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The Role of China's ETS in Power Sector Decarbonisation

中国碳市场在电力行业低碳转型中的作用

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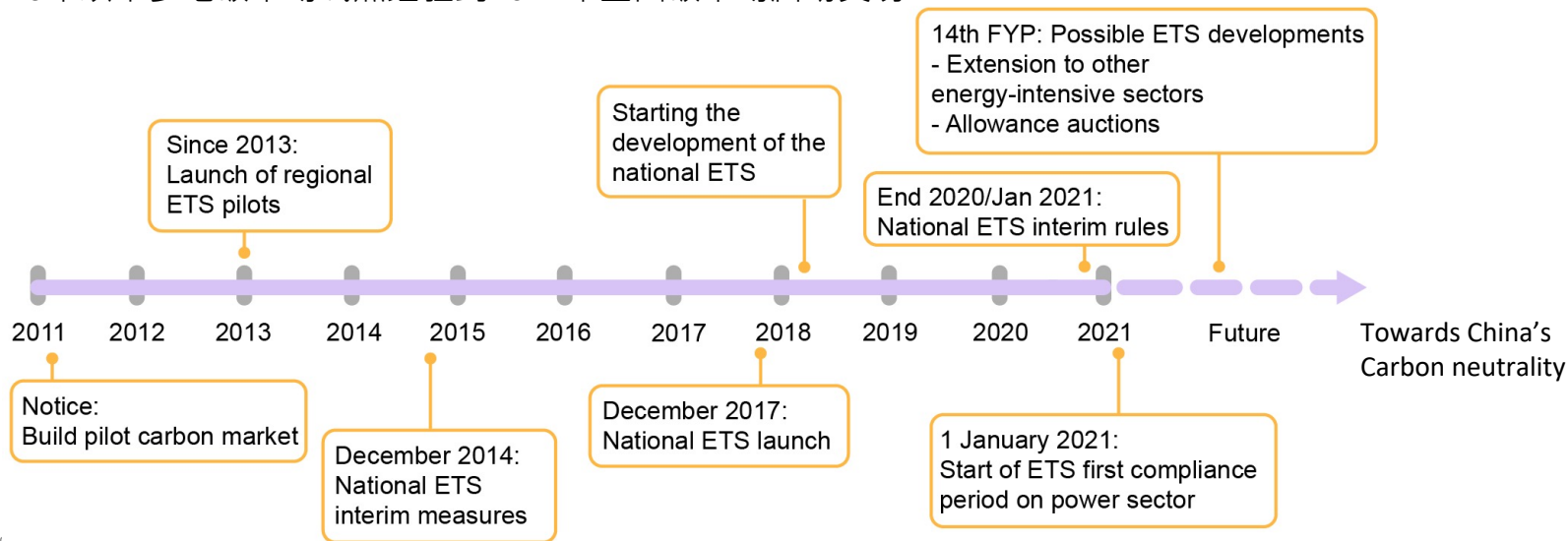
Overview of analysis design

