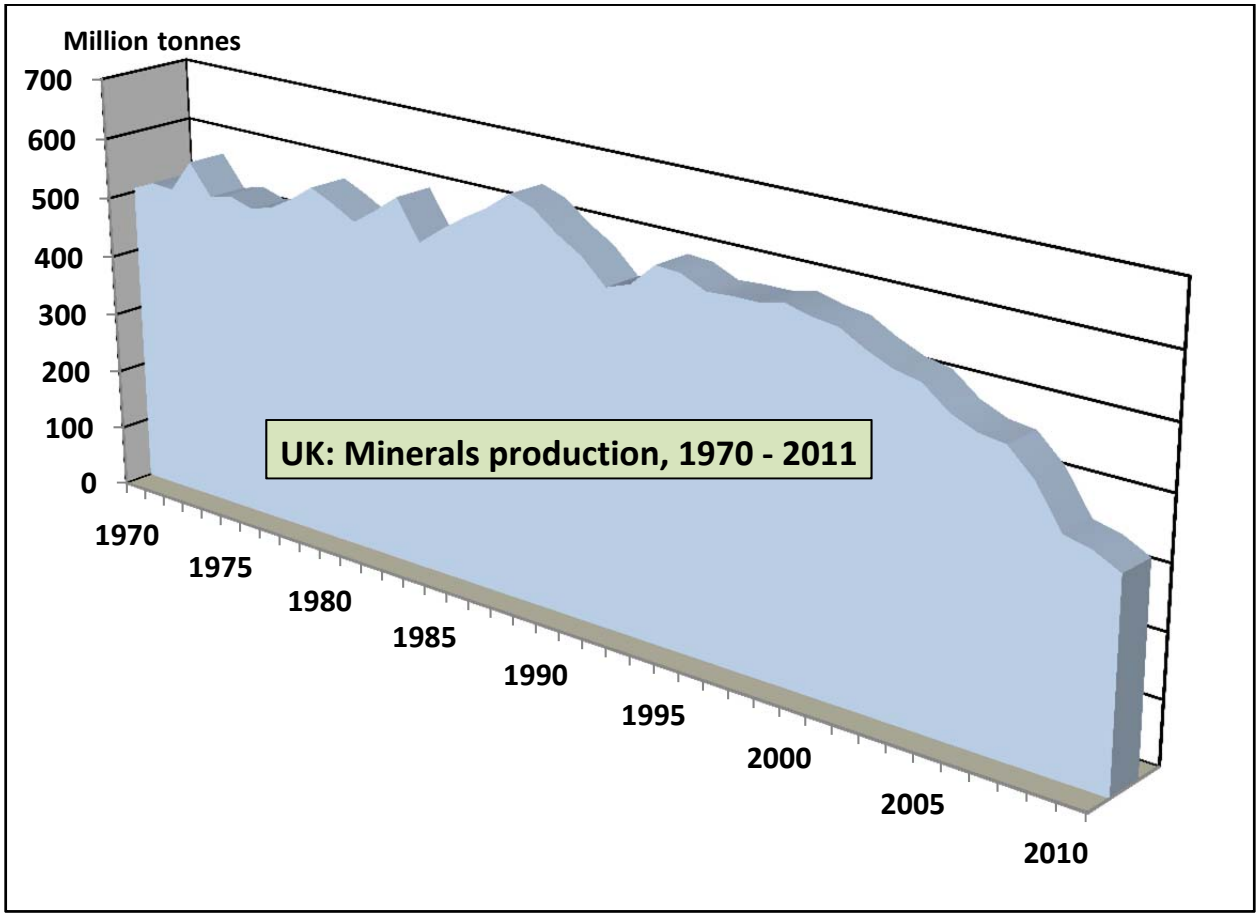
UK Minerals FORUM

Trends in UK Production of Minerals

UK Minerals Forum Working Group 2013-14 - Future Mineral Scenarios for the UK



February 2014

Foreword

The UK Minerals Forum (UKMF) brings together representatives of the UK's onshore extractive industries, NGOs with a particular interest in the environmental impacts and opportunities of mineral extraction, the sector's research organisation, local government planners and observers from central government, the territorial administrations and the main statutory regulators. The Forum is funded by the CBI Minerals Group and provides an opportunity for members to discuss matters of common interest in a neutral space, away from the pressures of traditional lobbying, campaigning, and formal dialogue about regulatory policy, legislation, minerals supply and environmental protection. The Forum sponsors Working Groups to look in detail at matters of particular interest or concern and to report their findings to UKMF and to the wider public through suitable websites and the biennial CBI *Living with Minerals* Conferences. Specific issues emerging from Working Groups are followed up with government as appropriate.

The UKMF Working Group on **Future Mineral Scenarios for the UK** is examining the possible impacts of alternative futures for UK minerals supply out to 2050. It is particularly interested in exploring:

- how demand, sourcing and supply of minerals might vary in different scenarios;
- how different scenarios might impact on current and future perspectives of the sector held by industry, policy makers, regulators and NGOs; and
- what the potential drivers of future minerals demand and supply might be.

The Working Group is meeting these objectives through a mix of desk research tracking past trends in minerals production in the UK, discussions with different mineral sectors on the issues that may impact on future minerals supply, and a Future Minerals Scenarios Workshop, designed to engage interested stakeholders in the process. The objective of the Workshop was to gather views on the key issues, and to inform the scenarios at 2050 which will be analysed and presented in the Working Group's report in mid-2014, to be presented at the *Living with Minerals 5* Conference on 17 November that year.

This interim report provides essential baseline information on the evolving pattern of the UK's mineral production in recent decades as background to the Forward Look.

Acknowledgements

The *Future Minerals Scenarios Working Group* would like to thank members of the UK Minerals Forum and CBI Minerals Group for their comments on the report.

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Executive Summary

Adequate and steady supplies of minerals are essential for the nation's economic and social development. For its small size Britain is relatively well endowed with mineral resources, and their extraction and use has played an important role in the historic development of the UK economy. The UK continues to have an economically significant minerals industry, with oil and gas, and construction minerals being the dominant sectors in terms of tonnage and value. Although UK coal production is much diminished, coal still makes an important contribution to our energy mix. A number of industrial minerals support downstream industries and some, important export markets.

As in the past, future demand for, and thus production and import of, minerals is continually evolving. Demand will continue to be strongly influenced by a range of economic, political, technical, social and environmental factors. This report takes a backward look at Britain's mineral production. The last three decades or so have witnessed major changes in the fortunes of each of Britain's extractive sectors – oil and gas, coal, construction and industrial minerals, and metals. Whilst the future cannot be simply extrapolated from the past, it is useful to record and analyse some of these trends to see if they identify any drivers for the future.

The UK is seeking transition towards a low carbon economy and now has a statutory target to reduce UK greenhouse gas emissions by at least 80% below a 1990 baseline by 2050. This is already having, and will continue to have, considerable ramifications for the UK minerals industry, notably for the fossil fuels used in electricity generation, and also for the energy intensive industries, such as ceramics, glass, chemicals, cement, lime and plaster products. These industries are major consumers of minerals principally sourced from the UK, but where the rising cost and potentially capped carbon content of their energy input is forcing a reappraisal about continued location within the UK and indeed the EU.

Trends in overall minerals consumption in the UK can be derived by assessing domestic minerals extraction, and mineral imports and exports. Over the last 40 years UK minerals consumption initially increased until the late 1980s but then declined, and markedly so since 2000. This was principally due to falling fossil fuel output (oil, gas and coal) and also, more recently, from the impact of the recession on the production of construction minerals (mainly aggregates), which account for almost 80% of UK land-based minerals production. Mineral exports, comprising mainly oil and gas, but also kaolin, have also been on a declining trend since 2002 while imports have increased, largely reflecting our increasing dependency on imported fossil fuels. This is a trend that is likely to continue into the future as offshore reserves of oil and natural gas are depleted. Domestic minerals consumption has fallen by some 200 million tonnes (35%) in total between 1970 and 2011.

Since 2008 declining minerals consumption reflects the effects of the recent recession, but over the longer term the data may indicate that the economy is under investing in housing construction and infrastructure, and foregoing the value added of working and processing indigenous (and imported) minerals in favour of importing manufactured products containing embodied minerals (and carbon emissions). Moves to try and rebalance the economy, particularly through increased investment in infrastructure as economic growth returns, could reverse the decline in UK minerals consumption. A revival of the depressed construction industry is now overdue and with it demand for construction minerals almost all of which are produced from indigenous sources.

This interim report presents trends in the production of a wide range of minerals, including the fossil fuels – coal, natural gas and oil; construction minerals – aggregates, brick clay, cement-making raw materials and gypsum; and a number of industrial minerals – kaolin, ball clay, silica sand, potash, industrial carbonates, fluorspar and barytes.

There have been substantial changes in the UK minerals industry over the last 30+ years. Overall the trend has been one of decline, both in terms of minerals production and consumption. The UK is also becoming increasingly dependent on imports of minerals and minerals-based products. This not only places increasing demands on the environments of our trading partners but also potentially makes us more vulnerable to supply disruptions through growing global demand for minerals driven by expanding populations and rising incomes and, in some regions, geopolitical instability. This means that there will be a continuing demand for the products of the UK's extractive industries for the foreseeable future. The extent to which domestic supply is able to meet that demand will ultimately depend on the wide range of relevant policies, both fiscal and regulatory, adopted by future governments, and also the political and environmental acceptability of continued minerals extraction. Britain's resource security and its longer term access to mineral supplies, both from domestic and overseas sources, will remain a key issue for the economy and politicians for many years to come.

1 Introduction

Britain's economy is dependent on adequate and steady supplies of essential mineral raw materials which are ultimately obtained from the natural environment, whether at home or overseas. The use of recycled materials and industrial by-products can, and rightly should, be maximised to meet some of our requirements and prevent waste, but new sources of primary minerals will always be required. Whilst Britain has a substantial, and growing, foreign dependency on minerals supply it is also fortunate in having important indigenous resources of a wide range of minerals and the extraction and processing of these supports an industry of considerable economic importance. This industry, and particularly the non-energy minerals sector, is now largely in foreign ownership, in sharp contrast to a decade or so ago when British companies were the leading world producers of a number of minerals.

Indigenous mineral resources represent national assets, or capital. That capital can only be released and wealth created by the extraction, processing and use of the minerals, which also make a major contribution to economic growth, the infrastructure needed by our society and the quality of life of individuals. The security of Britain's future mineral supplies, whether from domestic or overseas sources, will continue to be a key issue for the national economy[1].

As in the past, future demand for, and thus production and import of, minerals is continually evolving and will be strongly influenced by a range of economic, political (policy), technical, social and environmental factors. The last three decades or so have witnessed major changes in the fortunes of each of Britain's extractive sectors – oil and gas, coal, construction and industrial minerals, and metals. Whilst the future cannot be simply extrapolated from the past, it is useful to record and analyse some of these trends to see if they identify any drivers for the future.

2 Carbon dioxide emissions

The UK is seeking transition towards a low carbon economy. Carbon reduction cross cuts all sectors of the minerals industry and may have a significant impact on those industries that are highly dependent on minerals from domestic sources.

Total greenhouse gas emissions, which contribute to global warming, are mostly (about 85% for the UK economy as a whole) composed of carbon dioxide. Successive Government's have been committed to reducing the UK's carbon dioxide emissions and there is now a statutory target to reduce the UK's greenhouse gas emissions by at least 80% below a 1990 baseline by 2050. This is already having, and will continue to have, considerable ramifications for the UK minerals industry, notably for the fossil fuels used in electricity generation, but also for energy intensive industries, such as ceramics, glass, chemicals, cement, lime and plaster products, all of which are major consumers of minerals principally sourced from the UK. Although the data are complex, it is worth briefly recording the changes in carbon dioxide emissions that have been made by the 'Mining & Quarrying' sector since records began in 1990. 'Mining & Quarrying' accounted[2] for just over 3% of total carbon dioxide emissions by the UK economy in 2011, whilst electricity generation (of which fossil fuels generated nearly 70%, Figure 1) accounted for nearly 29% of emissions.

[1] Resource security is defined as reliable access to the resources on which society and the economy depend, at affordable cost. *Resources Future*. A Chatham House Report. December 2012.

[2] UK Environmental Accounts 2013. ONS

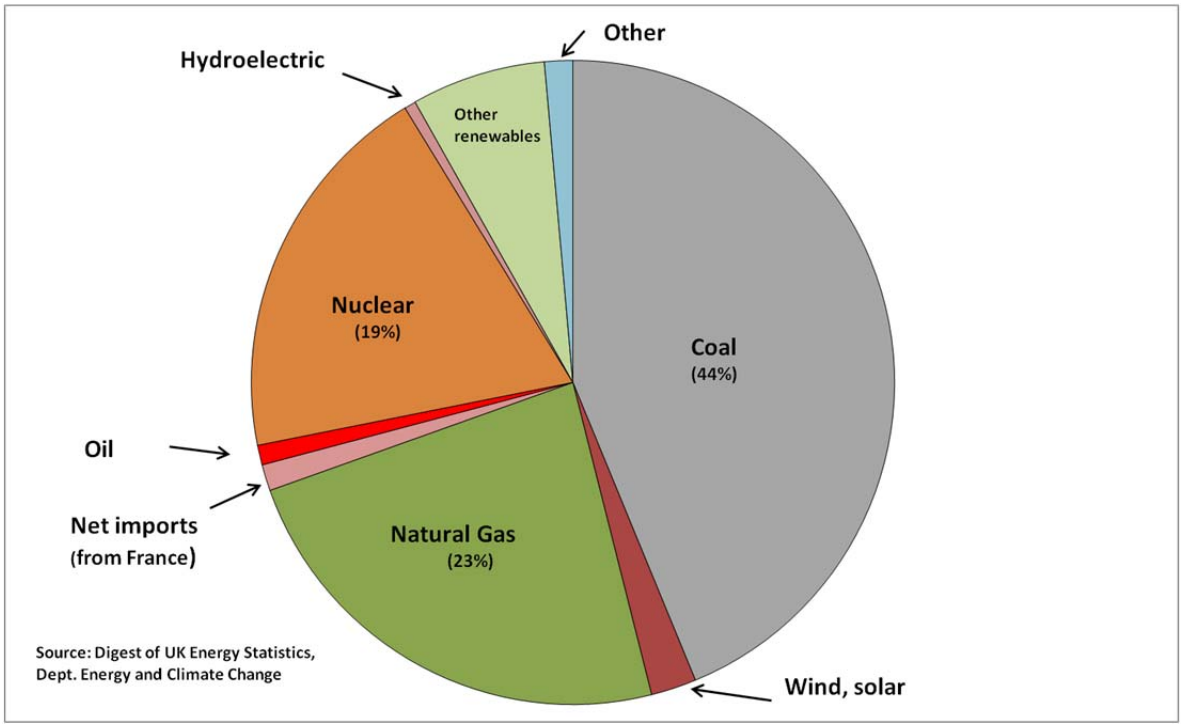

Figure 1. UK: Relative proportion of electricity generation by fuel type, 2012

In addition to coal mining, and the extraction of metal ores (now minimal) and construction and industrial minerals, the 'Mining & Quarrying' sector[3] also includes oil and gas extraction (by far the major contributor to carbon dioxide emissions by the sector), most of which takes place offshore in UK waters. Figure 2 shows the trends in total UK carbon dioxide emissions for the UK economy (on UK resident basis) compared with the trends for (a) 'Mining & Quarrying' as a whole and (b) for inferred onshore mineral production, i.e. excluding oil and gas extraction (and mining support services). Whilst emissions of carbon dioxide by the UK economy have declined by about 13%, emissions by the Mining & Quarrying sector initially increased but have shown no overall decrease over the whole period. This is believed to reflect rising oil and gas production during part of this period (see Figure 7 and Figure 9 below). In sharp contrast, inferred emissions by the onshore sector have declined by over 60%, principally reflecting the decline in onshore mineral production over this period. Taking account of total greenhouse gas emissions (i.e. including all greenhouse gases, mainly methane, not just carbon dioxide as shown in Figure 2), Mining & Quarrying emissions have fallen significantly more than for the UK economy as whole, with the onshore minerals sector declining by 85%. The principal cause of this decrease is a significant reduction in methane emissions resulting from the contraction of the coal industry (a major emitter of methane).

[3] Extraction of crude minerals and their preparation for sale. Also included are 'Mining support services' which includes exploration work, drilling, foundations for hydrocarbon wells and overburden removal. Official data for this sector show a remarkable reduction in CO_2 emissions from 1.362 Mt in 1990 to 98,000 tonnes in 2011. (The reasons for this are unclear but may be due to very large investment offshore in the early 1990s.)

