International Energy Agency

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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

Key findings and recommendations
主要结论与建议

20 April 2021
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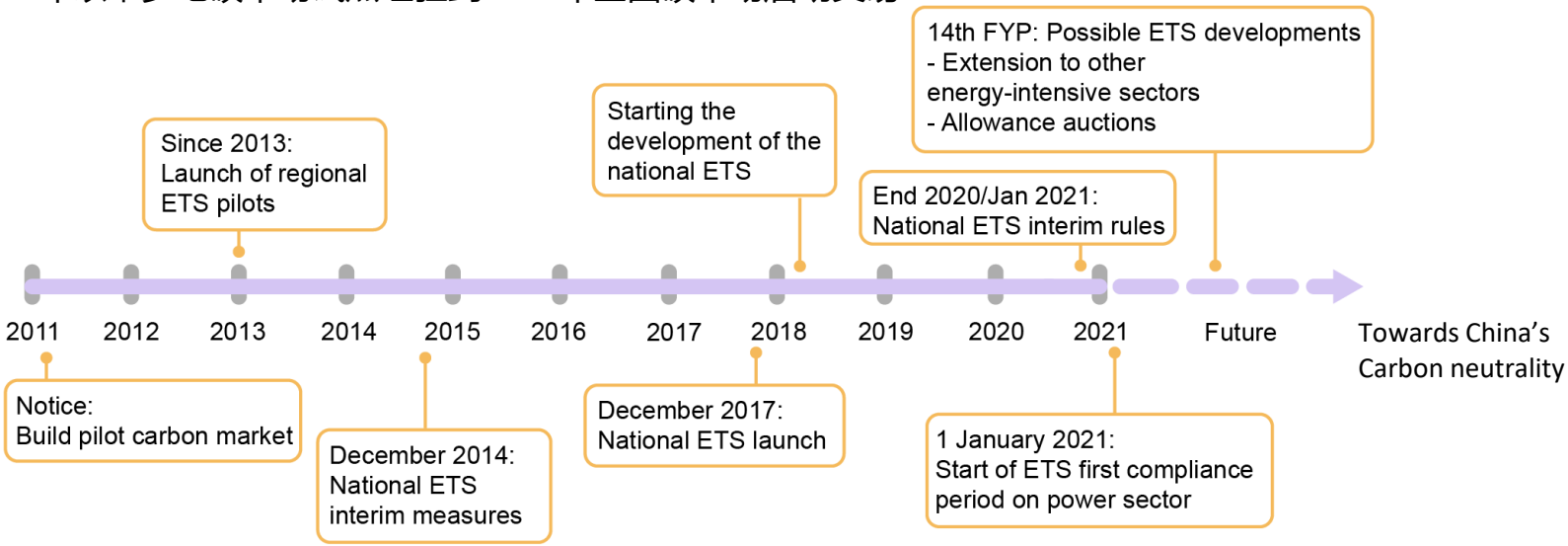
Overview of analysis design
研究设计概述

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 annouced that China have CO_2 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



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 CO_2 each year (~40% of China's CO_2 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

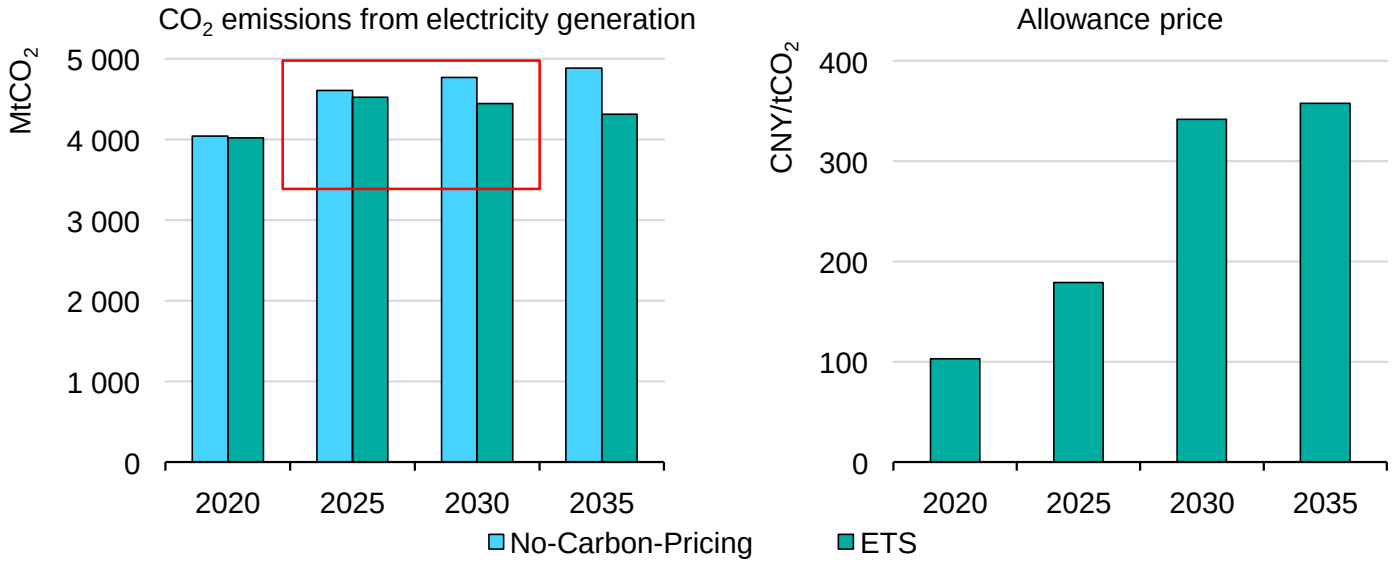
Scenario 情景	Emissions-control instrument 碳排放控制机制	Instrument adjustment over time 政策演变设计				Objective 情景目标
No-Carbon-Pricing Scenario 无碳价情景	No specific emissions controls 无碳排放控制	-/-				Counterfactual 对照情景
		Allowance allocation 配额分配	Benchmark trajectory 基准线调整			
				2020-25	*2025-30*	*2030-35*	
ETS Scenario 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: 0% / *2025*: 10% / *2030*: 30% / *2035*: 50%	Constant benchmark for gas-fired units. 气电机组基准线保持不变				

