A PATHWAY TO REDUCING EMISSIONS FROM COAL POWER IN INDIA

This study, commissioned by the International Energy Agency's Coal Industry Advisory Board, offers a pathway to reduce emissions from India's coal fired power generation industry. It will help India deliver on its climate change commitments, improve air quality and enhance electricity reliability and access. In completing the study, the IEA Clean Coal Centre worked with key Indian stakeholders both in government and in the power sector.

INDIAN ECONOMY RELIES ON COAL

India is a vast country of 1.37 billion people which has undergone rapid economic growth over the last 20 years to become the world's fifth largest economy. This growth has been inextricably linked with a successful drive to increase the availability of electricity, with total power generation increasing by 40% over the last decade. Owing to the country's enormous coal reserves and limited oil and gas, coal fired power has remained dominant over this period, even slightly increasing its share of total generation to 72% (1135 TWh) in 2019.

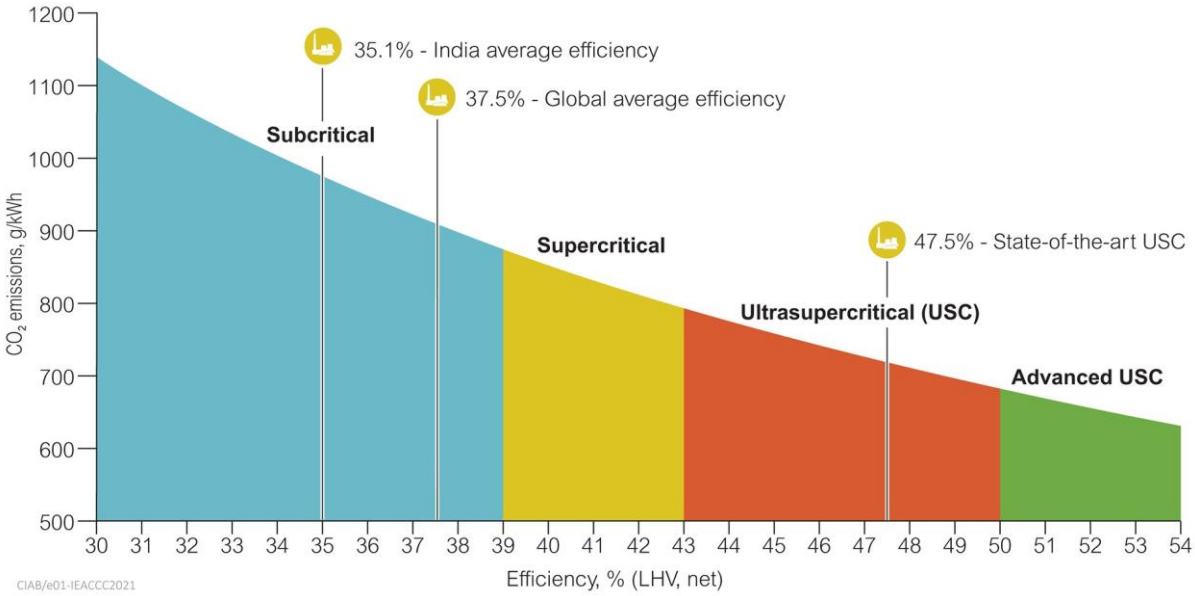
India is a success story in many respects. Rapid power plant deployment in recent years has meant that there is abundant generating capacity. Electricity access for all is mostly successful. Despite this remarkable rise, Indians still experience a per capita energy consumption of only around 10% that of high-income countries, and further growth in standards of living and associated energy demand is therefore urgently needed. While the Government of India has ambitious plans to meet much of the expected growth with wind and solar power capacity – up to 400 GW in 2030 – coal will continue to play a fundamental role in providing India with dispatchable power and energy security for the next 20 years and beyond.

REDUCING CARBON EMISSIONS WITH A FLEXIBLE, EFFICIENT FLEET

However, the Indian coal fleet emitted 1.1 $GtCO_2$ in 2019 and contributes to poor air quality in some regions, due to emissions of SO_2, nitrogen oxides (NOx) and particulate matter, with associated impacts on health, ecology and economy. Coal quality varies substantially across India. A key challenge is the impact of burning high ash content (25–50%), indigenous coal on plant performance and emissions management.