研究设计概述

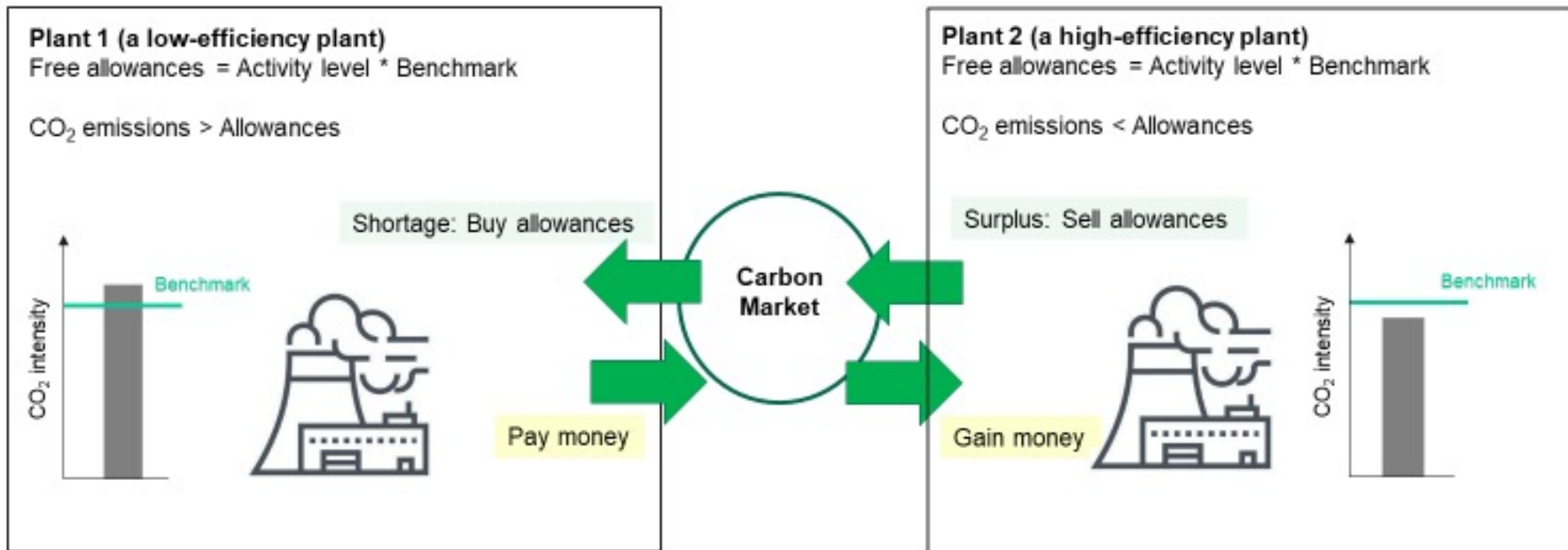
China's Emissions Trading System (ETS) in the new context

新背景下的中国碳排放权交易体系

- In September 2020, President Xi Jinping announced that China have CO₂ emissions peak before 2030 and achieve carbon neutrality before 2060
2020年9月，习近平主席宣布中国将力争于2030年前碳达峰，努力争取2060年前碳中和
- China's ETS takes part in a suite of policies to achieve China's ambitious climate goals
中国碳市场是实现中国气候雄心的政策之一
- From the ETS Pilots experiences since 2013 to the operation of the national ETS from 2021
从2013年以来多地碳市场试点经验到2021年全国碳市场启动交易



A stylized example of China's ETS



Output- and rate-based ETS allowance allocation design

基于产出和基准值的碳市场配额分配设计

- ETS first covers the power sector which emits over 4 Gt CO₂ each year (~40% of China's CO₂ emissions from fuel combustion)
碳市场将首先覆盖年排放总量超过40亿吨二氧化碳的电力行业 (占中国燃料燃烧产生的二氧化碳排放量的约40%)
- Output-based allowance allocation with emission intensity benchmarks for four categories of coal- and gas-fired units
基于产出的配额分配方案中，四类煤电和气电机组的排放强度基准

Mapping China's ETS benchmark categories with technologies
发电技术与其在中国碳市场基准适用类别对应关系

Fuel 燃料	Benchmark category 适用基准类别	Technology type 技术类型
Coal 燃煤	Unconventional coal-fired units 非常规煤电机组	Circulating fluidised bed (CFB) 循环流化床机组
	Conventional coal-fired units at and below 300 MW 300兆瓦级及以下常规煤电机组	High Pressure 高压机组 Subcritical ≤ 300 MW 亚临界300兆瓦级及以下机组 Supercritical ≤ 300 MW 超临界300兆瓦级及以下机组
	Conventional coal-fired units above 300 MW 300兆瓦级以上常规煤电机组	Subcritical > 300 MW 亚临界300兆瓦级以上机组 Supercritical > 300 MW 超临界300兆瓦级以上机组 Ultra-supercritical 超超临界机组 Coal+CCS 煤电耦合碳捕集与封存技术机组
Gas 燃气	Gas-fired units 燃气机组	Gas 燃气机组 Gas+CCS 燃气耦合碳捕集与封存技术机组