Note: Percentage values show reductions over the five-year periods.

Key findings
主要结论

China ETS can cost-effectively peak power sector CO_2 emissions well before 2030… 中国碳市场可经济有效地促使电力行业碳排放在2030年前达峰

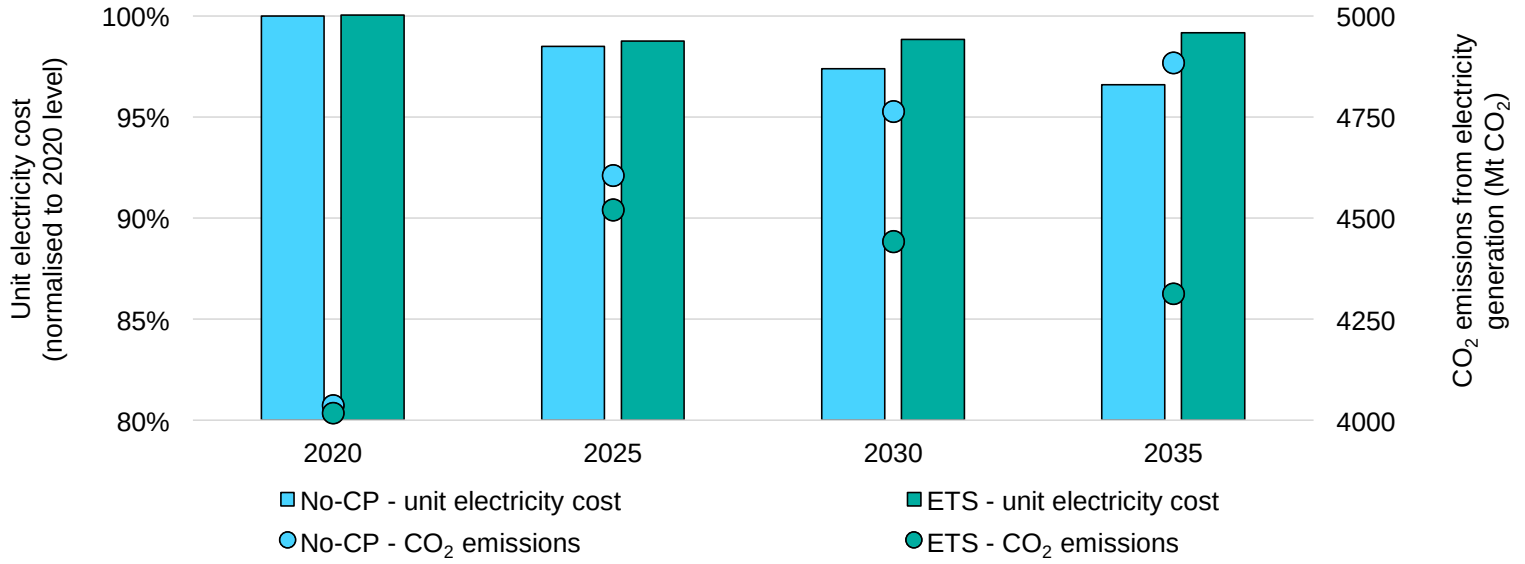
CO_2 emissions from electricity generation and allowance prices in the No-Carbon-Pricing and ETS scenarios
无碳价情景和碳市场情景下发电产生的碳排放和碳市场配额价格



- **With benchmarks that are gradually tightened,** China's national ETS can effectively **reverse the upward trend of CO_2 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, CO_2 emissions from electricity generation would be **12% lower** in the ETS Scenario **(a drop of ~570 Mt CO_2)**. 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）。

…while the average electricity cost remains at the 2020 level
且平均度电成本保持与2020年水平相当

