as Africa, Australia and the U.S., and new suppliers using the “southern corridor” such as Azerbaijan.

Figure 1: European natural gas en crude oil prices 1960-2012



Price formation in the European gas market has been dominated by long term delivery contracts with gas prices indexed to the price of oil – once a substitute for gas –. This is clearly illustrated in Figure 1.[6] A more or less constant difference in real terms can be observed between European (average) natural gas prices (in US$ 2005) and the world market price of crude oil. Indeed, a typical contract with Gazprom (Russia's supplying company), was the delivery of natural gas for 20 to 30 years, using take-or-pay clauses with gas price indexation following the international oil price (The Economist, 2012). Figure 1 also nicely shows that both oil and gas prices reach the highest levels in real terms at the end of the period, but also show a sharp increase in volatility, in particular since the economic crisis in 2008.

A closer look at the average European natural gas price index presented in Figure 1 suggest some decline of the gas price relative to oil at the end of the period. Indeed, gas-to-gas competition or spot trading has increasingly become important for gas price formation in the last decade (IEA, 2013b). More European producers, mainly from the U.K. and the Netherlands, are trading their supplies on a spot basis. Spot trading was responsible for 20% of gas supply in 2005, but currently about half of the gas supplied in Europe is based on competitive market prices (The Economist, 2012; IEA, 2013a, p.172ff;Gény, 2010).

Spot market contracts are not using oil price indexation and more likely reflect market fundamentals such as changes in demand and production.[7] Decoupling of gas from oil prices is likely to increase as long-term gas delivery contracts using oil-price indexation are increasingly being negotiated (IEA, 2013a, IEA, 2013b). Further liberalization of EU energy

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[6] All prices are derived from World bank and are free-on-board, i.e. without excises, other taxes or import tariffs and reflect real 2010 US$.

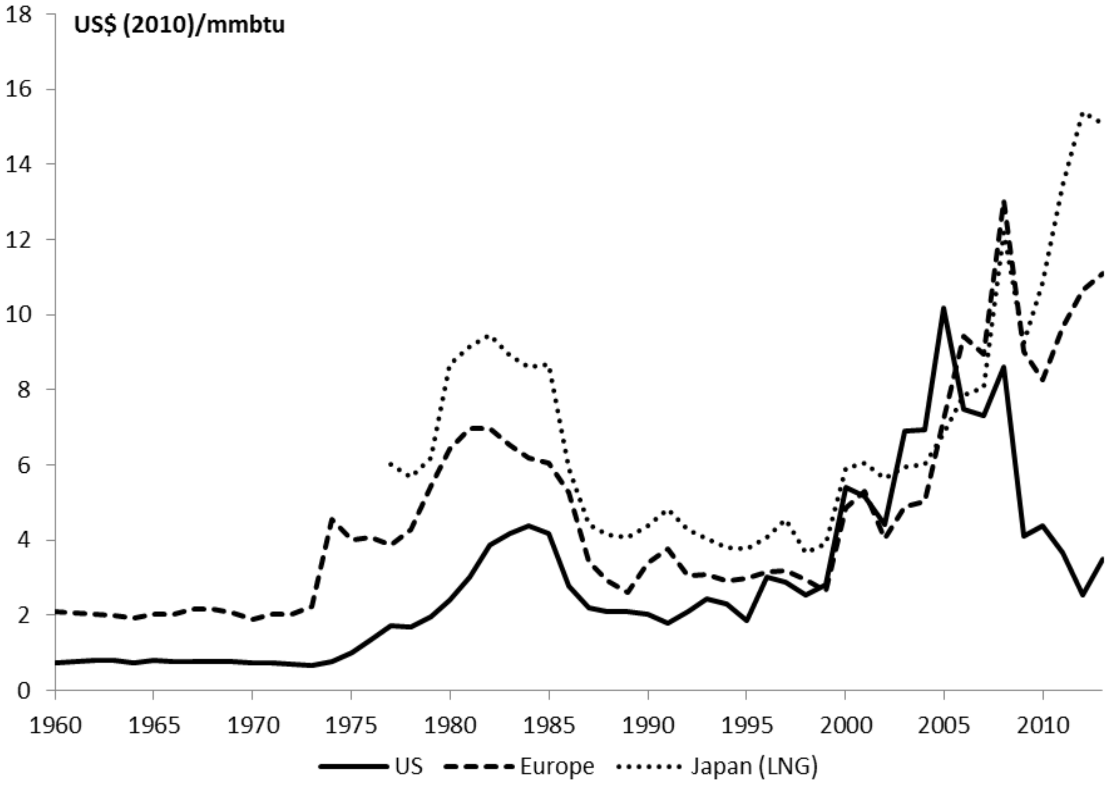
[7] The increasing impact of gas-to-gas competition on energy price formation is discussed in more detail by the IEA (2013a, p. 167ff). A clear, widening gap is visible between gas spot market prices and the oil price (Brent) in recent years, in particular after the turbulence of the economic crisis. The gap increases over time coinciding with growing trading volumes as share of the overall gas market. The growing importance, however, is not yet so clear if one considers the development of the average gas price for the whole of the EU as presented in the previous section.

markets remains a challenge, however. Most gas is still supplied by a few state-owned companies like Russian Gazprom and Norwegian Statoil using state-owned pipelines. Nevertheless European customers, such as RWE and EON, are increasingly successful in renegotiating the terms of their long term contracts. This indicates that Europe's main suppliers may be able to renegotiate their contracts and to realize price cuts even for the gas share that is not traded on the spot market (The Economist, 2012).

2.2 Developments in world market prices for natural gas

Gas markets are primarily regional because of limited interconnectivity. Pipelines do not easily cut through continents, like North America, Europe and Asia. However, recent developments in creating LNG may change this in a fundamental way. The main trends for the most important natural gas markets are visualized in Figure 2.

Figure 2: Natural Gas and LNG Prices 1960 - 2013



Source: World Bank Commodity Prices

Like the European (real) gas price, also other gas prices peaked after the second oil crisis in the early 1980s and again in the last decade. The U.S. natural gas price has always been lower than EU (average import) prices except for a relatively very short period (2000-2004). Indeed, this rapid increase in gas prices in the U.S. is even considered to be one of the reasons for the rapid development of shale gas in the 2000s (Wang and Krupnick, 2013).

After the U.S. gas price reached its peak in 2005 a clear downward trend is visible in the succeeding years. Indeed, a remarkable disparity can be observed between the U.S. gas price and the other two major markets since this peak. U.S. shale gas developments clearly have an impressive impact already. By contrast gas prices in Europe and Japan have an increasing trend after 2005. U.S. prices are now almost below the level of the early 1980s, whereas prices for both other regions are well above their peak levels and even reached all-time highs.

The Japanese gas market is much different from the EU and U.S. gas market because it is highly dependent on LNG. LNG is more costly to produce and trade which explains why it is usually more expensive (shown is average import price). The very high peak at the end of the period is due to the Fukushima disaster which in combination with a cold winter induced very high spot prices for LNG in Japan in 2012 (IEA, 2013b, p.267). But also in Europe prices were 5 times higher than the price in the U.S. around mid 2012, although the ratio declined to 3 at the end of 2013.