Objective of the analysis and scenario design 研究目标和情景设计

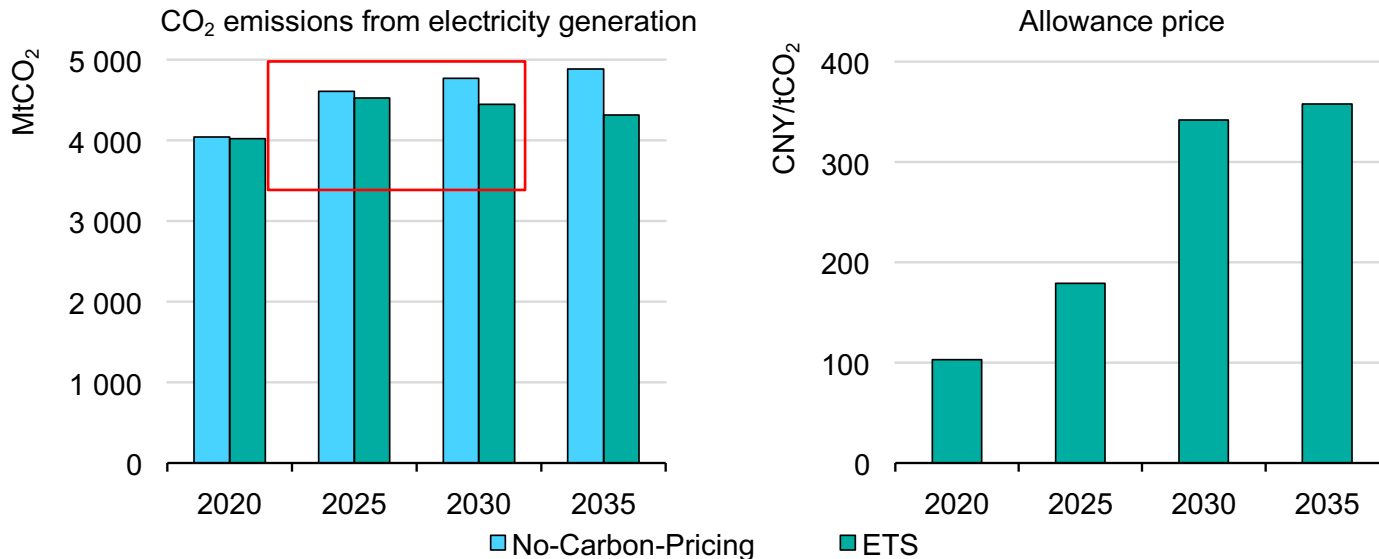
Scenario 情景	Emissions-control instrument 碳排放控制机制	Instrument adjustment over time 政策演变设计						Objective 情景目标		
No-Carbon-Pricing Scenario 无碳价情景	No specific emissions controls 无碳排放控制	-/-						Counterfactual 对照情景		
		Allowance allocation 配额分配				Benchmark trajectory 基准线调整				
						2020-25	2025-30	2030-35		
ETS Scenario 碳市场情景	Emission Trading System 碳市场	Free allocation 免费分配				Benchmark tightening at the same rate for all coal-fired units' benchmarks. 煤电机组基准线以同样速率收紧	3%	6%	6%	Main ETS scenario 主碳市场情景
						Constant benchmark for gas-fired units. 气电机组基准线保持不变				
ETS Auctioning Scenario 碳市场拍卖情景	Emission Trading System 碳市场	Share of allowances auctioned 配额拍卖比例				Benchmark tightening at the same rate for all coal-fired units' benchmarks. 煤电机组基准线以同样速率收紧	3%	6%	6%	Explore impacts of gradual phase-in of allowance auctioning 探究逐步引入配额拍卖的影响
		2020	2025	2030	2035					
		0%	10%	30%	50%					
						Constant benchmark for gas-fired units. 气电机组基准线保持不变				

