



ENERGY FOUNDATION
能源基金会

Synthesis Report 2020 on China's Carbon Neutrality 中国碳中和综合报告2020

Leon Clarke for the Research and Writing Team Leon Clarke代表全体研究和报告撰写团队

December 10, 2020 2020年12月10日

Author Team 作者团队



SCHOOL OF
PUBLIC POLICY
CENTER FOR GLOBAL
SUSTAINABILITY

Coordinating lead authors 主要协调作者

- Energy Foundation China: Sha Fu, Xuan Du 能源基金会（中国）：傅莎，杜譔
- University of Maryland: Leon Clarke, Sha Yu 美国马里兰大学：Leon Clarke，余莎



哈爾濱工業大學
HARBIN INSTITUTE OF TECHNOLOGY



交通运输部科学研究院
China Academy of Transportation Sciences

Lead authors (Listed by alphabetical order of institutions and authors)

主要作者（按照单位和作者字母顺序排列）

- China Academy of Transportation Sciences: Zhenhua Feng, Xuecheng Wang 交通运输部科学研究院 凤振华，王雪成
- Energy Foundation China: Lingyan Chen, Zhuoxiang Yang 能源基金会（中国）陈灵艳，杨卓翔
- Harbin Institute of Technology, Shenzhen: Junling Liu 哈尔滨工业大学（深圳）刘俊伶
- Innovative Green Development Program: Li Yang 绿色创新发展中心 杨鹏
- International Institute for Applied Systems Analysis: Nicklas Forsell, Fei Guo, Volker Krey 国际应用系统分析研究所 Nicklas Forsell, 郭非, Volker Krey
- Renmin University of China: Minpeng Chen, Ke Wang 中国人民大学 陈敏鹏，王克
- Tsinghua University: Qimin Chai, Qiang Zhang 清华大学 柴麒敏，张强
- University of Maryland: Ryna Cui, Nathan Hultman, Jiehong Lou, Jiawei Song 美国马里兰大学 崔宜筠，Nathan Hultman，楼洁红，宋嘉玮



