Impacts of seaborne trade on coal importing countries – Atlantic market

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Abstract

In recent years, there has been a convergence of international trade with traditional domestic markets. With imports increasing in many coal-producing regions, the influence of trade on domestic markets has been twofold: firstly, imported coal displaces domestic production, and in doing so, and secondly international price trends may drive prices of what remains of the indigenous market for coal.

While international trade does not provide any additional benefits in terms of reduced CO_2 from coal-fired power stations, importing coal provides many benefits, such as cost savings, improved coal quality, enhanced supply diversity, and often fills a gap left by domestic supply. This report examines the various factors that have led to rise in popularity of seaborne traded coal, and seeks to discuss the future of domestically-produced coal in some of the major coal markets of the world.

This report, which concentrates on the Atlantic market, is one of three reports that examine how coal markets have evolved over the decades with utilities and heavy industry moving away from their seemingly secure yet captive markets of domestic coal to procuring more supplies from the international market to reduce costs and provide a better quality coal. The two sister reports look at the Pacific market and a global summary of international coal trade.

Acronyms and abbreviations

API2	coal price indices for northwest Europe
AR	as received
ARA	Amsterdam, Rotterdam, and Antwerp
AUS	Australia
BAFA	German domestic pricing system
BAT	best available technology
Ca	Calcium
CAA	Clean Air Act (USA)
CAPP	Central Appalachia
CCGT	combined cycle gas turbine
CFBC	circulating fluidised bed combustion
CIF	cost, insurance and freight (coal price at destination port prior to unloading)
CIL	Coal India Limited
Cl	chlorine
CNCIEC	China National Coal Import Export Commission
COL	Colombia
COP	Conference of the Parties
Crore	10 million
DB	Deutsche Bahn
DES	delivered ex-ship
DGTREN	Directorate General of Transport and Energy (EU)
dwt	dead weight (freight capacity, typically the maximum cargo capacity)
EC	European Commission
EIA	Energy Information Administration (US Department of Energy)
ELV	emission limit values
EUETS	European Union emissions trading system
FGD	Flue gas desulphurisation
FOB	free on board (coal price at export port)
GDP	gross domestic product
GJ/t	gigajoule per metric tonne
Gt	gigatonne (1000 Mt)
GWe	Gigawatt electrical generating capacity (= 1000 MWe, one watt = 1 joule per second)
ha	hectare
HCl	hydrogen chloride
HEPCO	Hokkaido electric Power Company
HGI	Hardgrove Grindability Index
IDT	Fusibility of Ash
IEA	International Energy Agency
IEA CCC	International Energy Agency Clean Coal Centre
IED	Industrial Emissions Directive
IGCC	integrated gasification in combined cycle
INDO	Indonesia
INR	Indian rupees
IPP	independent power producer/production
kcal/kg	kilocalorie per kilogramme (typically net), referring to the heating value of steam coal
km	kilometre
KRW	Korean wong (currency)
Lakh	100 units, 10^2
LCPD	Large Combustion Plant Directive (EU)

LHV	lower heating value
MCIS	McCloskey Coal Information Services
METI	Ministry of Economy, Trade, and Industry
Mg	magnesium
mg/m^3	milligrammes per cubic metre
MJ/kg	megajoules per kilogramme
MoU	memorandum of understanding
MPa	mega Pascal
Mt	million metric tonnes
Mtce	million tonnes of coal equivalent (multiply by 0.7 to obtain Mtoe)
Mtoe	million tonnes of oil equivalent (divide by 0.7 to obtain Mtce)
MWe	megawatt (1000 kWe)
MWth	megawatt capacity (thermal)
NAPP	Northern Appalachia
NAR	net as received, for coal pricing
NCV	net calorific value
NDRC	National Development and Reform Commission
nm	nautical mile
NOx	nitrogen oxide compounds
NWE	northwest Europe
OECD	Organisation for Economic Cooperation and Development (OECD)
POL	Poland
PRB	Powder River Basin
R&D	Research and development
R/P	reserves to production ratio
RB	Richard's Bay (same as RBCT)
RBCT	Richard's Bay Coal Terminal (Republic of South Africa)
RMB	Chinese renminbi (currency)
RUSS	Russia
ScoTa	Standard Coal Trading Agreement
SCR	selective catalytic reduction
SOx	sulphur oxide compounds
SSY	Simpson, Spence, and Young
t	metric tonne
TEPCO	Tokyo Electric Power Company
TPES	Total primary energy supply (net balance of production, trade, storage and losses)
TWh	terawatt hour (equal to 1000 GWh; 1,000,000 MWh)
UMPP	ultra mega power project
WTO	World Trade Organisation

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1 Introduction

Over the last 30–40 years, the international market for seaborne traded coal has matured with immense potential for further growth. This market is now around 1 billion tonnes (Gt), some 0.7 Gt being steam coal and the rest metallurgical coal; international trade accounts for 15–20% of world hard coal supply. Locally produced coal therefore accounts for more than 80% of all the hard coal consumed in the world.

Over some years, there has been a convergence between internationally-traded coal and traditional domestic markets. The influence of trade on domestic markets has been twofold. Where the transport infrastructure exists, cheaper imported coal has displaced locally-produced coal, causing a decline in local production especially in many OECD countries. Secondly, international price trends can drive the prices of all or part of domestic coal markets. Blending domestic and imported coal is commonplace, while a complete switch to imported coals is necessary when domestic supplies have disappeared, or become prohibitively expensive to produce.

Imported coal provides many benefits, notably lower cost and often offers an improvement in coal quality, which enables power stations to operate within stricter emission regulations. Stricter local environmental planning-based regulations often limit mining activity in certain parts of Europe, enabling imported coal from countries with fewer such restrictions to operate more competitively. This aspect of planning is not covered in the report as land use restrictions and opposition to certain energy projects also hamper nuclear and some renewable energy projects.

Historically, imports filled a temporary shortfall in domestic supplies mainly in the Atlantic market (*see* Baruya, 2012). Once the appetite for imported coal developed, shifting towards imports was commonplace. World trade patterns have shifted towards Asia with large customers situated in almost every country between India and Japan.

This report focuses on the impact of coal imports in selected OECD countries located in the Atlantic market. An accompanying report on global trends provides a rudimentary introduction to world coal trade, and another report examines major Asia Pacific import markets of Japan, Korea, India, and PR China.

The Atlantic market serves as an important model for global market trends as many OECD countries importing coal into this region have mining industries that serve power markets which operate under strict environmental regulations on air pollution (as well as water and waste). Crucially, the air pollution regulations operate in combination with legally binding reductions in greenhouse gas emissions creating an extremely challenging climate for all participants. As such, OECD Europe serves as an excellent model.

The coal importing OECD countries studied in this report are **Germany**, **Spain**, the **UK**, and the **USA.** These economies all have a long history of producing coal, but in turn have seen local coal industries experience intense competition from non-local and/or foreign coal supplies. Much of this market pressure comes from price competition from cheaper coal supplies being transported, sometimes over vast distances from lower cost producers. Coal pricing is discussed generally in the Global Summary report, but in this report a simple coal price comparison between imported and domestic products (to large customers such as power utilities) is considered for each country. The main issues which cause a displacement of domestically-produced coal are described as follows:
- coal’s role in primary energy supply;
- coal supply trends and the increasing role of international trade;
- the demand for steam coal in the power generating sector;
- cost advantages of coal importing;

- coal import logistics.

One issue that is not considered in this report is the impact of rising imports on the exporter countries. Europe accounts for half of Russian coal exports, although Asian demand will open up better opportunities for exports to the east. Much of the new coal development in Russia will therefore be in eastern coalfields, while European business could dwindle. However, the decline of domestic hard coal production in parts of Europe could maintain demand for Russian coal for the time being while the industry restructures to export coal elsewhere.

2 Germany

Germany is Europe's largest economy and is a leading exporter of machinery, automobiles, chemicals and household goods. The former East Germany remains relatively underdeveloped, with high unemployment rates in some municipalities. GDP contraction was in line with almost every other major economy in Europe falling by more than 4–5% in 2009, but rebounded in 2010 by approximately 4%. GDP is roughly US$3.0–3.5 trillion, with exports worth around US$1.3 trillion.

The coal industry was the driving force for the energy economy in much of the 20th century, but coal no longer enjoys the same status. Both hard coal and brown coal (lignite) are mined, but restructuring and competition means the future of mining in Germany is uncertain, at least for hard coal. Mining technology and expertise is, however, an area in which Germany could expand, providing services in mine operations around the world. The prospects for lignite mining are better than for hard coal given lignite reserves are plentiful and more easily mined, and furthermore the lignite fields are located in more economically-challenged parts of Germany, so forced closure of mining in this area is politically sensitive.

2.1 Primary energy

The market for hard coal in Germany is dominated by demand from the power sector, although a considerable amount is used by the steel sector. However over the years, coal consumption declined. Germany has faced a long-term decline in primary energy supply for many years, with an annual average fall of roughly 0.5%/y since 1990, yet still requires conventional thermal energy to supply its market. In 2009, the country's total primary energy supply (TPES) fell 6% to 319 Mtoe, the same level as it was in 1972, yet German TPES was still more than the combined consumption for the UK and Spain. Germany has undergone a period of uncertainty in its energy markets, not least from the forced closure of nuclear power plants, which appears to be ever more pressing in the face of the moratorium on nuclear output from older stations in the first half of 2011.

Oil products dominate the energy market accounting for almost 33% of TPES, mostly accounted for by transport fuels. Germany has committed itself to massive investment in renewable energy for the 21st century. According to the Renewable Energy Source Act or *Enreuerbare Eregien Gesetz* (EEG) 2012, renewable energy will account for 35% of the electricity production by 2020, for 50% by 2030, for 65% by 2040 and for 80% by 2050, encompassing all forms of renewable power but awarding different feed-in tariffs for each.

However in terms of TPES, renewable energy currently accounts for less than 2%, so establishing a renewable foothold in the economy will depend upon the power sector. Nuclear energy accounts for 23% of TPES, while coal is just 11% of TPES. It is therefore a stark reminder of the gap that will be left both in TPES and most notably the power generation supply market when Germany's nuclear stations come offline in coming years. Energy-efficiency measures and renewable technologies will require a massive step jump in the advancement of 'market destruction' of fossil fuels and nuclear power, along with advancements in energy storage to fulfil such impressive ambitions.

2.2 Coal supply

While there is fluctuation on a year-by-year basis, the average level of hard coal demand hovers around 35 Mtce/y. Yet the supply of coal over the years shows a displacement of local production in favour of imported coal. Figure 1 shows the trend in steam coal imports into Germany, some of which come via the ports located in Northern Germany, Belgium and Netherlands (*see below*). Lignite

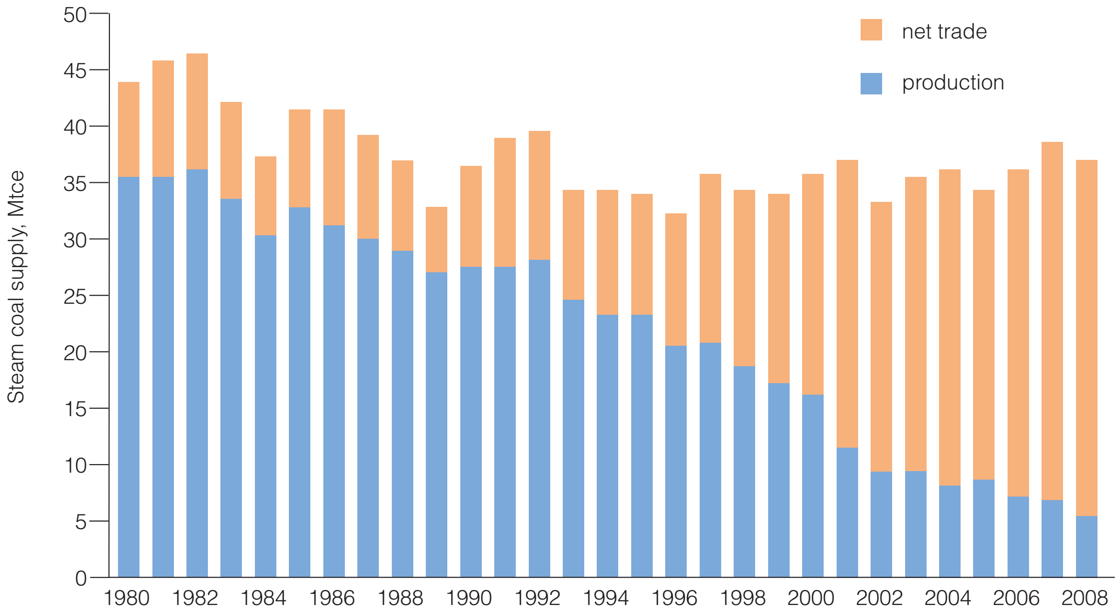

Figure 1 German steam coal supply, Mtce (IEA, 2010b)

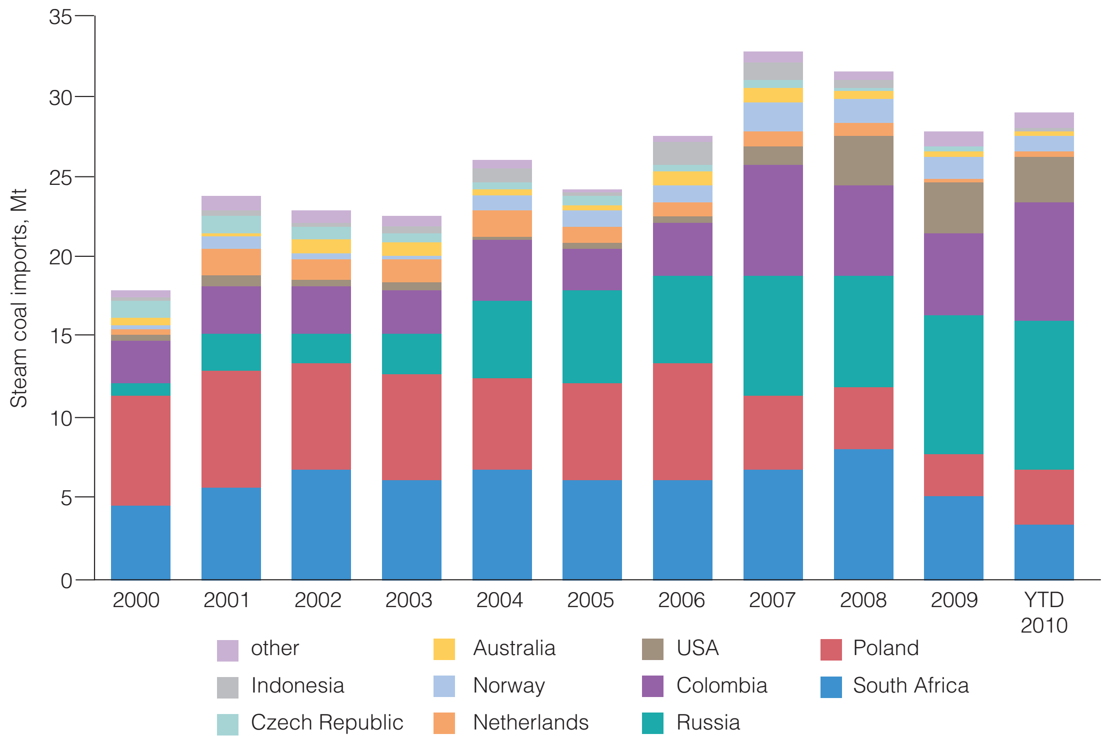

Figure 2 German steam coal imports by source country, Mt (MCIS, 2012)

production has been fairly constant for many years, at a level of around 50–60 Mtce/y of which just 3–5 Mtce/y is imported by rail, but this fuel is not covered in this report. Figure 2 shows the countries from which the German coal buyers procure their foreign steam coal supplies. In the past, South Africa, Poland and Russia have been the main sources of imports, but in recent years, business has shifted towards Colombia and the USA. Russian trade has grown steadily and, like much of Europe, accounts for the bulk of Germany's imports.

2.3 Coal production

In 2002, the IEA carried out an Energy Policy Review for Germany which stated that coal and lignite were the most important indigenous energy resources in Germany (IEA, 2002). However, rationalisation in the coal industry has meant employee levels falling from 166,000 in 1985 to 35,000 in the 2000s.

Production occurs in the regions where the hard coal deposits are located – these are in two areas both on the western border of Germany. On the Netherlands border is the North Rhine-Westphalia (Ruhr mining area), and on the border with France in Saarland is the Saar mining area. Smaller deposits are found Ibbenbüren, north of the Ruhr area. Lignite coalfields are more widespread with deposits scattered from the western borders with the Netherlands (Rhenish) all the way to the Polish border in the Saxony, Saxony Anhalt and Brandenburg regions in the east. Some lignite coalfields are located throughout the centre of Germany.

Production in 2007 from the major coalfields can be broken down as follows: 74% from the Ruhr area, 17% from the Saar and 9% from the Ibbenbüren coalfield. Hard coal production is therefore mainly concentrated in North Rhine Westphalia Ruhr area. By 2010, the production capacity for bituminous and anthracite coals totalled 13 Mtce/y (VdK, 2010). The largest producing mines were *West*, *Prosper Haniel* and *Auguste Viktoria*, each with capacities of 3 Mtce/y (*see* Table 1). *West, Prosper-Haniel, Lippe, AugusteVictoria/Blumenthal* and *Ost* are located in the Ruhr area, the Saar mine in the Saar coalfield and another mine near Ibbenbüren. *West Ensdorf* and *Ost* were earmarked for closure between 2010 and 2013. *Auguste Viktoria* and *Ibbenbüren* and *Prosper Haniel* as potentially the only viable operations to exist in 2014. *Auguste Viktoria* is an underground mine operating at maximum depths of 1.2 km below ground producing high quality coal from a highly mechanised operation using longwall shearers.

In 1996, the ‘Kohlepfennig’ tax on electricity was abolished, this ended an important source of income that helped finance the hard coal industry in Germany. The German courts ruled the policy to be against the German constitution, which at the same time voided the ‘Jahrhundertvertrag,’ the treaty that also aided subsidised coal production. In March 1997 a new ‘Coal Compromise’ was negotiated between the coal industry, the mining trade union, the German federal government, and the state governments of the key producing regions of North Rhine-Westfalia and the Saarland. As part of a restructuring programme, the 90,000 employees that were on the payroll in 1997 would be cut by a massive 50% in 2005 but, as mentioned above, employee levels could be closer to less than 35,000.

In 1997, Germany’s largest hard coal producing corporation, Ruhrkohle (RAG) Bergbau AG, took over Saarbergwerke AG, a government-owned coal mining company based in Saarbrücken. This takeover/merger of RAG and Saarbrucken led to a new combined coal production company, Deutsche Steinkohle AG. Another new subsidiary, the Saarberg AG, organised all non-coal activities of the former Saarbergwerke, RAG’s environmental services and oil trade.