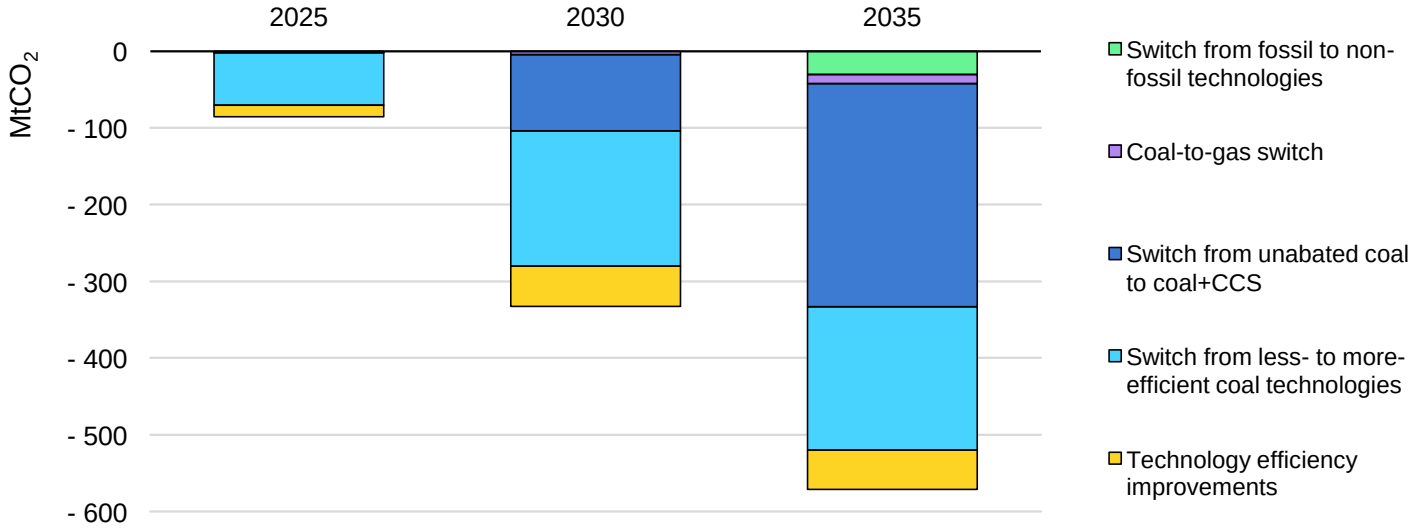
Unit electricity cost and CO_2 emissions from electricity generation in the No-Carbon-Pricing and ETS scenarios
无碳价情景和碳市场情景下度电成本和发电碳排放总量



- By 2035, the ETS, in combination with power sector reform, could achieve **a 12% annual emissions reduction** while unit electricity cost is **only 2.7% higher** than in the No-Carbon-Pricing Scenario. 到2035年，结合电力体制改革，碳市场相比无碳价情景可在实现年12%减排量的同时，保持度电成本仅增长2.7%。

The output-based ETS drives emissions reductions mainly by improving coal power efficiency and incentivising CCUS deployment
基于产出的碳市场主要通过提高煤电效率和激励CCUS技术部署实现减排

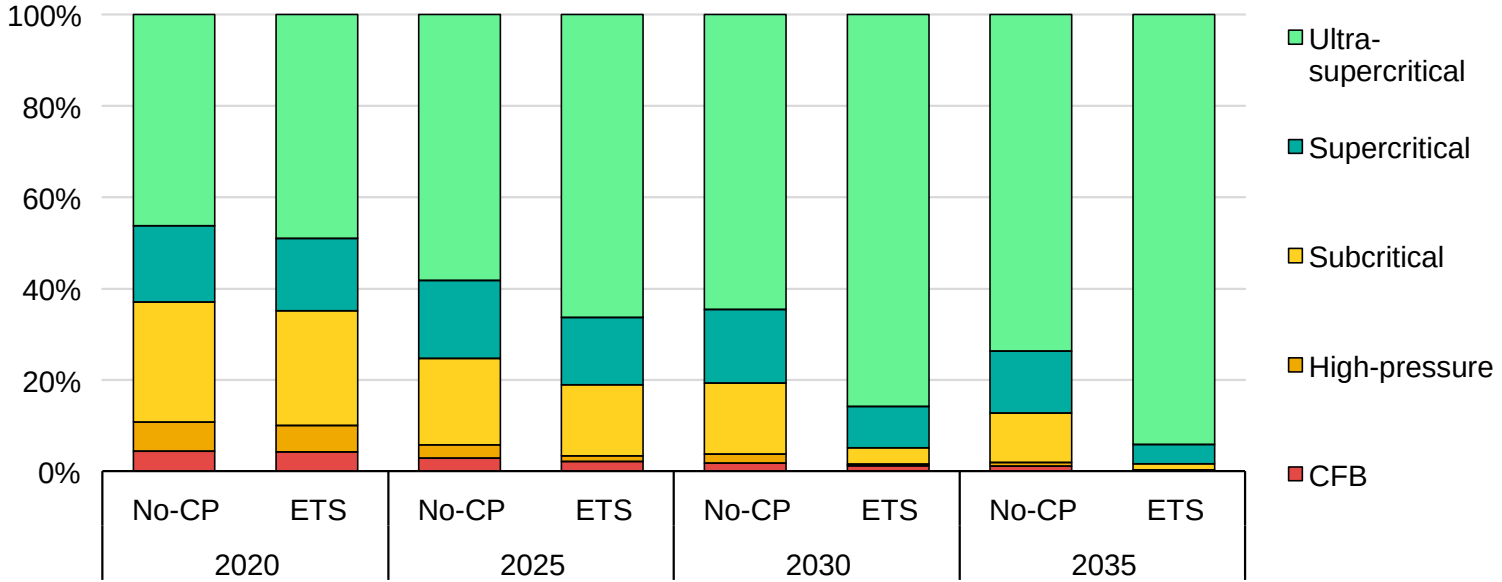
Factors yielding additional emissions reductions in the ETS Scenario compared with the No-Carbon-Pricing Scenario
碳市场情景相比无碳价情景的额外减排量分解



