INTERNATIONAL CENTRE FOR SUSTAINABLE CARBON

CIAB
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THE ROLE OF LOW EMISSION COAL TECHNOLOGIES IN A NET ZERO ASIAN FUTURE

The 26th Conference of the Parties (COP26) to the United Nations Framework Convention on Climate Change (UNFCCC) held in Glasgow in November 2021, was an important moment for global action on the combined challenges of energy and climate. More than 130 countries have pledged to reach net zero emissions (NZE) before 2050. China is aiming for carbon neutrality by 2060 and India has a target date of 2070. Combined, the net zero target covers 88% of GHG emissions, 85% of the population and 90% of GDP (PPP) (Net Zero Tracker, 2021).

The coal industry is a key stakeholder in the UNFCCC process. As an advisory board to the International Energy Agency (IEA) on matters relating to the utilisation of coal, the Coal Industry Advisory Board (CIAB) worked with the International Centre for Sustainable Carbon (ICSC) to produce this report which considers the indispensable role of advanced coal technologies in fulfilling the goals of the Paris Agreement. The CIAB recommends the IEA supports this technology-centred approach to the challenge of reducing emissions in Asia.

There is a widely held assumption that achieving NZE means the end of using coal. Many developed countries have already committed to phase it out. They are generally high-income countries with slow-growing, service-based economies, stable populations and the options of nuclear power, relatively cheap natural gas and renewables. However, much of Asia depends on coal for energy security, where it remains the dominant source of energy as it is relatively cheap and readily available.

Asian countries tend to have relatively fast-growing economies and populations, which are also becoming more urban. This means that demand for energy and electricity is increasing. Urbanisation and industrialisation also raise the demand for infrastructure. These developments require large amounts of steel and cement, the production of which is also still largely coal dependent. Thus, it is much harder for a growing Asian economy to stop using coal than it is for a developed, service-based one in Europe or North America where the population already has 100% access to secure and reliable electricity.

Asia is home to over 60% of the world's population and relies on oil, coal and gas for 90% of its energy needs. It is responsible for more than half of global CO_2 emissions from fossil fuels. Asia has a large, young coal fleet (the average age of units is 13-14 years), which provides 57% of the region's electricity (Asia-Pacific, 2020). This means the region will need to accelerate deployment of low emission coal technologies (LECT) to help the world achieve NZE by 2050.

CARBON CAPTURE UTILISATION AND STORAGE IS VITAL

Carbon capture, utilisation and storage (CCUS) is a necessary, strategic part of Asia's transition to NZE because coal and gas will remain important for years for existing industry, such as electricity generation and industrial processes that are hard to abate, for example steel and cement making; and new industries, including bioenergy, hydrogen, ammonia and dimethyl ether (DME).

CCUS technology is ready for widespread commercial roll-out and its deployment in Asia needs to expand significantly to remain in line with the temperature objectives of the Paris Agreement. There are 30 large-scale CCUS facilities operating globally which store around 40 $MtCO_2$/y; we know it works. The reliability and availability of CCUS plants continue to increase.

The cost of CCUS has fallen significantly; capture currently costs around 65 $/$tCO_2$. 'Learning by doing' will bring costs down further; a 50–75% cut may be achieved as the technology is rolled out commercially. CO_2 capture costs of 43–45 $/$tCO_2$ by 2024-28 are predicted (*see* Figure 1).

