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Incompatibility of HELE coal technology with 2°C pathways

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Lindee Wong

High-efficiency low-emissions coal power plants have been proposed as an emissions mitigation technology

- In COP 21, governments pledged to limit the global average temperature rise to **well below 2°C** above pre-industrial levels, and to **pursue efforts to keep it under 1.5°C**.

- High efficiency low-emissions coal power plants have been **proposed as a technology that can deliver emissions reductions**.

World Coal Association

"Deploying high efficiency, low emission (HELE) coal-fired power plants is a **key first step** along a pathway to near-zero emissions from **coal with carbon capture, use and storage (CCUS).** HELE technologies are commercially available now and, if deployed, can reduce greenhouse gas emissions from the entire power sector by around 20%."

Source: http://www.worldcoal.org/reducing-co2-emissions/high-efficiency-low-emission-coal

Aims of project

- **Is HELE coal-fired electricity generation compatible with the goal of limiting the temperature rise to 2°C.**

- Assess the implications of the Intergovernmental Panel on Climate Change (IPCC) and International Energy Agency (IEA) 2°C scenarios on coal-fired electricity generation and emissions.

- Evaluate whether the 1,400 GW of currently planned coal capacity is compatible with these scenarios.

HELE coal plants are higher in efficiency and produce lower emissions **compared to sub-critical** technology

> HELE coal technology has a **higher** efficiency and **lower** emissions **compared to sub-critical coal plants**.

Technology	Conversion efficiency	CO_2 emissions intensity (gCO_2/kWh)	Coal consumption (g/kWh)
Subcritical	Up to 38%	≥880	≥380
Supercritical	Up to 42%	800–880	340–380
Ultra-supercritical	Up to 45%	740–800	320–340
Advanced Ultra-Supercritical (A-USC)/ Integrated gasification combined cycle (IGCC)	45–50%	670–740	290–320

Source: International Energy Agency, 2012, High-Efficiency, Low-Emissions Coal-Fired Power Generation Technology Roadmap.

> Other electricity generation technologies have higher efficiencies, e.g. up to 60% for gas turbines, and lower CO_2 emissions intensities, e.g. 350–490 gCO_2/kWh for gas turbines and 0 gCO_2/kWh for wind and solar power.

Carbon capture and storage reduces the emissions intensity but also the efficiency of electricity generation

- Carbon capture and storage (CCS) process:

- Emissions intensity is estimated to be 50–150gCO_2/kWh.

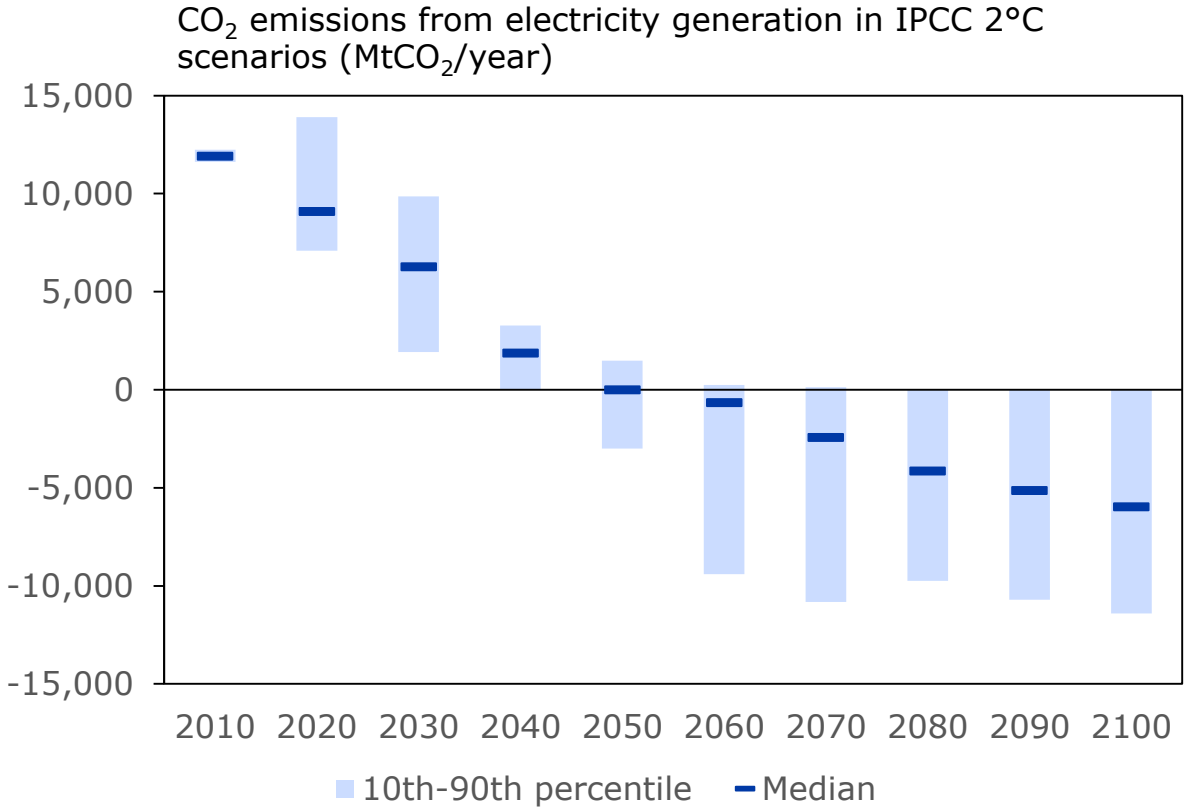
- Full lifecycle emissions (mining, processing, transport) add 95-150 gCO_2/kWh to this figure.

