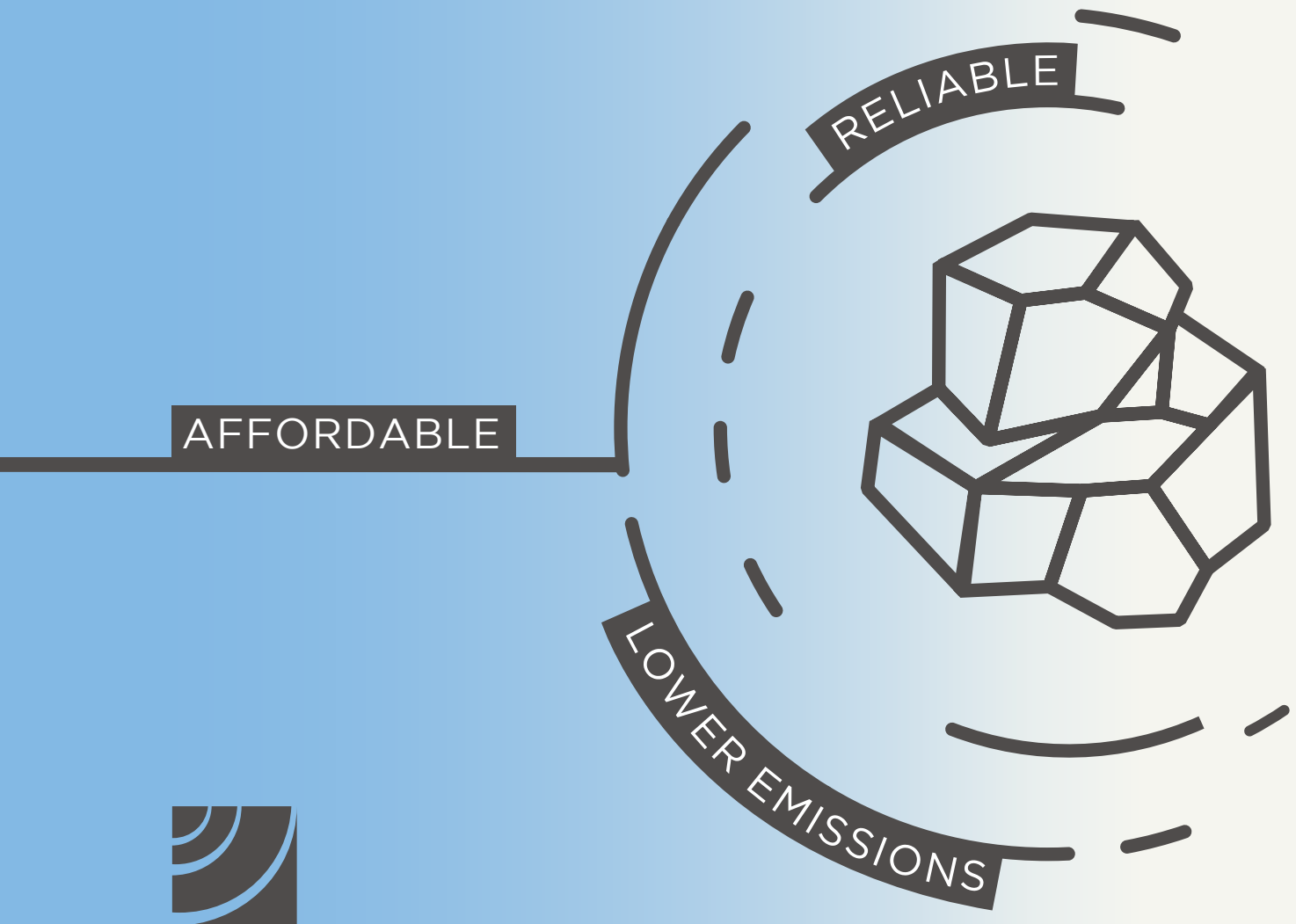
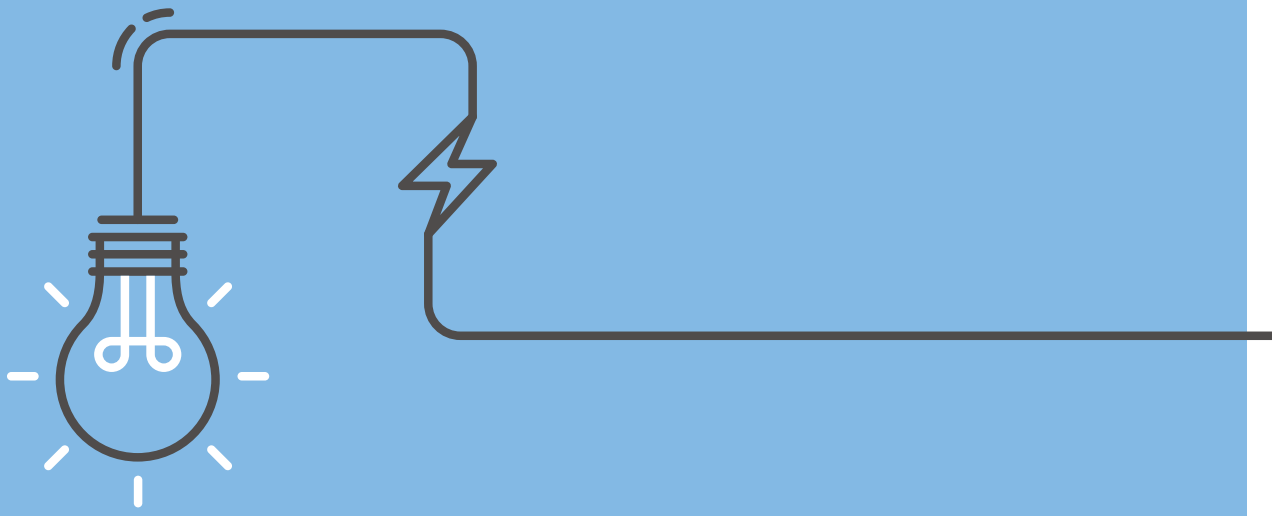
NEW GENERATION COAL TECHNOLOGY

Why HELE coal-fired power generation is part of Australia's energy solution



Minerals Council of Australia

HELE = high efficiency, low emissions coal-fired power generation technology



WHAT'S AT STAKE

The competitiveness, reliability and stability of Australia's electricity system is diminishing. The nation had the cheapest electricity at the beginning of the century; now it is among the most expensive.

