CSE

FACTSHEET

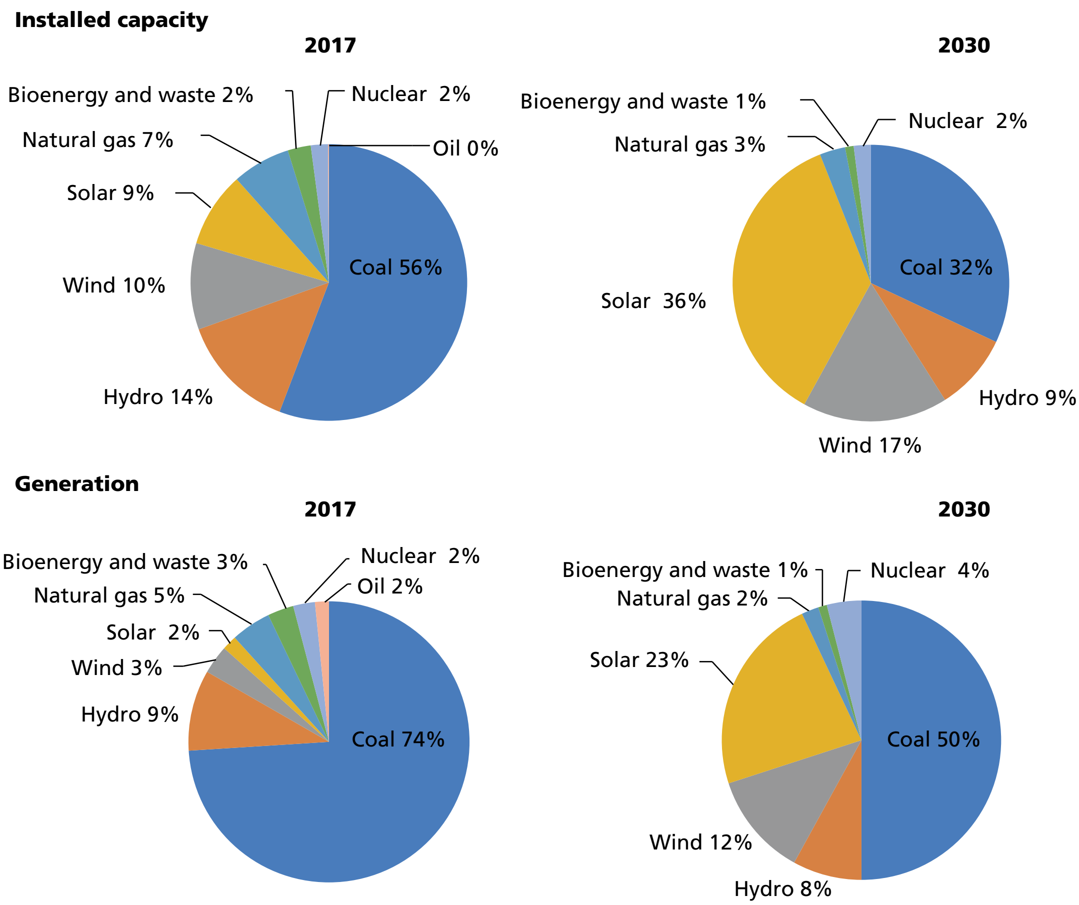
REDUCING CO_2 FOOTPRINTS OF INDIA'S COAL-BASED POWER

CO_2 EMISSIONS FROM INDIA'S COAL FLEET

- The sector's coal consumption increased from 300 million tonnes in 2006–07 to 600 million tonnes in 2017–18 (which is about two-thirds of the country's total coal consumption).
- Carbon dioxide (CO_2) emissions from the sector have also risen, from 500 million tonnes in 2005 to 1,000 million tonnes in 2015.
- In 2016, India generated 3.1 giga tonnes (Gt) of CO_2 equivalent (CO_2 eq) emissions—nearly 6.5 per cent of global GHG emissions.
- India's coal power generation's contribution was nearly 1.1 Gt CO_2 eq; approximately 2.4 per cent of global emissions and one-third of India's total GHG emissions.
- Coal-based power contributes around 50 per cent of the country's fuel-related CO_2 emissions.
- The capacity is expected to rise from 205 GW in 2020 to 266 GW in 2030.