Table 1 Estimated production at German mines, Mtce (VdK, 2010)

	2009	2010
West	3.0	3.0
Prosper Haniel	3.2	3.2
Auguste Viktoria	3.2	3.2
Ost (closing Sep 2010)	1.8	0.8
Ensdorf	1.0	1.0
Ibbenbüren	1.9	1.9
Total	14.1	13.1

More than ten years after the formation of Deutsche Steinkohle, the European Commission announced proposals to phase out state coal aid by 2014 (announced in July 2010). Under this initial plan German hard coal production would cease, although lignite mining which is unsubsidised would appear unaffected. The German government

Table 2	**Planned programme of coal mine operations in Germany, Mtce** (VdK, 2010)
	Estimate up to 2018
2009	14.1 (closure of Lippe 1 Jan 2009)
2010	13.1 (closure of Ost 30 Sep 2010)
2011	12.3
2012	11.3 (closure of Ensdorf)
2013	8.0 (closure of West)
2014	8.0
2015	6.0
21016	6.0
2017	4.0
2018	4.0

pre-empted the EU with a phase-out programme of subsidised coal mining, with state aid ceasing in 2018 under the German hard coal Financing Act which was passed at the end of 2007; the EU ceded to the German plan and 2018 is the current target for subsidy cessation. While the schedule for mine closure could change, in early 2010 the VdK set out a likely plan that the closure might take, with some 4 Mtce of production capacity still available in 2018 (*see* Table 2).

While Germany's subsidised coal mines are undergoing closure, supporters of coal mining in Germany point out that keeping some pits open will limit Germany's dependence on imported coal and provide a base for the country's world-leading mining equipment industry. A similar situation exists for Japan for its dwindling underground mining sector, but still thriving training and R&D industry which exports expertise for coal exploration and mining to the rest of Asia.

As part of the programme, some mining housing in the Ruhr area was being refurbished. Some housing in the outskirts of Dortmund, Duisburg and Essen are placed under monument protection along with the steel hulks of pit heads. However, other areas are struggling to cope with the decline. The Ruhr town of Gelsenkirchen has an unemployment rate of 16%, on a par with cities in the more economically-depressed eastern regions. Clearly industry restructuring comes at a price of some local communities.

2.4 Coal demand

Despite the decline in domestic production, coal remains very much in demand. Coal-fired power commands more than a 40% share of the electricity generating market, comprising hard coal and lignite generation. Fuels derived from coal, such as blast furnace gas and industrial process gas, are also used to generate power. In 2009, coal consumption by power generators (public and autoproduction) and combined heat and power plants was 86 Mtce. A further 7.5–8.0 Mtce/y of coal was used in heavy industry, of which 4–5 Mtce/y was coking coal for steel production; the remainder was used in cement manufacture, paper production, and other energy intensive industries.

Demand for domestically-produced coal comes from both power stations and large industrial operations located in the Ruhr area. Some examples of domestic coal consumers include the Evonik plant operated by Steag, and a number of power plants operated by the utilities E.ON and EnBW are located in the Ruhr mining region.

Based on IEA CCC research, at least 40 power stations are known to have burned domestic coal, either in blend with imported coal or on their own. These stations, where such data are known, amount to roughly 23 GWe of Germany's generating capacity, but it is likely many more stations burn domestic and/or imported coal. Some stations, such as Wilhelmshaven and Rostock, that are located on or close to Germany's north coast are dependent on imported coal, but such stations are fewer in number. Perhaps 3–4 GW large power stations are firing a feed of 100% imported coal.

With regards to the majority of stations that burn domestic products, the 23 GWe of capacity or so could equate to a coal burn of more than 40 Mtce of coal per year. However, domestic production of hard coal will never fulfil this level of demand given the cost of production and the committed closure plans. By 2014, whatever is left of domestic steam coal production is likely to be delivered to a handful of plants in the Ruhr operated by Steag, and the Ibbenbüren anthracite mine, which supplies RWE's Ibbenbüren coal plant. From 2015, most of the power stations that are affected by the closure of German mines will seek to import coal or be decommissioned (VdK, 2010).

In recent years, demand for coal was affected by a number of other factors, not least the softening in demand as a result of the economic decline since 2007. Electricity generation fell for the third year in a row in 2009 to less than 600 TWh, a massive reduction of 40 TWh on previous years, a drop equivalent to all the electricity generated in Denmark. By 2010, generation grew again by just over 2% to bring total generation to 614 TWh.

While coal-fired power stations were typically base load stations, some of the nation's fleet is adopting a new role as a *load follower* to renewable generation, and so some stations might operate at lower loads. Unpredictability in the output of renewable power can be balanced with power imports and thermal generation. Wind and solar (power) generating capacity accounts for a massive 21% of the country's total capacity, but the actual output accounts for just 8% of national generation. Renewable output rises to a more creditable 18% (of national generation) when hydroelectricity, biofuels and waste are considered. While this seems impressive, these data can mislead since 40% of hydro production is from pumped storage plants. These hydro power stations are extremely effective and large-scale renewable storage plants. However, they consume vast amounts of electricity to pump the 'depleted' water back up into the storage reservoir, an average of 7000 GWh of electricity every year; the highest pumped storage output (and consumption) in Europe and almost a third of that produced in the USA. Battery/capacitor storage, flywheels, and compressed fluid storage systems are at small scale and cost too much to replace the current fleet of thermal power stations, although there is some potential in hybrid systems that use water and compressed air in natural bodies of water.

Nevertheless, thermal power generation from conventional sources (coal, natural gas, nuclear, and oil products) still accounts for 81% of Germany's power generation. The Government target to generate 80% of electricity from renewables by 2050 is ambitious and noble, but thermal generation capabilities are significant enough to seriously consider how energy tariffs could increase if coal-fired power (and indeed nuclear power) is eradicated from the German power system.

2.5 Quality advantage of imported coals

As mentioned earlier in this report, German coal-fired power plants were originally designed for local domestic coals. These included bituminous coals mined in the Ruhr and Saar regions, with lignite stations in the Rhenish region of western Germany and the Saxony regions of eastern Germany.

Imported coal displaces domestic coal easily since the coal qualities of international coals, particularly those from South Africa, are very similar to those mined in Germany. When comparing imported and domestic hard coal qualities, sulphur content and heating values are almost identical; ash content is also similar although mineral matter composition may differ. Other factors such as chlorine may well be an issue. In the short and medium term, domestic lignite production is unaffected by imported hard coal, although blending is feasible.

The heating (calorific) values of coals from the Ruhr region can range from 29 to 32 MJ/kg (LHV), while some power stations use Saarland coal which might range from 21.6 to 27.2 MJ/kg (LHV). These are only sample ranges, and the true representative qualities may well differ from these figures. In the past, German utilities designed boilers to take coal of some 29 MJ/kg NAR (7000 kcal/kg). However, the quality of coals being imported via ARA is around 24.9 MJ/kg NAR (6000 kcal/kg) (Teicher, 2008).

Power stations burning imported coals blended with domestic coals show a heating value range of 23–33 MJ/kg; the average heating value of imported coal is slightly lower than that of the average heating value of German coals (25.7 MJ/kg versus German coal at 27.1 MJ/kg). This suggests domestic bituminous coals are of a slightly better quality with respect to heat content than imported products. The ash content of domestic coals is in the range 4–19%, and moisture is little more than 9%, so the overall quality is comparable with internationally-traded coals. Coal quality has therefore not been a major issue for German utilities when switching from domestic to imported coals.

When comparing sulphur content, the differences are small. Sulphur in domestic coal might average just 0.1% *higher* than the content of the average blend of domestic and imported coals. Some coals from the Ruhr exceed 1% sulphur (AR), but little seems to exceed 1.2% and many are around 0.9–1.0% (AR). These levels put most coals mined in the Ruhr on the periphery of a high sulphur coal compared with the international coals, which trade typically at 0.7% or below; Saarland coals average around 0.7–0.8%.

Based on these sulphur contents, if burnt unabated a 1% sulphur domestic coal (as received basis) would lead to an emission concentration of around 2000 mg/m^3. Blending or replacing with 0.7% sulphur coals reduces unabated SO_2 emissions to roughly 1550 mg/m^3. Reductions of 20% or so are therefore achieved by coal switching and blending, assuming all other qualities remain broadly unchanged. This level of desulphurisation however is not enough. Large combustion plants falling under EU regulations have a sliding scale for sulphur emissions, ranging from 400 mg/m^3 for large plants (>500 MWth) while newly-built plants must meet sulphur levels of 200 mg/m^3. Some variation is permitted when determining daily mean values. Rates of desulphurisation are therefore stipulated in addition to the emission concentrations from the stack.

Germany's standards are tighter than those required by the EU, although the regulations are not straightforward. EU regulations demand a desulphurisation rate of roughly 92–94% for large plants to 60% for small plants; German regulations demand 92% desulphurisation for even the smallest plants. The reduction in SOx emissions in Germany will have logically resulted from the installation of FGD to the nation's power stations, either through a retrofit programme or the fitting as standard to newer stations. Nearly all GWe of hard coal-fired power capacity has been fitted with FGD. When combined with a low sulphur coal feed, power stations in Germany can achieve very low emission values.

Sourcing low sulphur coals from foreign sources is not problematic. Imports regularly come overland by rail from Poland; Russian coal comes via the Baltic ports; and seaborne coal comes from Colombia, South Africa and the USA, entering via ARA or German ports (*see below*). In past years, German buyers have bought steam and metallurgical coals from more than 40 countries. For power generation, utilities like E.ON are exploring the use of biomass to meet environmental objectives, so future import choices could change depending on the compatibility of cofiring with sustainable fuels. Each power station has individual challenges regarding fuel procurement depending on the location of the power station to the port and the environmental performance of the plant with the imported fuel. However, the next section discusses one of the most important issues that is partly driven by coal quality, and that is the cost of coal.

2.6 Cost advantages of imported coal

Germany is well known for having a high-cost mining industry which is heavily subsidised to maintain operations. According to the VdK (2010), the average cost of production in German mines was 170 €/tce in 2009 (*see* Table 3). German coal had a premium of 96–111 €/tce over imported coal in 2009. Rademaekers and others (2008) carried out research covering German coal production and state aid. In this report, an estimated world price for coal was just 46 €/tce and, despite the change in the world market price since 2005, the overall conclusion was similar with sales aid averaging around 100 €/tce. The conclusions all point to a heavy burden of state aid on federal budgets.

Table 3 **Comparison of German steam coal/spot prices CIF ARA in 2009, €/tce** (VdK, 2010)			
	1 January	30 June	31 December
Costs German coal – free mine	170	170	170
Spot price	74	59	62
Advantage import coal	96	111	108

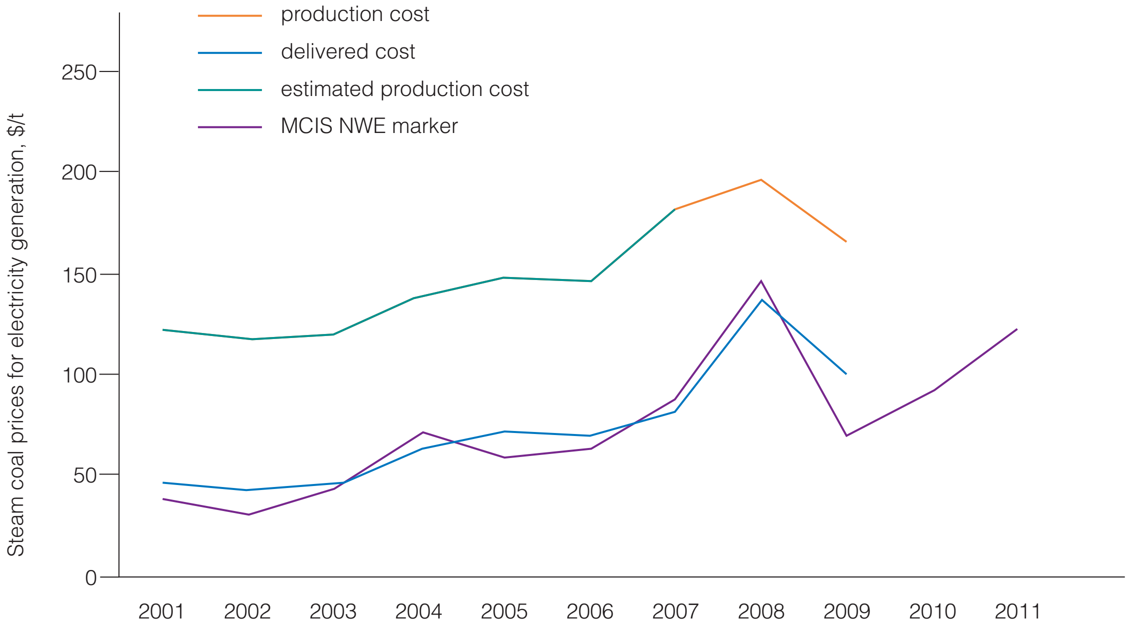

Figure 3 Steam coal prices to German power stations, $/t (IEA, 2010a; MCIS, 2012; Author's estimates)

In 2007, the total level of state aid to the hard coal industry in Germany was €2.9 billion. Almost €1 billion was allocated to cover *exceptional* costs and *reducing mining activity* under Articles 5-3 and 4 of the EU state aid regulations. Almost €2 billion was paid (directly or indirectly) to finance the high-cost operations of domestic mines so that they could compete with imported coal. As Figure 3 shows, the cost of coal delivered at German power stations more or less tracks the cost of coal imports, but with much less volatility (*see* Figure 3). The same is true for the price trends for coal produced in the UK. Based on this evidence, German and UK generators are shielded from the price volatility due to having a certain proportion of their coal supplies from contracts with domestic producers. The reason why German prices follow world prices is due to the pricing system that uses reported world prices to calculate the operating subsidies. This system is devised by the Federal Office of Economics and Export Control (*Bundesamt fur Wirtshaft und Ausfuhrkontrolle* or BAFA).

BAFA determines the level of subsidies for German hard coal mining after collecting domestic production costs and monthly prices for imports for steam and coking coal at the German border (BAFA, 2010). Companies that import coal have to report the volumes and prices monthly. The BAFA mechanism calculates the border price for imported hard coal in €/SKE (standard coal equivalent or 29.3 GJ/t) which determines coal import values for subsidy calculations. The BAFA prices lag behind the reported indices such as the API2 benchmark price for coal imported into northwest Europe (calculated as an average of the Coal Argus CIF Rotterdam assessment and McCloskey's northwest European steam coal marker). The BAFA price is calculated monthly and quarterly.

Price competition between imported and domestic coal has clearly been one of the major factors to cause the displacement of high cost domestic coal. It is not straightforward to determine the reason behind the high costs, but productivity is low by world standards. Low productivity suggests the industry is overmanned despite being highly mechanised, an issue also seen in the UK. This is partly because of the difficult geological conditions faced in deep underground mines. In addition, European operations might work fewer (yet longer) shifts, to avoid local environmental impacts. This would make competing difficult, especially with coal being supplied from large-scale opencast mines that operate for 24 hours/day in favourable geological conditions. Furthermore, the German industry, being predominantly underground, may deploy more cautious working practices (not applicable to lignite mining), as well as awarding better remuneration on a per employee basis.

German hard coal production has shrunk from 150 Mt in 1957, the heyday of the postwar economic recovery, when the industry employed 607,000 miners. By 2006, the coal industry was employing 35,000 people (Spiegel, 2007). Since then, there are suggestions that the workforce has been further reduced to 32,000, with a subsidy equivalent of US$100,000 per worker.

Few reports (if any) state clearly what the employment rate is in the hard coal and lignite mines, but some clues suggest that around 2004, the lignite mining industry employed some 11,200 workers, of which 8200 or so were directly linked to mining.

This suggests that the hard coal industry employed 20,000 people in underground operations with production levels for hard coal being 10 Mtce/t of steam coal and 15 Mtce/y of coking coal; productivity in the hard coal sector is an estimated 1250 tce/manyear (steam and coking mines).

At around this time, the lignite industry produced 50–60 Mtce/y (100 Mt/y) from opencast sites. Productivity was therefore 6600 tce/manyear (9000 Mt/manyear) in the lignite mines. If only mine-related staff are considered, then productivity would be in excess of 12,000 t/manyear.

Given the relatively high quality of German coal, the adjustment of tce to metric tonnes would barely hide the low productivity of the German hard coal industry. Coal mining is mechanised, but the reserves are facing increasingly difficult geology. The average production depth is 920 metres, and much of DSK's operations are based on longwall mining. Seam thicknesses range from 1 to 4.8 metres, with ploughs and shearers being employed in thinner seams and thicker seams respectively. German mines make use of German mine equipment, so the closure of mine operations will have considerably wider effects in the engineering sector.

2.7 Coal import logistics

Seaborne coal imports enter Germany through ports located on the North Sea and the Baltic Sea, while other seaborne trade arriving through ARA is transferred to stockpiles and overland transportation systems such as river barges along the Rhine river and/or rail lines to the German border. Imports can be sent by rail from the inland Silesian coal mines in southern Poland.

The rail network across Europe is extensive, but there is a dearth of publicly-available information with regards to the actual routes taken. The major German corporation RAG owns 600 km of railway and 140 locomotives which can transport 70 Mt of coal across the Ruhr. In addition, Ruhrkohle owns ten harbours and a shipping company at Duisburg harbour on the Rhine river as well as owning shares in a shipping company at Rotterdam.

DB Schenker Rail is a major rail company operating in Germany and across Europe. In 2010, DB Schenker Rail Business Unit transported 65.5 Mt of hard coal and coke, and 7.4 Mt of lignite (DB, 2010). DB Schenker also transports lignite briquettes, but lignite products are generally transported locally. Most coal from ARA is transported to the German border via the Emmerich rail terminal by DB Schenker Nederland, and then to the rail hub at Oberhausen West. DB Schenker Rail also operates a subsidiary, RBH Logistics, which receives coal from E.ON, and then blends coals for onward transportation to customers. DAP Barging BV organises shipping by inland waterways from ARA to the terminal at the inland Port of Duisburg at the heart of the steam coal market in *Nordrhein Westfalen* (Ruhr coalfields) and *Rheinland Pfalz* (Saar coalfields). Based on the locations of the main ports and major power stations, a simplified map of inland transport routes is shown in Figures 4 and 5, and described as follows:

- *Amsterdam-Rotterdam-Antwerp ports (ARA)*: coal is imported via ARA and then transported either by barge or train eastwards to the power plants in Nordrhein-Westfalen. ARA transhipments account for approximately 40–50% of all imports.
- *Northern German ports of Wilhelmshaven, Cuxhaven, Hamburg, or Rostock*. Coal is directly transferred to the power plant where the plant is located coastally, or forwarded to the power plants further inland via barge or rail.
- *Eastern German/Polish border* (*see* Figures 4 and 5) – coal is transported across the border by rail from Poland or Czech Republic, although supplies from Czech Republic have dwindled considerably in recent years along with a reduction in Polish imports. Poland's trade has reduced to around 10% of Germany's coal imports, compared with 20–40% seen before 2007. Rail routes traverse the south of Germany to transport coal to plants in Hessen, Rheinland-Pfalz, and Baden-Wuertemburg.

