CACP

CHINA AUTOMOTIVE INDUSTRY
LOW CARBON ACTION PLAN SEMINAR
中国汽车产业链低碳行动计划研讨会

中国汽车产业链低碳行动计划研讨会

汽车产业链上下游联动协同降碳

2023.06.20 北京

全生态系统下的钢铁行业低碳转型战略：供给-需求-政策-金融联动



主题演讲嘉宾

李抒苡

落基山研究所
工业脱碳部门总监

演讲要点

- **行业的低碳转型需要整个产业链的协同合作，政府的政策激励、下游对低碳产品的支持与采购、金融机构的倡导，　三个抓手缺一不可。其中来自需求侧的支持是低碳转型可持续性的重要保障，未来30年，中国钢铁行业的低碳、零碳转型至少需要1.6万亿元投资。**

落基山研究所（RMI）工业脱碳部门总监，负责工业领域低碳、零碳转型工作，包括钢铁、水泥、化工等重点行业转型路线图研究，氢能、循环经济、CCUS等解决方案应用场景搭建，企业碳中和战略和试点支持等。加入RMI前，李抒苡曾参与多项工业能效和低碳发展政府课题。同时，她是美国环保协会气候拓新者项目William K. Bowes, Jr.领导力奖获得者和中国项目导师，以及全球能源转型女性网络、GIZ、德国联邦经济事务和能源部共同设立的“女性赋能能源转型”项目导师。

中汽中心 | 碳经济
中汽碳（北京）数字技术中心有限公司

全生态系统下的钢铁行业低碳转型战略：
供给-需求-政策-金融联动

Global Perspectives on Steel Industry Decarbonisation
Strategies across Supply, Demand, Policy & Finance