Installed and generation capacity of coal-based power plants

Coal capacity will increase to 266 GW by 2030, contributing 50 per cent of the total electricity generated



Source: IEA, 2020

POTENTIAL PATHWAYS TO REDUCE CO_2 EMISSIONS OF INDIA'S COAL FLEET

Coal fleet: Age, technology and efficiency

- India has a relatively young fleet—around 64 per cent of the capacity is less than a decade old.
- About 16 per cent (33 GW) of the capacity is older than 25 years. Of this, a major share (about 76 per cent) is in the form of small units of up to 250 MW and less.

Age distribution of India's coal fleet

Most Indian coal power plants are young, and can look forward to many years of financial viability

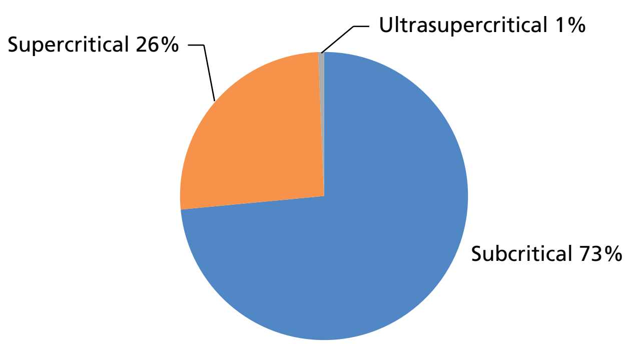
Unit capacity	Vintage					Total
	> 35	26–35	16–25	3–15	0–2	
Up to 250 MW	9	16.15	12.95	20.78	1.95	61
> 250 and < 500 MW	0	0	0.6	14.71	2.67	18
500 MW and < 650 MW	0.5	7	7	55.29	1.7	72
650 MW and above	0	0	0	38.39	16.16	55

Source: CSE, 2020

- Less than one-third of India's coal capacity is supercritical, only 1 per cent in ultra-supercritical and the rest is subcritical, whereas China and Japan have significant portions with ultra-supercritical technology.

India's coal fleet technology

Less than one-third of the capacity is supercritical

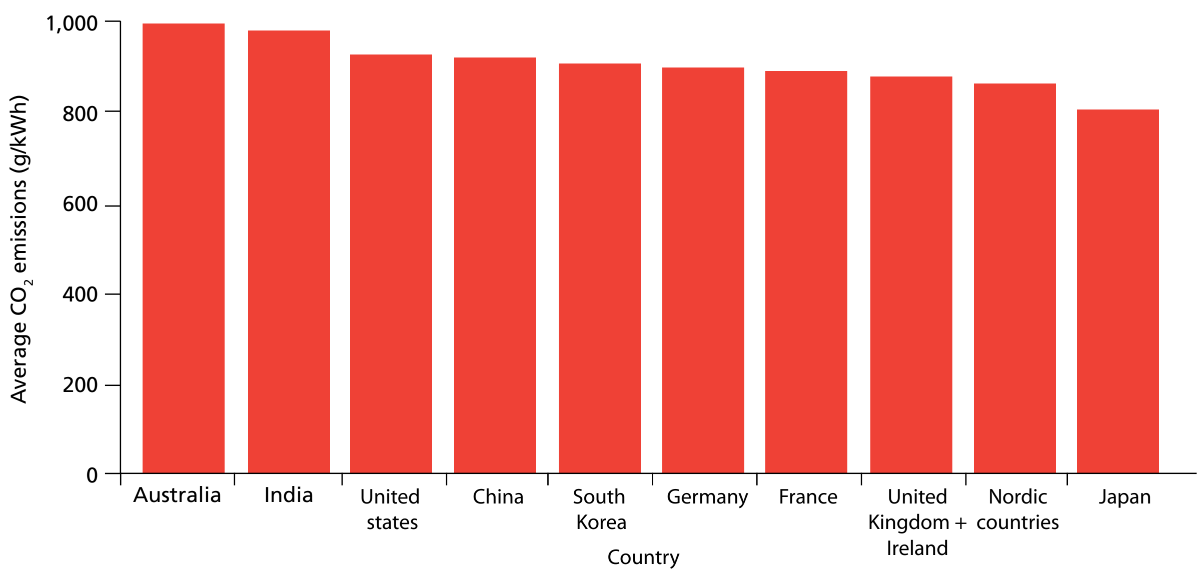


Source: CSE analysis

- India's average efficiency is lower than China's (39 per cent) and Japan's (43 per cent). The country has the second highest specific CO_2 emissions, standing at 983 g/kWh; 22 per cent higher than the world's lowest specific CO_2 emissions.