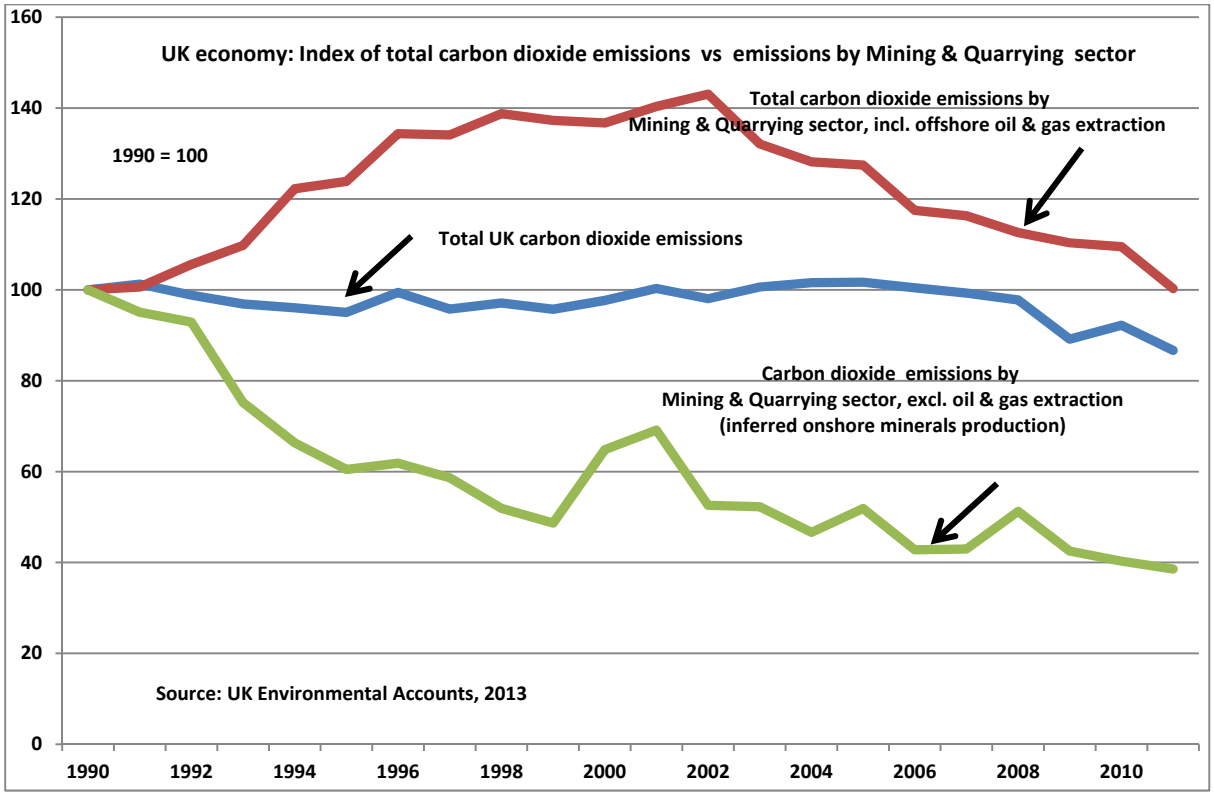

Figure 2. UK: Index of trends in total carbon dioxide emissions by the economy compared with those for the Mining & Quarrying sector, 1990 – 2011. (1990 = 100 - based on thousand tonnes of carbon dioxide)

The UK's production emissions are those that are physically emitted in the UK, for example from power stations, factories and transport[4] . These are the emissions that have been discussed above. However, the UK's consumption-based emissions also take into account the greenhouse gas emissions generated in another country during the manufacture of goods and services that are then imported and 'consumed' in the UK[5]. Emissions that are 'embedded' in imports are not as easily measured as those generated within UK borders and the data are conflicting[6,7]. However, the UK's consumption-based emissions far exceed its production emissions and Britain has a carbon footprint that is around 80% larger than its production emissions.

There are two main reasons for the decline in the UK's production emissions; the replacement of coal by gas in electricity generation in the 1990s; and the shift in manufacturing industries away from the UK in response to the pressures of globalised markets. With respect to minerals, increasing dependency on mineral imports (see Figure 3), particularly coal (see Figure 11), and minerals-based manufactures (see Figure 25), and including the embedded carbon through their transport to Britain, have all contributed to moving part Britain's carbon footprint to our trading partners. This situation may be exacerbated in the future if energy intensive, yet energy-efficient, minerals-based sectors move activities overseas.

[4] Emissions produced with UK borders plus UK international aviation and shipping emissions.
[5] Also subtracting UK emissions associated with goods and services exported to other countries.
[6] Reducing the UK's carbon footprint. Committee on Climate Change. Full Technical Report. 1st April 2013.
[7] UK's Carbon Footprint 1997 – 2011. Defra Official Statistics Release. November 2013.

3 Domestic minerals consumption

Trends in total minerals consumption in the UK can be derived by assessing domestic minerals extraction (including offshore fossil fuels), together with the UK's mineral imports and exports. Data for the last 40 years is presented in Figure 3 which shows an initial increase in minerals extraction (production) until the late 1980s but then decline, markedly so, from about 2000. This was principally due to falling fossil fuel output (oil, gas and coal) and also, more recently, the impact of the recession on the production of construction minerals (mainly aggregates), which account for almost 80% of UK land-based minerals production. At the same time mineral exports have declined (mainly oil and gas, kaolin) and mineral imports have increased, largely reflecting our increasing dependency on imported fossil fuels, a trend that is likely to continue into the future. Figure 4 shows that domestic minerals consumption has fallen by some 200 million tonnes in total between 1970 and 2011.

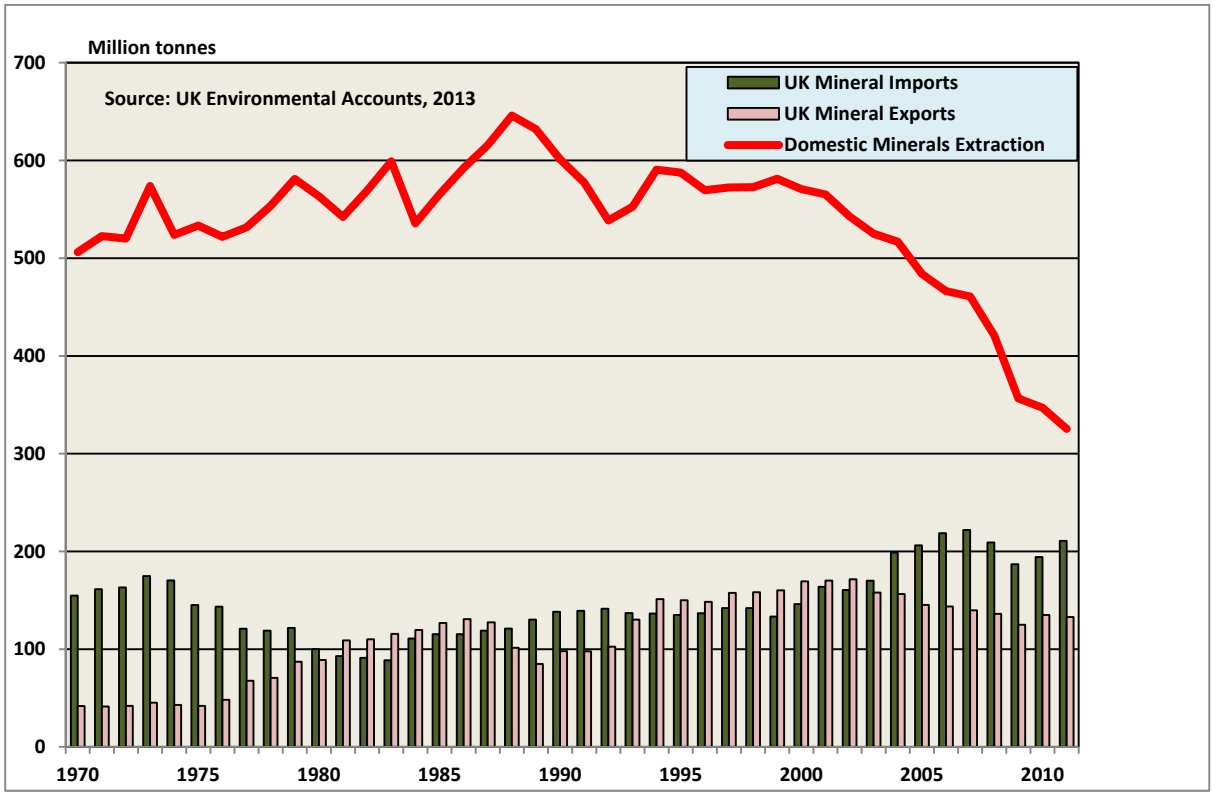

Figure 3. UK: Domestic minerals extraction and trade in minerals, 1970 – 2011

During the same period UK Gross Domestic Product has almost trebled[8], indicating that minerals consumption per unit of GDP is declining in relation to the level of economic activity. This concept is used to assess resource efficiency and progress towards sustainable development, apparently supporting the view that the UK economy is sustaining GDP growth without having an increasing negative impact on the domestic natural environment.

In recent years declining mineral consumption reflects the effects of the recession but over the longer term the figures may also indicate that the economy is under investing in infrastructure and housing and also foregoing the value added by working and processing domestic (and imported) minerals in favour of importing higher value manufactured products containing embodied minerals (and carbon emissions). Moves to try and rebalance the economy, particularly through increased investment in infrastructure as economic growth returns, could reverse the decline in domestic minerals consumption.

[8] UK GDP increased from £561 billion in 1970 to £1,502 billion in 2011. (based on constant 2010 prices).

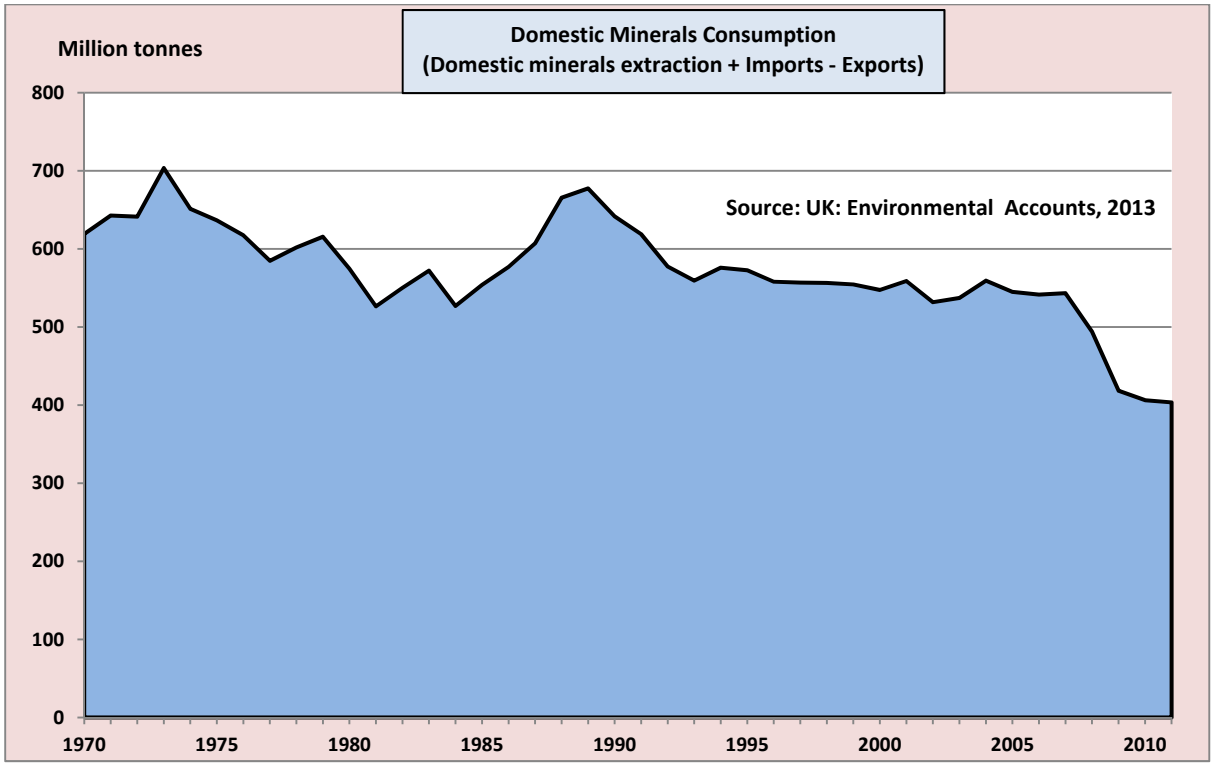

Figure 4. UK: Domestic minerals consumption, 1970 – 2011

4 Value of minerals output

Minerals extraction and initial processing is an important primary industry that meets the essential needs of the economy for a wide range of energy fuels, and construction and industrial raw materials. A measure of the importance of the extractive industries to the national economy is their contribution to GDP. This is a key economic indicator and defined as the value of all goods and services produced in the UK. There is a close relationship between GDP and Gross Value Added. GVA is defined as the gross output of an industry minus the value of the goods and services used to produce the output. The GVA if an industry can be thought to be its contribution to national GDP.

'Mining and quarrying', which also includes oil and gas extraction, contributed about £34,000 million in 2012 equivalent to about 2% of total UK GVA (Office for National Statistics). The contribution during the period 1970 to 2011 is shown in Figure 5. Hydrocarbons extraction, particularly offshore oil production, is the dominant component of 'mining and quarrying GVA' and this in turn is dictated not only by the amount produced but also the world market price of oil. The collapse in the oil price in 1986 led to a major decline in the value of its contribution to UK GVA, although more recent high oil prices have partly reversed that trend despite falling production. With declining oil and gas production from the UK Continental Shelf (UKCS), because of the depletion of reserves, the contribution that 'minerals extraction' makes to the national economy will ultimately fall in the long term. This may, to some extent, be offset by potential future production of alternative energy sources, such as shale hydrocarbons, coalbed methane and underground coal gasification, should these prove to be technically, economically and politically feasible.

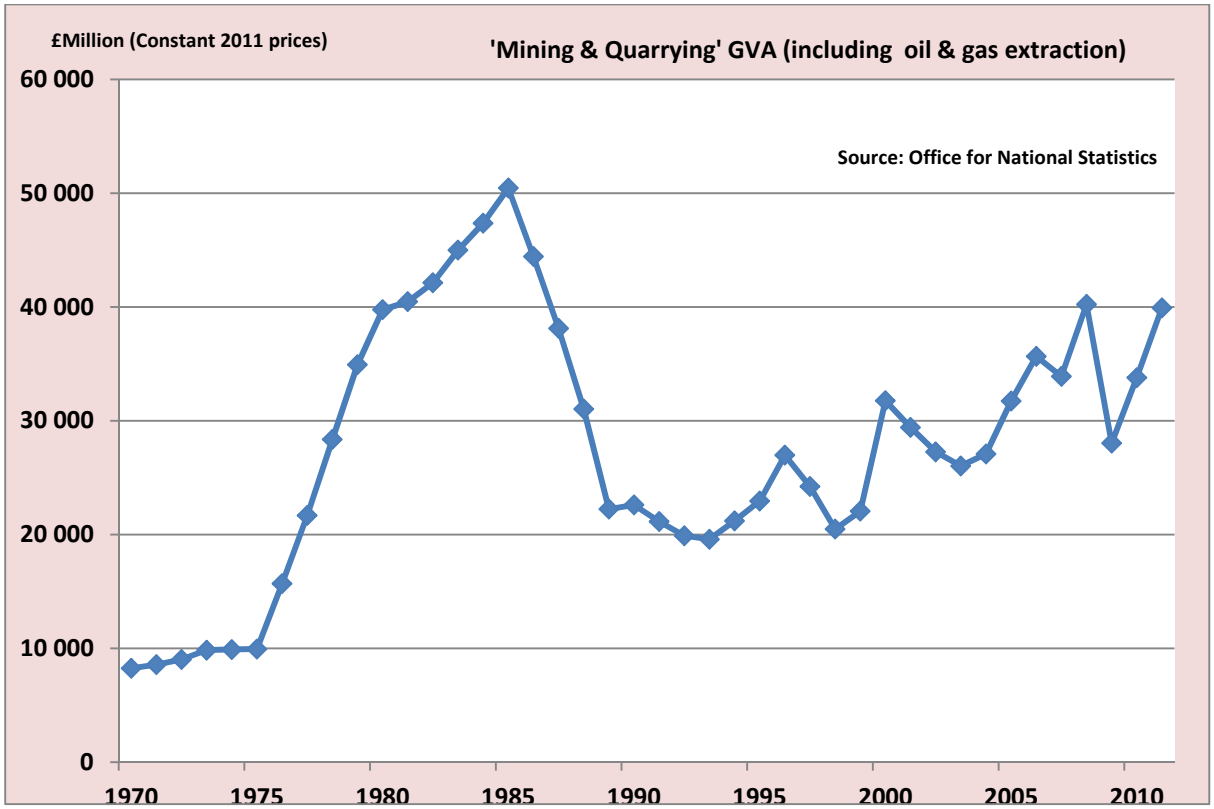

Figure 5. Value of Mining and Quarrying (including oil & gas extraction) GVA, 1970 - 2011

For many years the British Geological Survey (BGS) has estimated the approximate value of UK mineral output (ex-works sales basis) for publication in the *UK Minerals Yearbook*. This allows the relative importance of the different mineral sectors to be compared over time. The value, in constant prices, of the principal mineral sectors from 1970 to 2011 is shown in Figure 6. On this basis, UK mineral production has been dominated by energy minerals, initially coal, but later oil and gas following the development of offshore reserves from the 1970s. The overall total values broadly mirror those shown in Figure 5, but the data also highlights some striking changes, notably the decline in the value of coal production and the increase in the value of oil and gas output. Despite falling oil and gas production since 2000, the value of both have held up well because of high prices. Ultimately, however, as reserves are depleted their value will decline.

The value of construction and industrial minerals has also fallen, reflecting the decline in the production of industrial minerals such as kaolin, but mainly because of the recent significantly depressed state of the UK construction industry and its impact on aggregates production in particular. Although too small to show on Figure 6, the decline in the value of metalliferous minerals production is principally because of the demise of tin mining in Cornwall in the 1990s.