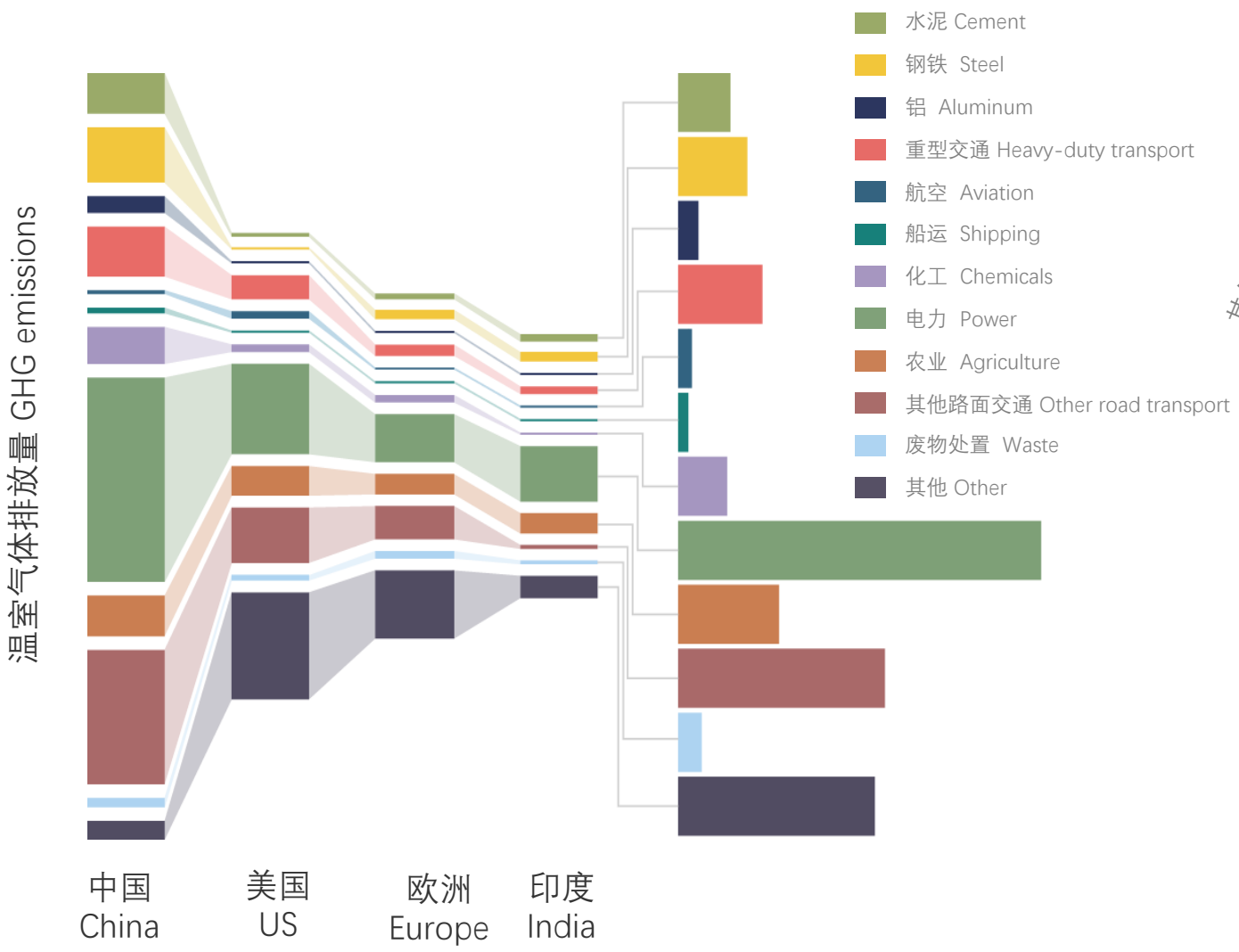


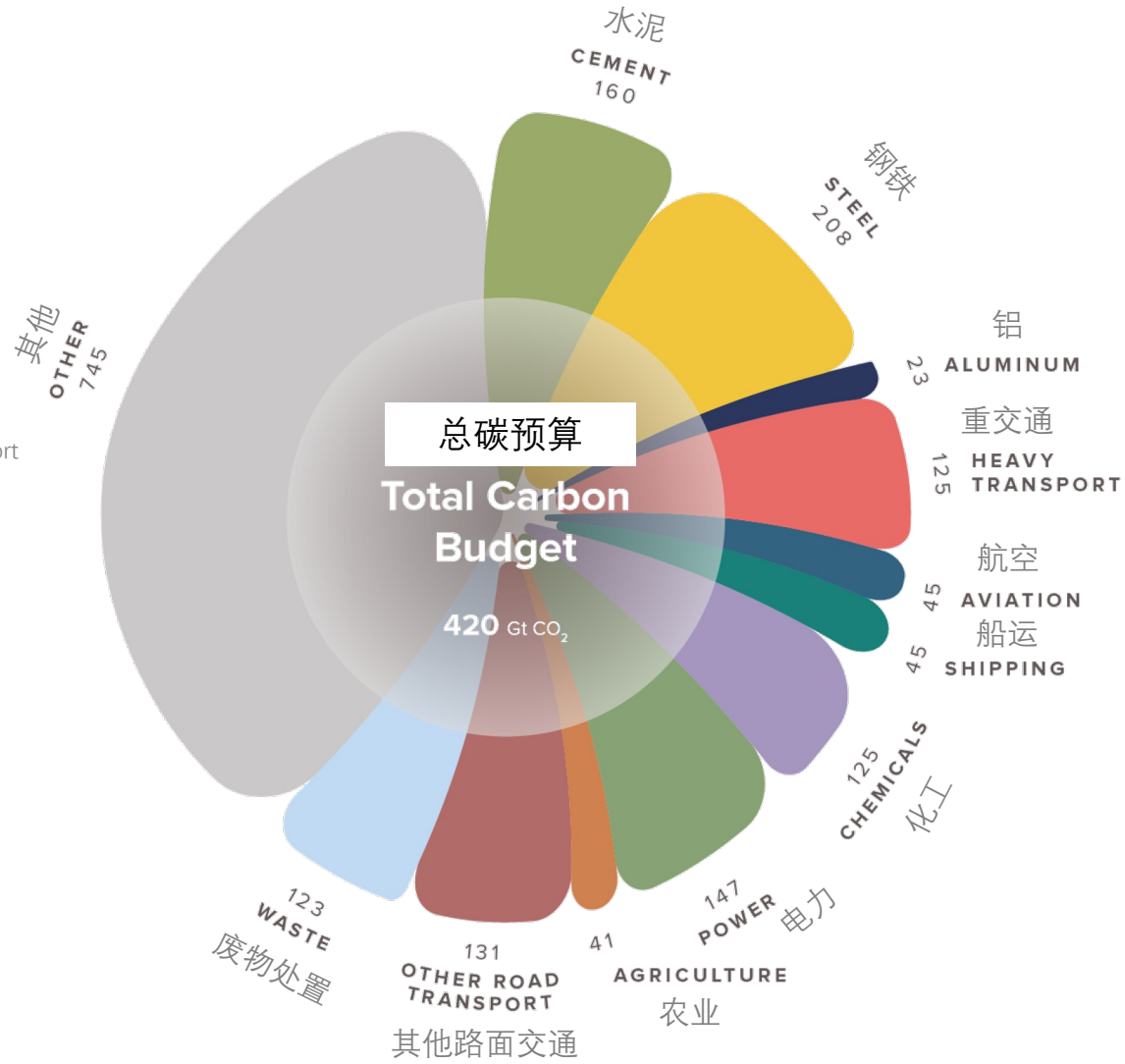
落基山研究所（RMI）
工业脱碳部门总监 李抒苡 sli@rmi.org

2023.6

重工业领域碳减排对实现气候目标至关重要

Decarbonizing heavy industries is critical to achieve climate targets





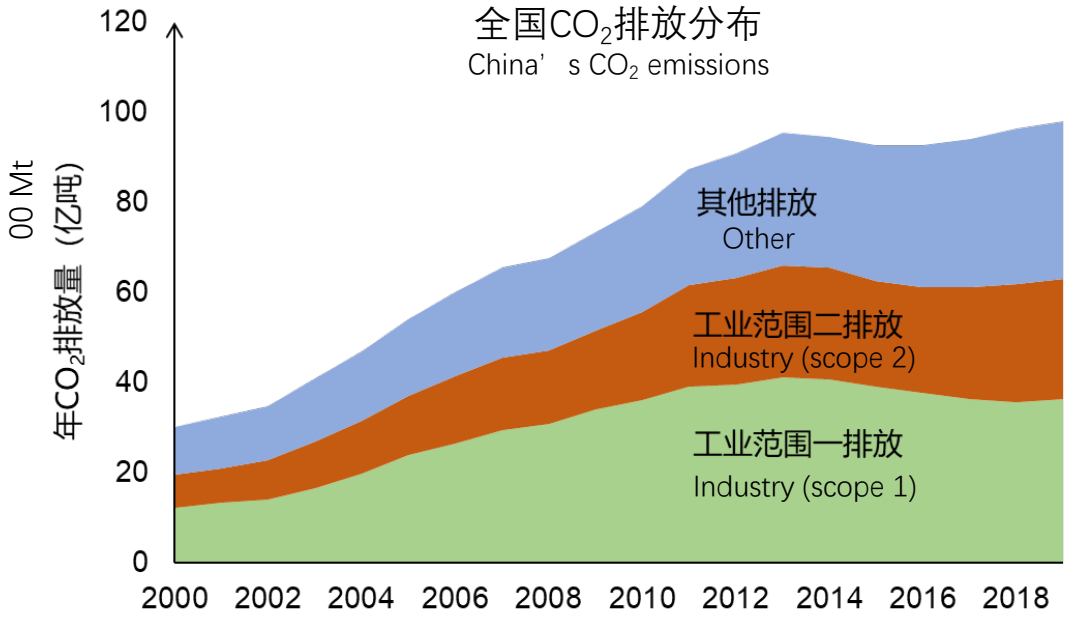
数据来源：可完成使命伙伴关系，Mission Possible Partnership

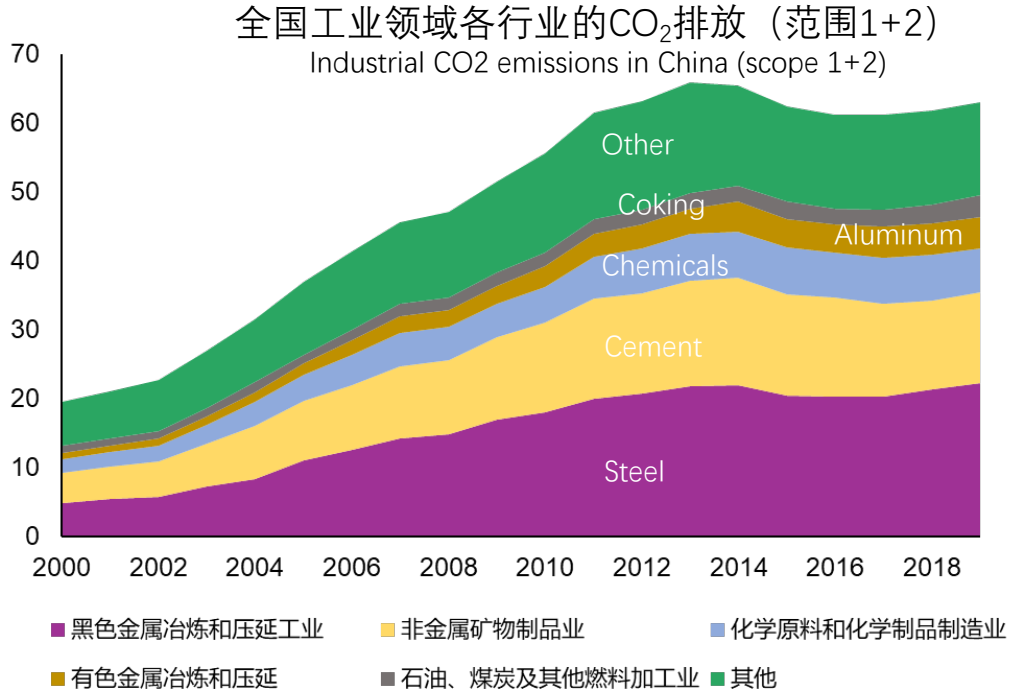
工业直接碳排放占全国总量的40%，是实现双碳目标的关键领域

In China, industry is responsible for 40% of total carbon emissions

- 我国主要重工业产品产量占全球比例：粗钢55%、水泥57%、电解铝58%、合成氨33%
- 中国工业领域二氧化碳直接排放占全国总量近40%，若含间接排放，则占到全国总量64%左右
- 五大行业占到了工业领域CO_2总排放的80%：黑色金属冶炼和压延加工业（钢铁）、非金属矿物制品业（水泥）、化学原料和化学制品制造业（化工）、有色金属冶炼和压延业（铝业）、石油煤炭及其他燃料加工业（石化、炼焦）

- China's major heavy industrial products of global total: 55% steel, 57% cement, 58% aluminum, 33% ammonia
- China's direct industrial CO2 emissions account for nearly 40% of the national total, and if indirect emissions are included, they account for about 64% of the national total
- Five major industries account for 80% of total CO_2 emissions in industry: steel, cement, chemicals, aluminum, coking



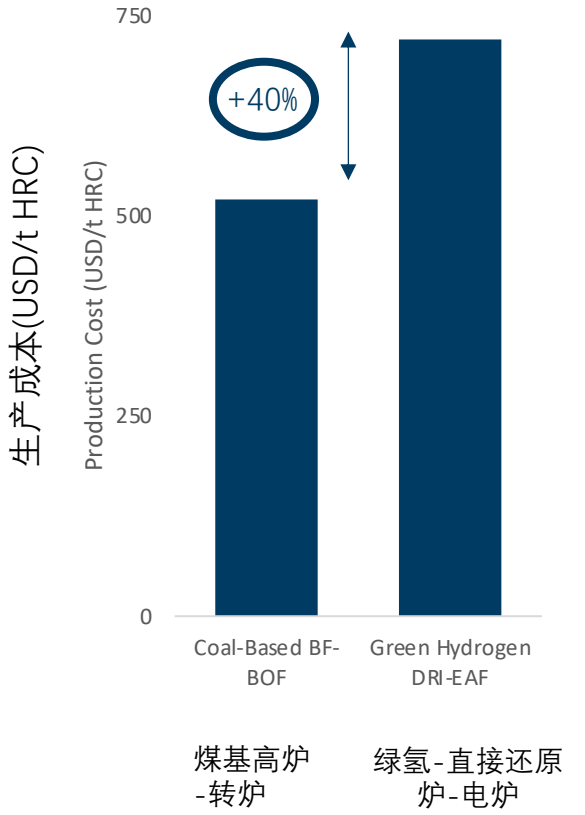


数据来源：全国碳核算数据库，CEADs, https://www.ceads.net.cn/

生产接近零排放的重工业材料仍然存在成本溢价

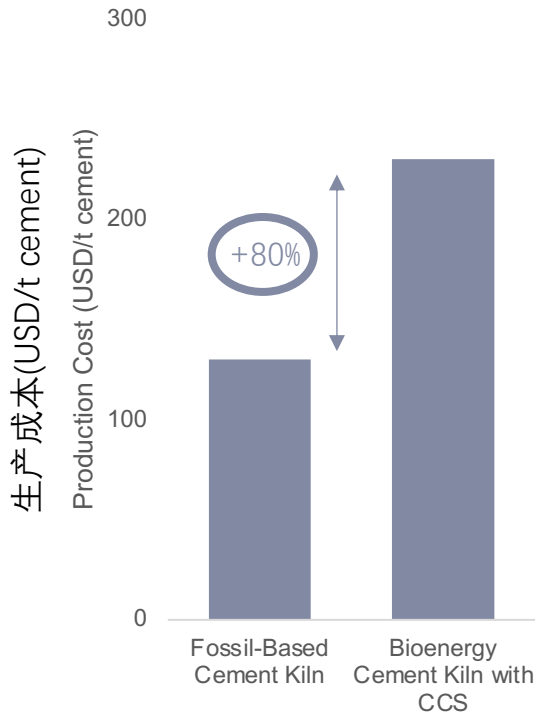
Producing near-zero heavy industrial materials today still has a cost premium