Coal entering via ARA can be transported to the German border, where large rail terminals such as *Emmerich, Oberhausen, or Venlo* can receive coal for further transport into the German regions. Rail and river routes traverse deep into Germany, as far south as Frankfurt and Stuttgart. In Figures 4 and 5, the power stations marked with D & M in parentheses indicate stations which are known to have used a blend of domestic (D) and imported (M) coals. Many stations are also combined heat and power (cogeneration) plants that are located throughout Germany such as Staudinger, Heilbronn, Rhienhafen, Gersteinwerk, and Scholven. Almost all of these stations are linked by rail capable of taking coal from ARA. The Port of Rotterdam is capable of some of the highest annual throughput in mainland Europe. Ports in Belgium also serve the German market. Netherlands and Belgium still operate a number of coal-fired power stations.

In 2010, the key ports that served northern Europe handled 73.7 Mt of hard coal, down from 90 Mt/y in 2008. German ports have a throughput capacity of around 63 Mt/y, although hard coal imports into Germany were well below maximum capacity at roughly 40 Mt/y (of which 30 Mt/y steam coal; 10 Mt/y metallurgical coal). Some 25–30 Mt/y was imported via ARA, and less than 3 Mt/y came from Poland. The German ports of Hamburg, Bremen and Wilhelmshaven received imports of 8.9 Mt (*see* Table 4)). Wilhelmshaven is also the location of the power station of the same name with its own port facilities. Coal arrives at Wilhelmshaven in capesize vessel and is unloaded at the Niedersachsenbrücke Quay. The coal is then transported 3.5 km via a conveyer belt to a storage facility at the power station. Other stations located on the north coast with port facilities include the 533 MWe Rostock CHP plant and the 323 MWe (295 MWth) Kiel CHP plant.

It becomes apparent that in Germany, many large power stations have heat raising capabilities to provide district heating. Some inland CHP stations are located further inland but connected directly by river from the German ports. The 350 MW Farge power station I is located south of the Port of Bremen while the Wedel and Moorburg stations serve Hamburg, but all have burned significant quantities of imported coal. While this region of Northern Germany has a lower density of coal-fired plants, the biggest potential for imports could remain amongst the plants located around the Ruhr region where the domestic coal industry operates.

Figure 4 Coal importing power stations in Germany, with possible rail and river routes from ARA

Figure 5 **Coal importing power stations in Germany and rail routes from Polish coalfields**

Table 4 **European port throughput** (VdK, 2010)

Ports	2007	2008	2009
Hamburg	5.7	5.2	5.2
Bremen	2	1.8	1.4
Wilhelmshaven	1.3	2.2	2.2
Amsterdam	22.2	22.2	18
Rotterdam	28.2	28.6	24.8
Zeeland seaports	3.5	4.4	3.9
Antwerp	8.6	9.9	6.1
Ghent	3.4	4.2	2.6
Dunkirk	9.6	9.7	6.1
Le Havre	2.4	2.7	2.2
Total	86.9	90.9	72.5

3 Spain

Spain is the 15th largest economy in the world with a GDP of US$ 1.4 trillion. In 2011, per capita GDP dropped for a second consecutive year to less than 30,000 US$/head. Spain is an example, alongside Germany, where coal was an economically strategic fuel. The Spanish coal industry once employed tens of thousands of workers in Spain in the north, north east of the country, and on the island of Majorca.

Hard coal and lignite production has dwindled in recent years as gas-fired power and renewable energy emerge as major power sources. Spain is one a group of countries in Europe that have been permitted a *rise* in greenhouse gases under the Kyoto Protocol, with a 2012 target of 15% above 1990 levels. Despite Spain's attempts to be a leading country in renewable power, emissions in 2020 are likely to be closer to 31% (EU, 2011). Coal-fired power is one of the most important sources of generation that is necessary to balance out the variability in the country's hydroelectric power. However, competition from imported coal adds considerable pressure to domestic coal production.

3.1 Primary energy supply

In 2009, total primary energy supply fell for a second year to 128 Mtoe, a level below that seen in 2002. Spanish primary energy demand since 2000 increased at just 0.6 %/y, yet a decade earlier, in the 1990s, Spain was one of the fastest-growing energy economies, with energy use rising by 3.1 %/y, well above that seen in Germany, France and the UK.

After peaking in 2007 at 144 Mtoe, the market has since contracted by 10%, and so could have a beneficial impact on per capita CO_2 and energy consumption. This positive outcome is a side effect of the country experiencing the worst economic hardship and unemployment for many years. Almost half of the primary energy supply is attributed to crude oil and oil products; natural gas made up almost a quarter of total energy supplies. Coal accounted for just 8%, equal to the amount of energy supplied by biomass and renewable energy. While coal remains a smaller proportion of primary energy compared to other sources, its role in the economy is seen as essential.

Spain relies on imported coal for around 80% of the country's needs, but it remains one of the few indigenous sources of energy, apart from hydroelectricity and solar. There is almost no production of natural gas and oil. Despite there being ample coal reserves (73 years at current production), more than half of the annual coal supplies come from imports. Indigenous coal provides less than 4% of the primary energy to Spain. At least 90% of the coal used in Spain is for power generation.

3.2 Coal supply

Coal production is now concentrated in the northernmost region of Asturias; this region of Spain is known for its mountains and variable climate. Lignite mining in regions such as Andorra has now ended (*see* Figure 6). The coal industry is still largely made up of the leading producer Hunosa, which operates eight opencast and underground mines in various regions in the areas of Nalon and Caudal. Hunosa also owns and operates two washery plants in La Pereda and Modesta and a CFBC plant in the northernmost province of Spain.

Spain has a long history of coal mining. Rabal (2009) published a comprehensive account of the Spanish coal industry from its beginnings in the 1960s to Spain's entry into the EEC in 1986 and thereafter. Production increased significantly between 1970 and 1980 during the aftermath of General Franco's death. Major reforms, the oil crises, and the withdrawal of consumer oil subsidies went some

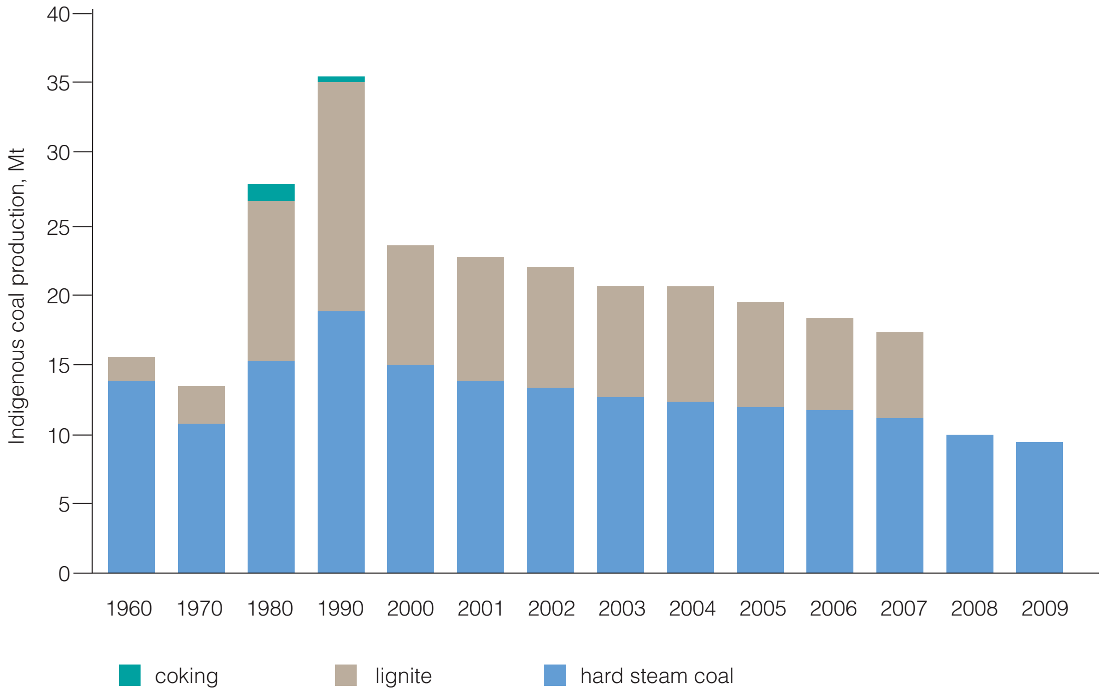

Figure 6 Spanish indigenous coal production, Mt (IEA, 2010b)

way to causing a collapse of oil-fired power generation from 1983. Both lignite and hard coal mines ramped up production in this period. Spain joined the EEC in 1986, by which time the state coal mining company, Hunosa, was producing more than 3 Mt/y of coal. The company operated with a workforce of more than 20,700, but at an annual financial loss of 35,200 million pesetas. By 1990, when Spain became a fully-fledged member of the EEC, foreign direct investment was rising as a percentage of GDP, especially from Japan where investment rose from US$ 1 million to US$ 200 million within a few years.

In 1997, the Hunosa plan (in the framework of the 1998-2005 *Plan for the coalmining sector and alternative development on the mining basins* – ES9707119N) was negotiated in order to reduce losses and stabilise production and the workforce. By 2001, the plan reduced production to 2.1 Mt and cut the workforce to 7000. The EC were initially reticent to allow all of the plan to be carried out. However, an agreement was made in the *Plan for the Future of Spanish Coal Mining 1998-2005* which required a progressive reduction in public aid, a 30% reduction in production, and a 30% reduction in employment. Redundancies were to be non-traumatic through the use of incentives to take voluntary and early retirement, and support for various measures to boost the prospects of the regions affected.

By 6 June 2006, the Ministry of Industry, Tourism and Trade presented a plan for the estimated costs associated with the closure process of uncompetitive mines. However according to the results, it seems that producing coal remained a loss-making business, despite the ongoing restructuring and the scaling down of production.

Coal production is now a third of what it was in the 1980 and 1990s, with the closure of mine capacity and the large-scale replacement of domestic coal by imported products. Coal production has steadily fallen since the 1990s, while demand remained more-or-less steady, only to drop sharply in 2008 and 2009 (*see* Figure 7). These were years when the power utilities drew heavily on coal stocks. By 2009, anthracite accounted for perhaps half of the country's hard coal production, while subbituminous and bituminous coals made up the balance in equal shares.

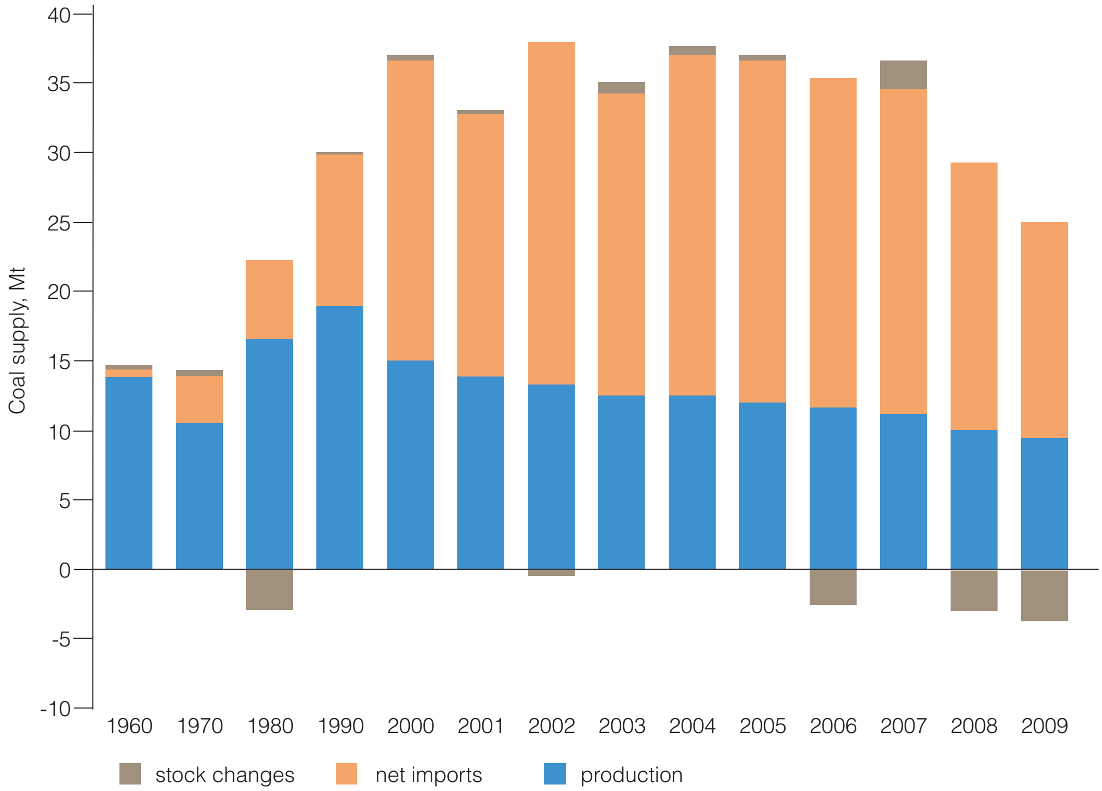

Figure 7 Hard coal supply to Spain by source, Mt (IEA, 2010b)

Domestic lignite has not been produced since 2008. One of the most fundamental laws governing EU energy, the 1997 *Directive on the European Internal Market for Electricity*, changed the market for coal. The combination of EU electricity liberalisation, the directives on coal industry reform, and provision of some employment to the labour force led to the P*lan for Coal Mining and Alternative Development* in mining areas for 1998-2005 (*see above*). The plan was not endorsed by the mining industry or the power generators although the terms of the agreement followed previous agreements. Guaranteed quotas were still considered, although the guaranteed purchase by power utilities would eventually fall to 13 Mt by 2005, equivalent to a reduction of 28%. Financial aid would be provided to utilities where stocks of coal would exceed 720 hours, a useful feature during periods of high hydro availability.

In 2006, the Ministry of Industry, Commerce and Tourism introduced a new plan called the *National Plan for Strategic Coal Reserves 2006-12*, although the EU Directives (Regulation CEE No. 1407/2002) expired on 31 December 2010. All of these regulations will be superseded by the EU agreement to end producer subsidies by December 2018, although state aid that is destined for closure works of mine facilities that are not related to production, such as social welfare benefits and rehabilitation of sites can be provided until 2027 (EU, 2010).

3.3 Coal in power generation

Thermal power generation provides an important means to stabilise the short- and medium-term shortfalls that regularly occur from hydroelectricity and wind. Spain is one of the world's leaders in renewable generation. Coal-fired power had historically been the lead balancing system, although in more recent years this has become complicated by the addition of gas-fired power (*see below*).

In the past, the Spanish power generating market was heavily influenced by the availability of

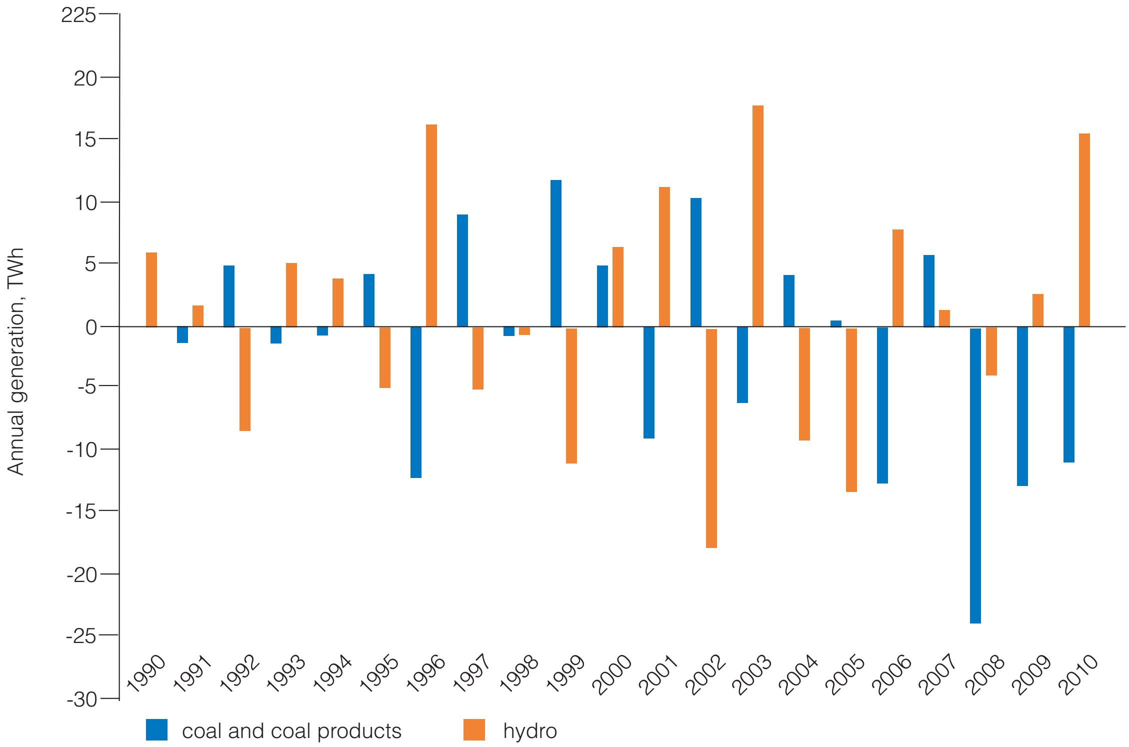

Figure 8 Growth or fall in annual generation from coal and hydro in Spain, TWh (IEA, 2011)

hydroelectricity, while nuclear power delivered base load power. All other forms of generation altered operations in response to hydropower shortage or surplus. Figure 8 illustrates how annual variations in hydroelectricity drive the need for thermal generation, in this case coal-fired, on a year-by-year basis. In the 20 years this figure represents, sixteen of the years show an 'inversion' where hydroelectricity delivery has resulted in the rise or fall of coal-fired power. Hydroelectric power is available in the whole country, but the key regions appear to be Castilla y Leon and Galicia. Coal-fired power is available in most Spanish regions, but is concentrated in four main ones: Andalucia, Asturias, Balearis and Aragon. The grid system is managed by Red Electrica, and numerous cross border links are available for trade with Portugal and France to assist in load management.

In Spain therefore, coal-fired power effectively balanced output from renewable power. In many ways, the Spanish system provided a predictable and measurable level of hydro output, with dry or wet rainy seasons in the spring and autumn (fall) determining the hydro availability in the following drier periods of winter and summer. However, with the 'dash for gas' and the rise of wind and solar power since the late 1990s, a staggering contraction of coal-fired power resulted (falling by 25%).

This massive reduction in coal-fired power occurred in conjunction with the closure of brown coal/lignite mining in Spain, and the continuing contraction in what was left of the hard coal industry. Although the coal industry will still continue with some state aid in coming years, there remains a risk that it will be further marginalised by other forms of generation.

