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Thinking ahead for Europe

The 'Unknown Knowns' of the Global Gas Market

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Abstract. *Energy markets evolve at least as quickly as the economies they fuel. But development unfolds at an irregular pace, with starts and stops often precipitated by seemingly unpredictable dynamics. Is it really impossible to forecast these 'revolutions', if the past can be seen as prologue? The answer might be in the way we look at future events; even if we accept that some events are unpredictable, we may be able to infer much more about the future trends through a broader reading of available data, thus revealing 'unknown knowns' that may be useful in understanding paradigm shifts ahead. This paper presents an analysis of the global gas market, offering views on what the most relevant 'unknown knowns' of today look like, and hypotheses about some of the possible game-changing events that the market is likely to face in the short to medium term.*

Ten years ago the ban on crude oil exports from the United States, which had been in place since 1975, was still an agreeable security proposition to uphold: perhaps the country no longer felt threatened by a foreign supply shock like the one of 1973, but its status as a significant net importer allowed it to absorb all the domestic product without the risk of triggering a downward price spiral that would have killed domestic investment. Within a decade, the tide has turned: domestic supply is hugely on the rise, and the government is realising that the price tag of an export ban may no longer be justifiable on the same security grounds.[1] This story reveals how quickly the face of the energy industry can change in the wake of events.

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[1] Blake Clayton (2013), *The Case for Allowing U.S. Crude Oil Exports*, Policy Innovation Memorandum No. 34, Council on Foreign Relations, July (http://www.cfr.org/oil/case-allowing-us-crude-oil-exports/p31005).

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Constant change in energy markets is no big news: the dynamism of the energy sector is simply the mirror of the fast-evolving trends of today's industrial economies, as well as of the aspiration of not yet fully industrial economies to complete the transition themselves. This industrialisation pattern, with first-comers reaping positional benefits and second-comers poised to close the gap,[2] also explains the dominance of hydrocarbons as the energy source of choice: industrial economies, at least as we know them, require centralised production [3] and the most flexible possible transportation of raw materials and manufactured goods in order to remove trade barriers. Coal and oil are relatively cheap, storable, and easy to move around; and in regions where appropriate infrastructure has been developed, the same applies to gas. One may debate which is the cause and which the effect, but it is a fact that the industrial revolution was first possible in the UK thanks to a coal-intensive application; the steam engine. The inextricable link between the industrial economy and hydrocarbons has changed little over centuries, given today's debate over the need for industrialising regions to be left free to power their growth with cheap energy, which still means coal. History is full of such relations, and it is often said that what is past is prologue. Why then is it so difficult to predict future trends in this field?

The answer might have to do with the conceptual framework we usually deploy when looking ahead. Former US Secretary of Defense, Donald Rumsfeld, famously warned the policy community against neglecting "unknown unknowns". There are things we know we know, he explained, and things we know we don't know; these are controllable, as we know at least something about them. It is the things we don't even know the existence of, the "unknown unknowns" that we cannot control and that will catch us by surprise when we least expect it.[4] All-encompassing as it may have appeared, one slice of that categorisation was missing: is it not logical to assume that there may also be things that we don't know we know? Slavoj Žižek raised the question, only to come to the conclusion that "unknown knowns" are basically the unconscious that underpins a society or a policy.[5] This is a good observation, although it is not comprehensive, in that unknown knowns may also emerge as a result of information that we are perfectly conscious of, but that we have not connected in a causal way.

This rather philosophical point has, in fact, profound practical implications. Industrial development takes place via incentives and disincentives determined by the advantages and drawbacks of different paths – just as the already described match between hydrocarbons

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[2] Alexander Gerschenkron (1962), *Economic backwardness in historical perspective, a book of essays*, Cambridge, Massachusetts: Belknap Press of Harvard University Press.

[3] Alfred Marshall's *Industry and Trade* (1919) provides a compelling and still very relevant explanation of how the optimal size of the business unit, especially in heavy industry, is influenced by a multitude of factors, most of them ultimately revolving around economies of scale. On energy input, Marshall observes that "[…] the individual masses to be handled have mostly become so bulky that every operation must be performed by mechanical force: and thus a new economy arises from increase of size."

[4] "There are known knowns; there are things we know that we know. There are known unknowns; that is to say, there are things that we now know we don't know. But there are also unknown unknowns – there are things we do not know we don't know." US Secretary of Defense, Donald Rumsfeld, at a press conference in Washington, D.C. on 12 February 2002, addressing the absence of evidence for the development of weapons of mass destruction by the Iraqi regime.

[5] "[...] the Abu Ghraib scandal shows that the main dangers lie in the 'unknown knowns' – the disavowed beliefs, suppositions and obscene practices we pretend not to know about, even though they form the background of our public values." Slavoj Žižek (2004), "What Rumsfeld Doesn't Know that He Knows about Abu Ghraib", *In These Times*, 17 September.

and centralised production. These connections are known in advance; yet, they are not always used to determine the likelihood of scenarios. This paper tries to outline the current unknown knowns of a specific industrial sector that is of particular prominence in many of today's outstanding debates on the future of energy sources: the global gas market.