A closer look at the latest trends suggests that the declining price trend in the U.S. as well as the rising trend in the EU and Japan has come to a halt. Because inflation has been (very) low in recent years, no evidence exists for a further decrease of the U.S. natural gas price since 2009. Also the rise in the gas price in Japan has come to a halt very recently which is also partly explained as a consequence of a revaluation of the Yen against both the Euro and the dollar.[8]

2.3 Developments in world market prices for coal and oil markets

The *coal* prices for three major export markets, i.e. the coal markets for Australia, Colombia and South Africa, as well as at the U.S. market, reflect more or less the same pattern as the gas prices, i.e. a peak at the end of the 1970s and again a considerably rise since 2000. The rise is less pronounced compared to gas, however. On average not much difference exists between the development of the coal prices in exporting regions and the U.S.. This has changed in the beginning of the new century. In the more export oriented coal markets a strong increase in the price (as well as in its volatility) is visible in the last decade, but the coal price in the U.S. has increased at a much lower pace since the early 2000s. Again the shale gas revolution leaves its mark here: power plants within the U.S. increasingly switch to gas creating a clear downward pressure on (relative) U.S. coal prices (see also Wang and Krupnick, 2013). At the same time, a clear trend becomes visible in, for instance, Europe where power companies increasingly switch to imported (cheap) U.S. coal. Recent developments provide no indications of a further rise in the coal price trend (on average) after the economic crisis (see also IEA 2013b, p.268). The sharp increase was followed by a sharp decline in 2012, and the price stabilizes since.

Like the prices on the other fossil markets, the *oil* prices also show a spike in the 1970s and 1980s with a clear downward trend afterwards until the turn of the century, and, then again, a steep rise in real terms since 2000. After a strong recovery after the economic crisis in 2008, oil prices stabilize since 2011. Oil prices in recent years are almost twice as

[8] After 2000 the Euro initially revaluated relative to the dollar but the exchange rate stabilizes since the economic crisis in 2008. By contrast the dollar and Yen were on parity until the crisis. After the crisis the Yen first revaluated strongly against the Dollar but devaluated in 2013 (see also IEA, 2013c, p.281).

high as at the oil price peak in the 1970s and 1980s. To what extent price volatility is increasing is not entirely clear, although the impact of the financial crisis is clearly visible in the trend.

The oil prices in the different markets show almost no difference since the end of the 1970s. Only the U.S. price (WTI) follows a somewhat different pattern recently and starts to deviate at the end of the period. This price is now substantially lower than the Brent- and Dubai-prices since 2011. Recent developments suggest that this is likely to be a temporary phenomenon. The recent difference can be explained by the increasing production of tight oil (also from shale formations) that supply U.S. refineries (EIA, 2013b). The US$20 price differential between WTI and Brent during 2012 was due to limited transport capabilities of light tight oil to the Gulf coast (EIA, 2013c). The recent expansion of pipeline capacity within the U.S. seems to be mainly responsible for the recent market arbitrage that reduces the price gap between the different oil markets.

2.4 Relative fossil fuel price changes

Apart from the trends within each fossil fuel market, increasing substitution between the different fossil fuels is another important trend. Substitution processes in the energy market relate mainly to the relative prices. The IEA recently provided some useful data to assess these changes in the last decade (see Table 1). The table provides standardized prices for natural gas, oil and coal in terms of their energy content and also compare prices across the different regions.

The data confirm, first of all, earlier observations: U.S. prices were relatively high for gas and oil at the beginning of the 21st century, but are now the lowest at *all* major fossil fuel markets. In the most recent years Japan faces the highest prices, while the EU prices for both gas and coal are moderate.

Table 1 Fuel prices (USD/MBtu)

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Natural gas										
Henry Hub (U.S.)	5,47	5,90	8,84	6,75	6,98	8,86	3,95	4,39	4,00	2,75
NBP (UK)	3,33	4,47	7,34	7,64	6,03	10,47	4,77	6,56	9,02	9,48
German border price	4,06	4,30	5,83	7,88	8,00	11,61	8,53	8,03	10,62	11,09
Japan LNG	4,79	5,19	6,02	7,12	7,74	12,66	9,04	10,90	14,78	16,70
Oil										
WTI (U.S.)	5,36	7,14	9,73	11,38	12,46	17,18	10,63	13,69	16,36	16,23
Brent (EU)	4,97	6,59	9,38	11,23	12,50	16,72	10,60	13,70	19,18	19,25
JCC (Japan)	5,02	6,27	8,79	11,05	11,90	17,65	10,45	13,65	18,81	19,79
Coal										
U.S. Appalachian	1,32	2,38	2,38	2,09	1,81	4,27	2,07	2,67	3,07	2,43
NW European steamcoal	1,83	3,03	2,55	2,69	3,72	6,18	2,96	3,82	5,10	3,89
Asian coal marker	1,53	3,04	2,60	2,37	3,55	6,22	3,31	4,43	5,28	4,43

Source: IEA (2013a, p. 182)

Second, the strong impact of the shale gas revolution in the U.S. is visible in these data as well. Within the U.S. gas prices halved in this period, whereas prices in the EU and Japan rose with almost a factor three. EU gas prices are now three times higher compared to the U.S.. Oil prices were also highest in the U.S. in 2003 but lowest in 2012. The differences are small, however. Coal prices have always been low in the U.S. but the price gap has increased considerably at the end of the period.

Third, relative prices between the markets have changed as well. In 2003, gas was more than four times more expensive than coal in the U.S., whereas the price difference between coal and gas was just above 10 percent in 2012. In Japan gas was more than three times more expensive than coal per unit energy in 2003, but the price gap is almost four times in 2012. A similar trend can be observed in the EU market. If such price developments are stable and lasting, they are very likely to have strong consequences on fuel input choices throughout economies as well as on firm location decisions.

3. Projecting unconventional gas and its impact on EU fossil fuel markets

Projecting developments of fossil fuel markets and their impact on the wider economy is a notoriously difficult task (Kilian, 2008). A close interaction exists between fossil fuel prices in different markets and with wider economic developments, such as the recent upsurge of developing countries like China or the lasting economic crisis in the EU. Moreover, both demand and supply in the different markets interact and sudden shocks in one market usually has a strong impact in the other markets. The oil market in the 1970s was a case in point, but the current boom in unconventional gas (and oil) in the U.S. is another candidate too. Future developments depend on the question as to whether this unconventional boom will spread to other regions as well. This section discusses current projections of future developments in unconventional gas markets and its likely impact on both the gas and other fossil fuel markets in the EU.

3.1 Current and potential production of gas within and outside the EU

Although unconventional gas production in the U.S. has grown rapidly, most of the global supply of technically recoverable natural gas is still found in conventional sources (see Table 2). These sources are in Eastern Europe and Eurasia (mostly Russia) and the Middle East, while unconventional sources are more likely to be found in Asia-Pacific, such as China, Africa and North America. Estimates of potential supply of both conventional and unconventional have been adjusted upward at multiple instances, however (IEA, 2012a).

Table 2 Mean estimates of remaining technically recoverable gas resources (Tcm)

Region	Conven-tional	Tight	Coalbed Methane	Shale		
				Low	mean	high
USA	27,2	12,7	3,7	8,0	23,5	47,4
Canada	8,8	6,7	2,0	1,4	11,1	28,3
Europe	11,6	1,4	1,4	2,3	8,9	17,6
China	12,5	9,9	2,8	4,2	19,2	39,8
Rest of world (implied)	364,9	14,6	15,6		34,7	
Global	424,9	45,4	25,5	7,1	97,4	186,4

Source: JRC (2012)

Most authoritative sources indicate that European production potentials of shale gas are limited compared to other regions (IEA 2012b and 2013b; JRC, 2012; EIA, 2013a). Shale formations in the EU would be less rich of hydrocarbons in the EU compared to the U.S.. The uncertainty, however, is very large. Recent estimation of global reserves by the U.S. Energy Information Administration is 18% higher compared to the high estimates from JRC (2012) and for Europe even 42% higher (EIA, 2013a).[9] The main areas with potentially large shale gas reserves in the EU are concentrated around the Baltics and Poland and in the triad of England, France and Germany (JRC, 2012; EIA, 2013a). Outside the EU, other European countries with substantial reserves are Russia (8 tcm) and the Ukraine (4 tcm) (EIA, 2013a).