In 2007, the output from renewable power (solar and wind) exceeded the output from hydroelectricity. In 2008, Spain had more installed solar generating capacity than the USA with almost 4000 MWe, and is gradually catching up with Germany in terms of wind capacity at 20 GWe (versus 28 GWe for Germany). In February 2012, the country's wind power reached a record monthly output of 4890 GWh, but equivalent to a load factor of just 33%.

3.4 Quality advantage of coal imports

Spain is one of the most interesting countries to analyse since the coal market is an assortment of anthracite, bituminous, and subbituminous coals (and formerly lignite). What is more interesting is that the power stations blend and burn a most unusual mix of fuels. One example of a power station that has blended imported coals with domestic coal is Endesa's Turuel plant in Andorra. The power station originally burned fuel, considered to be lignite, with a LHV of 15.8 MJ/kg. The ash content was 27.3%. However, Arauzo and others (1997) considers the quality of the domestic coal to be subbituminous, which is a more plausible quality since the power station was modelled, tested, and burned a blend of internationally-traded and domestic coals. The Turuel plant has 3 x 350 MWe units with a coal blend of 30% South African bituminous and 70% subbituminous local coals.

The coal qualities tested in the Teruel plant are shown in Table 5. The addition of Indonesian coals reduces the sulphur and ash content considerably, but raises the volatile matter of the fuel blend. Indonesian coals also have lower heating values, which can be improved by blending South African coals with higher heating values with reasonable sulphur and ash contents. In blend, two very different coals require testing and, in some cases, plant modification to ensure stable operation in the boiler.

The paper published by Arauzo and others (1997) discussed many issues such as unburnt coal loss, slagging and fouling, and the effect of higher heating value coals on boiler tubes. Many of these problems have been overcome to accommodate a blend of coals that are vastly different from the domestic coals. This ensures that the plant is able to operate with much lower SO_2 emissions as well as diversifying its coal supply sources. With the cessation of domestic lignite production in 2008, some 4 GWe of generating capacity will either shut or convert fully to burning imported bituminous coals.

As mentioned earlier, Spain has power stations that use a wide range of coals consisting of local anthracite along with imported bituminous coals. Anthracite is a high rank coal, often with a high heating value, but accompanied by a very low volatile matter content. This often makes pulverised combustion difficult and so an appropriate system called the downshot firing boiler is used to cope with the lowest volatile content anthracites. This technology is described in a report on coal and clean coal prospects in Vietnam (Baruya, 2010), a country which has prospered using anthracite coal in the past, and will continue to do so alongside the increased demand for imported coal.

The Spanish coal-fired power stations that utilise anthracites with bituminous coals are Compostilla (1312 MW), Guardo (515 MWe), La Robla (620 MWe), Narcea (569 MWe), and Puente Nuevo (324 MWe). The Puento Nuevo power station in the south of Spain is located in the municipality of Espiel. It is situated on the banks of the River Guadito at the Puento Nuevo reservoir. Coal is mined at the nearby operations of Espiel and Peñarroya. Until recently, the station had access to a rail link

Table 5 Typical proximate analysis (% in weight on AR basis) of coals blended at the Teruel power plant (Arauzo and others, 1997)

	Indonesian subbituminous	South African bituminous	Domestic subbituminous 1	Domestic subbituminous 2	Domestic subbituminous 3
Fixed carbon	38.53	52.50	25.79	23.00	20.23
Moisture	24.07	7.88	22.69	21.21	30.27
Volatile matter	36.36	26.64	26.84	25.01	25.71
Ash	1.04	12.97	24.66	30.78	23.80
Sulphur	0.08	0.54	5.15	6.15	5.31
HHV, kcal/kg	5358	6336	3622	3156	3225

between Peñarroya to the power station storage piles, but this has been replaced by road haulage.

Compostilla I was the first of Endesa's plants to come into production in the early 1950s. Compostilla II was commissioned in 1972 as Spain's second largest plant after the As Pontes power plant. Compostilla was designed initially for the consumption of coal from the basins of El Bierzo and Laciana, but has since increased the consumption of imported coal and petroleum coke. In the past, some 70% of the coal feed was domestic coal, with the largest supplier being the Siderurgica de Ponferrada coal mine producing 2 Mt/y of coal per year. Endesa is collaborating with research institution CIUDEN to set up a 30 MWth Foster Wheeler-built *circulating fluidised bed combustor* (CFBC) unit to test Foster Wheeler's Flexi-Burn carbon capture technology. The unit will test a wide range of domestic (mostly anthracite) and imported coals well as biomass and started in 2011.

The *Integrated Gasification Combined Cycle* (IGCC) project at Puertollano is owned by the Elcogas consortium, which is parly owned by E.ON Espana along with Puerto Nuevo. The Puertollano IGCC plant, located 200 km south of Madrid, began commercial operation in 1996 with natural gas, and two years later with syngas from the gasification plant.

In October 2010, Elcogas started capturing CO_2 from a 14 MW pilot plant at the 335 MW facility. The main fuel for this IGCC system is 50% local coal, and 50% local petcoke. The domestic coal is a high-ash (>40%) subbituminous coal from the local Encasur mine in Puertollano and the petcoke is very high sulphur (5.5%) from the Repsol Puertollano refinery located 7 km away. The coal contract was a 12-year agreement that started in March 1998 between Elcogas and coal producer Encasur. The petcoke contract was signed with Repsol with similar conditions. Natural gas was also supplied by Enagas. The local coal is 18 km distance from the IGCC complex and some feedstock is carried in by 25-tonne trucks. Conveyor systems take the coal and coke to a storage silo which has a capacity of 100,000 t. Puertollano is therefore an important test case for the exploitation of non-standard coals, opening up the potential to develop (almost) zero emissions plants in many parts of the world which currently burn low quality coals inefficiently.

3.5 Cost advantage of imported coal

The level of state aid offered to the Spanish coal industry in past years is discussed in detail in Baruya (2012). In 1998, the cost of coal produced by the public sector HUNOSA was as high as 120.9 €/t, while the coal produced in the private sector was a more competitive 51.42 €/t. Subsidies to the public sector rose to €360 million, against the €30.1 million awarded to the private sector. In more recent years, the total subsidy budget to the Spanish coal industry rose to just above €1 billion, considerably less than that for the German hard coal industry at €2.7 billion. Less than half of the Spanish budget is geared towards financing operations and so, strictly speaking, the subsidy used to keep coal mines operational is closer to €0.5 billion. On a per tce basis, the aid required to keep mines operating is estimated to be around 70 €/tce.

The subsidy payments ensure that Spanish coal mines are able to supply coal to power generators at a delivered price equivalent to that of imported coal. By adding the subsidy value to the delivered price of imported coal, it is possible to get an indication of the true cost of producing hard coal in Spain.

The CIF value of coal imports is readily available from the IEA. Assuming a reasonable transport and handling charge of say 10 $/t to the power station (*see below*), the total cost of Spanish domestic coal production in 2009 could be as high as 200–240 $/t.

As of 2012, the coal industry remained underpinned by state subsidies. Since the mid-1980s, Spain has seen its industry contract from 234 mining companies to just 27. The industry once employed 45,212 employees, today it survives with just 8284 employees. This figure does not include indirect job losses in coal related activities or wider employment in areas where there is a strong tradition of

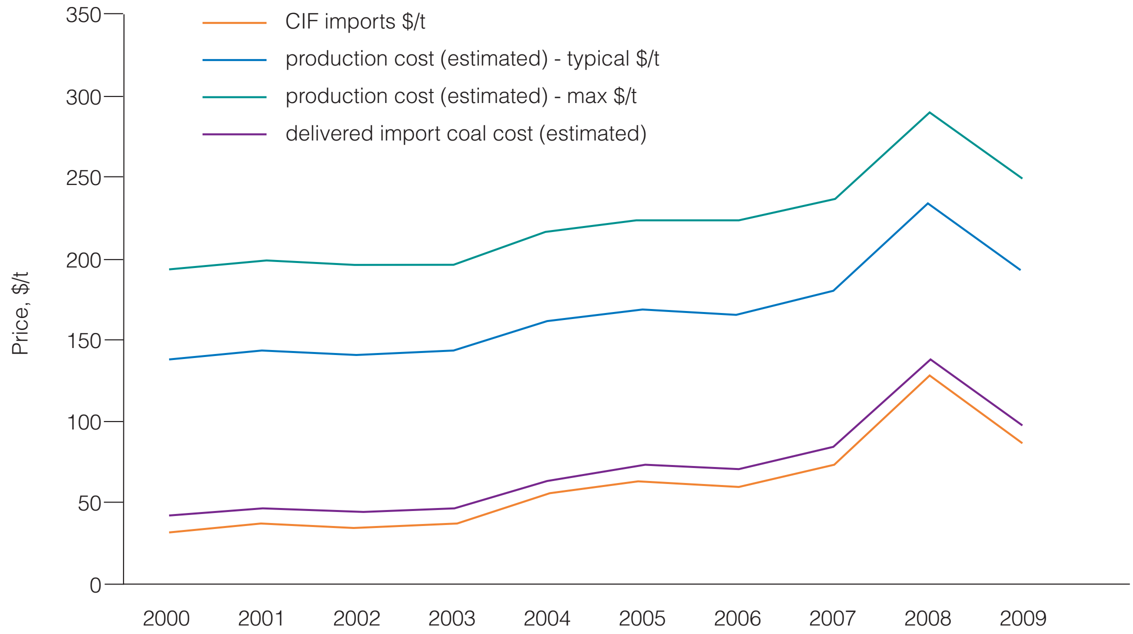

Figure 9 Delivered price of steam coal to Spanish power stations (IEA, 2010a; Author's estimates)

coal mining. Based on these figures, productivity was a lowly 420 t/manyear in the 1980s, but was improved to 1448 t/manyear in the 2000s. When compared with productivity in some Australian mines of more than 10,000 t/manyear and South Africa at around 6000 t/manyear, the Spanish coal industry yields relatively little coal per employee, despite the period of restructuring. However, the value of preserving some domestic energy security and employment (alongside renewable energy) is high given the lack of natural gas and oil within the country.

3.6 Coal import logistics

Coal-fired power stations in Spain are located in and around the major coalfields (*see* Figure 10. These coalfields are also conveniently located close to the coast, enabling access to various ports around the Spanish coastline, but the high costs of production never allowed Spanish coal to become a significant player in the export market. As such, almost all the coal transportation is for coal imports.

Renfe Freight and Logistics owns the Bulk & Multiproduct business which specialises in the transportation of dry bulk. According to the Renfe (2010), revenues for all freight carried by the company amounted to €231.4 million, carrying 16 Mt of freight. There are likely to be variable charges for different freight commodities, whether for volume or safety reasons, but as a proxy these figures equate to a freight rate of 14.5 €/t (10–11 US$/t). Other stations are located in the southernmost regions of Spain and costs of inland transportation are probably not too dissimilar to those in the north.

Table 6 lists the major coal-fired power stations operating in Spain, the origin of the coal used within these stations, and the means by which the coal is transported from port to power station. All but one of the 19 stations listed use imported coal. Eight power stations rely solely on imported coal and as mentioned earlier, most are located on the coast by the port and so further inland rail transport is not necessary.

In the southern region of Andalucia, Los Barrios and Litoral de Almeria are two stations which have dedicated import jetties with conveyors linked directly to the coal storage piles for the power stations.

Figure 10 Coal-fired power stations in Spain

In the northern regions of Asturias and Castilla y Leon, the ports of Gijon and Aviles are linked by rail to the power stations at Abono, Lada, Soto de Ribera, and La Robla. The port of Santander delivers to the Guardo station. While the stations are located within the coalfield regions of Spain, access to the ports by rail is straightforward, but slowed by the Cantabrian Mountains.

The Lada and Meirama stations receive coal via the national state rail company Renfe. Eleven power stations, many located in the north, use both domestic and imported coals in blend. Gijon serves six power stations, although Puertollano and Puente Nuevo stations in the south use the southern port of Huelva. The Spanish power market is therefore geared up towards burning import coal, and even if the domestic industry declines, there appears to be little impediment to the operation of any of the country's power stations.

Table 6 Spanish coal import logistics (UNESA, 2010)

Power station name	Domestic coal source	Import coal source	Port	Rail transport (freight company)	Truck transport	Conveyor belt transport
Soto de Ribera	Yes	Yes	Gijón	Yes (Renfe)	Yes	No
Narcea	Yes	Yes	Gijón or Avilés	No	Yes	No
Anilares	Yes	Yes	Gijón or Avilés or La Coruňa	Yes (Renfe)	Yes	No
Compostilla	Yes	Yes	Ferrol or Gijón	Yes (Renfe)	Yes	No
La Robla	Yes	Yes	Gijón or Avilés	Yes (Renfe)	Yes	No
Guardo	Yes	Yes	Gijón or Santander	Yes (Renfe and Feve)	Yes	No
Puertollano	Yes	Yes	Huelva	Yes (Renfe)	Yes	No
Elcogas	Yes					
Puentenuevo	Yes	Yes	Huelva	Yes (Renfe)	Yes	No
Serch	Yes	Yes	Tarragona	No	Yes	No
Teruel	Yes	Yes	Tarragona	Yes (Renfe)	Yes	No
Escucha	Yes	Yes	Tarragona	No	Yes	No
Aboňo			Gijón	No	Yes	Yes
Lada			Gijón	Yes (Renfe)	Yes	No
Puentes de Garcia Rodriguez			Ferrol	No	Yes	No
Meirama			La Coruňa	Yes (Renfe)	No	No
Pasajes			Bilbao and Pasajes	No	No	No
Los Barrios			Los Barrios	No	No	Yes
Carboneras (Litoral de Almeria)			Carboneras	No	No	Yes
Alcudia			Tarragona and Alcudia	No	Yes	No

4 UK

The UK is Europe's third largest economy and prior to the economic crash of 2007-08, the UK experienced some of the highest growth and consumer spending. After experiencing considerable economic contraction in 2009, growth resumed in 2010 with gross domestic product reaching US$ 2.2 trillion. UK energy policy is geared towards wholesale and retail competition, but providing state aid to sectors that meet strategic targets, notably the renewable sector and energy efficiency. The *Climate Change Act 2008* establishes a long-term framework to tackle climate change. The Act aims to encourage the transition to a low-carbon economy in the UK through unilateral legally-binding emissions reduction targets. This means a reduction of at least 34% in greenhouse gas emissions by 2020 and at least 80% by 2050.

Coal-fired power in the UK faces stricter emission legislation under EU rules. New coal-fired power stations will not be built unless carbon capture and storage is fitted to at least 400 MWe of power output from its first day of operation. CCS is being supported by the UK government in the form of funding for CCS R&D and deployment totalling more than £1 billion. The prospects for coal demand in the medium term are dependent on the operation of existing power stations that will operate under the Industrial Emissions Directive.

4.1 Primary energy

In 2010, the primary energy supply to the UK was 204 Mtoe, half that of Japan and one tenth that of the USA. TPES per capita is 3.28 toe per head, less than half that of the average US citizen. The same pattern emerges for electricity consumption, with a consumption of 5741 kWh/head, lower than Spain which is 6053 kWh/head. While energy intensity (toe per GDP) has fallen since 1990 from 169 to 115, energy per capita has remained constant for 20 years, yet the UK is set to meet its Kyoto targets successfully, partly due to the shift from coal-fired power to gas, but also by the decline in heavy industry and rising energy prices all of which have a direct effect on fossil energy use and CO_2 emissions. Many major OECD economies suffered an average 5% reduction in primary energy demand just after the 2008 banking crisis, including the UK which dropped 5.5% in 2009. Germany, Japan and the USA have such large energy markets, that the market contraction is large in volume terms.

4.2 Coal supply

UK coal production increased steadily in the early 1900s to over 250 Mt/y. However, a succession of industrial disputes, the development of nuclear power, and gas-fired plants capable of 40% plus efficiency in the 1990s displaced coal as a commodity, and now domestic production is around 30 Mt/y. Britain's mines now employ just 7,000, down from 220,000 in 1985. According to the UK Coal Forum, indigenous coal producers have an objective of a production output of 20 Mt/y for the foreseeable future, and consider that this level of output can be delivered up to and beyond 2025 (UKCF, 2010).

UK coal supply in the 2000s is about one quarter of what it was in the 1960s. Since 2000, the UK coal market has been hovering around 50–60 Mt/y, with some variation as it competes seasonally and yearly with gas-fired power (*see* Figure 11). Nuclear station closures are imminent, and renewable energy is yet to make any major impact despite the generous subsidies offered.

Coal production in the UK is around 50–60% opencast, and the rest is deep underground mining. Almost all the coal mined in the UK is steam coal, and resreves are considered to be at around 228 Mt

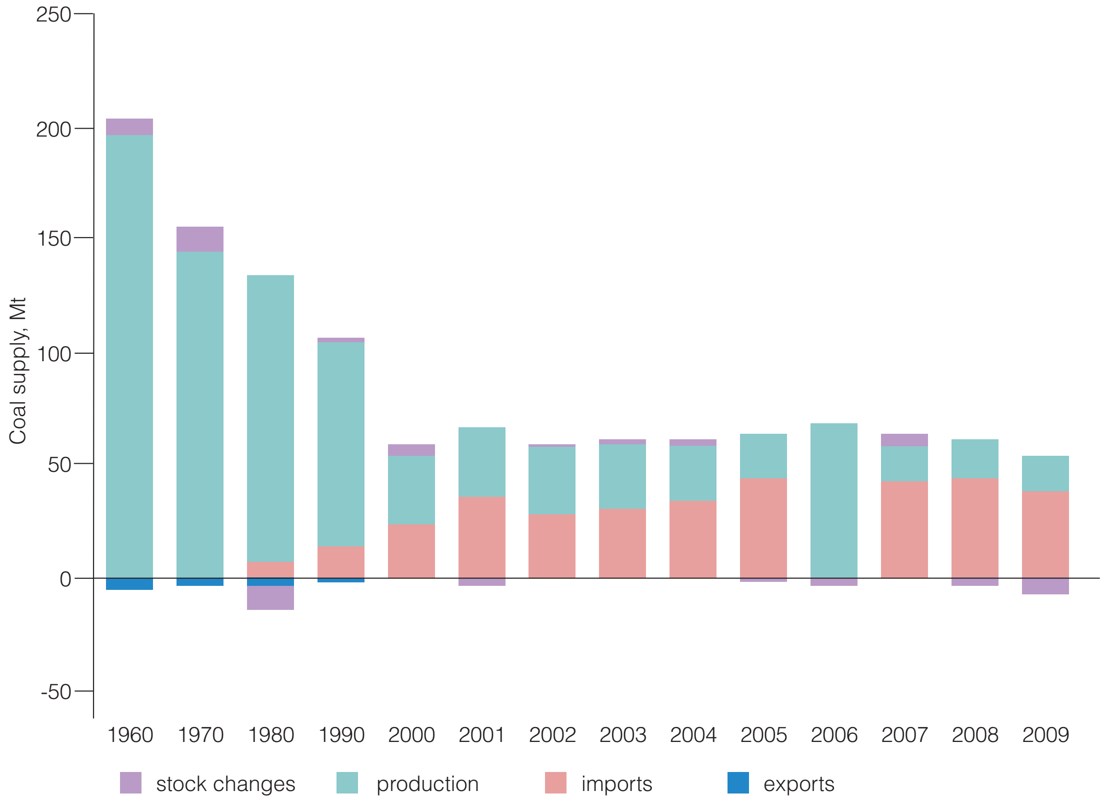

Figure 11 UK coal supply, Mt (IEA, 2010b)

(BP, 2011). This puts a reserve production ratio of some 13 years, although this figure could be misleading. Coal production is heavily regulated in the UK, and while a great deal of coal may exist in the country, the declared reserves may only be for working pits, many of which only have permits to work for several years at a time. Gaining permits in the UK to mine coal is far from straightforward, and so it is difficult to determine whether the reserves are those that mine operators have access to, or whether they include coal reserves that are known to exist offshore.