What we know about the unknown

Every attempt at predicting markets is exposed to the unpredictable nature of certain game-changing events, which determine discrete shifts in its fundamentals: these are commonly dubbed 'revolutions'. Frequent though they are, they remain difficult to predict – despite often appearing almost obvious in hindsight. They can be caused by two different categories of events.

Unknown knowns

Should it not have been clear to any reasonable observer that unpegging the dollar from gold would raise questions about the actual value of the currency and this, combined with tensions in the Middle East, would ultimately lead to what is now known as the 1973 oil shock? And yet, everyone was caught by surprise. The occurrence of this type of event is not obvious, because most actors and observers suffer from a strong path dependency, which makes it difficult for them to imagine scenarios too different from what the common discourse considers possible. But before their occurrence they were 'unknown knowns', in that the elements – that would have enabled their prediction – were already available in the public domain. Trying to join the dots in a more creative way is an exercise that should be done much more extensively. For example, the price of gold has dropped by 30% over the last two years, seemingly breaking a long-term correlation with the oil price. Was that causation? In which direction? Why was it broken and what would it take to restore it? Attempting to answer these questions leads towards a deeper understanding of the interactions among currently available information; it might lead to revealing an unknown known.

Normal accidents

Another, more sudden cause of discrete changes are technological breakthroughs. To reinterpret a concept proposed by Charles Perrow, these events are similar to "normal accidents", in other words, events that are likely to occur despite the impossibility of predicting them.[6] Contrary to popular belief, the production of shale gas in the US has been going on for decades; the reason why it grew by 71% year on year in 2008 was that in previous years new exploration technologies allowed geologists to find out that the reserve figures for the largest shale 'plays' (regions) in the country had been grossly underestimated – in other words there was ten-times more gas under the continent than had previously been thought. This has changed the gas market in North America, and possibly globally, forever, with wide implications for world politics.[7]

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[6] Perrow created the concept of "normal accident" in order to explain why the likelihood of a nuclear accident is higher than expected, but the same notion can be applied to the likelihood of predicting a technological breakthrough. Charles Perrow (1999), *Normal Accidents: Living with High Risk Technologies*, Princeton University Press.

[7] Edward L. Morse (2014), "Welcome to the Revolution", *Foreign Affairs*, May/June.

Breakthroughs can stem from disasters too: the nuclear incident at the Fukushima plant in early 2011 matched Perrow's definition of a "normal accident" – including the actual likelihood of it happening, roughly, within the predicted time framework.[8] It had immediate and important effects on energy markets globally: despite it being neither the first nor the most devastating among this type of incidents, it came at a very unexpected time and location, and the surprise effect spurred enough fear to lead several countries to reconsider their own nuclear programs. Evidently there had been some degree of overconfidence in the safety of nuclear power technology, suddenly public opinion woke up to that reality and the course of history changed direction.[9]

Revolutions

Unknown knowns and normal accidents may give rise to so-called 'revolutions'. Normal accidents escape prediction, nor may one use an unknown known to tell for sure how and when it will trigger a revolution. Even so, once a revolution has started, events do not necessarily unfold in unpredictable ways. Most often their development is itself an unknown known. For instance, one can be moderately confident that, sooner or later, someone will find out how to store large volumes of electricity cheaply and in an environmentally sustainable way. At that stage, there will be important consequences for the role of hydrocarbons, as storage will presumably become the backup source of choice, and this will reduce the need for gas-fired power plants used during peak demand, capacity payments and so forth. One would think that the big players have clear strategies in place in order to defend their market positions when this revolution takes place. Odds are they don't.

Currently available information provides at least some general indication as to where an industry will be heading as technology, relative prosperity and the aspirations of societies evolve. In the case of the global gas market, the trends emerging from the present junction allow us to identify some evident future developments. Their components are well known, but the industry is somewhat hesitant in drawing the logical conclusions from them: they are, in other words, unknown knowns. A few of these are presented below.

The weight of natural gas in the electricity mix will grow

Quite unlike 2014, the year 2013 began with a record long and harsh winter in Europe. By mid-March, many EU countries were running out of gas in storage, and the spot price at the hubs reflected this reality. LNG cargoes from time to time became the marginal source of supply and that gave rise to a sort of game of musical chairs, sending prices even higher. Many wholesale players found themselves in trouble, and there have been several instances of utility companies raising consumer tariffs in order to offset the increased financial distress. The policy lesson of this event is that natural gas has been treated as belonging to the dirty side of the energy mix, due to its carbon impact; but without the possibility to have an entirely renewable mix, it remains a major baseload source, as well as a necessary complement to intermittent generation thanks to its flexibility, and it is still rather cleaner

[8] "[…] the probability of a nuclear plant meltdown with dispersion of radioactive materials to the atmosphere is not one chance in a million a year, but more like one chance in the next decade." Perrow (1999), op. cit.