The value to the UK economy of minerals produced from indigenous sources is, however, derived not only from the minerals themselves but also the downstream industries and employment these support. Low cost construction and industrial minerals, in particular, serve as essential raw materials for the construction, cement, concrete products, glass, ceramics, lime, plaster products, castings and inorganic chemical industries were the value added may be several fold. The economic benefits derived from the domestic extractive industries goes much further than the values indicated suggest[9].

[9] The Mineral Products Association estimate that the annual turnover of their industry is about £9 billion and supports over £400 billion turnover in the industries they supply. *The mineral products industry's contribution to the UK.* Mineral Products Association, 2012.

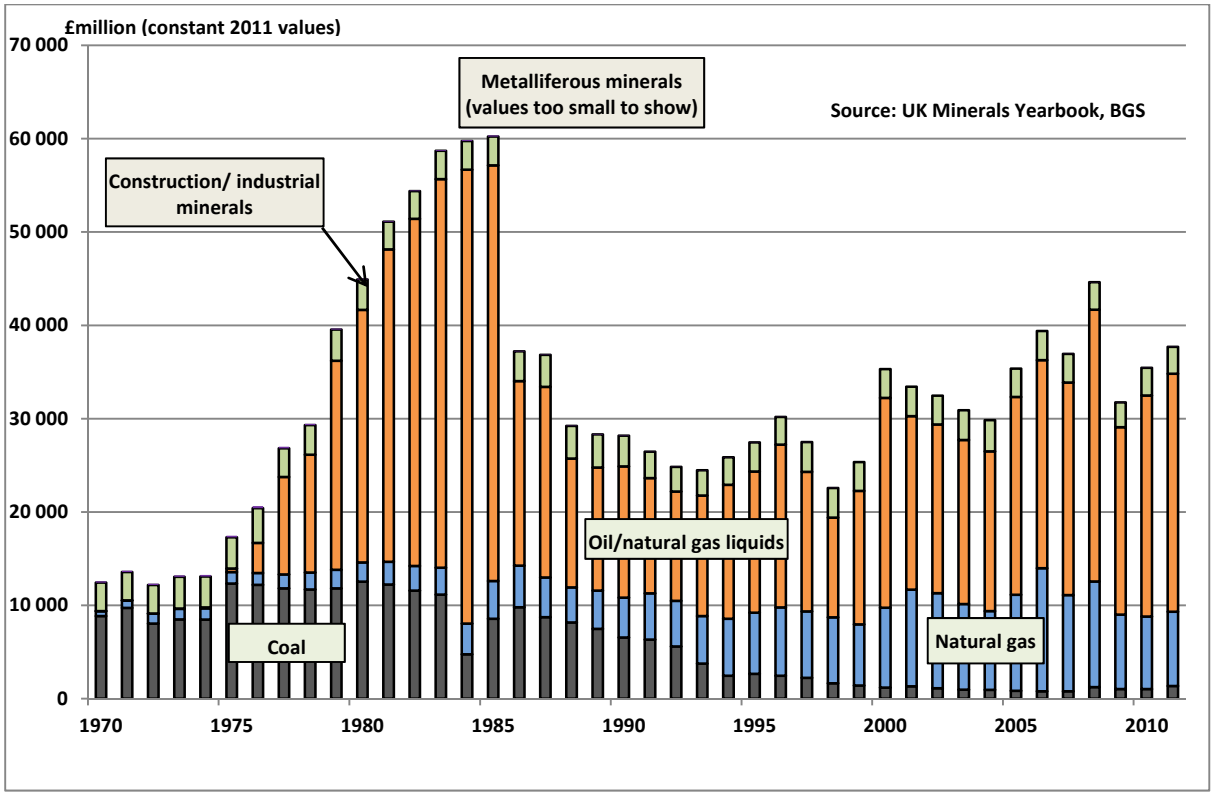

Figure 6. UK: Value of mineral production, 1970 - 2011 (constant 2011 prices; ex-works sales basis)

5 Energy minerals

The energy sector, and notably the fuels used in electricity generation, has witnessed the most significant changes in its fortunes. With the drive to reduce carbon dioxide emissions, tempered with concerns about security of future energy supply, it is likely that major changes will continue in this sector. The relative cost of these in turn could have major impacts on other sectors of Britain's minerals industry, particularly those that are energy intensive.

5.1 OIL

The energy sector, and particularly offshore oil, dominates the total value of minerals production in Britain. With the discovery on the UKCS of natural gas in 1965 and oil in 1970, and the rapid build-up in production thereafter, Britain emerged as a major world producer of hydrocarbons. In real terms the value of oil production overtook that of coal in 1978 and peaked at £48.6 billion (in 2011 prices) in 1984. The slump in world prices at the end of 1985, and again in 1988, and also the loss of production through the Piper Alpha tragedy reversed this trend and the value of oil production shrank significantly. Following rising oil prices since 2000 the value of UK oil production has risen and was still £25.5 billion in 2011.

In 1985 it was widely accepted that the zenith of UK oil production at 127.6 million tonnes had been achieved. Initial forecasts that production would decline rapidly thereafter proved to be false and crude oil production (including natural gas liquids) achieved a new peak of 137.6 million tonnes in 1998. However, as reserves are depleted and new discoveries have been more modest, output is now declining markedly and was 44.6 million tonnes in 2012 (Figure 7). This overall trend is likely to continue into the future, but perhaps with periodic modest increases in production as new fields come on stream and enhanced extraction technologies are deployed.

The upper projected range of the UK's total oil reserves, including proved, probable and possible reserves (1.106 billion tonnes) and the upper range (1.321 billion tonnes) of undiscovered

reserves, was estimated to be 2.427 billion tonnes at the end of 2011[10]. Cumulative production of oil in the UK to 2011 is about 3.5 billion tonnes.

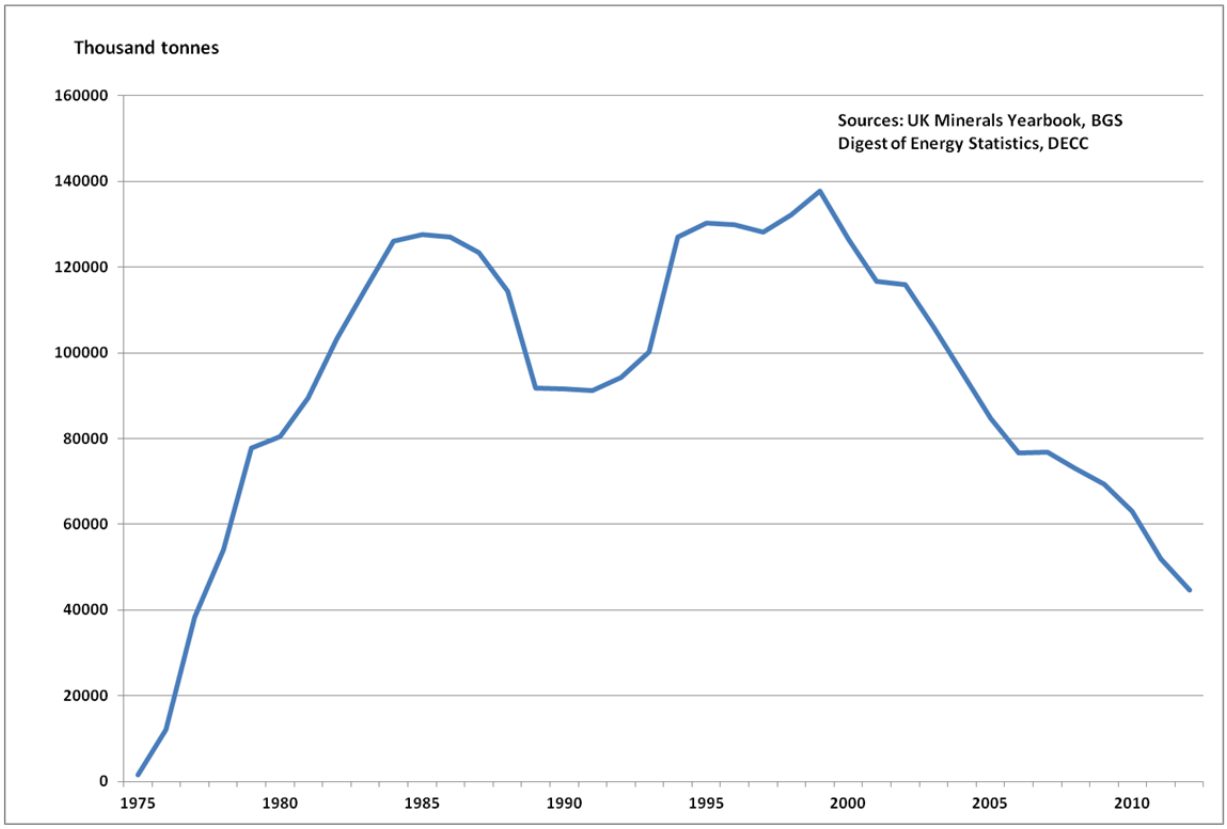

Figure 7. UK: Crude oil production, including natural gas liquids, 1975 - 2012

5.2 NATURAL GAS

Natural gas production from the UKCS started in 1967 and grew rapidly thereafter, replacing town gas in the public supply system in Great Britain by 1977. This resulted in the loss of a major market for coal with 26.7 million tonnes used for town gas manufacture in 1965.

Following the energy shocks of the 1970s, few would have predicted that natural gas would become the favoured fuel for electricity generation. Privatisation of British Gas, the repeal in 1991 of the EC 'Gas Burn' Directive, the privatisation of the UK electricity supply industry, together with environmental policy linked to climate change have all contributed to making natural gas more important for electricity generation. Combined cycle gas turbines offered cheaper generation with almost no sulphur dioxide and some 55% less carbon dioxide emissions than coal-fired power plants per kilowatt hour generated. Consequently gas's share of UK electricity generation rose from about 1% in 1990 to 40.5% in 2010, although fell to 23% in 2012, because of its high price (Figure 8). In 1993 the value of gas production exceeded that of coal for the first time.

[10] UK Environmental Accounts, 2013.

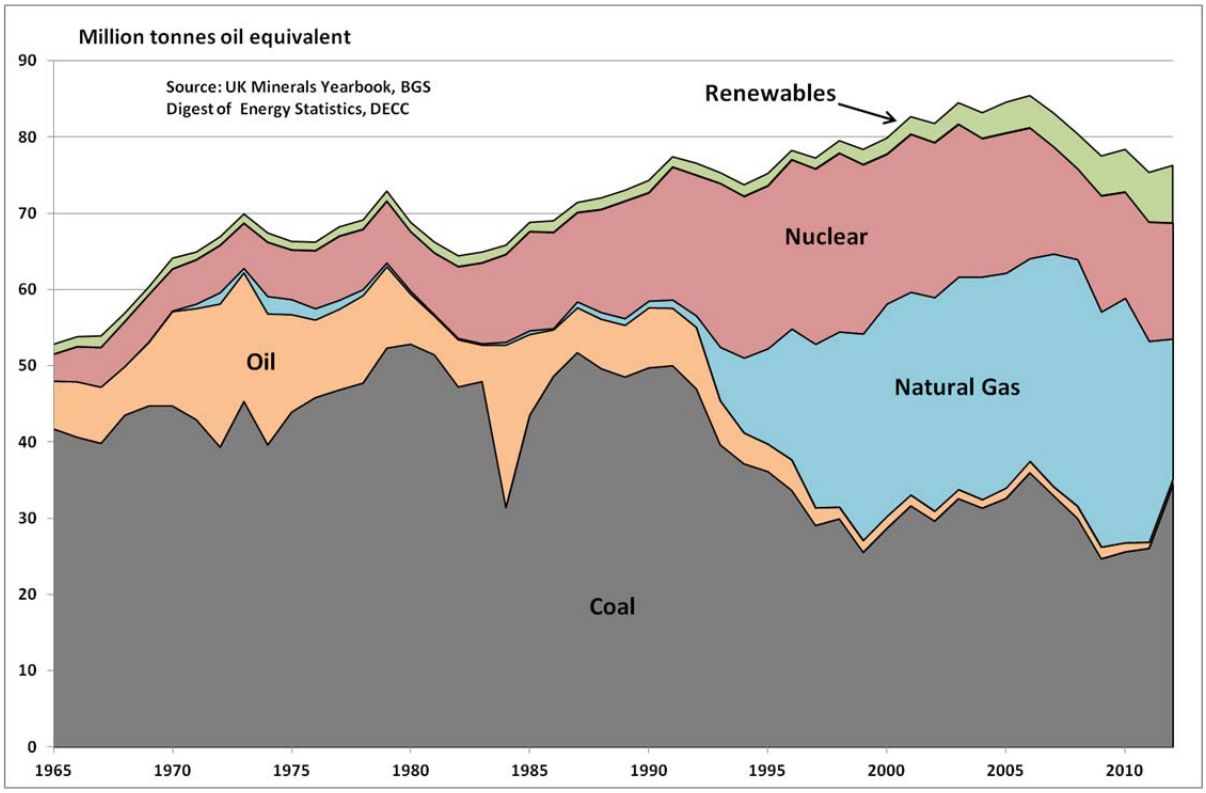

Figure 8. UK: Fuels used in electricity generation, 1965 – 2012. (Note: minor sources and net imports of electricity excluded for clarity)

UK natural gas production rose sharply through the 70s, 80s, and 90s, peaking at 114,880 million m^3 in 2000. Since then, with the rapid depletion of reserves, output has declined by nearly a half. As a result, Britain only achieved self-sufficiency in natural gas for the short period between 1995 and 2003 (Figure 9). Unless other forms of gas extraction, such as shale gas, coalbed methane and underground coal gasification, prove economically viable and environmentally acceptable on the substantial scale required, Britain will increasingly become dependent on expensive imports of natural gas via pipelines from Europe and Liquefied Natural Gas (LNG) shipments from further afield.

A major issue in gas supply is also the low level of storage in Britain, a legacy of the direct on-stream connections to UKCS production developed since the mid-1960s. Despite considerable recent investment, which is continuing in subsurface geological formations, storage capacity has risen to only about 15 days of supply, meaning that Britain is becoming more vulnerable to supply disruption as import dependence on gas is increasing.

The upper range of the UK's total gas reserves was estimated to be 1,686 billion cubic metres at the end of 2011, including the upper range of undiscovered reserves at 977 billion cubic metres. [11]

[11] UK Environmental Accounts, 2013

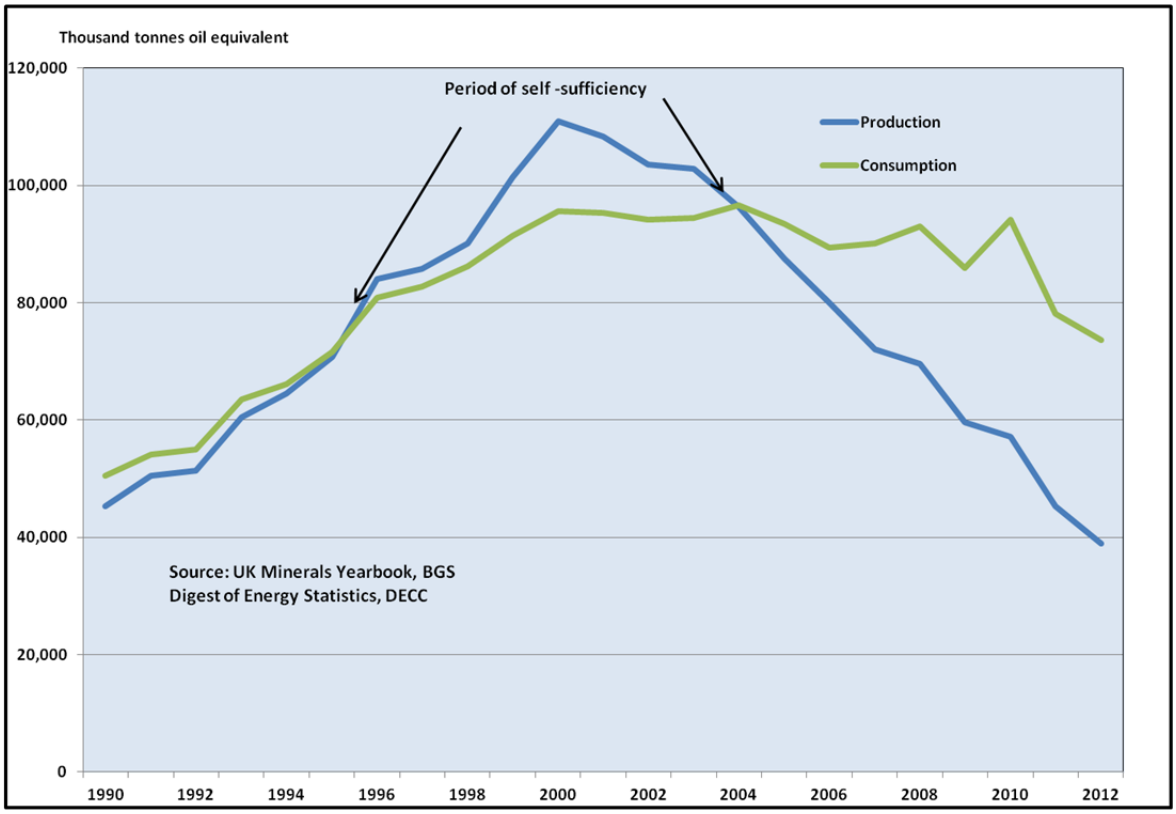

Figure 9. Production of natural gas and gas consumption, 1990 - 2012

5.3 COAL

The UK's deep-mined coal production has been in retreat since peak production of 292 million tonnes in 1913. However, following the oil crisis in the early 1970s, it was perceived that the world could no longer count on long term supplies of cheap oil. The *Plan for Coal*, published in 1974, envisaged that UK coal output would increase to about 150 million tonnes by 1990 based on the concept of '300 years of coal reserves', i.e. coal considered technically workable, but much of which was not economically recoverable. In reality UK coal consumption was 108 million tonnes in 1990 and already on a downward trend. This decline accelerated due to the increasing use of natural gas in electricity generation (the 'dash for gas') following increasing concerns about carbon emissions and climate change, the exhaustion of reserves in many of the older pits and the lack of the (considerable) capital investment to develop new ones in the face of environmental and policy uncertainty. Following the miners' strike of 1984 the nation became a net importer of coal, a trend that has continued (Figure 10), and imports of coal at 36 million tonnes exceeded that of UK production of 32 million tonnes for the first time in 2001. Since it was privatised in 1994, the British coal industry has continued to face difficult market and technical conditions, which has been accompanied by a succession of deep mine closures, including the relatively recently developed Selby complex and the Asfordby mine in Leicestershire. Concerns about security and diversity of energy supply have not halted the industry's decline and following the recent (2013) closure of the UK's most productive pit at Daw Mill following a disastrous underground fire, today only three major deep mines remain operating. Nevertheless, underground coal prospects remain. For example, at the Lochinvar project in the Canonbie Coalfield of southern Scotland, north of Carlisle, exploration is being undertaken for the possible development of a mine to produce higher value coking (metallurgical) coal used in steelmaking. Coking coal prospects also exist in South Wales.