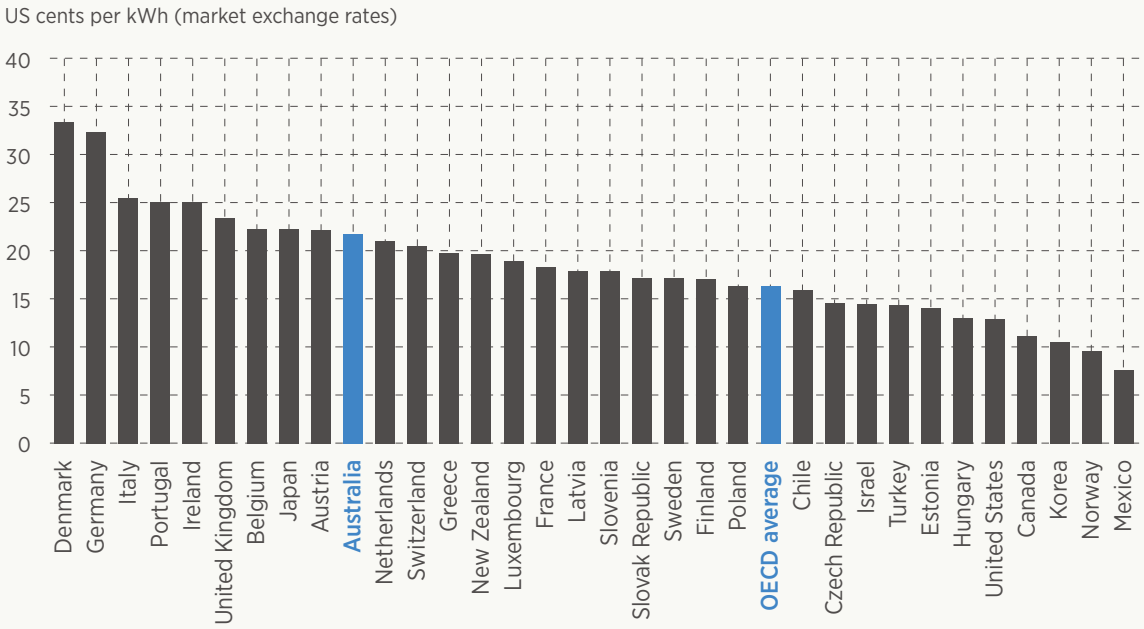
System security is more fragile. Blackouts costing hundreds of millions of dollars are now a real occurrence and regulators warn that there is a greater risk of instability.[1]

In the effort to continue to improve environmental performance, the fundamentals of the electricity system have been forgotten or ignored. New intermittent technologies are being forced on to the system regardless of the technical and economic consequences.

Meanwhile, there is a transformation across the world and particularly in Asia, aided by the work of Australian engineers and scientists, to provide a pragmatic path that meets energy needs and lowers emissions through better use of coal.

That transformation is being driven by HELE – high efficiency, low emissions coal technology. Reducing greenhouse gas emissions is important for meeting the nation's climate goals – and HELE is part of the solution because it reduces emissions while providing affordable and reliable energy supplies.

OECD residential electricity prices



Source: Australian Government, *Preliminary report of the independent review into the future security of the national electricity market*, Dec 2016

THE HELE SOLUTION TO CO_2 EMISSIONS REDUCTION

HELE coal-fired power plants produce more electricity using less coal by harnessing new generation technology and materials.

What are HELE technologies

HELE plants operate at higher temperatures and air pressure to more rapidly convert water to steam. This significantly improves the efficiency of boilers and turbines, which saves fuel and reduces CO_2 emissions by up to 50 per cent. The rapid conversion of water to steam determines the efficiency rating of these technologies, as shown below.

Supercritical and ultra-supercritical plants have already reduced global output of CO_2 emissions by over 1 billion tonnes since 2000.[2] For every one per cent efficiency improvement made to an existing coal-fired power plant, a 2.5 per cent reduction in CO_2 emissions is achievable.[3] The next wave of advanced ultra-supercritical plants are on their way with greater emissions reduction potential.

HELE plants also can be designed to ramp up and down to meet electricity demand, bolstering the security of the energy network.[4]