[9] The history of finance is full of such events and refers to them as "black swans", which can be seen as a parallel to Perrow's "normal accidents".

than coal. In a cold winter, given that its environmental ambitions rule out coal, Western economies cannot do without natural gas at present.

Accordingly, price incentives and policy converged in sending signals for the gas industry to expand. Several OECD countries have responded with a substantial coal to gas switch – the US and Japan in particular, each for different reasons – while Europe has been somewhat trapped between a market dominated by long-term contracts, fragmented hubs and transportation systems, and a policy discourse that has struggled to re-admit natural gas into the debate as a legitimate component of the energy mix. Some countries like the UK, Germany and Italy have been quicker than others to realise the need for flexible, gas-fired generation and they have considered capacity mechanisms to foster the construction of capacity..

But Asia is responding much quicker, with gas consumption in East Asia increasing at a faster pace than in Europe and North America.[10] Over time, this trend will also need to be multiplied by the fact that many Asian economies are growing at an annual pace closer to 10% than to the 0-2%, which is the norm across the OECD area. This sustained demand, combined with Japan's need for gas to cover the nuclear gap, provides the explanation to the skyrocketing LNG prices of East Asia.

North America will soon become a net LNG exporter

With such a focus on the least GHG emitting and polluting hydrocarbon, natural gas,[11] and its more easily movable liquid counterpart, crude oil and its derivatives, the shale revolution came as a boon for the US and to an extent also for Canada. Within a decade, the US has become self-sufficient in natural gas,[12] and oil might be next to follow.[13] Besides stranding some LNG,[14] the shale gas revolution also made North America gas abundant, and the depressed regional price at Henry Hub creates a strong rationale for LNG exports,[15] which are going to be the next logical step.

The very high Asian gas price offers the demand pull, and the abundance of shale gas within the US market will soon provide a supply push through LNG exports. A significant number of domestic and international companies have been looking into the creation of export

[10] Warner ten Kate, Lászlo Varró and Anne-Sophie Corbeau (2013), *Developing a Natural Gas Trading Hub in Asia: Obstacles and Opportunities*, Partner Country Series, International Energy Agency.

[11] Natural gas is composed of around 90% methane, the simplest hydrocarbon and the one which, therefore, has the highest calorific value: this translates into the lowest CO_2 emissions per unit. Natural gas is also the least polluting hydrocarbon in terms of emissions of NOx, SOx and particulates.

[12] The net imports figure is expected "to decline to 3.3 Bcf/d in 2014 and to 2.6 Bcf/d in 2015", most of which are regional imports from Canada, given that LNG imports are expected to remain at minimal levels of 0.17 Bcf/d in both 2014 and 2015. EIA, Short-Term Energy Outlook, 12 August 2014, section on "Natural Gas".

[13] Net imports of oil into the US are in sharp decline since a 2005 peak of 12.5 million bbl/d, and the year-on-year decline has sharpened since 2010, by about 1 million bbl/d each year. EIA (2013), op. cit., section on "Petroleum & Other Liquids".

[14] Julian Critchlow and Sharad Apte (2013) (Bain & Company), *How Shale Tilts the Scale*.

[15] Charles Ebinger, Kevin Massy and Govinda Avasarala (2012), "Evaluating the Prospects for Increased Exports of Liquefied Natural Gas from the United States: An Interim Report", The Brookings Energy Security Initiative, The Brookings Institution, Washington, D.C.

capacity, with the first project potentially becoming operational by 2015.[16] By the late 2020s, an important share of the growing North American domestic production could become available as LNG, with official estimates suggesting a figure of 45 bcm/yr by 2027, possibly to be reached much earlier in the decade.[17] What has perhaps been underestimated is the momentum this process is going to create: US producers are currently experiencing financial difficulties, due to the very depressed domestic price environment, with many smaller independents deciding to shut in their production instead of fully exploiting the acreage.[18] With LNG exports acting as a pressure valve in the system, the Henry Hub price would go up again beyond the current break-even level, hence fostering more production, which in turn will make an even stronger case for further LNG capacity. This virtuous circle will only reach equilibrium once the LNG market is saturated. To discuss the saturation point of the LNG market is tantamount to discussing the demand growth potential of the Asian region, which at the moment is represented by a spot price twice as high as those prevailing at the European hubs, and one order of magnitude higher than Henry Hub. It will take a long time for LNG supply to match the demand growth rate, and until then, the Asian demand pool will absorb any additional supply, including the volumes originated in North America. There will be an interplay with new volumes from non-Gulf of Mexico production (Canada, Australia, Qatar) but this will only affect the pace of price adaptation, not the overall dynamics.