Global comparison of specific CO_2 emissions of coal-based power

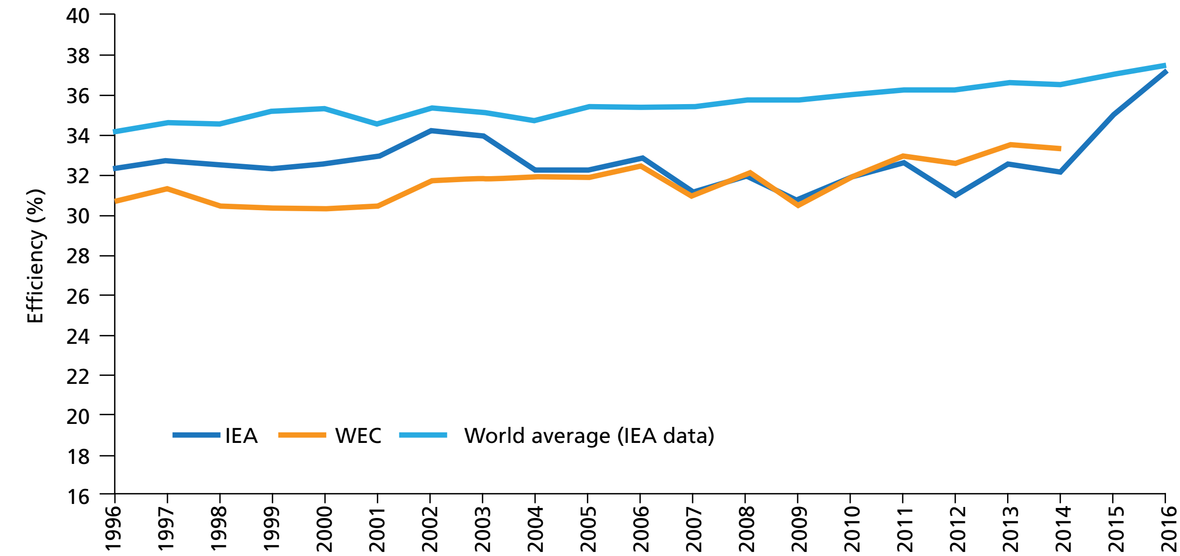
India's coal-based fleet has the second highest specific emissions of CO_2



Source: Ecofys, 2018

Efficiency of India's coal fleet over the years

Efficiency of India's coal fleet has increased between 2014 and 2016

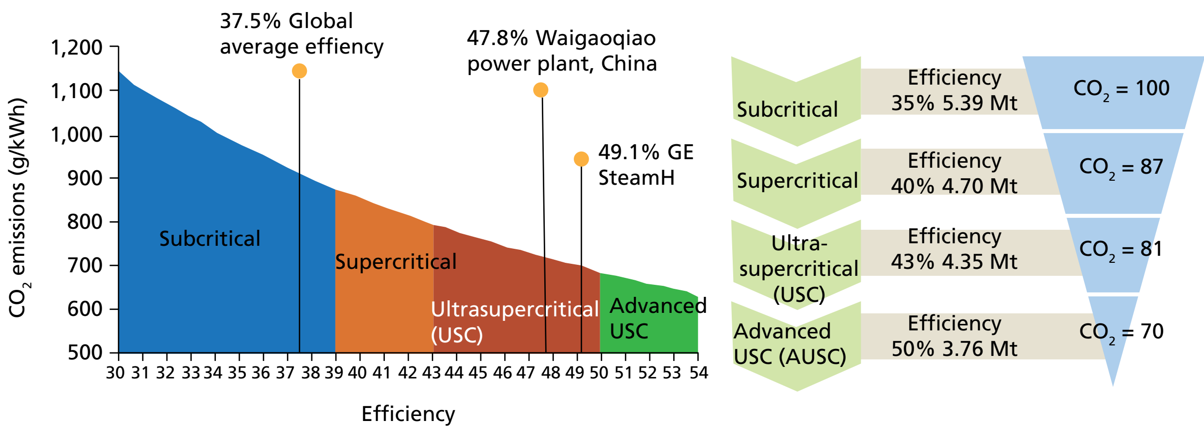


Source: IEA, 2020

- Efficiency of a thermal power plant directly affects its CO_2 emissions, i.e., a 1 per cent rise in efficiency reduces CO_2 emissions by 2–3 per cent.
- When a supercritical plant replaces a subcritical plant, CO_2 footprints are reduced by 10-15 per cent; and when an ultra-supercritical plant replaces a supercritical plant, CO_2 footprints can be reduced by 6–9 per cent.
- Coal capacity has been continuously missing installation targets since 2017, it is extremely difficult to predict future installations of coal power in India.
- No official roadmap or projection for technology of the coal-power fleet by 2030 is available.

