INTRODUCTION
The theme of this issue is the role of fossil fuels in Europe today and in the years ahead.

To date, generally speaking, it has been European society which has been the most vocal and pro-active when it comes to issues relating to environmental sustainability. Individually and as a group, the member states of the European Union have set several aggressive targets aimed at minimising, if not completely reversing, the environmental degradation that occurred over the past two centuries of economic development. Specifically, in terms of climate and energy, a “20-20-20” package was announced in March 2007 which set three targets for 2020, namely, a reduction in greenhouse gas emissions by at least 20 per cent compared to 1990 levels or by 30 per cent if other major economies in the developed and developing worlds commit to undertake their fair share of a global emissions reductions effort; an increase in the share of renewable energy in final energy consumption to 20 per cent; and an increase of 20 per cent in energy efficiency.

Prior to the Fukushima Disaster in March 2011, many European governments had hoped to make significant reductions in the amounts of carbon emitted from their power generation sectors by substituting fossil fuels with more nuclear power and more renewable forms of energy. However, the disaster in Japan caused some European countries to become more apprehensive towards nuclear power. Now, over two years following this disaster, they are still closely watching the situation in Japan, as alarmingly high concentrations of radioactive water continue to leak. The construction of new reactors has been banned in Switzerland and Spain and certain quarters of French society are calling for their government to diversify away from its heavy reliance on nuclear power. However, other European countries, such as Bulgaria, Finland, Poland, Romania, Slovakia, Sweden and the UK remain undeterred and are planning to build new nuclear power plants. They are of course mindful of the safety concerns, but they are more concerned about construction delays and cost over-runs.

At the same time, most European countries have embarked on ambitious programmes to develop renewable sources of energy, especially solar and wind power. For example, Latvia and Sweden are aiming to have the share of renewables in their total energy mix reach over 40 per cent by 2020. Austria, Denmark, Portugal and Finland are aiming for at least 30 per cent, 5 other countries are aiming for at least 20 per cent and 15 are aiming for at least 10 per cent. Several energy ministries, research institutes and finance houses around the world have run models, with a great range of energy supply, energy demand and cost assumptions, to try to estimate various countries’ energy mix in twenty or thirty years. To cite one organisation’s work in this area, the International Energy Agency (IEA), in its Current Policy Scenario (CPS), expects that the scepticism towards nuclear power felt by large numbers of Europeans will mean that the contribution of nuclear power will drop from 33 per cent in the region’s overall power mix 2010 to 22 per cent in 2035. In its New Policy Scenario (NPS), the role of nuclear is only slightly less at 30 per cent, but in the 450 Scenario (450S), it is enhanced to 40 per cent.

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As for increasing the role of renewable forms of electricity generation in Europe, as the main rivers have long ago been harnessed, the IEA expects almost no change in hydropower’s contribution of about 4 per cent of the generation mix today. However, there is very large wind and solar energy potential and these sectors have been significantly developed in recent years. In some places the intermittency and cost problems associated with these forms of energy are being managed satisfactorily, but in other places they continue to be problematic. The use of geothermal, tidal and wave energy is still very limited in places they continue to be problematic. The use of geothermal, tidal and wave energy is still very limited in Europe and these are not expected to develop quickly in the immediate future. But there is anticipation that bioenergy will increasingly substitute for some of the fossil fuel- and nuclear-powered generation plants in use today. The IEA estimates that the share of bioenergy in Europe’s overall power generation mix could rise from 7 per cent in 2010 to 10, 12 and 15 per cent in its CPS, NPS and 450S, respectively. Though not intermittent in nature, the main issue with bioenergy is procurement and use of steadily increasing amounts of biomass in ways which do not inherently consume large amounts of energy or emit large amounts of carbon.

In 2010, the shares of coal, gas and oil together amounted to over half of the European Union’s power generation mix, at 29, 20 and 3 per cent, respectively. The IEA expects that fossil fuels will continue to dominate power generation to 2035. In its CPS, the contribution of gas will increase to 30 per cent, while that of coal will drop to 21 per cent. In its NPS, the role of gas will increase to only 26 per cent and the share of coal will drop noticeably to 12 per cent. In the 450S, gas and coal will together account for less than 20 per cent of the power generation mix, at 11 and 7 per cent, respectively. In each of the CPS, NPS and 450S, the share of oil is 1 per cent.

As for energy use in the transport sector, the IEA foresees that oil products will continue to dominate. In 2010, 93 per cent of the transport fuel used in the EU was in the form of oil products. In the CPS, NPS and 450S, the shares are 86, 81 and 65 per cent, respectively. While the IEA does foresee a significant increase in the use of biofuels in this sector over the next 25 years, the use of electricity and other fuels is not expected to rise much.

These scenario figures are all from the IEA’s 2012 World Energy Outlook (WEO). It will be interesting to see if the 2013 WEO, which is due to come out soon, will show figures which are considerably different due to high expectations for unconventional gas — both imported to Europe and local extraction. In the first article in this issue, Anton Finenko, an Energy Analyst at ESI, discusses the estimates of potential unconventional gas resources in the EU and the expected problems that will need to be resolved if they are to be developed. It would seem that there is still a tremendous amount of geological data required before large-scale extraction can proceed. The French, Bulgarian and Dutch governments have all banned fracking, but there is considerable enthusiasm in other countries, such as Germany and Poland. However, many of the geological and policy conditions which made it possible for unconventional gas production to soar in the United States in recent years are simply not present in the EU and will likely never be.