- CO_2 separation technology consumes energy and reduces the conversion efficiency.

- Coal-fired electricity generation with CCS has a substantial role in 2°C scenarios from the IPCC and IEA.

The electricity sector needs to be **decarbonised by 2050** to keep the 2°C within reach

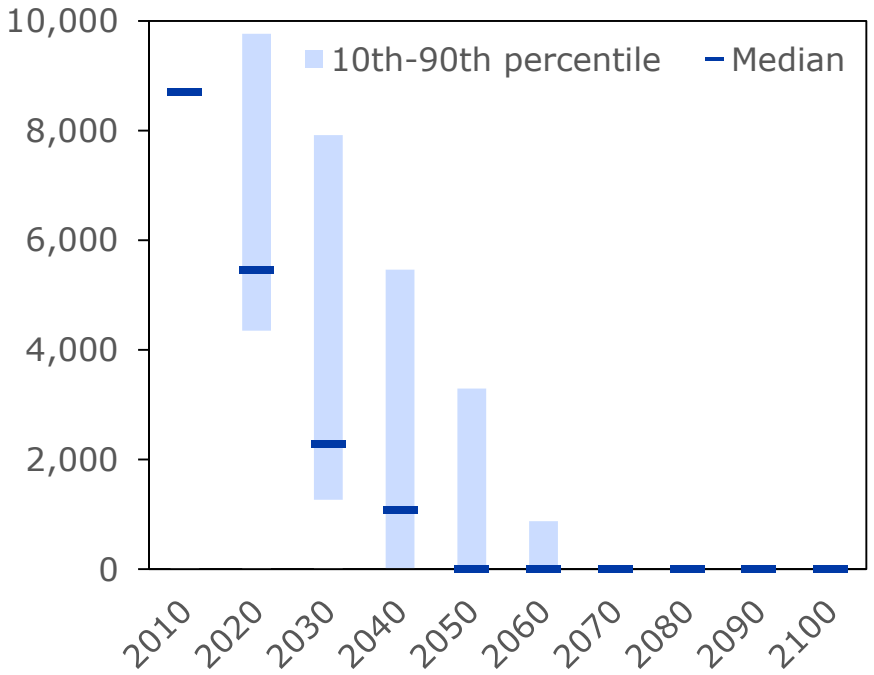
- IPCC 2°C scenarios show that the electricity sector needs to be decarbonised by 2050.
- **From 2050 onwards, negative emissions** from the electricity sector are needed.