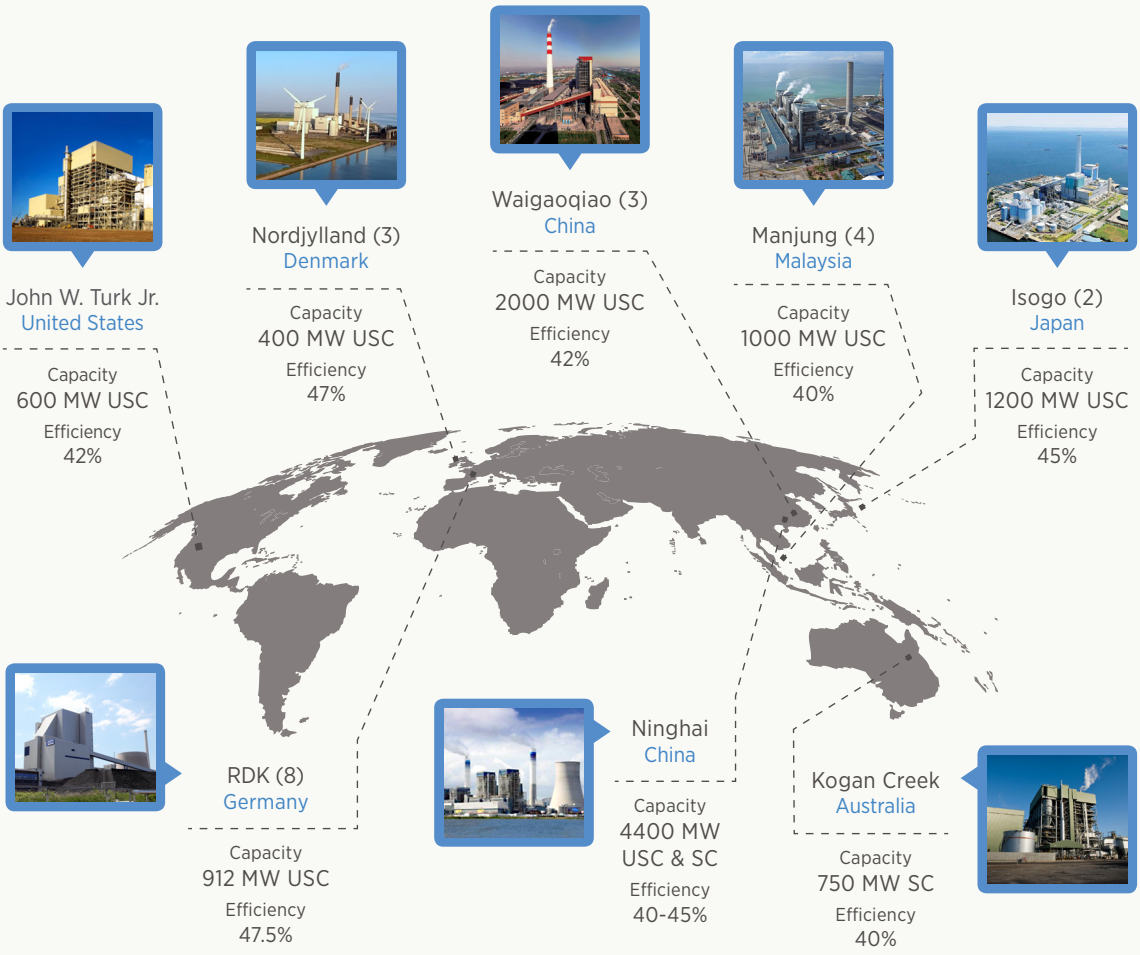
HELE technologies and efficiency improvements

	Efficiency rate+	CO_2 intensity	Coal consumption	Steam temperature
Advanced ultra-supercritical	45–50%	670-740g CO_2/kWh	230-320g/kWh	700°C+
Ultra-supercritical	Up to 45%	740-800g CO_2/kWh	320-340g/kWh	600°C+
Supercritical	Up to 42%	800-880g CO_2/kWh	340-380g/kWh	Approx. 550°C-600°C
Subcritical	Up to 38%	≥880g CO_2/kWh	>380g/kWh	≤550°C

+ Lower heating value

Source: Adapted from IEA, *Technology roadmap: High-efficiency, low-emissions coal-fired power generation*, 2012

Some of the hundreds of HELE plants operating around the world



HELE around the world

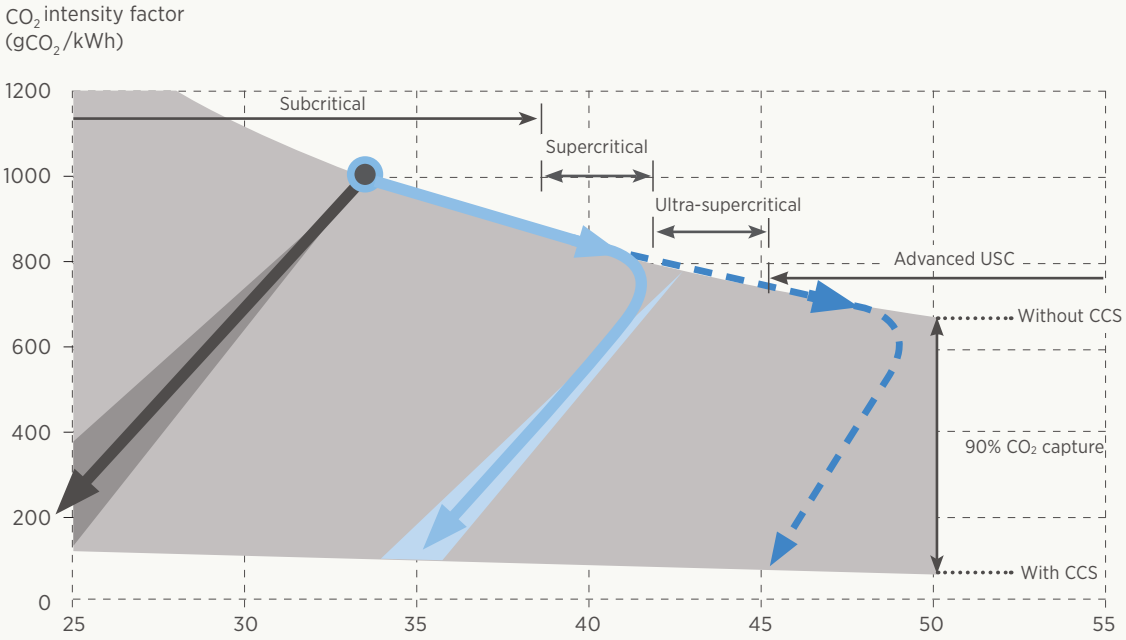
HELE plants operate throughout the world, including in Germany, Italy, India, South Korea, Japan, Poland, Indonesia, the Czech Republic, the Netherlands, Slovenia, the United States, South Africa and China. It is not a new technology – Japan began adopting supercritical technologies in the 1980s and built its first ultra-supercritical plant in 1993.[5]

Improving the global average efficiency rate from 33 per cent to 40 per cent with HELE technology would reduce CO_2 emissions by 2 billion tonnes a year – that's the equivalent of India's annual emissions.[6]

Ultra-supercritical plants in China, Denmark, Germany and Japan are already achieving efficiencies of up to 47.8 per cent, with further improvements anticipated.[7]

The number of supercritical and ultra-supercritical units is 1015, with a further 1231 planned or under construction.[8] New generation coal technologies are now central to many nations' efforts to meet emissions reduction targets while maintaining affordable and reliable energy supply.