The second article, by Roh Pin Lee, PhD Candidate and Research Associate, Chair of Management, Leadership and Human Resources, TU Bergakademie Freiberg, German Centre for Energy Resources, examines the dilemma faced by the German government with respect to coal. Germany launched its Energiewende (Energy Transition) in 2011. This programme includes very ambitious targets for greenhouse gas reductions, the share of renewable forms of energy in the power generation mix and increases in electric power generation efficiency. The results of the implementation measures taken thus far, especially the gains in the contribution of renewable forms of energy, have been quite spectacular. At the same time, 27 nuclear power plants, including experimental, prototype and demonstration facilities, have been closed and the remaining nine are to be closed earlier than anticipated. However, as Roh Pin points out, a consequence of the increased proportion of electricity generated from renewable forms of energy has been greater instability in power supply and higher power costs. Thus, recently more coal has been used to ensure stable and affordable electricity and more coal-fired plants are planned. But, as coal is by far the most polluting form of energy, this is definitely a step backwards in terms of managing environmental sustainability.

The final article, by Manouchehr Takin, Senior Petroleum Upstream Analyst at the Centre for Global Energy Studies and ESI Energy Analyst, Augustin Boey, compares the rates of peaking in oil and gas production in the British and European sections of the North Sea. Starting from about the mid-1970s, the economies of these two countries surged as a result of the massive oil and gas production which peaked in 1999 in the United Kingdom’s section and in 2001 in Norway’s. The authors discuss the differing approaches that these two governments took in managing the resources and the consequences therefrom over the past decade. While Britain became a net importer of gas and oil in 2004 and 2005, respectively, Norway is still a net exporter of both. Alas, production in both sections has been steadily declining and will ultimately taper off completely. This will mean that Europe’s dependence on oil imports from Russia, Libya, Saudi Arabia, Iran, other Middle Eastern countries, Western Asian countries, Africa, etc., will rise until such time that Europeans find other ways to power their vehicles.

At the time of writing, the sky-rocketing production of shale gas in the United States is completely transforming its power generation mix and observers are now watching to see what impact, if any, it has on the transport sector. However, the outlook for unconventional gas in Europe, at least for now, does not appear to be as promising. Thus, it is likely that nuclear power will in future play a greater role in Europe’s power generation mix as it offers a stable and economical supply of electricity. Many Europeans also hope that means can be found to make use of renewables throughout the region equally stable and cost-effective. However, there is some way to go before this will be realised. Thus, without doubt, over the next two decades at least, Europe will continue to rely very heavily on fossil fuels in both the power generation and transport sectors.

Dr. Elspeth Thomson, ESI Senior Fellow and Head of the Environment Division (On behalf of the Bulletin Team)


2 The IEA’s CPS assumes no changes in policies from the mid-point of the year of publication. The NPS takes account of broad policy commitments and plans that have been announced by countries, including national pledges to reduce greenhouse gas emissions and plans to phase out fossil energy subsidies even if the measures to implement these commitments have yet to be identified or announced. The 450S sets out an energy pathway consistent with the goal of limiting the global increase in temperature to 2°C by 2050 (as agreed at the UN Climate Change Conference in Copenhagen in 2009). The IEA argues that to achieve this goal, all energy pathways must be consistent with the 450S by 2020. The 450S sets out a pathway consistent with the goal of limiting the global increase in temperature to 2°C by 2050 (as agreed at the UN Climate Change Conference in Copenhagen in 2009). The IEA argues that to achieve this goal, all energy pathways must be consistent with the 450S by 2020.

3 The IEA defines bioenergy as material which is directly or indirectly produced by photosynthesis and which is utilised as a feedstock in the manufacture of fuels and substitutes for petrochemical and other energy intensive products.
A number of energy companies as well as policy-makers in the European Union are actively seeking how to replicate and improve upon the North American model of unconventional gas production. Unconventional gas may offer a number of security-of-supply benefits for the Union. With less need to rely on imports of natural gas, the cost of gas in the region may fall as it becomes more readily available. This would be especially beneficial for energy-intensive industries which currently face increasing cost disadvantages relative to their US counterparts. According to the International Energy Agency (IEA) and the European Commission (EC), the EU’s demand for gas will continue to grow over the coming decades, despite the fact that the European economy is currently plagued by economic recession.

Since 2009, a number of reports have been published that provide preliminary estimates of technically recoverable unconventional gas in Europe. They range from 2.3 to 17.6 trillion cubic metres (tcm) with a mean of 7.1 tcm which is less than the estimates for the United States and China (see Table 1).

However, there is still much which is not known, such as the productive limits of the emerging gas plays and the impact of advances in well drilling and completion technologies on the productivity of wells. Therefore, these estimates must be viewed with a high level of uncertainty.1

As can be seen in Figure 2, there are three known shale gas basins in Europe: one spreads from Eastern Denmark and Southern Sweden to Northern and Eastern Poland; another is the Carboniferous marine basin which lies across the northwestern part of England, through the Netherlands and northwest Germany to the North of France; and the third is between Slovakia and Bulgaria spanning across vast territories of the Balkan states.