Coal imports have averaged well in excess of 30 Mt/y since 2001, leading to one of the most mature and established import markets for steam coal in Europe. Security of supply (of coal) is partly ensured by imports from diverse sources, the two major suppliers being Russia and Colombia. Russian coal is considered some of the best quality due to the high calorific value, averaging more than 6500 kcal/kg with low sulphur and ash contents. Colombian coal offers a lower calorific value coal than Russian products. In recent years, coal imports have declined considerably, but one advance has been the rising share of Colombian coal exports to UK coal supplies. This has occurred partly to fill the gap created by South African suppliers moving coal towards the Indian market. Russian coal products are of good quality in most respects, although Russian coal supplies have been known to occasionally suffer from quality issues, when other non-coal products have been found in railcars to make up extra volumes. While Colombian coal enjoys an increasing market share, it is worth discussing the role of Russian coal in the UK (*see* Figure 13).

Minaghan (2007) researched some of the diplomatic connections between the UK and Russian coal interests, and noted that by 2006, Russian coal imports exceeded UK coal production, and could have contributed to fuelling 15% of the country's electricity supply. SUEK supplied some 22% of steam coal exports to the UK with 8.75 Mt in 2006, up from 5.3 Mt in 2005. The UK was also active in the Russian coal sector. The former Department of Trade and Industry supported a technology transfer project to examine the key issues affecting coal mine methane and abandoned mine methane project development.

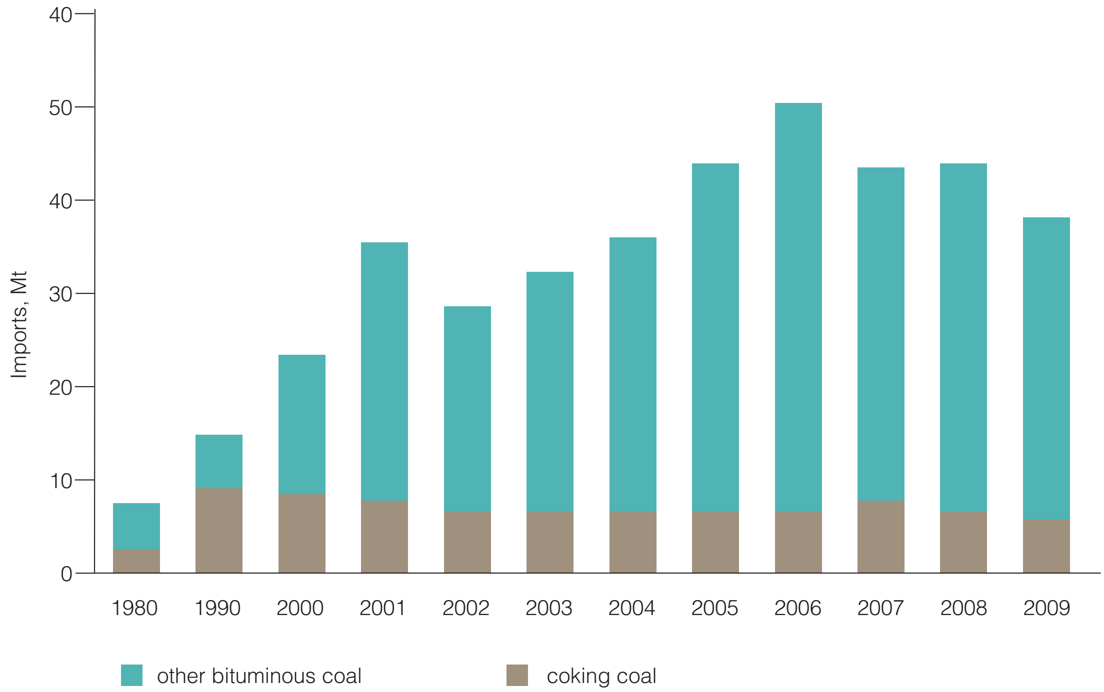

Figure 12 UK imports, Mt (IEA, 2010b)

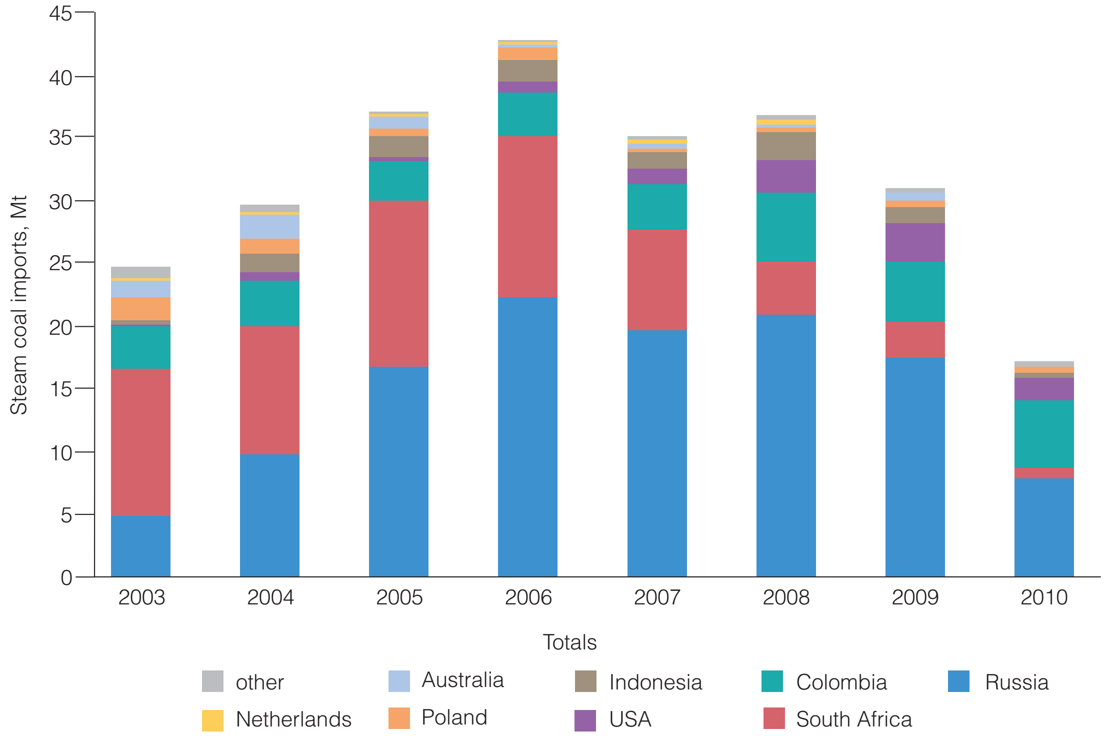

Figure 13 UK steam coal imports, Mt (IEA, 2010b)

Despite some anecdotes about Russian coal supplies, coal imports are relatively reliable and far less of a concern than the wider geopolitical problems raised by Russian oil and gas supplies to Europe. There are however concerns over safety in Russian mines, and the country's attempts to diversify its coal exports to move into the Asian market where demand is growing. Russian domestic policies are crucial for the availability of export coal to Europe, not only to the UK, but also to Germany. The Russian electricity sector is recognised as inefficient and ageing and in desperate need of investment. In order to promote investment in the massive gas sector, gas prices must rise, and thus could make coal more competitive domestically in Russia.

A coal renaissance in Russia has been in discussion since the late 1990s, and by 2006 announcements were being made to accelerate investment in the coal sector and to redress Russia's energy problem, which is complicated by the country's gas policy. However, it took six years for RAO UES to commission one power station (215 MWe Khronor plant). By 2015, RAO UES had intended to build 22,000 MWe of coal-fired capacity. Whether this happens by this time is not certain, but ambitions for more coal use over the long term could have an impact on the availability of steam coal to countries such as the UK.

4.3 Coal demand

In the UK, the Large Combustion Plant Directive (LCPD) is a key driver for coal-fired power, and out of around 29 GWe of coal-fired power stations, only 20.6 GWe will be operating in 2016 when new emissions legislation comes into force. Some 8.2 GWe will close after being permitted a 20,000 hour operating life (from January 2008), equivalent to an average load factor of 28.5%, effectively rendering many of these stations obsolete. Many stations are using up their allocation of hours and will cease operation early. The 20.6 GWe that will continue to operate will have appropriate FGD systems in place, and will probably source low sulphur coal that could reduce the operating load on the FGD, or could source high sulphur coal from the USA, which has favourably high calorific values.

In 2016, unless stations are equipped with SCR, NOx limits could cause further closure of plants, as these limits are not easily met by coal switching. As such, coal imports will offer a cost-effective supply of coal, but will not necessarily improve the compliance of coal-fired power stations regarding NOx emissions. The LCPD with regards to UK policy can be found on the UK government archive (Defra, 2011). The Industrial Emissions Directive supersedes the LCPD.

4.4 Quality advantages of imported coal

UK domestic coals are generally have a high sulphur content in the range 1.2–1.6%, except for some steam coals mined in Scotland which can have a sulphur content of less 1%. The heating values of UK coals in general range around 23.6–24.5 GJ/t, ash content is 14–15%, and moisture is 9–11%. Coal products mined in South Wales are low to mid volatile products with high heating values (27.5 GJ/t), but high in sulphur (1.3%). Ash content however is low at 10% and moisture is around 10%. In most areas of coal quality, UK coal is competitive with internationally-traded coal except mainly for sulphur content.

4.5 Cost advantage of imported coal

Coal production in the UK has been operating without operational subsidies since 1994, and has been competing with imported coal from Russia, South Africa, Colombia and the USA for many years. Some state aid has been awarded for restructuring, social welfare, and other purposes to deal with the legacy of past operations, but none has been used for the commercial extraction of coal.

Figure 14 shows the cost of coal delivered to UK power stations. It shows the cost of imported coal from ARA, plus freight, handling, and rail freight in the UK as published by MCIS, as well as UK Coal and IEA sources. The imported coal price which has been subject to intense volatility since 2007 is also shown in Figure 14. The McCloskey Aire Valley marker price shows the cost of importing coal

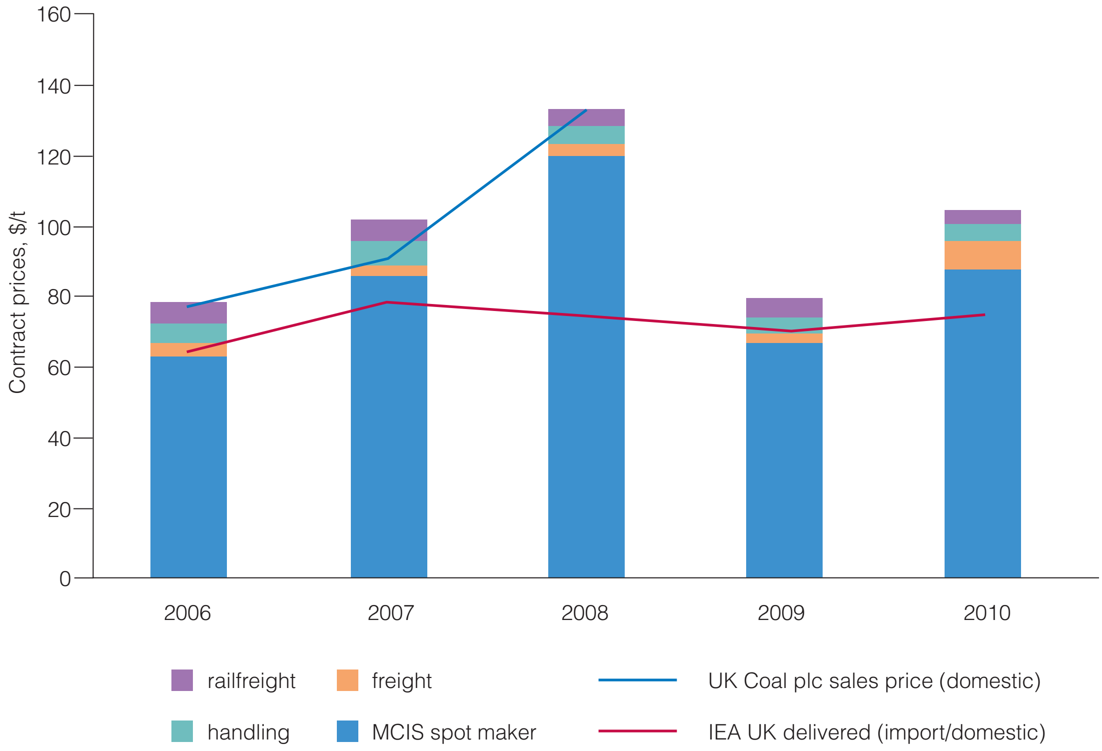

Figure 14 Delivered import cost versus domestic UK contract prices US$/t (MCIS, 2012; UK Coal, various)

to one of the country's centres of coal-fired power generation in the north east of England. The cost of imported coal to the Aire Valley ranged from 80 $/t in 2006 to 160 $/t in 2008. The key driver of this variability was the influence of international prices, particularly ARA, which drove a large proportion of the country's coal supply (*see* Baruya, 2012).

Taking the ARA price at any point in time, it is possible to build a delivered price based on estimates of supply chain costs between ARA and the Aire Valley. Onward handling fees and freight from ARA add an additional 12–22 $/t (range of average fees and freight in 2006-10). This cost comprises of freight from ARA to the UK ports ranging from 2 to 8 $/t, averaging 4 $/t. Inland transport of coal accounts for perhaps 10–14 $/t, consisting of handling costs averaging 6 $/t while inland rail costs since 2006 averaged 5 $/t. Inland power stations such as Rugeley, Ratcliffe and Didcot will probably have encountered higher rail costs due to the greater distances, but it is difficult to establish the correct rail rates for these power stations.

As Figure 14 shows, the price trends for contracts with UK coal suppliers and the delivered price of all coals regardless of source (blue and red lines) both follow the trend set by imported coals. One interesting trend, however, is the coal sale price for products supplied by the country's largest producer, UK Coal plc. The price trend is based on the £/GJ sales price, and adjusted to a heating value of 23.9 MJ/kg (GJ/t). Using the nominal market exchange rate there appears to be a much flatter price trend when expressed in US dollars. In some years, UK Coal made a financial operating loss, yet had to maintain competitive against imported coal which met lower sulphur criteria. This was during a period when UK generators were undergoing a belated FGD programme compared with countries like Germany and certain regions of Eastern Europe. Sulphur content therefore had to have some bearing on the UK Coal discount margin against imported coals. Nevertheless coal quality is only part of the explanation. When the sales price of UK Coal is expressed in its original £/GJ, the trend is more in keeping with the rise in world prices (*see* Figure 15).

However, the UK sterling value plummeted in value from $2.0 to just $1.62 between 2007 and 2008.

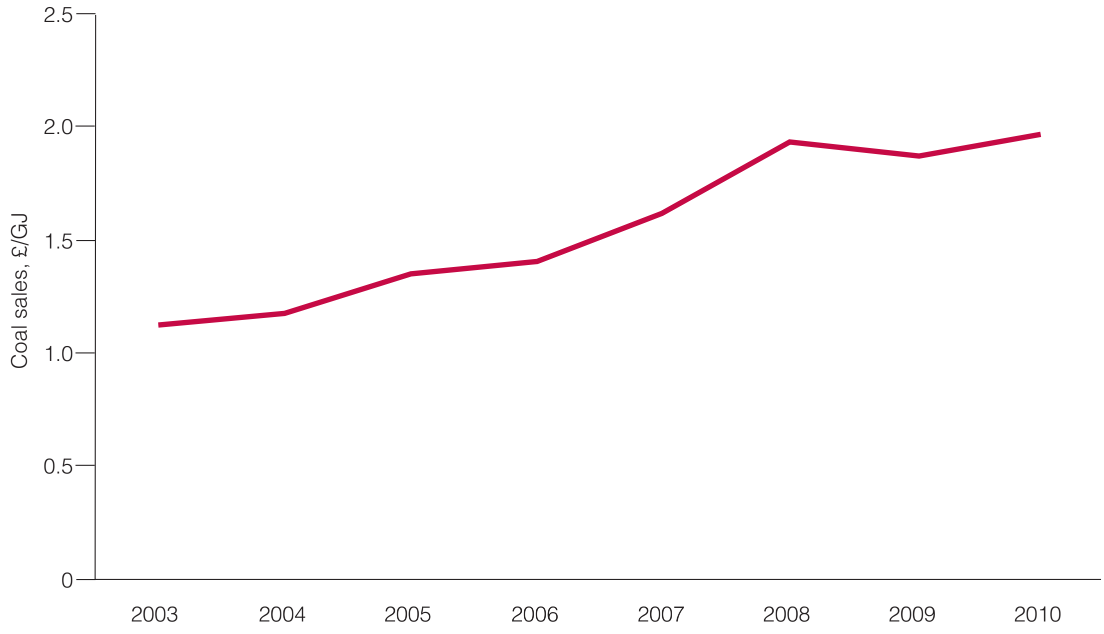

Figure 15 UK coal sales (UK Coal, various)

The cost of imported coal for UK generators was therefore inflated by a massive 20% in 2008 due to exchange rates, perpetuated by falling interest rates resulting from the failure in the UK banking sector. More importantly, UK generators are owned by the largest European utilities, and so the drop in the value of sterling would have meant that converting profits (in sterling) from the UK business to euros would yield less value.

UK coal prices still remain below world prices, which is an extremely challenging task since the UK coal industry does not operate large-scale opencast pits with 24-hour dragline operations. One of the major obstacles to UK coal production is the requirement for planning permission to operate mines, particularly opencast mines. Mines in Scotland have achieved better success in recent years. Surface mine planning consent in Wales and England is particularly difficult to obtain since other local interests and public opinion is often against new developments of any kind, particularly opencast mining and wind turbine arrays. The South Wales opencast mine, Ffos-y-Fran, has gained successful permits since part of the revenue earned by 11 Mt of coal production is being diverted to a land reclamation scheme to redevelop 400 ha of derelict land. Due to the demise of heavy industry and manufacturing, South Wales is blighted by many sites of dereliction so the sale of 11 Mt of steam coal is permitted as it will revitalise this region.

