COAL

Hard Facts

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Contents

Coal Hard Facts is a publication of the
Minerals Council of Australia

COAL BESTOWS A LASTING COMPARATIVE ADVANTAGE THAT BENEFITS ALL AUSTRALIANS

AUSTRALIA IS FORTUNATE TO BE RICHLY ENDOWED WITH A COMMODITY THAT IS INDISPENSABLE TO MODERN LIFE: COAL.

Thermal coal is the world's fuel of choice for electricity generation – accounting for 41 per cent of all generation[1] – because it is reliable and affordable. Metallurgical coal is also an essential ingredient in the manufacture of steel and cement.

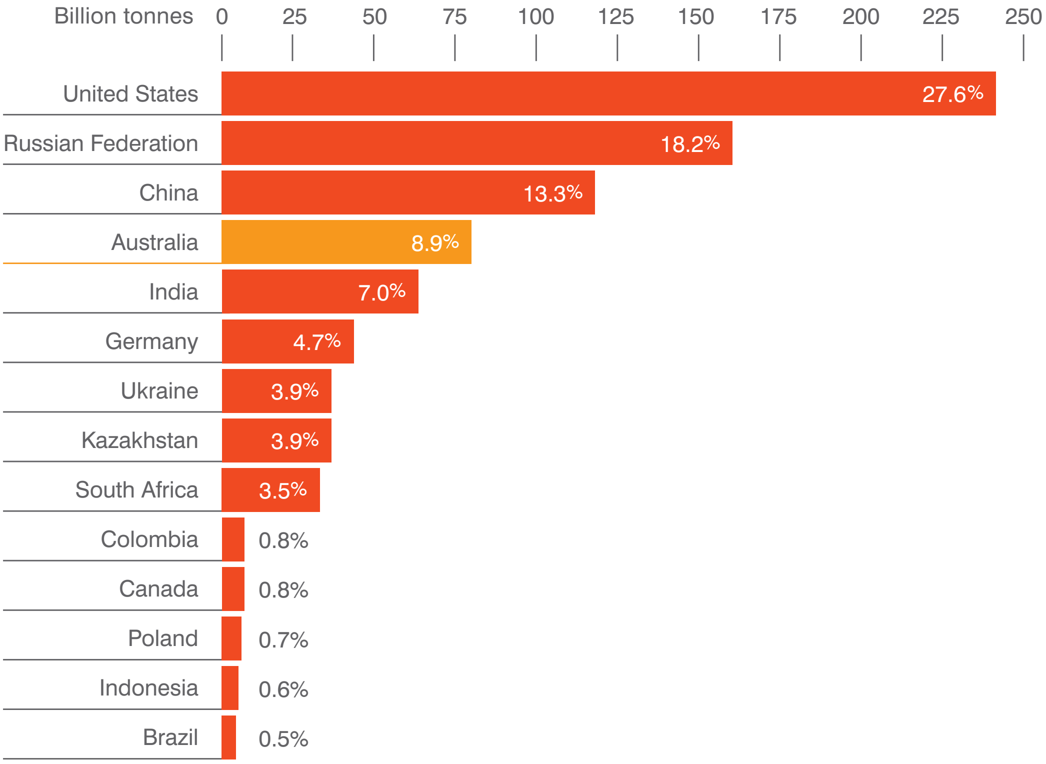
Australia has the fourth-largest share of proven coal reserves in the world (Chart 1). In terms of resource life, current estimates of Australia's economic demonstrated coal resources are 110 years for black coal and 510 years for brown coal (lignite).[2]

Coal benefits all Australians through its contribution to exports, wages, investment and tax and royalties revenue. It is Australia's comparative advantage in coal – together with iron ore – that has enabled Australians to sustain the longest period of continuous economic growth in the nation's history.

The underlying trend of rising world coal demand – driven by Asian industrialisation and electrification – will persist for decades.

CHART 1 **Selected national shares of proven world coal reserves as at Dec 2012 (Bt & %)[3]**

Source: BP Statistical Review of World Energy 2013



Export income

Australia is a major supplier of high-quality coal to both mature and emerging markets, accounting for 54 per cent of world trade in metallurgical coal and 24 per cent of world trade in thermal coal.[4]

Coal is Australia's second-largest export earner, after iron ore, and the largest export industry in both Queensland and New South Wales. Over the last five years, coal has accounted, on average, for more than 15 per cent of Australia's total exports. This is up from an average of 10 per cent over the previous five years. In the same period, Australia's coal exports have added on average $44 billion a year to national income (Chart 2).

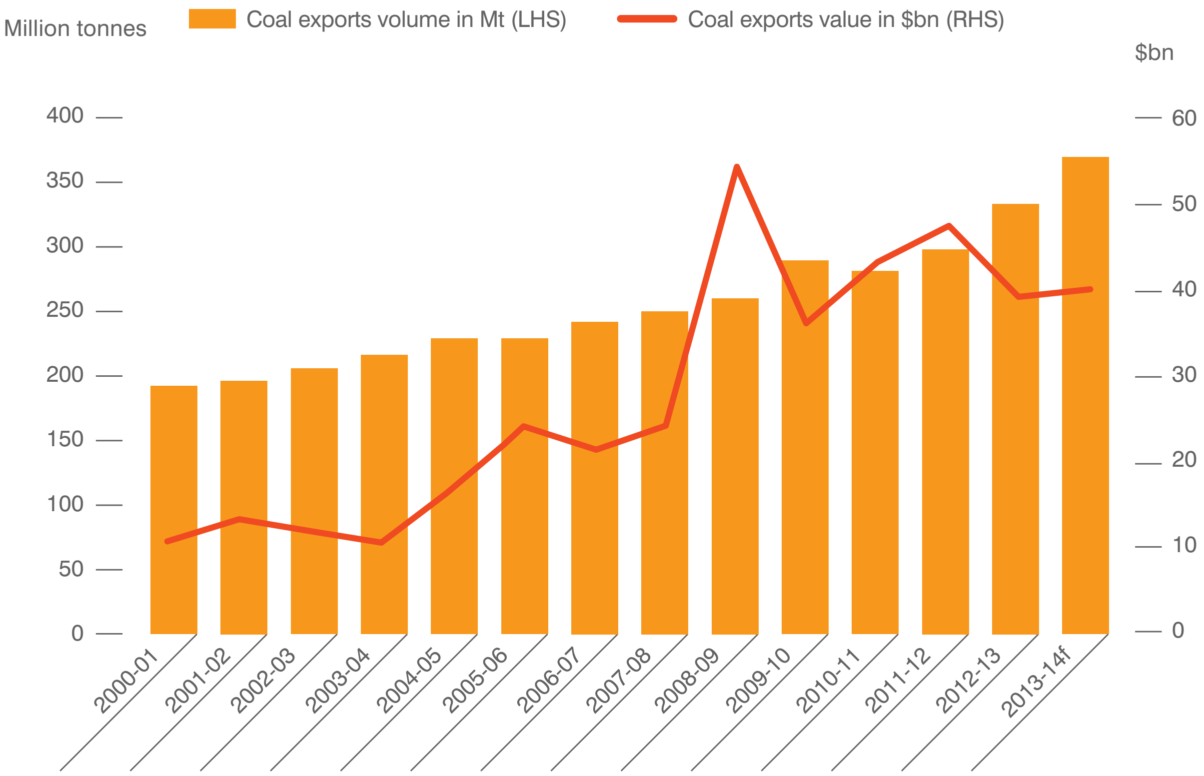
According to the Bureau of Resources and Energy Economics (BREE), export volumes of coal will rise to 372 Mt in 2013-14, an increase of 11 per cent from 2012-13. Coal exports in 2013-14 are forecast to be worth $40 billion in real terms, also a 2 per cent annual increase.[5] BREE expects that coal exports will expand to 438 Mt and $49 billion in 2018-19 in real terms, with average annual growth rates of 3 and 4 per cent, respectively.[6]

BREE is optimistic about Australia's prospects for both thermal and metallurgical coal exports. Australia is the only exporter that is projected to increase annual coal exports by more than 50 Mt. BREE projections suggest an increase in coal export volumes of 90 Mt between 2013 and 2019 for Australia, compared with an increase of 41 Mt for Colombia and a decline for Indonesia.[7]

Similarly, in the International Energy Agency's core scenario, Australia's coal production grows by almost 50 per cent between 2011 and 2035 (compound average annual growth rate of 1.7 per cent), driven by rising exports. The IEA expects Australia and Indonesia to be the biggest beneficiaries of increasing international trade in coal. Australia overtakes Indonesia as the world's biggest coal exporter by volume by 2030, although Indonesia remains the largest thermal coal exporter.[8]

CHART 2 **Australia's coal exports by volume and value, 2000-01 to 2013-13 (forecast)**

Source: Bureau of Resources and Energy Economics



AUSTRALIA WILL OVERTAKE INDONESIA AS THE WORLD'S BIGGEST COAL EXPORTER BY VOLUME BY 2030, ALTHOUGH INDONESIA REMAINS THE LARGEST THERMAL COAL EXPORTER. *Source:International Energy Agency*

+90Mt

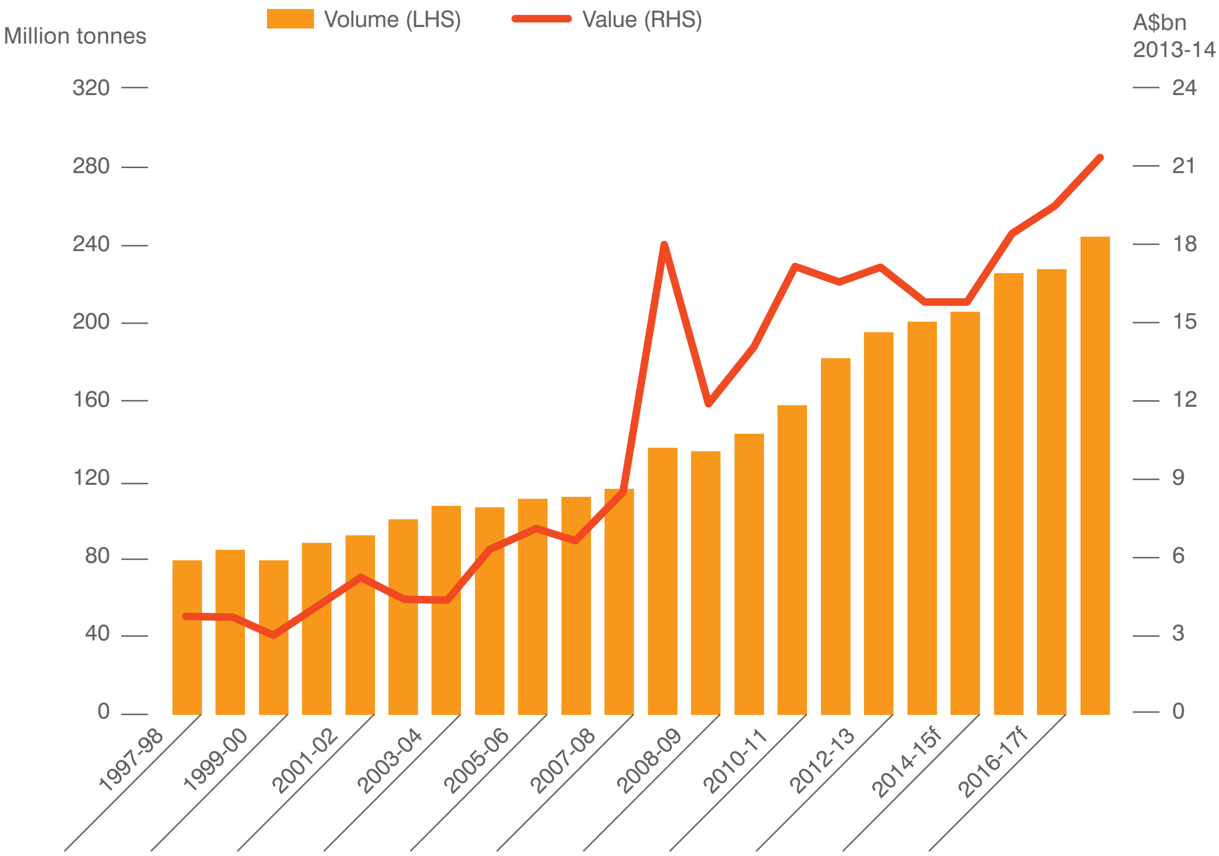
Projected increase in coal export volume between 2013-2019.