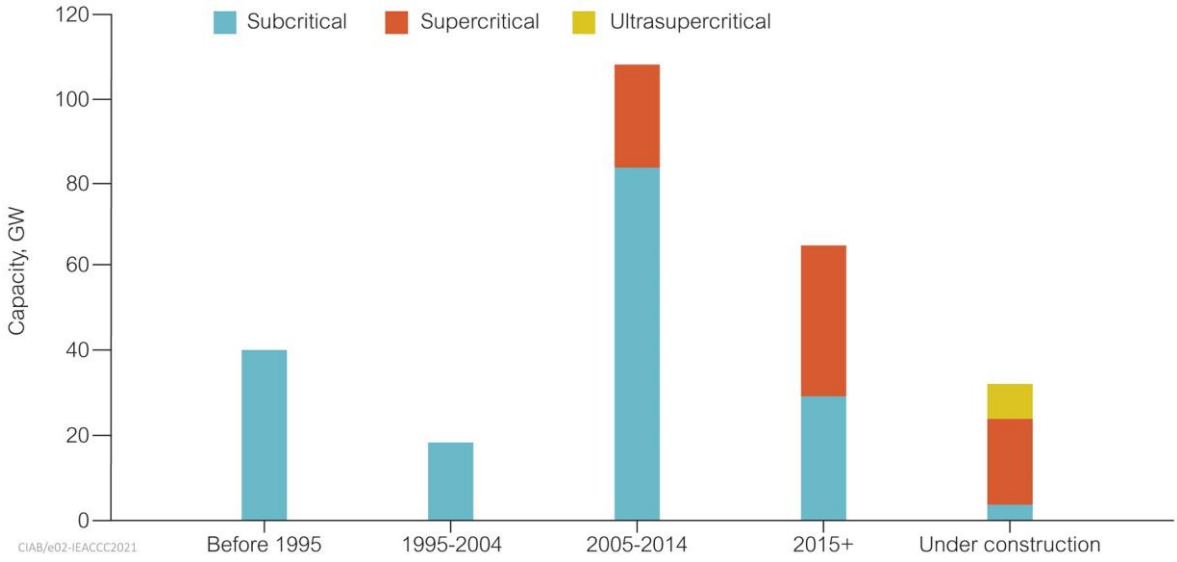
Increasing coal-fired power plant efficiency reduces emissions of CO_2 per MWh generated. In India the average unit efficiency is 35% compared to state-of-the-art efficiency of 47.5%. There is therefore significant potential to reduce CO_2 emissions from India's coal fleet through a combination of retiring or upgrading older units and building new efficient ones. There are various incentive schemes to promote upgrading of subcritical plants covering improved operation and maintenance (O&M) practices, instrumentation and control upgrades as well as more substantial turbine and boiler upgrades/retrofits.

For example, the upgrading of some small units (<200 MWe) has resulted in savings of over 100 kt/y coal and 165–190 kt/y of CO_2 emissions at each unit with a return on investment of less than 2 years.



CO_2 reductions achievable with increasing coal plant efficiency (IEACCC, 2020)

Coal-fired power plant capacity has more than quadrupled to over 205 GW (utility) in 20 years with a further 33 GW under construction. The first supercritical (SC) unit came online in 2010 and since then a further 52 GW of SC capacity has been added. The first ultrasupercritical (USC) plant was commissioned in 2019. By 2023 India is expected to have 250 GW of utility coal-fired generating capacity in operation, almost a third of which will be SC or USC. The hope is that this impressive performance of improving efficiency will be continued. However, new capacity additions have outpaced demand for electricity, so utilisation factors have fallen from approximately 70% in 2010 to 56% in 2019. Utilisation is likely to recover in the next few years.