Comparison of efficiency and CO_2 emissions of thermal power plant technologies

Replacing a subcritical unit with an advanced ultra-supercritical unit can reduce CO_2 emissions by 30 per cent



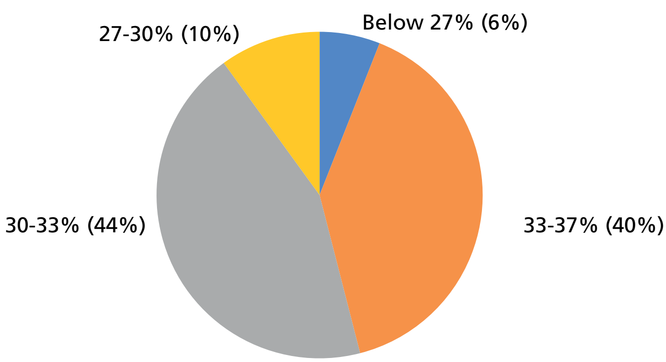
Source: IEA, 2020

Retirement

- As per a CSE analysis in 2016, gross efficiency of around 60 per cent of the old capacity (34 GW) is lower than 33 per cent. Poor efficiency results in excessive coal consumption.
- Replacement of this 34 GW capacity by supercritical capacity will reduce coal consumption by over 20 million tonnes per annum and CO_2 emissions by 35–40 million tonnes.
- In 2018, the NEP included a new target for the closure of 48.3 GW of end-of-life coal plants. Coal-based capacity of 22,716 MW is under consideration for retirement during 2017–22. Additionally, a coal-based capacity of 25,572 MW has been considered for retirement by 2017–22, which will be completing 25 years of operation by March 2022.
- India is missing out on the benefits of timely retirement of old capacity. Only 4.67 GW capacity has been retired between 2018–20 (March 2020)
- Employees, land and coal linkages are the important assets for these power plants, better utilization of existing resources will be critical in prudently reducing CO_2 emissions with minimum economic investment.

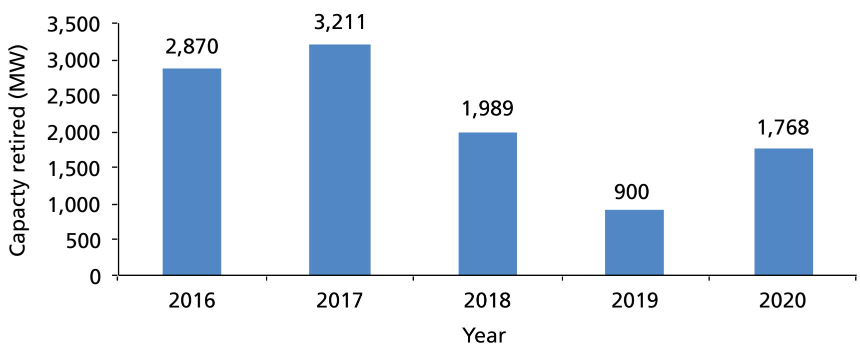
Gross efficiency of old power stations

Efficiency of almost 60 per cent of the capacity is lower than 33 per cent



Retirement of capacity over the years

On an average, 1–2 GW capacity is retired every year. At this pace, India will not be able to retire the targeted 48 GW capacity by 2027



Till March 2020

Source: CSE, 2020

Renovation and modernization

New installation is capital-intensive, it is considered prudent to maximize generation from existing power stations to ensure optimal utilization.

Renovation and modernization have a key role to play in ensuring:

- Flexible operation of coal-based power plants with growing competition from renewable energy.
- Catalysing biomass co-firing.