-21Mt

Projected increase in coal export volume between 2013-2019.

CHART 3 **Australian thermal coal exports by volume and value, 1997-98 to 2018-19**[11]

Source: Bureau of Resources and Energy Economics



Outlook for thermal coal exports

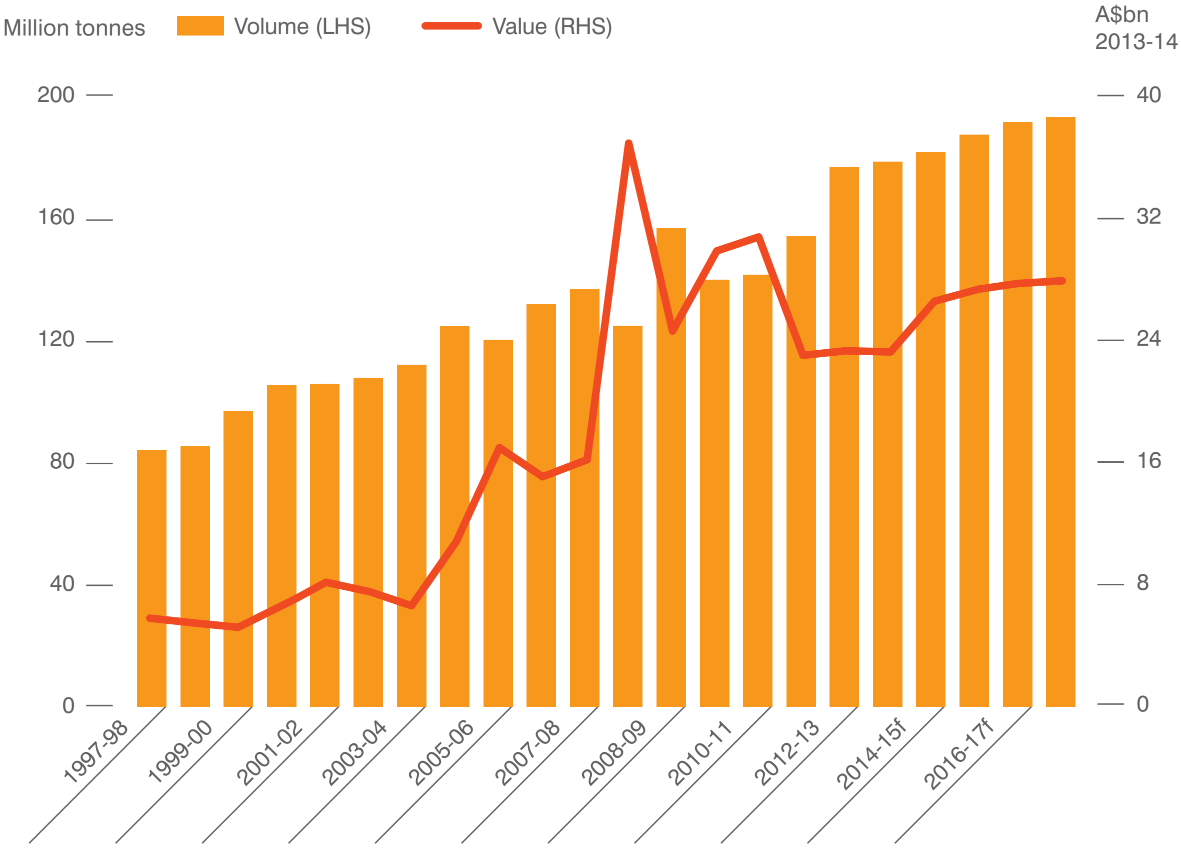
According to BREE, Australia's thermal coal export volumes increased by 15 per cent in 2012-13 to total 182 Mt. The value of these exports fell 6 per cent from $17 to $16 billion, with a lower Australian dollar thermal coal price more than offsetting higher export volumes.[9]

BREE forecasts that export volumes and values will increase by approximately 8 per cent in 2013-14 to total 195 Mt and $17 billion. For the rest of the outlook period, BREE projects that Australia's thermal coal export volumes will increase by an average rate of 5 per cent per annum to reach 244 Mt in 2018-19. Real export values are also projected to grow at an average annual rate of 5 per cent to total $21 billion in 2018-19 (Chart 3).[10]

BREE affirms that continued growth in thermal coal exports will be supported by the completion of expansions at the Glencore's–Xstrata's Rolleston mine (an extra 3 million tonnes a year), Peabody Energy's North Goonyella (an extra 5 million tonnes a year), and Middlemount (an extra 1.5 million tonnes a year) operations.[12] More generally, BREE expects that the rate of export growth will slow over the next three-to-four years, since rising construction and operating costs are rendering many planned thermal coal projects less viable.

CHART 4 **Australian metallurgical coal exports by volume and value, 1997-98 to 2018-19**[14]

Source: Bureau of Resources and Energy Economics



Outlook for metallurgical coal exports

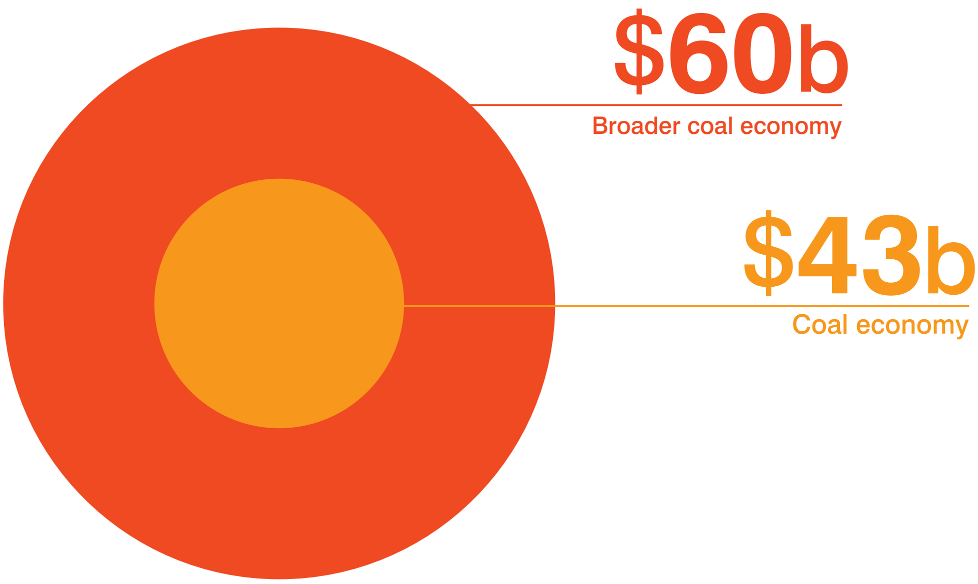
BREE reports that in 2012-13, metallurgical exports from Australia increased by 8 per cent to total 154 Mt. Although export volumes were higher, lower contract and spot prices resulted in export earnings declining from $32 to $22 billion. Over BREE's five-year projection period, Australia's exports increase at an average rate of 2 per cent a year to reach 193 Mt in 2018-19, at a real value of $28 billion (Chart 4).[13]

This export growth is expected to be supported by the following new and expanded mining projects:

- BMA's Caval Ridge project (8 Mt per annum);
- Anglo-American's Grosvenor underground mine (5 Mt); and
- BMA's Daunia project (4.5 Mt).[15]

CHART 5 **Contribution of coal to Australia's GDP, 2011-12**[16]

Source: Professor Sinclair Davidson



Wages, employment and contribution to gross domestic product

The Australian coal industry employs approximately 54,900 people directly[17] and pays wages and salaries worth over $6 billion per annum.[18] It employs a highly skilled workforce, including mine operators, engineers, geologists and skilled tradespeople.

The industry pays some of the highest wages in the country and provides support for education, training and apprenticeships, and contributes tens of millions of dollars annually to fund community social infrastructure. The coal industry also provides indirect employment for around 150,000 Australians, mainly in rural and provincial Australia.[19]

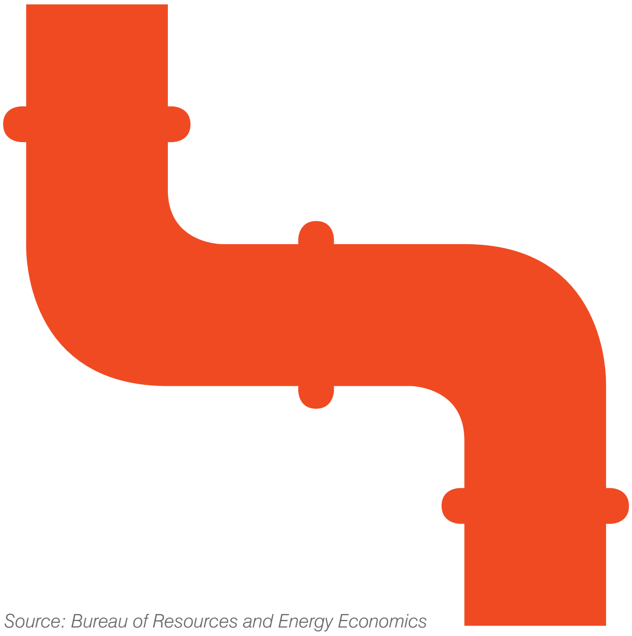
According to Professor Sinclair Davidson, output from the "coal economy" – that is, coal mining and related industries and services – represented 3.1 per cent of gross domestic product (GDP) or around $43 billion in 2011-12, rising by 18.25 per cent since 2006-07 (Chart 5).