钢铁 Steel



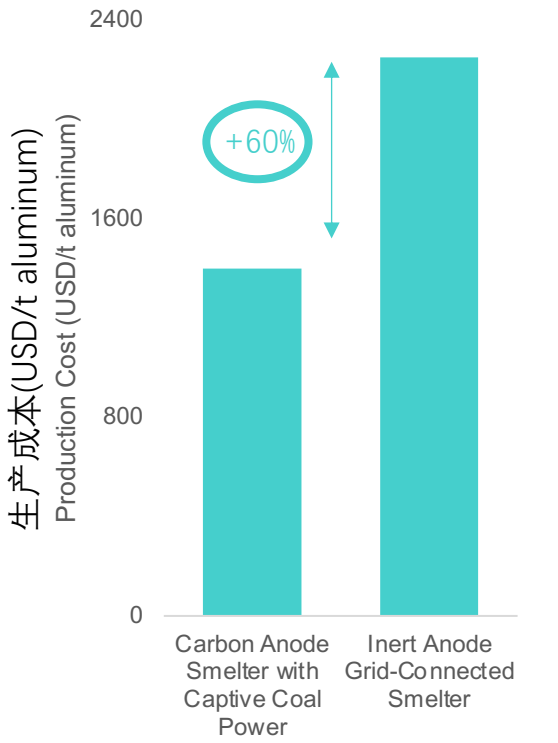
煤基高炉-转炉　　绿氢-直接还原炉-电炉

水泥 Cement



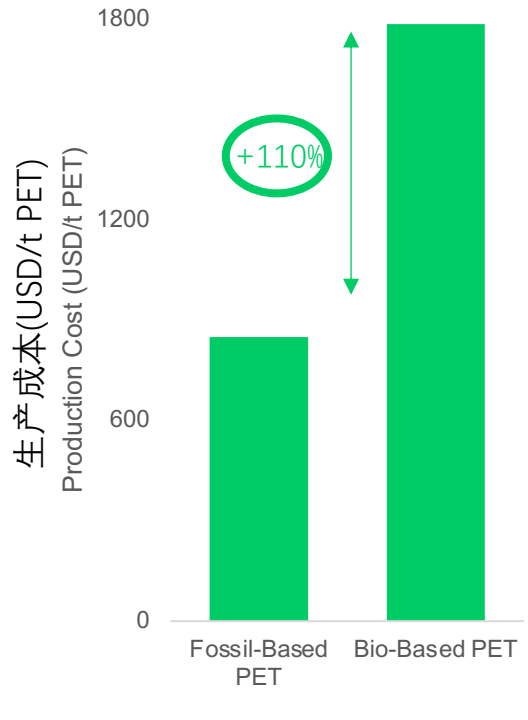
化石燃料基水泥窑　　具备CCS的生物能源水泥窑

铝 Aluminum



碳阳极-自备电厂连接电解槽　　惰性阳极-电网连接电解槽

塑料 Plastic

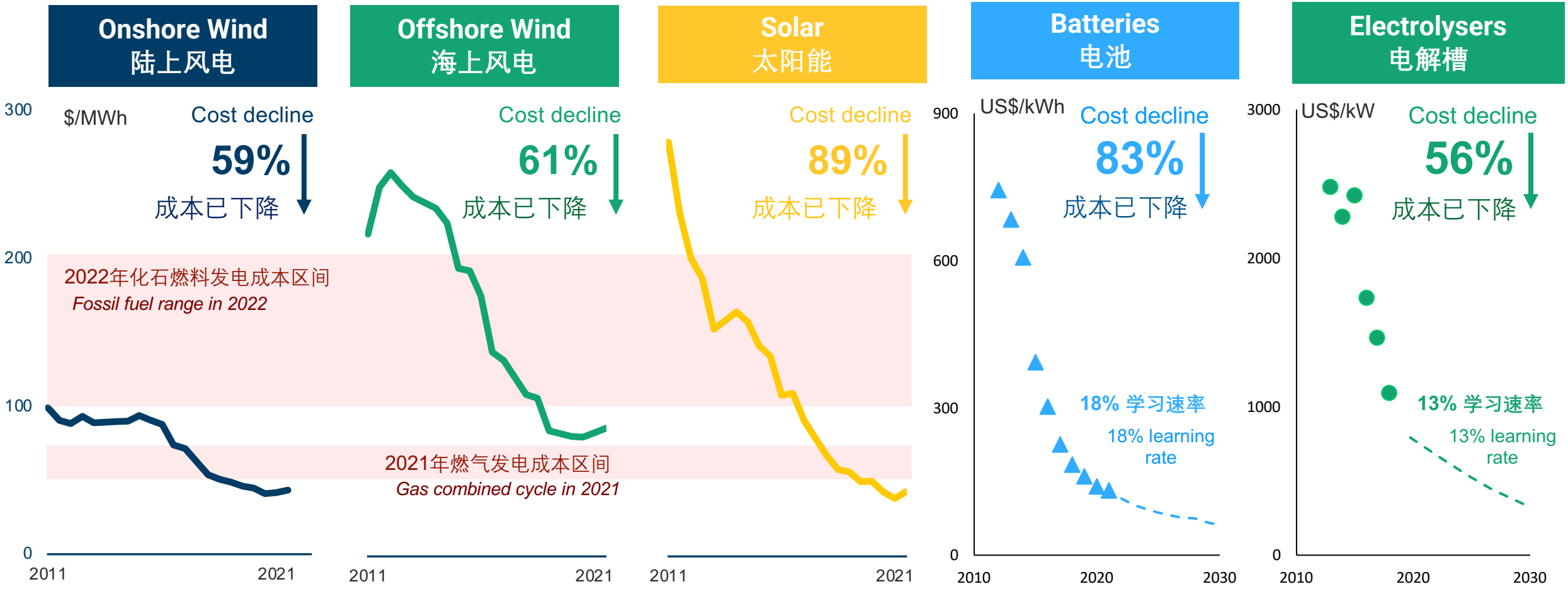


化石燃料基PET　　生物基PET

资料来源 （Source）：RMI, WEF, MPP, S&P, USGS, McKinsey

通过技术进步和规模效应，可再生能源技术成本将进一步降低，减少相应的成本溢价

Further cost reductions in clean energy technologies will reduce these cost premiums. Cost declines are expected from learning-by-doing and economies-of-scale



资料来源（Source）：BNEF, Lazard, INET Oxford

实现新能源成本下降，需要实施能够克服溢价的初期项目

Realising these declines requires initial projects which can overcome the premium

Supply
供给

重工业行业自身需开始考虑尽早投资低碳技术，增加近零排放产品产量。
低碳技术项目目前的投资成本较高，但通过合理运用**三大杠杆（需求、政策、金融）联动供给侧**，工业行业可以在近期**克服溢价**，并在远期形成规模效应大幅**降低生产成本**。

Hard-to-abate industries will need to invest in green projects with emissions reduction technologies to increase the supply of net zero products and meet emissions reductions targets. Such projects require massive investment. Support from demand, policy, and finance, can improve the business case to make these investments today. As the investment grows it is expected that future costs will decline with learning and scale.

Demand 需求

最终用户可以为绿色产品支付溢价，以刺激新的供应并满足其自身供应链减碳目标

End-use buyers can **pay a premium** for green products to induce new supply and satisfy their own supply chain decarbonisation goals

Policy 政策

决策者可以为绿色项目提供补贴（或对灰色项目征收费用），以实现国家和地区的目标

Policymakers can provide a **subsidy** for green projects (or impose a cost on grey projects) to meet national and regional targets

Finance 金融

相较于灰色项目，通过降低绿色项目的资本成本（通过识别降低风险），可以改善商业案例模式

Lowering the **cost of capital** (by recognising reduced risk) for green projects compared with grey alternatives can improve the business case