Summary of India's renovation and modernization, and life extension policy

Unlike old renovation and modernization policies, the new policy can significantly contribute to CO_2 reduction if utilized strategically

	1984–2005	**2005–19**	**2019 onwards (as per the latest draft guidelines)**
Primary objective	Generation maximization	Performance optimization and generation maximization	Efficient flexible operation with lower emissions
Primary focus unit	< 200 MW Renovation and modernization after 15 years and life extension after 20 years	> 200 – ≤ 500 Renovation and modernization after 15 years, and life extension after 20 years	> 500 MW Can be done before the stipulated time based on improving flexible generation
Key focus areas	Maximize the generation from existing power stations to ensure optimal utilization of resources, reliability, efficiency and availability	Included specific issues for renovation and modernization to maintain rated capacity and to deal with issues such as deteriorated coal quality and lower plant load factor. Environmental protection was considered, but it was limited to ESP upgradation. Renovation and modernization after 15 years. Life extension after 20 years.	High level of automation to ensure flexible and improved dynamic operations to work in tandem with renewable energy. Renovation and modernization interventions may be needed for refurbishments to improve plant efficiency at part load operation as well. Need for new emissions control equipment installations in power plants for environmental compliance. Biomass utilization for power generation through co-firing in thermal power plants. Conversion of coal-fired plants to biomass power plants. Lowering water consumption in coal-fired power plants. Due to uncertainties in the future operational regime of thermal power generation, life extension of shorter duration may have to be considered.

Source: CSE compilation

Biomass co-firing

- It has been generally accepted that co-firing biomass with coal can offer a quick, cost-effective way to partially decarbonize power generation in the short to medium term, especially in India, where agro-residue is abundant.
- As per International Energy Agency's (IEA) Roadmap on Biomass Heat and Power, biomass-based power generation will increase by at least a factor of ten from today till 2050, accounting for 7.5 per cent of world's electricity generation. This biomass-based power generation will almost entirely be based on combustion and co-firing technologies.
- The substitution of only 10 per cent of coal in the current globally installed coal-fired electrical capacity would result in installation of about 160–180 GW biomass power capacity, which is 2.5 times the current globally installed biomass power capacity.
- Currently, about 230 power and combined heat and power plants using co-firing techniques are in operation.
- Co-firing also helps to extend the life of a plant.
- Co-firing can play an important transitional role in the decarbonization of the coal fleet.
- CEA has issued an advisory to all thermal power generating plants and utilities to endeavour to use 5–10 per cent blend of biomass pellets, made primarily from agro-residue, along with coal, after assessing the technical feasibility and safety aspects.
- National Thermal Power Corporation (NTPC) has successfully demonstrated co-firing of 7 per cent blend of biomass pellets with coal at its Dadri power plant. This can be replicated in other coal-fired power plants.
- In September 2019, Ministry of New and Renewable Energy (MNRE) notified that power produced from biomass co-firing in coal-based power plants is renewable energy and will be eligible for non-solar renewable purchase obligation (RPO).
- Thus, if both utility and captive capacity attempts to utilize 5–10 per cent co-firing, it can amount to large-scale agro-residue utilization. Based on the present use of biomass co-firing of 5–10 per cent, some 50–100 million tonnes of coal will be replaced by biomass by 2030. It is equivalent to reducing 90 to 180 million of CO_2 emissions.

Coal beneficiation

High ash content is among the reasons why Indian coal scores poorly on energy value. High ash content (of 30–50 per cent) creates many problems for coal users, including difficulty in pulverization, poor emissivity and flame temperature, low radiative transfer, and generation of excessive amounts of fly ash containing large quantities of un-burnt carbon.

This reduces the efficiency and increases the auxiliary power consumption of the plant. It is one of the reasons for higher CO_2 emissions from Indian power plants.

Improvements in power plant efficiency through the use of clean (washed) coal can significantly reduce CO_2 emissions. CO_2 emissions can be reduced by 2–3 per cent by using 34 per cent ash coal as against 42 per cent ash coal.

Though washing increases the overall cost of the coal, the benefits accrued in terms of savings in transportation, operation and maintenance cost, and efficiency make the process financially sustainable.

State-of-the-art technologies such as supercritical and ultra-supercritical pulverized coal combustion or IGCC also benefit from the use of upgraded coals.

India's shifting view on coal washing

A 1997 notification required the use of beneficiated coal with an ash content of not more than 34 per cent with effect from 2001. This applied to all thermal power stations located beyond 1,000 km of the pithead and any thermal power plant located in an urban or sensitive area irrespective of its distance from the pithead.

In 2014, the then Ministry of Environment and Forests amended the rules with respect to the use of washed, blended or beneficiated coal, strengthening the 34 per cent ash content requirement, and also extended the rule to plants located at a distance of 500–1,000 km from the pithead.