绿色创新发展中心
innovative Green Development Program



中國人民大學
RENMIN UNIVERSITY OF CHINA



International Institute for
Applied Systems Analysis



清華大學
Tsinghua University

Models Assessed in this Study 本研究所采用的模型

Models Exploring China in a Global Context

从全球背景分析中国的模型

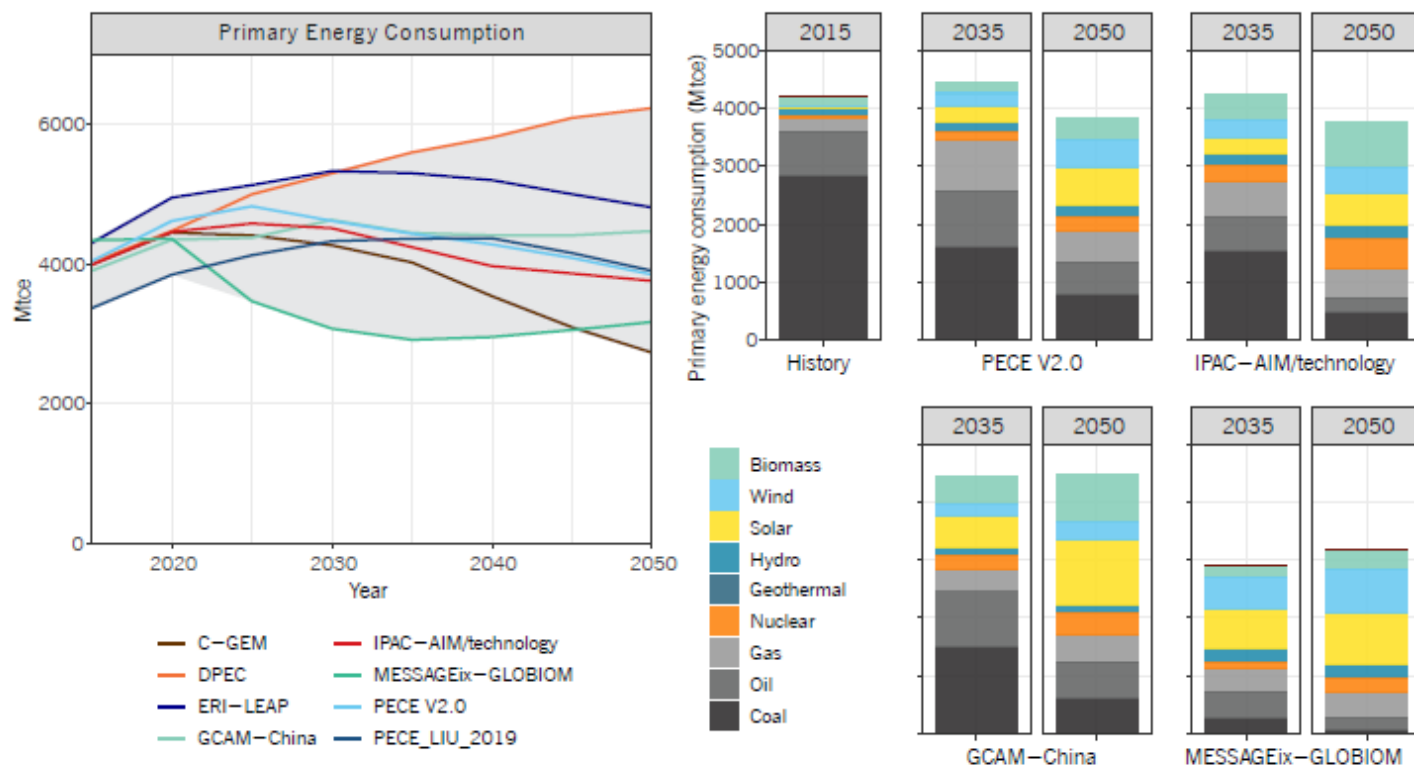
GCAM-China, IMAGE 3.0.1, MESSAGEix-GLOBIOM 1.0, POLES CD-LINKS, REMIND MAgPIE 1.7-3.0, WITCH-GLOBIOM 4.4

Models Exploring China Economy-Wide and Sectoral Transitions 探索中国全经济领域和行业转型的模型

C-GEM, DPEC, ERI-LEAP, GCAM-China, IPAC-AIM/technology技术, MESSAGEix-GLOBIOM, PECE V2.0, PECE_LIU_2019, and 和POLES-JRC 2019 version版本, AGHG-INV (agriculture and land use农业和土地利用), CBEM (buildings建筑), ERI-Industry (industry工业), ICCSD-LoMLog (electric power电力), Transportation-CATS (transportation交通)

FIGURE 3. PRIMARY ENERGY IN 1.5°C SCENARIOS.

The left panel shows the time path for multiple models; the right panel shows examples of the distribution of primary energy sources in 2035 and 2050 for two selected models.



Key Topic Areas 关键领域

- Linkages between China's growth and development goals and climate goals
中国增长和发展目标与气候目标之间的联系
- Coal retirement pathways 煤炭淘汰路径
- Air quality, health, and emissions reductions 空气质量、健康和减排
- Linkages between 1.5°C and China's carbon neutrality goal
1.5°C目标与中国碳中和目标之间的联系
- Cross-sectoral policy and strategy needs 跨部门政策和战略需求
- Sectoral emissions reduction goals 部门减排目标
- Long-term sectoral strategies 长期部门战略
- Near-term sectoral actions 近期部门行动
- Financial system actions to support the transition 金融体系支持低碳转型
- Key research needs 主要研究需求