4.6 Coal import logistics

Most inland power stations are located some 80–90 km from the UK coast and have good rail links. As mentioned above, inland transport and storage of coal accounts for perhaps 10–14 $/t, consisting of handling costs averaging 6 $/t while inland rail costs since 2006 averaged 5 $/t. While coal is usually transported by rail, truck transport is commonly used for short haul transport or for smaller and more niche products, between domestic mines or preparation plants to final consumers.

UK coal imports enter the country via 12 main entry ports, the main ones being Clydeport in Scotland, Immingham in the northeast of England, and Avonmouth in the southwest of England.

Many of England’s power plants are located further inland closer to the country’s key coalfields run by UK Coal, although the stations along the River Humber are located within easy reach of the ports

Figure 16 UK coal transport infrastructure (DB Schenke, 2010)

of Hull and Immingham in the northeast of England. In Scotland, Clydeport (Hunterston) has deep water to accommodate capesize vessels. Table 7 lists the major power stations in the UK based on a 2004 report on the prospects of UK coal production. Whilst dated, the report succinctly judges the ease at which imported coal can be transported to these power stations.

UK ports, listed in Table 8, have 43.5 Mt/y of annual port capacity, of which 29 Mt/y comprises large vessel berths where vessel sizes of panamax and capesize are capable of discharging coal (DTI, 2004). The largest port is Hunterston at 6.5 Mt/y, while Immingham and Bristol also have the capability

Table 7 Import prospects for UK coal-fired power stations (DTI, 2004)

Station	GW	No of units	FGD commission	Access to imports
Aberthaw	1.5	3	2008	Reasonable
Cockenzie	*1.2*	*2*	*Unlikely*	*Reasonable*
Cottam	1	2	2006-2008	Reasonable
Didcot A	*2*	*4*	*Unlikely*	*Very good*
Drax	4	6	1996	Reasonable
Eggborough	1	2	2005	Reasonable
Ferrybridge	2	4	2008	Reasonable
Fiddler's Ferry	2	4	2008	Good via Liverpool
Fifoot Point	0.4	3	2001	Reasonable
Ironbridge	*1*	*2*	*Unlikely*	*Poor*
Kingsnorth	*2*	*4*		*Very good*
Longannet	2.3	4	2009	Reasonable
Ratcliffe	2	4	1994-1995	Poor
Rugeley	1	2	2009	Poor
Tilbury	*1.2*	*3*	*Unlikely*	*Very good*
West Burton	2	4	2004	Reasonable

Italics indicate that the plant has oped out of LCPD and will cease operation in 2016

of 5.5–6.0 Mt/y throughput. Port Talbot and Redcar can receive the largest vessels of up to 165,000 dwt, although their throughput capacity is just 2 Mt/y and 3 Mt/y respectively. According to Fitzgerald (2009), Immingham port appears to have achieved some of the highest growth in import business handling some 16 Mt/y in 2008.

The UK rail market is fully deregulated, with a number of private operators owning licences to lease and/or operate rolling stock to carry passenger and freight services. The track and infrastructure is owned and run by Network Rail. Inland freight transport of coal is done largely by DB Schenker, a company owned by the German rail company Deutsche Bahn. DB Schenker took ownership of the UK company EWS (England, Wales and Scotland rail company). Freightliner is the second largest rail freight operator after DB Schenker, delivering coal from import ports to UK stations such as Cottam and West Burton. Freightliner also delivers domestic products from Scottish Coal's distribution point at Killoch, Ayrshire to Fiddlers Ferry Power Station near Warrington. First GBRf (Great Britain Rail freight) is a major freight operator that transports imported coal between the Port of Tyne and power stations such as Drax, as well as domestic coal between collieries in the Midlands to West Burton and Cottam in Nottinghamshire. DB Schenker has a wider business, as a major rail haulier between ARA and Germany, Poland and France.

Coal imports to the UK remain strong, but will ultimately be affected by the closure of coal-fired plants in coming years. UK domestic coal production will aim to compete aggressively, with a target production of no more than 20 Mt/y, but whether this will succeed is difficult to confirm. Import infrastructure is well developed, and port and rail infrastructure has met the needs of transporting both domestic and imported products. Yet, where coal commodities might decrease, it is possible that biomass import and biomass storage facilities could become an increasingly interesting prospect for importers.

Table 8 UK coal discharging ports (DTI, 2004)

Port	Max vessel, dwt	Capacity, Mt	Import capacity, UK target stations
East Coal large			
Redcar	165,000	3	Ferybridge, Eggborough, Drax
Immingham HIT1	120,000	6	Ferybridge, Eggborough, Drax
			W Burton, Cottam, Ratcliffe
Immingham IBT	120,000	1	Ferybridge, Eggborough, Drax
		10	
West Coast large			
Hunterston	200,000	6.5	Cockenzie, Longannet, Kilroot, Ironbridge, Rugeley
Port Talbot	165,000	2	Didcot, Aberthaw, Fifoots
Bristol Portbury	100,000	5.5	Didcot, Aberthaw, Fifoots
Liverpool	60,000	5	Fiddlers Ferry, Ironbridge, Rugeley
		19	
Total import capacity large		**29**	
East Coast handy			
Hull	30,000	2	Ferrybridge, Eggborough, Drax
Immingham Dock	30,000	2	Ferrybridge, Eggborough, Drax
		4	
West Coast handy			
Newport	30,000	2	
		2	
Thames			
Kingsnorth	25,000	5	Kingsnorth
Tilbury	25,000	3.5	Tilbury
		8.5	

* Building HIT2 could increase capacity to 10 Mt dependent on investment level
† Plans in place to upgrade to 8 Mt

5 USA

The USA remains by far the largest single economy in the world with a GDP of US$ 14–15 trillion. China has recently overtaken Japan as the second largest economy at just US$ 5.9 trillion. While being the largest economy, per capita GDP in the USA is only the ninth highest, at just 47,284 US$/head, marginally ahead of the Netherlands and Canada, but below many Scandinavian countries and Australia.

Energy use is high compared to other OECD economies, with per capita electricity consumption almost double that of Germany and the UK, and 60% higher than Japan, possibly indicating major inefficiencies in the US end-user markets. Total primary energy supply per capita shows the similar proportional comparison, with every US citizen consuming 7 toe/head. This massive disparity could be a result of relatively low energy prices, making energy consumption a smaller proportion of household income. Similar inefficiencies can be seen in developing countries where energy prices are heavily subsidised.

OECD North America has been undergoing a renaissance in energy production in recent years, with new and alternative oil and gas reserves being opened up, and in addition the US administration has committed the USA to reductions in greenhouse gases of 17% below 2020 levels. Power generation is inevitably the primary target for such emission cuts (34% of the reduction), but road transportation is also facing significant cuts (29% of the target). With natural gas prices in 2012 at historic lows (2.2 $/million Btu or 2.08 $/GJ) and stricter emission levels, existing coal-fired power is facing considerable pressure, while there are likely to be few new coal projects.

5.1 Coal supply

While the USA will continue with a growth in natural gas power and aims to reduce CO_2 emissions from coal-fired plants through closure and investment in higher efficiency investment, it nevertheless currently has the largest reserves of coal in the world. The US EIA estimates the country has 234 Gt or at least 200 years of coal left in the ground. Potentially, the USA has double this reserve that has been measured and indicated at specific depths and thicknesses. As of 2010, the USA had almost 30% of the world's reserves of coal, while Russia had 19%.

Figure 17 illustrates the world reserves of coal as columns, split into major coal types. In addition there is the estimated life of the reserves shown as a line. As a global commodity, coal is abundant. Reserves are spread widely across the world, with less of the risk associated with concentrated reserves seen in oil and natural gas. However, when looking at regional reserves, the level of supply security varies, with lower reserves seen in the world's largest producing country, China.

The USA still has a vast domestic production base from which coal and natural gas is supplied. Yet, the long-term trend for energy leads to a number of factors that make imports of coal attractive. Since 1980, the USA has seen a steady and almost continuous rise in electricity demand and generation, with just four years of decline, the worst events occurring in 2001 and 2009. Despite these setbacks, the prospects for coal demand remain relatively strong with a 980 Mt market (2011), with some contraction likely where old coal-fired power stations are unable to meet increasingly stringent air quality standards and close, to be replaced with gas-fired generation. While coal-fired power faces intense competition from gas power, new coal-fired projects are fewer due to developments in new CO_2 emission and mercury emission targets.

Where coal-fired units remain in operation, US utilities almost always favour domestic supplies over imports. US participation in the international market has been as an exporter of coking quality coal.

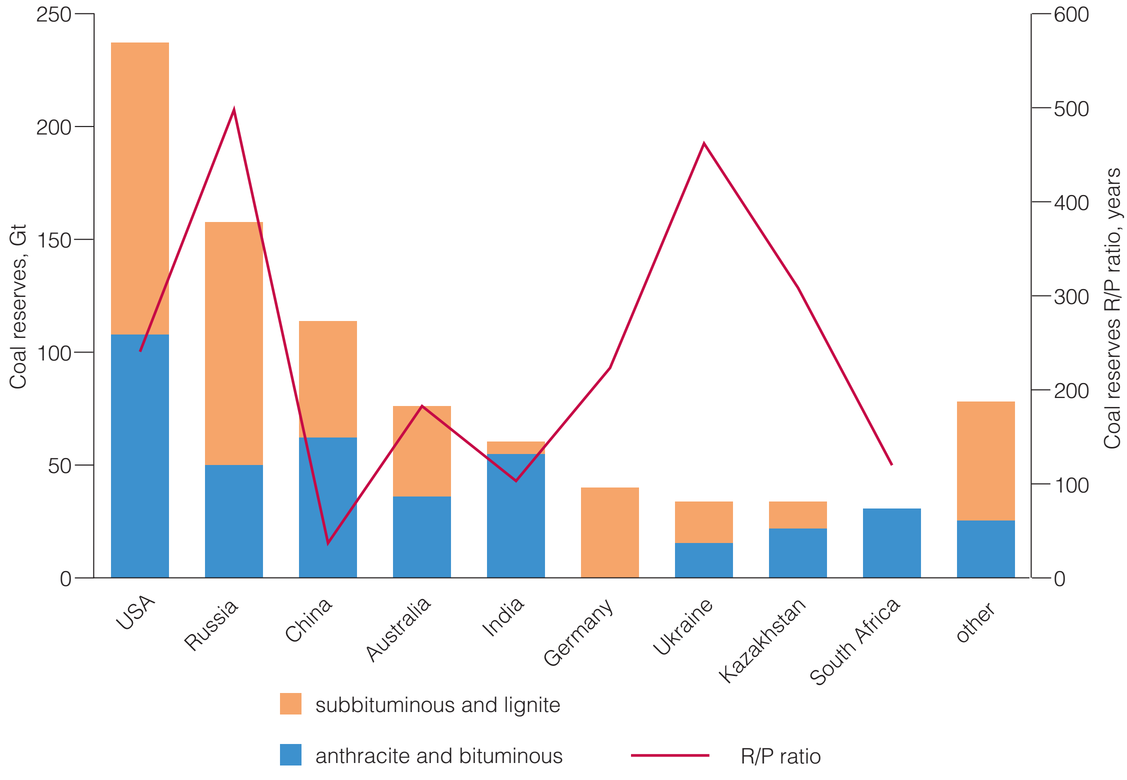

Figure 17 World coal reserves by region, Gt (BP, 2011)

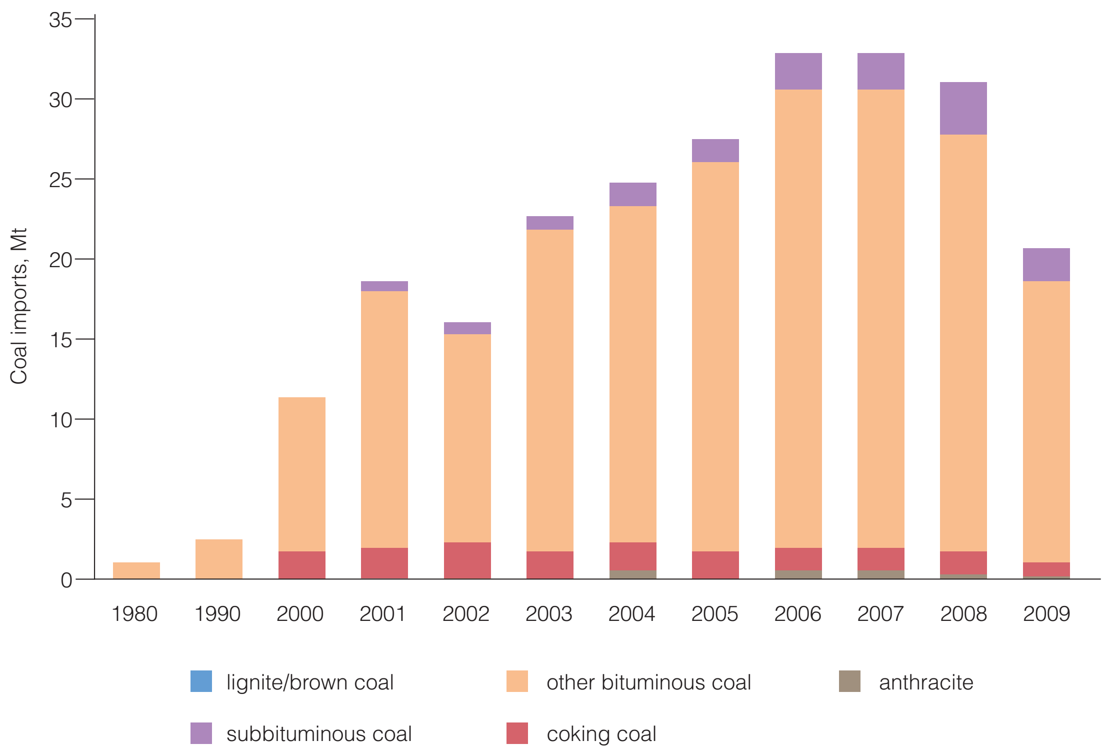

Figure 18 US coal imports (IEA, 2010b)

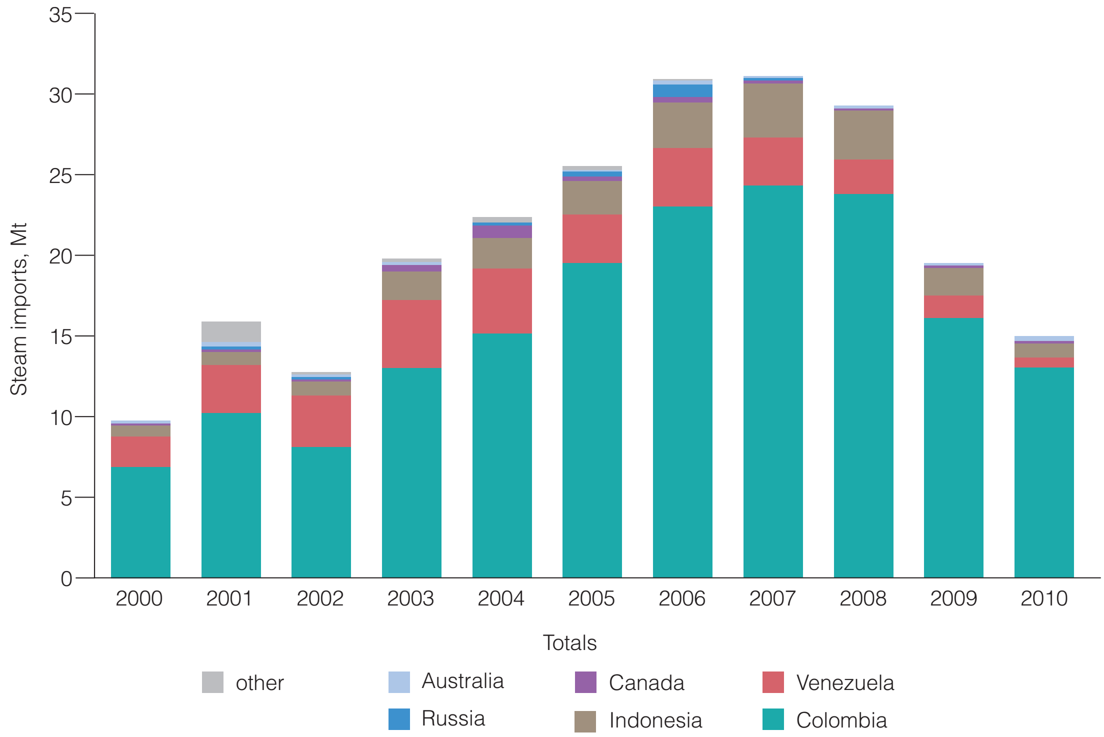

Figure 19 US steam coal imports by source (MCIS, 2012)

Imports (excluding Canada) are almost entirely steam quality coal (*see* Figure 18). Figure 19 shows steam coal imports by the country of origin, the largest single supplier being Colombia. Small amounts of subbituminous coal are being imported from Indonesia and coking coal is being sourced from Australia as well as other countries.

Coal import tonnages are relatively modest compared with the overall market for coal, with trade in the 20–30 Mt/y range, and account for just 2% of the country's coal supplies. At first glance, imports provide a small proportion of the US market's needs, and might seem unimportant, but from a supplier's point of view, exploiting even a small proportion of the US market could provide coal exporters with a growing opportunity to sell large quantities of steam coal, especially in areas which were previously served by higher sulphur coal producers.

Hard coal production in the USA is split into two broad regions, which are separated by the Mississippi River: 40% of the country's coal production to the east of the Mississippi River is bituminous coal mining in the *Illinois*, *Northern Appalachia* (NAPP), and *Central Appalachia* (CAPP) coalfields and 60% is to the west of the Missisipi, mainly in the states of Montana and Wyoming.

While interstate trading is strictly a movement of domestic coals, coal *imports* into Illinois sometimes refer to coals brought in by rail outside the state, from regions like the Midwest and not foreign coals imported by sea. There is a great deal of production in the Midwest, whilst demand is largely elsewhere around the USA. The largest concentration of coal-fired power stations is found east of the Mississippi River, supplying some of the more densely populated urban regions of the USA.

Opencast mining at the Midwest Powder River Basin operations has an impact on the environment due to the vastness of the operations, while controversial practices including *mountain top removal* (MTR) operate in the CAPP region. In 2006, some 70% of surface mining in West Virginia used the MTR method, making it an important yet high-impact part of the coal industry in West Virginia and East Kentucky (Britton and others, 2007). Some 100 Mt of coal was produced in 2008 using surface mining in the CAPP coal region. Amongst the CAPP producers, deeper and thinner seams and high manning levels were major causes of increasing mining costs (*see below*). In the wake of legislation that bans MTR, a large proportion of CAPP production could be affected, perhaps 50%. This could create a market for imported coal (either from Colombia, or the US Powder River Basin) by this amount, but with an increasing need for gas-fired power and renewables, the likelihood is that the market could contract.