The less obvious part of the North American LNG story is how developers would find the 20-year justification they would need in order to build export facilities, in a market not liquid enough to guarantee price stability for long horizons. Nonetheless, a number of projects have been tabled, including some using cutting-edge technology such as floating LNG, whereby a terminal would be re-deployable for use elsewhere should Henry Hub prices rise too much. For these developers, the perceived obstacle seems to be more on the political than on the commercial side.

But it is unlikely that North America will stop the prospects of LNG exports in the short to medium term, for three orders of reasons. First, two terminals in the US have so far been approved by the US regulator with one of them, Sabine Pass, already under construction;[19] and Canada approved 11 export licences to date, although no LNG terminal is under construction yet, with site approvals still pending.[20] The two countries will not find

[16] This is the Sabine Pass liquefaction plant in Louisiana, owned by Cheniere Energy.

[17] It is useful to quote the evolution of the official EIA position on this topic. Annual Energy Outlook 2011: "Although US LNG export projects have been proposed, their economic viability remains uncertain in view of the relatively inexpensive sources of natural gas supply available elsewhere in the world. As a result, existing liquefaction capacity in Alaska is the only source for US exports of LNG that is considered in the *AEO2011* Reference case". Annual Energy Outlook (2013), "US exports of LNG from domestic sources rise to approximately 1.6 trillion cubic feet in 2027".

[18] Nafeez Mosaddeq Ahmed (2013), "The Great Oil Swindle", *Le Monde Diplomatique*, March (http://mondediplo.com/2013/03/09gaz).

[19] Updated list of approved LNG import/export terminals is available at the US Federal Energy Research Commission (http://ferc.gov/industries/gas/indus-act/lng/lng-approved.pdf). A list of proposed facilities is also available, featuring a number of potential export terminals to be built by the end of this decade (http://ferc.gov/industries/gas/indus-act/lng/lng-proposed-potential.pdf).

[20] Updated list of approved LNG export licences at Canada's National Energy Board (http://www.neb-one.gc.ca/clf-nsi/rthnb/pplctnsbfrthnb/lngxprtlcncpplctns/lngxprtlcncpplctns-eng.html).

themselves competing in a Cournot duopoly:[21] as far as export capacity is concerned, the US and Canada volumes taken together will be significant but still represent a minority in a global LNG market poised to grow. Even with additional competition from planned LNG projects in Australia and North Africa, the increased global supply is likely to just about match the strong Asian demand growth, rather than outpace it. A second case for LNG exports is that gas from remote locations such as Alaska and British Columbia would not have a cheap means of reaching the US demand centres, with LNG proving a commercially viable option instead. It is therefore expected that no significant policy restrictions will be put in place, and the decision will be left to market forces, with the consequence that the short-term production and export of natural resources will be maximised. Exports of LNG from North America are therefore poised to make a significant entry into the global gas market before the end of this decade.

Shale gas will not remain an American exception

The North American shale gas revolution took place thanks to technological improvement;[22] shale reservoirs of similar size and quality exist elsewhere on the planet. It would be naive to think of an American exceptionalism in the ability to apply the exploration methods that have made it possible to locate shale gas reserves, as well as in the willingness to exploit such reserves once they are found. Three regions ought to be mentioned here for potential medium-term developments: China/India, Latin America, and Europe. The production of shale gas in these regions is not so much a matter of political choice as a matter of time.

That said, it will not be plain sailing: for a start, it will be much easier for the planned Chinese economy to fully exploit unconventional resources, than for the democratic, politically fragmented and environmentally aware Europe, or for shale gas-rich Latin American countries such as Brazil and Argentina, whose access to demand is less obvious. On a political level, China is much less worried about the drawbacks of unconventional production for the simple reason that in much of the country, population density is much lower, thus improving the possibility that unconventional discoveries be located in remote areas where the risk of water contamination would not imply threats to humans. The country's attitude to environmental issues is also yet to be proven. India's population is more evenly spread, nonetheless the country is undertaking significant shale gas exploration. Moreover, there is currently much less natural gas in the electricity mix in China and India than there is in Europe, Brazil or Argentina.[23] This implies that an increase in gas generation would bring about much more dramatic environmental improvements in the coal-dominated Chinese and Indian mixes than in Europe.

For its part, Europe cannot be treated as a uniform block. Despite the efforts of the European Commission and European Parliament to legislate on unconventional exploration, the issue

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[21] A Cournot duopoly is a type of market dominated by two actors, each making simultaneous and therefore independent decisions on the amount of output they will produce. It differs from the alternative to compete on pricing (the Bertrand duopoly). Duopolies tend to the Cournot model if output is difficult to adjust. In this case, 'output' is not LNG as such, but LNG *liquefaction capacity*. US and Canadian LNG ventures will make their investment decisions independently of each other, but will not turn into a duopoly due to the global nature of the LNG market.

