



Natural gas needs to compete more innovatively and cooperatively with coal and renewable energies to sustain growth



A cursory review of the distribution and growth of proved natural gas reserves, together with a trend of increased growth in global natural gas consumption implies that the industry is performing well. However, this perception is somewhat diminished when its growth and resource distribution is compared with that of its main competitors over recent years, coal and renewable energies (particularly solar photovoltaic (PV) and wind power). Using data from the latest BP Statistical Review of World Energy (BP, June 2016) the reserves and consumption positions are compared for coal and gas resources, together with installed capacity growth trends for wind and photovoltaic power. What becomes clear is that natural gas needs to find ways to compete more effectively with the challenges posed by other energy resources, finding ways that go beyond increasing resource volumes and developing technologies that can produce the more difficult-to-access natural gas resources (e.g. hydrates and deep-tight gas resources). Strategies that could improve the future uptake of natural gas as a more-favoured and versatile energy source globally are suggested.

1. Distribution of proved natural gas and coal reserves

Table 1 reveals how tightly held a significant portion of the world's natural gas reserves are by relatively few countries; the first three countries hold some 48.6% of the world's natural gas reserves, the first five countries (ranks#1 to #5) hold some 63.5%, and the first ten countries hold some 79.4%. Moreover, the majority of the top-ten-gas-reserves-holding countries are associated with high geopolitical risk and are remote from the main gas-consuming markets (e.g. Middle East, North Africa, Commonwealth of Independent States – CIS, which includes Russia and the gas-rich-central-Asian nations).

It is useful to compare the gas reserves holdings of Table 1 with those for coal (Table 2). The world's coal resources are even more tightly held by fewer countries than natural gas; the first three countries in Table 2 hold some 57.1% of the world's coal reserves, the first five countries (ranks#1 to #5) hold some 72.4%, and the first ten countries hold some 91.1%. However, several of the top-ten-coal-reserves-holding countries are among the world's most-significant energy consumers (e.g. US, China, India, Germany and Indonesia) and holding these resources helps to ease their security-of-supply concerns and vulnerability to geopolitical upheavals. Table 3 further highlights the significant regional distinctions between the distribution and holding of major gas and coal resources, with the OECD and North America

being clearly better endowed with coal resources than gas resources. Those high OECD and North American resource holdings for coal also translate into significant employment in the coal industry within the OECD and the coal sector having a strong influence, at least historically on the energy policies of many OECD nations.

Natural gas proved reserves, on an oil equivalent basis, constitute about 39% of coal proved reserves at the end of 2015, i.e., 168.2 trillion tonnes of oil equivalent (toe) for natural gas versus 431.6 trillion toe for coal (Tables 1 and 2). In addition, the global proved-reserves-to-production (R/P) ratio (or reserves-life index, as it is sometimes referred to) for gas is some 53 years, versus 114 years for coal. These figures confirm that, in terms of accessibility and security of long-term supply, the currently-exploited coal resources appear to be more extensive than the currently-exploited natural gas resources. Notwithstanding these characteristics, proved natural gas reserves have increased over the past decade by some 3.9% (at a compound average growth rate – CAGR – of 0.388%), whereas proved coal reserves, on an oil-equivalent basis, have decreased by some 6.7% (at a compound average decline rate – CAGR – of –0.691%) since 2005. The significant potential of the natural gas industry to add proved resources through exploitation of tight gas reservoirs, both inside and outside of North America, and through future technology breakthroughs enabling the commercial exploitation of gas hydrates, suggests that natural gas could further close the gap with coal on a resource-holding basis.