- From 2020 to 2030, CO_2 emissions reductions mainly result from shift **from less- to more-efficient unabated coal-fired technologies**. From 2030 onwards, the ETS could support CCUS deployment for coal power plants as benchmarks tighten.
  2020到2030年，碳减排主要来自高效煤电机组对低效煤电机组的替代。2030年后，随着基准线收紧，碳市场可推动碳捕集和封存技术在煤电行业的部署。
- Switch to **gas or non-fossil technologies** play only **marginal role** for additional emissions reductions in the ETS Scenario.
  煤电改气电和非化石能源发电对碳市场情景下额外减排的贡献非常有限。

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

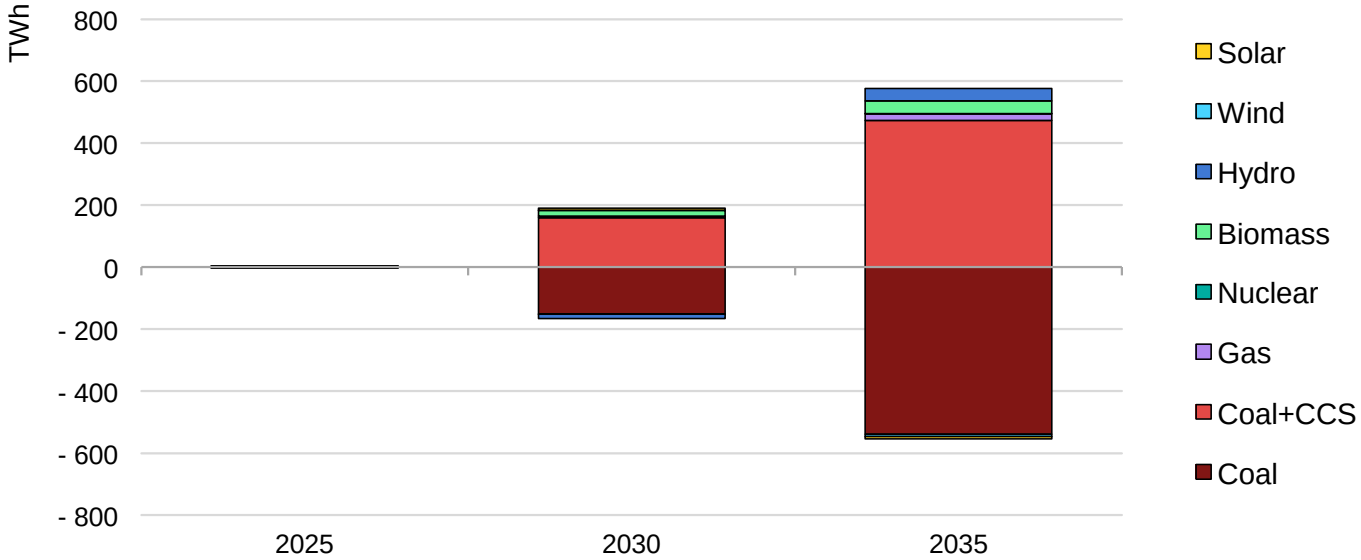
Electricity generation by unabated coal-fired power technology in the No-Carbon-Pricing and ETS scenarios
无碳价情景和碳市场情景下煤电发电结构



- 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 gCO_2/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。