Key findings

主要结论

China ETS can cost-effectively peak power sector CO₂ emissions well before 2030... 中国碳市场可经济有效地促使电力行业碳排在2030年前达峰

CO₂ emissions from electricity generation and allowance prices in the No-Carbon-Pricing and ETS scenarios
无碳价情景和碳市场情景下发电产生的碳排放和碳市场配额价格

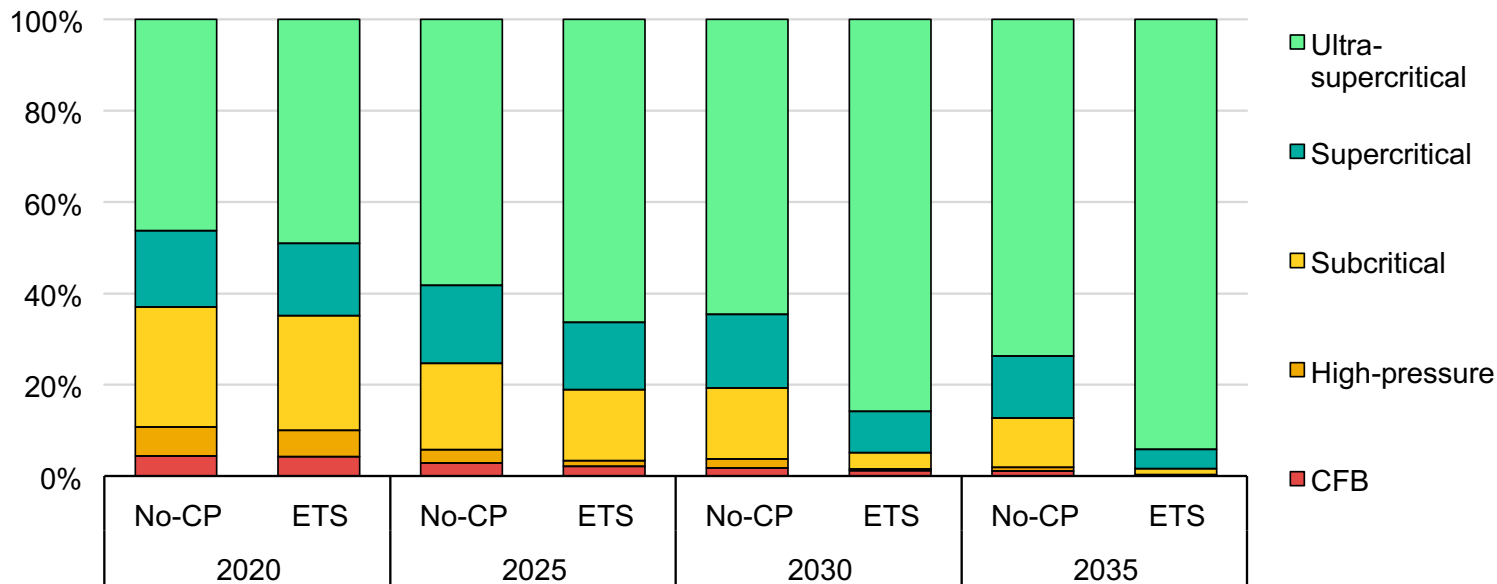


- **With benchmarks that are gradually tightened, China's national ETS can effectively reverse the upward trend of CO₂ emissions from electricity generation and support power sector emissions to peak well before 2030.** 随着基准线逐步收紧，中国碳市场可以有效地扭转发电产生的碳排放不断上升的趋势并支持发电碳排放远在2030年前达峰。
- **In 2035, CO₂ emissions from electricity generation would be 12% lower in the ETS Scenario (a drop of ~570 Mt CO₂).** 2035年，碳市场情景下发电碳排放将比无碳价情景低12%（约降低5.7亿吨二氧化碳）。