Whether technically recoverable sources are valuable enough for exploitation depends on costs and benefits of the extracted fuels. The cost are determined by a number of factors such as access to the shale formation, availability of water, environmental regulations, and proximity of demand and/or infrastructure. These costs include cost of drilling, well construction, infrastructure, water usage, loans and payments to land owners, but also consequences of (environmental) regulation imposed (EIA, 2013a; IEA, 2012b). Within the EU exploitation cost are estimated to be at least twice as high compared to U.S.: the range for well production is currently $2-9 million in the U.S., while the estimated costs in Europe ranges from $5-20 million (JRC, 2012).

Benefits depend in the first place on the price paid for unconventional gas at the market. At spot *gas* prices of around $10/MBtu shale gas exploitation is unlikely to be profitable in the short term in Europe (Gény, 2010; JRC, 2012, Table 3.20). Estimations for breakeven costs in Germany and Poland are in the range of $8-12 /MBtu although more recent estimations indicate prices of 28 $/MBTu (today), $7/MBTu (within 5 years) and $4/MBTu

[9] This difference can be explained by the inclusion of additional countries such as Russia. For the US the EIA has a 31% lower projection than JRC.

(within 10-15 years). Costs of producing conventional gas in Europe and the U.S. in 2007-2009 was estimated to be around US$ 10 /MBtu and US$ 6 /MBtu respectively.

Break even cost also depend on the *joint production* of ‘byproducts’ from the same wells (Keller, 2012; Ebinger and Avasarala, 2013).[10,11] Byproducts or liquids such as ethane, propane and butane can be sold or refined into oil products. Ethane is almost exclusively used in the petrochemical industry, butane is used as motor gasoline and propane as fuel for space heating. The ‘business case’ for exploiting shale gas clearly also depends on the market value of these ‘byproducts’. Indeed, ethylene, propane and butane are economically attractive in itself to retrieve, because these byproducts can be sold as or refined into oil products or used in the chemical industry to produce plastics in case of ethylene

The importance of these byproducts can be illustrated using recent shale gas market developments in the U.S. With U.S. gas prices around $2-3/MBtu in 2012 and early 2013, unconventional gas was probably produced below economic viable levels. Break even costs in the U.S. without taking the revenue from the byproducts into account is estimated at (at least) $ 4/MBtu (JRC, 2012; EIA, 2013a). Nevertheless production of shale gas still increased in this period. This increase is likely to be explained by the revenue of the liquids from the same wells. However, also other factors played a role such as co-production of gas with oil and conditions in the lease terms which often require drilling within a certain time period, often

[10] Exploitation of shale formations not only produces shale gas, but also unconventional liquids such as tight oil (or shale oil if produced from shale plays). In the same rock formations that are drilled for shale gas, liquids such as ethylene, propane, butane and other hydro-carbon rich condensates (“light tight oil”) may also be present. This is known as “wet gas”, whereas “dry gas” contains much less Natural Gas Liquids (NGL) than conventional, dry natural gas. In most shale basins in the U.S. natural gas contains 4 to 9 times the amount of NGLs found in dry natural gas, although there are some basins in Texas and Colorado/Wyoming where the amount of NGLs is smaller, 2 to 3 times that of dry natural gas. In particular the Ethane content in shale gas and oil is high (Keller, 2012).

[11] The joint production characteristic of unconventional gas exploitation also raises (additional) environmental concerns. If gas prices become ‘too low’ it becomes attractive to simply flare or vent the shale gas or methane in order to reduce unconventional gas output and, accordingly, increase market prices. However, the U.S. federal Environmental Protection Agency (EPA) issued regulations in 2012, also referred to as ‘green completion’, that requires well operators from 2015 to capture instead of vent or flare the methane from the well. Although the captured methane can be reused and sold, and therefore poses a potential opportunity to increase revenues, production costs are well likely to rise.

years (see Krupnick et al., 2013). It has been estimated that, with these low gas prices in the U.S., the liquid content must be around 40% in order to exploit a well without a loss (IEA, 2012a). To what extent the U.S. case would be applicable for the EU is an open question.[12]

Predictions of long run exploitation of global unconventional gas reserves are notoriously difficult. According to the New Policies scenario, the IEA (2013b) expects production by far to be the largest in the U.S.. In this scenario conditions in the U.S. remain most favorable compared to most other countries. The reason is that the U.S. has already a developed petrochemical industry and service sector with experience in other unconventional gas production like tight gas and coalbed methane, has favorable regulations with regard to ownership of mineral resources, and has a deregulated gas market and a culture of private entrepreneurship. In this scenario the IEA expectation of the future production of unconventional gas in the EU is very conservative. Production would grow slowly to around 20 bcm by 2035 (IEA, 2012a). Estimates for countries such as China, Canada and India are more optimistic.

In another study the IEA also has a much more optimistic scenario on the future production of unconventional gas in the EU (IEA, 2012b). In this so called "Golden Rules" scenario, production would rise to around 77 bcm by 2035, which is 47 percent of the total production of natural gas in the EU. Indeed, this is a very optimistic scenario even though it assumes clear environmental and social regulations. Not only is it assumed that the entire unconventional gas reserve in the EU will be fully accessible in this scenario, including countries with current moratoria, but also production costs would be between 5 and 10 U.S.$/MBtu.

[12] According to JRC (2012, Table 3.20) break-even costs *including NGL* would be 40-45% lower at current market conditions. These costs estimates assume production of NGL for the EU *on average* similar to the US.

3.2 Effects of unconventional gas developments on EU fossil fuel markets

How future unconventional gas development will affect EU natural gas prices not only depends on the growth of local exploitation within the EU, but also on the likelihood of its growth outside the EU ánd the possibility that shale gas will become a globally traded good. If gas markets remain local because of the necessity of pipeline connections, price formation will be mainly influenced by local developments, and only indirectly by other fossil fuel and energy markets. However, if gas will become a tradable good, local gas prices are much more likely to be affected by the combined impact of production and transportation cost within a global gas market.

Current prospects for unconventional gas exploitation *within* EU are rather modest in the medium term as has just been discussed. The main impact on EU gas prices in the next decade is more likely to depend on the further development of unconventional gas exploitation in the U.S. in the first place. Despite strong growth in demand for gas within the U.S., recent forecasts still predict the U.S. to become a net gas exporter (EIA, 2013b).

To what extent natural gas will be traded across continents, however, strongly depends on the development of the Liquefied Natural Gas (LNG) market. LNG can much more easily be transported (like oil tankers) and is more likely to compete with the traditional way of gas delivery through pipelines and their associated long term contracts. Global LNG trade has grown rapidly recently indeed (IEA, 2012a) and larger amounts of gas traded across the globe also more likely induce convergence of international gas prices.