However, in May 2020, the government decided to allow use of coal irrespective of ash content once again. The government claims that significant improvements in the quality of coal mined in India has necessitated this change. It also claims that third party sampling of coal at both the loading and unloading end of coal supply from Coal India Limited (CIL) to generators is taking place. It further claims that coal washeries are merely increasing cost of the coal and local pollution due to inefficient operations.

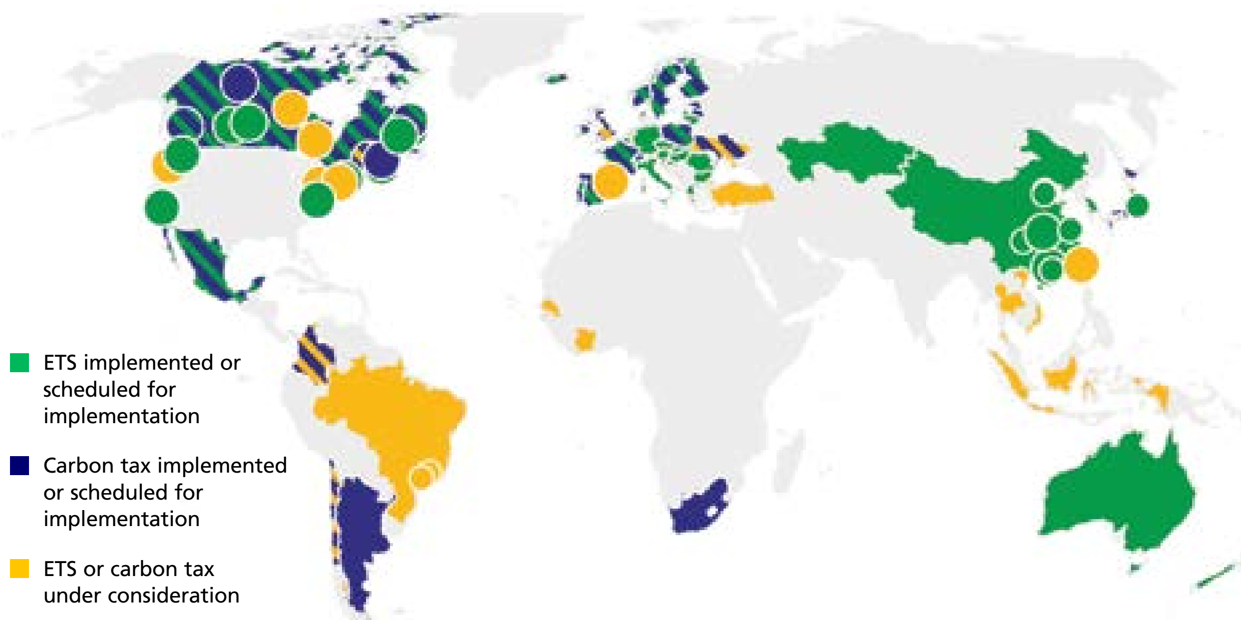
Various stakeholders hold different views on the subject. CSE believes this decision has been taken in haste; a wider stakeholder consultation should have been carried out before allowing the use of unwashed coal once again.

Carbon taxes and trading system

Of the 185 countries that have submitted their intended nationally determined contributions (INDCs)to the UN as per the Paris Agreement on Climate Change, 96 have stated that they are planning or considering to use a carbon pricing mechanism as a tool to achieve their INDC commitments.

Global scenario of carbon pricing and emissions trading systems

Most developed countries have introduced some form of incentive mechanisms



Source: World Bank, 2019

As of 1 April 2020, there were 58 different carbon pricing mechanisms worldwide, of which 28 were carbon emissions trading markets and 30 were carbon tax mechanisms.

The first major carbon emissions trading system was initiated in the EU in 2005. EU-ETS is the biggest emissions trading scheme operating in the world. It covers around 40 per cent of emissions from EU, including those from the power and aviation sectors. The US has the second largest carbon trading market and has built a relatively mature carbon ETS. In China, an ETS scheme is scheduled to be launched in 2020.