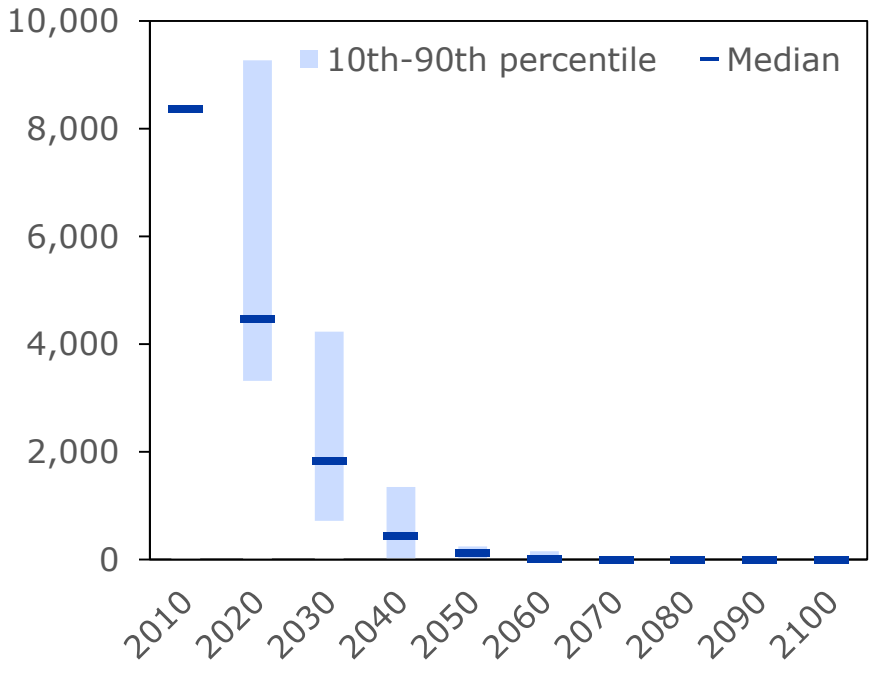
Source: Intergovernmental Panel on Climate Change, 2014, Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessr Report of the Intergovernmental Panel on Climate Change.

Coal power plants not equipped with CCS need to be **phased out by 2050**

Coal generation without CCS in IPCC **2°C** scenarios (TWh/year)



Coal generation without CCS in **1.5°C** scenarios (TWh/year)



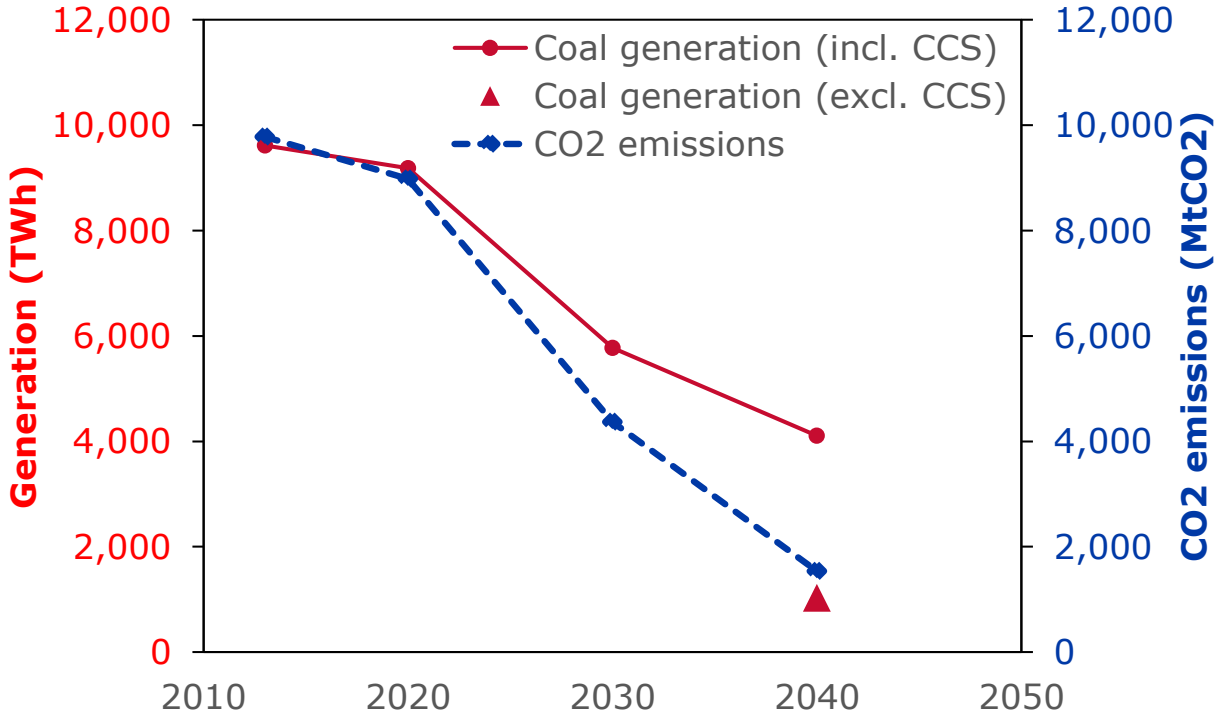
Phase out rate of coal power (without CCS)