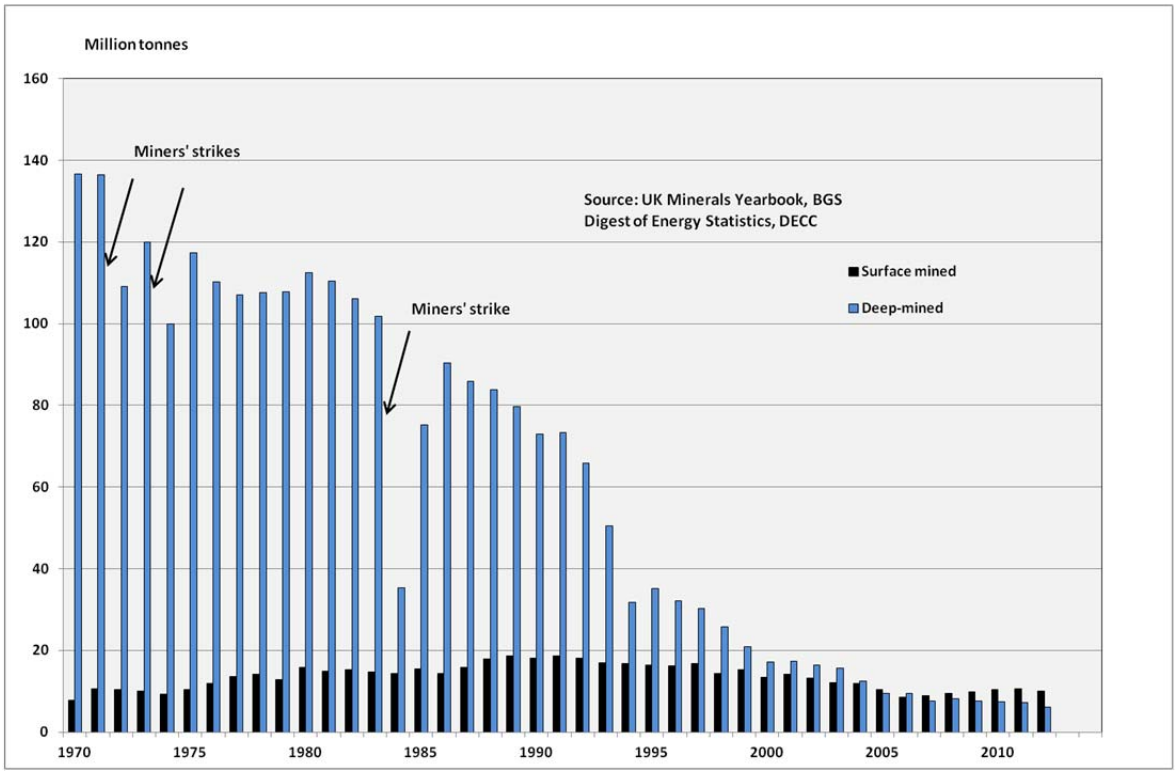

Figure 10. UK: Production of deep and surface mined coal, 1970 - 2012

In contrast, surface mining, which started as a wartime emergency measure in 1942, has proved to be a cost effective source of coal. Production increased to a peak of 18.6 million tonnes in 1991, and although has since declined, surface mined coal has contributed an increasing proportion to total UK coal output, particularly in Scotland, overtaking deep mine production for the first time in 2007. In 2012 surface mine output was 10.1 million tonnes compared to 6.2 million tonnes for deep-mined coal. The longer term future for surface coal mining will depend on finding new sites which are economically and environmentally feasible to work and, ultimately, the extent of workable reserves. Rail access charges for moving coal to power stations in England have also recently become a major issue for Scottish sites.

In 2012 The Coal Authority estimated that total identified reserves and resources of coal suitable for surface mining were 838 million tonnes, of which 101 million tonnes were in sites with planning permission or in licence. To place this figures in context, cumulative production of surface mined coal between 1942 and 2012 was about 840 million tonnes.

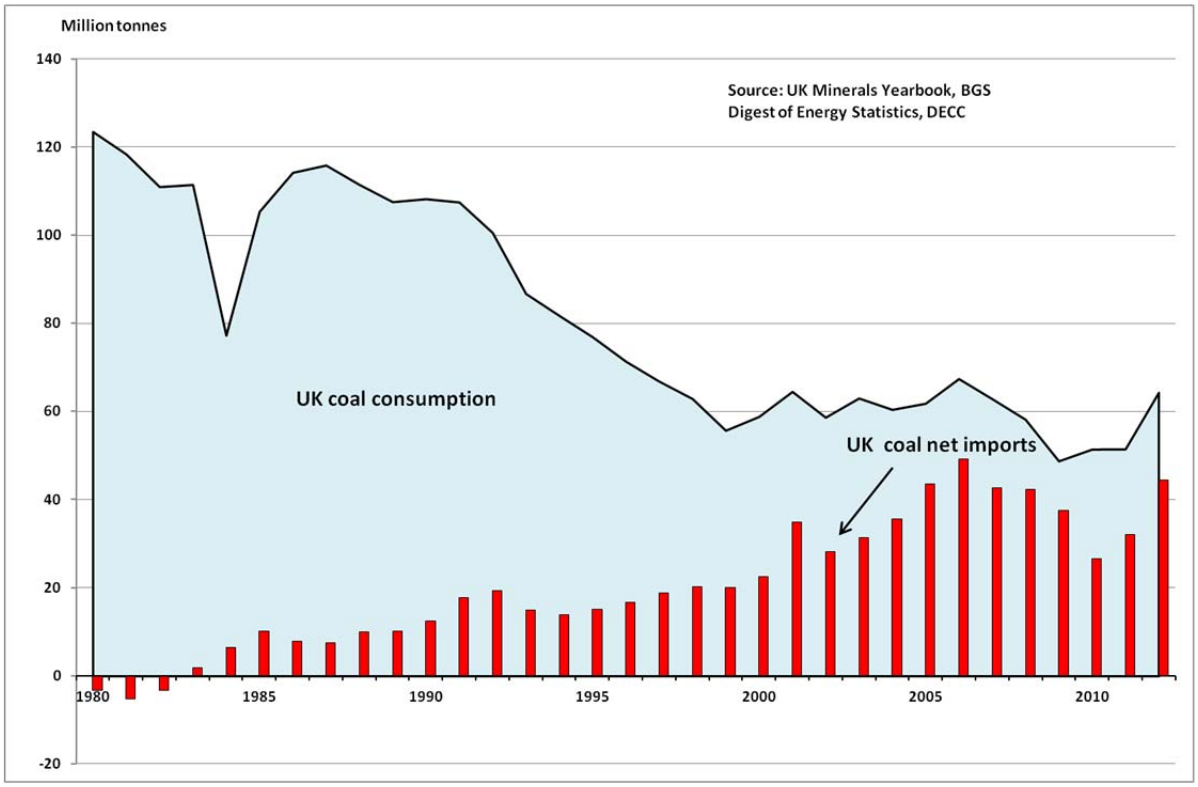

Figure 11. UK: Coal consumption and net imports, 1980 – 2012

UK coal consumption in 2012 was some 64.3 million tonnes, with net imports, mainly of steam coal, but also coking coal, contributing 44 million tonnes. The value of coal production has continued to decrease in line with declining output and was about £1.3 billion in 2011. This still represents a substantial industry. In addition, coal-fired power stations continue to supply a significant proportion of our electricity needs, and on price grounds was nearly 50% during periods of cold weather in early 2013. (This reversal of trend was stimulated by the fall in world coal prices largely caused by the shift from coal to shale gas in US power generation, leading to surplus US coal becoming available for export.) In 2012 coal supplied some 44% of the total fuels used for electricity generation, significantly more than natural gas (23%). However, several core coal-fired power stations that have 'opted out' of the EU's Large Combustion Plant Directive, which sets strict limits on emissions of sulphur dioxide and nitrogen oxides, are set to close. The first two, Didcot A and Cockenzie – representing 4000 MW of generating capacity - closed in March 2013. Nevertheless, there will continue to be a significant market for coal for power generation in Britain for at least the next 20 years, but it remains to be seen both how large that will be and what proportion is derived from indigenous sources. Ultimately the longer term future for coal in the UK energy mix will depend on the deployment of commercial-scale carbon capture and storage (CCS) technologies. The two preferred bidders in the UK's £1bn Carbon Capture and Storage Commercialisation Programme Competition were announced in March 2013. However, the large-scale investment in CCS generation plant that will be required is still vulnerable to considerable uncertainty over future EU regulatory policy and competition in world energy fuel markets. It is most unlikely at present that there would be corresponding investment in high-capacity deep mines in the UK to supply the coal for CCS stations.

6 Construction minerals

6.1 AGGREGATES

The production of primary aggregates represents the largest material flow in the economy and comprises the major proportion of the tonnage of all land-won minerals extraction. Of total aggregate use about 29% is obtained from recycled and secondary sources[12], 5% from marine dredging, and the remainder from land-won quarries working crushed rock (44%) and sand and gravel (22%). Although some crushed rock is imported into the UK, this is roughly balanced by crushed rock exports; some marine sand and gravel is also exported. This sourcing mix is unlikely to change much in the near future. The use of recycled aggregates has increased significantly over the last decade or so, but it is likely that effective capacity is being approached. There may, however, be scope for their use in higher quality applications.

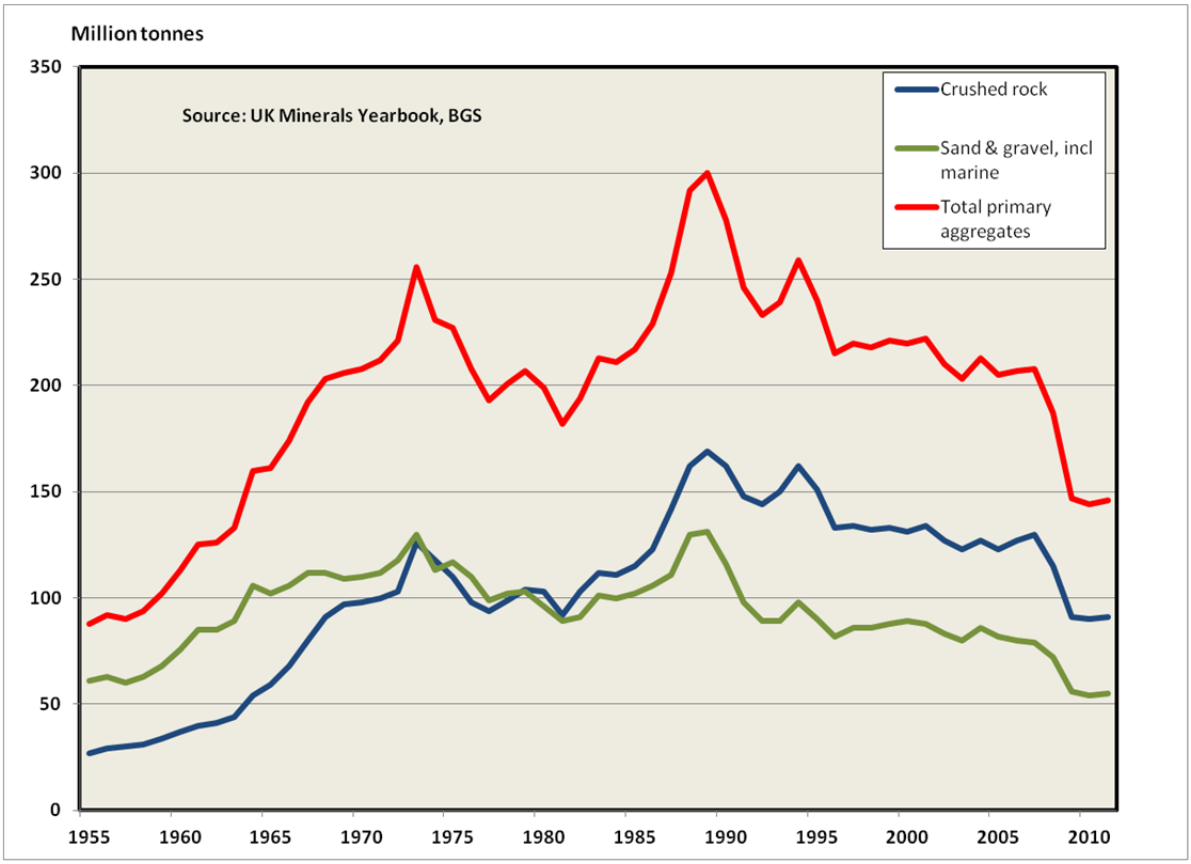

Figure 12. Great Britain: Consumption of primary aggregates, 1955 – 2011

Since the mid-1990s the market for primary aggregates has declined dramatically (Figure 12). The recent downturn from 2008 has been particularly marked and has seen primary aggregates production and consumption fall to levels not seen since the 1960s. For many years primary growth in aggregates demand has not only followed but outperformed construction output, suggesting an increase in the intensity of use of aggregates (i.e. an increase in the tonnage of aggregates consumed per unit of construction output) (Figure 13). Since the mid-1990s that relationship has been broken and until the recent downturn, strong growth in construction activity was not accompanied by an increase in demand for primary aggregates. Part of this may be due to an increasing use of recycled aggregates, not factored into Figure 13, but a further factor may be that the balance of construction activity may have shifted away from more aggregate intensive use - (i.e. concrete and asphalt) civil engineering work, notably road

[12] Mineral Products Association: According to the European Aggregates Association, this is almost three times higher than the latest data for Europe which was 10% in 2011.

construction, and towards commercial and housing development, where alternative building materials, such as steel, glass and timber, can more readily be used, although aggregates are still required.

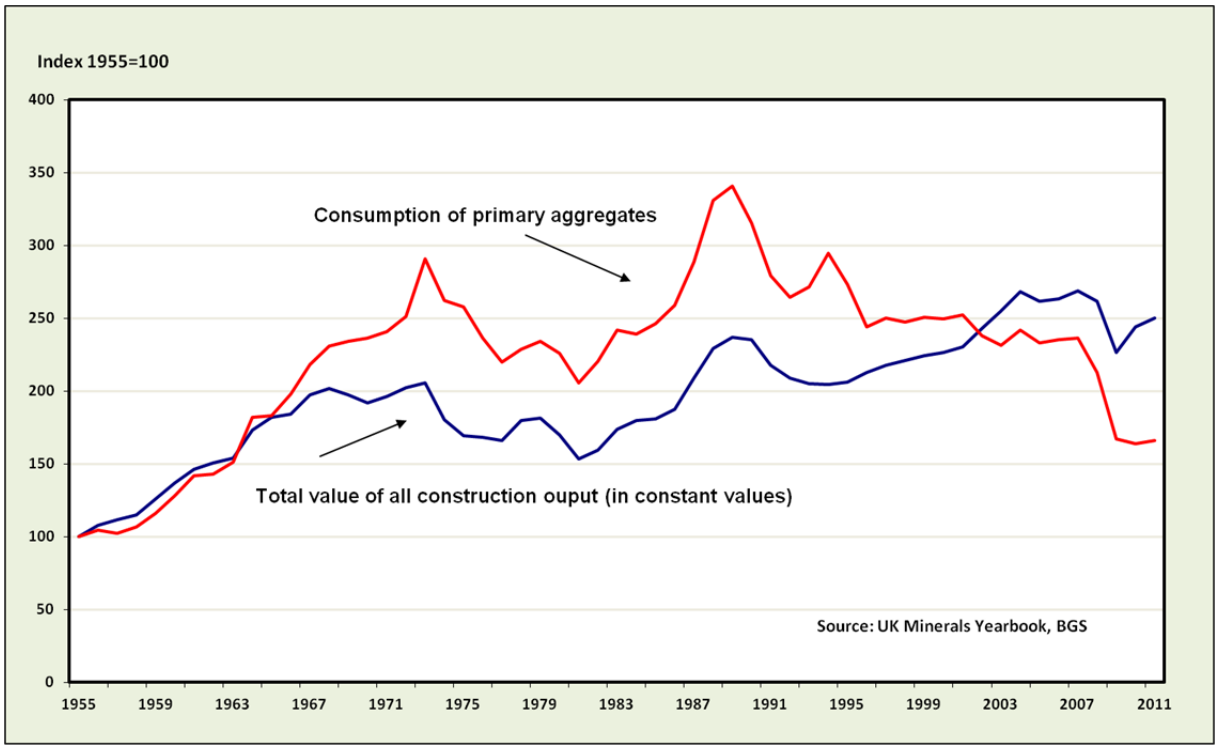

Figure 13. Great Britain: Comparison of consumption of primary aggregates and total value of construction output, 1955 – 2011

Econometric demand forecasts based on projected construction activity have, in the past, produced some wildly inaccurate forecasts for aggregates demand (even a low forecast of projected annual demand was over 400 million tonnes by 2011). Nevertheless, aggregates remain the basic raw material for almost all forms of construction, and their steady and adequate availability is crucial if construction activity, essential for social, economic and environmental reasons, is not to be frustrated. It is, therefore, widely accepted, including by the present Coalition government, that some form of quantitative assessment of future requirements is essential as part of a Managed Aggregates Supply System.