If it indeed turns out that there are large, technically and economically available resources in Europe, the EC will need to decide whether it should support their development. A complex combination of geological, environmental, regulatory and social challenges needs to be carefully examined in order to make the decision.

Collecting and analysing the relevant geological information is the first major barrier that operators must overcome. The poor availability of geological information is due mainly to the fact that in the past there was little commercial interest in investigating this type of gas resource, leading to very few test drillings of potentially prospective regions.2

Environmental risks combined with a high population density in Europe is the second key aspect that must be addressed. Many unconventional gas deposits in Europe lie beneath highly urbanised regions which are encompassed by safety zones in which exploration activities are not permitted.3 The wider distribution of shale-gas resources, relative to conventional deposits, means that there are a larger number of wells per given volume of production and this increases the potential for excessive water usage, drinking water well

<table>
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<th>Region</th>
<th>Conventional</th>
<th>Tight</th>
<th>CBM</th>
<th>Shale</th>
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<td></td>
<td>Lowest estimate</td>
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<td>Mean of estimate</td>
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<td>Europe</td>
<td>11.6</td>
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<tr>
<td>China</td>
<td>12.5</td>
<td>9.9</td>
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<td>(Implied rest of world)</td>
<td>(364.9)</td>
<td>(14.6)</td>
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<tr>
<td>Global</td>
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contamination and surface water contamination. The production of shale gas can also potentially create serious road congestion and noise as the operations require the conveyance of large amounts of equipment and materials.

Thirdly, given the low experience of unconventional gas production in Europe, the production costs are expected to be much higher than in the US. Drilling costs in Europe are currently 2-4 times higher per unit than they are in North America. Labour costs are also significantly higher than in the US. Then when additional expenses relating to EU environmental standards and the fact that the unconventional gas service industry in Europe is not yet well equipped with the necessary technology and staff, the use of unconventional gas will certainly not bring immediate energy cost reductions. High precision drilling techniques, which are very expensive, may be required to successfully develop projects in densely populated areas. Commercially viable harnessing of such fields can become realistic only if gas prices continue to rise at the same time that the cost of the relevant technologies and services drop. The energy consulting agency, Wood Mackenzie, predicts that the break-even price for shale gas in Europe will be around US$9/mm Btu, or almost double what it is in the United States.4

Complicated land ownership rules and the smaller concession size, due to the high population densities, are another constraining factor for the emerging gas industry in Europe. The property rights situation in Europe is very different to that in the US. There, the owner of the land also owns the ground profile beneath the surface and receives revenues from the resources accumulated within. This provides a lucrative incentive to landowners to permit gas drilling and production on their land. By contrast, in most European countries, all resources belong to the state. For exploration and production companies, this means that they must negotiate with both the state and the land owner, which makes the process considerably more complicated. This has two major implications as far as the public is concerned. Firstly, since the landowner does not receive any revenues from the drilling, the incentive to accept the inconvenience is reduced. Secondly, given that Europeans are typically more ecologically sensitive, local opposition to onshore drilling is likely to be high, especially if the community will not gain financially in any way.5

Relevance of EU Provisions

Given the complexity of geological, economic and institutional factors, the future development of unconventional gas in Europe will be dictated by the degree of potential intervention on the part of EU institutions in the process of exploration and production. The role of operators and their readiness to invest in exploratory and drilling measures raises fewer concerns as they are dictated by the market conditions.6

According to the provisions of the Treaty on the Functioning of the European Union (Art. 194 Section 2 l. c TFEU) the right to determine the conditions for exploiting energy resources, the choice of energy sources and the general energy supply structure belongs to the member states, meaning that all legal acts suspending exploration work should be adopted at the national level. At the same time, the member states which plan to introduce unconventional gas exploration are entitled to make them compatible with the objectives of EU environmental policy.7

Although it has some of the largest reserves of unconventional gas in Europe, France outlawed hydraulic fracturing in 2011, followed by Bulgaria and the Netherlands.8 The public in these counties generally disregarded the possible benefits of unconventional gas, focused on the potential environmental problems that could occur and questioned the point of promoting fossil fuels over renewable
technologies like wind and solar power. Meanwhile, German industries continue to put pressure on the government to develop unconventional gas as soon as possible, arguing it would boost the economy and keep domestic energy intensive industries cost-competitive. In early 2013, the German government published a draft law allowing the development of shale gas under certain conditions despite firm opposition from several political parties. The fracking will be prohibited in protected areas and near drinking water wells, a ban that would apply to 14 per cent of German territory. In addition, environmental impact studies will be a mandatory condition. Poland, the country with the largest unconventional gas resources in Europe, has seen a lot of enthusiasm about the possibilities for enhancing domestic energy security and decarbonizing the country’s coal-heavy fuel mix through developing its own gas reserves. The Polish government openly favours the development of shale gas, but asked several major energy companies to scale down their initial investments due to the complex regulatory climate and unsatisfactory test drillings.

Conclusion

There are many controversies surrounding the exploration and production of unconventional gas in Europe that need to be addressed in order to make the use of the new gas resource possible. At the time of writing, due to the poor geological data, high costs of production, constrained access to land and very complex legal and political environments, investors were not keen to pursue large-scale projects in the EU. Specialists argue, however, that technological and market constraints, despite being challenges today, will be met over time if the regulatory framework can be developed quickly. Thus, the main obstacles to unconventional gas development in Europe are linked to the policy issues which are less predictable by nature and usually take a long time to resolve.