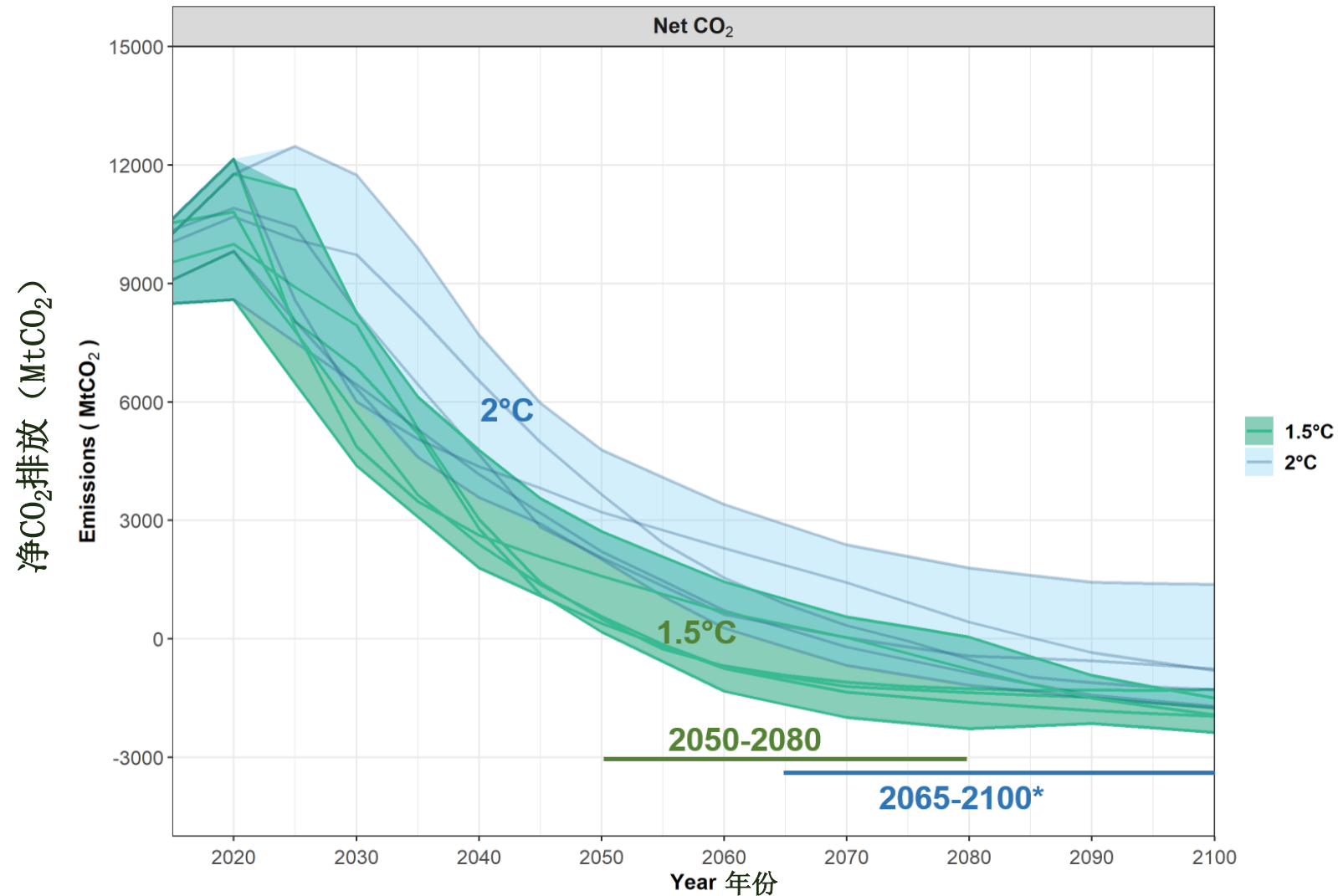
New Growth Pathway 新增长路径



- International leadership, industrial expansion, and competitiveness
国际领导力、产业升级和竞争力
- Jobs and prosperity 就业与繁荣
- Structural reform 结构化改革
- Improved health, cleaner air
改善健康状况、清洁空气
- Enhanced energy security
增强能源安全

1.5°C and Carbon Neutrality Before 2060

1.5°C 目标与2060年碳中和目标



SECTORAL STRATEGIES: The Pathway to Carbon Neutrality

Electricity

Emissions peak and start to decline immediately; they reach zero or are negative by 2050.