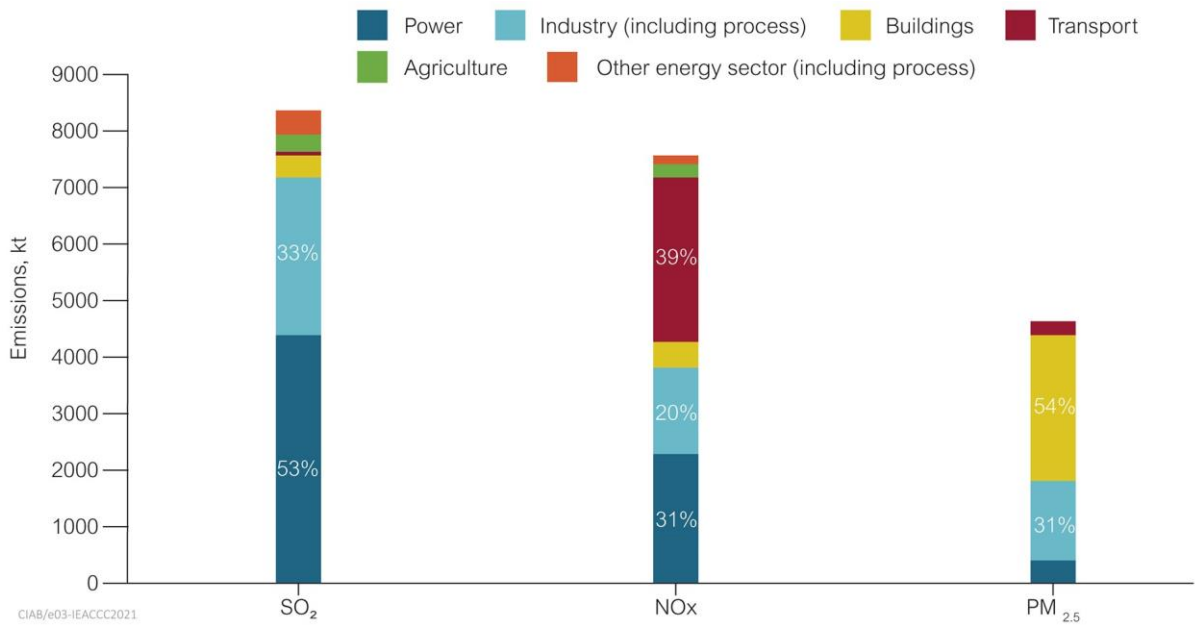
Composition of India's coal fleet by age and technology type (S&P Global, 2020)

The transition to higher efficiency technologies has already made good progress. However, further reductions in emissions could be achieved through changes to dispatch mechanisms and implementation of supporting policies such as:

- Continuing the transition towards economic-based merit-order dispatch to provide market incentives for more efficient, flexible units;
- Introducing efficiency standards to ensure all new units are supercritical as a minimum and ultrasupercritical from 2025;
- Easing the regulatory process for retirement of inefficient units and replacement with new ones;
- Encouraging greater use of digital tools to facilitate optimal operation, efficiency and flexibility; and
- Supporting technical capacity building and international knowledge sharing in the manufacture and operation of high-efficiency, flexible units.

Based on experience in Europe and other regions, the ability to operate in a flexible manner will be key if coal power plants are to remain competitive in a market with a greater proportion of renewables. More emphasis will need to be placed on planning and readiness for likely changes in the market and operational environment.

EMISSIONS CONTROLS AND AIR QUALITY



India's SOx, NOx, and $PM_{2.5}$ emissions by source, 2018 (IEA, 2019a)

The introduction of more stringent emission standards 'norms' for coal power in 2015 was a significant step in mitigating air pollutants including SO_2, NOx, and particulates. However, progress in meeting these standards through the widespread deployment of flue gas desulphurisation and NOx control technologies has been slow, with the deadline extended to 2022 and some NOx limits relaxed. Significant NOx reductions are achievable in most Indian coal plants simply through the effective combination of combustion optimisation and appropriate primary control measures. More costly secondary measures will be needed to achieve the stricter NOx limits for newer plants, but these technologies can be successfully applied even to the relatively high-ash environments associated with firing Indian coals. Rather than