ETS encourages shift to ultra-supercritical generation and improves average efficiency of China's coal power

碳市场激励煤电转向超超临界技术并提高中国煤电的平均效率

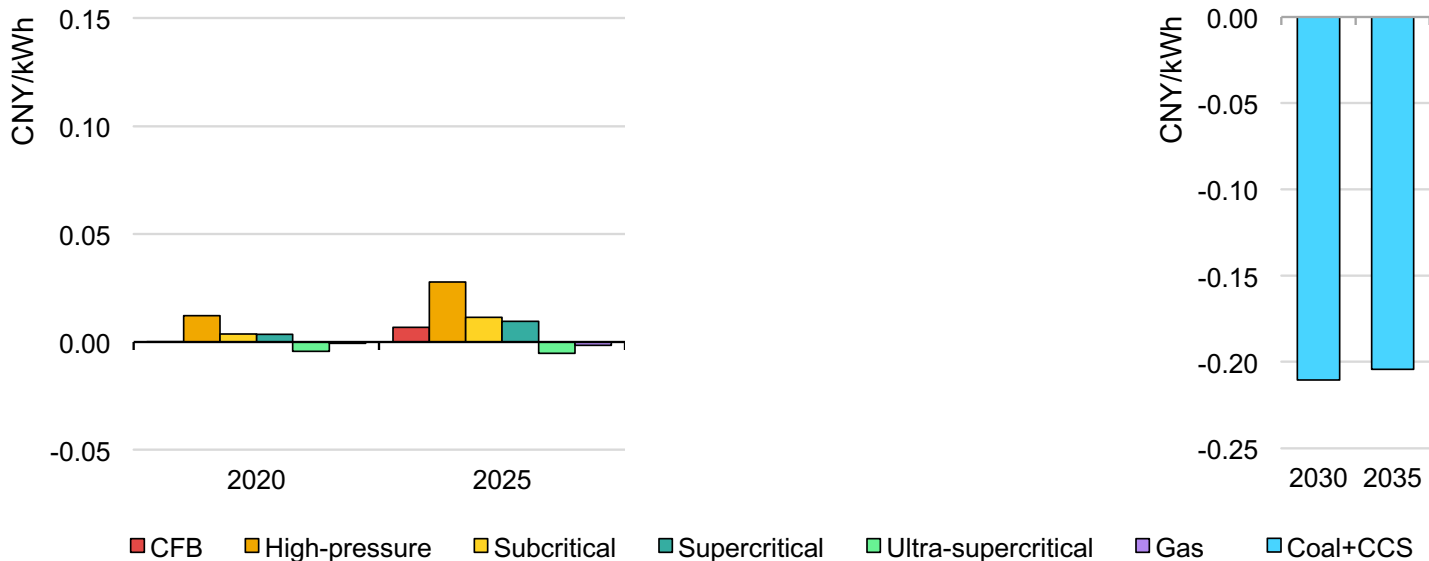
Electricity generation by unabated coal-fired power technology in the No-Carbon-Pricing and ETS scenarios
无碳价情景和碳市场情景下煤电发电结构



- Average **energy consumption** level of unabated coal generation improves to **275 gce/kWh by 2035** in the ETS Scenario, 11% lower than the 13th FYP target of 310 gce/kWh; **emission intensity decreases to 764 gCO₂/kWh**.
2035年碳市场情景下煤电平均供电煤耗降低至275克标煤/千瓦时，比“十三五”目标的310克标煤/千瓦时低11%；未加装CCUS的燃煤发电的碳排放强度相应降低到764克二氧化碳/千瓦时。