Status of carbon pricing and emissions trading systems

Many developing countries are actively considering carbon tax and emissions trading systems

Status	Carbon taxes	Carbon trading system	Total	Scope	Countries
Implemented	30	28	58	These initiatives would cover 9 Gt CO_2 eq, representing 16 per cent of global GHG emissions	Mainly Europe and the US, also Argentina and South Africa
Scheduled	0	3	3	In 2020, these initiatives would cover 4 Gt CO_2 eq, representing 7.2 per cent of global GHG emissions	China, Germany and the US
Under consideration	Brazil, Thailand, Ukraine, Turkey, Indonesia, Taiwan, Vietnam, and some states of the US are actively considering various carbon pricing regimes				

Note: Till 1 April 2020

Source: Carbon pricing dashboard, World Bank

In India

- A nationwide Clean Energy Tax on coal (or coal cess) was adopted in 2010.
- The tax was initially set at Rs 50 (US $0.72) per tonne of domestic and imported coal, but was quadrupled to Rs 200 (US $2.88) per tonne of coal in 2015 and doubled again to Rs 400 (US $5.75) per tonne in 2016.
- In 2017, it was subsumed under the Goods and Services Tax (GST). Earlier known as the Clean Energy Cess, it was renamed GST Compensation Cess.
- In late 2019, the Central government proposed to cancel the coal cess altogether.

Carbon capture and storage (CCS)

- Global progress on the development of CCS technology has been poor.
- By 2019, less than 10 per cent of the expected capacity had been created.
- CCS is absent from INDCs of most countries, only 11 of 189 countries have mentioned CCS technology in their INDCs.
- It is clear that national policies have not accepted CCS as a promising technology.
- By 2019, there were only 19 operational CCS facilities capturing around 36–40 million tonnes of carbon per year. Only two of them were in coal-based power plants.
- Four CCS facilities are under construction, 10 are at an advanced design stage, and another 18 are in the early stages of development.

Opportunities

- **Capital cost of CCS has been reduced significantly, from US $105 per tonne of CO_2 in 2011 to US $45 per tonne of CO_2 in 2019**
- **Countries with cheap labour and materials, like China, will have the lowest CCS installation cost**
- **Combining CCS with biomass co-firing can further reduce capital and operating costs**
- **In developing countries, hotspots of power generation, where power plants are located in clusters, should be targeted to reduce material, transportation and storage costs**

Barriers

- **Net zero emissions are almost impossible with fossil-fuel based CCS, and still incur higher costs than renewable energy-based energy systems**
- **Advanced treatment for clean flue gas input to CCS is required. To requires significant investment**
- **Insufficient national carbon pricing has impacted installation of CCS**
- **Lack of shared transport and storage networks raises per unit CCS cost**

Tariff-based incentives

Transparency in the disclosure of unit-wise heat rates:

- Flexibility needs to be provided to generating companies to supply power requisitioned by beneficiaries or states through Merit Order operation of stations on the national level, maximizing the electricity generation from cheaper stations before moving to other stations.
- Stringent targets need to be set to align PAT cycles with CERCs norms on heat rate.
  - Deeper analysis of the sector for a better rationale for target setting under PAT.
  - Clarity on enforcement and timelines for defaulters on energy targets.
  - Transparency and clarity in the trading mechanism regulations that will build confidence.

- **Commercial availability of CCS in India depends largely on successful implementation of CCS technologies in advanced industrialized countries**
- **The future of CCS technlogies in industries looks promising as they generate much lesser CO_2 than coal-based power plants**
- **CCS does not have promising prospects in power plants in India, at least before 2030**
- **NTPC has signed a memorandum of understanding with Larson and Turbo Hydrocarbon Engineering (L&THE) to build a CO_2-to-methanol demonstration plant at an NTPC power station**
- **The most crucial requirement of a long-term CCS strategy for coal-based power in India is a reliable CO_2 storage capacity assessment for the country**

SCENARIOS OF CO_2 EMISSIONS REDUCTION IN INDIA'S COAL FLEET BY 2030

Baseline CO_2 emissions for India's coal fleet

Small and subcritical capacity has a large share in the country's CO_2 emissions

Capacity	Vintage (years)					Capacity (GW)	Plant load factor (per cent)	Specific CO_2 emissions (kg/kWh)	Annual CO_2 emissions (million tonnes)
	> 35	26–35	16–25	3–15	0–2				
Up to 250	9	16.15	12.95	20.78	1.95	60.83	50	1.19	317.06
> 250 and < 500 MW	0	0	0.6	14.71	2.67	17.98	50	1.05	82.69
500 MW and < 650 MW	0.5	7	7	55.29	1.7	71.49	65	1	407.06
650 MW and above (supercritical)	0	0	0	38.39	16.16	54.55	70	0.85	284.33
650 MW and above (ultra-supercritical)					1.3	1.3	70	0.75	5.98
Advanced ultra-supercritical							0		
Total	9.5	23.15	20.55	129.17	22.48	206			1,097.11