Three levers to accelerate industrial decarbonization 加速行业减碳的三大杠杆

钢铁生产减碳、脱碳技术成熟度水平与发展时间线

Timeline and maturity level of different steel decarbonization technologies

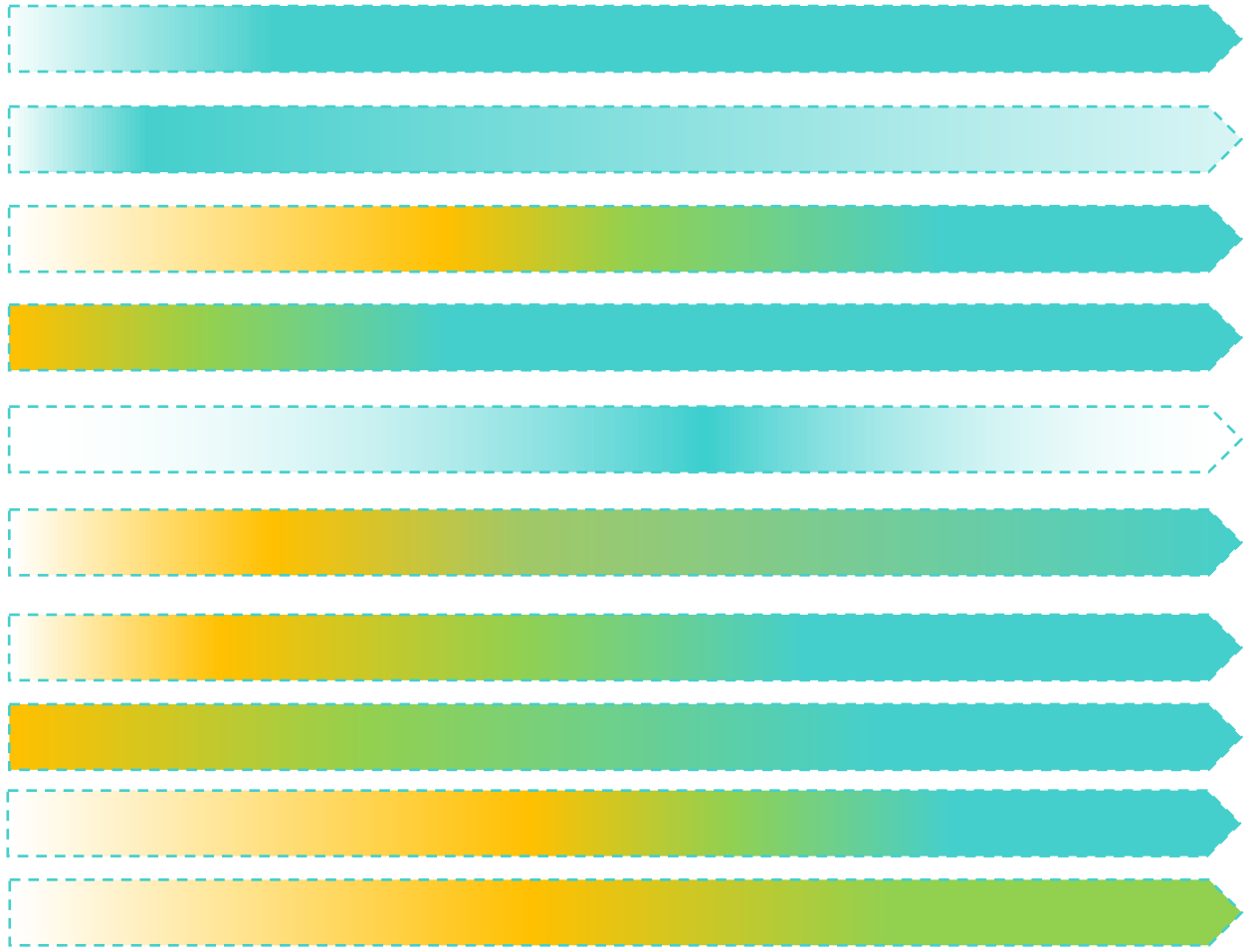
供给 Supply

需求 Demand | 政策 Policy | 金融 Finance

	技术路线 Technology option	技术成熟度 TRL	减排潜力 Mitigation potential (% of BF-BOF)
短流程 Secondary	废钢-电炉 Scrap-based EAF	9	95%
长流程改进性技术 Intermediate technology	能效提高 Energy efficiency	9	15-20%
	纯氧高炉 Oxygen blast furnace	2-7	30%
	高炉喷吹氢气 H_2 blended in BF	5-9	20%
	生物质 Biomass	2-7	30% (95% +CCS)
	碳捕集与封存 CCS	5-6	60%
	熔融还原 Smelting reduction	6	20% (80% +CCS)
颠覆性初级钢技术 Fully decarbonized steel	氢气直接还原铁 H_2-DRI	6-8	95%
	氢等离子体熔融还原 H_2 plasma smelting reduction	5	95%
	直接电解 Direct electrolysis	2	95%

中国发展时间表 Market entry in China

2020 2025 2030 2035 2040 2045 2050 2055 2060



试点 Pilot

商业化试点 Commercial pilot

规模化 Scale-up

颜色加深表示技术需求的不断扩大
Increased color illustrates rise in demand

钢铁零碳生产路径碳减排成本变化趋势

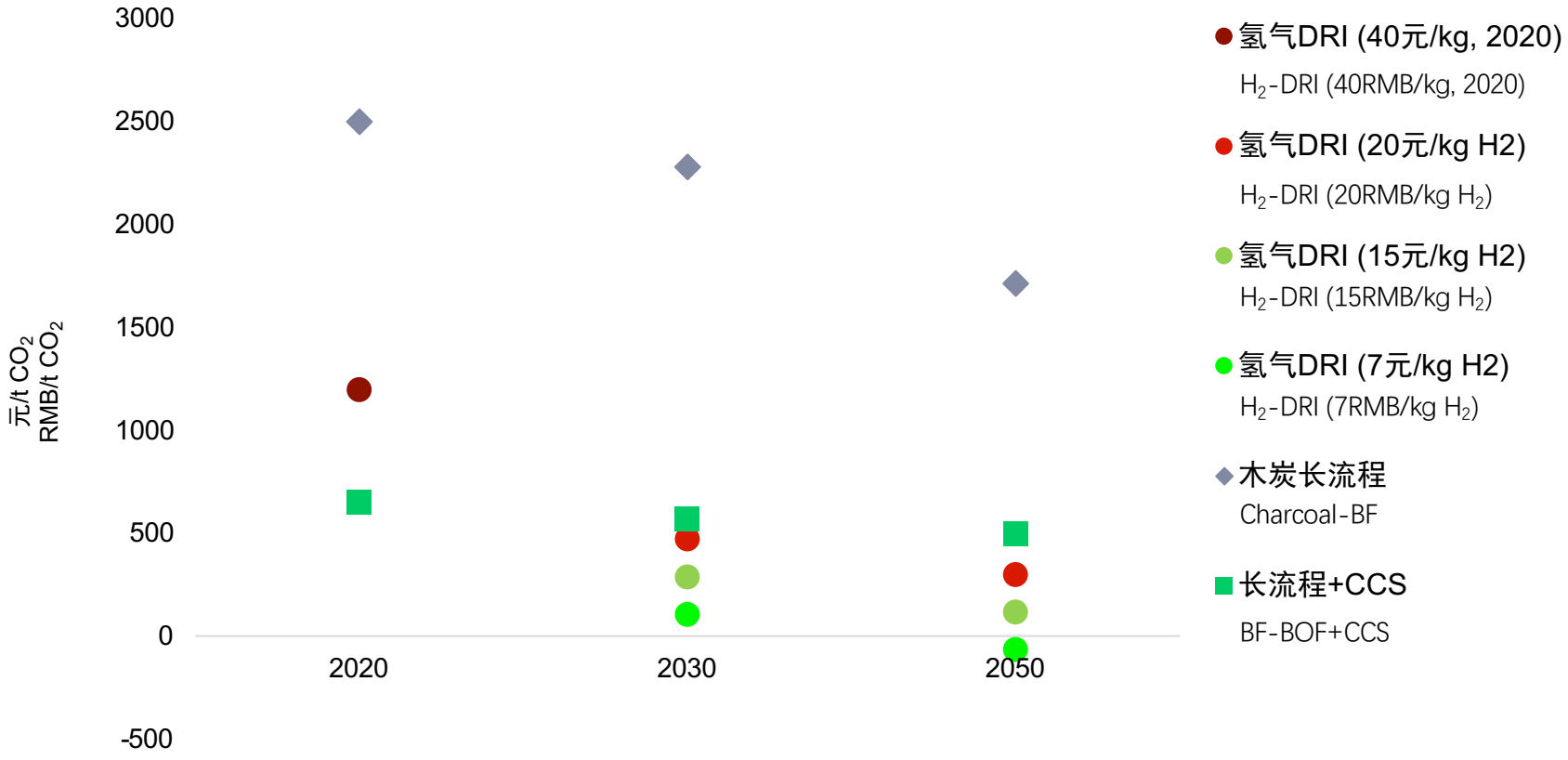
Trend of decarbonization cost for net-zero production routes in the steel industry

到2050年，基于碳捕集和氢气直接还原铁的钢铁生产都可以低于700元/吨二氧化碳的碳减排成本得到实施。

By 2050, both carbon capture-based and hydrogen DRI-based steel production can be implemented at costs below 700 RMB/t CO_2.