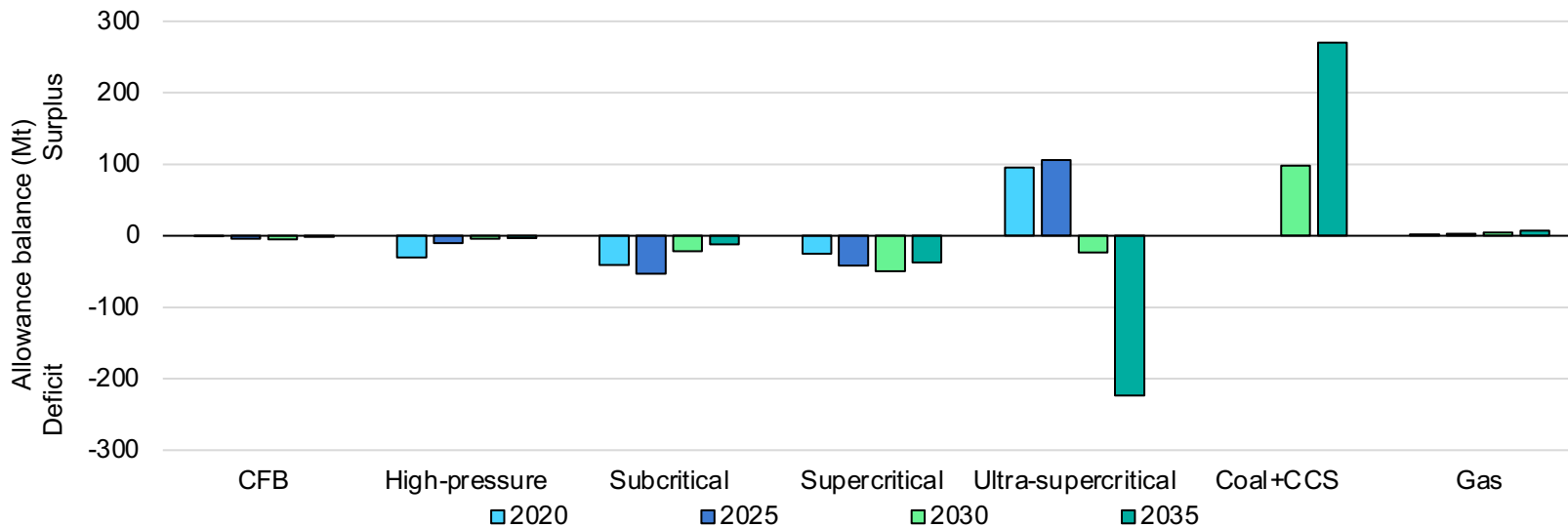
With multiple benchmarks and free allocation, ETS could make CCUS competitive, but provides little incentives to gas and non-fossil sources 在多基准线且免费分配配额的情况下，碳市场可使CCUS技术具备成本竞争力，但对气电和非化石能源发电的激励有限

Average CO₂ cost by technology in the ETS Scenario
碳市场情景下分技术平均实际碳成本



- The **effective CO₂ cost for coal units remains limited** under output-based and free allocation design (CNY ~0.02/kWh on average in 2035), which is too small to close the cost gap and incentivise fuel switch. 在基于产出且配额免费分配的设计下，煤电技术面临的实际碳成本有限（2035年平均为0.02元/千瓦时），这一碳成本无法弥补发电成本差距，难以有效激励燃料替代