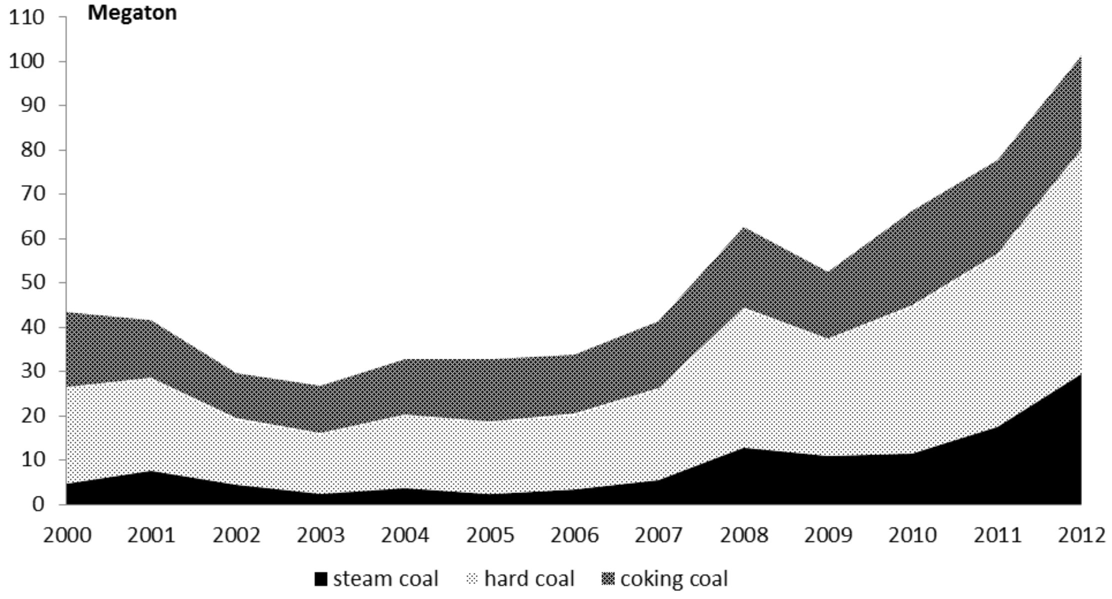
An increase in global LNG importing and exporting capacity will have an impact on EU natural gas prices if LNG exports from the U.S. (or elsewhere) would go to Europe. Whether this will happen – and to what extent – is not evident however. The substantial price differential between Asia and Europe illustrates that most LNG might very well be exported to Asia instead because gas prices are substantially higher. Indeed, LNG export from Qatar to the EU was on the rise for some years, but this has changed since the Fukushima disaster in Japan. Gas demand has increased considerably in Asia and more LNG has been shipped to Asian markets since (BP, 2014).[13] And even if more LNG would be shipped to the EU, this does not necessarily reduce gas prices *within* the EU. This also depends on the likelihood that more gas will be handled on a spot basis. However, investors in LNG terminals may be reluctant to invest in that case because high capital costs are involved.

The extent to which other EU fossil fuel markets will be affected by shale gas exploitation depends on interfuel substitution in the first place. Recent developments within the U.S. illustrate how fast gas demand could rise at the expense of coal. Coal use in the U.S. power sector declined from 53% in 1990 to 43% in 2011 while gas use increased to around 30%. This switch from coal to gas in the U.S. power sector is not only due to the change in the gas to coal price ratio (see also Table 1), but is also supported by more stringent environmental regulations (IEA, 2013b). As a consequence domestic demand for coal in the U.S. is under pressure reducing coal prices (EIA, 2013b; EIA, 2013c).

Interestingly, these developments within the U.S. already have an impact on EU fossil fuel markets. The reduction in demand for coal within the U.S. induced an increase in (cheap) coal imports by the EU. Figure 3 shows that imports from the U.S. already rise rapidly for the most important types of (traded) coal, i.e. hard, cooking and other bituminous coal, since 2007.[14] This trend is likely to continue in the next few years as long as the price differential between different coal prices would remain or even further increase in favor of U.S. coal.

[13] Also recent predictions for the development of a potential LNG export market for the U.S. reflect these market forces (EIA, 2013a).
[14] In some countries, like the Netherlands, imports started to rise only recently, i.e. since 2012.

Figure 3: Coal Imports from the U.S. by OECD-Europe 2000 - 2012



Source: IEA/OECD

The lower U.S. coal price and its impact on EU coal imports clearly is the most direct visible impact from U.S. unconventional gas production on EU fossil fuel markets. Whether this impact will be sustainable depends on future developments of unconventional gas exploitation in the U.S. in the first place. If future U.S. unconventional gas exploitation will become more expensive, the gas for coal substitution in the U.S. might be reversed as well as the coal for gas substitution within the EU. The most recent trends suggest that this is not a far-fetched possibility (EIA, 2013c).

4. Impact of changes on the competitiveness of EU economies

The growing gap between gas prices in the different world regions has raised concerns whether EU economies wouldn't face serious competitiveness disadvantages. These disadvantages would materialize in the long run if a similar unconventional gas boom and associated gas price reduction within Europe is not going to happen. This boom changes relative global energy prices which, in turn, puts a lot of pressure on existing input choices by gas- and energy-intensive firms as well as on their location decisions. However, only sectors will be vulnerable in countries where gas, NGLs and electricity play a relatively large role in either cost or benefits of firms. Moreover, to what extent such a shock will be important for competitiveness also depends on the *exposedness* of industries to international trade with countries or regions *outside the EU.* As far as natural gas or its byproduct is used in *sheltered* sectors, i.e. in sectors that do not compete with U.S. or Asian businesses, no such impact is to be expected.[15]

This section explores how EU economies and, in particular, what sectors would be affected. After a short review of the potential impact channels, we explore which sectors seem to be most vulnerable in the EU for a sustainable gas price gap as well as more indirect channels such as changing electricity prices. Finally, we also discuss competitiveness issues related to the production and trade in NGLs. Our focus is on relative position of the EU in world markets and we do not look at potential impacts at the EU internal market.

4.1 Impact channels of unconventional gas exploitation on competitiveness

Natural resources, like conventional or unconventional gas, are an important factor for international specialization because they provide a strong comparative advantage for countries. Indeed, fossil fuel producing countries often specialize in sectors and technologies that also exploit these fuels. A particular specialization pattern will be challenged, however, if a major shock hits the existing equilibrium. Unconventional gas production is such a shock, even if the shock would remain restricted to the U.S.

The overall impact of the unconventional gas boom in the U.S. on the *competitiveness* of sectors within the EU is not easy to predict and depends on many factors. First, a changing gas price in the U.S is most likely to have an impact on energy-intensive industries that use gas for heating or as feedstock both within the U.S. as for its trading partners. Also interfuel

[15] Of course, even sheltered sectors may suffer or benefit from more indirect incidence effects, but we do leave an analysis of these effects for future work.

switching is most likely to affect sectors with high energy input costs that are also exposed to international competition. Apart from such marginal impacts on trade, changes in the gas price also affect decisions at the extensive margin, i.e. decisions where to expand or locate (new) industries. Those decisions are typically linked to inframarginal cost of (capital) investment which, in turn, may be driven by energy cost consideration for energy-intensive sectors.

A starting point of the analysis is to identify for what purpose natural gas is used in what sector. The most important (downstream) natural gas (methane) applications are:

- use for *heating* by households, service sectors, horticulture, as well as industrial sectors;
- use for *heating* in industrial sectors for the manufacturing and the processing of products under low temperatures;
- use in *power plants* to generate electricity;
- use as a *feedstock* in the *fertilizer industry* for the production of ammonia which serves as the primary ingredient in most nitrogen fertilizers and is an essential ingredient in many phosphate fertilizers;
- use as a *feedstock* in the *petrochemical industry* for the production of methanol, which is a feedstock for plastics, pharmaceuticals, electronic materials and many other products (American Chemistry Council, 2013).

In addition to these natural gas applications also the NGLs, mainly ethane, propane and butane, have important industrial applications (IEA, 2013b, p.275ff):

- use of ethane and propane which are both used by the *petrochemical industry* to produce ethylene and propylene, which are then turned into plastics and a variety of other products;
- use of butane as motor gasoline and propane for other fuel uses such as space heating.

This broad set of applications can be linked to particular sectors and the direct and indirect channels through which a resource boom like the U.S. unconventional gas revolution may have an impact.