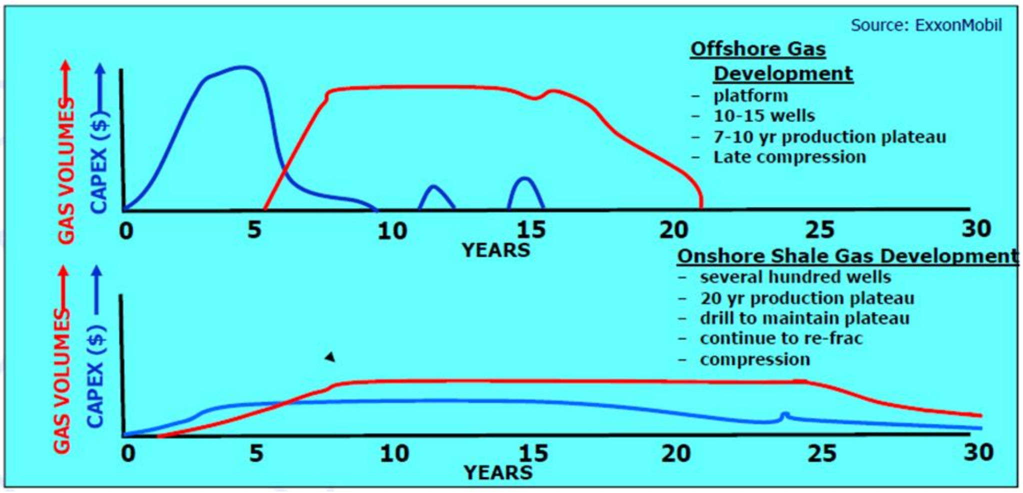
[22] IHS CERA (2009), *Fueling North America's Energy Future: The Unconventional Natural Gas Revolution and the Carbon Agenda*, special report.

[23] The share of gas-fired generation in the EU27 electricity mix is 23%, versus 4% for China. EIA data 2012. Eurelectric 2011 for EU27.

remains very much one of national sovereignty, and the interests of the member states are vastly diverse. First of all, a number of countries have been left out of this debate for sheer lack of unconventional potential. Among the potentially gas abundant, it is not clear what the overall picture will look like and how much of Europe's unconventional reserves will escape regulation, but it seems quite clear that in the end there will be some production in selected regions. The declining indigenous production of conventional hydrocarbons in many EU countries, which is matched by a growing import dependency,[24] will be a key incentive in this development.

Brazil and Argentina offer two interesting, although different, cases. Brazil's energy mix is dominated by oil and biomass with only about one-tenth natural gas, hence offering a large switch potential, while Argentina is already half fuelled by natural gas, prospecting to become a major exporter of gas produced from shale reservoirs. In neither country will environmental concerns stop the development of shale gas, and the challenging investment atmosphere does not seem to be stopping the flurry of international companies rushing to acquire stakes in unconventional ventures in the region.

Figure 1. Investment timescale for conventional and unconventional oil and gas ventures



Sources: ExxonMobil, as part of an OGP presentation at the *European Commission Workshop on Environmental, Economic, Climate and Energy Security Implications of Shale Gas in Europe*, Brussels, 12/9/2011.

Shale gas ventures will, of course, require a favourable investment environment. Shorter lead times and the ability to control production require less long-term exposure (see Figure 1), thereby offering an investment timescale that is more favourable to smaller ventures. There is likely to be a reshaping of the upstream environment in all the regions with shale gas potential, with a larger role to be played by smaller, leveraged independents. Concerns have been raised as to the ability of the shale industry outside the US to source the necessary finance, and even the machinery[25] required to reproduce the US shale revolution. These concerns, however, have an impact on timing, rather than on the actual likelihood that reserves will be exploited. A more complex concern exists around the drilling economics, and the prospects for shale production to ever become cash positive; but while this argument certainly applies to the US due to the currently depressed prices, it is unlikely that

[24] Data on the growing import dependency are available from Eurostat (http://ec.europa.eu/eurostat).

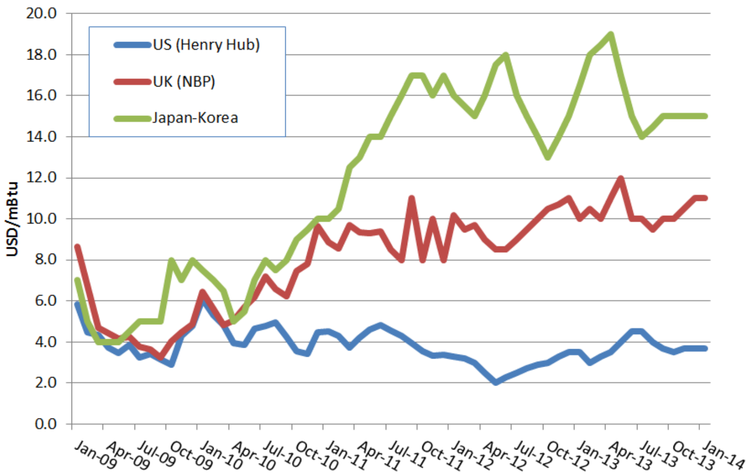
[25] Ivan Sandrea (2014), *US shale gas and tight oil industry performance: challenges and opportunities*, Oxford Energy Comment, Oxford Institute for Energy Studies, March.

it will apply the same way for shale ventures in locations where the production can be easily sold at more than twice the American price.