Year	2°C scenario	1.5°C scenario
2010 – 2020	-4%/year	-5%/year
2020 – 2030	-6%/year	-6%/year
2030 – 2040	-5%/year	-8%/year

Source: Intergovernmental Panel on Climate Change, 2014, Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change; Rogelj, J., G. Luderer, R. C. Pietzcker, E. Kriegler, M. Schaeffer, V. Krey and K. Riahi (2015). "Energy system transformations for limiting end-of-century warming to below 1.5°C." Nature Clim. Change 5(6): 519-527.

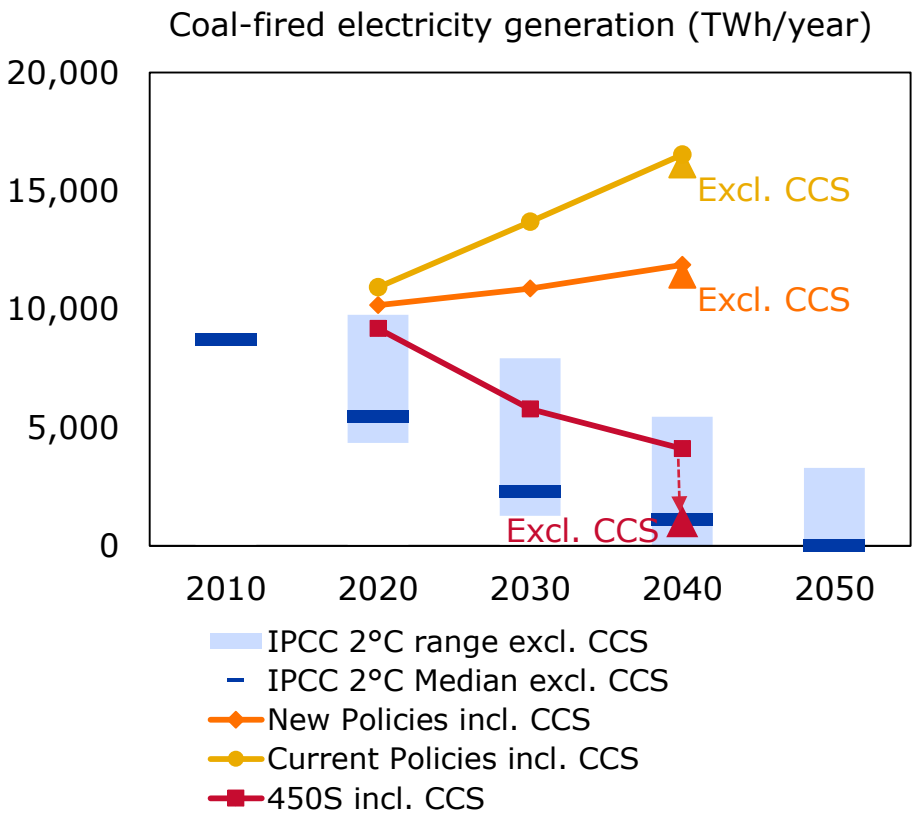
IEA 450 Scenario assumes **75% of coal power is from CCS** equipped plants in 2040