- Rapid electrification in all end-use sectors.
- Conventional coal-fired power plants without CCUS are nearly phased out by 2040 or 2045.
- Renewable power generation contributes around 70% of generation by 2050.
- CCUS and nuclear are retained as complementary options to complement renewable power.
- The flexibility of the power grid is significantly improved through flexible generation, improved grid infrastructure, demand side response, and deployment of storage technologies.

Buildings

Emissions peak immediately and decline by around 90% in 2050 relative to 2015.

- Around 75% of buildings energy use is supplied by electricity by 2050.
- Most district heating systems in northern urban China are decarbonized by 2050.
- Embodied energy in buildings is reduced by extending building lifetimes through retrofits and/or using higher-quality building materials.
- The scale of the building stock is controlled while continuing to improve the standards of living.

Industry

Emissions peak immediately and decline by around 90% by 2050 relative to 2015.

- A modernized industrial sector constrains the overall scale of industrial energy demands and reduces carbon intensity.
- Energy efficiency improvements, material substitution, and the circular economy reduce energy demand.
- Industry electrification continues through digital transformation and switching from fossil fuels to electricity.
- Zero-carbon hydrogen or biomass substitute for fossil fuels in hard-to-electrify applications.
- CCUS is applied to exhaust gases in applications with high CO₂ concentrations.

Transportation

Emissions peak between 2025 and 2035 and then decline by around 80% by 2050 relative to 2015.

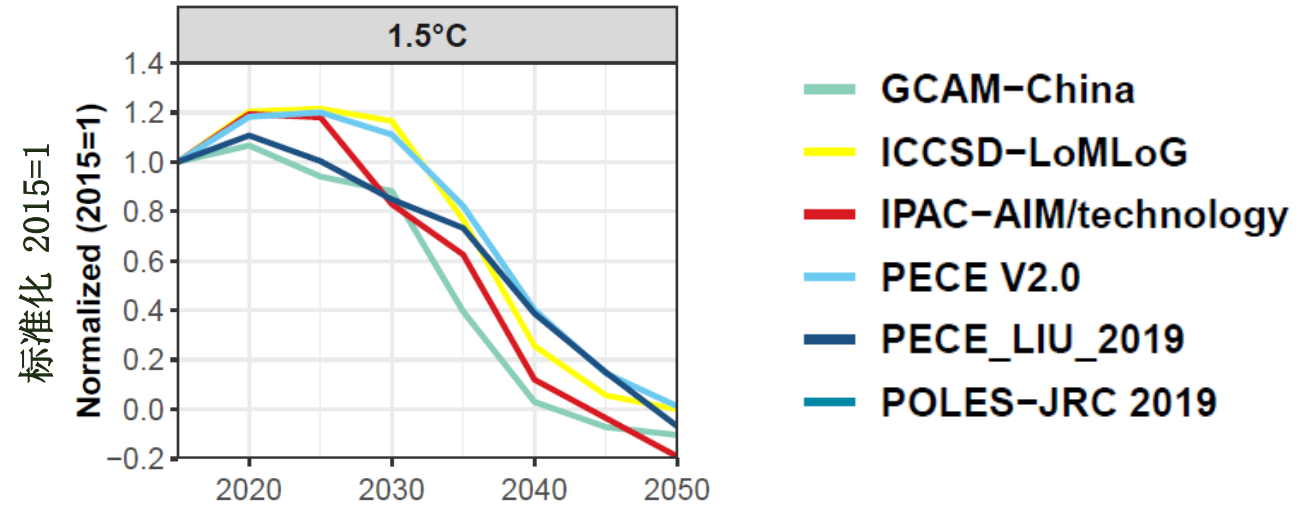
- Transportation transitions to low-carbon energy, including electricity, sustainable biofuels, and hydrogen.
- Comprehensive transportation planning increases energy efficiency and use of low-carbon transport modes.
- Increased integration of innovative technologies, such as big data, 5G, artificial intelligence, blockchain, supercomputers with infrastructure and vehicles to build an electrified, smart, and shared transportation system.

Agriculture, Forestry, and Other Land Use

Non-CO₂ emissions dramatically decline and AFOLU sectors offset emissions as a carbon sink.