Europe is too set in its ways to benefit from a shale-driven LNG market

With the US turning into a net gas exporter and with global production growth, the supply side of the LNG market is expanding. Even so, the Asian price premium is essentially a measure of how much it remains short compared to the demand side (see Figure 2), as the new demand created by the Fukushima disaster, and the organic growth of Chinese and Indian demand, created an ideal outlet for the new volumes.

Figure 2. Natural gas price trends



Sources: US Energy Information Administration (2012). Argos, Heren, Platts front month prices (2014).

Europe would benefit from the added optionality represented by American LNG diversifying its supply pool, and various politically charged claims to this effect have been made since the Ukrainian crisis gave rise to new concerns about Russian gas.

The argument for having more LNG supply reaching Europe is twofold: one is that Russia has not proved a reliable supplier to everyone all the time, and diversification into LNG might be desirable, even at a 'security premium' over the price of the traditional sources of piped gas. The second rationale would be to provide arbitrage opportunities effectively working as a cap when hub prices fluctuate, which is already the case in countries where LNG terminals are present, but not so much in other countries, especially in Eastern Europe.

As things stand, however, the Old Continent is not well placed to absorb any American LNG. European gas prices are somewhere between the high Asian price and the depressed Henry Hub. The European arena is somewhat less flexible due to the traditional reliance on long-term contracts, the latter effectively taking away large chunks on both market curves, leaving the observable prices to be determined by the minority of the gas that is actually traded at the hubs.[26] Transport is also more complicated in the European continent than it is

[26] As late as 2008, the proportion of oil-indexed to market-priced trade for the EU27 + Turkey + Switzerland was almost 3 to 1, with the total 563 bcm market size split into 442 bcm oil-indexed (i.e. as part of long-term contracts) and only 121 bcm priced on a gas hub, either part of long-term contracts or traded spot. (Anthony J. Melling (2010), *Natural Gas Pricing and Its Future: Europe as the Battleground*, Carnegie Endowment for International Peace.) Since then, a period of contract

elsewhere: in much of the rest of the world, the only way to reach markets is LNG, a more expensive but ultimately simpler method of transport from an economic modelling perspective.[27] European grids, on the other hand, are fragmented along national boundaries, with a typical entry/exit point structure and often rigid and complex methods for the allocation of transportation capacity,[28] and lower regulated rates of return compared to the US.[29] The direct consequence of this system for the present reasoning is that shippers often need to adopt a country-specific attitude with regard to the use of assets. This includes LNG regasification capacity: for instance, Spain built a large amount of such capacity over the last few years,[30] while at the other end of the continent countries like Slovakia and Bulgaria are almost entirely dependent on Russian gas supply, which proved an energy security threat in the winter disputes of 2006 and 2009.[31] However, Spanish LNG capacity is not able to work towards the common benefit of gas supply in the region, due to lack of reverse flow at the

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renegotiations has started: many of the long-term contracts that underpinned the development of the North Sea were either expiring or reaching renegotiation gates, and the dynamics of European gas pricing called for a realignment, in particular opening the possibility of gas hub indexation. As a result of this transition, it is estimated that since 2013 only the minority of overall European gas supply is still oil-indexed. This has led to an increase in hub liquidity, although it must be noted that the renegotiated gas-indexed contracts remain bilateral relationships – the implication being that the demand-supply balance, which determines the prevailing spot prices at European hubs, is likely to remain composed of a minority of the market.

[27] A producer entering a long-term relationship usually owns most of the transportation part of the value chain, i.e. the liquefaction facility and the cargoes. The delivery takes place ‘at beach’, where the customer has regasification and transport capacity in the pipeline system. This is simpler compared to a traditional European long-term contract with delivery ‘at hub’, which requires the producer to book matching transportation capacities in the transmission systems that the gas needs to cross before reaching the nominated hub.

[28] DNV KEMA (2013), *Study on Entry-Exit Regimes in Gas*, contracted by DG ENER, December.

[29] Tim Boersma (2012), *Safeguarding Investments in Natural Gas Infrastructure: Lessons Learned from Regulatory Regimes in the United States and the European Union*, Transatlantic Academy.

[30] GLE presentation to CEER LNG Workshop “LNG Terminals in Europe”, 6 September 2011 (http://www.gie.eu/index.php/events-diary/workshops/gle-workshops/cat_view/16-gle-workshops/33-2011-workshops/34-first-ceer-workshop-on-access-to-european-lng-terminals).