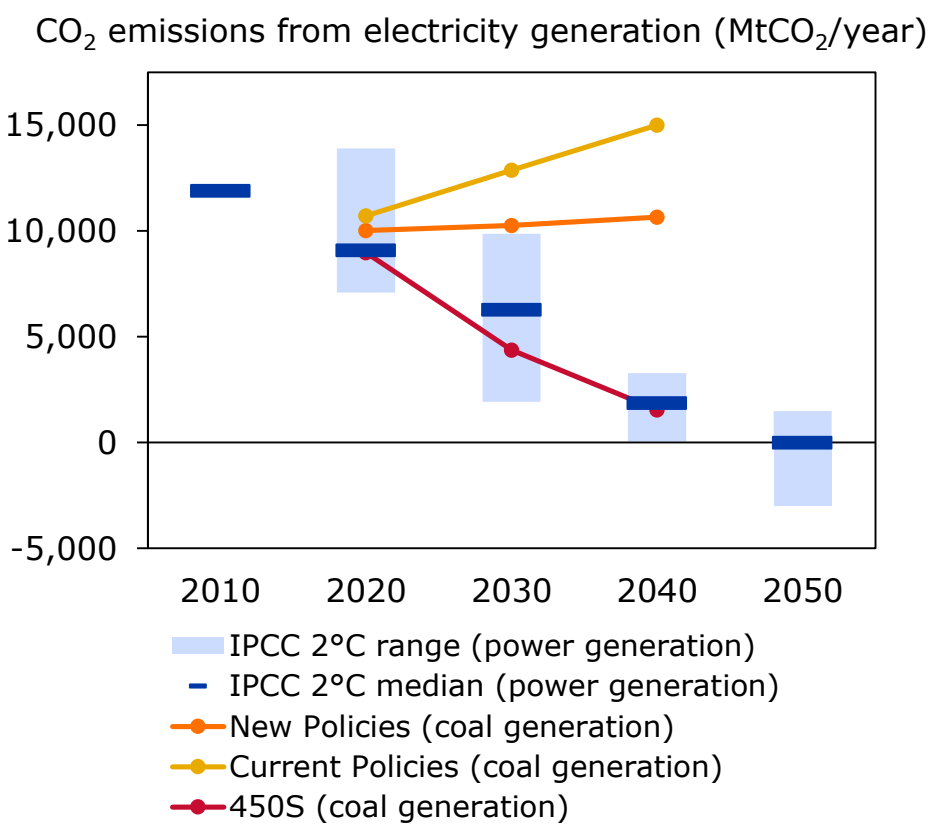
- IEA 450 scenario (450S) assumes a set of policies that are consistent with limiting the global temperature rise to <2°C. These include CCS assumptions:
  - CCS is deployed in the power sector from around 2020 in China, and 2025 in India
  - CCS is introduced to coal-fired power generation in Japan
  - Extended support to CCS is provided in the US and EU.
- 75% of coal power is from CCS equipped plants in 2040.



Source: International Energy Agency, 2015, World Energy Outlook.

Coal generation in 450S **consumes the total 2°C carbon budget** for electricity; emissions in New/Current Policy Scenarios are too high



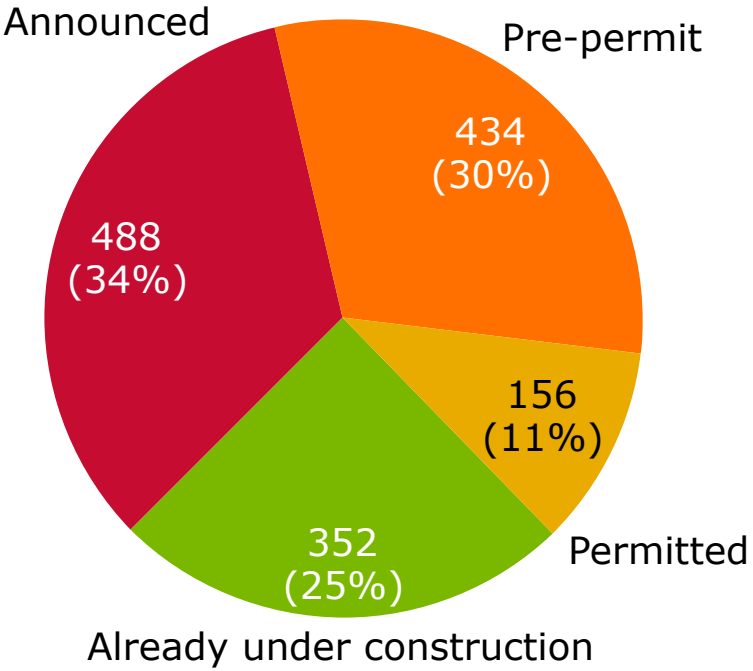


- **IEA Current Policies Scenario** – takes into consideration only policies for which implementing measures have been formally adopted and assumes that these policies are unchanged in the future.
- **IEA New Policies Scenario** – incorporates policies and measures which have been adopted or announced, including energy related components of intended nationally determined contributions (INDCs).