Germany’s Coal Dilemma

by Roh Pin Lee, PhD Candidate and Research Associate
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Coal in the German Economy

Coal plays a key role in the German economy. In 2012, coal (including both lignite and hard coal) accounted for 44.7 per cent of the country’s electricity generation (see Figure 1). In particular lignite, also known as brown coal, is an important domestic energy source. Germany is the largest lignite producer in the world, with lignite mining and lignite-based power generation industries contributing to over 85,000 jobs in the country. Almost 90 per cent of Germany’s lignite output is utilised for domestic power and district heat generation, with the rest being used in synthetic fuel plants and production.

Following the Fukushima nuclear accident in March 2011, Germany embarked on an ambitious ‘Energiewende’ (Energy Transformation) project to restructure its energy system. The key goals are to phase out nuclear energy by 2022, to derive at least 35 per cent of the country’s electricity from renewable energy sources by 2030, and to increase the share of renewables in the electricity mix to 80 per cent by 2050. In addition to the commitment to raise the share of renewables in Germany’s electricity mix, energy policy makers, experts as well as industry leaders are also emphasising how fossil-based energy sources such as coal and natural gas, in contributing to a secure, reliable and competitive energy supply, will continue to be indispensable in fuelling Germany’s economy over the long term.

Germany’s Environmental Minister, Peter Altmeier, notes that if renewables account for 35 per cent of the country’s electricity generation mix...
in 2030, 65 per cent will need to be generated from other energy sources. As such, he is supportive of replacing old and inefficient lignite and hard coal power plants with modern and efficient coal and gas power plants.5

In 2011, Germany’s lignite and hard coal power plants, located all over the country, had an installed capacity of about 47.6GW.7 Numerous new ones are currently under construction.2,5

Drivers for Coal Power Generation in Germany

There are numerous drivers for coal power generation in Germany. For one, mining and power generation activities represent significant job and business opportunities as well as new construction projects. Policy and industry decision-makers also want the planned new coal power plants to help bridge the electricity gap that may arise due to the phasing out of nuclear energy, and to replace obsolete coal-based power plants which are going offline.8 Moreover, whereas nuclear and fossil energy sources are able to provide a consistent level of baseload power, fluctuations in renewable energy input have been placing a strain on the German power grid.9 In recent years, system engineers have increasingly had to intervene in order to maintain the stability of the grid.9 Germany’s power grid is also not the only one affected. Neighbouring countries such as Poland and the Czech Republic are also experiencing problems because Germany uses their grids to help stabilise its own systems by exporting excess electricity across the border without prior notice.10 Sudden fluctuations in the German power grid have also resulted in significant costs to German industries in terms of damaged machines and goods. Businesses are thus taking steps such as investing in emergency power supplies so as to protect themselves from damage arising from electricity disruptions.11 To prevent jeopardising the stability of the country’s power grid and the competitiveness of its industry, the German government is emphasising the crucial role of conventional fossil-based generation in safeguarding the system’s stability and off-setting fluctuations in electricity feed-in from renewable generation facilities.6

There are also significant cost factors in favour of coal power generation in Germany. As one of Europe’s major industrial nations, the cost of electricity has implications not only for the German population but also for the competitiveness of its industrial sector. As electricity from renewable energy sources is still relatively expensive, Peter Altmeier sees fossil energy sources, in particular coal, as playing an important role in ensuring the competitiveness of the German economy.7 The price of natural gas in Europe is also considerably higher than that of coal.2,12 Hence coal continues to dominate Germany’s electricity mix.

In addition, there is a political/strategic aspect to coal use in Germany. Werner Brinker, CEO of the energy company EWE AG in Oldenburg, highlighted the important role of coal in ensuring a reliable and secure energy mix for Germany by pointing out that petroleum tends to be crisis-prone and natural gas (which Germany imports mainly from Russia) is seen as politically risky.8 By contrast, coal reserves are available in almost every country around the world.13

Concerns about Coal Power Generation in Germany

Despite the important advantages of coal power generation, there are increasing concerns that Germany’s energy transformation is leading to the rise of “dirty coal”.14,15,16 Fossil-fuelled power plants are the biggest greenhouse gas emitters worldwide,17 with coal power plants accounting for over 28 per cent of global carbon dioxide emissions.18 Environmental organisations are therefore warning that an expansion of coal power generation will lead to increased greenhouse gas emissions.15,19 Also, Germany’s Chancellor Angela Merkel has declared that the country’s goal is to lower emissions by 40 per cent from 1990 levels by 2020.12 Thus, some observers contend that investing in coal power generation will be incompatible with this goal.

To mitigate the coal-related carbon emissions, there have been developments to capture emissions from coal power plants and to deposit them in the ground using carbon capture and storage (CCS) technology. However, the introduction of this controversial technology in Germany has failed due to residents opposing the technology as well as a lack of political support.17,20,21

There is significant local and environmental opposition to coal mining, coal power generation and related technologies in the country. Anti-coal campaigns organised by groups such as Climate-Alliance Germany

Figure 1: Electricity Generation Mix in Germany, 2012

Where is Coal Headed in Germany?