Source: CSE, 2020

Projected CO_2 emissions under BAU scenario by 2030

Overall emissions from coal-power plants will increase in a BAU scenario

Present capacity : 205 GW
Expected capacity: 266 GW (CEA)
Expected generation: 1,250 BU (CEA)
Expected overall PLF: 54 per cent (rough estimate)
Total CO_2 emissions : 1,120 million tonnes

Assumptions for calculation:

Parameter	Actions and their impacts
Retiring old and inefficient plants	Retiring 25 GW* Included in new capacity addition
Installing new technology (supercritical, ultra-supercritical and advanced ultra-supercritical)	266 GW = 205 - 25 + 60 (supercritical) + 26 (ultra-supercritical)**
Renovation and modernization	1–2 per cent reduction in overall CO_2 emissions. However, this reduction will be neutralized by frequent ramping and cycling of plants due to increased renewable generation
Biomass co-firing	10 per cent biomass co-firing in 20 per cent of the capacity***
BEE's PAT	1–2 per cent reduction in overall CO_2 emissions
Merit Order based on national availability	1–2 per cent reduction in overall CO_2 emissions
Carbon capture and storage (CCS)	Not feasible till 2030
Heat rate tracking through CEMS	Not feasible
Carbon tax and carbon trading	Not included
Coal beneficiation	Not included

*Retiring only small old and inefficient units (based on 2–3 GW of annual retirement)
** Based on the current trend of technology adoption in India
*** Considering only states with agro-residue burning issues adopt co-firing
Source: CSE analysis

CO_2 emissions under the best-case reduction scenario by 2030

This scenario will roughly translate into reduced CO_2 emissions to the tune of 250 million tonnes from a BAU scenario

Expected capacity: 266 GW (CEA)
Expected generation: 1,250 BU (CEA)
Expected overall plant load factor: 54 per cent (rough estimate)
Projected CO_2 emissions: 850 million tonnes

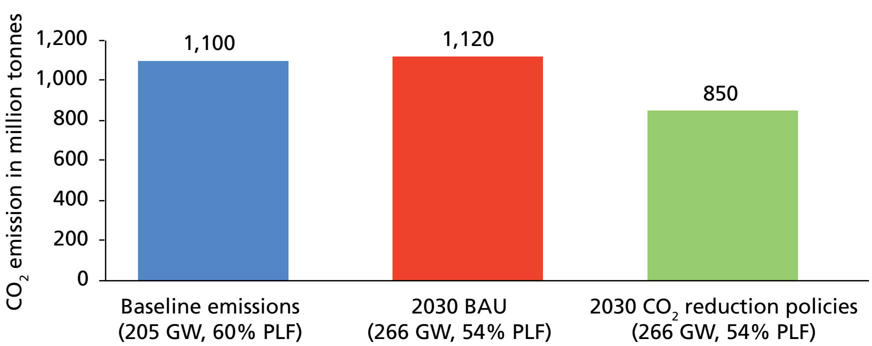
Assumptions:

	Actions and their impacts
Retiring old and inefficient plants	Retiring 48 GW* Adding 10 GW of biomass capacity (impact will be covered in new capacity addition)
Installing new technology (ultra-supercritical and advanced ultra-supercritical)	266 GW = 205 – 45 +50 (supercritical) + 30 (ultra-supercritical) + 16 advance ultra-supercritical + 10 GW biomass
Renovation and modernization	1–2 per cent reduction in overall CO_2 emissions. However, this reduction will be neutralized by frequent ramping and cycling of plants due to excessive renewable generation
Biomass co-firing	10 per cent biomass co-firing in 100 per cent of the capacity
Carbon capture and storage (CCS)	Not feasible till 2030
Heat rate tracking	Impact dependant on other policies
BEE's PAT	2–3 per cent reduction in overall CO_2 emissions when targets are based on deeper analysis, aligning with CERC normative heat rate targets
Merit Order based on national availability	Impact clubbed with other policies
Carbon tax and carbon trading	8 per cent reduction
Coal beneficiation	2–3 per cent reduction in overall CO_2 emissions

*As per the National Electricity Plan, 2018
Source: CSE analysis

Projected trend of CO_2 emissions, comparing BAU scenario and the best case scenario

CO_2 emissions will increase in a BAU scenario but can decrease by as much as 22 per cent in the best case scenario



Source: CSE, 2020