2. Consumption trends for natural gas and coal

Figs. 1 and 2 illustrate the consumption trends for natural gas and coal over the past twenty years. From 2014 to 2015 natural gas consumption expanded at 1.7%, which involved expansions of 1.9% in North America, 3.1% in South America, 6.2% in Middle East, 5.5% in Africa and 0.5% in Asia (although several countries in Asia recorded declines, e.g. Indonesia, Japan, South Korea and Australia). Europe & Eurasia was the only region to post a decline in gas consumption (–0.3%); continuing a downward trend that started in 2011. On the other hand, coal consumption declined globally by 1.8% from 2014 to 2015; the first annual decline recorded since 2008/2009. That global decline was driven primarily by a 12.7% decline in coal consumption in the United States as a consequence of very-low-priced gas displacing coal in the power generation sector. Declines in coal consumption were also posted in other regions (2.7% in Europe & Eurasia; 1.7% Middle East;

Table 1
Proved natural gas reserves ranked by country for the 25-largest-resource holders and for the total world at 31st December 2015 (data sourced from BP, 2016). Natural gas reserves are transformed into tonnes of oil equivalent (toe) using the conversion 39.239 bcf/1 toe.

| Proved natural Gas reserves at 31st dec 2015 | | | | | | | |
|--|---------------------------------------|---------------------------|----------------------------------|--|--------------------------|-------------------------------------|---|
| Country | Rank (largest-reserves holders first) | Trillion cubic feet (tcf) | Billion tonnes of oil equivalent | Trillion cubic metres (tcm) | Share of global reserves | Cumulative share of global reserves | Proved reserves/ Production (R/P) years |
| Iran | 1 | 1201 | 30.6 | 34.0 | 18.2% | 18.2% | 176.8 |
| Russian Federation | 2 | 1140 | 29.0 | 32.3 | 17.3% | 35.5% | 56.3 |
| Qatar | 3 | 866 | 22.1 | 24.5 | 13.1% | 48.6% | 135.2 |
| Turkmenistan | 4 | 617 | 15.7 | 17.5 | 9.4% | 58.0% | 241.4 |
| US | 5 | 369 | 9.4 | 10.4 | 5.6% | 63.5% | 13.6 |
| Saudi Arabia | 6 | 294 | 7.5 | 8.3 | 4.5% | 68.0% | 78.2 |
| United Arab Emirates | 7 | 215 | 5.5 | 6.1 | 3.3% | 71.3% | 109.2 |
| Venezuela | 8 | 198 | 5.1 | 5.6 | 3.0% | 74.3% | 173.2 |
| Nigeria | 9 | 180 | 4.6 | 5.1 | 2.7% | 77.0% | 102.1 |
| Algeria | 10 | 159 | 4.1 | 4.5 | 2.4% | 79.4% | 54.3 |
| China | 11 | 136 | 3.5 | 3.8 | 2.1% | 81.5% | 27.8 |
| Iraq | 12 | 130 | 3.3 | 3.7 | 2.0% | 83.4% | 3597.9 |
| Australia | 13 | 123 | 3.1 | 3.5 | 1.9% | 85.3% | 51.8 |
| Indonesia | 14 | 100 | 2.6 | 2.8 | 1.5% | 86.8% | 37.8 |
| Canada | 15 | 70 | 1.8 | 2.0 | 1.1% | 87.9% | 12.2 |
| Norway | 16 | 66 | 1.7 | 1.9 | 1.0% | 88.9% | 15.9 |
| Egypt | 17 | 65 | 1.7 | 1.8 | 1.0% | 89.9% | 40.5 |
| Kuwait | 18 | 63 | 1.6 | 1.8 | 1.0% | 90.8% | 119.1 |
| Libya | 19 | 53 | 1.4 | 1.5 | 0.8% | 91.6% | 118.0 |
| India | 20 | 53 | 1.3 | 1.5 | 0.8% | 92.4% | 50.9 |
| Malaysia | 21 | 41 | 1.1 | 1.2 | 0.6% | 93.0% | 17.1 |
| Azerbaijan | 22 | 41 | 1.0 | 1.1 | 0.6% | 93.7% | 63.2 |
| Uzbekistan | 23 | 38 | 1.0 | 1.1 | 0.6% | 94.2% | 18.8 |
| Kazakhstan | 24 | 33 | 0.8 | 0.9 | 0.5% | 94.7% | 75.7 |
| Oman | 25 | 24 | 0.6 | 0.7 | 0.4% | 95.1% | 19.7 |
| Sum of top 25 Countries | | 6276 | 160.0 | 177.7 | 95.1% | | |
| Rest of World | | 323 | 8.2 | 9.1 | 4.9% | | |
| Total World 31st Dec 2015 | | 6599 | 168.2 | 186.9 | 100.0% | | 52.8 |
| Total World 31st Dec 2005 | | 6348 | 161.8 | 179.8 | 100.0% | | 65.1 |
| Global growth over decade: | | 3.96% | | Compound annual growth rate (2005–2015): | | | 0.388% |