HELE and CCS power generation efficiencies



Note: The quantity of CO_2 that has to be captured per unit of electricity generated decreases markedly as the efficiency of the plant increases.

Source: IEA Clean Coal Centre

HELE and carbon capture and storage

The next step towards a near zero emissions coal future is the integration of HELE technology with carbon capture and storage (CCS).

An established technology in many parts of the world, CCS captures CO_2 from power stations or other industrial facilities and stores it in deep underground reservoirs. Emissions savings from combined HELE and CCS deployment increase to 90 per cent.[9]

HELE technology is integral to the further adoption of CCS because these plants reduce the volume of CO_2 to be captured, transported and stored.

New plant is increasingly being built CCS ready. CCS is recognised by the United Nations, International Energy Agency (IEA) and many countries as a crucial technology for both energy security and emission reduction over this century.[10]

ASIA'S EMBRACE OF HELE TECHNOLOGY

A transformation is underway in coal-fired power generation in Asia, with high performance coal fleets making significant gains in operating efficiency and reducing emissions.

Morgan Stanley research shows 88 per cent of new coal-fired power generation built over the next five years will be in Asia, and 69 per cent will be supercritical or ultra-supercritical. [11]

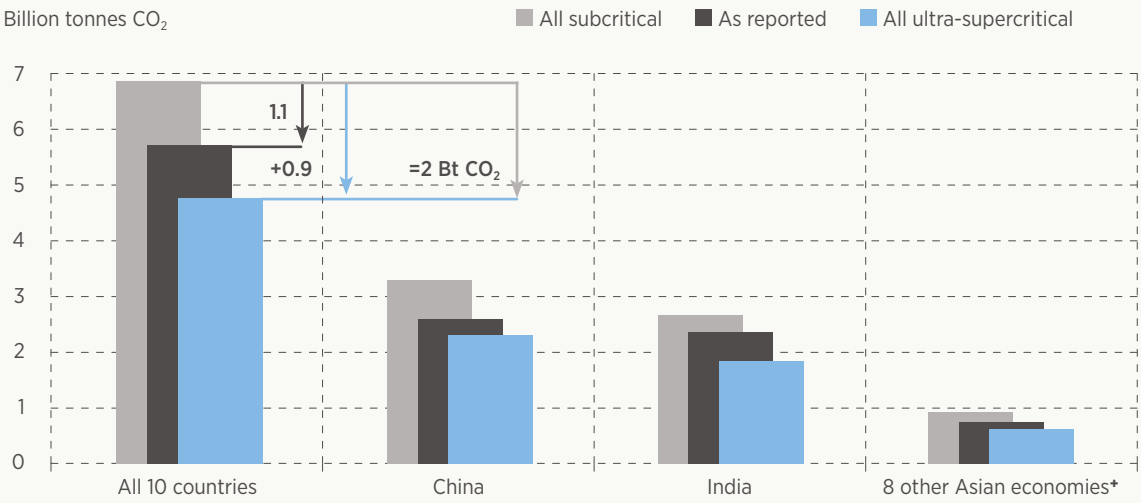
Japan and China are leading the way with high performance fleets with HELE plants achieving average efficiencies of 41.6 and 38.6 per cent respectively. They are rapidly being followed by India and South-East Asia.[12]

The IEA estimates the top 10 Asian countries could save up to 2 billion tonnes of CO_2 a year by converting all new build coal-fired generators to ultra-supercritical, and at least 1 billion tonnes on the current planned technology mix.

The Asian momentum for HELE generation is driving demand for Australia's high quality coal – the preferred fuel for achieving the greatest efficiencies from HELE plants.

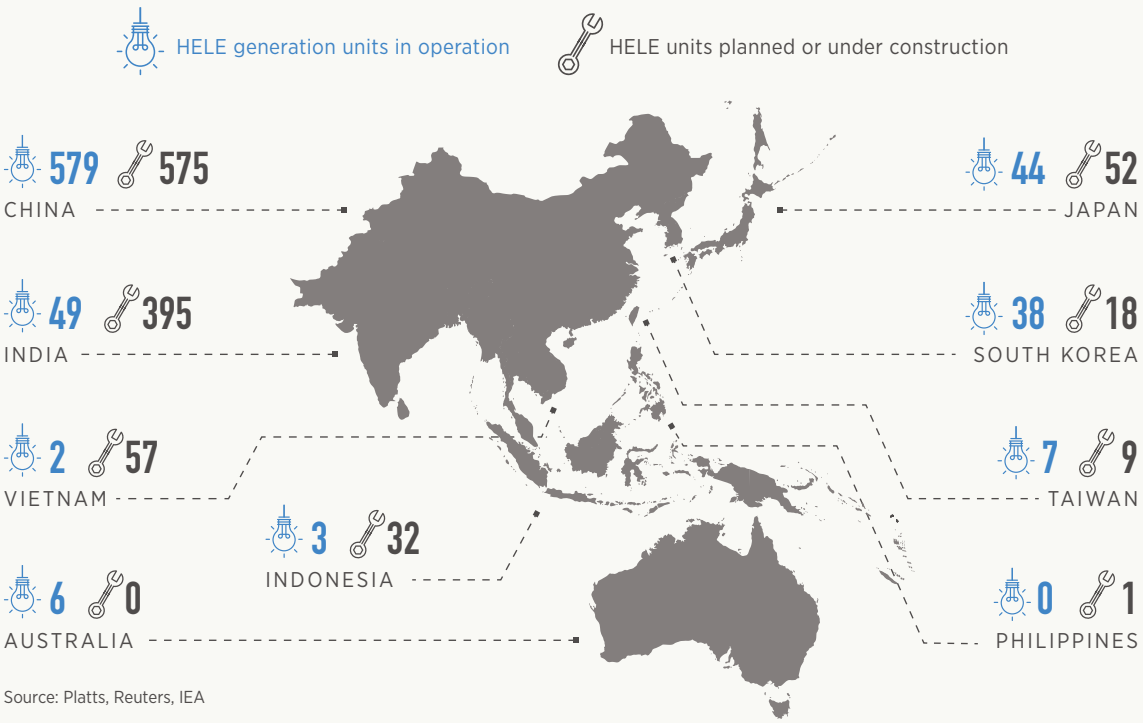
According to the IEA's *World Energy Outlook 2016*, coal will generate more electricity in 2040 than all new renewable technologies (excluding hydro) combined. HELE is making reliable, affordable energy accessible to Asian nations, and cutting CO_2 emissions.[13]