With the accelerated nuclear phase out plan and the current inability of renewables to provide a stable and affordable energy supply, coal appears to be experiencing a renaissance in Germany. However, in view of the country’s ambitious climate targets and the lack of public support for coal-related developments, German policy-makers are facing a “dilemma between nuclear phase out, coal dominance and climate leadership”.

Going forward, as Germany attempts to meet the 80 per cent renewable power generation target by 2050, coal resources will be increasingly released from power generation. As such, once released from the use of coal power plants, a recent study by Greenpeace, entitled “Tod aus dem Schlot” (loosely translated as “Death Out of the Chimney Stack”), has also drawn public attention to the adverse health impacts associated with emissions from coal power plants.

Moreover, coal tends to be associated among young Germans with negative images of digging and mining, carbon emissions, filth and pollution. These negative associations have been observed to be resilient to change. This aversion to coal was only surpassed by their opposition to nuclear energy.

To summarise, beyond energetic utilisation for power generation, coal has the potential to become a major raw material for the chemical industry and to contribute to a reduction in Germany’s dependence on oil and natural gas imports. Industry experts are already postulating a raw material change in the chemical industry. However, the German public may still not accept coal no matter how it is used. The reluctance on the part of the German public to support the use of any coal at all represents a significant obstacle to future policy development, R&D activities and business investments, in addition to impeding Germany’s technological leadership in the coming raw material revolution in the chemical industry.

Source: German Centre for Energy Resources.
Benchmark for pricing two-thirds of the world’s oil and gas that has been extracted from the North Sea. These national and regional effects have also had a wide ranging effects on the economies and energy security policies of the main consuming countries. Security policies of the main consuming countries.

Hydrocarbons extracted from the North Sea have had a pivotal role in the post-WW2 energy landscape. It is defined geographically as a partially enclosed sea that extend across the North Sea to British waters. Hydrocarbons extracted from the North Sea have had significant political and economic implications for the countries –– the United Kingdom, Norway, the Netherlands, Denmark, Belgium, Germany and France. In the oil industry, however, the North Sea has been pivotal role in the post-WW2 energy landscape. It is defined geographically as a partially enclosed sea that extend across the North Sea to British waters. choppy, rocky terrain. The geological data that has been gathered from the Groningen gas field in 1959, and the realisation in 1963 of its immense size, in 1967, which was followed by the discovery of the large Ekofisk oil field in Norway in 1969. Oil had already been discovered in onshore areas within the region around a century earlier, with the discovery of oil in 1859 near Hanover in Germany and the discovery of oil in the Netherlands at De Mient in 1938. Gas was discovered in onshore areas within the region around a century earlier, with the discovery of oil in 1859 near Hanover in Germany and the discovery of oil in the Netherlands at De Mient in 1938. Gas was discovered in onshore areas within the region around a century earlier, with the discovery of oil in 1859 near Hanover in Germany and the discovery of oil in the Netherlands at De Mient in 1938. Gas was discovered in 1910 near Hamburg in the north of Germany. However, it was the discovery of the Groningen gas field in the north of the Netherlands by a Shell/Esso consortium in 1959, and the realisation in 1963 of its immense size, that provided the impetus for offshore exploration to commence in the North Sea. The geological data that had been gathered from the Groningen gas field suggested that its gas-bearing sandstone reservoirs could extend across the North Sea to British waters. Reconnaissance efforts were therefore carried out by various commercial enterprises via marine seismic work and aeromagnetic surveys to provide a rough picture of the geological configuration of the undersea bedrock.
Several early successes in commercially viable gas discoveries were made subsequently within geologically contiguous areas to the Groningen reservoir. These early exploration efforts refined the understanding of the petroleum geology in the North Sea. It was also during this period that the limits of the gas-bearing geological structures began to be clarified, particularly with the realisation of the commercial non-viability of the German offshore sector. The discovery of oil in the giant Ekofisk field in the Norwegian sector of the North Sea by Phillips within a chalk reservoir in 1969 was the first major oil field discovery in the North Sea. This was the event that sparked the rapid growth of exploration efforts for oil in the North Sea. The largest hydrocarbon reserves were subsequently determined to be in the United Kingdom’s and Norway’s offshore sectors.

**Pace of Exploration and Development**

Various factors influenced the pace of exploration and commercial development. Chief amongst these was the issue of territorial licensing. Drilling efforts could only proceed in earnest after the clarification of exclusive economic zones through bilateral arrangements made in 1966 between the United Kingdom, Norway, Denmark and the Netherlands and the further settling of offshore territorial disputes by the International Court of Justice between Denmark, Germany and the Netherlands in 1970. Legislation for offshore petroleum licensing to energy companies was enacted by individual countries within this period. This regulatory framework defined the allocation process for offshore territorial blocks to various energy companies. The competition that resulted between energy companies within each national offshore sector varied across the national sectors. The offshore Denmark region, for instance, was given entirely to a single Danish consortium from 1962 to 1982, whereas a more open bidding regime characterised the United Kingdom’s licensing process.

Other important factors that influenced the rate of exploration and extraction were the advances made in technology that enabled the growth of geological knowledge and production from previously commercially marginal oil and gas fields. These technological developments took the form of innovations in production technologies and drilling and oil rig designs and techniques. Improved geological surveying techniques, such as the spread of digital seismic recording techniques in the late 1960s and the adoption of three-dimensional survey techniques in the 1970s, led to improvements in hydrocarbon exploration techniques. The application of these techniques, along with the vast volume of data gathered from the expanding exploration efforts, led to the rapid improvement in the understanding of the stratigraphy and geological structure of the North Sea and facilitated further rounds of oil exploration.