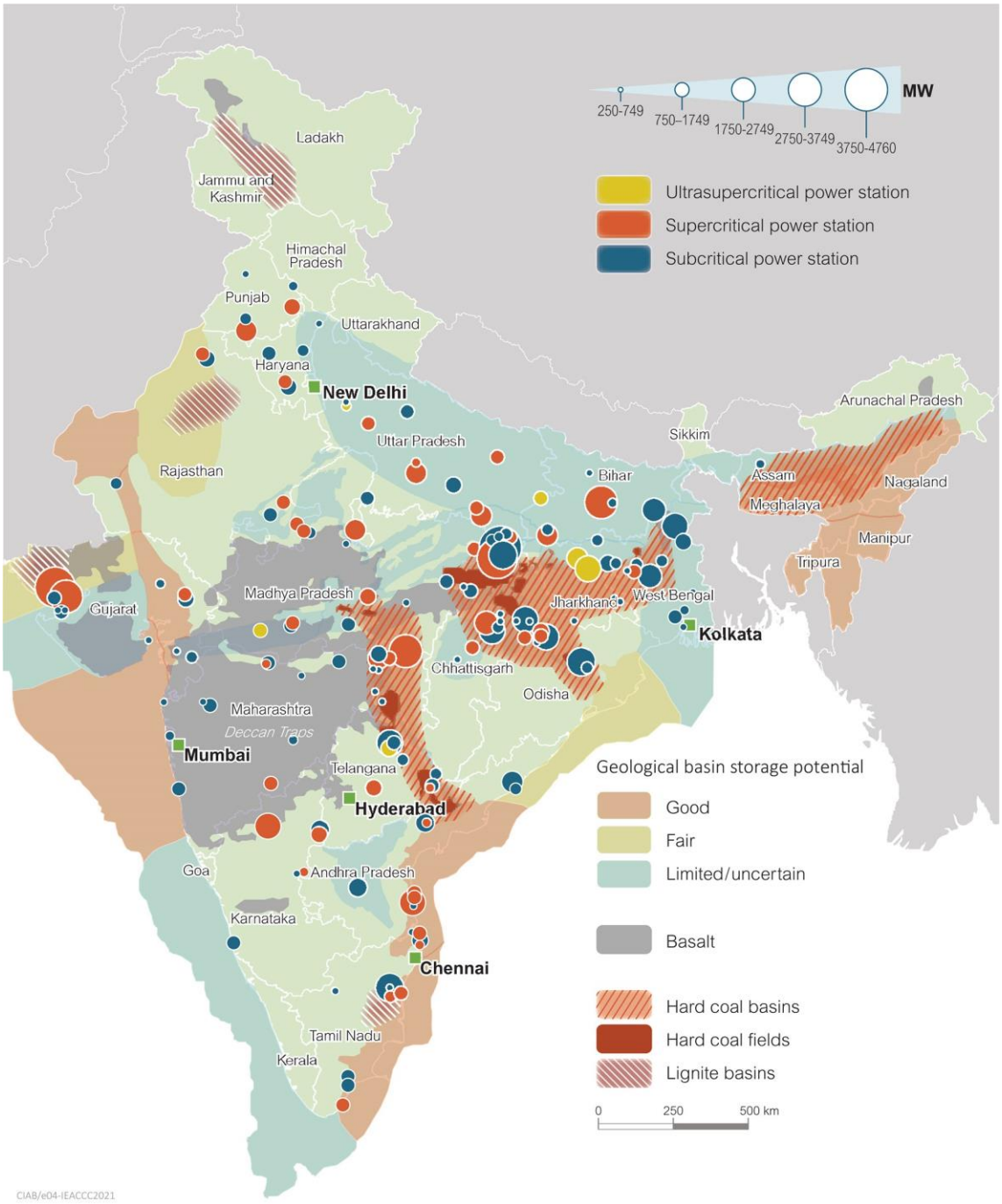
seeking to delay implementation of the existing norms, the sector should work to anticipate the globally observed trend of progressively tightening standards. The recommendations include:

- Significant NOx reduction (around 10%) and efficiency gains (up to 2 percentage points) can be achieved through optimisation and accurate monitoring of combustion parameters; In combination with optimised combustion, primary NOx controls such as separated overfire air and low NOx burners can be used effectively to reach 300 mg/m^3;
- Selective catalytic reduction (SCR) can be adapted to the high-ash conditions associated with firing Indian coal, and should be further explored through full-scale trials, including 'cold-side' operation;
- Strong incentives to meet the emission standards, such as placing compliant plants higher in the merit order or imposing stronger penalties on those which do not take action;
- Emission standards should be met on a rolling average basis, helping to make lower emission standards (such as 300 mg/m^3 for NOx) practically achievable with primary measures alone;
- Reconsider the relaxation of the NOx standard to 450 mg/m^3 for plants built 2004 to 2017;
- Consider tightening the standard for plants commissioned before 2004 to 450 mg/m^3, which should be easily achieved through primary controls; and
- The limit of 100 mg/m^3 for plants built after January 2017 should be upheld, and achieved with a combination of advanced primary measures, appropriate operating and maintenance practice, and secondary controls.