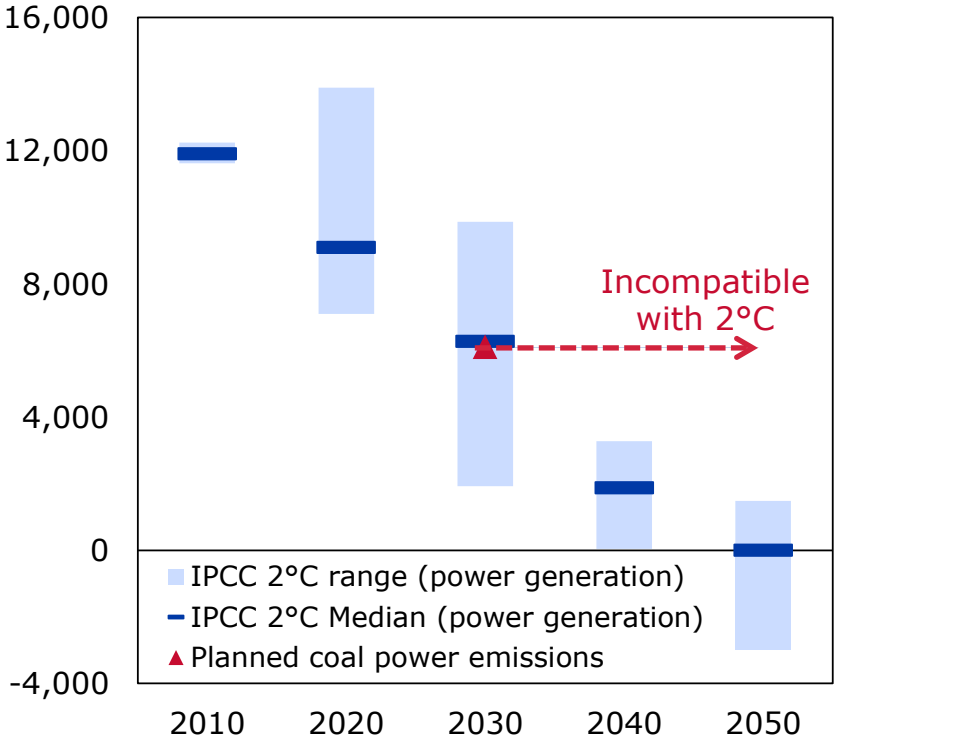
Annual emissions of planned coal plants would **consume the total 2°C carbon budget** for electricity generation in 2030

- 1,400 GW coal capacity is planned.
- Capacity factor of planned coal is **< 20%** (1,600 hours) in 2°C scenarios. This implies that there is a **weak business case** for planned coal capacity.
- The average emissions factor of this coal capacity is 830 gCO_2/kWh. This implies that **not all of these plants are HELE coal-fired electricity generation**.

Planned coal capacity (GW)



CO_2 emissions from planned coal electricity generation compared to 2°C scenarios ($MtCO_2$/year)