中国钢铁零碳排放生产路径碳减排成本

Decarbonization costs for net-zero steel production routes in China



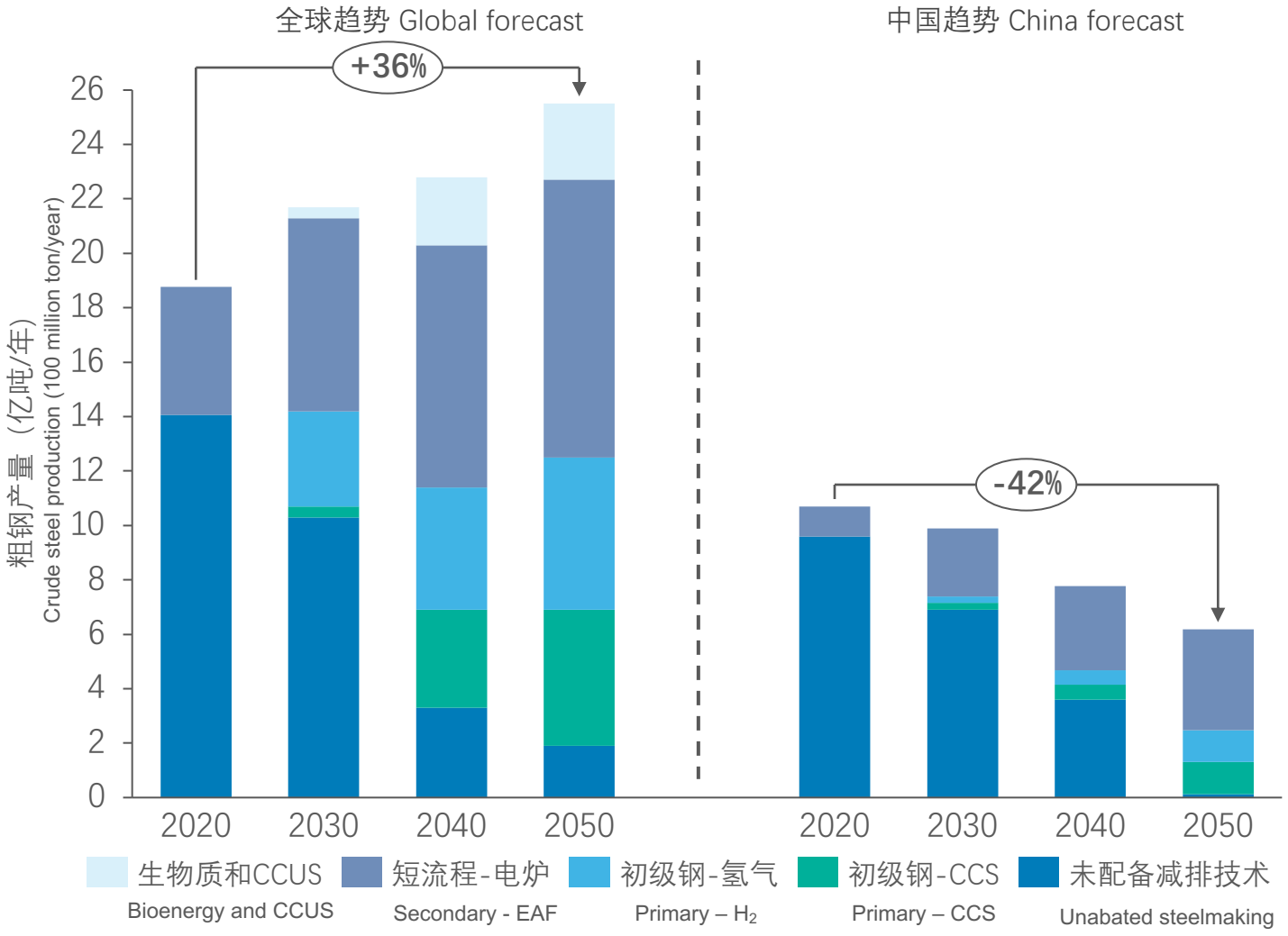
数据来源：RMI, 碳中和目标下的中国钢铁零碳之路, 2021

规模化废钢利用与推进初级钢低碳生产路径是钢铁行业转型的关键手段

Scaled scrap utilization and promotion of low-carbon primary steel are key means of transforming the steel industry

钢铁行业生产路径的变化趋势（2020-2050）

Production route forecast of the steel industry (2020-2050)



总产量

- 中国的粗钢产量占全球的一半以上；
  China crude steel production is more than half of global total production;
- 全球粗钢产量在逐年增长，而中国产量稳中有降。
  Global crude steel production is increasing, while China's production is steadily decreasing.

再生钢

- 基于废钢的再生钢在国际和国内都将成为重要生产方式；
  Scrap-based secondary steel becomes a vital production route both globally and in China;
- 随着中国废钢资源量的增加，中国的短流程再生钢的发展潜能也更大。
  As the amount of scrap resources in China increases, there is more potential for the development of scrap-based secondary steel in China.

初级钢

- 中国初级钢生产技术基于煤炭还原，而国际也可基于天然气还原；
  Chinese primary steel production technology based on coal reduction, while globally it can also be based on natural gas reduction;
- 生物质将在远期应用于国际的钢铁生产，而在中国钢铁行业应用潜力有限。
  Bioenergy will be utilized in steel production in the long term globally, with limited potential for application in China's steel industry.

数据来源：MPP, RMI

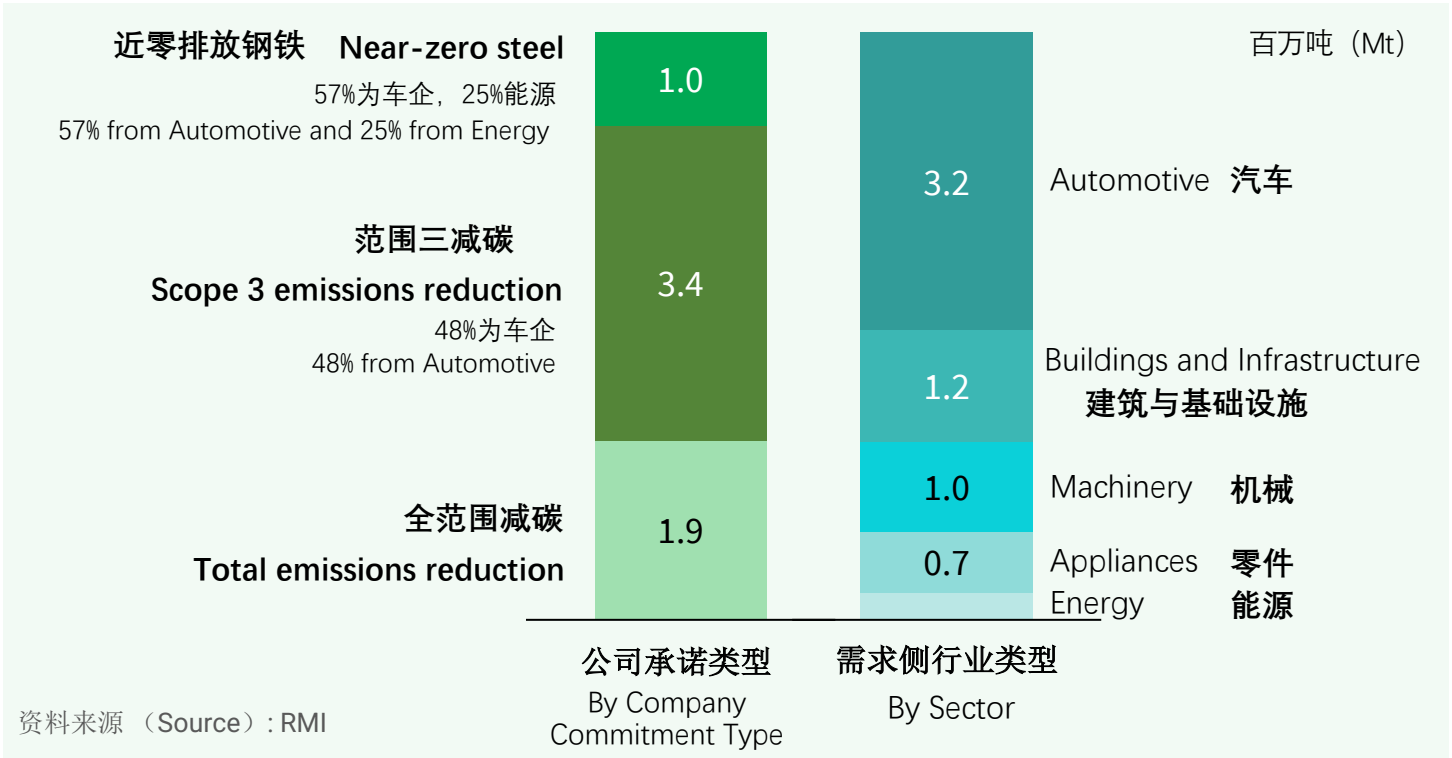
需求侧对减少上游难以减少的排放的承诺有所增加

Purchaser commitments to reduce upstream hard-to-abate emissions are increasing

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需求 Demand | 政策 Policy | 金融 Finance