CO_2 emissions reduction in Asia with the adoption of HELE



Source: Based on IEA Clean Coal Centre, 2015, Table 13, 15 and 16. *The other eight Asian economies are Japan, Korea, Taiwan, Vietnam, the Phillipines, Bangladesh, Thailand and Malaysia

HELE power generation across Asia, including Australia



Source: Platts, Reuters, IEA

China

Over the past 15 years China has focused on reducing CO_2 emissions and other pollutants such as nitrogen oxides (NOx), sulphur dioxide (SO_2) and particulate matter (PM) from its power generation. It has achieved this through the largest deployment of HELE technologies in the world, including new capacity to replace an ageing fleet and refurbishment of some its younger plants. The investment has paid off.

From 2015, the use of HELE in China is forecast to reduce annual CO_2 emissions by 434 Mt. HELE technology also makes up 86 per cent of new coal-fired capacity planned or under construction in China. It is estimated this additional investment will produce a further 687 Mt abatement annually.[14] China is now at the forefront of developing and deploying HELE technologies.

> *Over the next five years, 88 per cent of new coal-fired power generation built will be in Asia, and 69 per cent will be supercritical or ultra-supercritical design.*
>
> *The cost per tonne of carbon emission reduction via these plants is US$10/t, making them a highly effective transition technology; something that stands in contrast to views often encountered.*
>
> **Morgan Stanley**
> June 2016

Japan

Japan built the world's first ultra-supercritical unit in 1993 and remains a global leader in HELE technologies, boasting the highest average efficiency fleet in the world. Its Isogo power plant is ranked the cleanest black coal power plant in the world in terms of emissions intensity. Its non-greenhouse gas emission levels (NOx, SO_2 and PM) are comparable to those of a natural gas-fired combined cycle plant.[15]

As a leading advocate of the global adoption of HELE coal technologies in place of subcritical technologies, Japan disseminates its technologies throughout the region and provides financial support in developing countries to promote energy access and secure supply. Japan is also designing the emerging advanced ultra-supercritical plants that will be exported across the region.

> *Japan plans to build more coal-fired power plants, using the most efficient clean coal technologies. The Japanese Government also advocates HELE technologies around the world, indicating it will 'make utmost efforts to maintain the international circumstances for continuing utilisation of coal, while contributing to the reduction of the global greenhouse gas emissions.*
>
> **Dr Malgorzata Wiatros-Motyka**
> IEA Clean Coal Centre
> December 2016

South-East Asia

Coal will play a rapidly expanding role in the fuel mix in South-East Asia to 2040, according to the IEA. South-East Asia's population is projected to grow more than 20 per cent to 760 million over this period, with electricity demand to grow almost 4 per cent a year. Coal power will increase threefold to 1000 TWh and steel, aluminium and paper production will triple. Household demand will also increase.[16]

As the world's fastest growing coal consumer, South-East Asia is showing a real commitment to reducing carbon emissions through HELE technology. The Philippines, for example, a nation with a GDP one-fifth the size of Australia, is building its first ultra-supercritical plant, the 500 MW San Buenaventura Power Plant, 100 kilometres east of Manila. It will start commercial operation in June 2019.[17]

> *On current national power plans, South-East Asia's coal capacity will increase by 140 per cent in the period to 2025... In Vietnam, all 13 GW of new plants will use HELE technologies, reducing CO_2 emissions by 30 per cent. Malaysia commissioned two HELE new plants in the last year and several more are planned. Thailand commissioned its first HELE plant in 2012 and 7.4 GW of new capacity is planned.*
>
> **Sylvie Cornot-Gandolfe**
> Oxford Institute for Energy Studies
> December 2016

HELE COAL IS PART OF AUSTRALIA'S ENERGY SOLUTION

Australian energy costs have risen markedly. This hits households' cost of living and the competitiveness of Australian business.