CO_2 CAPTURE UTILISATION AND STORAGE (CCUS)

As the only means of imposing deep cuts on fossil fuel CO_2 emissions, CCUS is experiencing a resurgence in global interest and should represent the ultimate goal for India's coal fleet. Although India continues to actively support research in CO_2 capture and utilisation, energy shortages and perceptions of high costs and unpromising geological storage capacity have deterred political backing for large-scale deployment. However, recent rapid growth in coal power capacity and more ambitious climate targets present a more favourable environment for CCUS.

Recent studies estimate that the country has the potential to store at least 100 GtCO_2 (90 years of current coal emissions), even without considering emerging opportunities in basalt and deep coal seams. However, the true potential will only be clear once more targeted characterisation has been carried out. This study has mapped India's coal plants against geological resources as a means of highlighting the most suitable storage locations and plant clusters for near-term development.



Locations of India's major coal plants with respect to CO_2 storage options

India can take a number of preliminary steps to drive early demonstration of CCUS and attain a state of readiness for greater deployment from 2030 onwards:

- A more detailed assessment of geological storage potential is urgently needed, including characterisation of promising saline aquifers in coal-producing regions;
- Priority dispatch for CCUS-equipped coal plant, together with tariff pass-through of additional coal costs, could act as an incentive for early projects;
- Enhanced oil recovery and CO_2 conversion technologies can also play a role in kickstarting first-mover projects, supported by incentives for domestic, low-carbon products;
- New coal plants in India should be 'capture-ready', including a storage assessment;

- The Methanol Economy is an opportunity to develop CCUS clusters associated with gasification clusters, incorporating production of high-value products and power;
- Government should coordinate an integrated, cross-sectoral technology demonstration strategy among relevant public sector undertakings; and
- CCUS should be explicitly included in India's international climate commitments.

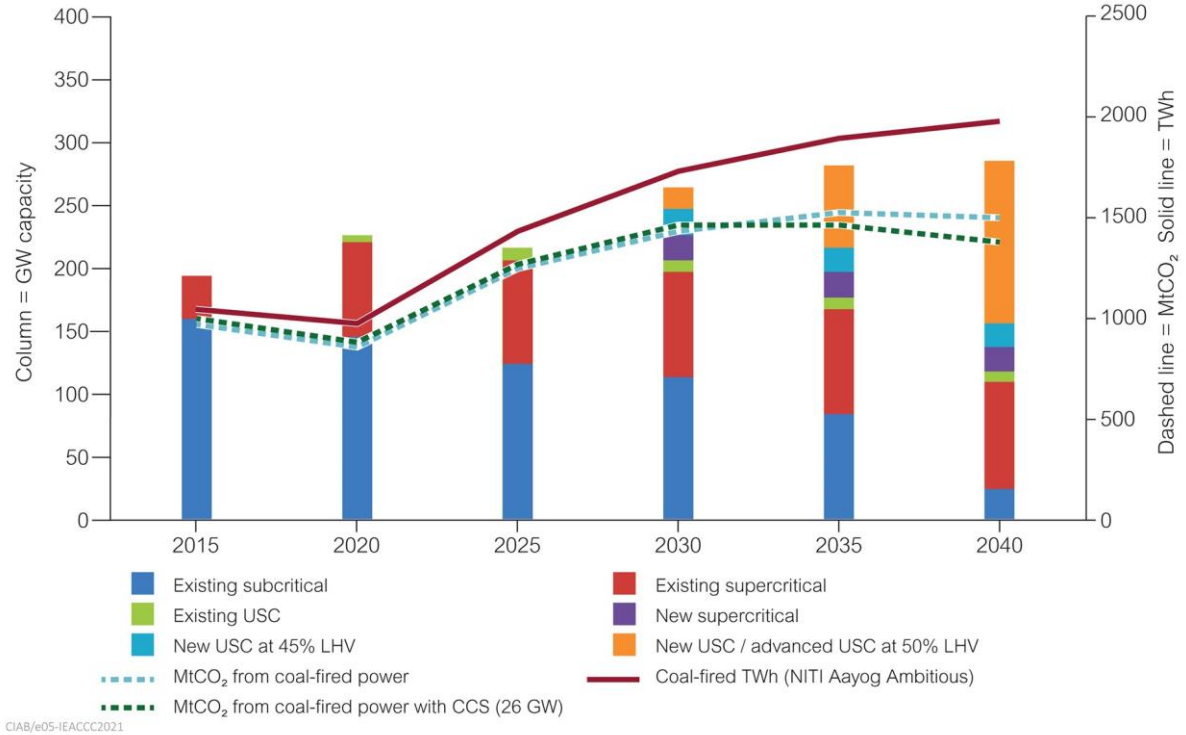
Initial financing of CCUS deployment will likely require international investment, international support, including through multi-lateral development banks, and policy incentives. Other incentives such as tax credits may be needed to further support CCUS deployment and wide-spread power system decarbonisation.