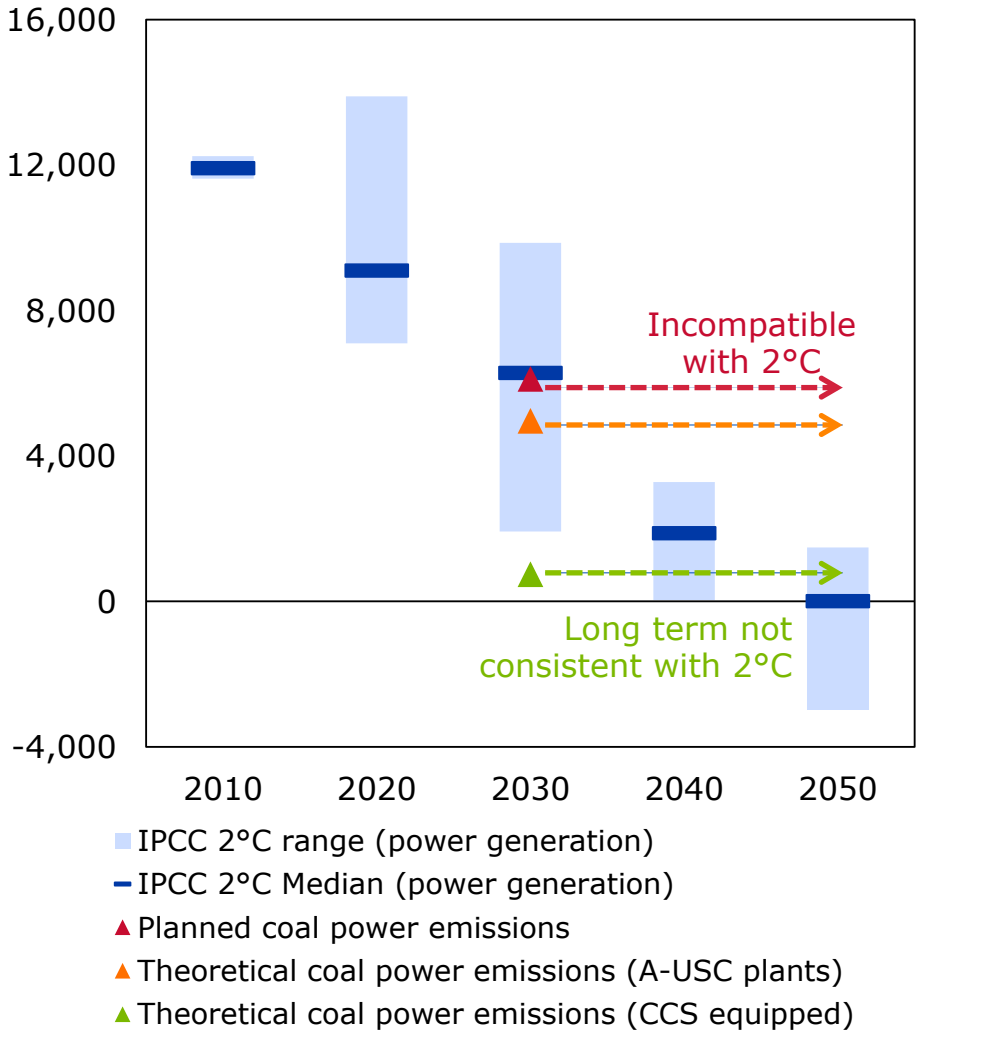
Source: Global Plant Tracker, 2016, Proposed Coal Plants by Country (MW) – January 2016.

If all planned coal capacity were HELE coal or CCS equipped, the 2°C goal would still not be in reach in the long term

- If all planned coal capacity were **HELE coal plants**, the CO_2 emissions is more than double the carbon budget from the entire power sector in 2040.

- If all planned coal capacity were **equipped with CCS**:
  - This is compatible with 2°C trajectory in 2030 and 2040.
  - **Low feasibility in 2030** as 5,400 $MtCO_2$/year needs to be captured (currently only 1 CCS power plant in operation, with capture capacity of 1 $MtCO_2$/year)
  - The CO_2 emissions from these plants will still **exceed the carbon budget in 2050** in 2°C pathways.

CO_2 emissions from planned/theoretical coal generation compared to 2°C scenarios ($MtCO_2$/year)



HELE coal technology is not compatible with 2°C pathways

- To be 2°C compatible, the electricity sector needs to be decarbonised by 2050 and coal-fired electricity generation without CCS needs to be phased out by 2050.
- Coal generation in the IEA 450 scenario consumes the total 2°C carbon budget for electricity sector in 2040, even with 75% of coal plants equipped with CCS.
- The IEA Current Policies and New Policies scenarios are not consistent with 2°C compatible pathways.
- 1,400 GW of planned coal capacity is not compatible with limiting warming to 2°C, even if all of the planned capacity were HELE plants. In 2050, this capacity of CCS plants is also not compatible with 2°C.
- The deviation from 2°C pathways would be even larger using more realistic assumptions:
  - This analysis used optimistic conversion efficiencies and deployment rates assumed for CCS/HELE generation
  - Lifecycle emissions were not included in this analysis.