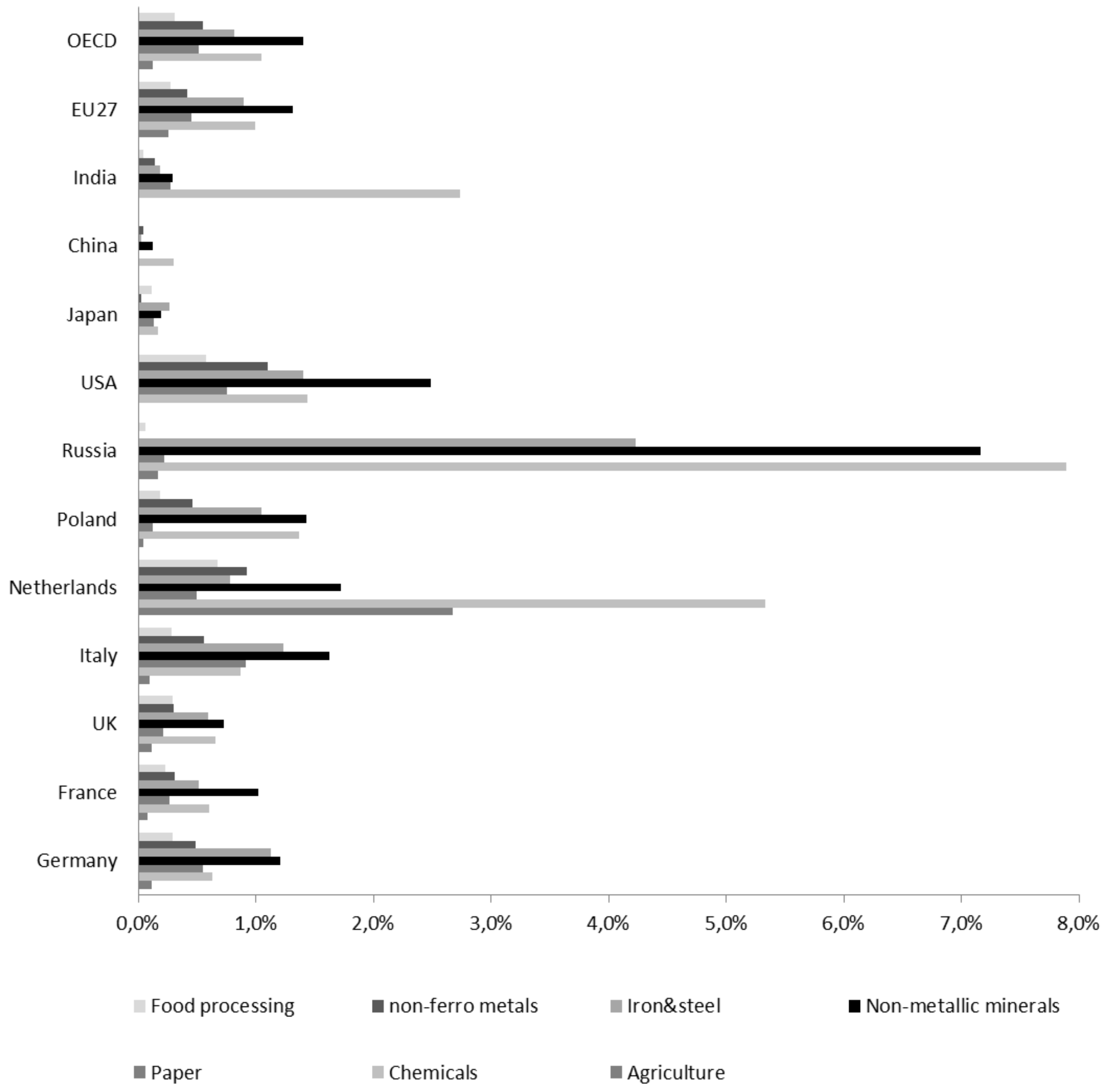
4.2 Gas input shares in different sectors across countries

To what extent the incidence effects are likely to play a role depends on the existing pattern of specialization of industries within and across the EU. In this section we provide an indicative analysis of how a change in the gas price itself is likely to have such an impact using some rough (initial) indicators on natural gas use and its cost share in production. For this purpose we start with a descriptive analysis of the gas input share in different sectors across countries as well as its exposure to international competition using the well-known and internationally standardized GTAP dataset.[16]

Apart from household heating gas is most likely to play a role in industrial and electricity sectors. For an indicative role of natural gas as an input in *major energy-intensive industrial sectors* we use gas input values (volume*price) as a share of the overall value of production (output*price). This indicator shows the economic value of gas in generating a given amount of output value across sectors. Figure 4 presents the share of the value of gas inputs in the production value for different energy-intensive industrial sectors and agriculture in the largest economies around the world.

[16] The GTAP database is a global database with economy-wide coverage combining detailed bilateral trade, transport and protection data characterizing economic linkages among regions, together with individual country input-output data bases which account for inter-sectoral linkages within regions through trade (Narayan et al., 2012). These data are commonly used by existing CGE models, like the WorldScan model and the GEM-E3 model, that assess different policies across countries and world regions. The advantage of using GTAP data is that considerable effort has been put in making the data comparable across countries. The disadvantage is that the most recent trends are not captured by the data set. Currently, the most recent data available are from 2007.

Figure 4: Share of gas in the value of the output for energy-intensive industrial sectors, 2007



Source: GTAP, 2007

The figure shows this share is on average only 1% in the more gas intensive sectors both within the EU and the OECD. Even in sectors in countries that use a lot of natural gas, the share never crosses the 8% level. Indeed, gas input costs are usually a small share of overall input costs because in many sectors labor cost are much more important. However, the gas input shares can be much higher *within* these sectors (e.g. at 2 digit level). For instance, the chemical, rubber and plastic product industry (CRP) includes the highly energy-intensive petrochemical industry, but this level of detail is not provided by the GTAP database.[17]

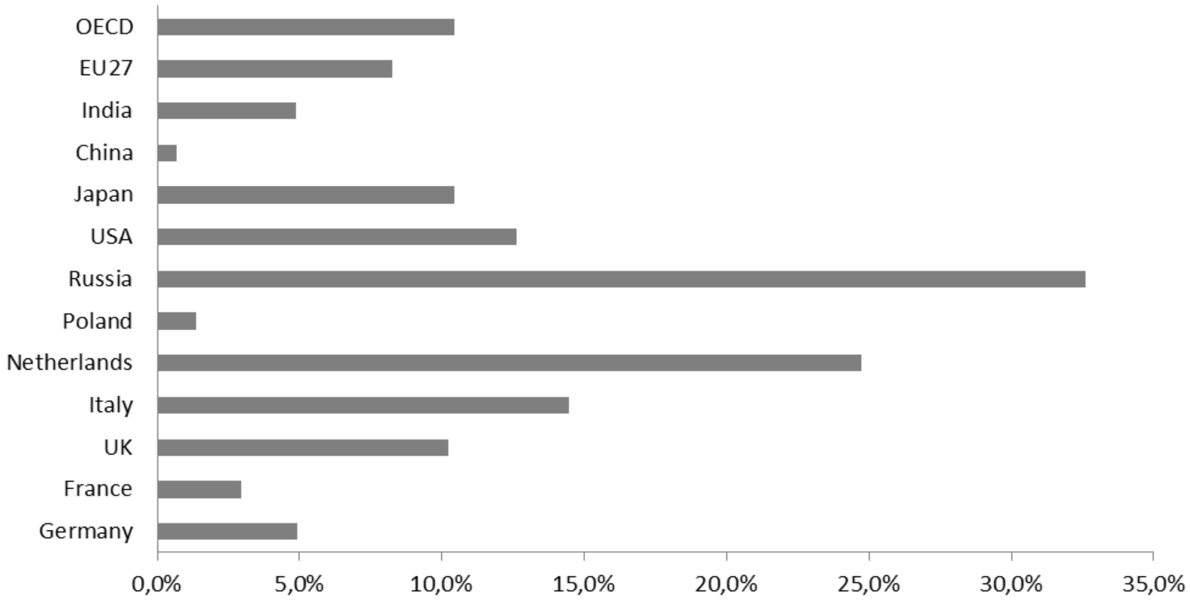
Second, gas use is, on average, largest in the non-metallic minerals sector and chemicals. Gas use is also quite high in the iron and steel industry followed by non-ferro metals and paper industry, but the variety across countries is large within sectors. The same sector may consume considerably different amounts of gas across countries. For instance, the chemicals industry uses a lot more gas in the Netherlands and Russia compared to countries such as France or Italy. Similar differences apply to other sectors.