Over the years, surface mining has increased, while underground mining has declined. The largest coal-producing basin is the Powder River Basin, although in energy terms, the share is smaller due to the lower calorific value of the lower rank coals found in this area. PRB mines are vast opencast operations; some of the largest coal mines in the world are located in north east Wyoming. Three massive operations in this region are located adjacent to each other: these are North Antelope Rochelle (80 Mt/y), Black Thunder (75 Mt/y), and Jacobs Ranch (34 Mt/y). These three mines produce approximately the same tonnage that Indonesia exports every year. Producers operating in the Illinois Basin have the smallest market share of US coal production, although Illinois (and NAPP) coalfields are expected to increase output and market share at the expense of the CAPP coals. There will be little displacement of PRB coals.

5.2 Coal demand

The coal market in the USA has been transformed by the availability of subbituminous PRB coals, but the demand for these coals came about primarily due to the implementation of sulphur regulations. The *Clean Air Act* (CAA) of 1970 addressed emissions from industrial plants, but the Clean Air Act Amendments of 1990 had the most profound impact on the US power and coal industry. The Clean Air Act II imposed stricter SO_2 emission caps on utilities, and to achieve these emission reductions a national market for tradeable SO_2 permits was introduced. Penalties for non-compliance could be avoided by buying credits from utilities that had a surplus of credits and, in doing so, the whole market would reduce SO_2 compared to a baseline emission level, at least cost. In 2000, Phase II of the CAA required more stringent sulphur emission standards forcing around 2000 power plants to fit FGD, compared with just 110 plants in Phase I.

As of January 2012, the *Cross State Air Pollution Rule* (CSAPR) came into effect requiring further reductions in SO_2 and NOx and more investment in FGD and selective catalytic reduction (SCR). According to Sjostrom (2012), the US DOE estimate that 62% of the 316 GW of US coal-fired power plants will have invested in FGD. The new regulations would also help reduce mercury emissions. Research by the US Geological Survey suggests that mercury levels in Appalachian coals are higher than the coals found in the Midwest (USGS, 2001). Given trade flows have already altered (in favour of Midwest coals) due to sulphur contents, that there may be little or no change in the trade flows as a result of mercury, but this is complicated by the presence (or lack of) halogen compounds which can determine mercury absorption (or release) in scrubber systems.

In terms of sulphur content, Midwest coals are lower rank subbituminous coals that are low in sulphur. Illinois and NAPP coals are high in sulphur, while CAPP coals are generally lower in sulphur. Yet in a bid to reduce costs, utilities continued to switch to cheaper low sulphur PRB coals as a means of complying with the CAA. Coals mined in the CAPP region benefited in the early days of the CAA, when utilities switched to low sulphur coals in preference to fitting FGD. FGD was fitted to captive plants where minemouth locations meant they were tied to local high sulphur products, although blending with low sulphur coal would still be practised. As the power station emissions legislation became increasingly stringent, the installation of FGD became more widespread. The heavy capital investment might have forced many station operators to seek lower cost coal as well for blending with higher CV bituminous coals, which could include PRB coals.

The massive fleet of coal-fired power capacity and the US appetite for electricity means that demand for steam coal has remained strong for many years (*see* Figure 20). According to McIlmoil and

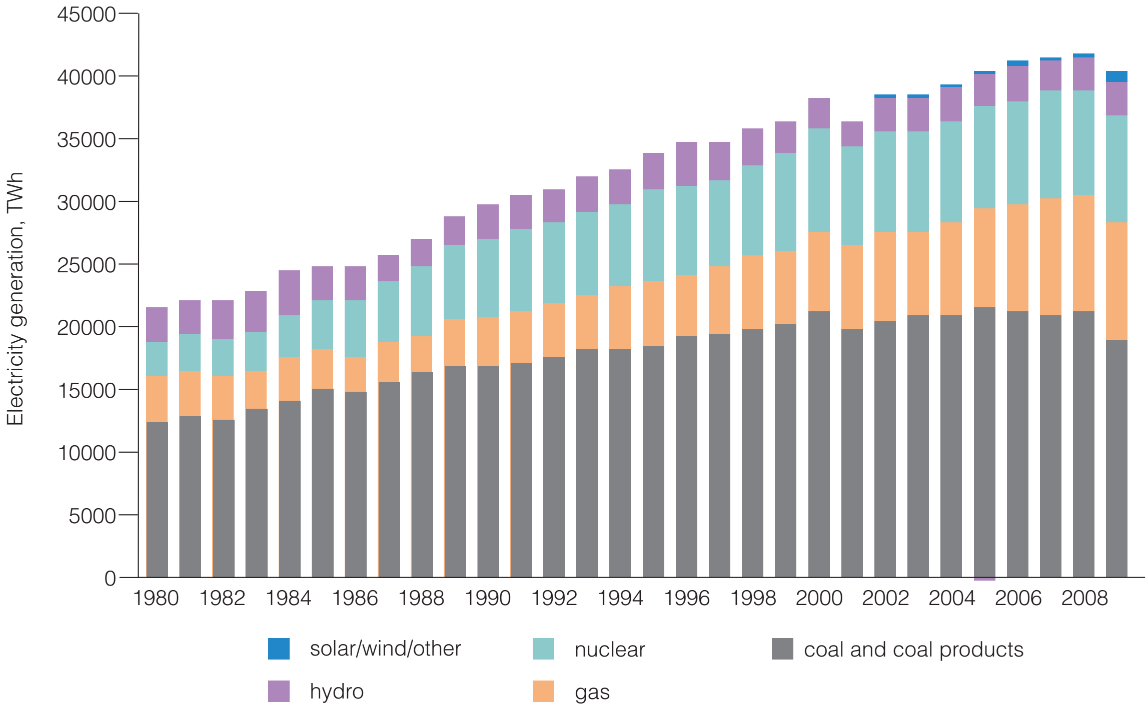

Figure 20 Electricity generation in the USA, TWh (IEA, 2010b)

Hansen (2010), Ohio and Pennsylvania burned more coal for electricity than most other states in the USA. While coal demand is strong in the USA, different regions have experienced different patterns of growth and contraction. Pennsylvania increased its consumption of low sulphur Central Appalachian and Powder River Basin coals following the 1990 CAA amendments, while decreasing the consumption of higher-sulphur Northern Appalachian coal. In 1990, some 5 GWe of generating capacity in Pennsylvania were equipped with FGD. Since 1995, when the first phase of the CAA amendments took effect, another 4.5 GWe of generating capacity was equipped with FGD, nearly doubling the total scrubbing capacity.

As of 2007, 35% of all coal-fired units comprising nearly 50% of all coal-fired generating capacity in Pennsylvania were equipped with FGD (NETL, 2007). Annual consumption of Central Appalachian coal since 2000 declined by 8–9 Mt in Pennsylvania as the plants were then equipped to burn higher sulphur Northern Appalachian coal. Ohio took a different course of action, that is mentioned throughout this report, with utilities choosing to switch to low sulphur PRB coal to reduce SO_2 emissions, while also reducing fuel costs. In the 1990s, utilities in Ohio reduced their annual consumption of both Northern and Central Appalachian coal by 13–14 Mt, while increasing their demand for PRB coal by 8–9 Mt. This marks a significant decline in Central Appalachian coal and Northern Appalachian coal, in relation to coal from the PRB.

There is considerable uncertainty regarding foreign coal imports into the USA, not least that the cost of internationally-traded (steam) coal continues to average above 100 $/t due to demand from Asia. US utilities are being pressure bound by local and federal emission regulations to close older stations and replace them with natural gas CCGT. Low natural gas prices due to a glut from alternative gas reserves (mainly shale gas) are competing aggressively with coal for power generation in 2011-12. New rules governing mercury emissions will lead to many gigawatts of coal plant closures and require billions of dollars in additional investment in equipment on existing plants. Ozone standards could feature in future legislation. This does not mean the market for coal in the USA will disappear, a certain proportion of that market will be served by imported supplies in one way or another.

5.3 Cost advantage of coal imports

Within the US domestic market, the prices paid by US generators are among the lowest in the OECD. Figure 21 illustrates the average cost of coal delivered to power stations in various IEA countries over a ten-year period between 2001 and 2009. The upper end of the range occurred during the unusual episode of price hikes in 2008, while the lower end occurred in the early 2000s. Prices in 2010-11 settled in the top half of this range. Clearly, the USA benefits from some of the lowest coal prices of any country in the OECD. The average delivered prices were below 60 $/tce compared with major coal importers in countries such as Germany and the UK paying on average 100 $/tce.

Since steam coal is not imorted in large amounts, international prices have not greatly influenced those in the US market. Despite the size of the US coal market, it has little influence on the international market. The US market is driven by a number of complex influences, which includes market deregulation, competition from gas power, the cap-and trade mechanism to reduce SO_2 emissions, and now mercury and CO_2 emissions.

Under usual circumstances, the US coal market is a challenge for foreign suppliers to penetrate, but not insurmountable. Importing coal has proved useful in enhancing coal supply security during times when domestically-mined supplies were affected by weather, transportation disruption, or production, and stock shortfalls. For example, in the mid 2000s, domestic coal producers and local rail operators struggled to meet coal deliveries, supply tightened and domestic prices increased faster than they did internationally. Under these circumstances, there is some arbitrage between domestic and foreign imported coals, such as utilities in the southern states which are located close to the Gulf of Mexico and the Atlantic ocean which can easily handle seaborne coal shipments from Colombia.

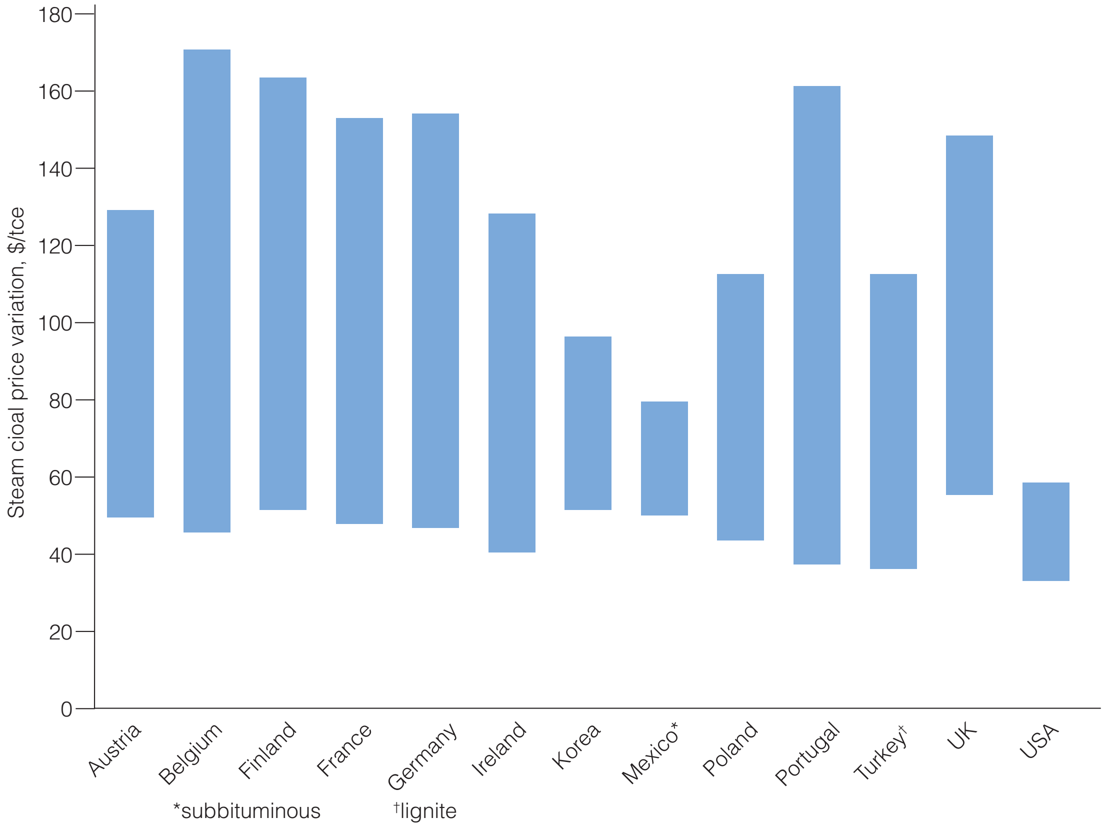

Figure 21 Variation in the delivered price of steam coal to power stations 2001-09, $/tce (IEA P&T, 2010)

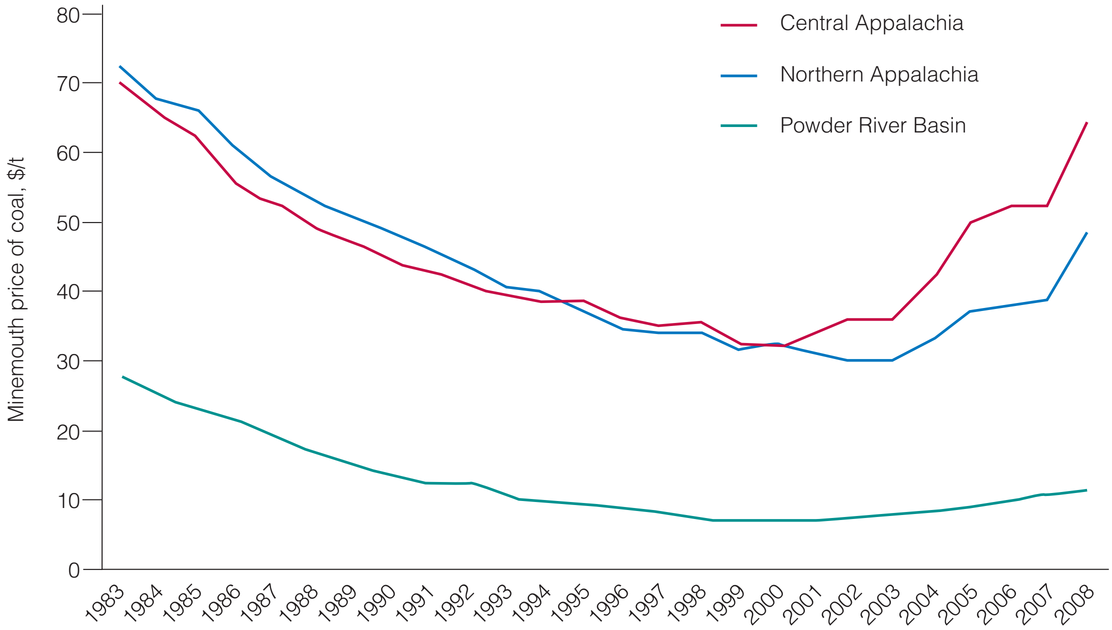

Figure 22 Comparison of coal prices for the PRB, Northern Appalachia, and Central Appalachia (2008 $) (McIlmoil and Hansen, 2010)

Figure 22 illustrates some key prices for coal in the USA, showing the minemouth prices of coal from CAPP, NAPP and PRB regions since the 1980s. The costs of all coals up to 2000 were on a downward trend due to rising productivity from both opencast and deep mines. Costs rose again post-2000, but more markedly for producers in the NAPP and CAPP regions. The mines in the PRB experienced a modest rise in cost, probably due to the rise in operational expenses such as fuel, tyres, and equipment maintenance. To compare the cost with foreign coals, these are shown in Figure 23, which illustrates the export price trend for Colombian coal (FOB at Puerto Bolivar); up until 2004, Colombian coal was below the minemouth cost of coal in the USA, making Colombian coals extremely attractive.

The cost of insurance and shipping is added to the FOB to obtain the CIF cost. Seaborne shipping ranges widely at 4–60 US$/t (since 2000), averaging perhaps less than 15 US$/t (based on Colombia to ARA). The cost of transporting Colombian coal to the USA is probably lower as the voyage period is shorter and the vessel sizes are probably smaller so charter rates would be lower for fewer days than shipments to Europe. Inland transportation adds to the CIF cost at the port, perhaps as much as 20–45 $/st (short tons) for some longer distance rail routes within the USA. In metric tonnes these costs averaged around 10 US$/t since 2000. So taking the FOB cost of coal at Colombia, the onward cost to get coal to the power station could add at least 14 $/t.

In 2008, the price of coal peaked for both US coals (minemouth) and Colombian coals (FOB). The delivered price to US power stations averaged 65 US$/st at its highest (IEA, 2011). Colombian FOB costs were 110 $/st, almost double that of the average for US coals (based on market conditions in early 2012). The cost of producing some US bituminous coals can be as high as the FOB price of Colombian coals even at 110 $/t, these are typically marginal mines that occasionally export steam coal to the Atlantic market, reprising the country's role as a swing supplier to the world market.

At 100–110 $/t, internationally-traded coal is unlikely to be imported into the USA. Even with rising domestic rail rates (as high as 20–30 US$/st), Midwest PRB coals could still compete with foreign imports to many northern and eastern locations in the USA, although southern and eastern coastal stations with port facilities would probably retain a regular supply of Colombian coal (*see* Figure 24) as they would incur little more than the CIF price plus a small handling and storage charge. In 2009,

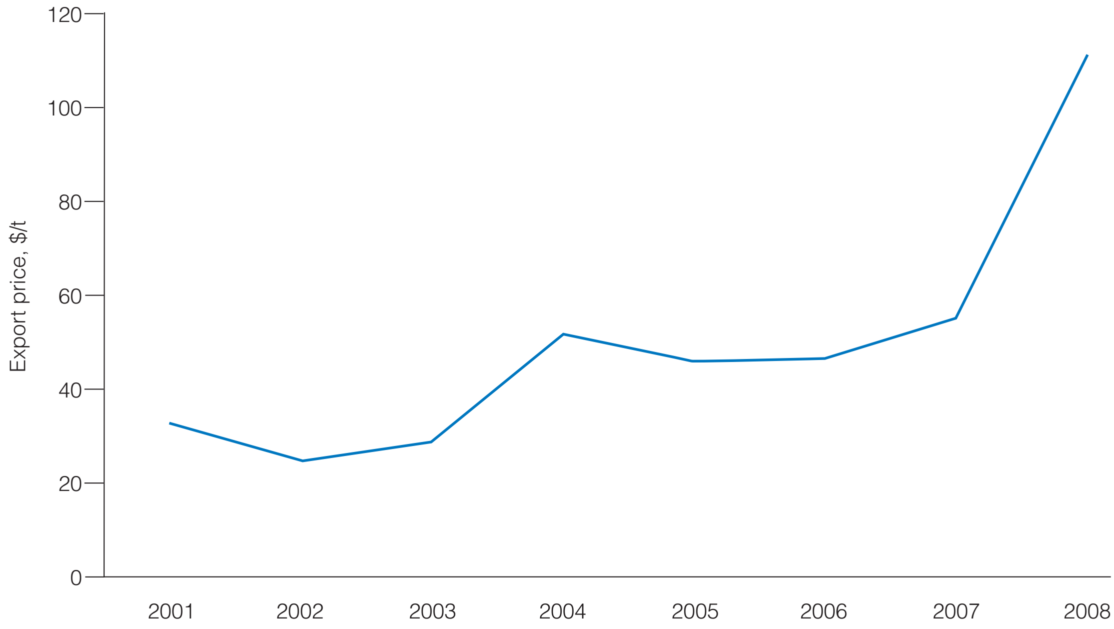

Figure 23 Colombian export prices, FOB US$/t (MCIS, 2012)

Colombia exported coal to the 16 major US states that line the southern and eastern coastlines from Mississippi to Maine. The only landlocked state to have taken Colombian coal is Tennessee which is well served by barge up the Mississippi river. Some states such as Pennsylvania, West Virginia, and Illinois already have a large hard coal industry, while Texas in the south has a large lignite market.