Whereas the United Kingdom followed a relatively “hands off” approach by the government, allowing “free market forces” to control the level of investment and field operations, Norway adopted a more regulated approach with much greater control by the government and also by the parliament with respect to the level of investment and the approval and supervision of field development projects. The government policy differences partly reflected the political differences between the ruling parties in the two countries — mostly Conservative in the UK and Socialist in Norway. However, the differences also reflected the differences in the size of the population and the GDP of the two countries. The fluctuations in the level of investment and the rapid variations in revenues would have been much more disruptive for the smaller economy of Norway than the UK. Thus, there was some justification for the greater control in Norway.

The impact of the government policies on the oil production history of the two countries can be seen in Figure 1. The UK’s open market policy resulted in a rush of investment and a rapid growth in oil production that started in the mid-1970s and reached 2.6 million barrels per day (mbpd) by 1986. By contrast, Norway’s more controlled and regulated policy resulted in a slower rate of growth. Production started earlier but had reached only 0.8 mbpd by 1986. There was also a clear difference between the two countries in terms of the impact of the collapse of the price of oil in 1986. The Norwegian oil production continued growing more slowly, but continuously, throughout the 1980s. Despite the oil price collapse, crude oil production increased by 79 per cent, from 0.8 mbpd in 1986 to 1.5 mbpd in 1989. In the UK, however, oil production declined by 33 per cent, from 2.6 mbpd in 1986 to 1.7 mbpd in 1989. With the improvement in the price of oil, investment gradually resumed in the UK sector in the second half of the 1980s and oil production began to rise again.
As shown in Figure 1, oil production in both countries reached a maximum which was more or less maintained for a few years and then began to decline. The peak oil production in the United Kingdom occurred in 1999 at around 2.7 mbpd and in Norway in 2001 at 3.25 mbpd. The details of the two production profiles differ due to the policy differences between the two countries. However, the broad picture common to both is that of growth, a short plateau and then decline—a “Hubbert” curve or a bell-shaped curve that reflects the beginning, growth to a plateau and then decline in a typical production profile from a finite resource base. In other words, the North Sea has reached and passed its peak.

By the mid-1980s, government income from taxation in the North Sea grew to provide the United Kingdom with around 10 per cent of its Treasury revenues, although taxation receipts have since fallen almost threefold to around an estimated 6.7 billion pounds in 2013.8 Taxation in the North Sea has also been a factor affecting the commercial viability of hydrocarbon extraction and thus the rate of production in the North Sea. The higher taxes in the United Kingdom, for instance, had a slowing influence on the pace of production until tax revisions were enacted in the late 80s. Production fell again in the new millennium, with the blame partly attributed to the introduction of the “supplementary charge” in 2002 and its subsequent increases over the decade.9 Nevertheless, the North Sea continues to remain an important generator of employment. In 2012, for instance, the United Kingdom’s oil industry employed around 440,000 people.10 While Norway remains a net exporter of energy, the United Kingdom became a net importer of natural gas and crude oil in 2004 and 2005 respectively, after more than two decades of recording net energy exports.11

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The areas below the two oil production curves in Figure 1 are about the same. In other words, the ultimate recoverable reserves appear to be similar in size. The historically reported annual remaining oil reserves for the two countries (see Figure 2) reflect the UK’s more rapid rate of investment and field operations in its early years, in contrast with the slower but a more persistent trend in Norway. The cumulative annual crude oil “discoveries” (gross additions to reserves) has the shape of a typical “creaming curve” (see Figure 3). As the annual additions have become gradually smaller over the years, the cumulative curves are gradually flattening out—approaching their asymptotic values, i.e., their ultimate recoverable reserves. An important observation from Figure 3 is that although the two curves are significantly different over the first two decades, they have more or
less overlapped since the mid-1990s. They are approaching similar asymptotes, suggesting comparable volumes of the ultimate recoverable oil reserves.

A similar brief analysis for natural gas shows that while gas production in the UK reached its peak around the turn of the century (see Figure 4), it has continued to grow in Norway. The dip after 2010 could be temporary and not the start of a declining trend. The development of some major gas fields is expected to result in the resumption in the growth of Norwegian gas production. The shapes of the curves of annual cumulative gas “discoveries” for the two countries (see Figure 5) differ from those for oil (Figure 3). This is due to the impact of intermittent but large gas discoveries, limitations in the data series and more importantly, the continuation of success with gas exploration.

A key point that should be emphasised here is that the above oil and gas production and reserves analyses are simplified and approximate since they include data from areas outside the North Sea proper. This factor is less important for the analyses of production data but introduces some distortion into the analyses of reserves and “discoveries”. Nevertheless, the analyses are informative and broadly valid.

Conclusion
The contrasting policy approaches and rates of investment in the Norwegian and British sectors of the North Sea resulted in different production and discovery growth rates in the 1970s and 1980s, but similar ones in the 1990s and the 2000s, especially for oil. The recent similarities could be due to the realities of geology and the impact of the finite size of the oil resources. The ultimate oil resources appear to be comparable in both sectors, though they are marginally greater in Norway.