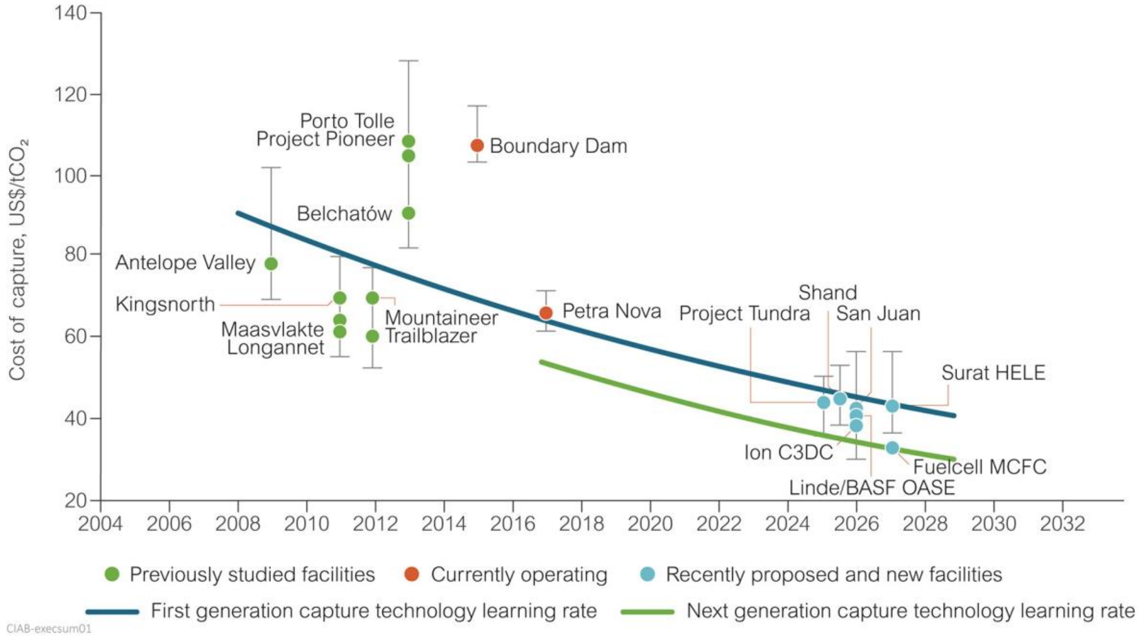

Figure 1 Levelised cost of electricity for large-scale coal power generation plants with post-combustion carbon capture (Zapantis and others, 2019)

Asia, and China in particular, should become a key focus for the wider commercial roll-out of CCUS. A current example in China is the Jinjie project, capturing 0.15 $MtCO_2$/y. Other projects include the Huaneng Longdong Energy Base 2 GW USC plant with 1.5 $MtCO_2$/y capture capacity with a planned completion date of end 2023 and the GreenGen integrated gasification combined cycle (IGCC) (Phase 3) planned to capture 1–2 $MtCO_2$/y by 2025.

The CO_2 captured could be stored permanently in local geological structures deep underground. Regional cooperation is an option for individual countries where this is not possible. For example, countries with limited geological storage could still use hydrogen and other feedstocks from coal (with the storage occurring where the coal is located) as part of attaining NZE.

The business case for CCUS can be boosted by using the CO_2 for enhanced oil/gas recovery and as a carbon source for new, value-adding circular economy activities in cement and chemicals manufacture.

There are no technical barriers to CCUS becoming a key strategic part of the NZE solution for Asia. However, strong financial, regulatory and incentive regimes will be needed to achieve large-scale roll-out.

MORE EFFICIENT POWER GENERATION IS EFFECTIVE

The power generation sector in Asia emits over 8 $GtCO_2$/y, almost half of the total CO_2 emissions of the region. Small, inefficient and unabated coal power plants should be closed. Improved efficiency of power plants can dramatically reduce emissions of CO_2 and other pollutants. Coal power plants with efficiencies of 47% (LHV) (equivalent to ~720 gCO_2/kWh) are in operation, while the global average is 37.5%. Each percentage increase in efficiency reduces CO_2 emissions by 2–3%, plus high efficiency, low emissions (HELE) power plants are more suitable for CCUS. There is the potential to lift efficiencies to almost 50% in the near term (reducing emissions by another ~10%, to around 680 gCO_2/kWh). Thus, all new, large coal units should adopt HELE ultrasupercritical (USC) conditions and best-available pollutant controls, while in the longer term all coal-fired units will need to be abated with CCUS.

Several alternative high-efficiency pathways are based on an IGCC, offering potential additional benefits of fuel flexibility, generation of high-value products, and good compatibility with carbon capture. The integration of fuel cell technology, particularly solid oxide fuel cells and molten carbonate fuel cells into IGCC coal-fired power plant, has the potential to further increase the efficiency of LECT. In the long term, efficiencies of around 60% LHV basis have been projected for such power plants. Supercritical CO_2 (sCO_2) cycles such as the Allam-Fetvedt Cycle hold great potential to provide advanced power generation systems that can achieve higher plant efficiency and close to full carbon capture at lower costs.