Exceptional patterns can be observed in some countries as well. Usually agriculture does not consume much gas at all. However, agriculture in the Netherlands uses even more natural gas than in most other sectors in other countries. The reason is the large (greenhouse based) horticulture (sub)sector which uses a lot of natural gas. The Base Metal industry in the U.S. is another example. Indeed, gas shares are often correlated with the amount of gas available within a country. Typical gas producing countries as the Netherlands and the U.S. use a lot more gas on average in all sectors compared to other non-gas producing countries.

Another sector where gas plays a direct role as an input is the electricity sector. Obviously energy input shares simply provide the bulk of the overall input costs in this sector. The gas input share in the overall value of electricity production differs strongly as Figure 5 illustrates. Russia and the Netherlands have very high shares for gas while the shares are very low for China (mainly coal based) and France (mainly nuclear based). Again gas plays the largest role in countries that produce gas themselves, like Russia and the Netherlands. Note that the data are from 2007 and do not capture recent changes in the mix.

[17] This may also explain why applied CGE models using GTAP are not likely to find large impacts on sectoral composition nor on the overall economy and why recent macro-economic analysis did not find much substantial overall economic effects on the EU economy as a whole (ICF, 2014)

Figure 5: Share of Gas Input Value in Total Value of Electricity Production, 2007



Source: GTAP, 2007

We conclude that the importance of gas use differs considerably across sectors and countries. Furthermore, the general pattern is that sectors using more gas can be mainly found in gas producing countries. However, industries at the *subsectoral level* might still suffer considerably, in particular if their gas use is large, which is often the case for applications as feedstock or if NGLs matter. Finally, even though the electricity sector is not exposed to international trade across the globe, exposed sectors consuming large amounts of electricity might still be affected indirectly.

4.3 Gas-intensive sectors and their exposure to international trade

The second step in identifying whether and how the unconventional gas shock will have an impact on international competitiveness in the EU is by exploring to what extent particular (gas) intensive activities are also *exposed* to international competition from outside the EU. We define the exposedness of a sector as the share of export in the total value of production in each sector. Figure 6 illustrates the diversity in export shares across the different sectors in different countries. The export intensity differs considerably across gas-intensive sectors as well as across EU member states and other countries. The most energy-intensive sectors in the small open economy of the Netherlands are all much more exposed than comparable sectors in other countries.[18] Also exposedness of most EU Member States is– on average – much higher than other countries in the world.

It should be noted, however, that these trade data also include *intra*-EU exports. Accordingly, the vulnerability of sectors for an *international* gas shock is likely to be overestimated because intra-EU exports tend to be much larger than exports (and imports) to other non-EU countries.[19] If intra-trade is excluded, the exposedness across countries is much less diverge (cf. Figure 6).

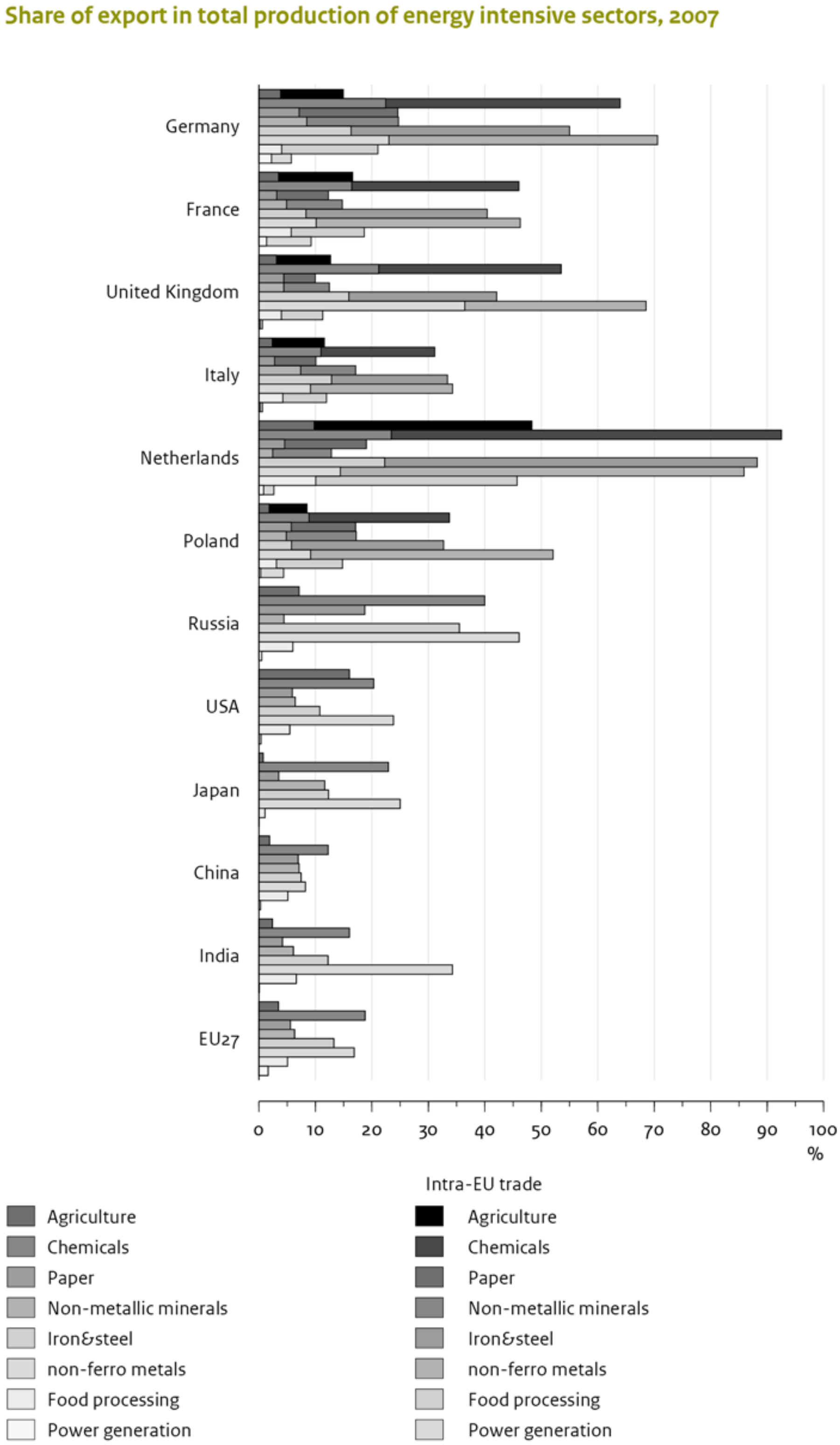
Furthermore, differences between *sectors* are large as well. The electricity industry itself was clearly non-exposed in 2007 even with intra-EU trade included.[20] Only France (9%) and Germany (6%) were exporting some electricity. However, the chemical sector as well as the iron & steel and the non-ferro metal industry belong to the most exposed industries in all countries. Export intensity of other energy-intensive industrial sectors, like the food processing, beverages and tobacco industry as well as the paper and non-metallic mineral industry is much smaller. Again this picture does not change if intra-EU trade is excluded.