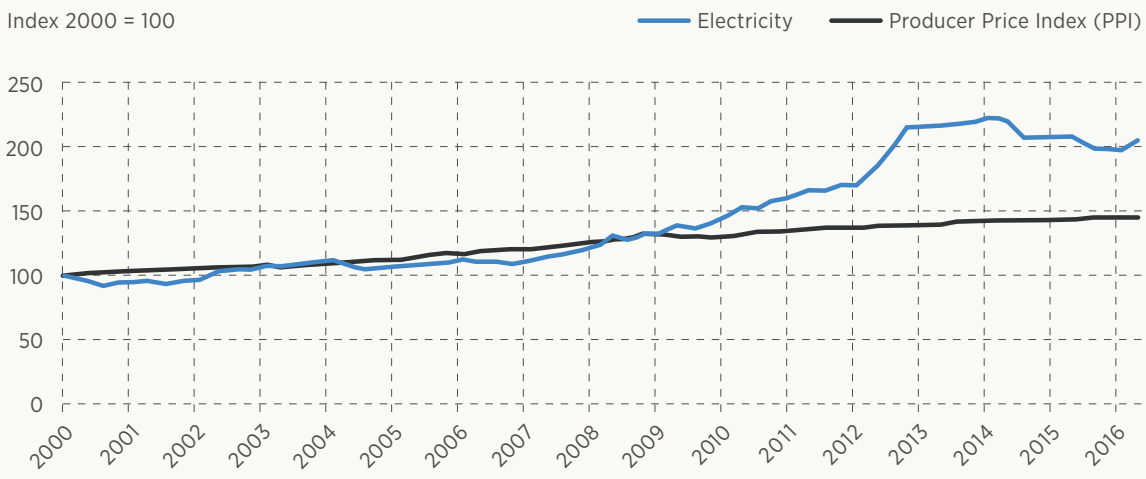
HELE: The affordable energy solution

Australian business users have seen energy costs rise 60 per cent in the past seven years. Wholesale price volatility, a product of the high proportion of intermittent sources, translates into higher retail and contract prices.

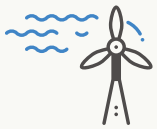
Under the modified Renewable Energy Target (RET), the estimated cost of building new wind turbines and solar installations is around $22 billion in direct costs to 2030, met by around $24 billion in government mandated payments to renewable energy generators.[18] In aggregate, the RET cost consumers almost $3 billion in 2015-16 alone.[19] This money ultimately has to be paid by consumers but is not always transparent. Australia's competitors do not face the same policy-induced distortions in their energy markets.[20]

The system is being further undermined by a lack of renewable energy projects needed to meet the RET. Bloomberg New Energy Finance calculates Australia will need $2.5 billion of new investment in large scale renewables every year from now until 2020 to meet the 33,000 GWh RET. The investment shortfall means some retailers are opting to pay unproductive penalties instead.[21]

Energy costs for Australian business users

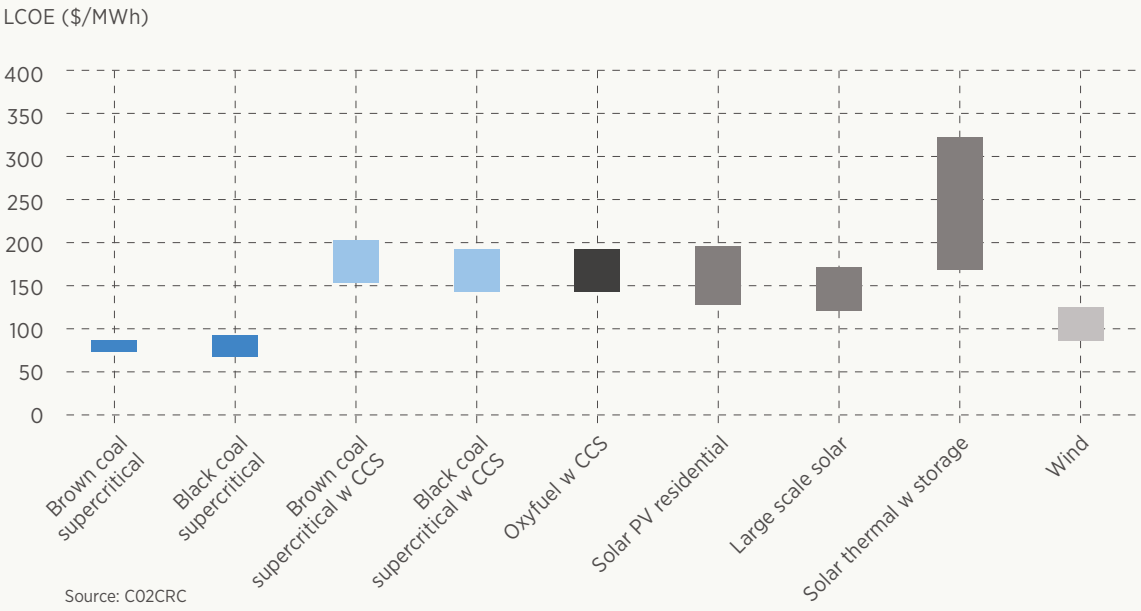


Source: Australian Bureau of Statistics, Cat. no. 6401.0



The cost of building a 1 GW ultra-supercritical power station today is equivalent to the annual subsidy received by the intermittent renewable energy sector in 2015-16.