COFIRING WITH LOW CARBON FUELS REDUCES EMISSIONS

Cofiring coal with agricultural and forestry wastes as well as low-emissions hydrogen and ammonia reduces GHG emissions from power plants and may offer a cheaper option to achieve NZE at a power plant, for example with 90% capture and 10% cofiring. The role of cofiring is increasing in Asia: China, Japan and Indonesia have specific policy tools to support biomass cofiring, either in place or planned. There are substantial agricultural and forestry waste resources suitable for cofiring with coal. Such action would also improve local air quality if the waste was no longer burnt in the field.

In Japan, the option to cofire low emissions ammonia, produced from fossil fuels with CCUS, or from water electrolysis using electricity, is being pursued. Work is underway to develop a global supply chain to provide the required levels of low emissions ammonia.

COAL SUPPORTS MORE RENEWABLE ENERGY ON THE GRID

As the proportion of variable renewable energy (VRE) supplying the grid increases in Asia, dispatchable coal-fired power plays an important role in the overall grid response to demand When there is little wind or sunshine, coal-fired power plants can be ramped up to maintain stable supplies of electricity. Even when high levels of VRE are achieved >50–70%, coal power will remain key to ensuring security of supply. Thus, an increase in VRE capacity lowers the output from coal plants but does not necessarily mean their closure. Coal power plants do not compete with VRE. Instead, they facilitate the increased penetration of VRE into Asian power networks by maintaining a stable grid while producing low emissions power when necessary.

However, as investments and policies for power sector transformation focus on VRE, inefficient coal power plants continue to operate, instead of being replaced by HELE plant with CCUS. This is exacerbated by the flight of international finance and technology providers from the coal sector. While coal remains fundamental to many Asian electricity grids, the sector should be supported in a rapid transition to HELE technologies through appropriate valuation of dispatchable capacity to make the grid reliable, with continued support for R&D, and greater international collaboration.

COAL HAS A MASSIVE, HARD TO REPLACE ROLE IN ASIAN INDUSTRY

Industry already produces about 8 $GtCO_2$/y of direct emissions, 70% of which are from the cement, iron and steel, and chemical sectors. Almost 2 $GtCO_2$/y of industrial emissions are a by-product of chemical reactions within the production process and currently cannot be avoided. Demand for products is forecast to continue to grow, driven by population and economic growth.

China is responsible for 50–60% of the global production of cement, steel and aluminium, where coal is the dominant feedstock and source of process heat. This means that coal accounts for 70% of steel, 83% of cement and 75% of aluminium production in China (*see* Figure 2).

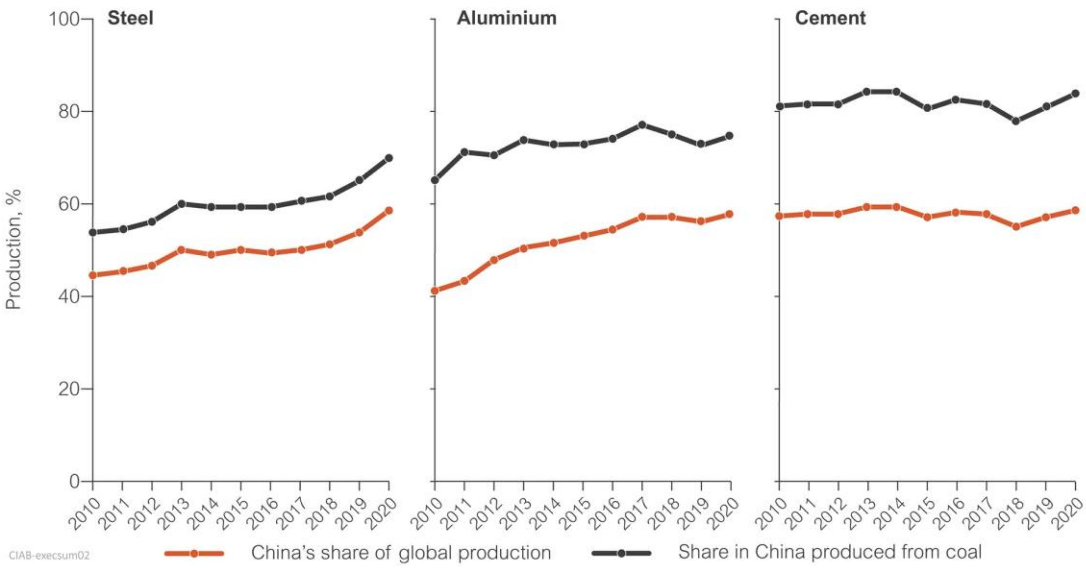

Figure 2 **Proportion of steel, aluminium and cement production in China derived using coal as a feedstock and energy source (Yang, 2020)**