- Technical mitigation options (e.g., anaerobic digesters) and structural mitigation options (e.g., improved manure management) are broadly implemented.
- China transitions to a healthier and more sustainable diet with lower environmental impact.
- Forest carbon sink is sustained and enhanced through continued afforestation and reforestation efforts; increase the forest area by 35 Million hectares in 2050 relative to 2015.

Electricity emissions peak and start to decline immediately; they reach zero or are negative by 2050. 电力行业排放量达到峰值后立即下降；到2050年，排放量为零或负。



Emissions peak immediately and are reduced by around 90% in 2050 relative to 2015. 建筑行业排放量立即达到峰值，到2050年，在2015年基础上实现约90%的减排量。

Emissions peak immediately and decline by around 90% by 2050 relative to 2015. 工业部门排放量立即达到峰值，到2050年，在2015年基础上实现近90%的减排量。

Emissions peak between 2025 and 2035 and then decline by around 80% by 2050 relative to 2015. 交通行业排放量在2025-2035年间达到峰值，然后到2050年，排放量相对于2015年减少80%左右。

SECTORAL STRATEGIES: The Pathway to Carbon Neutrality

Electricity

Emissions peak and start to decline immediately; they reach zero or are negative by 2050.

- Rapid electrification in all end-use sectors.
- Conventional coal-fired power plants without CCUS are nearly phased out by 2040 or 2045.
- Renewable power generation contributes around 70% of generation by 2050.
- CCUS and nuclear are retained as complementary options to complement renewable power.
- The flexibility of the power grid is significantly improved through flexible generation, improved grid infrastructure, demand side response, and deployment of storage technologies.

The flexibility of the power grid is significantly improved through flexible generation, improved grid infrastructure, demand side response, and deployment of storage technologies. 通过灵活发电、改进电网基础设施、需求侧响应以及部署储能技术提高电网灵活性。

Buildings

Emissions peak immediately and decline by around 90% in 2050 relative to 2015.

- Around 75% of buildings energy use is supplied by electricity by 2050.
- Most district heating systems in northern urban China are decarbonized by 2050.
- Embodied energy in buildings is reduced by extending building lifetimes through retrofits and/or using higher-quality building materials.
- The scale of the building stock is controlled while continuing to improve the standards of living.

Most district heating systems in Northern urban China are decarbonized by 2050. 到2050年，中国北方城市的大多数区域供暖系统实现脱碳。

Industry

Emissions peak immediately and decline by around 90% by 2050 relative to 2015.

- A modernized industrial sector constrains the overall scale of industrial energy demands and reduces carbon intensity.
- Energy efficiency improvements, material substitution, and the circular economy reduce energy demand.
- Industry electrification continues through digital transformation and switching from fossil fuels to electricity.
- Zero-carbon hydrogen or biomass substitute for fossil fuels in hard-to-electrify applications.
- CCUS is applied to exhaust gases in applications with high CO₂ concentrations.

A modernized industrial sector constrains the overall scale of industrial energy demands and reduces carbon intensity. 控制现代化工业能源需求的总体规模，并降低碳强度。

Transportation

Emissions peak between 2025 and 2035 and then decline by around 80% by 2050 relative to 2015.

- Transportation transitions to low-carbon energy, including electricity, sustainable biofuels, and hydrogen.
- Comprehensive transportation planning increases energy efficiency and use of low-carbon transport modes.
- Increased integration of innovative technologies, such as big data, 5G, artificial intelligence, blockchain, supercomputers with infrastructure and vehicles to build an electrified, smart, and shared transportation system.

Comprehensive transportation planning increases energy efficiency and use of low-carbon transport modes. 交通规划实现综合管理，以促进能效提升及低碳交通工具的使用。

Agriculture, Forestry, and Other Land Use

Non-CO₂ emissions dramatically decline and AFOLU sectors offset emissions as a carbon sink.

- Technical mitigation options (e.g., anaerobic digesters) and structural mitigation options (e.g., improved manure management) are broadly implemented.
- China transitions to a healthier and more sustainable diet with lower environmental impact.
- Forest carbon sink is sustained and enhanced through continued afforestation and reforestation efforts; increase the forest area by 35 Million hectares in 2050 relative to 2015.