On both sides of the North Sea, almost all the major, independent and international oil companies have been active. The best technology, field services, industry practice and management systems have also been available. These have resulted in a slowing of the decline rates that would have been expected from a symmetrical bell-shaped production curve, but one cannot escape the reality that the resources are finite and that decline is inevitable. New technologies could still lead to the discovery of new oil and gas reserves, develop new exploration concepts and plays and could increase the recovery factor of the oil and gas in place. Indeed, such technologies are expected to boost the United Kingdom’s oil and gas production to above 2 million barrels of oil equivalent a day (mboepd) by 2017 from 1.55 mboepd in 2012, and Norway’s oil and gas production to around 3.8 mboepd by 2017 from 3.7 mboepd in 2013.12 Realistically though, the standard life span of the offshore platforms imposes a time constraint for the application of such technologies and concepts.

3 Brennand et al., “Historical Review”.
4 Brennand et al., “Historical Review”.
6 Brennand et al., “Historical Review”.
7 Ibid.
Publications

Internationally Refereed Journals


Staff Presentations and Moderating


21 August Abhishek Rohatgi presented, “Extreme Learning Machine Based Forecasting of Photovoltaic Power Output”, at the 13th *IAEE European Conference*, Dusseldorf, Germany organised by the International Association of Energy Economics (IAEE) and Gesellschaft für Energiewissenschaft und Energiepolitik e.V., Deutschland (GEE).


25 June Anton Finenko presented “Temporal Emissions Associated with Electricity Generation: Case Study of Singapore” at the 7th International Conference of the International Society for Industrial Ecology, Ulsan, South Korea.

24 June Tilak K. Doshi presented “NUS Carbon Footprint”, at the Office of Environmental Sustainability meeting, NUS, Singapore.


11 June Elspeth Thomson presented “Energy Trends in the EU” at The European Union and the 21st Century European Studies Programme, NUS, Singapore.


16 May Tilak K. Doshi was a panelist on “The Future of Gas in Asia”, at The Economist Panel Discussion, Singapore.

7 May Tilak K. Doshi moderated, “Improving Energy Efficiency and Environmental Sustainability”, at the IEA-ERIA Workshop on ASEAN Energy Outlook, Bangkok.

Media Contributions


Philip Andrews-Speed interviewed by Radio Free Asia on China’s gas price reform, 10 July 2013.


Nur Azha Putra interviewed by APAC for Rigzone on South China Sea disputes and ASEAN’s response, 5 July 2013.

Christopher Len interviewed by Energy Intelligence on China-Vietnam energy cooperation in the Gulf of Tonkin, 20 June 2013.


Philip Andrews-Speed interviewed by Energy Intelligence on China’s new rules on investment, 10 May 2013.

Hooman Peimani interviewed by Energy Compass on Piggy-backing on big brother’s oil/gas deal, 10 May 2013.

Nahim Bin Zahur quoted in “Southeast Asia Oil, Gas Sector Unfazed by Haze”, Rigzone, 10 July 2013.
Recent Events

26 July, “Electricity Regulation and Electricity Market Reform in China” Seminar
Dr. Xiying Liu, an Assistant Professor of the School of Energy Research at the Xiamen University, China presented her research on regulation and reform in China’s electricity market. She focused on three issues: the regulation system and institutional reform, direct purchase of electricity from power plants to major end users, and the electricity pricing mechanism. She discussed how regulating China’s electricity market has proven to be an obstacle for future reform, but noted that institutional reform is paramount in order to solve current electricity-related problems. She added that while the recently approved direct purchases of electricity from power plants to major end users are considered an important step toward market-oriented reform in China, several barriers exist in their full implementation.

15–19 July, Workshop on Energy Economy Modelling in ENPEP BALANCE
Conducted by Mr. Guenter Conzelmann, Director of the Center for Energy, Environmental, and Economic Systems Analysis at the Argonne National Laboratory in Chicago, this course on the Energy and Power Evaluation Program (ENPEP – BALANCE) at ESI included an introduction to the ENPEP modelling framework for energy system supply and demand analysis and involved hands-on work sessions for participants to learn key model features, how to operate and run the model, develop model inputs and interpret the results. Part of the workshop was devoted to reviewing and improving the current ENPEP model representation of Singapore’s energy system.

12 June, “Energy Security in China: Role of Oil and Gas in the Global Context” Seminar
Dr. Kang Wu, Senior Fellow at the East-West Center, presented some of the key findings from his recently published book, *Energy Economy in China: Policy Imperatives, Market Dynamics, and Regional Developments* (World Scientific, 2013). He discussed China’s oil and gas import and investment strategies, its progress towards becoming self-sufficient in refining capacity and in building strategic petroleum reserves, as well as the prospects for unconventional gas.