示例：美国需求侧企业承诺钢铁相关减碳目标



资料来源 （Source）: RMI

需求侧低碳采购联盟

First Movers Coalition

SteelZero

到2030年，美国约有56家企业将需要约**640万吨绿色钢材**来实现减碳目标

By 2030, ~6.4 Mt of green steel will be required in the US across ~56 companies to meet carbon targets

供给-需求侧协同形成脱碳合力：部分案例

Supply-demand collaborations to further drive industry decarbonization: case study

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H2 Green Steel

contract

瑞典 (Sweden) Boden

H_2 **制氢**： 800 MW
Iron **炼铁**：190 万吨/年 DRI
Steel **炼钢**：250 万吨/年 EAF
1st prod. **首批生产**：2026
Full prod. **全面生产**：250 万吨/年 2027

一些承购商和供应商已入股该公司，承购合同讨论中

Salzgitter AG – SALCOS

MOU

德国(Germany) Salzgitter

H_2 **制氢**：100 MW
Iron **炼铁**：210 万吨/年 DRI
Steel **炼钢**：190 万吨/年 EAF
1st prod. **首批生产**：2025
Full prod. **全面生产**：60 万吨/年 2026

奔驰、宝马和大众已与萨尔茨吉特公司达成承购合同

河钢集团-宝马集团 HBIS - BMW

MOU

- 120 万吨 氢冶金示范项目
  1.2 Mt hydrogen-based steelmaking
- 2026年起，宝马沈阳生产基地在整车量产中使用河钢生产的 “绿钢”
  Green steel supply from 2026
- 从2026年起，每年预计将减少碳排放约23万吨
  230kt carbon reduction per year from 2026

签署《打造绿色低碳钢铁供应链合作备忘录》

SSAB – HYBRIT

contract

瑞典 (Sweden) Luleå和Gällivare

H_2 **制氢**：2.0 GW
Iron **炼铁**：130 万吨/年 DRI
Steel **炼钢**：230 万吨/年 EAF
1st prod. **首批生产**：2025
Full prod. **全面生产**：230 万吨/年 2026

HYBRIT由LKAB、Vattenfall和SSAB联合创立，沃尔沃参与了研究和开发，并将成为绿色钢铁的承购商

GravitHy

MOU

法国 (France) Fos-sur-Mer

H_2 **制氢**：MW级
Iron **炼铁**：200 万吨/年 DRI
Steel **炼钢**：-
1st prod. **首批生产**：2027
Full prod. **全面生产**：200 万吨/年 DRI 2027

GravitHy项目由Engie、Forvia、IDEC、PLUG和Primetals共同开发

宝钢股份-北京奔驰 Baosteel - Benz

MOU

- 2023年逐步提供碳排放强度大幅降低的低碳钢
  Low-carbon emissions steel from 2023
- 2026年起，宝钢股份提供车辆用钢的碳排放强度将逐步降低50%-80%；随后进一步提供减碳95%的绿钢
  From 2026, steel carbon intensity decreases by 50%-80%. Reaching 95% reduction afterwards.

签署《打造绿色钢铁供应链合作备忘录》

采购方面临的挑战 ：如何提高减排透明度以实现溢价定价

Challenge for buyers – transparency on emissions reductions to enable premium

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在多个论坛上，采购方均提到一个**关键障碍**：
如何确保任何绿色溢价与减排成本直接挂钩

Key barrier cited by buyers in multiple forums was ensuring that any green premium relates to abatement costs

RMI召集的钢铁生产/采购论坛

RMI Convened Forums for Steel Producers/Buyers

美国的**突破性投资论坛**汇聚了钢铁生产商、采购方和金融机构与能源转型委员会（ETC）

US **breakthrough investment forums** bring together steel producers, buyers and financial institutions in conjunction with ETC

在世界可持续发展委员会协议（WBCSD PACT）下由汽车制造商和钢铁生产商组成的**钢铁工作组**

Steel working group of automotive manufacturers and steel producers convened under WBCSD PACT

示例：美国某直接还原铁-电炉减排成本



减排技术

Abatement Technology

- 绿氢 Green hydrogen
- 生物质 Bioenergy
- 可再生能源 Renewable eletricitiy
- 碳捕集和利用 Carbon capture & use
- 碳捕集和储存 Carbon capture & storage

减排技术的成本各不相同，有些甚至是负成本。披露应用了哪些技术可以让采购方更确信任何溢价都直接支持减排。

Alternative abatement technologies have varying costs, with some even negative. Disclosure on which technologies were applied can provide confidence to buyers that any premium is directly supporting emissions reduction.

来源 Source: RMI

生产企业面临的挑战：需要清晰的需求信号促进绿色投资

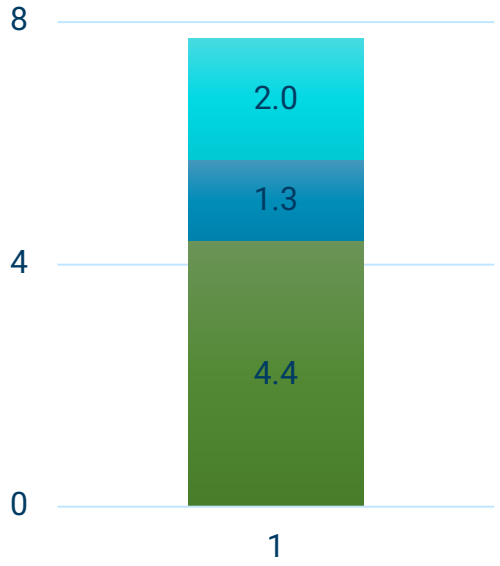
Challenge for producers – clear demand signals are needed to enable investment

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需求 Demand | 政策 Policy | 金融 Finance

示例：绿氢钢铁厂的资本性支出 Capital Cost for Green Hydrogen Steel Plant

单位(unit): 十亿美元(USD billions)



通常一个2 Mtpa 的**钢铁厂**需要……

Typical 2 Mtpa **steel plant** requires….

2 GW 的**电解槽**，还需要……

2 GW of **electrolysers** powered by…

4 GW **风电、光电**

4 GW of solar and wind

绿氢钢铁设施需要大量的资本投资，因此生产商需要以**长期合同形式的购买协议**来获得一定程度的长期确定性，以筹集所需的资本

Large capital investment required for a green hydrogen steel facility means that producers need some level of longer-term certainty from buyers in the form of offtake agreements to raise the necessary capital.

RMI正在通过**可持续钢铁采购平台**，召集**承诺的需求侧企业**，开启一个两阶段的**集体采购流程**，旨在通过**协调承购协议**发出**明确的需求信号**。

RMI is convening **committed buyers** via the Sustainable Steel Purchasing Platform which is a two-stage **collective procurement** process designed to result in a clear demand signal via a coordinated **off-take agreements**.

阶段1: 征求信息书 Request for Information

生产商提供可供货数量、首选合同期限、潜在生产技术途径等非约束性信息。

Producers to provide non-binding information of feasible **volumes**, preferred **contract length**, potential **production technology pathways.**

阶段2: 投标、征求建议书 Request for Proposal

采购方发布要求规范，包括所需数量、交货计划和产品的碳绩效信息等详细信息辅助议价。

Buyers issue a specification of requirements including details on required volumes, **delivery timelines** and **emissions performance** for pricing by producers.