COAL POWER TO 2040

The future of coal-fired power generation is fundamentally determined by the overall rise in electricity demand and the penetration of non-coal power sources into the market. Thus, the share of the market taken by coal is likely to diminish but remain significant. In this study, analysis of coal power to 2040 in India is based on two pathways – one higher growth based on the NITI Aayog Draft Energy Policy (2017) and the other based on the lower rate of growth of the Stated Energy Policies (STEPS) scenario of the IEA (2020). Both scenarios show the CO_2 emissions that can be avoided if coal-fired units are retired after 25 years and replaced with HELE technologies. They also include the addition of CCS to 26 GW of coal-fired capacity.

Higher growth

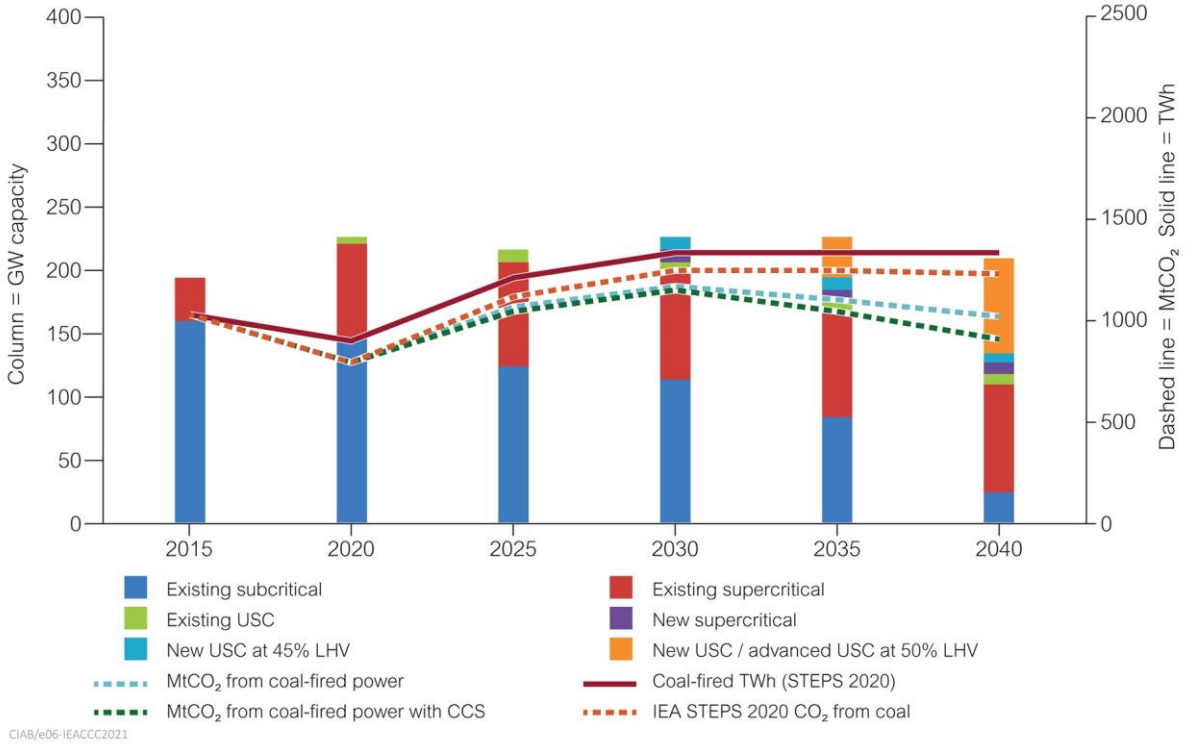
In the higher growth scenario, the replacement of 25 year old subcritical units with a range of HELE technologies decouples the rate of CO_2 emissions growth (blue line) from that of coal-fired capacity (red line). The addition of CCS from 2030 onwards to around 10% of the fleet reduces emissions further (green line). The results indicate that HELE plants with the addition of CCS on 26 GW of coal-fired capacity could avoid up to 4300 $MtCO_2$ between 2021 and 2040, equivalent to roughly 215 $MtCO_2$/y.