The "broader coal economy" – that is, coal economy output plus spending of wages earned in the coal economy – represented 4.2 per cent of GDP or almost $60 billion in 2011-12. This is about the same size as iron ore and agriculture (at the farm gate).[20]

BREE REPORTS THAT THE COAL INVESTMENT PIPELINE CURRENTLY CONSISTS OF 93 PROJECTS WORTH APPROXIMATELY $118 BILLION.

$118b

Approximate value of the 93 projects in the pipeline.



75,000

Employment estimate for 64 of the pipeline projects.

Source: Bureau of Resources and Energy Economics

Investment

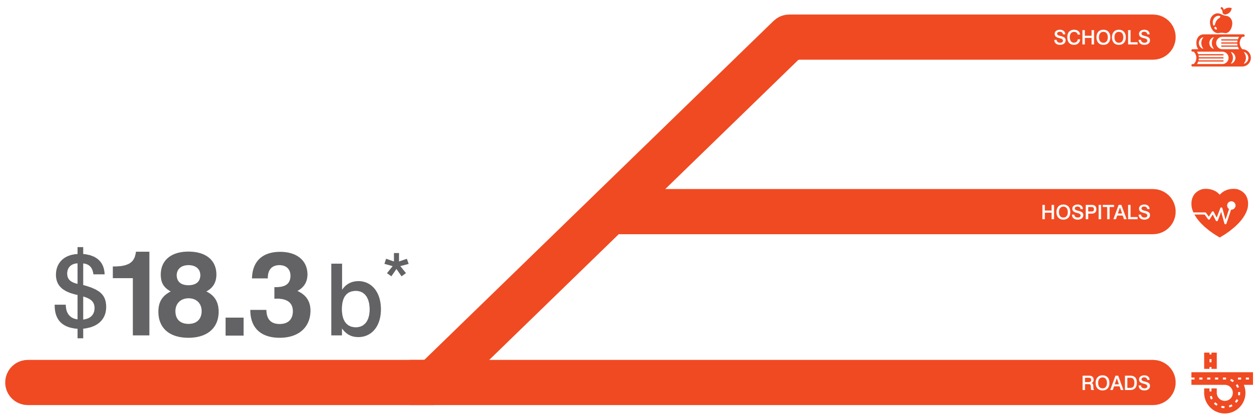
The Bureau of Resources and Energy Economics (BREE) reports that the coal investment pipeline (including both mines and related infrastructure) currently consists of 93 projects worth approximately $118 billion. BREE provides employment estimates for 64 of these projects, which collectively could generate up to 75,000 jobs (42,000 in construction, 33,000 ongoing).[21]

BREE identifies 50 new coal mining projects under feasibility examination with a combined value of $54 billion. There are more coal projects at the feasibility stage than any other commodity.[22]

BREE reveals that in the twelve months to October 2013, there has been a production capacity increase of 13 million tonnes of coal per annum – with a further 60 million tonnes under construction. Queensland is the primary location for proposed coal mine developments, accounting for 37 of the 50 projects at the feasibility stage. By value, almost 90 per cent of all coal projects at the feasibility stage are in Queensland, thanks to large greenfield projects in the Galilee Basin.

In contrast, New South Wales has twelve coal projects at the feasibility stage, chiefly expansions to existing mines. Expansions are generally less expensive than greenfield developments.[23]

COAL ROYALTIES FLOW BACK INTO THE COMMUNITY IN THE FORM OF STATE FUNDING FOR HOSPITALS, SCHOOLS AND ROADS.



* Total expected coal royalties to be paid from Queensland, New South Wales and Victoria over the next four financial years.

Tax and royalty revenue

The Australian coal industry makes a significant contribution to Federal and State governments every year in the form of taxes, royalties and charges, including company tax, payroll tax, fringe benefits tax, land taxes and charges for transport and port services.

Combined coal royalties for Queensland, New South Wales and Victoria are estimated to be $3.0 billion in 2012-13 alone. Over the next four financial years, a further $18.3 billion is expected to be paid.[24] These royalties flow back into the community in the form of state funding for hospitals, schools and roads.

The MCA's third annual tax survey, conducted with Deloitte Access Economics, was released in October 2013. Covering 21 companies, the survey focuses on company tax and royalties paid by the industry to calculate effective tax rates (company tax and royalties as a share of pre-tax taxable income).

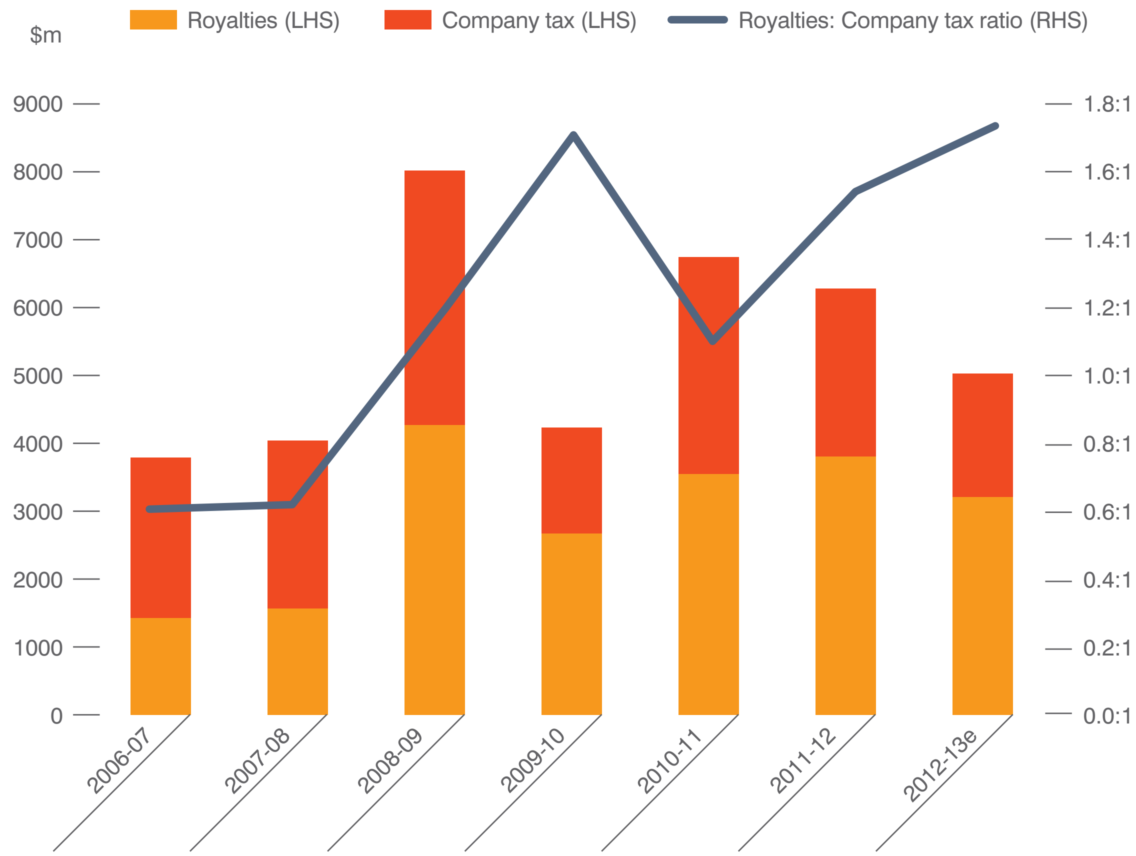
The survey shows that the minerals industry's overall tax rate has remained high and stable, with a rate of 41 per cent in 2011-12. For coal, the 2013 survey found that:

- The effective tax rate on coal was higher than the minerals industry average at 48.9 per cent in 2011-12.
- Coal's tax rate has been increasing over the past five years.
- This higher tax rate is being driven by royalties.

Deloitte Access Economics was also asked to make industry-wide estimates for coal's contribution from company tax and royalties since 2006-07. These

CHART 6 **Coal royalties and company tax (total estimates)**

Source: Deloitte Access Economics



estimates show that the coal industry contributed a total of $38.1 billion from these two instruments since 2006-07, comprising $17.7 billion in company tax and $20.5 billion in royalties (Chart 6).

Between 2006-07 and 2012-13, coal royalty payments rose from $1.4 billion to $3.2 billion at an average annual growth rate of 14 per cent. Royalties have consistently accounted for a larger share of the tax rate on coal compared with other major mineral commodities. Chart 6 shows that royalty rises have contributed to a sharp increase in the ratio of royalties to company tax paid, from around 0.6:1 in 2006-07 to an estimated level of almost 1.8:1 in 2012-13. ■

COAL UNDERPINS AUSTRALIA'S RELIABLE AND HISTORICALLY CHEAP ELECTRICITY SUPPLY

APART FROM BOOSTING NATIONAL INCOME, COAL PROVIDES RELIABLE AND AFFORDABLE ELECTRICITY FOR AUSTRALIAN HOMES AND BUSINESSES.

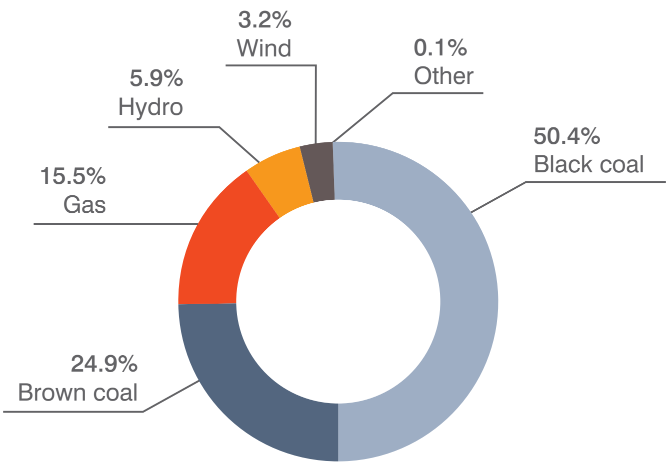
Low cost, reliable energy has been a critical element of the international competitiveness of Australian industry and the living standards of households for several decades.