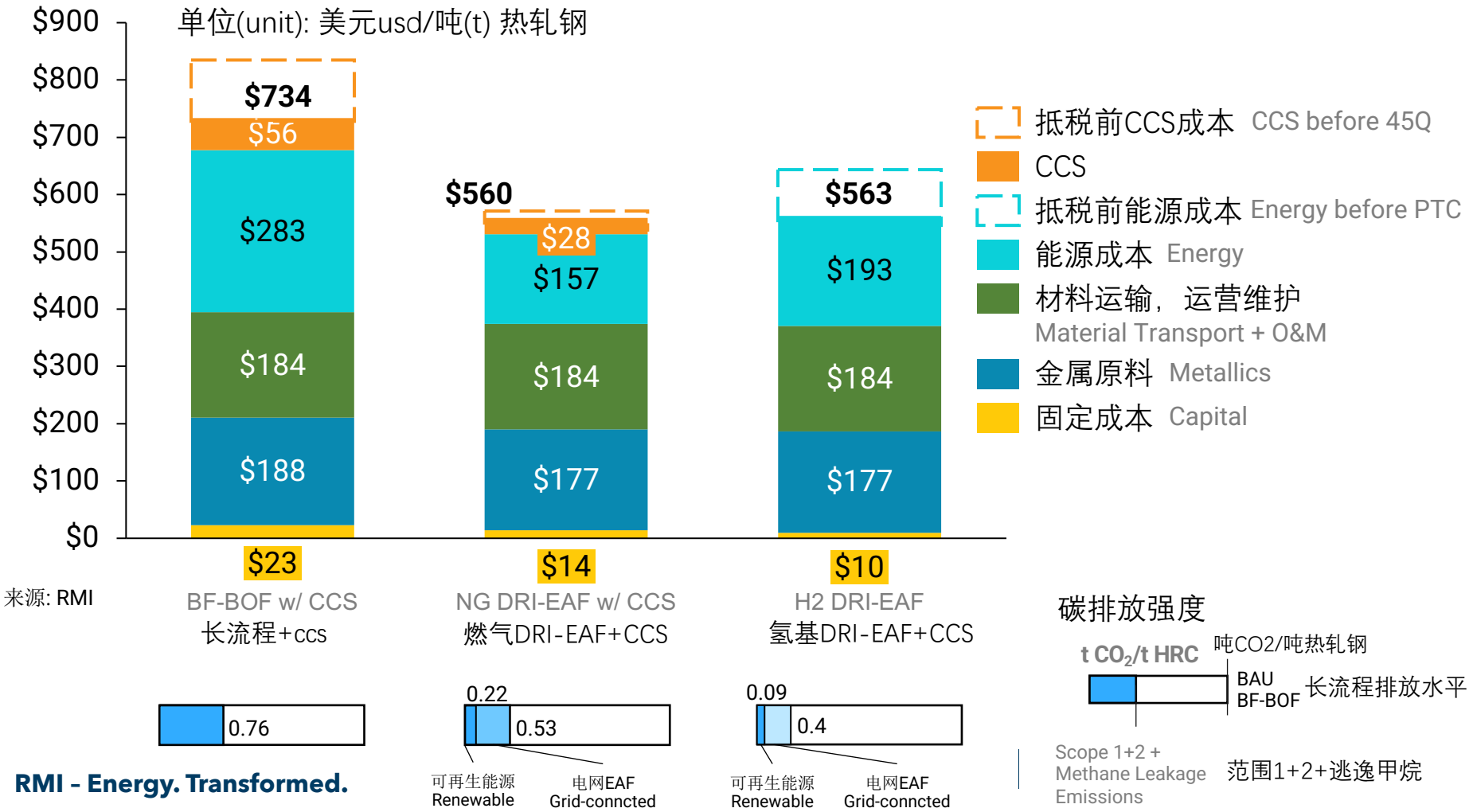
来源 Source: RMI

美国: 通胀削减法案（IRA）产品税收抵免提高成本竞争力

US IRA product tax credits enable cost competitiveness

钢铁平准化成本：对比在当前能源价格下，氢基和传统高炉生产的成本

Levelized Cost of Steel: Hydrogen-Based vs BF-BOF Production at Today's Fossil Prices



来源: RMI

碳排放强度

t CO_2/t HRC 吨CO2/吨热轧钢

BAU BF-BOF 长流程排放水平

Scope 1+2 + Methane Leakage Emissions 范围1+2+逃逸甲烷

美国通胀削减法案通过**税收抵免**，使新的炼钢技术能够与现有高炉相比更有**成本竞争力**，特别是在如今化石燃料价格相对较高的情况下。

US IRA **tax credits** enable new steelmaking technology to be **cost competitive with incumbent** blast furnaces, particularly at today's relative high fossil fuel prices

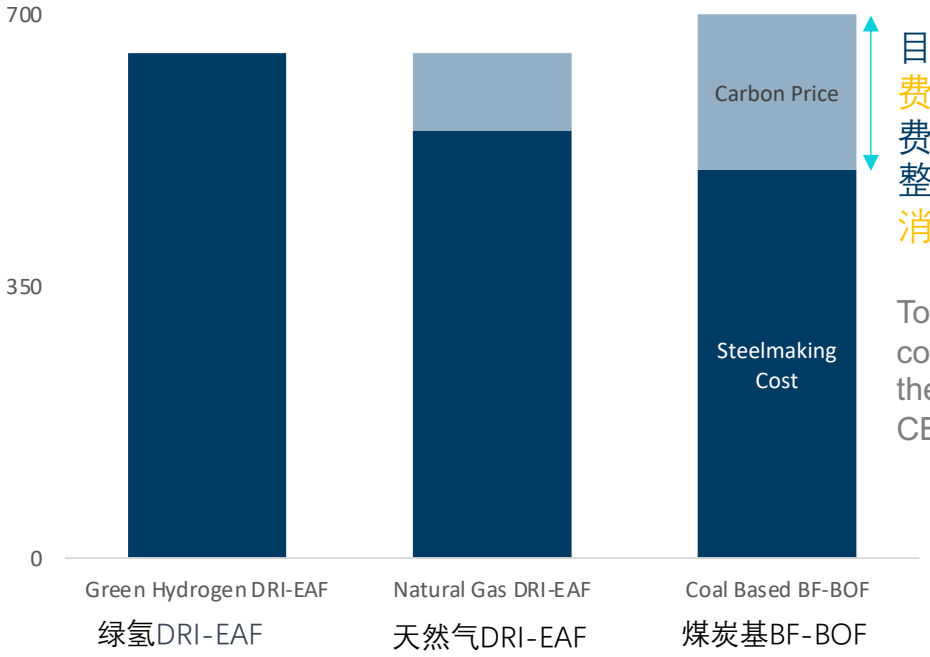
欧盟: 碳边境调节机制（CBAM）逐步取消免费碳配额，创造公平竞争环境

EU phase-out of free allowances through CBAM aims to create level playing field

欧盟包括碳价在内的钢铁生产成本

EU Cost of Steelmaking incl. Carbon Price

单位(unit): 欧元/吨热轧钢(€/t HRC)



目前约80%的碳定价通过免费配额来覆盖，而这些免费配额将会随着碳边境调整机制（CBAM）的逐步取消而逐渐淘汰

Today ~80% of carbon price is covered by free allowances – these will be phased out with CBAM

与CBAM相结合，欧盟成员国直接支持新绿色项目的措施

This has been coupled with direct support for new green projects by EU member states

西班牙政府向安米提供 4.5 亿欧元赠款，帮助将高炉转型为氢基直接还原炉

Spanish government provide €450m grant to ArcelorMittal to transition blast furnace to hydrogen-based direct reduction.

瑞典的 HYBRIT 氢基项目已从欧盟创新基金获得 1.53 亿欧元，并从瑞典能源署获得 5100 万欧元用于研发和商业化

Sweden's HYBRIT hydrogen-based steel project has received €153m from the EU innovation fund and €51m from the Swedish Energy Agency for R&D and commercialisation.

中国: 纲领性政策提出支持氢冶金技术研发、建设联盟和开展试点示范

China: high-level policies supporting R&D, industrial alliances & piloting of hydrogen-based steelmaking

供给 Supply

需求 Demand | 政策 Policy | 金融 Finance

2020.12 《关于推动钢铁工业高质量发展的指导意见（征求意见稿）》
Guiding Opinions on Promoting High-quality Development of the Steel Industry (Draft for Comment)

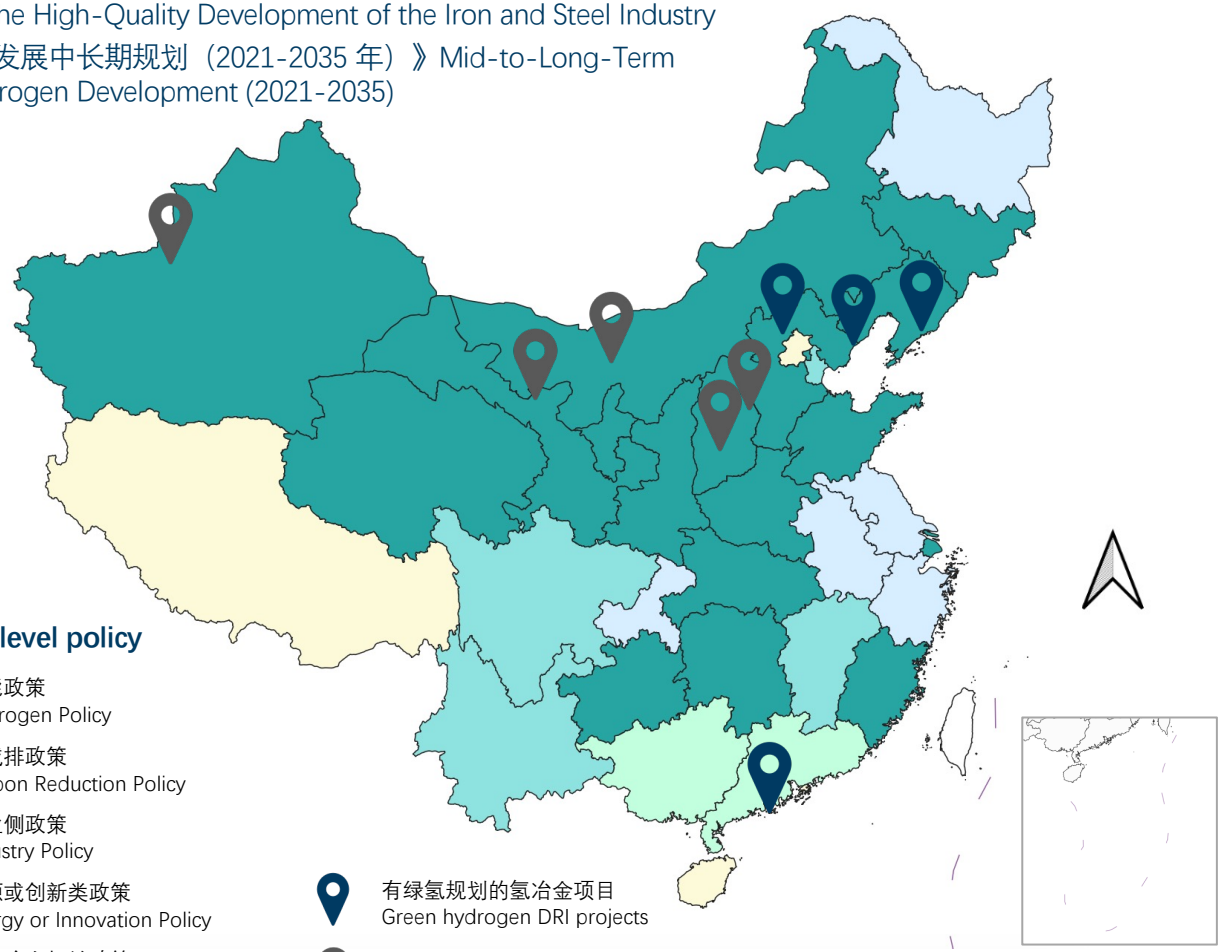
2021.05 《钢铁行业产能置换实施办法》
Implementation Measures for Capacity Replacement in the Steel Industry