A portfolio of approaches will be needed to achieve NZE from industry, including:

- deployment of CCUS;
- 'fuel' switching to hydrogen, biomass and electricity where available at a competitive price; and
- improved energy efficiency and increasing the use of scrap steel and aluminium.

Coal will continue to be key through the transition to NZE, with CCUS retrofit essential to decarbonise industry.

GROWING CHEMICALS SECTOR RELIES ON COAL

For chemicals and fuel production from coal, gasification can offer the best production route in Asia and has a strong track record in China. The chemical and fuel sectors are growing and are likely to expand through the transition. The use of methanol as an intermediate, substitute natural gas, coal-to-liquids and coal-to-tar, deep processing and hydrogenation, and lignite upgrading are all expected to grow strongly. Process optimisation can improve conversion efficiencies, but again CCUS must be adopted for this industry to develop in a way consistent with NZE.

LOW-CARBON EMISSIONS HYDROGEN INCREASING IN IMPORTANCE

Hydrogen is a very versatile fuel, with a potential role in all sectors; global demand in 2050 may be up to 650 MtH_2/y, a 560% increase from 2018. It is likely to be used for industrial feedstock and energy supply, transportation, heating and power in buildings, and power generation usage including hydrogen buffering.

The preferred method of hydrogen production depends on local factors. In China, low emissions hydrogen production via gasification from coal with CCUS is lower cost than low emissions hydrogen based on water electrolysis, typically by a factor of almost 3. This economic advantage of coal gasification with CCUS means it will probably continue to be a low-cost source of large-scale hydrogen in Asia. The Sinopec Qilu CCUS retrofit to the existing coal gasification plant in China could lead the way to a wider roll-out of low-carbon hydrogen technology in Asia.

The addition of CCUS to coal gasification for hydrogen production can reduce the carbon intensity of hydrogen to 0.4–0.6 $kgCO_2/kgH_2$, at a 98% rate of carbon capture. This is 2% of the CO_2 compared to hydrogen production from the global average electricity mix. Cofiring biomass or ammonia with the coal, increasing the capture rate, or using advanced technology such as the Allam-Fetvedt Cycle, could all reduce the CO_2 emissions closer to net zero, or even below, in the case of cofiring with CCUS.

MEETING THE CHALLENGE IN ASIA

Achieving NZE will require an increase in the level of VRE in Asia and a reduction in the emissions traditionally associated with fossil fuels. Coal will continue to be used in Asia in the coming years because: security of energy supply is vital; coal provides dispatchable power to help maintain a stable power grid as the level of VRE increases; natural gas is relatively expensive; and coal is difficult to replace as a feedstock in many industries.

Thus, Asian countries reliant on coal now will need low emissions technologies for power generation and especially for the foundation industries of steel, cement and aluminium, for the chemicals industry and for the hydrogen sector which can contribute to power generation, industry, building and transport.

CCUS, together with HELE power plants, biomass and waste cofiring with coal will be key enabling technologies to help large parts of Asia approach NZE while maintaining economic growth. There are low emission technologies available and others close to commercialisation that are vital to enable Asia to approach NZE.

Investment in advanced coal technologies is an essential part of global action to meet emissions objectives and achieve the intended outcomes of the Paris Agreement. This study aims to accelerate the transition.

The International Centre for Sustainable Carbon (ICSC) was commissioned to produce this study by the International Energy Agency's (IEA) Coal Industry Advisory Board. The ICSC is organised under the auspices of the IEA but is functionally and legally autonomous. Views, findings and publications of the ICSC do not necessarily represent the views or policies of the IEA Secretariat or its individual member countries.

This summary is based on the report: The role of low emission coal technologies in a net zero Asian future by Greg Kelsall and Paul Baruya, ICSC, January 2022