Black and brown coal (lignite) comprise Australia's principal energy source, providing 34 per cent of its primary energy[25] and 75 per cent of its grid electricity.[26] Black coal fuels half of Australia's grid electricity generation and brown coal fuels one-quarter. Black coal provides 90 per cent of grid electricity in New South Wales and 77 per cent in Queensland, while brown coal generates 93 per cent of electricity in Victoria (Chart 7). ■

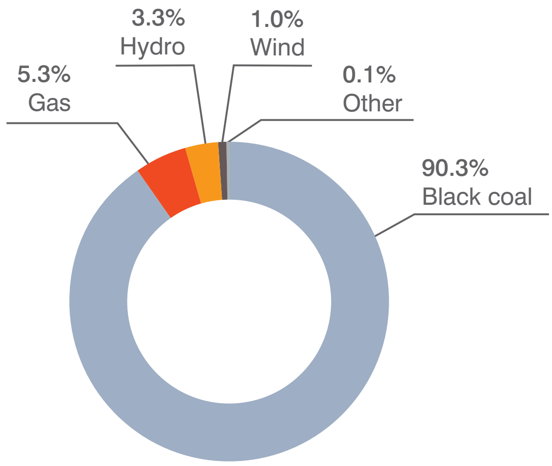
CHART 7 **Percentage share of grid electricity generation by fuel**
Australia and selected states, 2011-2012[27]

Source: Energy Supply Association of Australia, Electricity Gas Australia 2013

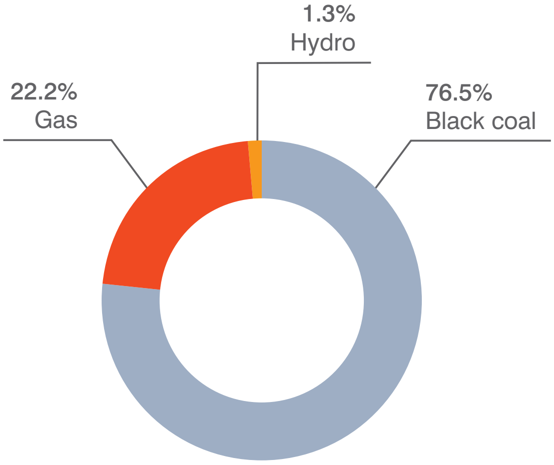
Australia



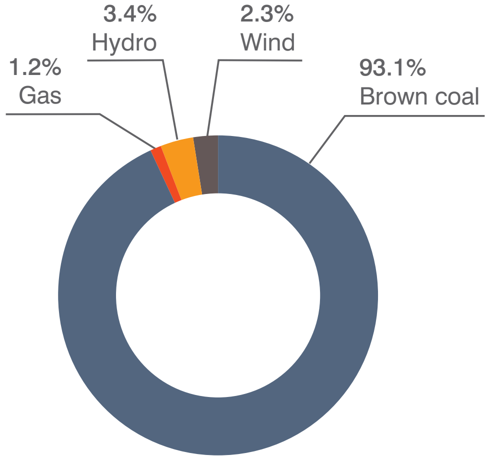
NSW & ACT



Queensland



Victoria



LOW COST, RELIABLE ENERGY HAS BEEN A CRITICAL ELEMENT OF THE INTERNATIONAL COMPETITIVENESS OF AUSTRALIAN INDUSTRY AND THE LIVING STANDARDS OF HOUSEHOLDS FOR SEVERAL DECADES.

Poverty alleviation = electrification + indu

COAL IS ESSENTIAL TO PROVIDING ENERGY ACCESS TO ALL

ACCESS TO ELECTRICITY IS FUNDAMENTAL TO INDUSTRIAL ACTIVITIES AND THE JOBS AND PROSPERITY THEY CREATE.

Electrification also means that fewer people must rely on wood, crop residues and animal waste as their main cooking and heating fuels.

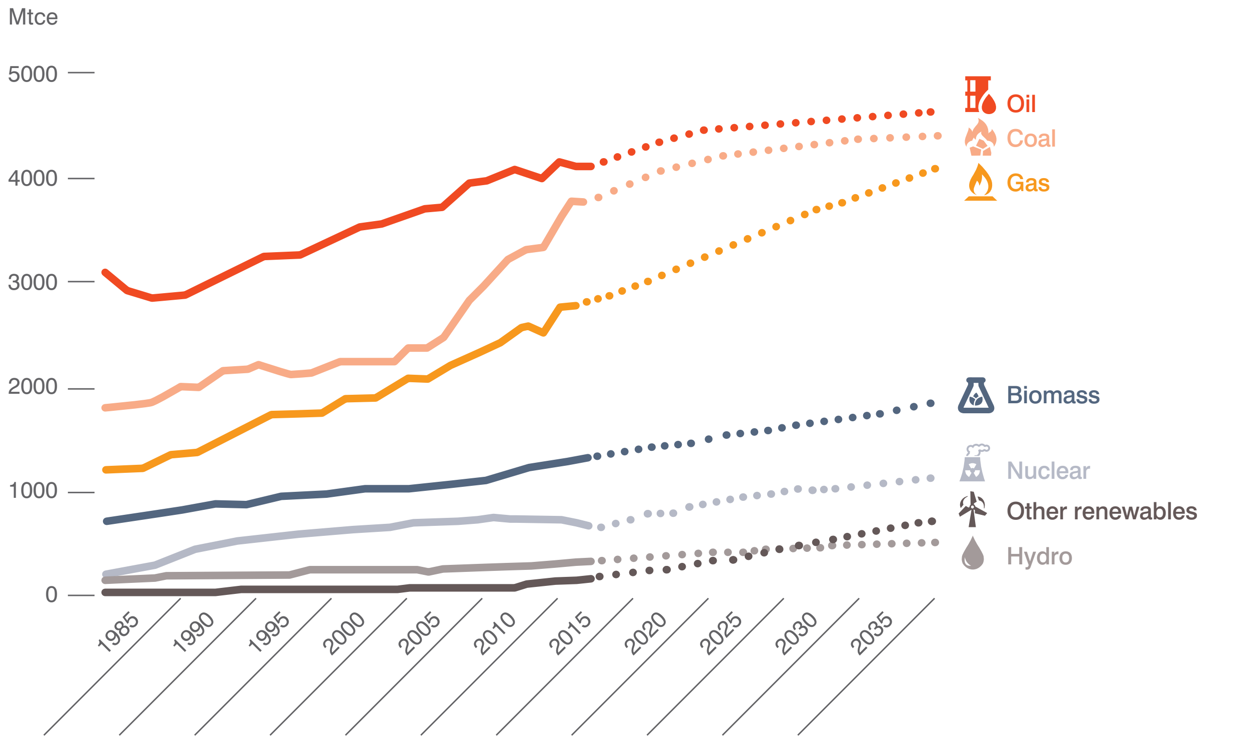
This in turn encourages social and economic development by:

- Increasing life expectancy by reducing exposure to noxious fumes from indoor biomass stoves. Household air pollution from solid fuels contributes to 3.5 million premature deaths per year from respiratory disease – more annual deaths than from HIV/AIDS and malaria combined in sub-Saharan Africa.
- Freeing up hours for farming and education that would otherwise be spent gathering fuel.
- Reallocating crop residues and dung from household use to more productive employment as fertiliser.

strialisation = thermal + metallurgical coal

CHART 8 **World primary energy demand by fuel, 1980 to 2035**
International Energy Agency's core "New Policies Scenario"[32]

Source: International Energy Agency



- Enabling refrigeration and the local storage of vital medicines.[28]

The International Energy Agency (IEA) expects global energy demand to increase by one-third by 2035, with developing economies contributing 90 per cent of this growth. The IEA projects that world coal consumption will rise from around 5,390 million tonnes of coal equivalent (Mtce) in 2011 to 6,325 Mtce in 2035. This growth will be driven by developing economies and centred in electricity generation, with nearly three-quarters of the increase in world coal demand coming from the power sector.[29]

Progressive electrification is narrowing the gap in demand between oil and coal.[30] While the IEA's core "New Policies Scenario" still has oil as the world's largest primary energy source in 2035 (Chart 8), Wood Mackenzie predicts that coal will overtake oil later this decade.[31]

In projecting energy trends to 2035, the IEA concludes that demand for electricity will increase by two-thirds, more than any other form of final energy. Coal continues to be the largest source of electricity generation, growing steadily at around 1.2 per cent per year (Chart 8).[33]

The IEA projects that international trade in coal will rise from 900 Mtce in 2011 to 1,152 Mtce in 2020, before rising at a more modest pace to 1,261 Mtce in 2035. Asia consolidates its position as the centre of gravity of world coal trade.[34] ■

DEVELOPING ECONOMIES WILL DRIVE ROBUST COAL DEMAND FOR DECADES TO COME

ACCORDING TO THE UNITED NATIONS' CORE (MEDIAN-VARIANT) PROJECTION, THE WORLD'S TOTAL POPULATION WILL INCREASE FROM 7.2 BILLION IN MID-2013 TO 9.6 BILLION IN 2050.[35]

The United Nations also projects that the world's urban population will rise from 3.6 billion in 2010 to 6.3 billion in 2050; that is, by almost 70 million people every year.[36]

Developing Asia will continue to converge with the advanced world, with China adding nearly 9 million people a year to urban areas, India over 12 million, and the rest of developing Asia nearly 16 million (Chart 9). This development path is not simply an Asian phenomenon; Africa is projected to urbanise almost 30 million people a year between 2010 and 2050, while Latin America and the Caribbean – a region which is already more urbanised than Europe[37] – will move an additional 5 million people per annum to cities.

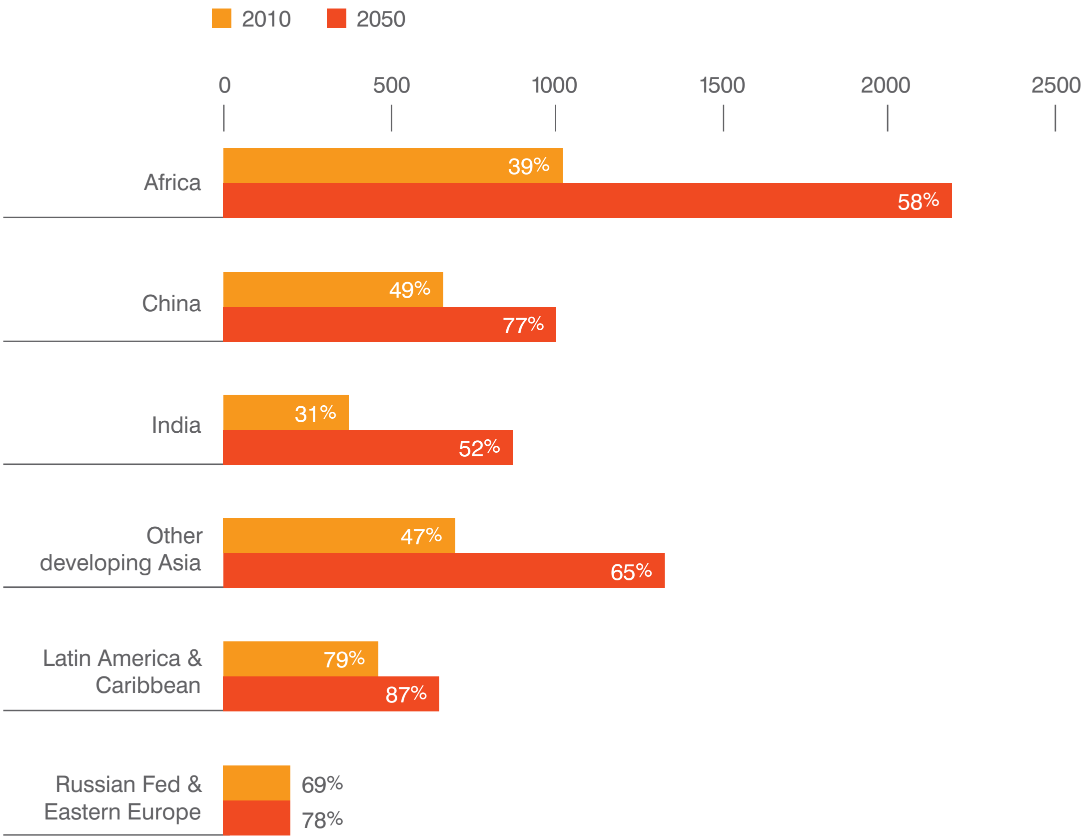
McKinsey Global Institute estimates that annual consumption in emerging markets will rise from just