There is abundant evidence of a long term decline in permitted reserves of aggregates and notably of sand and gravel[13]. Most new reserves now come from extensions to existing quarries (83% between 1998-2009) rather than new operations[14] and during this same period total reserves granted planning permission were 1.2 billion tonnes compared to production of 2.5 billion tonnes. This underlying decline in reserves indicates that before too long there will be supply issues if production continues to exceed the rate of replenishment, and new sites will be required. The uneven geological distribution of aggregate resources, a range of environmental constraints and widespread public and local political opposition to all forms of mineral development are major obstacles to future aggregate sourcing.

[13] Over the 10 years to 2012 only 43% of sand and gravel reserves have been replenished. Around 98% of crushed rock reserves were replenished but these are unevenly distributed and concentrated in a few major sites. 2nd *Mineral Products Association Annual Mineral Planning Survey.*

[14] In England & Wales between 1998-2009, 470.5 Mt of sand & gravel were granted permission of which 69% were for extensions. The comparable figures for crushed rock were 763 Mt and 98%. *Collation of the results of the 1998, 2001, 2005 & 2009 aggregates minerals survey for England & Wales*. DCLG, Welsh Assembly Government, BGS. 2011.

6.2 BRICK CLAY

Brick clays are used in the manufacture of structural clay products, notably facing and engineering bricks, pavers, clay tiles for roofing and cladding, and pipes. Brick manufacture is the largest tonnage use and bricks are one of the most visible components of the built environment in our villages, towns and cities. The production of 'brick clays' for the period 1974 – 2011 is shown in Figure 14. The significant decline in brick clay production from 18 million tonnes in 1974 to 4 million tonnes in 2011 is broadly correlated with the decline in the manufacture of clay bricks. However, as most brick clays are red-firing, fireclays are also essential raw materials for the manufacture of buff and pale-bodied facing bricks, but have not been factored in to Figure 14. Brick clay extraction takes place mainly in England reflecting the location of brick manufacturing capacity. The close association of fireclay and coal means that supply of fireclays is highly dependent on surface coal mining operations.

Production of building bricks largely reflects activity in the construction sector. The domestic housing market is the major market, although bricks are also used in other construction, for example office development, supermarkets and hotels, and also for repair and maintenance. The initial decline in the manufacture of clay bricks (Figure 14) was due to the demise of 'common' bricks in the inner leaf of cavity walls, where they were replaced by materials such as breeze blocks. However, later a significant decline in the number of new houses being built (Figure 15), together with a trend towards smaller houses and flats and the increasing use of timber-framed prefabricated construction which relegates bricks to an external cosmetic and weather-facing skin, has resulted in the decline in the demand for bricks. However, with increasing pressure for new homes driven by population increases, this trend must ultimately be reversed, although how far this translates into increased demand for brick clay or imports of bricks, in the light of the above trends in unit size and construction methods, remains to be seen.

The UK has large and geologically diverse resources of brick clay and, historically, has been largely self-sufficient in the manufacture and supply of bricks. The UK socio-economic and global environmental benefits of maintaining the future supply of a diverse range of bricks and related construction materials through an anticipated upward trend in demand are considerable.

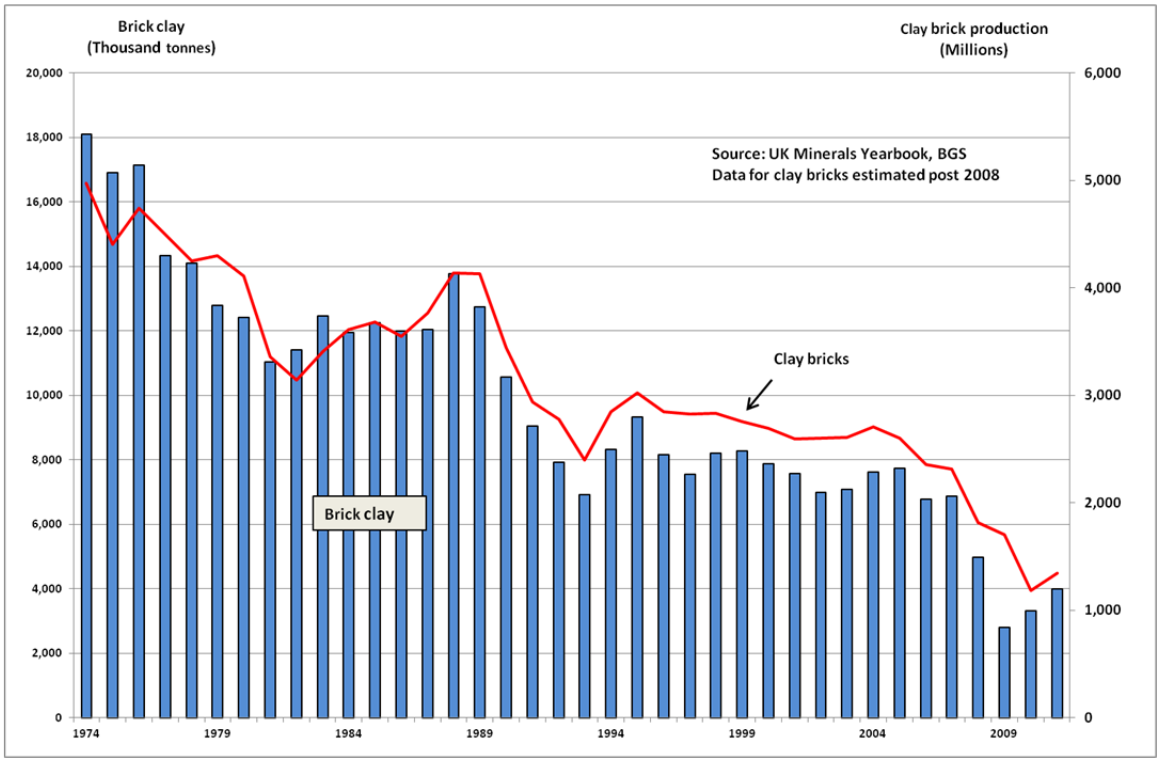

Figure 14. GB: Sales of clay and shale for bricks, pipes and tiles, 1974 – 2011 and the production of clay building bricks

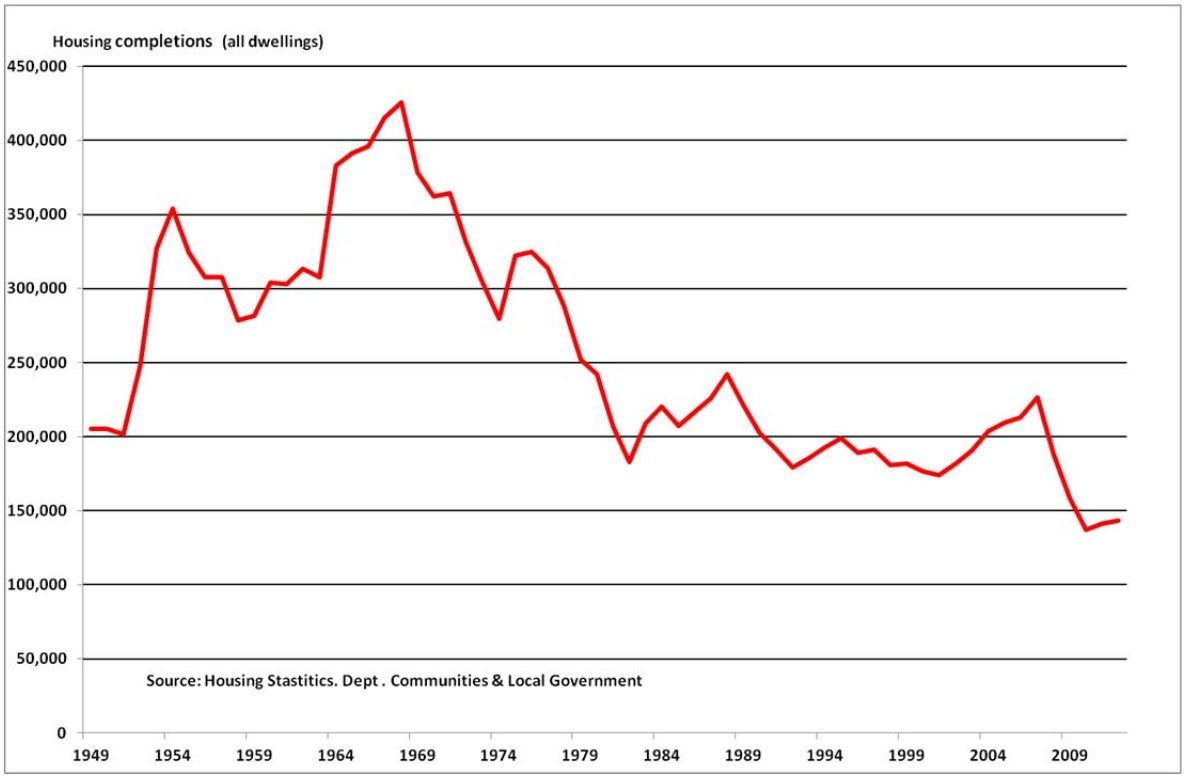

Figure 15. UK: House building completions, 1949 – 2012

6.3 CEMENT RAW MATERIALS

Cement is an essential constituent of concrete and mortar, both of which are highly versatile and irreplaceable construction materials in building and civil engineering[15]. Cement is produced from heating together limestone, or chalk, and clay/mudstone at very high temperatures to produce cement clinker. The finished cement is produced by finely grinding together about 95% cement clinker and 5% gypsum/anhydrite; the latter helps to retard the setting time of the cement. Britain is fortunate in having very large resources of the raw materials used in cement manufacture.

Cement plants are large consumers of raw materials (and energy intensive) with about 1.6 dry tonnes of materials being required for each tonne of cement clinker produced. Production of limestone/chalk for cement manufacture has declined significantly over the years (Figure 16). This is partly due to a decline in cement production (Figure 17), which may well be closely linked to the decline in aggregate demand, through the shift away from concrete-intensive major civil engineering projects in recent years noted above. However, it may also, in part, reflect a decline in the more energy intensive wet process using chalk (with its much higher moisture content) in favour of limestone using the dry process. In addition, there has been a reduction in domestic cement capacity, increased imports and increasing use of blended cements where a proportion of the cement is replaced by other materials.

[15] *Cementing the future – sustaining an essential British industry.* Mineral Products Association, 2013

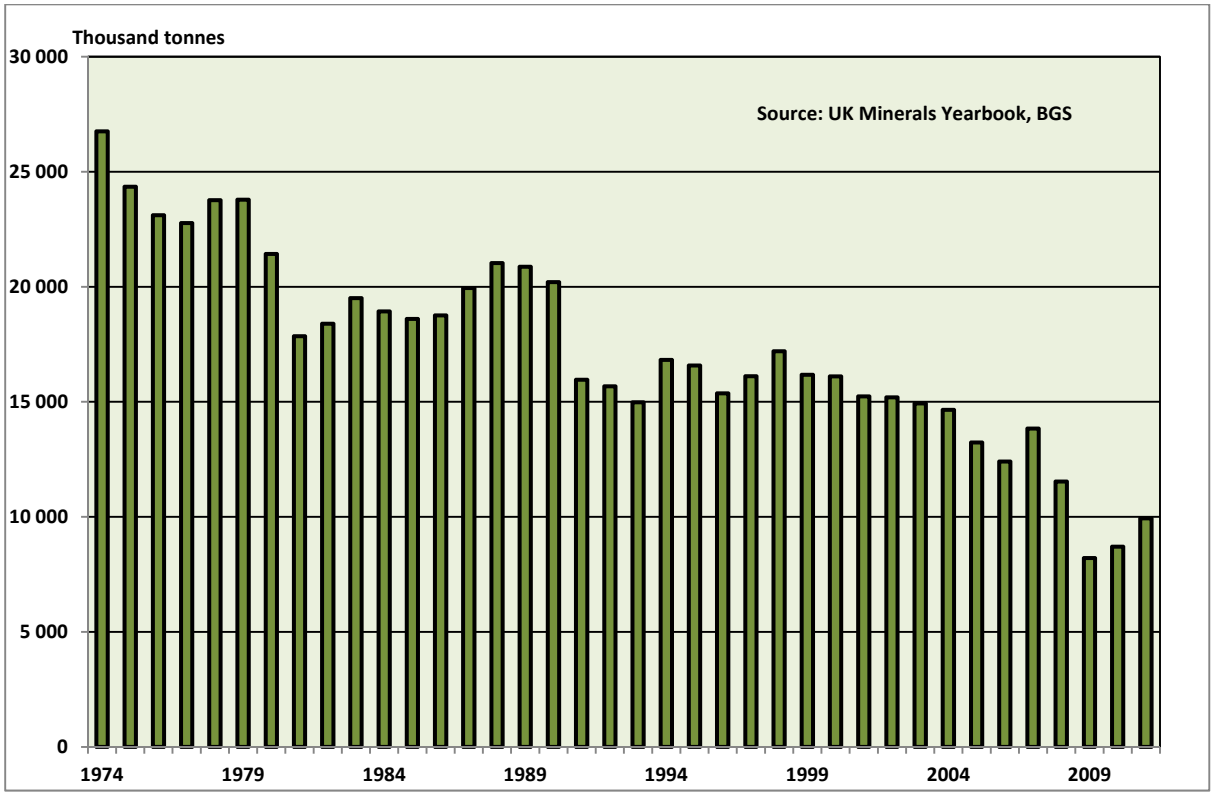

Figure 16. GB: Production of limestone and chalk for cement manufacture, 1974 - 2011

Cement manufacture is, by its nature, energy and carbon intensive. The industry has made great strides in reducing its CO_2 emissions through the use of alternative waste fuels, such as natural rubber from scrap tyres, sewage sludge, meat and bone meal, and waste solvents, effectively also providing a waste facility under the highly controlled conditions of cement kilns. Moreover, secondary materials, including pulverised fuel ash (pfa) from coal-fired power stations and blast furnace slag (a by-product of iron making) are used in blended cements as lower cost diluents. These also impart additional technical properties as both pfa and slag have cementitious properties that improve the long-term strength and durability of concrete. Their long-term availability is not assured, however, in view of the existing and expected future decline in coal-fired power generation and steelmaking in the UK.

Demand for cement is a function of economic activity as a whole, but construction activity in particular. This is highly cyclical and the current downturn has hit the industry hard (Figure 17).The UK has been a net importer of cement clinker and finished cement for many years. It is not difficult to see how cement manufacture could be driven overseas through higher energy costs and penalties on carbon emissions and so making the UK increasingly dependent on imports for this ‘strategic’ material. This would be another example of how the primacy of price and cost factors leads Britain to forego the value added through making use of its own resources whilst also exporting carbon emissions overseas.