Increase forest area by 35 Million hectares in 2050 relative to 2015. 到2050年，中国将比2015年增加3500万公顷的森林面积。

SECTORAL ACTIONS TODAY

Electricity



- Stop new construction of conventional coal-fired power plants without CCUS.
- Identify and quickly close a small fraction of the old, dirty, and inefficient coal plants.
- Continue to increase the share of non-fossil generation (to around 45% by 2025).
- Establish electricity spot markets.
- Increase interprovincial trade through power market reform.
- Enhance CCUS policies to promote CCS-ready in new fossil fuel plants and/or CCS retrofit in existing facilities.

Stop new construction of conventional coal-fired power plants without CCUS; Identify and quickly close a small fraction of the old, dirty, and inefficient coal plants. 停止新建未应用CCUS技术的常规燃煤电厂；识别并关停一小部分老旧、高污染且效率低下的现有燃煤电厂。

Buildings



- Continue to enhance building design standard for energy efficiency by improving requirements, including electrification and renewable energy integration.
- Continue to improve energy efficiency standards and labeling schemes of appliances to incorporate smart-enabling technologies and address system energy savings opportunities.
- Phase out coal use in rural residential buildings by promoting onsite PV and efficient biomass use.
- Encourage the use of passive technologies, such as natural ventilation and lighting, by developing small-sized commercial buildings and reducing the focus on large-size commercial buildings.
- Deploy smart technologies in order to improve demand side response and grid flexibility.

Continue to improve energy efficiency standards and labeling schemes for appliances to incorporate smart-enabling technologies and address system energy savings opportunities. 继续完善家电能效标准和标签计划，纳入智能技术以实现系统节能。

Industry



- Further remove excess capacity, increase concentration, and optimize industry structure in order to improve efficiency and increase innovation.
- Improve the relevant processes and standards of environmental impact assessment and energy technology assessment to guide investment and control capacity expansion in high energy consuming industries.
- Implement demand management measures to control the output of industrial products and lower total energy demand.
- Prioritize energy efficient technology deployment to control total energy demand.
- Increase electrification, particularly to replace coal consumption.

Further remove excess capacity, increase concentration, and optimize industry structure in order to improve efficiency and increase innovation. 进一步消除产能过剩，优化工业结构，提高效率和创新能力。

Transportation



- Accelerate the adjustment of long-distance freight transport by supporting the use of railways and waterways.
- Accelerate the improvement of the green travel system, focusing on "public transportation and cycling/walking".
- Improve the level of clean technology, promoting the transition to new energy vehicles.
- Vigorously develop intelligent transportation.
- Significantly improve overall energy efficiency.
- Strengthen the innovation in transportation demand management policies.

Accelerate the adjustment of long-distance freight transport by supporting the use of railways and waterways. 发挥铁路、水运的效用，加快长途货运结构的调整。

Agriculture, Forestry, and Other Land Use



- Continue to embrace sustainable agriculture by promoting circular agriculture, recycling of waste reduction, and increased resource use efficiency.
- Encourage the integration of new technologies and innovation, such as climate smart agriculture and artificial intelligence in the agricultural sector.
- Continue to implement and enforce sustainable forest management to sustain and enhance the forest sink.
- Implement actions that provide synergies and actively consider the links between agriculture, water, pollution, biodiversity, diets, and greenhouse gas emissions.

Continue to implement and enforce sustainable forest management to sustain and enhance the forest sink. 继续实施和加强可持续森林管理，以保持并增强森林碳汇。

The Road Ahead: Key Research Needs

未来展望：主要研究需求

- **Shared vision for a new growth pathway** 达成新增长路径的共识
- **Industrial transitions** 行业转型
- **Full economy coal phaseout** 全经济领域煤炭淘汰
- **Sustainable finance** 可持续金融
- **Technology and technology transitions** 技术和技术转型
- **Non-CO₂ gases** 非二氧化碳温室气体
- **Province-level strategy and actions** 省级战略和行动





ENERGY FOUNDATION
能源基金会

THANK YOU

谢谢