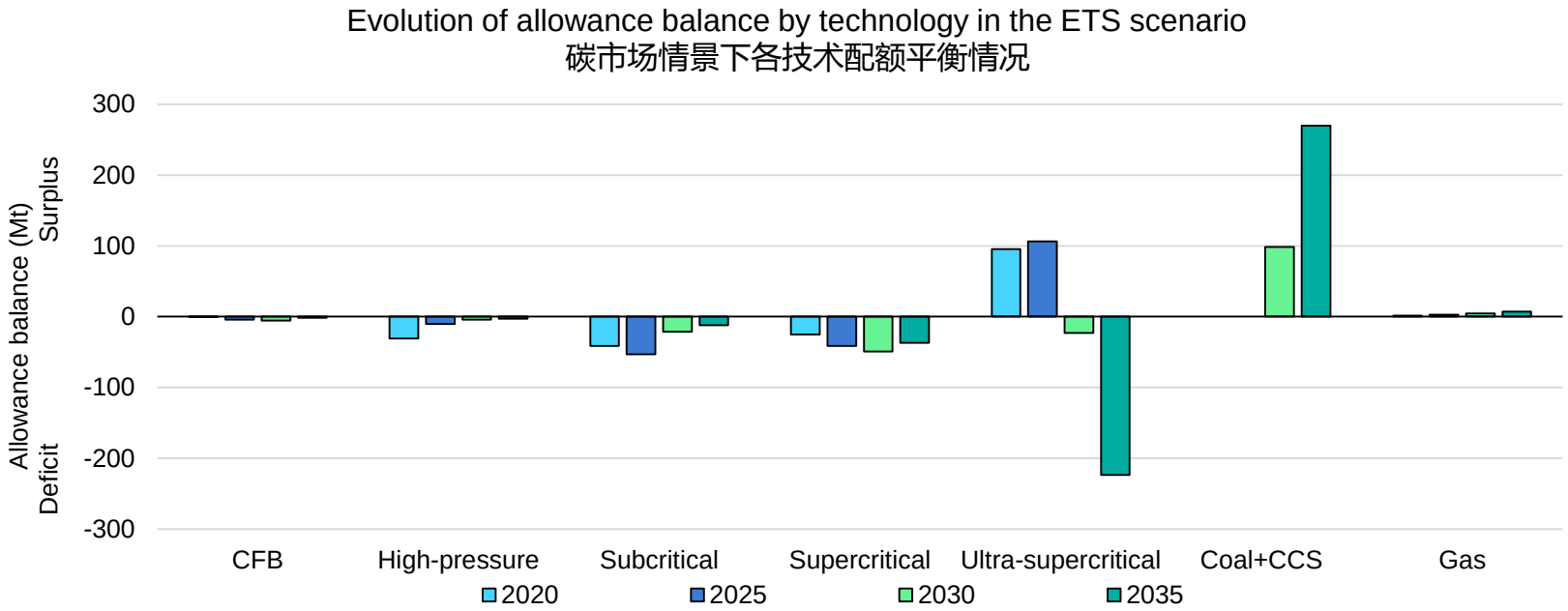
ETS could serve as a key driver for CCUS uptake in the power sector, but has limited effect on encouraging gas or non-fossil sources 碳市场可能成为电力行业部署CCUS技术的重要驱动力，但对激励气电和非化石能源利用的作用有限

Power generation difference by fuel between the No-Carbon-Pricing and ETS scenarios
无碳价情景和碳市场情景下发电量差异



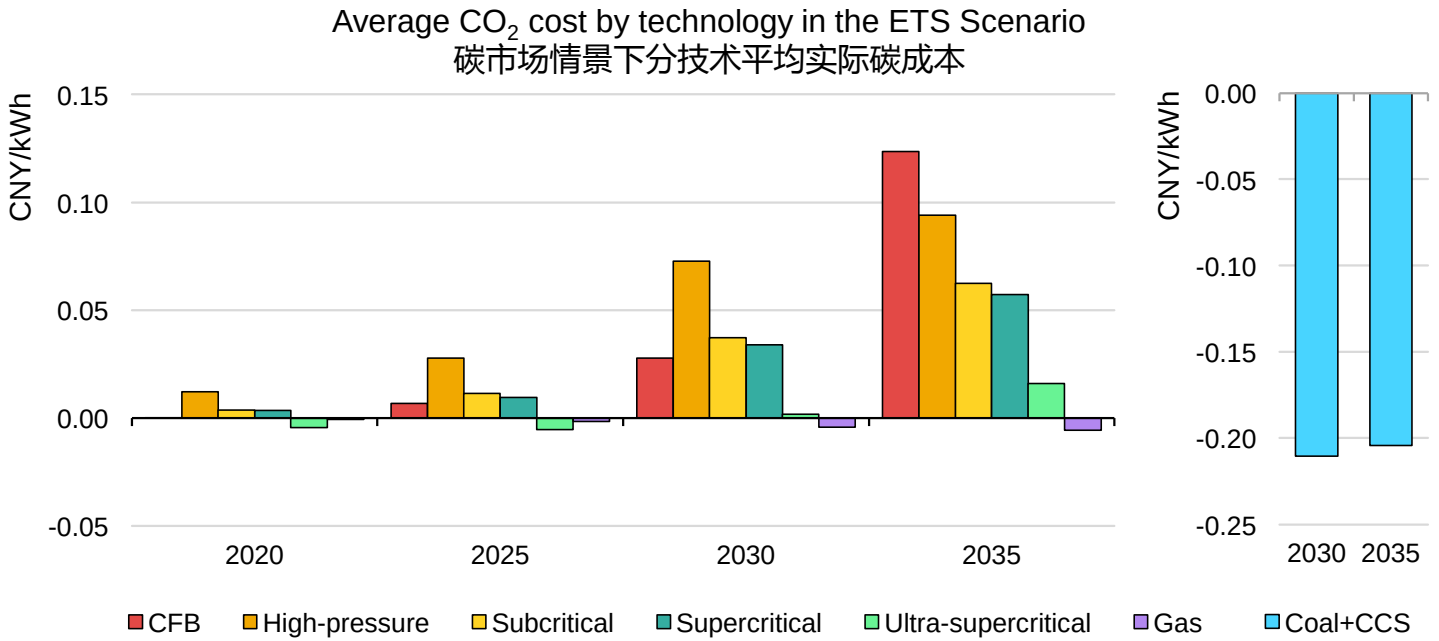
- Coal+CCS technology enters the mix by 2030 in the ETS Scenario, and could account for 8% (473 TWh) of coal power generation in 2035. However, **gas- and non-fossil-based power only see marginal increase** compared with the No-Carbon-Pricing Scenario. 在碳市场情景下，CCS技术在2030年前应用于电力行业，到2035年加装CCS的燃煤机组的发电量可占燃煤发电总量的8%。然而， 燃气发电量和非化石能源发电量相比无碳价情景仅有略微增长。