CHART 9

Urbanisation (millions of people and share of total population)

2010 and 2050 projection, selected regions and countries[38]

Source: United Nations



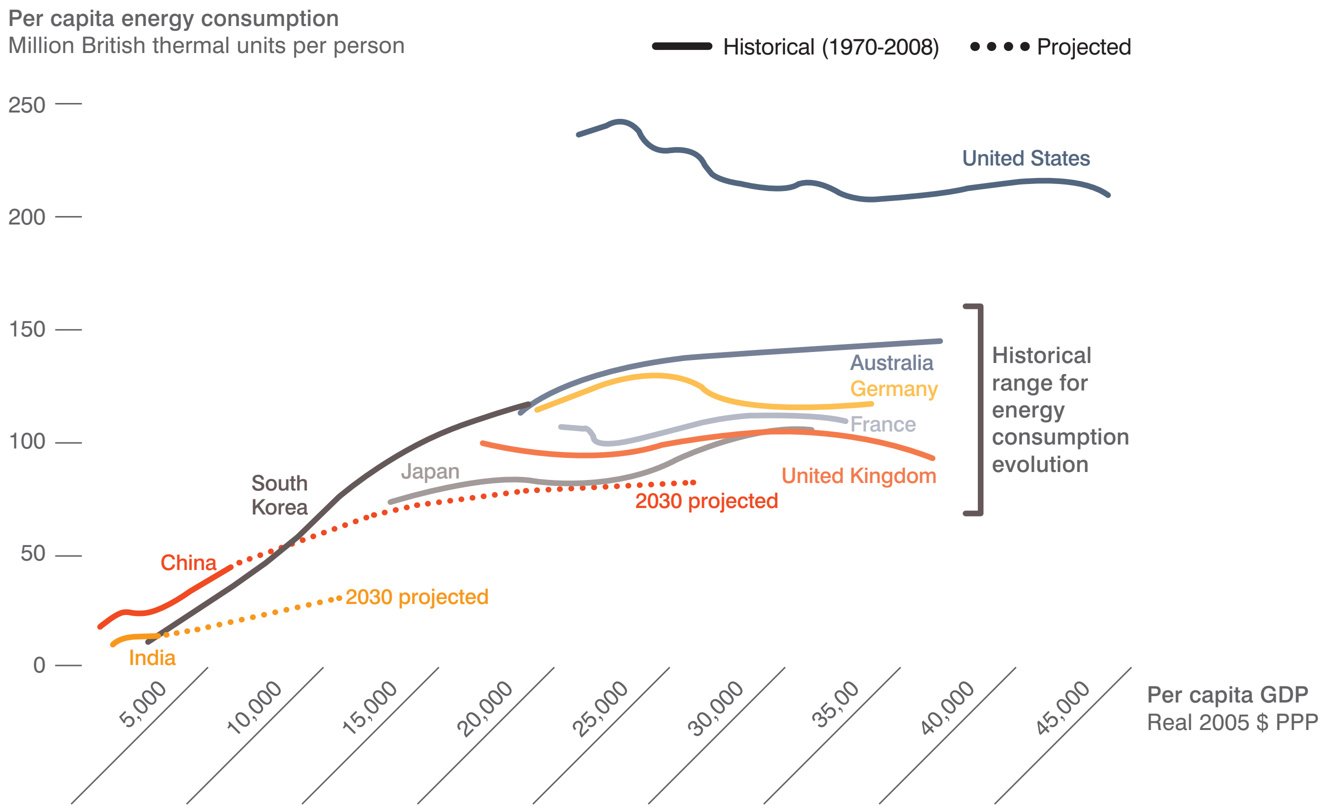
under a third of world consumption to nearly one-half, from US$12 trillion in 2010 to US$30 trillion in 2025. McKinsey also estimates that more than 1.8 billion people will join the world's consuming class in the same period, swelling its number to 4.2 billion. (Members of the consuming class are defined as having a daily disposable income greater than or equal to $10 in purchasing power parity terms.)[39]

Demand from the expanding middle class and associated growth in global urban infrastructure will continue to drive demand for minerals and energy commodities used in the construction of housing, buildings, bridges and subway systems. According to HSBC research, US$11 trillion needs to be spent on urban infrastructure in Asia alone by 2030 as 650 million people are expected to move to cities.[40] McKinsey has predicted that 136 cities will enter the top 600 (in terms of contribution to global output) by 2025 – all from developing countries and 100 just from China.[41]

Demand for commodities continues to grow as countries move from low to upper middle income levels. Based on historical patterns, consumption of energy and metals typically grows together with income until real GDP per capita reaches about $15,000 to $20,000 (purchasing power parity adjusted US dollars) as countries go through a period of industrialisation and infrastructure construction.[42] According to McKinsey, China's energy consumption per capita is currently equivalent to those levels seen in South Korea and Singapore in the late 1980s. McKinsey projects that by 2030, China will reach an energy intensity achieved by those economies in the late 1990s (Chart 10).[43]

CHART 10 **Energy consumption intensities**
Selected economies, historical and projected

Source: International Energy Agency; IHS Global Insight; McKinsey analysis



The IEA affirms that: "China's economic success has been fuelled primarily by coal, which provides over two-thirds of China's primary energy demand. The country now uses nearly twice as much coal as all OECD countries combined."[44] China is not just the world's largest consumer of coal; it is also the world's largest producer and importer of coal (having overtaken Japan as the leading coal importer in 2012). The IEA expects that China's growth in coal demand to 2020 will exceed that of the rest of the world put together.[45]

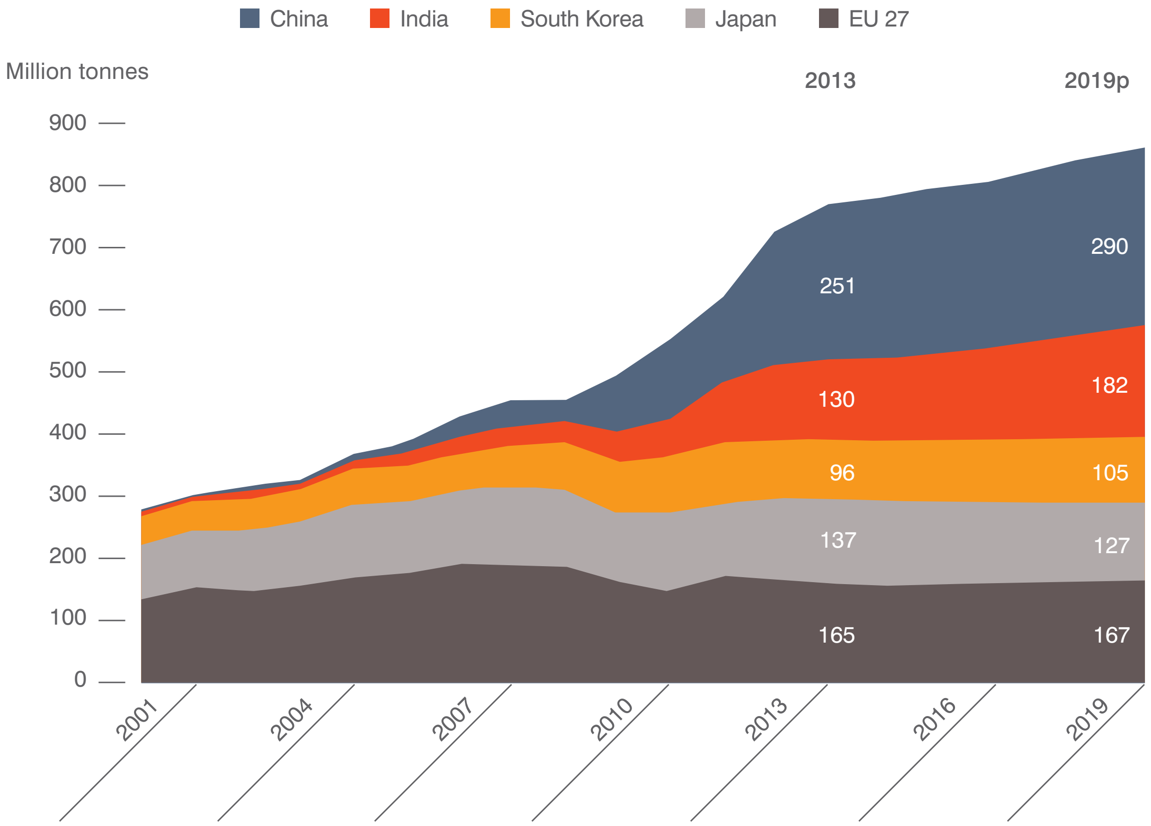
The IEA notes that coal is the "backbone" of China's electricity system, fuelling nearly 80 per cent of national generation. China's rapid and extensive investment in coal-fired power has allowed it to secure electricity access for over 99 per cent of Chinese people, with universal access expected within the next few years. And while China's rate of growth in thermal coal demand will plateau after 2025, coal will continue to dominate China's energy mix to 2035. The depletion of mature mines in northern China, combined with long transport distances, will make some domestic coal relatively expensive, contributing to a slight absolute decline in domestic production after 2030.[46] Therefore, in the IEA's projections to 2035, "China continues to import substantial amounts of coal, remaining a strong force in global coal markets".[47] China's net imports of coal peak before 2020 but stay above or around 2012 levels for the remainder of the outlook.[48]

Like the IEA, Australia's Bureau of Resources and Energy Economics (BREE) projects that China's consumption and importation of thermal coal will decelerate, but not contract. BREE expects China to remain the world's largest coal producer by far over the next five years. Nevertheless, China's imports of thermal coal are projected to increase at an average rate of 2 per cent per year between 2014 and 2019, reaching 290 Mt in 2019 (Chart 11).[49]

BREE points out that while Japan remains the primary destination for Australia's thermal coal exports (82 Mt in 2013), the majority of additional tonnage is going to China (43 Mt in 2013, a 25 per cent increase relative to 2012).[51]

CHART 11 **Major thermal coal importers**
Bureau of Resources and Energy Economics projections[50]

Source: Bureau of Resources and Energy Economics



According to BREE, China was the world's largest consumer of steel in 2013, accounting for around 46 per cent of world consumption. Steel consumption is estimated to have increased by 6 per cent, to total 729 million tonnes for the year. Credit restrictions that have tightened up housing investment and a decrease in investment in railway networks dampened growth in the latter part of 2013. The Chinese government has announced several fiscal spending programs for the period 2014 to 2020. The programs are aimed at expanding urbanisation, including improving the quality of urban housing stock and building more transportation infrastructure, both of which are steel intensive.