[31] The three days of physical cuts resulting from the 2006 crisis were limited to Ukraine and did not spread to any EU countries. The 2009 crisis was much more serious, with the cuts lasting for 20 days and its physical effects were felt beyond Ukraine in Slovakia, Bulgaria and Serbia (John Lough (2011), *Russia’s Energy Diplomacy*, Chatham House). Two things are worth noting: first, the supply shortage was initially solved not by political action, but by a private consortium among supply companies that took care of the costs of moving the gas (Simon Pirani, Jonathan Stern and Katja Yafimava (2009), *The Russo-Ukrainian gas dispute of January 2009: A comprehensive assessment*, Oxford Institute for Energy Studies); second, Greece is also dependent on Russian gas for 82% of its demand, which translates into about 9 mcm/d during winter, but thanks to its Revithoussa LNG terminal, it was able to entirely offset the absence of Russian supply by using it at close to full capacity (12.6 mcm/d) for the duration of the crisis, unloading four cargoes on 10, 13, 16 and 20 January 2009 and even managing to export some of the extra supply to Bulgaria (Aleksandar Kovacevic (2009), *The Impact of the Russia–Ukraine Gas Crisis in South Eastern Europe*, Oxford Institute for Energy Studies, March; Pierre Noël and Sachi Findlater (2010), “Measuring Gas Supply Security: An Indicator for Russia-Dependent Europe”, University of Cambridge EPRG, presentation, 31 May). These two observations do not change the assessment that there was a security of supply problem, but perhaps offers a useful hint as to what type of risk mitigation should be put in place.

land entry points from France.[32] Hypothetical LNG supply unloaded at Bilbao (point 314 in Figure 3) would have to cross five balancing zones, acquiring the relevant entry/exit capacities, to reach the Austrian exit point at Baumgarten into Slovakia (point 46).[33]

Figure 3. Natural gas pipelines and entry/exit points in continental Europe (detail)

Source: ENTSO-G, *The European Natural Gas Network*, April 2014.

The paradoxical result is that at the same time as half of Spain's LNG import capacity sits unused, most of Eastern Europe is suffering import dependency from one single supplier. Nor is the market alone seemingly able to fix the problem: the marginal buyer at the hub is an opportunistic arbitrager, and LNG capacity acts as a cap on hub prices even when it is unused: hence it would be very uncommon for a hub to actually send a price signal for foreign LNG capacity to be used – at least as long as regulation makes it complicated to do so.

Europe's problem is that national sovereignty still largely rules its energy markets extent, and the borders of nation states are too narrow to address any of the dynamics above. First of all, many large corporations are present in all of them: the sheer volumes they are able to bring in exerts a strong influence on policy-makers, and large companies obviously thrive in a system whose complexity works as an entry barrier to small entrants. Secondly, availability of transport capacity in primary and secondary markets across Europe varies widely, as do auction calendars, product types and durations.

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[32] The current entry points into Spain are indicated by the yellow markers 32 and 33 in Figure 3: the bulk of the imported volumes pass through Col de Larrau (no. 32) which has a capacity of 165 GWh/day, while Biriatou (no. 33) is ancillary with only 10 GWh/day. Both are bidirectional, but the reverse flow capacity is never used in practice. The relevant Spanish and French TSOs are making an attempt at a virtual FR-ES trading point at Larrau, starting from 2015, to try and enable this.

[33] In Figure 3, the balancing zones to be crossed are Peg-TIGF (410), Peg-Sud (409), Peg-Nord (408), NCG (404) and CEGH (414) or VOB (405). In reality, in the event of a shortage of Russian supply reaching Baumgarten, it might be enough for Spanish LNG to physically flow into France and alleviate the westbound flow, which as a domino effect would create virtual supply at CEGH. There are a number of similar bottlenecks across the continent.

The idiosyncrasy between this state of affairs and the interdependence of European energy markets will not be solved anytime soon. As a result, the most likely outcomes are a persistence of the current, unattractive environment for LNG supplies; a push toward the new build of LNG terminals located on the eastern side of the Mediterranean and the Baltic states, on security of supply grounds; a focus on natural gas from the Caspian region and eastern Mediterranean instead of LNG; a continuation of the slow integration of the continental gas market via European Union regulation, namely the tabling of a Fourth Package for market liberalisation enshrining a piecemeal approach to the problem, fostering cross-border measures, bundled capacity products and so forth.

In this scenario, the possibility to lock in the benefits of increased LNG availability during the current decade will not materialise, as the price of LNG itself summed up to the transportation cost into central European hubs, given the present capacity constraints, will remain significantly higher than hub prices. Asia, therefore, despite its lack of hub liquidity and transparent price signals, is poised to remain the main demand centre for LNG for the time being.