The allowance allocation design affects technology competitiveness
碳市场配额分配设计影响各技术竞争力



- 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。

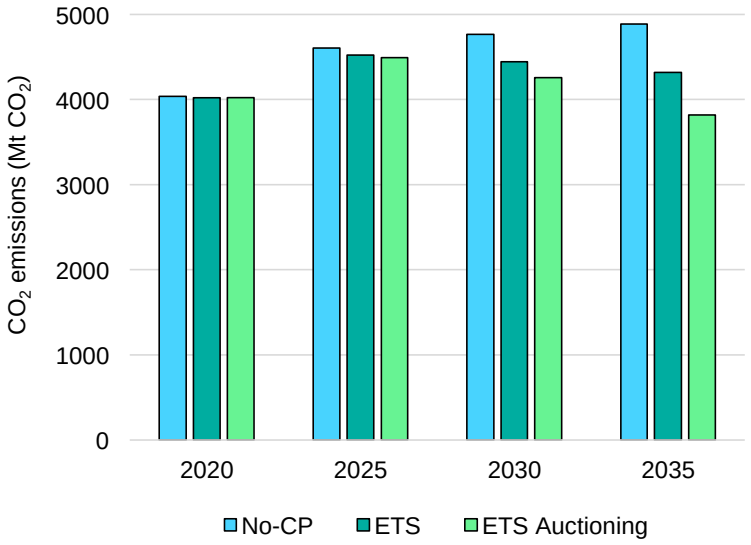
With multiple benchmarks and free allocation, ETS could make CCUS competitive, but provides little incentives to gas and non-fossil sources在多基准线且免费分配配额的情况下，碳市场可使CCUS技术具备成本竞争力，但对气电和非化石能源发电的激励有限



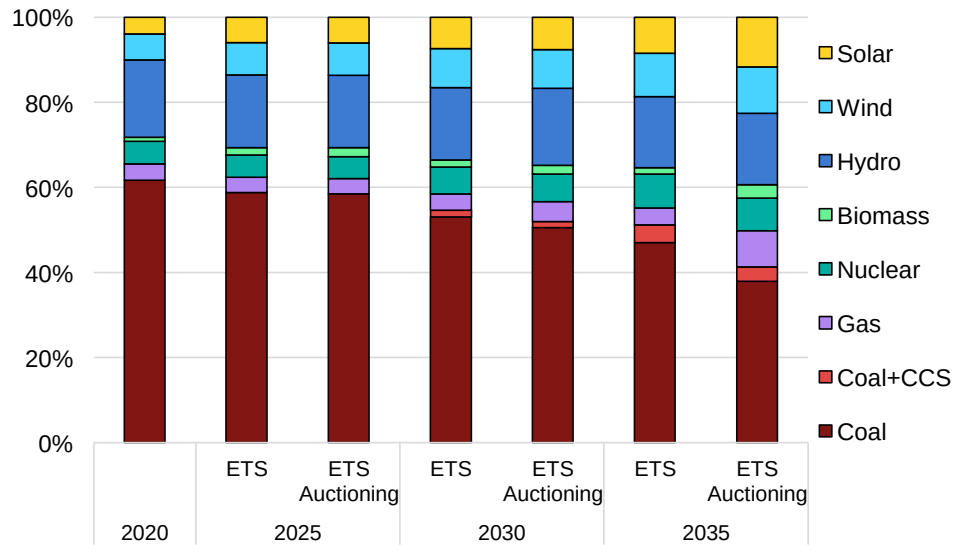
- The **effective CO_2 cost for coal units remains limited** under output-based and free allocation design (CNY ~0.02/kWh on average in 2035), which is too small to close the cost gap and incentivise fuel switch. 在基于产出且配额免费分配的设计下，煤电技术面临的实际碳成本有限（2035年平均为0.02元/千瓦时），这一碳成本无法弥补发电成本差距，难以有效激励燃料替代