Over the remainder of the outlook period, China's steel consumption growth rates are expected to moderate to a projected average annual rate of 1.8 per cent and total 832 million tonnes in 2019. Although these rates of growth are much lower than those seen during the preceding decade, they are starting from a much higher base and still result in robust additional volumes each year.[52]

BREE expects China to have the fastest growth in metallurgical coal imports, with import demand from other countries remaining steady. BREE expects that the bulk of China's additional imports will be sourced from Australia. Over the next five years, BREE projects that import growth will average 2.3 per cent per annum, reaching 113 million tonnes in 2019.[53]

Importantly, while China now looms large in absolute terms as the world's second largest economy, it is still at a relatively early stage of development with a long way to go to catch up with per capita living standards in major advanced economies. The IMF projects China's per person GDP (in PPP terms) to be around $14,600 in 2017, equivalent to around one quarter of the United States.

As with China, India's economic development has a long way to run. With a GDP per capita that is only 3 per cent of the US, India is arguably twenty years behind China in terms of development. Moreover, India has a young population – 60 per cent under the age of 35 – and is forecast to overtake China as the most populous nation by around 2020.[54]

According to the IEA, India has doubled its coal use between 2000 and 2011 and the IEA expects its coal demand to double again by 2035, overtaking the US as the second largest coal consumer soon after 2020. The IEA projects that India's imports will more than triple by 2035, overtaking those of Japan and the EU before 2020, and those of China soon after, to make India the world's largest coal importer.[55]

Similarly, BREE expects India to become more reliant on imports of thermal coal over the next five years, notwithstanding a considerable expansion of its coal-fired generation capacity. This is because additional domestic production is unlikely to keep pace with rising demand. India's thermal coal exports are projected to grow at an average rate of 6 per cent per annum to reach 182 Mt in 2019.[56]

India's electricity consumption per capita is very low: less than 1 MWh, compared to 7 MWh for Germany and nearly 14 MWh for the US.[57] The IEA projects that 147 million Indians will still have no access to electricity in 2030. This suggests that there is considerable future demand growth for electricity and thermal coal.[58]

India's development is also boosting demand for steel and metallurgical coal. BREE projects India's steel consumption to grow at an average annual rate of 5 per cent from 2015 to total 107 Mt in 2019. This increase will be supported by government efforts to increase the coverage and quality of its national infrastructure network. This includes its road networks (including bridges), rail systems and electricity generation and supply network. A gradual increase in consumption of consumer durables in response to rising incomes will also support higher levels of steel consumption. Accordingly, BREE projects that over the next five years, India's imports of metallurgical coal will rise 1.2 per cent per annum on average to reach 40 Mt in 2019.[59] Australia will be a major beneficiary of this growth as it is the key supplier of metallurgical coal to India.[60]

HDR Salva observes that India is a highly service-based economy, unusual for a developing country. This is largely due to Western outsourcing and the growth in IT services. As India industrialises, its services sector

will become a smaller part of the economy, while the agricultural and manufacturing sectors will grow in relative terms. This will result in higher energy intensity per unit of GDP, and higher consumption of coal and other minerals.[61]

The ten economies belonging to the Association of Southeast Asian Nations (ASEAN) are embarking on the same process of coal-fired electrification as China and India. The IEA projects that demand for electricity in ASEAN will double between 2011 and 2035 and that coal use will triple in the same period. Demand for coal in ASEAN is set to grow at 4.8 per cent a year – the fastest growth rate of any major coal consuming region or country – and ASEAN's coal consumption will exceed that of the EU by 2030. The IEA expects Australia and Indonesia to be the biggest beneficiaries of increasing international trade in coal.[62]

Even though developing countries are driving world demand for coal, it remains an essential fuel in developed economies. The USA is the world's second largest consumer of coal and coal accounts for 40 per cent of US electricity generation.[63] Coal is also enjoying a resurgence in Western Europe. Between 2011 and 2012, coal-fired electricity generation increased 65 per cent in Spain, 35 per cent in Great Britain and 8 per cent in Germany.[64]

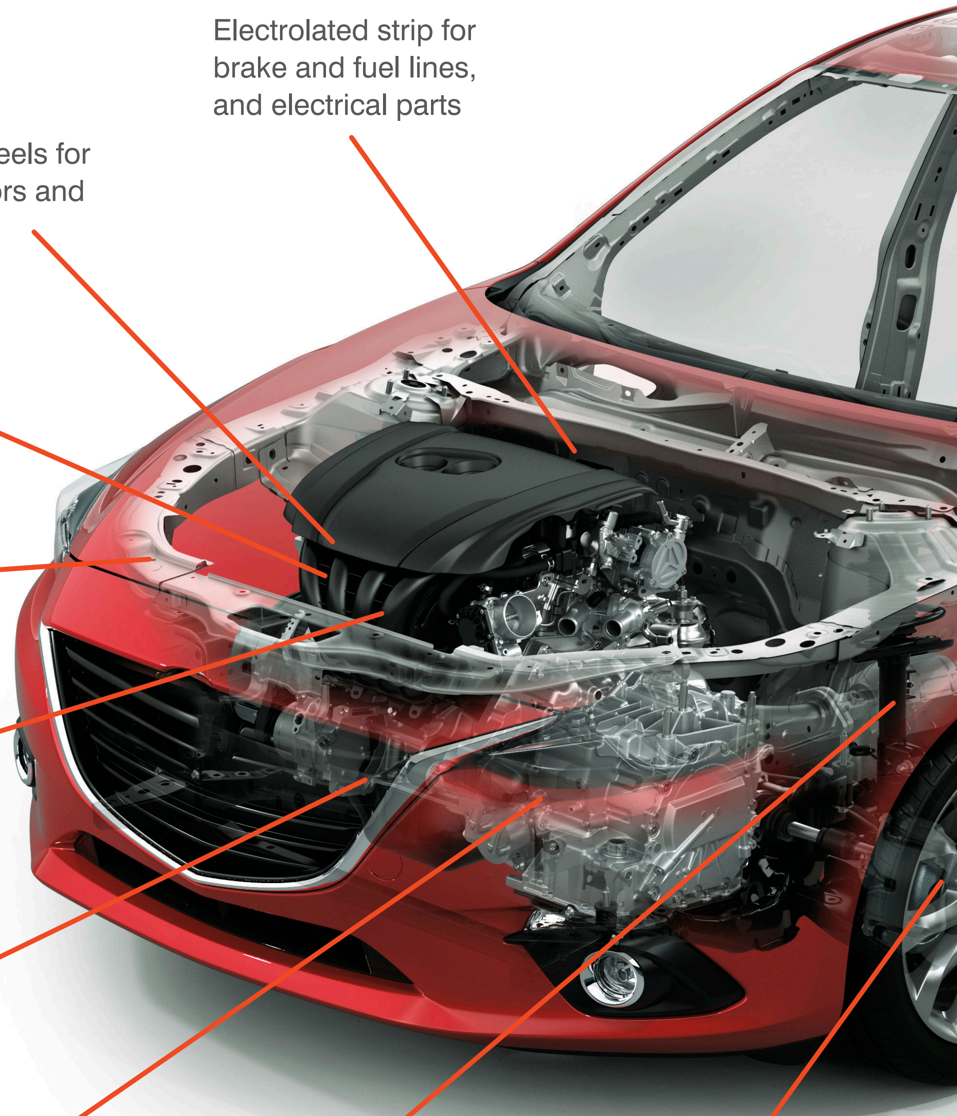
Little wonder that the IEA concludes that: "It is currently difficult to envisage a future in which coal is not used to meet growing power demand – not only in non-OECD regions, but also in many OECD countries."[65]

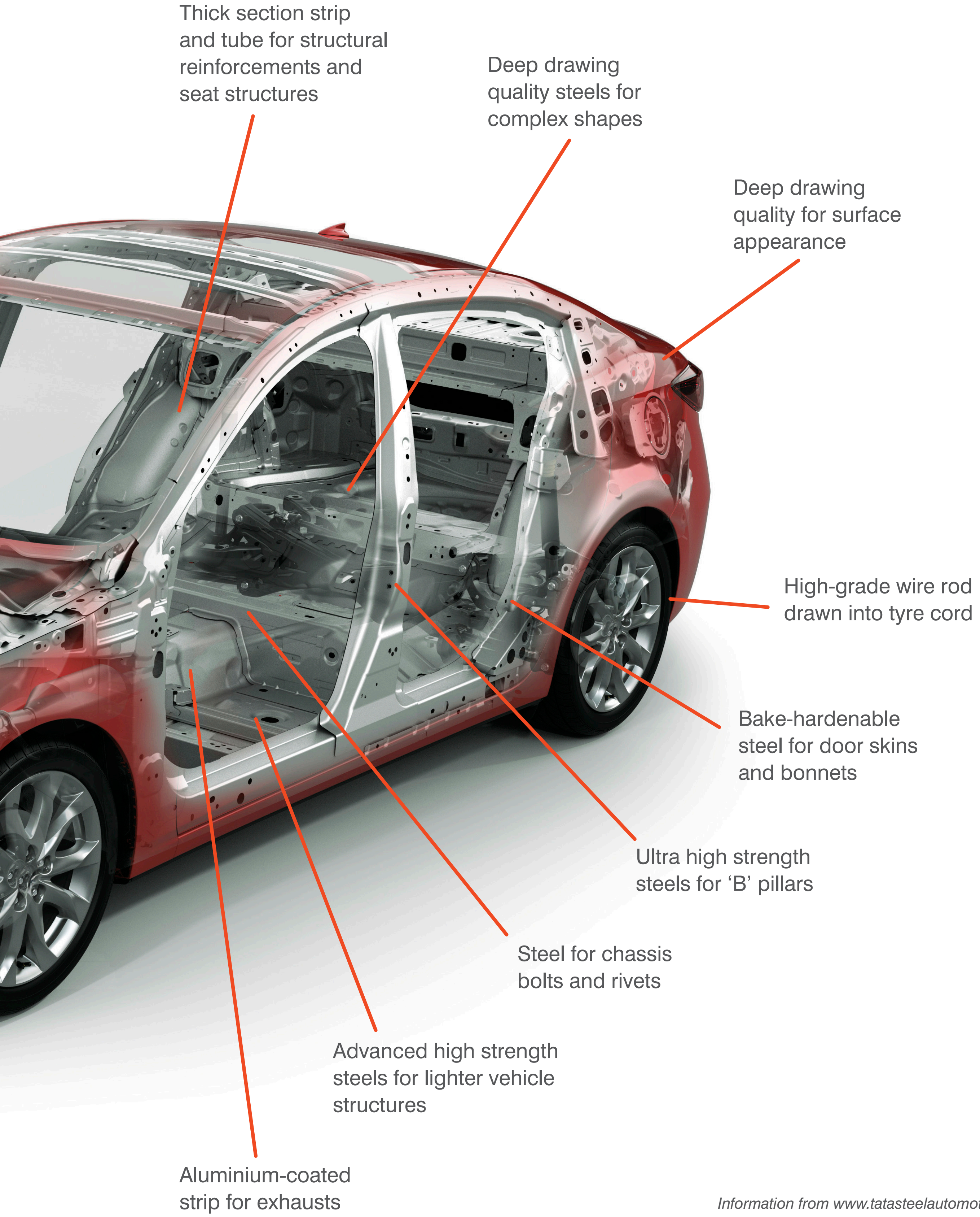
Wood Mackenzie agrees that coal demand will be sustained in developed economies:

> *If you take China and India out of the equation, what is more surprising [than developing countries' preference for coal] is that under current regulations, coal demand in the rest of the world will remain at current levels. Even though natural gas and renewables make up the bulk of incremental power capacity in Europe, the US and other parts of Asia; coal demand will be sustained because of its price competitiveness.*[66] ■

CARS = COAL

New steel is the product of iron ore and coking coal.
Every tonne of steel needs about 800 kilograms of coal.
That means every car on the road is a product of the coal industry.





Information from www.tatasteelautomotive.com

AUSTRALIA DOES NOT HAVE TO CHOOSE BETWEEN COAL AND A LOW EMISSIONS FUTURE

FOSSIL FUELS – COAL, OIL AND NATURAL GAS – WILL BE REQUIRED FOR A LONG TIME YET TO MEET RAPIDLY GROWING WORLD ENERGY DEMAND.

Renewables may have a growing role, but they will continue to account for a relatively modest proportion of the global energy mix for the foreseeable future. In the IEA's core scenario, renewables meet 18 per cent of world energy demand in 2035, while fossil fuels meet 76 per cent. Coal and nuclear power will together account for 31 per cent of world energy consumption in 2035 (Chart 12).

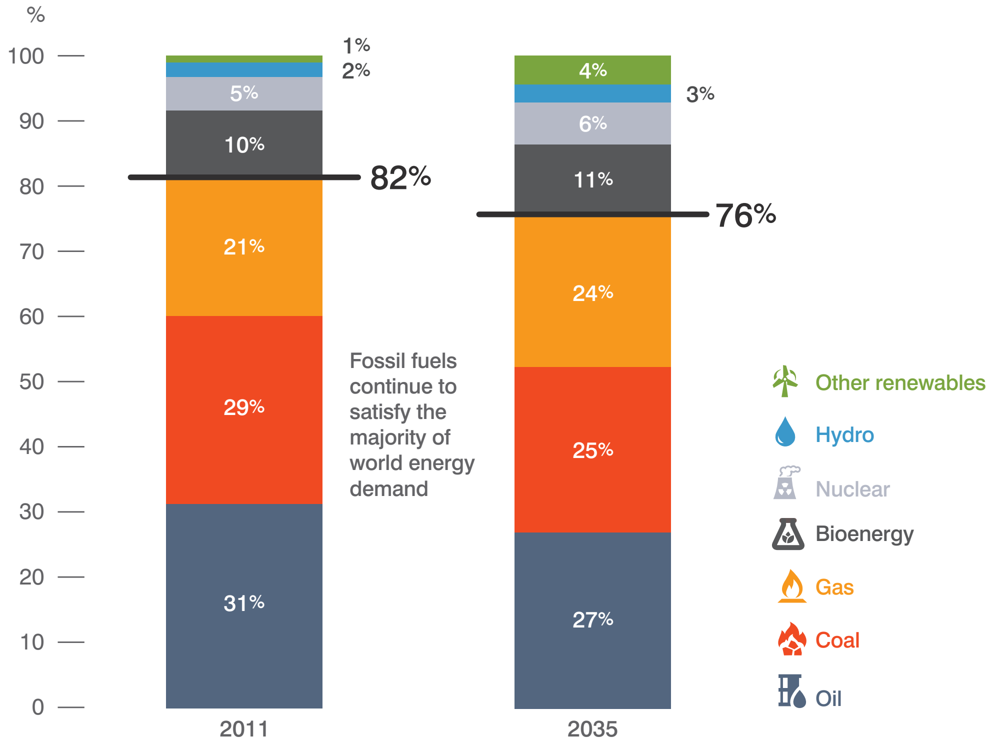
Low emissions coal technologies, including more efficient coal-fired power plants and carbon capture and storage (CCS), will therefore be essential to addressing global growth in emissions, while allowing continued growth and development based on the reliable supply of affordable energy. As the US Secretary of Energy, Dr Ernest Moniz, puts it:

> *[C]oal will be a major part of our energy future for decades … That's why any serious effort to protect future generations from the worst effects of climate change must also include developing, demonstrating and deploying the technologies to use our abundant fossil fuel resources as cleanly as possible.*[68]

Just like the US, coal remains a competitive source of baseload energy in Australia. Black and brown coal comprise Australia's principal energy source, providing

CHART 12 **World primary energy demand by fuel 2011 & 2035**
International Energy Agency's core "New Policies Scenario"[67]

Source: International Energy Agency



Note: Owing to rounding, percentage shares may not sum to the totals indicated.

34 per cent of its primary energy[69] and 75 per cent of its grid electricity. Black coal provides 90 per cent of grid electricity in New South Wales and 77 per cent in Queensland, while brown coal (lignite) generates 93 per cent of electricity in Victoria.[70]

The roadmap to a low emissions coal future is increasingly clear. New technology coal plants, including ultra-supercritical coal plants, are achieving CO_2 emissions reductions of up to 30 per cent compared with the existing fleet. According to the International Energy Agency (IEA), current state-of-the-art technology operating under ultra-supercritical steam conditions can achieve net efficiencies of up to 46 per cent. If the 550 GW of new coal-fired generating capacity added between 2000 and 2011 had been ultra-supercritical, then cumulative greenhouse gas emissions over that period would have been reduced by nearly 2 Gt (8 per cent).[71]

Substantial progress is also being made in the development and deployment of CCS around the world and should remain a central element of Australia's medium term energy vision. CCS offers both a near-zero emissions solution as well as the promise of keeping energy costs competitive.

As the IEA points out:

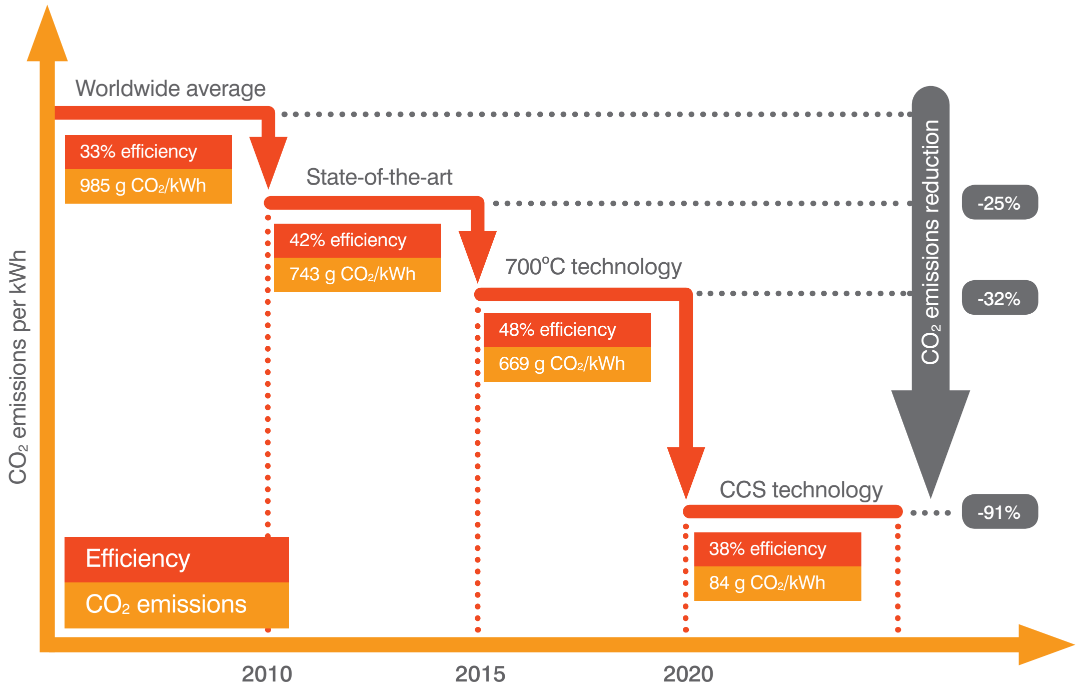
> *To achieve CO_2 intensity factors that are consistent with halving CO_2 emissions by 2050, deployment of CCS is essential. CCS offers the potential to reduce CO_2 emissions to less than 100 g/kWh. … [R]ecent demonstration projects show that CCS is technically viable and, in fact, essential to achieving long-term CO_2 reduction targets.*[72]

Consequently, the IEA advocates a two-step strategic approach to prepare coal generation for a low emissions future:

1. Improving the efficiency of coal-fired power production while minimising emissions where economically and technically feasible.
   - These include supercritical, ultra super critical and integrated gasification combined cycle generation plants.
2. Developing CCS such that it can subsequently be integrated into power plants using fossil-fuels (e.g. gas, coal, lignite, diesel and oil) and other industrial plant (e.g., steel mills, smelting and refining) when the implementation conditions are appropriate.[73]

CHART 13 **Increased thermodynamic efficiency reduces the amount of CO_2 generated per unit of plant output**[74]

Source: International Energy Agency



Note: The figure shows CO_2 reductions at coal-fuelled stream-electric power plants from higher efficiency / CCS technologies (hard coal, 26 GJ/kg HHV, North Sea cooling water).