Build and operate cost estimate, 2015



Source: C02CRC

Coal is competitive

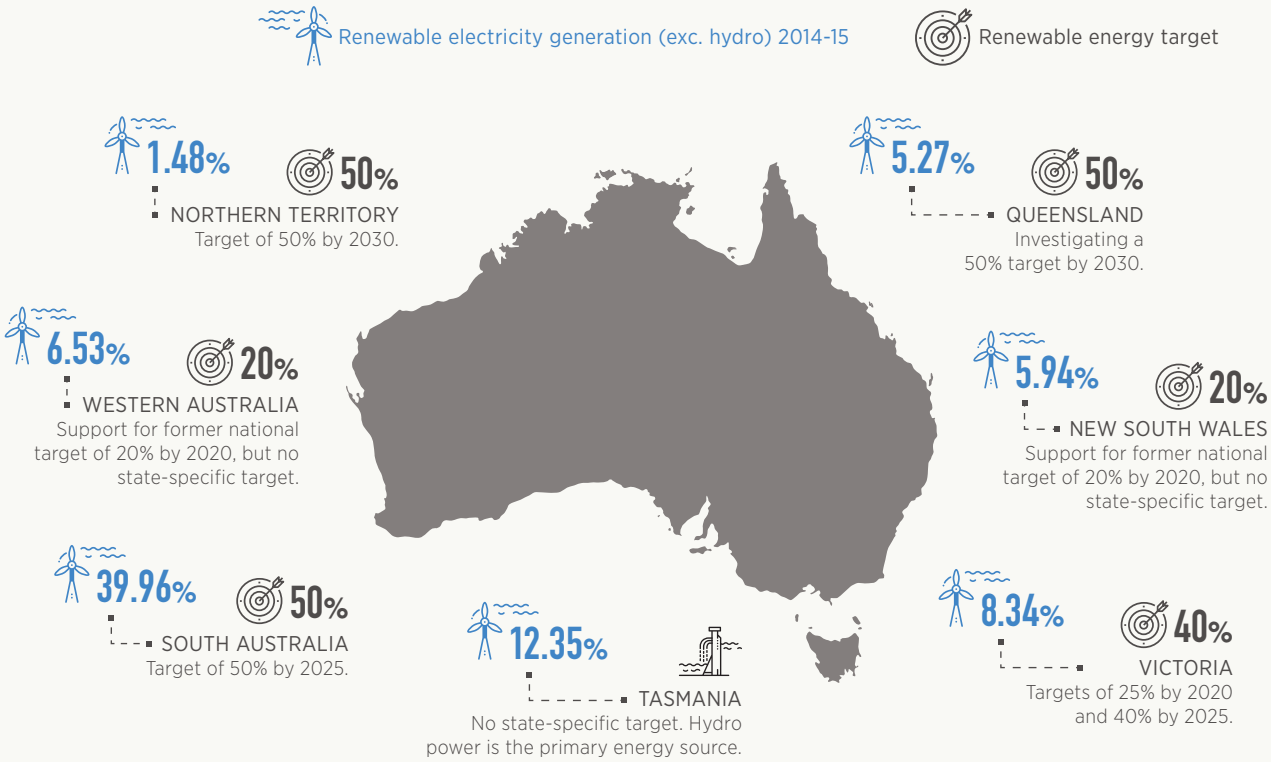
Coal and gas technologies remain the lowest cost to build and operate, with the levelised cost of electricity output (LCOE) of a black coal supercritical plant $67-91/MWh; a gas combined cycle $64-91/MWh, and brown coal supercritical $75-88/MWh. For low emissions technologies, wind costs from $85-121/MWh while solar photovoltaic is $118-172/MWh.[22]

Coal with CCS costs are expected to fall rapidly as experience accumulates and knowledge is shared from the use of the technologies in plants such as Boundary Dam in Canada and Petra Nova in Texas.[23]

Available 24/7, HELE coal generation will keep system-wide costs down by lessening the risk of wholesale price volatility which drives higher retail and contract prices.

The cost of building a 1 GW ultra-supercritical power station today is equivalent to the **annual** subsidy received by the intermittent renewable energy sector in 2015-16.[24]

Renewable energy generation and targets across Australia



Source: Office of the Chief Economist; Norton Rose Fulbright, *Australia's climate policy: The emerging patchwork*, January 2017

HELE: The reliable energy solution

Reliability and security have been undermined by the higher proportion of intermittent technologies in the system. Mandatory quotas for intermittent technologies are forcing out other generation sources that are needed to keep the grid stable and reliable; in addition, renewables are receiving high subsidies – an estimated $3 billion from consumers in 2015-16 alone.[25]

Studies show the cost of integrating this intermittent power – balancing demand and supply, and additional grid and transmission costs – increases rapidly as the proportion of this form of generation increases.[26]

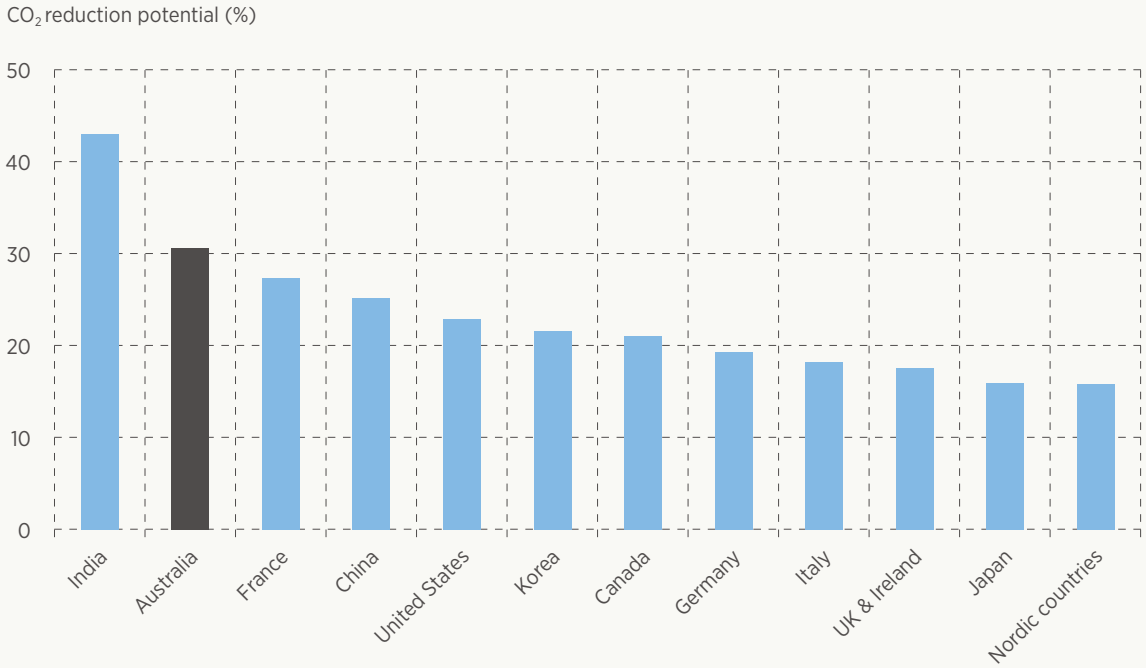
Loss of electricity supply in South Australia and Victoria late last year underscored the importance of reliable power supply.