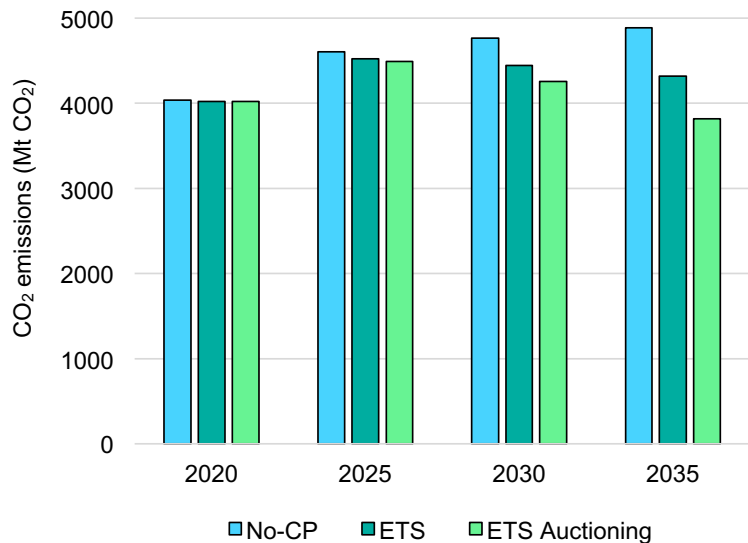
Evolution of allowance balance by technology in the ETS scenario
碳市场情景下各技术配额平衡情况



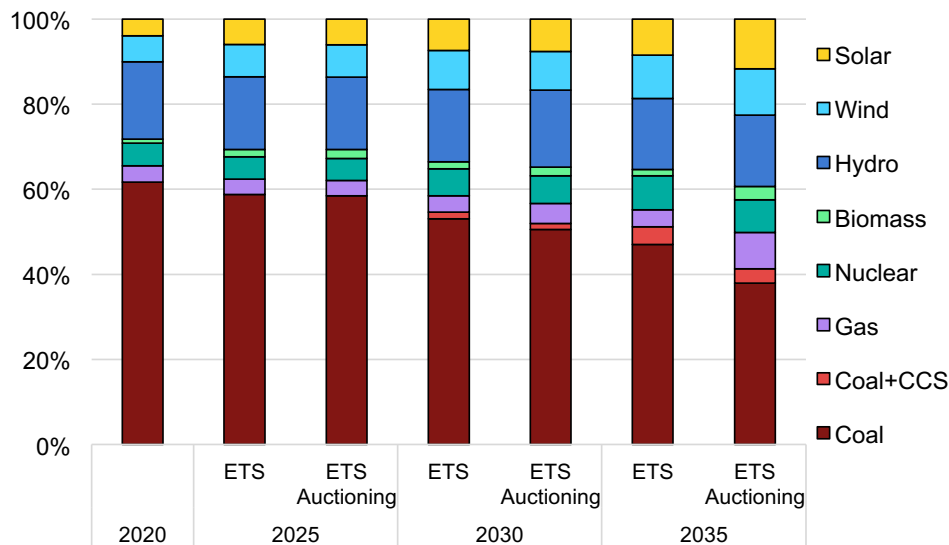
- As benchmarks tighten, the main beneficiary of the ETS shifts **from ultra-supercritical** units which perform better than the benchmark, **to coal+CCS technology** by around 2030. 随着基准线的缩紧，到2030年左右，碳市场的主要受益者从表现优于基准线要求的超超临界机组，转向部署了碳捕集和封存技术的煤电。

Gradual introduction of allowance auctioning can further decarbonise the power sector... 逐步引入配额拍卖可进一步促进电力行业的低碳转型

CO₂ emissions from electricity generation by scenario
不同情景下的发电碳排放



Electricity generation by technology
in the ETS and ETS Auctioning scenarios
碳市场情景和碳市场拍卖情景下的发电结构



- A moderate phase-in of allowance auctioning in the output-based ETS could reduce CO₂ emissions from electricity generation **by an additional 10% (~500 Mt CO₂) in 2035**, leading CO₂ emissions from the electricity system to **fall below 2020-levels**. 在采用基于产出设计的碳市场中适度引入配额拍卖可使2035年的发电碳排放进一步降低10% (约5亿吨二氧化碳), 从而使其降低到2020年水平之下。

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