The High Efficiency, Low Emissions Road Map

Step 1

Improving power plant thermal efficiency while providing meaningful reductions in CO_2 emissions

The average thermal efficiency of coal-fuelled power plants is 33 per cent, which is substantially below the state of the art rate of 42 per cent (Chart 13). This efficiency varies across the major coal-using countries from under 30 per cent to 45 per cent. Such differences arise due to the age of the plant, coal quality and impurity profiles (e.g. ash, sulphur and moisture content and physical and chemical "rank" properties), operating conditions, maintenance practices and application of new and improved technologies.

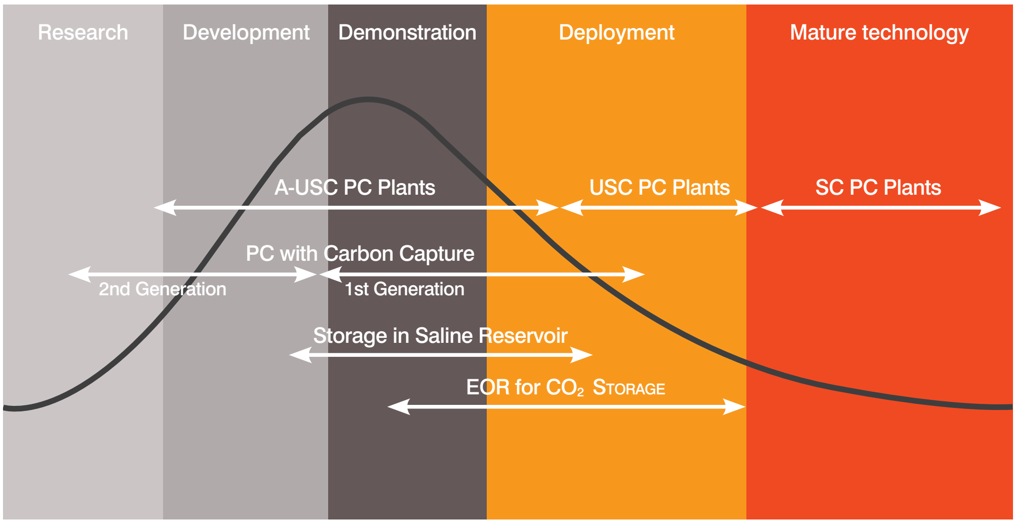
As illustrated in Chart 13, improvements in thermal efficiency following implementation of technology advances reduce CO_2 emissions while improving generation efficiency. This means that substantial CO_2 savings can be made by renovating old plants or replacing them by more efficient ones. In fact, increasing the efficiency of coal-fired power plants by 1 per cent reduces CO_2 emissions by between 2 and 3 per cent.

The IEA estimates that advanced coal technologies, including Supercritical (SC), Ultra-supercritical (USC) and integrated gasification combined cycle (IGCC) plants, could deliver 7 per cent of the necessary CO_2 emissions cuts in the power sector through to 2050. This is just as much as the estimated contribution of solar photovoltaics (PV) and slightly less than the potential contribution of wind turbines. CCS could deliver almost one third of the entire mitigation effort needed in the power sector.[75]

As illustrated by Chart 14, some advanced coal power technologies are relatively mature, but many are still in the development phase. Technologies are particularly vulnerable during this period. For example, first-of-a-kind project cost estimates often increase over time as more information is assembled about the scale-up and application challenges. To maintain momentum during this critical phase it is essential that there is a clear pathway to future cost reduction.

CHART 14 **The importance of early deployment of advanced coal technologies**[76]

Source: International Energy Agency



Left end of arrow indicates current status **Right end** of arrow indicates estimated 2030 development level

List of abbreviations:
A-USC PC is advanced ultra-supercritical pulverised coal; USC PC is ultra-supercritical pulverised coal; SC PC is supercritical pulverised coal; EOR is enhanced oil recovery aimed at boosting oil recovery above an average of about 40 per cent by injecting CO_2.

Step 2

Advancing CCS technologies to commercial scale

In the IEA's core "New Policies Scenario", the average efficiency of coal-fired generation worldwide improves from 36 per cent to 40 per cent between 2011 and 2035, as old plants, based on subcritical technology, are retired and increasingly replaced by supercritical and other higher efficiency technologies. Over half (55 per cent) of total emission savings in the IEA's core scenario come from efficiency improvements across all sectors in the global economy. In particular, efficiency gains in power plants, transmission and distribution, refineries, and oil and gas extraction are responsible for around 7 per cent of emission savings in 2035. CCS remains nascent in this scenario.[77]

The role of CCS becomes more critical under other scenarios for greater emissions reductions such as the IEA's "450 Scenario", which assumes new policy actions consistent with a 50 per cent chance of limiting the long-term average increase in global temperature to 2°C. Here, CCS is projected to account for nearly 60 per cent of total coal-fired electricity generation in 2035. The IEA argues that a 2°C target "puts into sharp focus the need to increase the adoption of technologies such as CCS rapidly and at scale" and estimates that CCS could reduce the cost of decarbonising the power sector by $1 trillion between now and 2035.[78]

The challenge for CCS is not to prove the feasibility of its constituent technologies, but to deploy integrated large-scale projects at a cost that is commercially competitive. While the same commercial challenge faces all low emissions technologies, CCS does have the advantage of being applicable to any large source of CO_2 emissions. CCS can be applied to power generation (from coal, gas, diesel, fuel oil or biomass), production of industrial goods (such as iron and steel, cement and fertiliser), coal-to-liquids processes, oil refining and natural gas processing. CCS also has the advantage of being independent of the weather.

As illustrated in Chart 13, CCS – the only technology capable of achieving the necessary deep cuts – can

China

CHINA IS MAKING CONSIDERABLE EFFORT TO IMPROVE ITS COAL-FIRED POWER PLANT EFFICIENCIES AND LOWER THE ASSOCIATED GREENHOUSE GAS EMISSIONS.

THE CHALLENGE FOR CCS IS NOT TO PROVE THE FEASIBILITY OF ITS CONSTITUENT TECHNOLOGIES, BUT TO DEPLOY INTEGRATED LARGE-SCALE PROJECTS AT A COST THAT IS COMMERCIALLY COMPETITIVE.

reduce CO_2 emissions by 80 to 90 per cent. These technologies will also be required for other fossil fuel generation, including gas, and other industrial plant.

An important relationship between plant efficiency and the need for CCS needs to be emphasised. Compared to a Subcritical plant with an efficiency of 35 per cent, an Ultra-supercritical coal plant of the same size with an efficiency of 45 per cent requires about 25 per cent less CO_2 capture. Consequently, for the same net electrical output, higher-efficiency plants require CCS units with smaller capacity; hence, high efficiency plants have lower operating costs for CCS.

It follows that Step 1 involving deploying high-efficiency, low emissions technologies to increase plant efficiency is important to subsequently reduce the eventual cost of CO_2 abatement in Step 2.

ROADMAP CASE STUDY

Various studies have shown that, under current and planned policies, China's absolute CO_2 emissions will continue to rise although at a decreasing rate. With further introduction of advanced coal technologies, emissions could plateau by about 2030. After that, CCS will be required if emissions are subsequently to decline.[79]

So, alongside its short to medium term strategic approach to establish ever less emissions-intensive coal technologies, China is also developing various CCS systems that can be deployed when the time is deemed appropriate. Thus, according to Andrew Minchener, General Manager of the IEA's Clean Coal Centre:

> *From a technical perspective, China is well positioned to move forward from the industrial pilot-scale trials towards demonstrations of various CO_2 capture and utilisation/storage options, and discussions are underway with various multi-lateral donors.*[80]

The future of CCS will depend on developing technologies that reduce its energy penalty and cost, particularly by testing and gaining operational experience on large-scale, demonstration projects.

Programmes to demonstrate large-scale, integrated CCS on coal-fired power units are being developed in many countries, including China, the US and Canada. Some commercial scale demonstration of CCS is expected in North America in the coming year, and other places by the 2020s with broader deployment from 2030-35 onwards. Australia is well-placed to contribute to, and benefit from, this development.

Australia should play to its strengths in low emissions technologies

The Australian coal industry is committed to playing its part in the global effort to mitigate greenhouse gas emissions. In 2006, the industry established the $1 billion COAL21 Fund as part of a world-first, whole-of-industry funding approach to support greenhouse gas abatement. The COAL21 Fund is based on a voluntary levy on coal production to support the pre-commercial demonstration of low emissions coal technologies, especially carbon capture and storage. Australian Coal Association Low Emissions Technology Ltd (ACALET) is the body established to manage the fund on behalf of Australia's black coal industry.

More than a quarter of the fund has now been committed to demonstration projects. Some ten projects have been either completed or are underway supported by COAL21 funding with further projects being assessed. The fund's commitment to completed and current projects now totals $260 million, with all but one of the projects co-funded by industry partners or by government, including international partners.

The black coal industry has also made it a priority to address fugitive emissions in coal production. Emissions generated from the production of coal are much smaller than those arising from the use of coal. However, they have had a high impact on the industry in recent years because of the design of Australia's carbon tax, which taxes fugitive emissions – unlike any other coal exporting nation in the world.

Turning to brown coal, Victoria is fortunate in having the largest and highest potential CO_2 storage reserve in Australia, in the Gippsland basin. This area is very close to the power stations of the Latrobe Valley. The Victorian and Australian Governments, together with the brown coal industry, are investigating the potential for a shared, large-scale CCS network in the Gippsland region. Currently, extensive research, engineering and commercial studies are being undertaken, including modelling of potential CO_2 storage sites. In February 2012, CarbonNet was selected by the Australian Government as a CCS Flagship project and awarded $100 million in joint Commonwealth and Victorian government funding for feasibility studies, which are under way. ■

JOBS

54,900

Direct employment in the coal industry.

$6b

WAGES

paid every year in the coal industry.

$43b

GDP

Contribution to GDP from coal and related services industry.

90Mt ▲

EXPORT VOLUME

Australia's projected increase in coal export volume between 2013-2019.

CO_2

$260m

INDUSTRY FUND

Total committed to date to the COAL21 fund supporting low emissions technologies.

82Mt

JAPAN

is the primary destination for Australia's thermal coal exports – 82 Mt in 2013.

$20.5b

ROYALTIES

paid by the coal industry
between 2006-07 to 2012-13.

75%

GRID ELECTRICITY

in Australia provided by black and brown coal.

37

PROJECTS

Queensland is the location of 37 of the 50
proposed coal mine developments.

15%

COAL EXPORTS

Coal has accounted, on average, for
more than 15 per cent of Australia's
total exports over the last five years.

$17.7b

COMPANY TAX

paid by the coal industry
between 2006-07 to 2012-13.

COAL

Hard Facts

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COAL
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Minerals Council of Australia

Walter Turnbull Building, Level 3,
44 Sydney Ave, Forrest ACT 2603
PO Box 4497, Kingston ACT 2604
P. + 61 2 6233 0600
F. + 61 2 6233 0699
W. www.minerals.org.au
E. info@minerals.org.au

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Minerals Council of Australia