[18] Interestingly the exposedness of several basic material sectors in China is not large compared to other countries.

[19] This, again, illustrates that the GTAP data only provide a rough first approximation for the relevance of unconventional gas shock in the U.S. to EU exposed sectors.

[20] Intra EU trade in electricity is still limited though growing as trade in electricity across borders is growing within the EU (e.g. Fell et al., 2014). Depending on their electricity portfolio mix, some countries are therefore more vulnerable than others to a gas shock.

Figure 6



Combining the exposedness of sectors with their gas use intensity, we conclude that the direct impact of an unconventional gas price shock is most likely to hit the quite heavily exposed chemical industry, the non-ferro metal industry as well as iron & metal across the whole EU. Although the non-metallic mineral products sector also uses quite some gas on average, this sector is much less exposed.

4.4 Indirect channels

Previous sections have illustrated that indirect price effects already are having an impact. In particular, lower input cost reduce electricity prices which, in turn, affect downstream sectors using electricity as an input. Falling gas prices cause electricity costs in the U.S. to fall which improves the competitiveness position of electricity-intensive industries in this region if other regions do not face similar cost reductions such as the EU.

Interestingly, interfuel switching with gas substituting for coal within the U.S. has a dampening indirect impact in the EU. With falling coal prices, export of U.S. coal to the EU increased which, in turn, created a downward pressure on electricity prices within the EU. Indeed, the smaller gas/coal differential in the EU has already had a significant impact on the functioning of the EU electricity markets in recent years. Because coal has become relatively cheap compared to natural gas, electricity producers across Europe are increasingly switching from gas to coal (see also IEA, 2013a). The switch from gas to coal combustion in electricity power plants softened the rise in the relative disadvantage that occurred because of the U.S. shale gas boom.

Another indirect impact runs through the CO_2-price in the ETS market. This impact works through different channels in the complex energy system. In particular in the electricity market fossil fuel inputs, electricity and carbon prices are strongly related (see Fell et al., 2014). The smaller gas/coal differential also has an upward impact on the EU ETS price because CO_2-emissions for a coal fired power plant are roughly 2 times higher than for a natural gas fired plant. From empirical studies we know that a stronger demand for coal has such an upward impact, whereas a fall in gas demand reduces it. Even though carbon prices are more or less completely passed through in electricity prices this upward effect is unlikely to be very important, however. The current EU ETS carbon price is very low due to the large overhang of permits in the market.

4.5 Competitiveness impacts on subsectors in the EU

Even if competitiveness concerns may appear somewhat exaggerated because gas input costs are limited and the impact of lower gas prices is dampened through indirect channels, some subsectors may still be severely affected. The choice of particular energy-intensive industries to locate and produce in a specific country or region as well as their choice to use gas, oil or other inputs is usually also closely linked to the access industries have to fossil fuel and electricity markets. Existing specialization (or location) of industries reflects those comparative differences. If, however, the fundamentals in these comparative differences change due to an energy (price) shock, industries may reconsider their (long run) strategy. Such impacts at the subsectoral level are unlikely to be identified by the GTAP database.

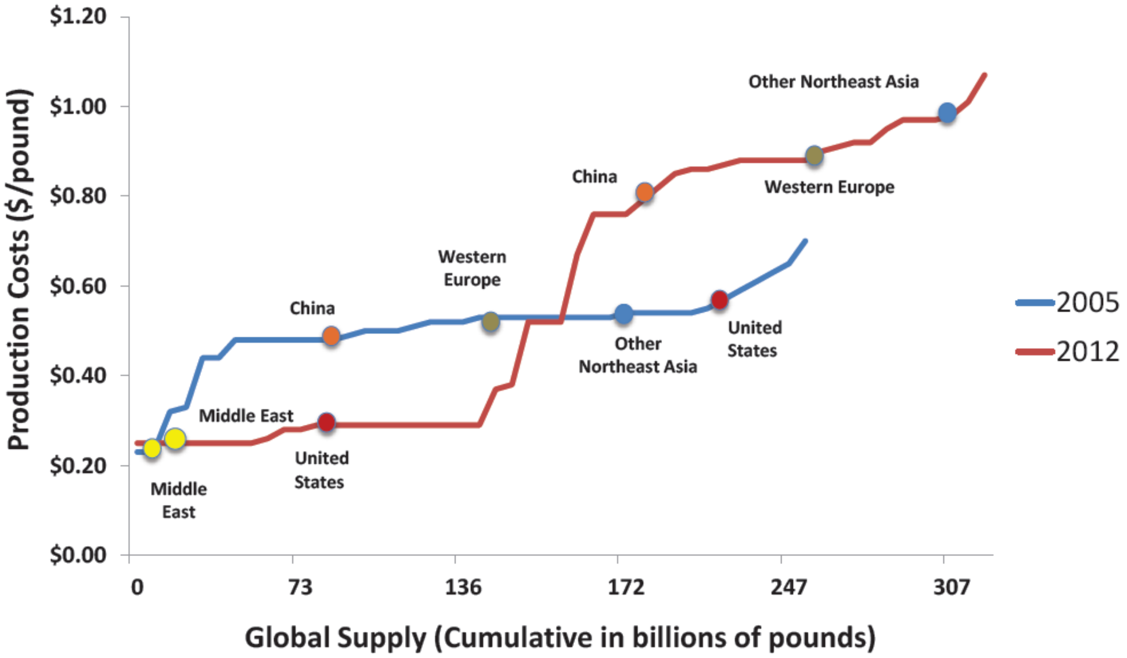
The most serious competitiveness issues of the unconventional gas revolution are related to the use of gas (methane) and its NGL byproducts (ethane, butane and propane) as feedstocks. One example is switching in feedstock from naphtha, derived from oil, to ethane, derived from gas in the U.S.. Almost all ethane and around one third of all propane is used by the petrochemical industry to produce ethylene and propylene. These compounds are then turned into plastics and a variety of other products. Worldwide only 15% of the market for NGL consists of ethane and about two thirds is butane and propane (Keller, 2012; Ebinger and Avasarala, 2013). The share of ethane at U.S.-market, however, is almost twice as high. Over 97% of ethane originates from gas processing and fractionation. For the other NGLs on the U.S.-market this figure is three-quarters while only 20% originates from crude oil refining, while the rest is imported.

This very different pattern in the U.S. market can be well explained by the U.S. unconventional gas revolution. The costs of producing ethylene from natural gas in the U.S. is now about a quarter of its historical costs. Ethylene can only be produced at lower costs in the Middle East now (PWC, 2012; American Chemistry Council, 2013). Figure 7 illustrates the dramatic change between 2005 and 2012. The position of the U.S. on the cost curve for ethylene has shifted from being one of the most expensive producers in 2005 to one of the cheapest in 2012. Indeed, the U.S. overtook China, Western Europe and Other Northeast Asian countries in this short relatively period.