2022.01 《关于促进钢铁工业高质量发展的指导意见 》
Guiding Opinions on Promoting High-quality Development of the Steel Industry

2022.02 《钢铁行业节能降碳改造升级实施指南》
Implementation Guide for Energy Saving and Carbon Reduction Transformation and Upgrading in the Steel Industry

总体政策 Overarching policy

- 《关于促进钢铁工业高质量发展的指导意见 》Guiding Opinions on Promoting the High-Quality Development of the Iron and Steel Industry
- 《氢能产业发展中长期规划（2021-2035 年）》Mid-to-Long-Term Plan on Hydrogen Development (2021-2035)



与可持续表现挂钩的资金进入钢铁低碳转型领域

Sustainability-linked financing flows into steel decarbonization

H2 green steel

- 35亿欧元：瑞典出口信贷公司、欧洲投资银行等的优先债务
- 15亿欧元：欧洲投资银行出口信贷挂钩担保
- 10亿欧元：瑞典国家债务办公室绿色信贷担保
- 5亿欧元：大型投资者基金的初级债务融资
- 2.6亿欧元：股权融资

- 3.5 billion EUR: senior debt of Swedish Export Credit Corporation, European Investment Bank, etc.
- 1.5 billion EUR: European Investment Bank export credit linkage guarantee
- 1 billion EUR: green credit guarantee from the Swedish National Debt Office
- 0.5 billion EUR: primary debt financing from large investor funds
- 260 million EUR: equity financing

ArcelorMittal

- 55亿美元：2021年循环信贷额度修改，与可持续性和气候行动战略保持一致
- 应付保证金将根据以下方面的表现而增加或减少：在欧洲运营活动的二氧化碳强度；获得ResponsibleSteel™认证的工厂数量

- 5.5 billion USD: 2021 revolving credit line modification, aligned with sustainability and climate action strategy
- Margin payable will increase or decrease based on performance in CO_2 intensity of operating activities in Europe and number of plants with ResponsibleSteel™ certification

USS

- 17.5 亿美元：可持续发展相关资产循环信贷机制（美国第一笔使用 ResponsibleSteel 认证的交易）
- 8亿欧元：U.S. Steel Košice签署与可持续发展相关的银团高级信贷安排（斯洛伐克的首个 SLL）
- 两者的定价机制都依赖于： 温室气体减排；无事故的健康和安全天数；获得ResponsibleSteel™ 认证的情况

- 1.75 billion USD: revolving credit facility for sustainability-related assets (first U.S. transaction using ResponsibleSteel certification)
- 800 million EUR: U.S. Steel Košice signs sustainability-linked syndicated senior credit arrangement (first SLL in Slovakia)
- Both pricing mechanisms rely on greenhouse gas emission reductions, accident-free health and safety days, and ResponsibleSteel™ certification

JSW

- 5亿美元：2021 年发行可持续发展相关债券 (SLB)，期限为 10.5 年（全球首个以硬通货发行的钢铁行业SLB）
- 需实现到 2030 年将二氧化碳排放强度从 2020 年基线降低 23% 的绩效目标

- 500 million USD: 2021 sustainability-linked bond (SLB) issuance with a 10.5 year term (world's first SLB issued in hard currency for the steel industry)
- Performance target of 23% reduction in CO_2 emissions intensity by 2030 from 2020 baseline

供给 Supply

需求 Demand | 政策 Policy | 金融 Finance

钢铁行业的主要信贷机构就气候相关融资协议达成一致

Leading lenders to the steel sector agree on climate aligned finance agreement

Sustainable Steel Principles 是RMI撰写的气候相关的**金融协议**，旨在帮助实现钢铁行业的净零排放。目前已帮助6 家领先的贷款机构同意向钢铁行业提供超过 **230 亿美元的贷款承诺**。

Sustainable Steel Principles is climate-aligned finance agreement designed to help achieve net-zero emissions in the steel industry agreed to by 6 leading lenders representing more than $23 billion in lending commitments to the steel sector.

SUSTAINABLE STEEL PRINCIPLES

citi

SOCIETE GENERALE

standard chartered

ING

CRÉDIT AGRICOLE CORPORATE & INVESTMENT BANK

UniCredit

该协议于2022年在纽约气候周推出，已经**帮助 3 个成员银行**（ING、UniCredit 和 Société Générale）签署了一份 **33 亿欧元债务的授权书**，用以资助 H2 Green Steel 在瑞典北部的新氢钢工厂。

Launched at NY Climate Week last year, already the agreement is having an impact with 3 members (ING, UniCredit, and Société Générale) recently signing a mandate letter for €3.3 billion in debt to finance H2 Green Steel's new hydrogen steel facility in Northern Sweden.

供给 Supply

需求 Demand | 政策 Policy | 金融 Finance

为符合气候目标，全球钢铁行业的低碳、零碳转型需要:

To achieve climate goals, the low-carbon and net-zero transition of the global steel industry requires the following measures:

从目前到2050年间总投资：

The total investment from the present to 2050

1.4万亿美元

14 trillion US dollars



绿氢

需要**5200万吨**

目前仅少量供应

Green Hydroden

In need of 52 million tons, current supply limited



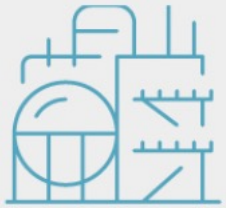
可再生电力装机

需要**2000GW**

占目前全球装机量2/3

Renewable Capacity

In need of 2,000 GW, 2/3 of current global renewable capacity.



碳捕集

需要**4-5亿吨**

目前仅少量实现

Carbon Capture

In need of 400-500 million tons, current supply limited



废钢

需要**13亿吨**

目前供应量的2倍

Scrap

In need of 1.3 billion tons, twice of current supply



高质量球团

需要**7.5亿吨**

目前需求的5.5倍

High-quality pellets

In need of 750 million tons 5.5 times of current supply

Source: Wood Mackenzie

落基山研究所工业脱碳工作重点

RMI's industry decarbonization work

供给 Supply

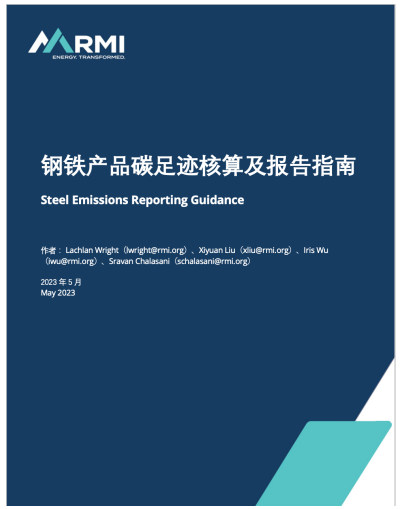
需求 Demand

政策 Policy

金融 Finance

Levers to accelerate industrial decarbonization 加速行业减碳的杠杆







SUSTAINABLE STEEL PRINCIPLES

行业转型路线图研究和企业战略、试点支持

Transition roadmap development and corporate strategies/pilots support

低碳、零碳钢铁绿色溢价传导机制和上下游协同模式探索

Explore green premium sharing mechanism and collaboration models for upstream/downstream players

推动和影响激励工业脱碳的政策制定

Influence and contribute to industry decarbonization related policy making process

制定和推广可持续钢铁原则，为钢铁减排提供金融支持

Develop and promote financial support for sustainable steel principles

RMI – Energy. Transformed.

RMI
能源. 转型.

谢谢

更多信息：

rmi.org

rmi.org.cn