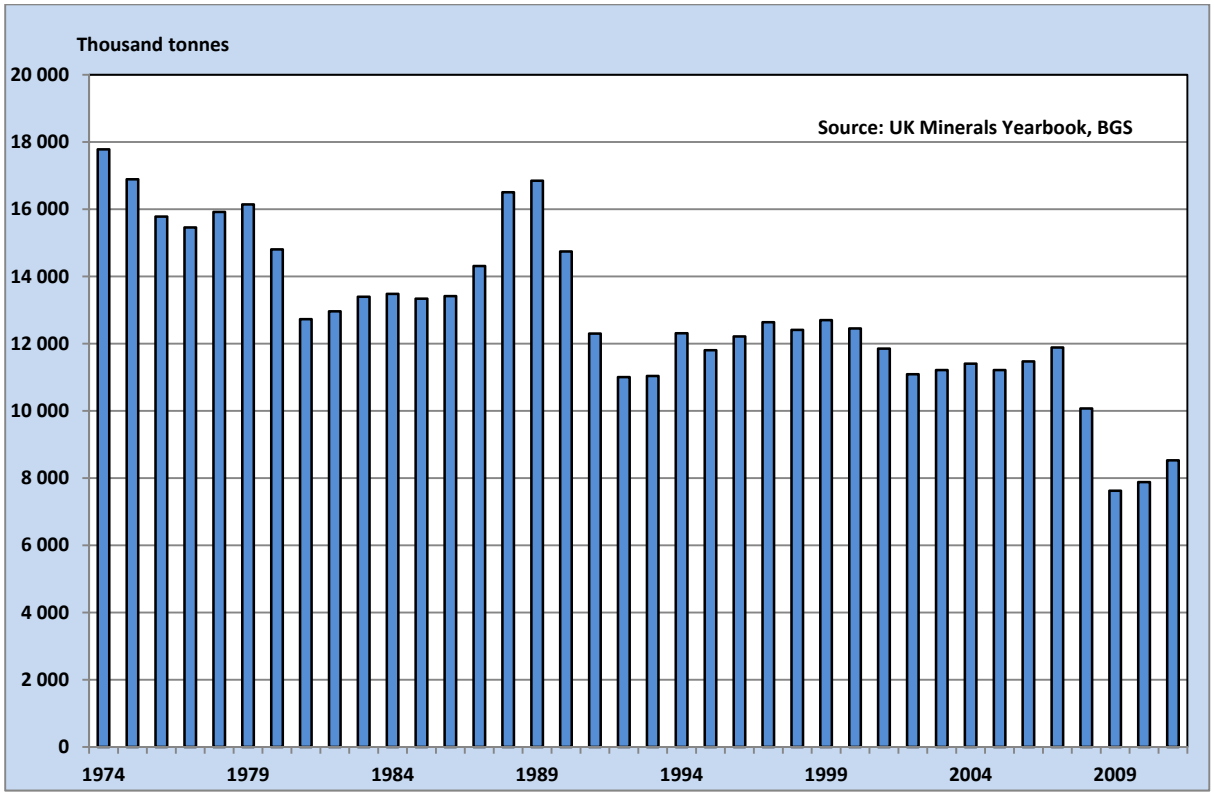

Figure 17. UK: Production of finished cement, 1974 – 2011 (GB only since 2002)

7 Industrial minerals

Britain is well endowed with a wide range of industrial minerals, the extraction of which supplies both downstream manufacturing industries in the UK, such as the chemicals, ceramics, plaster products and glass industries, and in the case of minerals like kaolin, ball clay and potash also important export markets.

7.1 KAOLIN

The UK is the world's third largest producer of kaolin - a fine, white clay formerly known as china clay, which is produced mainly in Cornwall, but also Devon. For many years kaolin has been Britain's most important mineral export after hydrocarbons. After many years of sustained growth, UK production of kaolin peaked at some 2.8 million dry tonnes in 1988 but has since declined markedly (Figure 18). Historically the major proportion of output has been exported, chiefly to Western Europe for papermaking, roughly equal proportions being used as a filler and for coating. During the 1990s kaolin from South West England faced increasing competition in papermaking markets from the USA and the Amazon Basin in Brazil and also from alternative white pigments, notably fine ground calcium carbonates. Difficult trading conditions culminated in English China Clays plc, then the world's largest kaolin producer, being acquired by the French group IMETAL in early 1999, forming a new company – Imerys, which also had kaolin operations in Brazil. In 2006 Imerys announced that it would reorganise their kaolin business by phasing out the production of value-added paper coating clays in the UK and transferring some production to Brazil. The main reason cited by Imerys was increasing energy costs in the UK on making this energy-intensive product. Consequently future UK production of kaolin for papermaking is being solely concentrated on filler grade material, which has a much lower value than paper coating clays. Clays for ceramic use and speciality filler applications are still produced. This is an example of where high regional energy costs influences a company's decision and, being foreign owned, has the options of diverting investment elsewhere.

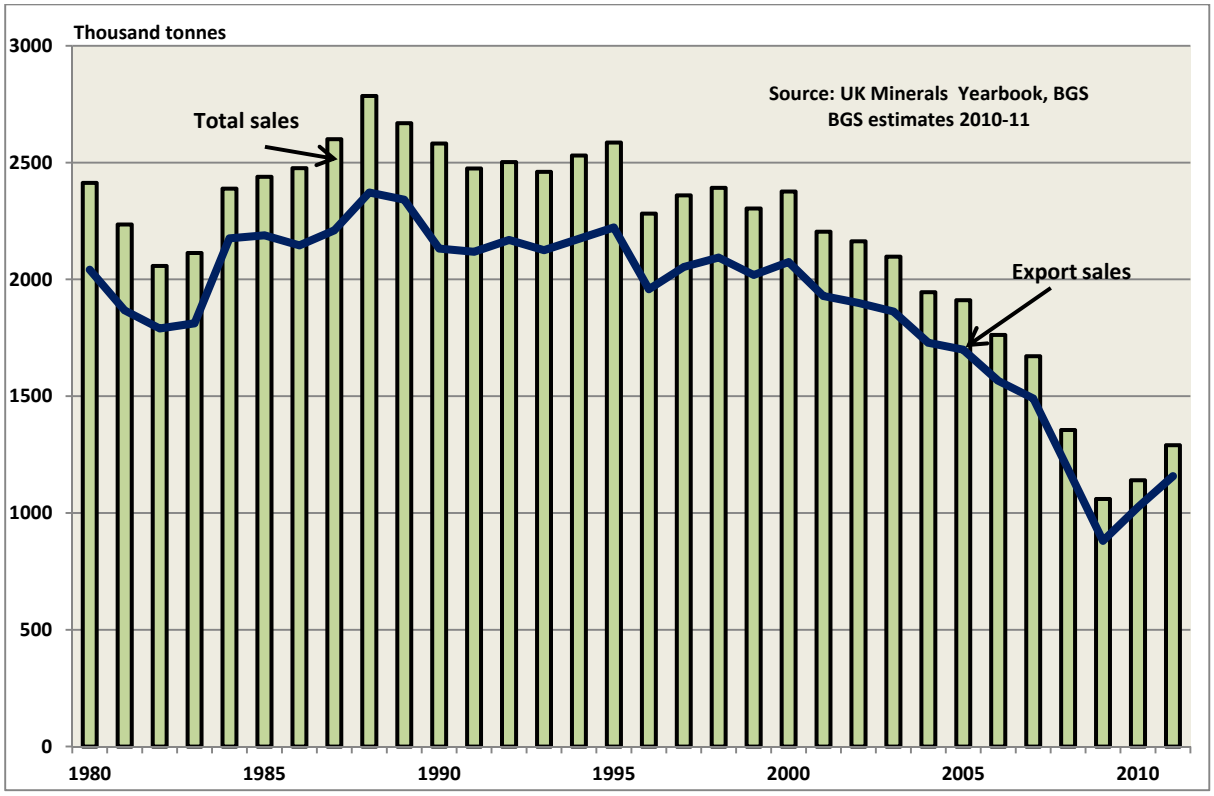

Figure 18. UK: Total sales and export sales of kaolin, 1980 – 2011

7.2 BALL CLAY

The UK is a leading world producer and exporter of high-quality ball clays, which are valued for their key properties of plasticity and light-firing characteristics. They are used principally in the manufacture of whiteware ceramics – sanitaryware, wall and floor tiles, and tableware. Production is confined to three small basins in Devon and Dorset, the deposits in the Bovey Basin of south Devon being the most important, both in terms of total sales, and the diversity and quality of the clays extracted. Blended ball clays are exported worldwide and over 50% of global sanitaryware production contains some British ball clay as an essential ingredient.

UK ball clay production has been on a rising trend for a number of years and sales of over 1 million tonnes a year were achieved between 2005 and 2008, with over 80% exported. Sales declined to a low of 727,000 tonnes in 2009, although have since risen (Figure 19). However, the future availability of high quality statistics for ball clay (and kaolin) may be in doubt due to the changes in the industry.

Ball clay is one of the very few, if not the only, mineral where future planning for development extends far longer than normal spatial planning horizons. A non-statutory *Strategy for the Bovey Basin*[16] has been developed to provide guidance for ball clay extraction and associated activities, both in the short and longer term (i.e. 100 years). This is the type of vision that is required for other minerals.

[16] *Bovey Basin Strategy*. Devon County Council. WS Atkins Consultants. December 2000.

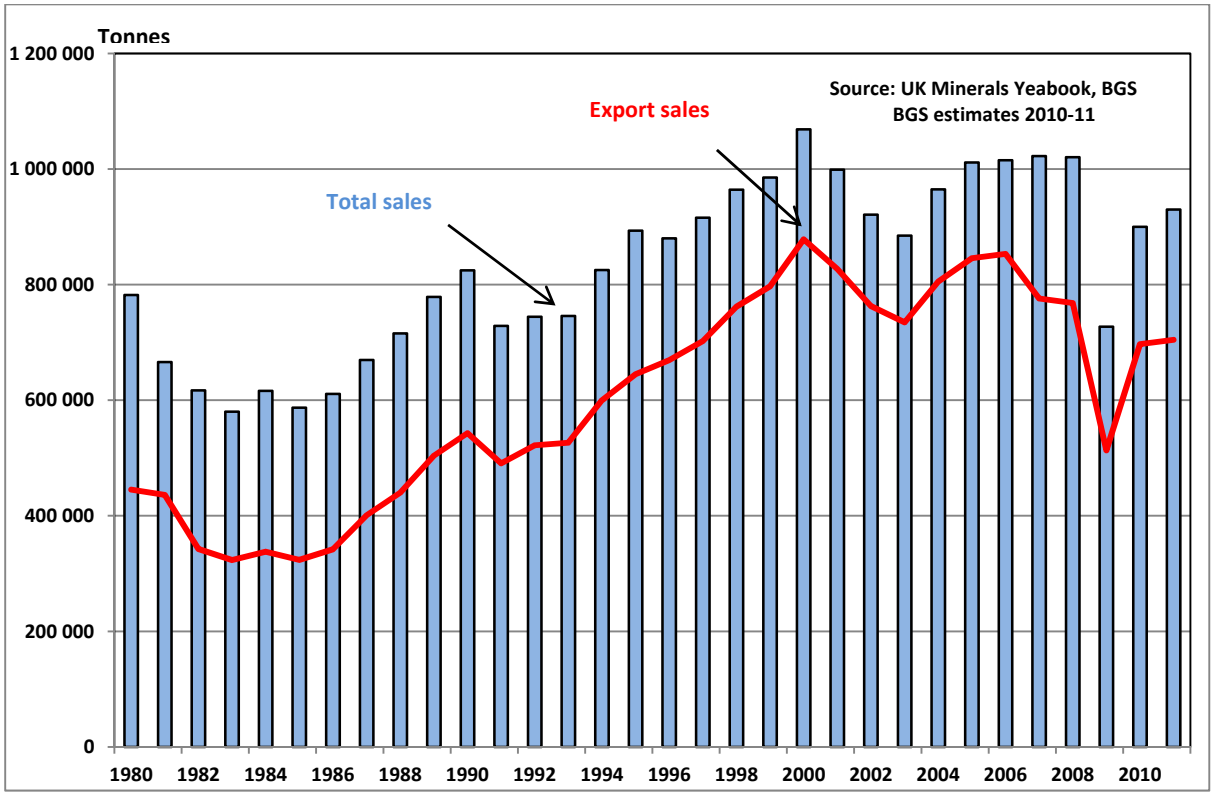

Figure 19. UK: Total sales and export sales of ball clay, 1980 – 2011

7.3 FULLER'S EARTH

There has been a long history of fuller's earth working in Britain, stretching back to Roman times. Fuller's earth is a scarce mineral and was only produced at a few locations. Following an expansion in production to a peak of 216,000 tonnes in 1985, output steadily declined as reserves with planning permission were depleted and new applications in Surrey and Bedfordshire were not granted. Production finally ceased in 2005 bringing to an end this long established industry. Although the industry ceased prematurely as a result of planning decisions, limited reserves meant there was no long term future for fuller's earth production in the UK. Total cumulative production of fuller's earth is estimated at some 10 million tonnes.

7.4 SILICA SAND

Silica sands contain a high proportion of silica (up to 99% SiO_2) in the form of quartz and are essential raw materials for glassmaking and a wide range of other industrial and horticultural applications. Britain is essentially self-sufficient in silica sand and UK trade in silica sand is small. Historically a major market for silica sand was in foundry casting, and over 3 Mt/y of moulding sands were consumed during the 1970s. However, the progressive decline in heavy manufacturing in the UK, and notably the foundry industry, has resulted in a significant decline in demand for foundry sand (Figure 20). Apart from the recent downturn, the demand for glass sand has held up reasonably well, although demand will have been adversely affected to some extent by increased glass recycling. The apparent large increase in demand for silica sand for 'industrial and agricultural/horticultural and leisure uses' most probably reflects the introduction of the Aggregates Levy in April 2002. Silica sands for prescribed industrial and agricultural processes are not subject to the levy and it is likely that sand 'for agricultural, horticultural and leisure purposes' formerly recorded elsewhere has been reclassified as silica sand.

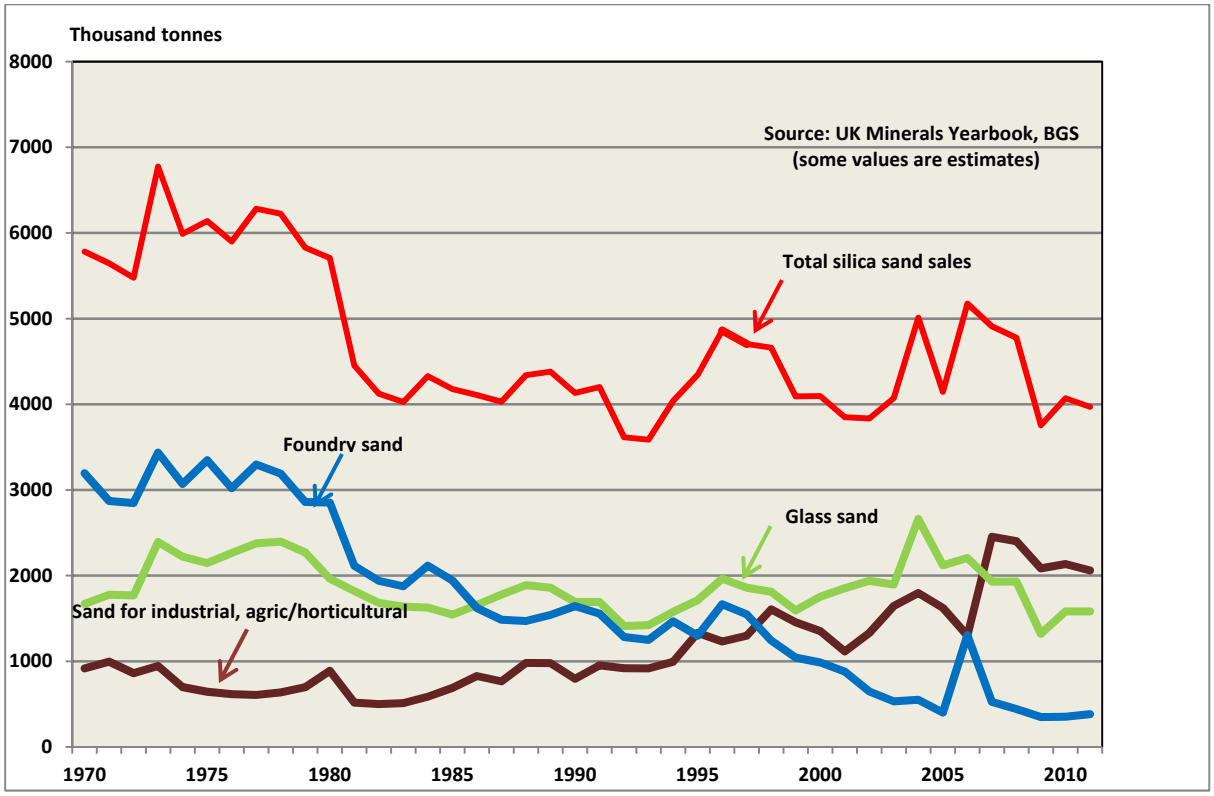

Figure 20. Great Britain: Sales of silica sand, 1970 – 2011

In terms of importance to the UK economy, the glass industry is perhaps the most significant consumer of silica sand, because of the higher value added products, such as glass containers, flat glass and speciality glasses. Glassmaking is, however, an energy intensive process and its future viability may be threatened if domestic energy costs rise with respect to other countries. The glass industry also consumes other minerals produced in the UK, notably salt (used to manufacture soda ash) and limestone.

Silica sands have long been used as proppants by the petroleum industry to improve reservoir permeability. However, a significant new market could develop for silica sand in the UK for use in shale gas extraction using hydraulic fracturing techniques.

7.5 GYPSUM AND ANHYDRITE

Anhydrite ($CaSO_4$) was formerly mined on a large scale in the UK as a source of sulphur for the manufacture of ammonium sulphate fertiliser and sulphuric acid; the latter was then regarded as a strategically important material for the UK chemical and fertiliser industries. Production of anhydrite peaked at just over 2 million tonnes in the early 1960s. The availability of cheap sulphur on world markets derived from sour (H_2S-bearing) natural gas made the energy intensive process of recovering sulphur from anhydrite uneconomic (a by-product of the process was cement) and the last major anhydrite mine closed in 1975. A mixture of gypsum/anhydrite is still used in cement manufacture.