IEACCC projections based on NITI Aayog Ambitious Scenario

Lower growth

In the lower growth scenario, based on IEA 2020 STEPS power plants still retire after 25 years, and there is a greater decline in the need for coal-fired power. The subcritical fleet decreases to 23 GW by 2040, and the need for additional coal capacity is lower. The aggressive replacement of older plants with HELE ones, as recommended in the study, leads to a total decrease in CO_2 emissions from approximately 1104 $MtCO_2$/y in 2019 to 1023 Mt/y in 2040 with HELE plant only and 905 Mt/y in 2040 with CCS on 26 GW. More rapid deployment of HELE technologies in this scenario leads to a 27% lower emissions intensity for the sector in 2040, compared with the STEPS 2020.



The IEACCC HELE projections applied to the IEA 2020 STEPS outlook for power generation

KEY MESSAGES

This study offers a pathway to reduced emissions and improved air quality, while still using affordable and reliable coal power in a growing economy. Plant efficiency can be improved with some measures being inexpensive. Emissions standards can be met in many instances without costly measures and payback of only a few years. The resulting improvements will have health, environmental and economic benefits. Market reforms to finance to incentivise adoption of new, proven technologies will be required to achieve the desired improvements. Deploying HELE coal can help support government objectives, from improving air quality to operational flexibility in a market with increasing renewables penetration. Specific recommendations include:

- Increased emphasis on ultrasupercritical technology or better by 2040, with remaining subcritical units confined to minimal operating hours;
- Further focus on compliance with 2015 emissions standards using available technologies;
- CCUS – the groundwork such as storage assessment and regulatory development must be laid now if it is to remain an option;

- The power market should aim to value all aspects of energy provision, including availability, flexibility, and grid reliability and resilience;
- International support in the form of both investment and expertise should be further encouraged; and
- Nurture India's capacity as a global centre of engineering excellence in HELE and CCUS technologies.

There is a real risk that prevailing perceptions of coal as an outmoded energy source, combined with financial challenges, will stifle efforts to transition to cleaner forms of coal power and slow the promising progress made in transforming India's coal fleet. Recognising that coal power will remain fundamental to the country's pursuit of UN Sustainable Development Goals, including affordable and clean energy (SDG7), decent work and economic growth (SDG8), and industry, innovation, and infrastructure (SDG9), maximising the use of HELE coal technologies and CCUS must be seen as key to India's actions on both public health (SDG3) and climate change (SDG13).

This report has been produced by the IEA Clean Coal Centre for the International Energy Agency's Coal Industry Advisory Board. It is based on a survey and analysis of published literature, and on information gathered in discussions with interested organisations and individuals. Views, findings and publications of the IEA Clean Coal Centre do not necessarily represent the views or policies of the IEA Secretariat or its individual member countries.

This executive summary is based on the report:
A pathway to reducing emissions from coal power in India by Debo Adams (Project Lead), Toby Lockwood, Paul, Baruya, Dr Malgorzata-Wiatros-Motyka and Dr Qian Zhu.

This report was produced in January 2021. Please visit www.iea-coal.org for further information.