This shift in the U.S. petrochemical sector has huge impacts on the same sector in the EU which is dependent upon oil-based naphtha to supply ethylene (Deloitte, 2013). Petrochemicals became cheaper in the U.S. even when oil prices peaked. Indeed, NGLs-based chemicals provide cheaper raw materials for than naphtha-based chemicals, and may also be exported to compete with the world's lowest-cost producers such as the state-owned petrochemicals firms in the Middle East. As a consequence the EU petrochemical industry already faces strong competitiveness challenges and this is likely to remain so in the near future. This challenge will also have impact on their location strategy. Naphtha crackers cannot be readily converted into ethane crackers, and a key prerequisite is a competent source of ethane, either through import, local production or both. For example, firms like Dow Chemical have announced numerous new investments in the U.S. to take advantage of low gas prices (PWC, 2012). Indeed, the U.S. might export fewer cheap raw materials to countries with low labour costs to be made into goods to export back to America, but could now process the raw materials by itself, shortening the supply chain and returning manufacturing jobs to the U.S. in industries where petrochemicals are a large part of the cost base.[21]

[21] PWC (2011) estimates that lower feedstock and energy costs could result in 1m more American factory jobs by 2025.

Figure 7 Change in the global cost curve for ethylene



Source: ACC, 2013, p.21

Apart from ethane, however, also other industrial sectors take advantage of unconventional gas exploitation. The American Chemistry Council calculated the effects of an increase of unconventional gas production with 25% on the production of eight energy-intensive manufacturing industries using the Input-Output model IMPLAN (American Chemistry Council, 2012; Krupnick et al., 2013). They report that approximately 85% of the output gains comes from the Chemicals and Plastics and Rubber Industry, where the direct output gains increased with 14,5% and 17,9%, respectively. The gains in other sectors follow mainly from lower energy prices, with the strongest increase in output in the Aluminum sector (7,6%) and Iron and Steel sector (4,4%).

Another chemical industry that benefits from conventional gas production is the *fertilizer industry*. This industry uses the gas (methane) itself for the production of ammonia, which serves as the primary ingredient in most nitrogen fertilizers and is an essential ingredient in many phosphate fertilizers. For nitrogen fertilizers, the cost of ammonia is about 70 to 90% of the total costs. During the 2000s, production capacity of ammonia in the U.S.

shrank by 40%, but large scale, low cost shale gas resources have reversed the trend and brought significant cost savings to the production of ammonia.

Table 3 Indication of significance of industry for economy by subsector and region, 2011

	Energy use	Value added		Net trade
	share of industry total (%)	Share of GDP (%)	Share of industry total (%)	As % of value added
Chemicals				
U.S.	36,3	2,3	11,2	14
Japan	33,2	2,5	9,3	15
EU	*32,0*	*0,5*	*2,1*	*155*
China	19,6	2,4	5,2	-7
World	27,8	2,2	7,2	-4
Refining				
U.S.	15,1	0,5	2,6	-55
Japan	6,2	0,2	0,9	-142
EU	*11,1*	*0,1*	*0,6*	*-1247*
China	3,1	0,1	0,3	n.a.
World	7,5	0,2	0,5	n.a.
Aluminium				
U.S.	2	0,1	0,3	-49
Japan	0,2	0,1	0,3	-146
EU	*2,3*	*0,1*	*0,2*	*-611*
China	3,9	n.a.	n.a.	n.a.
World	2,7	0	0,4	23
Iron and steel				
U.S.	6,5	0,6	3,1	-13
Japan	27,5	0,9	3,3	80
EU	*13,9*	*0,2*	*0,6*	*46*
China	35,9	1,3	2,9	3
World	20	0,7	2,2	-1

Note: Data for energy use are for 2011, while data for value added, net trade and employment are for 2010 due to data availability constraints. U.S. = United States. EU = European Union
Source: IEA (2013b), p. 277

Finally, methane is also used in the petrochemical industry as a feedstock, in particular for the production of methanol. Methanol is a primary petrochemical and also a feedstock for plastics, pharmaceuticals, electronic materials and many other products. The American Chemistry Council expects a revival in the methanol production in the United States. Methanex Corp. the world’s biggest methanol producer, announced to dismantle a methanol plant in Chile and rebuild it in Louisiana in the U.S. (Krupnick, Wang and Wang, 2013).

Despite these sometimes serious impacts at the industry level, the impact on the overall economy is unlikely to be as dramatic. Recently the IEA presented some useful indicators to put these subsectoral impacts in perspective (IEA, 2013b, p.277). Table 3 presents for some of these subsectors indicators that illustrate the relevance of several of these industries, like chemicals and refining industry, in different world regions. For comparison also two other energy-intensive sectors are included.

5. Conclusion

This article has shown past, current and potential changes in some global fossil fuel markets in relation to unconventional gas exploitation with a particular focus on consequences for EU competitiveness. Much of the impact is already 'priced' into the market. We have shown a clear and dramatic disparity between gas prices in the U.S., the EU and Asia in recent years. Further reduction of the U.S. gas price is unlikely because costs of extracting unconventional gas stabilize or even increase in the next few years. Some arbitrage between the highest, Asia, and lowest, U.S., gas markets may be expected, in particular if U.S. LNG exports would take off. In that case Asia will benefit more than the EU although the current imbalance has an advantage for the EU.

We have also found little evidence for a prosperous unconventional gas development in Europe, not in the short but also not in the longer run. Exploration is still underway and exploitation is relatively expensive compared to North American shales. Uncertainties of existing estimations are large, however. Accordingly we do not expect EU gas prices to fall due to a rise in European unconventional gas production. These relatively bleak prospects for lower gas and, in turn, electricity prices due to unconventional gas exploitation in Europe suggest that the EU firms and consumers have to cope with the U.S. unconventional gas price shock. Unconventional gas remains relatively cheap in the U.S. which changes relative energy prices both at home and abroad. This, in turn, puts a lot of pressure on existing input choices by firms as well as on their location decisions.

Indeed, the gas boom has an impact both through direct and more indirect channels. The current direct impact is most visible within the electricity sector in the U.S., where gas has become so cheap that it even outcompetes its traditional substitute in the power sector, which is coal. Moreover, cost pass through of lower input prices also benefits U.S. companies consuming a lot of electricity because these prices in the U.S. will remain (much) lower relative to European prices. Similar shocks to the comparative advantage for firms using gas as a feedstock are underway.

Another direct, but less known effect is related to the joint production characteristic of unconventional gas production. Unconventional gas production fields not only produce gas but also NGLs such as ethylene, propane and butane. Production of these so called 'byproducts' is economically even more attractive because they can be sold as or refined into oil products or used in the chemical industry to produce plastics in case of ethylene. These impacts may even be more important in the long run because the technical lifetime of petrochemical installations is quite long and adaptation costly and time consuming.

Indirect impacts soften these direct impacts, however. One channel is the indirect impact of the unconventional gas boom on (relative) U.S. coal export prices which, in turn, has induced much more shipment towards the EU. Coal import from the U.S. happens on a much wider scale than ever before. Coal consumption in the electricity industry across the EU is already rising, which, in turn, reduces electricity prices. Another indirect impact is shipping of LNG to the Asian market as already discussed. Moreover, larger exports would also be beneficial for the EU, in particular when traded at spot markets, because this also helps renegotiating long term contracts with Russia.

Current competitiveness concerns within the EU have strongly increased and up to some point with reason. The unconventional gas boom is lasting and seems to affect existing specialization patterns across sectors. However, only sectors in countries will be vulnerable if natural gas, NGLs or their fossil fuel substitutes play a relatively large role in the cost or benefits of firms. Note that these concerns are not restricted to gas use and their byproducts because also indirect impacts matter, such as changing electricity prices, in particular if input (cost) shares are large. To what extent the shock will be important for competitiveness depends also on the extent to which firms that use gas, its byproducts or electricity are exposed to international trade with countries or regions outside the EU. Currently most trade within the EU is also *intra*-EU trade even in the energy-intensive sectors. Therefore it is likely that the impact on the overall economy will be modest. The most seriously affected industries are only a small part of the overall economy with relatively low employment levels.

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