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

CO_2 emissions from electricity generation by scenario
不同情景下的发电碳排放



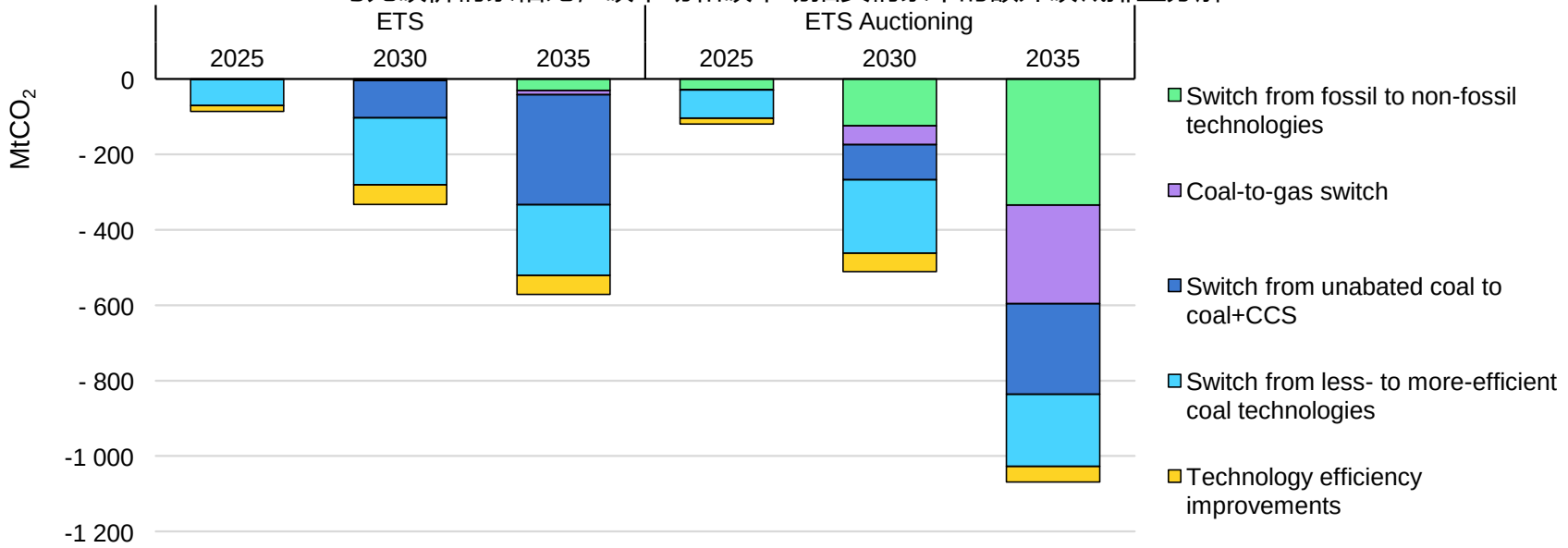
Electricity generation by technology
in the ETS and ETS Auctioning scenarios
碳市场情景和碳市场拍卖情景下的发电结构



- A moderate phase-in of allowance auctioning in the output-based ETS could reduce CO_2 emissions from electricity generation **by an additional 10% (~500 Mt CO_2) in 2035**, leading CO_2 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。

…by providing stronger incentives for fuel switching and structural transition 通过对燃料替代和结构转型提供更强有力的激励措施

Factors yielding additional emissions reductions in the ETS and ETS Auctioning scenarios compared with the No-Carbon-Pricing Scenario
与无碳价情景相比，碳市场和碳市场拍卖情景中的额外碳减排量分解



- **Gradually introducing allowance auctioning** in the output-based ETS could drive significant additional emissions reductions, mainly from fuel **switch from coal to gas and non-fossil technologies**. 在基于产出的碳市场中逐步引入配额拍卖可以明显推动碳排放的进一步降低，且额外碳减排将主要来自于气电和非化石燃料技术对煤电的替代。

Policy recommendations
政策建议

1. Tighten ETS benchmarks and gradually merge benchmarks
持续收紧配额基准值、逐步融合基准线

- **Stringent benchmarks** will be essential for an output-based ETS to have solid price signal and drive power sector decarbonisation.
  对于基于产出的碳市场，**碳排放基准值的严格程度**对其在推动电力行业减排方面的作用至关重要。

- **Benchmarks need to be gradually tightened** to integrate efficiency and emissions intensity improvements of the power fleet over time and to avoid **risk of over-allocation.**
  随着机组效率的提高、排放强度的降低，**基准值**需结合此变化**不断收紧**，**降低系统中配额过剩的风险。**

- **Merging benchmarks would guide more cost-effective** emissions reductions and provide stronger incentives for low-emission units and fuel switching.
  融合基准线将引导更为**经济有效**的减排措施，为低排放机组和燃料替代提供更有力的激励。

- **Clear benchmark trajectory will enhance ETS effectiveness** and provide visibility and certainty for market participants.
  清晰的基准值收紧方案将为市场参与者提供可预测性和确定性，提高碳市场有效性、加速电力行业的低碳转型。

2. Accelerate power market reform to amplify the effects of the ETS
加速电力体制改革以加强碳市场的作用

- **Coordinate ETS and power market reform** to be mutually supportive in transforming power sector to be more efficient, cost-optimized and low-carbon.
  电力体制改革和碳市场建设有共同的目标，即推动电力部门高效、低排放和低成本资源的利用，二者应彼此协调、相互支持。

- **Reform towards least-cost dispatch** will **allow the merit order to take into account the carbon cost** imposed by the ETS.
  经济调度改革将把碳市场给机组增加的**碳成本纳入电力调度决策中**，对碳市场在电力行业有效发挥作用尤为重要。