16 May, “Evaluating LNG Project Risk: Introducing the Keroge LNG Project Success Index” Seminar
Mr. Vivek Chandra, Principal of Kerogen Consultants, identified approximately 30 criteria, grouped in four major categories, as being the key “success criteria” for LNG projects. Data from the criteria are calculated and presented as the Kerogen LNG Project Success Index (KLPSI). This innovative – yet simple to use and comprehend – index is best suited for LNG projects that are speculative, pre-FID and under construction. The KLPSI scoring system is neutral and is largely based on non-disputable public information. Mr. Chandra noted that the KLPSI can be a valuable tool for analysts to study and evaluate the impact of very large LNG projects in the region.
Nuclear Governance Post-Fukushima Conference
Thursday, 31 October 2013, 9am - 5.15pm
Two years have passed since the Fukushima nuclear accident occurred. Since then, Japan’s energy policies have shifted from pro-nuclear to fossil-fuel oriented. As it stands today, the Japanese government has shut down almost all of its reactors. However, as evident in the reactivation of two reactors in 2012, the Japanese government is likely to partially rehabilitate the country’s nuclear energy sector due to a number of factors, including the high cost of natural gas and oil. In East and South Asia, as of October 2012, there were plans to build 92 more plants, mainly in China, in addition to the 44 under construction and 117 in operation. In Southeast Asia (SEA), Vietnam has begun serious preparations towards realising its nuclear energy ambitions and other SEA states such as Malaysia, Indonesia, Myanmar and Thailand have all indicated an interest in embarking on similar projects in the future. Thus, it appears that the Fukushima incident has not thwarted Asia’s nuclear energy aspirations. Against this background, the speakers at this event, organised jointly by ESI and the Rajaratnam School of International Studies (RSIS) will analyse the impact of Fukushima on nuclear governance in Asia, based on the International Atomic Energy Agency’s 3S: Security, Safeguards and Safety. They will also articulate and map out the various existing nuclear governance models and outline a model that is perhaps best suited to SEA’s social, cultural, economic and political landscapes.

Speakers:
• Professor Dato’Aishah Bidin, Dean, Law Faculty, Malaysia National University
• Associate Professor Mely Caballero-Anthony, Head, Centre for Non-Traditional Security Studies, RSIS
• Professor S.K. Chou, Executive Director, Energy Studies Institute, NUS
• Dr. Alistair D.B. Cook, Visiting Research Fellow, East Asian Institute NUS
• Ambassador Dr. Barry Desker, Dean, RSIS, NTU
• Mr. Nicholas Fang, Executive Director, Singapore Institute of International Affairs
• Mr. Andrí Gritzevski, International Atomic Energy Agency, Austria
• Ms Sofiah Jamil, Adjunct Research Associate, RSIS
• Dr. Kumiaki Moriya, Senior Chief Engineer, Hitachi-GE, Nuclear Energy Ltd., Japan
• Mdm. Ton Nu Thi Ninh, Former Ambassador of Vietnam to the European Union and Director, Tri Viet Center for Social and Educational Research, Vietnam
• Dr. Hans–Holger Rogner, International Institute for Applied Systems Analysis, Austria
• Mr. Fabby Tumiwa, Executive Director, Institute for Essential Services Reform (IESR), Indonesia
• Dr. Zhou Zhanglei, Assistant Director, Sunshine Law Firm, China

The Resurgence of Coal: Trends and Challenges Roundtable
Thursday, 31 October 2013, 2pm - 5.30pm
This roundtable, organised jointly by ESI and the International Energy Agency, will focus on the resurgence of coal in the energy landscape and discuss market realities and developments as well as the challenges in terms of climate change mitigation targets. After providing an overview of global coal supply trends and projections, the six speakers will then examine various coal demand and supply scenarios in Asia, notably China, India and ASEAN where countries such as Indonesia, Vietnam, Thailand, Malaysia and the Philippines are increasing cooperation through the ASEAN Forum on Coal (AFOC). The discussion will then focus on the high emissions resulting from coal use and the potential and challenges of various carbon capture and storage methods. Particular questions that will be addressed in this roundtable include:
• Are current coal prices incentive enough to trigger new investments in coal supply chains?
• Whereas gas is more competitive than coal in the US, in Europe it is the other way around. How might this competition evolve?
• Can coal be a low-carbon fuel in the future? Which policies can drive this?

Speakers:
• Dr. Carlos Fernández Alvarez, Senior Analyst, International Energy Agency
• Mr. Mark Gresswell, Director & Chief Analyst, Salva Resources Pty Ltd
• Mr. Bob Kamandaranu, Chairman, Indonesian Coal Mining Association
• Dr. John Kunkel, Deputy CEO of the Minerals Council of Australia
• Dr. Andrew Minchener, Clean Coal Centre, International Energy Agency

Unconventional Gas in East Asia Roundtable
Friday, 1 November 2013, 9am - 12 noon
Over the last decade, the application of horizontal drilling with hydraulic fracturing, multi-well pads with longer laterals and improved stimulation techniques have substantially lowered the cost of producing natural gas from shale and coalbed formations. These developments all first occurred in North America. Unconventional gas resources are now being found elsewhere in the world, including East Asia, but a range of legal, economic, political, technological and geological factors threaten to constrain production in the short term. As technology allows these shales to become economically viable, the world supply of natural gas will become more elastic, tending to lower prices and increase demand. In addition, the regional distribution of production will change, altering patterns of supply and demand. Over the last decade, the application of horizontal drilling with hydraulic fracturing, multi-well pads with longer laterals and improved stimulation techniques have substantially lowered...
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We welcome your feedback, comments and suggestions. The views expressed in each issue are solely those of the individual contributors.

If you would like to be put on our mailing list or know someone who should be on it, please write to Ms Jan Lui at esilyyj@nus.edu.sg.