Natural gypsum for plaster, plasterboard and cement manufacture has historically been mainly extracted by mining in Britain. The Barrow-upon-Soar mine in Leicestershire was the last to come into production in 1988. Natural gypsum production was over 3 million tonnes for most of the period 1970 to 1990, peaking at 3.8 Mt in 1973 and again at 3.7 Mt in 1988 (Figure 21). However, the amount of natural gypsum extracted in the UK has since declined appreciably because of the increasing availability of desulphogypsum derived from flue-gas desulphurisation (FGD) at coal-fired power stations and more recently the effects of the recession. The first desulphogyspum was delivered from Drax in North Yorkshire and Ratcliffe-on-Soar station in Nottinghamshire in 1994, but other coal-fired power stations have supplied desulphogysum more

recently. The amount of desulphogypsum produced at coal-fired power stations depends on two main factors; the electricity output of the station and the sulphur content of the coal. Total production of desulphogypsum was about 1.6 Mt in 2008 but more recent figures are incomplete (Figure 21).

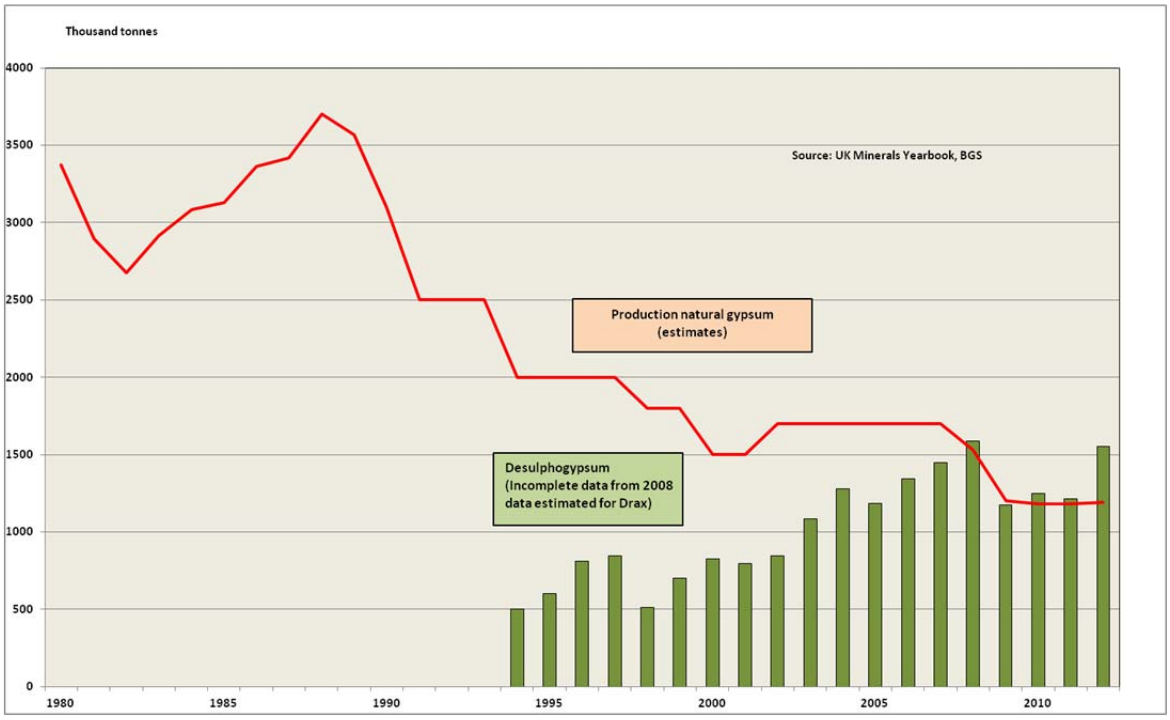

Figure 21. UK: Production of natural gypsum and desulphogypsum, 1980 - 2012

Despite the current availability of desulphogypsum, it is not viewed as a long term source of supply. FGD is a parasitic load on electricity generation at coal-fired power stations, reducing their efficiency. In addition, increasing dependency on imported lower sulphur coals and increasing use of biomass suggests that total desulphogypsum production will decline. The doubtful longer term future of coal-fired generation is a further general threat to its future availability.

Until the late 1980s, the UK was largely self-sufficient in gypsum. Since then imports of both natural and synthetic gypsum have increased, in part to supply plasterboard facilities that opt for this supply route. Imports of gypsum were 539,000 tonnes in 2011.

7.6 SALT

Cheshire is the most important centre for salt production accounting for over 80% of national output. The official figure for salt production in the Great Britain was 5.8 million tonnes in 2011[17]. The figure includes salt-in-brine, which is used as a feedstock for the inorganic chemicals industry, and brine or white salt derived from brine. Both are wholly obtained from Cheshire. Rock salt, principally used for winter road maintenance is, in addition, extracted at the Winsford mine in Cheshire, the Kilroot mine in Northern Ireland, and also as co-product at the Boulby potash mine in Yorkshire.

Britain has huge resources of salt and future supply should not be in question due to a lack of resource availability. The principal market for salt is as a chemical feedstock, where salt-in-brine is used in the electrochemical process for the production of chlorine and caustic soda (a by-product being hydrogen), and in the Ammonia-Soda Process for the production of soda ash (sodium carbonate). These chemicals are vital for further downstream manufacturing, with

[17] This figure should be treated with caution as production was recorded from Nottinghamshire and north-east Scotland - both geologically impossible.

chlorine in particular being an essential intermediate in the production of plastics and polymers, such as PVC, nylon and polyurethane. Continued large scale production for this market will depend on the future competitive strength of this important manufacturing sector. Future energy costs could have a major bearing on its survival.

7.7 POTASH

Britain has emerged as a major producer of potash over the last four decades with the development of the Boulby mine in the North York Moors National Park, which works deposits of Permian age. Shaft sinking to over 1100 m began in 1968 and was completed for production in 1976, although some production was possible from a single shaft from 1974. The Boulby mine, which is operated by Cleveland Potash Ltd, represents one of the largest mining developments ever undertaken in Britain and despite early problems production has expanded and was a record 1,040,000 tonnes of refined potassium chloride (95% KCl) in 2003, recovered from about 3 Mt/y of potash ore (sylvinite). However, production has since declined and was an estimated 770,000 tonnes potassium chloride in 2011. Potash is mainly used as a fertiliser, and although the Boulby mine could satisfy UK demand, large tonnages are exported to Europe and elsewhere. Rock salt produced from driving permanent roadways in the underlying halite (NaCl) in order to access the potash bed is also an important co-product and used as a de-icing salt. Output is about 800,000 t/y (95% NaCl).

Cleveland Potash has recently accessed and started to produce from deeper reserves of polyhalite, which are very extensive. Polyhalite, which is a potassium, magnesium, calcium sulphate, has a much lower K_2O content (the basis for comparing all potassium compounds) than sylvine (KCl), but also contains other plant nutrients. It is not produced elsewhere and a market for this new product is being developed.

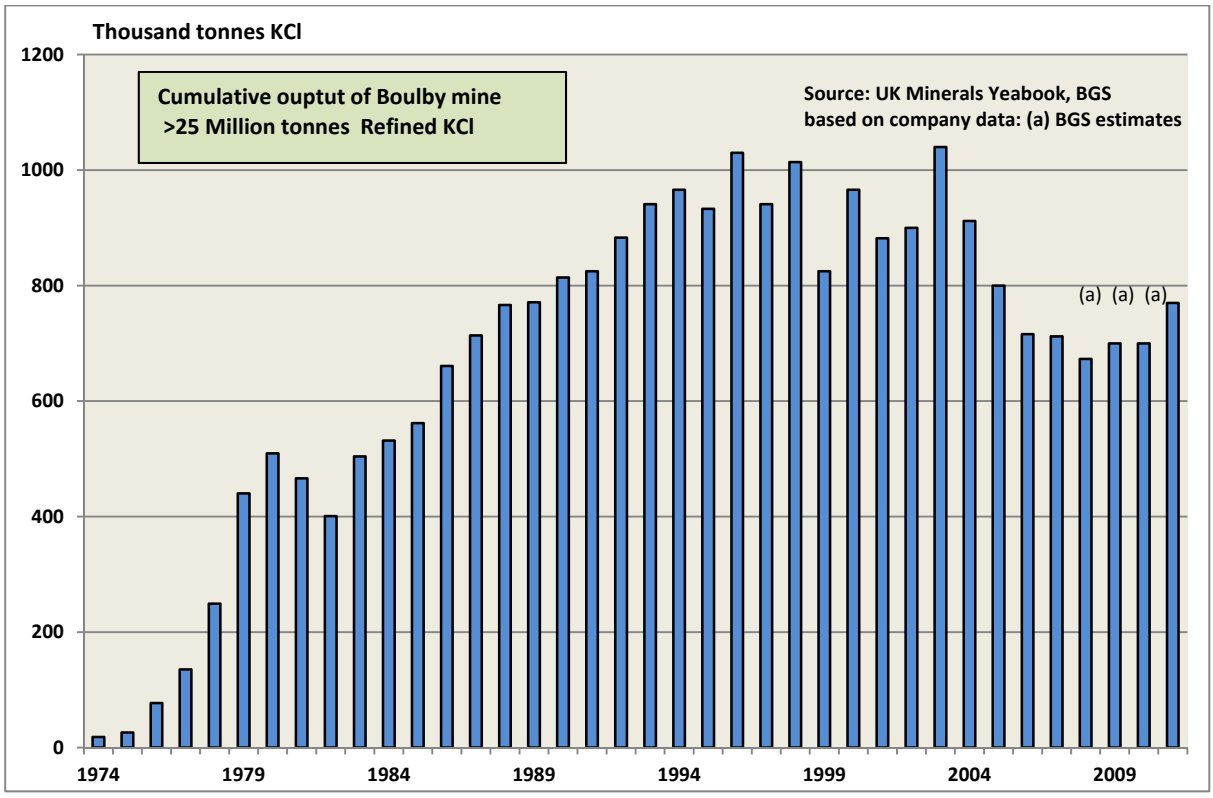

Figure 22. UK: Potash production (KCl) at the Boulby mine, 1974 – 2011

Proposals for a new potash mine, also in the North York Moors National Park to the south of the Boulby mine, are currently being developed by Sirius Minerals. The plan is to mine the very large polyhalite resources that occur.

Potash is produced in relatively few countries in the world, Canada being the largest, and a high proportion of total world output enters international trade. Global demand for potash, which is an important and essential plant nutrient, remains strong and potash prices have risen significantly in recent years. If plans for the new potash mine come to fruition, Britain could become a major world exporter of potash for several decades to come.

7.8 INDUSTRIAL CARBONATES

Three types of carbonate rock are extracted in Britain for industrial (and agricultural) purposes – limestone and chalk, both of which are composed principally of calcium carbonate ($CaCO_3$), and dolomite [$CaMg(CO_3)_2$], which also contains magnesium carbonate. Limestone is an important raw material and is often said to be the world's most versatile mineral. It has a wide variety of applications in addition to its primary uses as the principal source of crushed rock aggregate for construction in the UK and, together with its softer variant chalk, as an essential raw material for the manufacture of cement. Some of the UK's large resources of both limestone and chalk are valued for their high chemical purity and also, in the case of chalk, whiteness. Industrial limestone is an important raw material in iron and steel making, sugar refining, glass manufacture, numerous chemical processes, notably the manufacture of soda ash (sodium carbonate), and for flue gas desulphurisation. Fine limestone powders are also used as fillers in a wide range of products such as paints, plastics, rubber, paper, pharmaceuticals and cosmetics, and in agricultural and environmental applications. Some industries use raw limestone. For others the stone, both limestone and chalk, is 'burnt' in kilns at over 900^{o}C to produce lime or quicklime(CaO)[18], which is an energy intensive process.

Dolomite is also used in construction, but for industrial uses it is valued for its magnesia (MgO) content, for example as a flux in steelmaking where is used in calcined form (dolime). Other uses are in glassmaking, as a filler, and in agriculture to reduce soil acidity and as a source of magnesium.

Most of the markets for industrial carbonates are mature, or in decline, due to the decline of UK manufacturing, particularly iron and steel production. However, flue gas desulphurisation has emerged as a major market for limestone since 1994, although this market is tied to the future of coal-fired power generation in the UK.

[18] *Lime: the versatile mineral that supports our vital industries*. Mineral Products Association, 2013

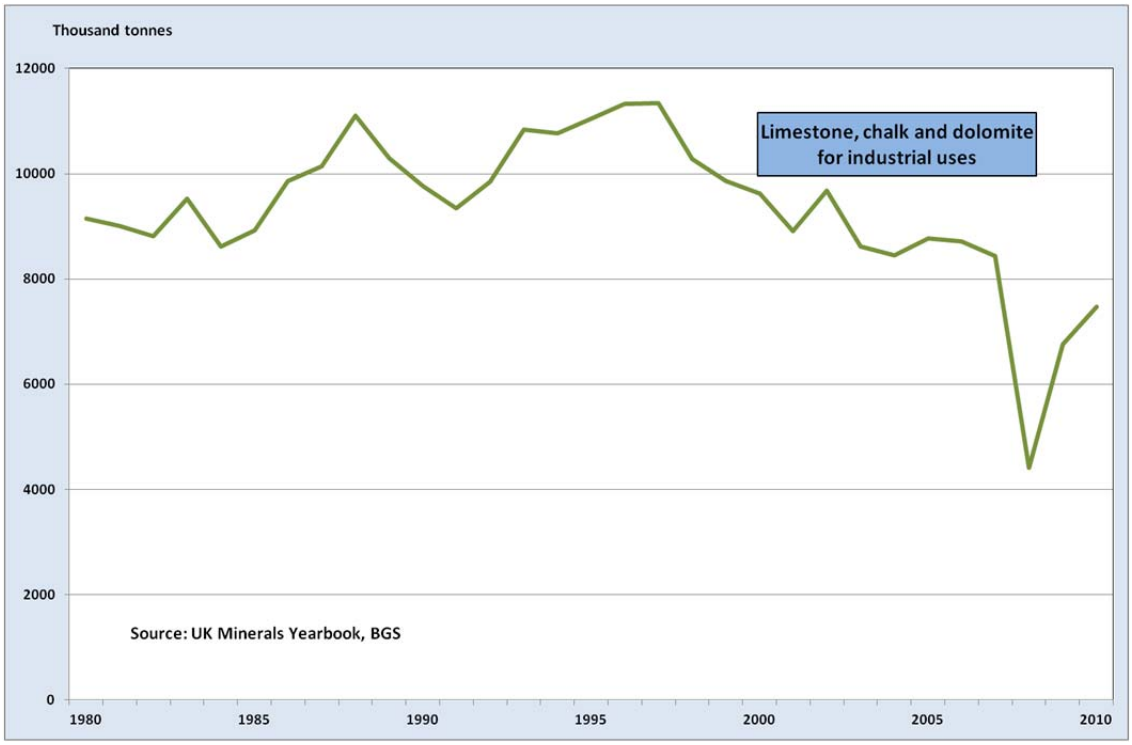

Figure 23. GB: Production of industrial carbonates, 1980 – 2011

7.9 FLUORSPAR

Fluorspar is the most important and only UK source of the element fluorine. Most is used in the manufacture of hydrofluoric acid, the starting point for the production of a wide range of fluorine-bearing chemicals.

Peak fluorspar production was 235,000 tonnes in 1975, but output has progressively declined since the mid-1980s and was only 26,420 tonnes in 2010 (Figure 24). With the closure of the last fluorspar mine in the Northern Pennine Orefield in 1999 output has almost wholly been derived from the Southern Pennine Orefield and principally from within the Peak District National Park, which has historically accounted for the major proportion of UK supply.

The future of the fluorspar mining industry in Britain has been in doubt on two occasions. In 1999 Laporte Minerals announced the closure of its Glebe Mines fluorspar mining and processing operations in the Peak District because of the loss of their major UK customer for acid-grade fluorspar to foreign competition. However, Glebe Mines was subsequently acquired and continued to supply the UK market under different ownerships until the end of 2010 when operations were placed on a care and maintenance basis, again because of foreign competition. Glebe Mines assets have, however, again been purchased and production resumed; the new owners (British Fluorspar Ltd) reopened the Milldam mine in the second half of 2012. Fluorspar ore, including material derived from local tributers, is processed at the refurbished Cavendish Mill, near Stoney Middleton, which started production in April 2013 for the production of acid-grade fluorspar, with barytes, lead concentrate and construction aggregates as by-products. The company report that capacity is 65,000 tonnes of acid-grade fluorspar and 10,000 tonnes of barytes.