Some implications for regional markets and policy directions

This simple study of a few evident unknown knowns at play in the global gas market was conducted by trying to identify latent knowledge and prolonging the effects of existing trends into the near future. Sure enough, normal accidents will also keep taking place, outdating the analysis in any of its parts: the fuzzy combination of events and trends leading to a normal accident does not belong to the realm of latent knowledge, and therefore observers cannot extrapolate them from their own knowledge in a Socratic way, as is the case with unknown knowns.

If the ability to see into the future cannot be improved, is there a way to at least get ready for some of the possible scenarios, pre-empting any downsides or maximising the benefit of any upsides? Hedging against predictable risks is a practice traders know very well. The problem lies with normal accidents, which are not foreseeable; but even in that case, it might be possible to devise some form of hedging. Japan was not able to predict the Fukushima disaster, and a long discussion could be had as to whether or not the probability of its occurrence had been correctly assessed in devising the practices and regulations for the nuclear industry. The country was, however, equipped with a large amount of spare LNG regasification capacity which, at least, was able to avert a broader collapse of the national economy in the necessary shutdown of nuclear capacity that followed the event. The LNG capacity had not been built as part of a hedging strategy, of course, but it worked as such. A nuclear disaster was very much outside the central scenario that the Japanese energy market expected for the spring of 2011, but what saved the market at least was the existence of LNG regasification capacity, which somewhat addressed the possibility that a large chunk of the power supply curve could go missing overnight. Japan suffered incalculable losses, and an environmental disaster of unprecedented scale, but its economy was not brought to its knees by an energy shortage, and this was the key to its speedy recovery.

Investing outside the central case of our scenarios might prove valuable, especially at a systemic level, and this conclusion can to some extent be generalised and applied to some of the dynamics analysed in this study. One of the most compelling suggestions offered by currently observable evidence is that the resurgence of the gas industry in the US will mostly benefit Asian growth, leaving Europe to fix the balance between its own gas supply and demand. As has been argued earlier, more LNG capacity in Eastern Europe or, even better, streamlining intra-European gas transportation would provide useful optionality.

With a civil war ongoing in Ukraine and economic sanctions in place against Russia, the situation that is looming beyond the eastern borders of Europe could easily escalate into something like what has been defined here as a normal accident; whatever the short-term developments, the Russia-Ukraine relationship has been and will remain difficult, so that investing in alternative options to Russian gas might prove valuable for Europe. And the effect of an energy embargo at any point in the future would certainly be disruptive in the immediate term, but might trigger responses on the economic and/or political level which, in a longer-term perspective, could in turn lead to beneficial developments – say, precipitate a diversification in the sources of European gas supply, and more broadly of the energy mix: not all normal accidents are necessarily black swans. Yet, it would be safer to be braced for whatever kind of beast this turns out to be.

Along the same lines, one should not rule out unexpected developments in the energy mix in the industrialising world either. The current state of play is that despite the European inability to tap into LNG growth, the role of gas in the energy mix is poised to increase both in the OECD space and in Asia, including a moderate substitution of coal with gas, within time frameworks that will differ between North America, Europe and Asia, depending on the levels of industrialisation and the existing energy mix, in a dynamics of first- and second-comers. But what if the disruptive potential of China and India's shale hydrocarbons reserves has been underestimated? This could be driven by either new discoveries or unexpected technological advancement, the latter reversing the current view that US shale technology is either not easily exportable or reproducible. In this picture, the most prominent second-comers might even end up overtaking the first-comers, operating a massive switch to gas. A scenario in which China sets clear emissions reduction goals in the next Five-Year Plan may suddenly become less unlikely than most expect. And even if, surely, this development would imply an increase in both Chinese production and consumption of gas, the net effect would have to be investigated carefully: like an elephant in a china shop, even a small net change might affect the Asian gas price. Should this be a downward move, it would also prove a game-changer in the structure of global LNG flows.

Furthermore, and as a result of the above, what would the carbon price be in this scenario, and where would all the displaced coal go in the end? It is time to form solid opinions on these questions. The observable reality is that displaced coal will keep heading towards the industrialising world, especially to China, but this will be mitigated by the latter's ability to escape Adam Smith's "invisible hand" by mandating policies favourable to the development of an indigenous gas industry and to attracting foreign supply. Should China succeed in making a significant move away from coal, identifying the remaining second-comers would become an important exercise: one that needs to be performed by industry players in order to find out what fuels they will be competing for within the regions where they forecast growth (an early hint could be India and Africa), as well as by environmental policy-makers in order to find new ways to address the centuries-old riddle that links the first phase of industrialisation with dirty sources of energy. Ultimately, since change is brought about in part by unknown knowns and in part by normal accidents, winners and losers will be constantly redefined according to their ability to visualise the unknown knowns, make solid hypotheses on the possible deviations due to normal accidents, and steer their business or policy accordingly.