- **ETS will help to internalize the carbon costs** of electricity generation and enable less-emitting technologies to operate more.
  碳市场可助力电力体制改革，**将发电的碳排放成本融入决策中**，提升排放强度较低的发电技术的利用率。

- Deeper power sector reform will also allow cost pass-through to end-use sectors in the future, guiding **decarbonisation on the demand side**.
  未来更加充分的电力体制改革能将碳价更好的传导到用电部门，**释放需求侧减排**的潜力。

3. Gradually introduce allowance auctioning
适时逐步引入配额拍卖制度

- Allowance auctioning in China's output-based ETS would **further incentivise fuel switching to non-fossil sources and gas-fired power, and drive more structural transformation** of the power sector.
在基于产出的碳市场中引入配额拍卖制度将强化碳市场对非化石能源和燃气替代燃煤发电的激励作用，从而推动电力部门进一步的**燃料替代和结构转型。**

- Introducing auctioning could provide guiding price signal and **increase market liquidity**.
配额拍卖制度还可以起到释放引导性价格信号，增强市场流动性的作用。

- **Gradually phasing in allowance auctioning according to a clear timeline** could keep electricity cost increase moderate.
配合清晰的政策时间线，逐步地引入部分配额拍卖可以在加速转型的同时把供电成本的提高程度控制在适当的水平。

- **Revenues generated by allowance auctioning** can be used to address **electricity affordability and the distributional effects** of the ETS, as well as to invest in **low-carbon technology development** to foster more rapid decarbonisation.
拍卖产生的收入可用于解决低收入群体**对于能源价格的负担能力**和碳市场**分配公平性**问题，亦可用于**投资低碳技术**，促进更快的脱碳。

4. Transition to a mass-based design with a fixed cap
适时引入总量控制的设计，设置固定的排放量上限

- Transitioning to a mass-based design with an absolute cap would **provide significantly more certainty for controlling total emissions** from sectors covered by the ETS.
  适时引入总量控制的设计，设置固定的排放量上限，将为**控制碳市场覆盖的各行业排放总量提供确定性。**

- **An ETS cap could further support China's climate ambitions** to have CO_2 emissions peak before 2030 and reach carbon neutrality before 2060.
  通过控制纳入碳市场的不同行业的碳排放总量，可更加有力地支撑中国到2030年前碳达峰、2060年前碳中和的气候目标的实现。

- Mass-based ETS design would **send uniform carbon price signals** and **promote the most cost-effective choices** for emissions reductions.
  采用总量控制的设计也将使碳市场**给出统一的碳价信号，推动最经济有效的减排方式。**

5. Strengthen policy co-ordination in ETS implementation and expansion
加强碳市场在实施和扩展过程中的政策协调

- **Renewables deployment 可再生能源发展政策:**
  - Co-ordinating the ETS with policies including the Chinese Certified Emissions Reduction (CCER) offsetting scheme, renewable portfolio standards or green power trading certificates to enhance mitigation and accelerate the low-carbon energy transition while reducing the overall costs
    将碳市场与中国核证自愿减排量(CCER)、可再生能源配额制或绿色电力证书交易机制等政策进行协调，将有助于促进减排、加速低碳能源转型，同时降低转型的总体成本

- **Technology innovation 技术创新支持:**
  - Combining direct support policy to de-risk investment for nascent technologies, build infrastructure and reduce costs, and ETS price signal to help critical technologies to be competitive and scale up
    结合直接支持政策来进行风险投资新兴技术、建设基础设施和降低成本，同时碳市场的价格信号可帮助关键技术提高成本竞争力和规模化发展。

- **Energy efficiency 能效提升政策:**
  - Explore synergies between ETS and energy efficiency measures, in power sector and in key energy-intensive industries, to drive supply- and demand-side switching to low-carbon sources.
    在电力部门和关键能源密集型行业，探索碳市场与能效政策的协同，推动供应侧和需求侧转向使用低碳能源。

Policy recommendations 政策建议

1. Tighten ETS benchmarks and gradually merge them to enhance the effectiveness of the output-based design.
   持续收紧配额基准值、逐步融合基准线，保证基于产出的碳市场的有效性
2. Accelerate power market reform to amplify the effects of the ETS.
   加速电力体制改革以加强碳市场的作用
3. Gradually introduce allowance auctioning to provide stronger signals for fuel switching and to generate revenues.
   适时逐步引入配额拍卖制度，为燃料替代提供更强的碳价信号，同时创造拍卖收入
4. Transition to a mass-based design with a fixed cap to guarantee emissions trajectory certainty and support its emissions-peaking and carbon-neutrality goals.
   逐步将碳市场转向总量控制的设计，设置固定的排放量上限，以保证碳排放总量的确定性，支持碳达峰和碳中和目标
5. Strengthen policy co-ordination for ETS implementation in the power sector and its expansion to other industries, e.g. co-ordinate it with renewables deployment, energy efficiency and CCUS support policies.
   加强碳市场与其它关联政策的协调，包括在电力行业实施和向其它行业扩展过程中，碳市场与可再生能源发展、能效提升、支持碳捕集和封存技术发展等政策的协调。

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Report:

- English version
- Chinese executive summary