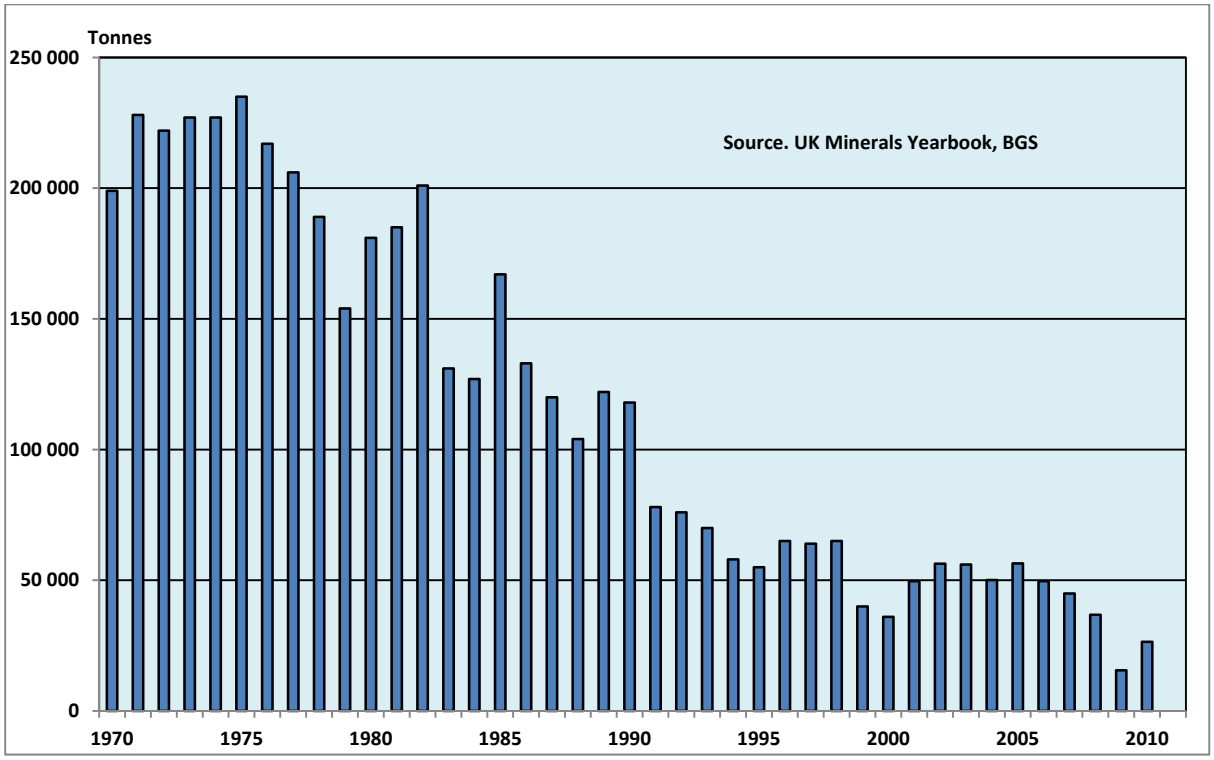

Figure 24. UK: Production of fluorspar, 1970 – 2011

7.10 BARYTES

Barytes is principally used as a weighting agent in drilling fluids for hydrocarbon exploration. Britain is not self-sufficient and imports were some 99,872 tonnes in 2011. Apparent consumption of barytes largely reflects offshore exploration activity (Figure 25). The major UK source of barytes has been the Foss mine, near Aberfeldy in Scotland which opened in 1984 with a capacity of about 50,000 t/y. Modest amounts have, for many years, also been produced in the Southern Pennine Orefield as a by-product of processing fluorspar ore at the Cavendish Mill in the Peak District. Fluorspar operations in the Peak District ceased in 2010 resulting in a decline in barytes output to only 33,000 tonnes in that year. However, fluorspar operations are currently being revived and small amounts of barytes should once again become available from this supplementary source as a by-product.

A major deposit of high-quality bedded baryte, with measured resources of 7 million tonnes, has been defined at Duntanlich, also near Aberfeldy in Scotland. A planning application to develop an underground mine with an output of 200,000 t/y was finally refused in 1996. Despite a domestic market for barytes in hydrocarbon exploration, and Scotland's leading role in that field within the UK, the refusal was on the grounds that the economic benefits did not outweigh the environmental disadvantages. A revised planning application may be submitted, but the fact remains that this world class baryte deposit may never be worked. The presence of indigenous mineral resources is no guarantee of supply.

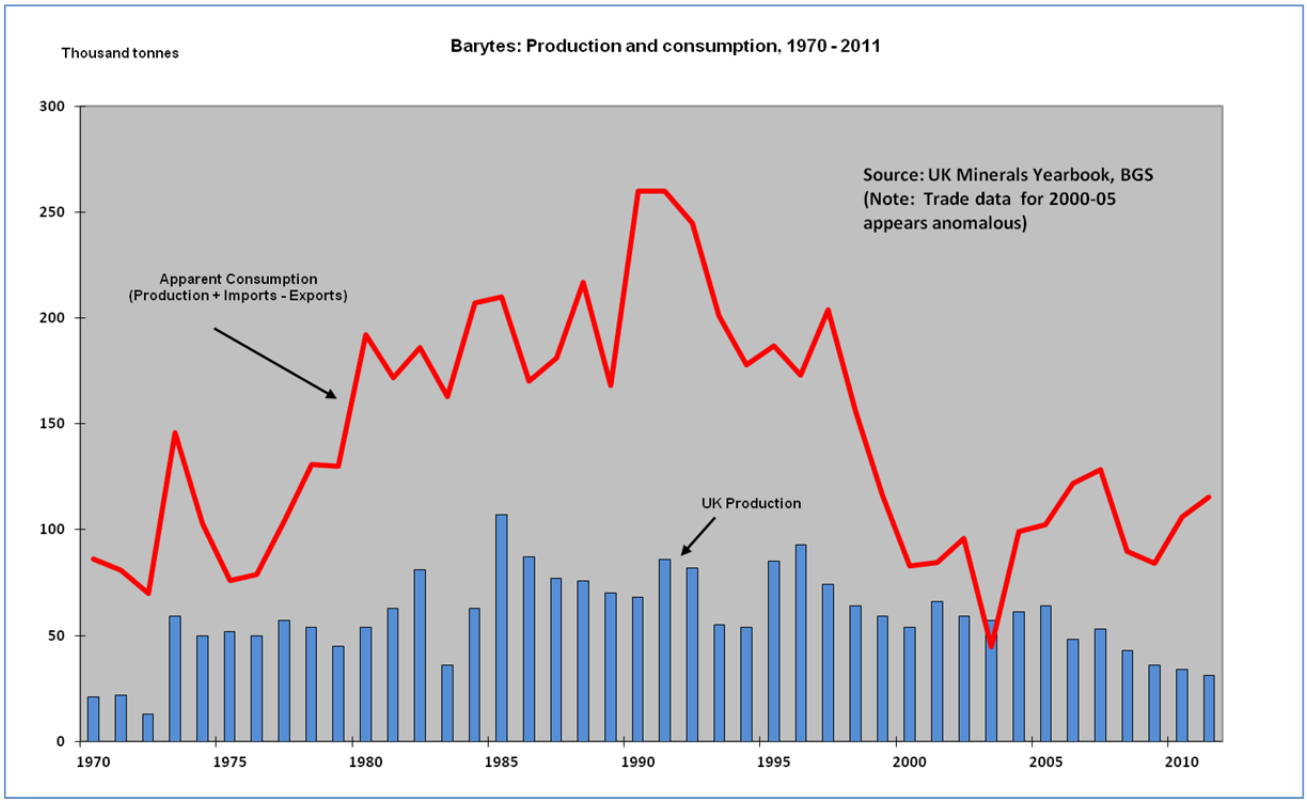

Figure 25. UK: Production and apparent consumption of barytes, 1970- 2011

8 Other minerals

Minor production of celestite ($SrSO_4$) near Bristol and diatomite in Northern Ireland ceased in 1994. Both minerals had been produced since the latter part of the 19th century. Britain was the world's largest source of celestite until the late 1960s when rising demand for strontium carbonate for colour television screens stimulated production elsewhere. Cumulative output was some 1 million tonnes.

8.1 METALS

The UK has a long history of metal mining; iron and a wide range of non-ferrous metals have been produced in the past. However, the metals sector declined during the latter part of the 19th century and iron ore and tin were the only metals to be produced in significant quantities during the 20th century.

Iron ore mining effectively ceased in 1980 with the closure of the integrated iron and steel works at Corby, the last plant to be based solely on indigenous iron ore – the Northampton Sand Ironstone. Small quantities of other Jurassic iron ores, with their high lime contents, were used as fluxes with significant iron contents but all production ceased by the early 1990s. British sedimentary iron ores are of very low grade and have relatively high phosphorus contents. It is difficult to foresee any future economic circumstances whereby they would prove viable again.

A resurgence in tin mining in Cornwall, following the commissioning of Wheal Jane in 1971, ultimately proved unsustainable. Annual production increased to a peak of 5,200 tonnes of tin-in-concentrate in 1984 and 1985, when it was approximately half the all-time maximum of 10,000 tonnes produced in 1870-71. However, Geevor mine closed in 1990 and Wheal Jane in 1991, the latter also bringing to an end by-product output of zinc, copper and silver. Finally South Crofty, Britain's last tin mine, closed in 1998 bringing to an end a 2500-year history of tin mining in Cornwall (attracting a reference in about 430 BC by Herodotus, the Greek inventor of the term

'history,' to the 'Cassiterides' – "the islands from which we are said to get our tin"). Plans to reopen the mine for the production of tin, copper, zinc and silver suffered a major set-back in July 2013 when retraction of investment by a major shareholder resulted in the mine being placed into administration.

Nevertheless, Britain continues to attract interest in its metallic minerals potential. The Hemerdon tungsten-tin deposit near Plymouth, which was formerly worked in small way during WWII, is currently being developed and first production from an open pit mine is scheduled for 2015. The deposit is one of the western world's largest tungsten deposits.

The increase in the price of gold over recent years has stimulated a revival in interest in UK gold and two small gold operations are now in operation at Omagh in Northern Island. Plans to open the Cononish mine at Tyndrum in Scotland have been delayed due to recent volatility in gold prices affecting market confidence. Northern Ireland is of a particular interest and over 50% of the land area is under licence with several companies exploring for precious metals and base metal deposits in a variety of geological settings.

Minor production of lead concentrates as a by-product of fluorspar production has recently re-started with the revival of fluorspar operations in the Peak District.

9 Foreign trade

The overall total balance of UK trade in goods has been in deficit for many years; it continues to deteriorate. As part of this pattern Britain has become increasingly dependent on imports for minerals and minerals-based products, particularly for energy minerals and metals (Figure 26). The move from being a major, long-term, net-exporter of energy minerals (coal, and then oil and gas) to a major importer has been particularly rapid, and with declining offshore reserves of both oil and gas this trend will not be reversed.

One sector in which the balance of trade has improved somewhat is in 'metal ores and scrap'. One possible explanation is an increase in exports of metal scrap, perhaps due to improved recovery and recycling but also a decline in facilities to reprocess recycled scrap into metal products at home.

Renewed concerns about security of supply have been focused on energy minerals and more exotic metals, such as rare earths, whose production is confined to a relatively few countries, notably China.

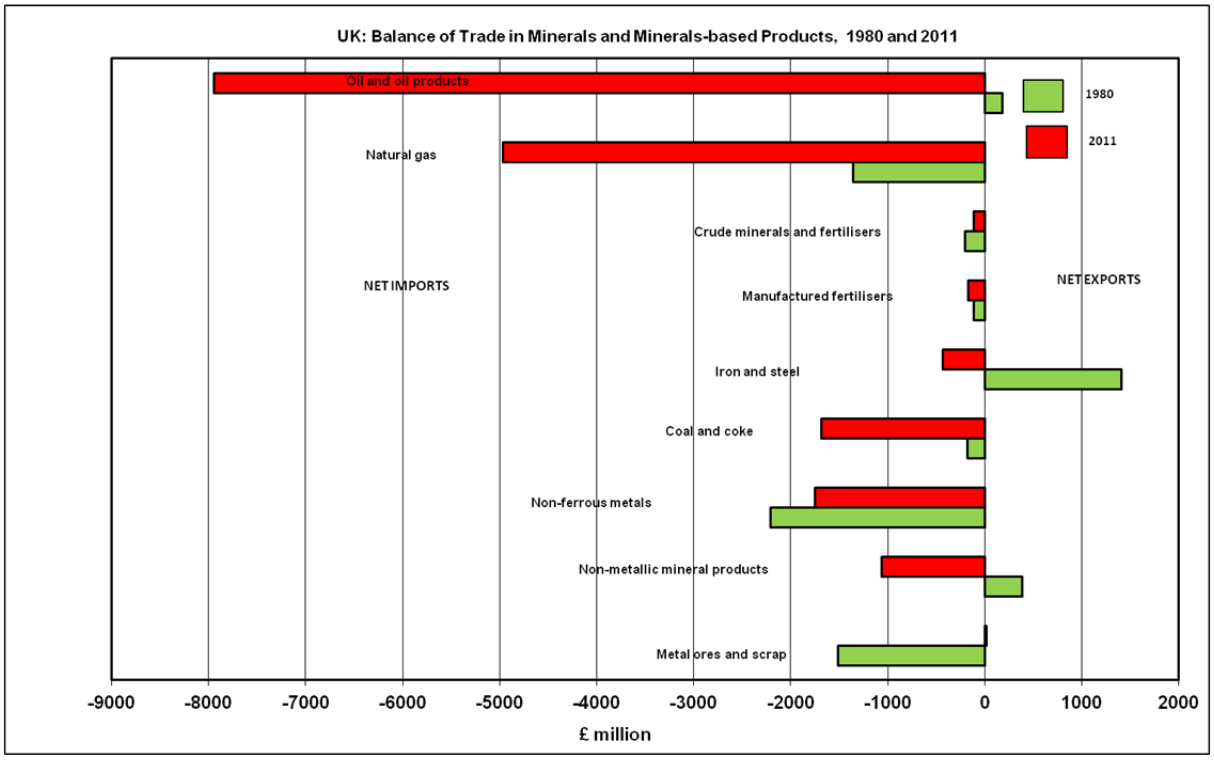

Figure 26. UK: Balance of trade in minerals and minerals-based products, 1980 and 2011 (Constant 2011 values)

10 Conclusions

There have been very substantial changes in the UK minerals industry over the last 30+ years. The overall trend has been one of decline, both in terms of domestic minerals extraction and domestic minerals consumption. The UK has also become increasingly dependent on imports of minerals and minerals-based products. The production (albeit at comparatively low tonnages) of some minerals, such as tin and fuller's earth, has ceased altogether whilst the output of others has declined significantly. Kaolin, which mainly serves overseas markets, has been badly hit because of the cessation of coating clays production, but construction minerals, and particularly natural aggregates, which are still very largely produced in the UK and have not been displaced by changes in construction technology, have witnessed a serious contraction of their markets, most notably during the recent recession, which began in 2008. One notable and desirable expansion within these contracted markets has been in the use of recycled and secondary aggregates, and materials. With the UK population forecast to rise significantly, there is a pressing need for more housing. The requirements to renew and decarbonise UK power generation, and for flood and coastal defences to mitigate the expected impacts of climate change are only two examples of the need for improvements to the nation's infrastructure. A revival of the depressed construction industry is now overdue and with it demand for construction minerals almost all of which are currently produced indigenously.

Some of the most profound changes have been in the fossil fuels used for electricity generation, largely driven by climate change policies. A combination of factors, including the depletion of our offshore gas reserves and the complexity and high cost of deep mining coal against an uncertain future for carbon regulation which deters the necessary investment, have together rapidly led the UK from energy self-sufficiency and surplus to greater and greater import dependency. With the closure of ageing nuclear power stations in coming years, in addition to those coal-fired power stations that have opted out of the EU Large Combustion Directive, together with the unpredictability of alternatives, Britain appears to be moving further towards high energy costs and insecurity of supply. This could have major ramifications for energy

intensive industries, notably steel, ceramics, glass, cement and lime, all of which are major consumers of minerals, and at present (except steel) principally sourced in the UK.

The British Geological Survey has shown that Britain has large shale gas resources (gas-in-place) contained within very thick Carboniferous shale-bearing sequences. However, as yet, we remain a long way from determining whether these resources will be economically viable or yield sufficient quantities of gas to improve national energy security, assist the UK's adverse trade balance in natural gas and sustain hydrocarbon tax revenues. There also remain big questions over the environmental and political acceptability of shale gas development. Shale gas development elsewhere in the world has the potential to change the geopolitics of energy supply[19].

Britain's resource security and its longer term access to mineral supplies, both from domestic and overseas sources, will remain a key issue for the national economy for many years to come.

11 Other sources of information

This report has drawn heavily on information published by the British Geological Survey in its annual *United Kingdom Minerals Yearbook*, which brings together statistical data derived from a wide range of official sources on minerals produced and consumed in the UK. This report, together with a wealth of other information on the UK minerals industry, can be found on the British Geological Survey's dedicated minerals website – www.mineralsUK.com . More detailed information on individual minerals can be found in a series of *Mineral Planning Factsheets*, which provide succinct overviews of each of the economically important minerals extracted onshore in Britain.

A valuable overview of key aspects of Britain's non-energy minerals sector can also be found in *The mineral products industry: key facts at a glance*. (Mineral Products Association, 2013). This report, together others more focused on individual minerals, can be found at http://www.mineralproducts.org/

12 Working Group Membership

Joseph Mankelow	Chairman, British Geological Survey
David Highley	Secretary, Independent
Andrew Bloodworth	British Geological Survey
Bob Brown	Campaign to Protect Rural England*
Lauren Darby	British Ceramic Confederation*
Jim Davies	Environment Agency
Bob Fenton	MAUK/MIRO/CBI Minerals Group
Peter Huxtable	British Aggregates Association/CBI MG
Jeremy Lake	English Heritage
Bob LeClerc	Executive Secretary, CBI Minerals Group
Jerry McLaughlin	Mineral Products Association
Mark North	Kier Minerals/CBI Minerals Group
Ian Selby	The Crown Estate/CBI Minerals Group
Michelle Spence	Derbyshire County Council/Planning Officers Society

* *Corresponding members*

[19] The Carboniferous Bowland Shale gas study: geology and resource estimation. I J Andrews. British Geological Survey for the Department of Energy and Climate Change, London, UK. (DECC, 2013).