Colombian exports have proven a compatible and reliable supplier to the US utility market as well as the rest of the world. Most Colombian supplies benefit from an integrated rail and port system linked to one of the largest opencast coal mines in the world, El Cerrejon. The Cerrejon mine began as a joint venture between Exxon and the Colombian government in 1982, but now is a joint venture of Anglo American (33%), Glencore International (33%), and BHP Billiton (33%). Cerrejon Coal is therefore a world-class operation operated by international mining companies. Cerrejon coal is exported out of Puerto Bolivar and some ports located in Venezuela and so some of the success comes partly from geographic proximity of its export ports to the US Gulf and Atlantic markets.

Also, the Colombian coal industry has a history of production from entirely US-owned operations. Drummond is a coal company based in Alabama, first establishing itself as one of the largest surface mines in Alabama, but it also recognised the importance of having reserves of low sulphur coal, which started the company's interest in Colombian coal. In the late 1980s, Drummond sought Colombian coal assets and by 1995, Mina Pribbenow started production. In 1997, the company acquired El Descanso, and the Dupela project in 2003. The new El Descanso mine that came into operation in 2010 pushes Drummond's production up to 30 Mt/t from 25 Mt/y in 2009 (Reuters, 2010).

Colombian coal imports have fallen to levels last seen in 2002. However, the cost of getting the Colombian product to US buyers could be competitive, possibly as little as 4.50 $/t to coastal power stations versus transporting domestic coal from the US Midwest at up to 40 $/t. In a time when natural gas (shale gas) prices have dropped to an extremely competitive 2 $/million Btu (1.89 $/GJ), the need for cheaper coals will be greater. Whether US utilities choose domestic PRB coals or include a greater proportion of Colombian coals is yet to be determined over the long term.

While rail rates for import coal are confidential, rail rates for export coal in 2011 are in the range 42–45 $/st (46–49.5 $/t) for selected routes between the Northern Appalachia (MGA District) or

Central Appalachia (Kanawha) to the ports of Baltimore and Newport News for transport into the Atlantic seaborne market (Heller, 2011).

In periods of rising rail rates such trade is threatened, for example PRB coals trading into the CAPP market, not least due to the introduction of a fuel surcharge in recent years. This cost has been passed on to coal transportation costs, and therefore new contracts for coal deals could be more than twice the rate seen in 2004. Since 2007, the rail rates have doubled from roughly 18 $/t to 44 $/t in 2011. Fuel surcharges accounted for less than 1 $/t of this rise. While these export rail rates may not resemble the costs for inland trades between PRB and CAPP regions, or indeed for imported coal between Gulf ports and power stations in the southern states, the trend shows the rate of increase that has occurred in the US rail industry in just a few years. In 2011, the rail rates were equivalent to the levels seen for transporting Russian coal to export ports. Whether these rates continue to increase is debatable given the changing face of the market, due to the competition by natural gas and the possible long-term softening of coal demand.

5.4 Quality advantages of imported coal

Steam coals produced in the USA vary in quality with subbituminous heating values ranging as low as 4667 kcal/kg for PRB products to bituminous anthracites as high as 7222 kcal/kg mined in Northern Appalachia (*see* Table 9), the latter being once a popular coal that was exported to Europe in large quantities in the 1980s and 1990s. As mentioned throughout this report, sulphur content is one of the key criteria (apart from cost) dictating the coal market dynamics in the USA; sulphur content ranges from 0.3% for the PRB coals to 3.45% in some of the bituminous coals mined in the Illinois Basin. Small percentage points make big differences, and so any content above 1% becomes almost unusable without FGD.

In this respect, some of the best coals are mined in Colorado and Utah, especially from the Uinta Basin where there are coals with 6500 kcal/kg and just 0.5% sulphur coal. Based on these qualities alone, Uinta coals would make a reasonable export coal. Imported coal compares well with Utah coals, with Colombian Cerrejon specification being typically 0.65% sulphur content, 9% ash and 5800–6000 kcal/kg (NAR).

Colombian coal has successfully been tested and burned in a number of US plants. According to Teicher, 2008, US plants designed for hard coals have had few problems testing and burning imported coals from Colombia. For example, Constellation Energy is a utility that operates a number of coal plants in Maryland, which were designed using CAPP coals. In 2007, Constellation Energy began environmental upgrades at the Brandon Shores power plant such as installation of FGD, part of a billion dollar plan on clean air equipment for its coal-fired generation fleet in Maryland (Reuters, 2007) to meet the emission requirements of Maryland’s Healthy Air Act, signed into law in 2006. The FGD units were installed in 2009, yet this same year, Brandon power station was also blending in some small amounts of Colombian coal. According to Teicher (2008), the cargoes burned with no derating to the power station. A number of stations that were designed for US coals have burned at least 50% or more of the coal blends using Colombian coals. A large power plant in Florida, was reported to burn roughly 3.5 Mt of coal every year, a typical consumption of a 1.7 GWe power plant. With half the fuel input comprised of CAPP and petroleum coke (by-product of oil refinery), which is high in sulphur, Colombian Cerrejon coal was an ideal blend to help bring plant emissions down while reducing cost and increasing security of supply of fuel.

Imported coals from either the PRB or Colombia offer many benefits to blending or switching for utilities that burn high sulphur NAPP coals, or high cost CAPP coals. Interestingly the issue is not as straightforward since the US coals have higher heating values, some in excess of 6500 kcal/kg, while some international coals are typically 5500–6350 kcal/kg. As such the US coals, while high in sulphur, can offer a good blending coal for export itself, provided the destination power station has

Table 9 Coal quality of US export coals (Argus, 2011)

Location	Basis	Heating value, kcal/kg	Heating value, MJ/kg	Sulphur, %
Central Appalachia				
Big Sandy 'Nymex spec'	FOB Barge	6667.2	27.9	1.00
Big Sandy	FOB Barge	6667.2	27.9	1.00
CSX Big Sandy/Kanawha	FOB Rail	6945	29.1	1.04
CSX Big Sandy/Kanawha	FOB Rail	6945	29.1	1.04
CSX Big Sandy/Kanawha	FOB Rail	6945	29.1	1.04
Powder River Basin				
UP & BNSF Converse/Campbell	FOB Mine	4889.28	20.5	0.35
UP & BNSF Converse/Campbell	FOB Mine	4667.04	19.5	0.34
Illinois Basin				
Ohio River/ W Kentucky	FOB Mine	6389.4	26.8	2.88
Illinois/Indiana	FOB Barge	6389.4	26.8	2.88
Illinois/Indiana	FOB Mine	6389.4	26.8	0.81
Ohio River/ W Kentucky	FOB Barge	6389.4	26.8	1.55
Illinois/Indiana	FOB Mine	6389.4	26.8	3.45
Ohio River/ W Kentucky	FOB Barge	6389.4	26.8	3.45
Colorado/Utah				
Western bituminous	FOB Mine	6500.52	27.2	0.53
Uinta Basin, Colorado	FOB Mine	6500.52	27.2	0.53
Uinta Basin, Utah	FOB Mine	6500.52	27.2	0.53
Northern Appalachia				
Pittsburgh Seam	MGA Rate District	7222.8	30.2	1.95
Pittsburgh Seam	MGA Rate District	7222.8	30.2	2.60
Pittsburgh Seam	MGA Rate District	6945	29.1	3.75

FGD fitted. This is what made the USA once a major swing supplier of steam coal in the 1980s and 1990s. With more utilities fitting FGD to their power stations, high sulphur coal is becoming a potentially growing market. However, if the cost of running the FGD becomes excessive, importing lower sulphur coal, whether from the PRB or Colombia can reduce the load onto the FGD, but this will also affect the station performance due to the lower heating values.

5.5 Coal import logistics

The USA is well served with port capacity to accommodate coal imports around various points along the Gulf of Mexico and the Atlantic coastline. Coal imported from Colombia comes into the USA via five ports, which are located in Mobile, (Alabama), Jacksonville (Florida FL), Baltimore (Maryland), Salem (Massachussetts), and Somerset (Maine). These are shown on Figure 24 which shows the eastern and southern USA and locates the power stations which are known to have imported coal in the past. Key import ports are also shown; each of these ports also serves a major power station. In Salem, the destination is the Salem Harbor Station, and in Somerset, Dominion's Brayton Point Station. Aside from Salem Harbor, coal imported to the USA from the Colombian La Loma mine mainly goes to the Brayton Point station (MA) and a plant in Mobile (AL). Plants in Newburgh (NY), Savannah (GA), and Tampa (FL) also receive coal from La Loma as well as plants in Nova Scotia and New Brunswick. A new coal terminal at the Port of Jacksonville, Florida opened in 2011, and could open markets in the southeastern and midwestern USA to more Colombian coal in coming years. Use of the Keystone Coal Company's $20 million terminal is expected to create access to imported coal that is 10–20% cheaper than domestic coal. Because rates for rail transport of US coal continue to increase, the cost of getting the Colombian product to buyers would be significantly less, possibly as little as 4.50 $/t, versus 40 $/t for domestic coal.

There are theoretically some 128 coal plants that are located within 750 miles of the US coast, potentially opening up a market of 260 Mt (Gatiss, 2009). This limit is highly dependent on access to rail and barge infrastructure. At least 40 power stations are known to have imported Colombian coal sometime during their operation or are located on the coast and are marked in Figure 24 which shows some of the known locations of some coal importing stations. This map is not exhaustive, and does not represent the actual number of operating coal-fired power stations in these regions, but includes those power stations whose fuel source includes imported coals. As expected, the stations that have burned imported coal are located in or around the coastal states, from Louisiana in the south to Maine in the north. Colombian coal generally does not get transported much further inland.

West coast power stations do not import coal, and Mid-West, Illinois and Texan stations generally burn domestically-produced coals. Other power stations which are located inland but close to rivers are also marked on Figure 24. These could have access to imported coals, but may well consider imports to be coal that is transported from outside the local coalfield region, such as those from the PRB in the US Midwest. Power plants in the Midwest of the USA would logically use entirely domestically-produced low sulphur coals in Montana and PRB.

Some inland power stations import coal using river barge up the Mississippi River in Alabama. The key port in Alabama is Mobile, which is on the Gulf coast. Florida has three stations around Tampa which also use Colombian coal. While Hampton Roads is an export port of metallurgical coals, coal imports make logistical sense if they can enter Hampton Roads with steam coal cargo, then once unladen can leave with export metallurgical shipments. The power station in Hampton Roads is Chesapeake. A new coal terminal at the Port of Jacksonville, Florida opened in 2011, and could open more markets in the southeastern US to Colombian coal. The Keystone Coal Company developed a US$ 150 Mt coal terminal and is expected to create access to imported coal, although the investment was made before the economic downturn and the dramatic reduction in natural gas prices in the USA in 2011-12.

The primary mode of coal transport throughout the USA is by rail, although river barge is also important. The key rail companies include those such as Burlington Northern which operates in and around the Midwest, while Norfolk Southern operates more in the eastern regions. The deregulation of the rail industry led to falling rail rates although in more recent years, rail tariffs have been on the rise. Rail operators such as Burlington Northern and Union Pacific became key providers of coal transport and made possible the transport of coal across the country, covering distances of more than 2000 km from the Midwest west of the Mississippi to the coal markets in the east of the Mississippi.

The US network of rivers has long been a form of transport from the Gulf of Mexico to many inland destinations. According to Vachal and others (2005), the Mississippi River and the Ohio River account for 26% and 14% of the waterway mileage. Adding the Tennessee River, Illinois Waterway, and Monogahela River these five waterways account for 83% of the traffic and 57% of the network miles in the USA. Traffic on US inland and intercoastal traffic lanes is lead by the petroleum industry, accounting for 43% of 2009 volumes (IWS, 2010). Coal/coke represent 13%, with the balance held by

Figure 24 US coal-fired power stations capable taking import coal

chemical products, food and farm products and other primary commodities and manufacturing goods.

The Mississippi River carried 154 Mt of coal in 2009, accounting for 28% of the systems total tonnage. A majority of this was domestic traffic. The Ohio River carried 123 Mt, but as a proportion of the system's total, coal accounts for almost 60% of total volumes. The Ohio River is a primary corridor in the coal transport network, which also happens to be one of the major coal export routes, serving the Illinois coal industry. The Tennessee River traffic includes coal which accounts for 38% of the waterway's traffic.

Recent events have given the USA new impetus to re-enter the seaborne market as a coal exporter. Suggestions that subbituminous PRB coals could come out of the west coast to the Asia-Pacific market could prove fruitful over the long term, while other reports suggest that coal exports of bituminous coals are on the increase. However, this switch to coal exporting, at least of bituminous coals is a result of the phenomena of Queensland flooding and the continued high demand of imported coals in the Asian markets. Most coal coming out of the USA is currently for metallurgical markets, with less for steam coal markets.

6 Conclusions

The Atlantic is a mature market with regards to international trade; the origins of bulk seaborne trade of coal lie in Europe and Japan. Historically, Europe had a large domestic mining industry throughout much of the 20th century, but imports were still an important supply source for some countries, especially those with dwindling or no reserves such as France and Italy.

Where coal mining flourished under national ownership, high costs of production were tolerated for the purpose of security of supply. In time, stricter environmental standards imposed on coal-fired power stations forced utilities to source lower-sulphur coal from the international market or fit emission control equipment. Different countries took different approaches, and so the displacement of domestic coal was staggered across OECD Europe.

European energy and environmental policy dictated a structural shift in the way European countries generated power. Emission limits on large combustion plants, chiefly coal and oil-fired stations, were drivers to limit local and national pollution levels, not least SO_2 emissions, but particulates and NOx were also tightly regulated. Current legislation in Europe (as well as the USA) has forced the installation of adequate flue gas desulphurisation (FGD) equipment. However, where FGD is not enough, lower cost imported coal with lower sulphur contents will continue to be sought. Under the Industrial Emissions Directive and the outgoing Large Combustion Plant Directive, power plants will have to adapt to even stricter sulphur and NOx emission levels. Without FGD, coal-fired power stations across OECD Europe and much of the USA are earmarked to close.

While the USA has a wholly privately owned and subsidy free coal industry, competition policy and deregulation in the EU is encouraging a withdrawal of coal producer subsidies wherever they are applied. Deregulation in the wholesale power generating market also leads to power plant operators seeking the cheapest coal (within adequate quality parameters), often leading to an increase in foreign imports. Without the commitment of long term contracts with local suppliers, utilities have turned to the world spot market for coal as the buffer stock for supplies.

While state aid will continue to be granted to social projects and restructuring activities, financial aid to support coal mine extraction in Germany and Spain will cease in 2018, at least in its current form. It is possible domestic hard coal production will disappear from Germany, Spain's future is uncertain. Lignite mining in Germany however may continue for many years as it operates without subsidy, and has a captive market in the form of large modern power stations located close to the mine facilities. These issues underpin the fact that domestic coal producers face a smaller market for coal than in the past, while at the same time, cheaper coal from foreign suppliers operating low cost operations have squeezed domestic suppliers even more.

Major coal import countries such as Spain, UK, and Germany have the port, rail and barge infrastructure to serve many power stations. Coal-fired power plants built in the last century were generally concentrated around areas where domestic coal was mined.

In Germany, the hard steam coal market is around 35 Mtce. In 1980, almost all of this was produced domestically, today just 5 Mtce is mined in the country. Many coal-fired plants designed for bituminous coal are located in the landlocked region of North Rhine-Westphalia where the domestic (hard) coal industry was strong. German coal qualities are very good, on par with qualities of internationally-traded coal. However, mining is becoming increasingly difficult as bituminous reserves are becoming more difficult to access and costs are prohibitive. While mine closures continue, the power stations are ever more dependent on the barge and rail network to deliver coal from ARA or the north German coal ports. Other imports enter Germany via the eastern border by rail from the Polish Silesian fields. While barge deliveries can be affected by river levels, the rail network is extensive and well connected to the ports. The cost of production is double that of imported coal, but subsidies paid to the German mine companies are governed by a formula that tracks the imported coal price.

In Spain, some 25 Mtce of hard steam coal is mined. Of this market, 10 Mtce is produced domestically, roughly double the production of Germany. The coal-fired power stations are located mainly in the north where much of the coal is mined, although some plants are located in the south. Both these regions are also accessible by inland transport to receive imported coal, so displacing domestic production has been straightforward with few logistical impediments other than geographical distance. Domestic coal is heavily subsidised, some of the highest in terms of subsidy per tonne produced. Also, coal-fired power stations burning domestic coal may be guaranteed a minimum offtake to ensure the demand for domestic coal does not fall so low as to close the industry. The cost of production is almost double that of imported coal, with utilities paying the full cost but reimbursed the difference.

While UK mining companies have a global presence in many commodities, the UK domestic coal companies produce only hard coal. UK mine operations have survived restructuring and operated without production subsidies since the 1990s. The UK market for steam coal is around 50 Mt (42 Mt for powers generation). Indigenous production is close to 18 Mt, with imports accounting for 26 Mt (the balance drawn from stocks). Most of the UK's power stations are capable of receiving imported coal and the few that are located inland are accessible by rail. UK coal is high in sulphur, but lower in cost compared to imported coal.

While the technology exists to clean up stack emissions of almost all pollutants, the commercial scale operation of CCS remains in development to tackle CO_2. Therefore, with ever stricter emission legislation and CO_2 targets, coal-fired power has declined in favour of natural gas and renewables, the cleaner alternatives, but not necessarily the more economic options.

In the USA, the importation of coal is limited as domestic coal serves almost all of the demand, however, it provides an excellent model of trade flow where lower cost coal with low-sulphur contents can be transported over long distances and displace higher cost products in other regions. Emission laws governing the output of SO_2 and the availability of low-sulphur coal within the country has changed the flow of trade across the country. The availability of rail and barge capacity has permitted low cost coal producing regions in the Midwest to displace much of the production in regions east of the Mississippi. These trade flows within the USA, in some ways, resemble the displacement of domestic coal in Europe with imported coal from the seaborne market. Moreover, the USA still has a large fleet of coal-fired power stations which are capable of importing coal from the Atlantic market, notable form Colombia. Low natural gas prices due to the glut from alternative gas reserves (mainly shale gas) are competing aggressively with coal for power generation.

New rules governing mercury emissions will lead to many gigawatts of coal plant closures and require billions of dollars of investment in additional equipment in existing plants. It is too early to determine how new mercury laws will impact coal trade flows. Nevertheless, the market could shrink for coal-fired power as more gas-fired plants are built to replace ageing coal plants. Whether foreign imported coals can continue business in the US market while PRB coals continue to dominate coal production in the country is open to debate.

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