Overdependence on wind in South Australia left the industrial sector in the north of the state without power for almost two weeks.

This matters to all users but for the industrial sector, which makes up 50 per cent of all demand and where constant and high volume power is essential to ongoing operations, the implications are significant. In Victoria, the unexpected loss of power in Portland almost crippled the local aluminium refinery.

It matters to households too. A snapshot of the east coast National Electricity Market (NEM) at 8.30am on any working day will show that it is coal that provides the electricity the nation needs – around 90 per cent. Intermittent generation cannot be relied upon to deliver power when Australians most need it.

Potential CO_2 reduction from replacing or upgrading plants with HELE technology



Source: Ecofys, *International comparison of fossil power efficiency and CO_2 intensity*, 2014

HELE: The lower emissions solution

Coal remains Australia's primary source of dependable, low-cost electricity, accounting for 63 per cent of generation in 2014-15.[27]

The coal fleet is ageing, but there is an opportunity to improve the efficiency and lower emissions as part of the national effort to meet international climate obligations. Simply refurbishing existing stock with HELE-grade componentry and system could cut 12 per cent of emissions.[28]

The Department of Industry, Science and Innovation suggests that replacing Australia's existing coal-fired power fleet with ultra-supercritical technologies could cut emissions from coal-fired electricity generation by between 21-34 per cent.

If Australia's current coal fleet of subcritical and supercritical power stations were replaced with ultra-supercritical technology today, emissions could be 21-27 per cent lower. If replaced by advanced ultra-supercritical technology, emissions could be 27-34 per cent lower.

Similarly, the former Gillard Government found new coal technologies can increase the efficiency of Australian plants to over 45 per cent and lower CO_2 emissions by up to 50 per cent.[29]

New technologies being trialled promise to reduce emissions even further. HELE coal-fired power stations integrated with CCS can reduce CO_2 emissions by approximately 90 per cent.[30]

Endnotes

1 Australian Electricity Market Operator, *Electricity statement of opportunities*, 2016; *Future power systems security program*, Aug 2016.

2 International Energy Agency, *World Energy Outlook 2015*, p. 335.

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4 Grevenbroich-Neurath, Germany is a lignite HELE plant that can power up and down each unit in 15 minutes. RWE Generation, KW Neurath BoA 2&3, viewed on 31 Jan 2017.

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6 World Coal Association, *A global platform for accelerating coal efficiency*, 2014, p. 5.

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13 WCA, 2016, op. cit.

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15 J Boyd, 'Japan's Isogo Power Plant Burnishes Clean Coal's Credentials', *IEEE-Spectrum*, 25 Sept 2013.

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18 Capital costs under the original RET target suggest a cross-subsidy from users to producers of about $22 billion to 2030 (see Australian Government, *Renewable Energy Target Scheme: Report of the expert panel*, 15 Aug 2014). Estimates largely unchanged by legislative changes in 2015.

19 BAEconomics, *Primer on renewable energy subsidies in Australia*, report to the Minerals Council of Australia, forthcoming, p. 2.

20 On an output basis, renewable subsidies translated into almost $413/MWh for solar technologies, $42/MMh for wind and $18/MWh for all other renewable sources. By comparison, coal-fired power and natural gas received less than $1/MWh. Principal Economics, *Electricity production subsidies in Australia*, a report for the Minerals Council of Australia, Aug 2015.

21 Clean Energy Regulator, *Annual report 2015*, and media commentary 2017.

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23 S Cornot-Gandolfe, *The role of coal in Southeast Asia's power sector and implications for global and regional coal trade*, Oxford Institute for Energy Studies, Dec 2016.

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25 BAEconomics, op. cit.

26 B S Fisher, S Schnittger, *Implications of Australian renewable energy mandates for the electricity sector*, Aug 2016. Integration costs are estimated to be in the range of A$37 to A$53 per MWh when wind penetration reaches 30 to 40 per cent.

27 Department of Industry, Innovation and Science, *2016 Australian energy statistics update*, 14 Oct 2016.

28 *GE global power plant efficiency analysis*, 2016.

29 See the Department of Resources, Energy and Tourism, *A cleaner future for power stations*, Interdepartmental Task Group Discussion Paper, 1 Nov 2010, p. 5.

30 IEA, 2013, op. cit., p.19.

Japan are building ultra-supercritical clean coal plants that produce 40 per cent less emissions, using Australian high quality coal. It would be a little silly for us to send our coal to Japan to use in clean coal plants but not even consider building them here.

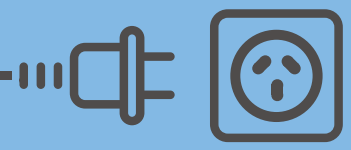
Minister Matt Canavan
Federal Resources Minister
Townsville Bulletin, 07.01.2017

To add certainty to the grid, why not build another coal-fired power station each in NSW and Queensland? There would then be no doubt for all those enterprises in South Australia or the people of the Eyre Peninsula, or big industrial enterprises in Victoria like the Portland aluminium smelter.

Graham Richardson
Former Labor Minister
The Australian, 06.01.2017

As the world's largest coal exporter, we have a vested interest in showing that we can provide both lower emissions and reliable baseload power with state-of-the-art, clean coal-fired technology.

The Hon Malcolm Turnbull MP
Prime Minister of Australia
National Press Club address, 01.02.2017



Cleaner coal is part of the solution, it is a proven technology which has application in Australia.

Minister Josh Frydenberg
Federal Environment and Energy Minister
The Australian, 24.01.2017

HELE coal-fired power generation mitigates more CO_2 emissions than renewables per dollar of investment.

World Coal Association

Solar works when the sun is shining, wind works when the wind is blowing, hydro works when there is water in the rivers. You must have coal.

Piyush Goyal
Power, Coal and Renewable Energy Minister, Government of India

HELE clean coal technologies are a key step towards near zero emissions from coal.

IEA Clean Coal Centre

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