Table 2
Proved coal reserves ranked by country for the 15-largest-resource holders and for the total world at 31st December 2016 (data sourced from BP, 2016). Anthracite and bituminous coal are transformed into tonnes of oil equivalent (toe) using the conversion 1.5 tonnes of coal/1 toe. Sub-bituminous coal and lignite are transformed into tonnes of oil equivalent (toe) using the conversion 3.0 tonnes of coal/1 toe.

| Proved coal reserves at 31st dec 2016 | | | | | | | | |
|---------------------------------------|---------------------------------------|--|---|--|--|----------------|---------------------------|---------------------------------|
| Country | Rank (largest-reserves holders first) | Anthracite and bituminous (millions of tonnes) | Sub-bituminous and lignite (millions of tonnes) | Total coal reserves (millions of tonnes) | Total coal reserves (billions of tonnes of oil equivalent) | Share of total | Cumulative share of total | Reserves/Production (R/P) years |
| US | 1 | 108,501 | 128,794 | 237,295 | 115.3 | 26.6% | 26.6% | 292 |
| Russian Federation | 2 | 49,088 | 107,922 | 157,010 | 68.7 | 17.6% | 44.2% | 422 |
| China | 3 | 62,200 | 52,300 | 114,500 | 58.9 | 12.8% | 57.1% | 31 |
| Australia | 4 | 37,100 | 39,300 | 76,400 | 37.8 | 8.6% | 65.6% | 158 |
| India | 5 | 56,100 | 4500 | 60,600 | 38.9 | 6.8% | 72.4% | 89 |
| Germany | 6 | 48 | 40,500 | 40,548 | 13.5 | 4.5% | 77.0% | 220 |
| Ukraine | 7 | 15,351 | 18,522 | 33,873 | 16.4 | 3.8% | 80.8% | 891 |
| Kazakhstan | 8 | 21,500 | 12,100 | 33,600 | 18.4 | 3.8% | 84.6% | 316 |
| South Africa | 9 | 30,156 | 0 | 30,156 | 20.1 | 3.4% | 87.9% | 120 |
| Indonesia | 10 | 0 | 28,017 | 28,017 | 9.3 | 3.1% | 91.1% | 71 |
| Serbia | 11 | 1 | 13,410 | 13,411 | 4.5 | 1.5% | 92.6% | 352 |
| Turkey | 12 | 322 | 8380 | 8702 | 3.0 | 1.0% | 93.6% | 192 |
| Colombia | 13 | 6746 | 0 | 6746 | 4.5 | 0.8% | 94.3% | 79 |
| Brazil | 14 | 0 | 6630 | 6630 | 2.2 | 0.7% | 95.1% | 835 |
| Canada | 15 | 3474 | 3108 | 6582 | 3.4 | 0.7% | 95.8% | 108 |
| Sum of top 15 Countries | | 390,587 | 463,483 | 854,070 | 414.9 | 95.8% | | |
| Rest of World | | 12,612 | 24,849 | 37,461 | 16.7 | 4.2% | | |
| Total World 31st Dec 2015 | | 403,199 | 488,332 | 891,531 | 431.6 | 100.0% | | 113.9 |
| Total World 31st Dec 2005 | | 478,771 | 430,293 | 909,064 | 462.6 | 100.0% | | 155.0 |
| Global growth over decade: | | -15.78% | 13.49% | -1.93% | Compound annual growth rate (OilEquiv): | | | -0.691% |

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