



Decarbonization - Challenges and Opportunities

去碳 - 机会和挑战

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For AMCHAM 美国商会

Shanghai

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CO₂ IS AN ASSET AND TREASURE, NOT A LIABILITY!

Summary

- 1. Company introduction**
 - 2. The market opportunity through decarbonization**
 - 3. What is driving the market**
 - 4. What are challenges to creating and scaling up market**
 - 5. How to develop & deliver technological solutions**
- 1. Who are we**

In 2020, Built & operated an industrial CCUS system in China

1. Green Carbon NanoTech (Jiangsu) Co., Ltd. was established in Suzhou in 2017 , and Shanxi Clean Carbon Economy Industrial Research Institute was established in Datong in 2019;
2. Since 2020, the company has built a system to capture 1,280 tons of CO₂ from the flue gas of thermal power plants in Datong;
3. The world's first production line for converting CO₂ from flue gas of thermal power plants into carbon nanotubes has been built and operated, with an annual output of 200 tons of carbon nanotubes;
4. Carbon nanotube purification system and 2,000 tons of lithium battery conductive slurry production line;
5. 8 authorized invention patents (China, America, Germany, Saudi Arabia, etc.), more than 30 patents are being filed and prepared;



One of 10 Finalists of Carbon XPRIZE 2016-2020

◆ Award Ceremony of 10 Finalists of Carbon XPRIZE in New York City, 2018



NRG Cosia Carbon XPRIZE and Southern Research visited and verified our pilot Systems of CO₂ Capture & Conversion in China, 2017.

Key Tech: Carbon nanotube (CNT) production through molten salt electrolysis of CO2

Carbon nanotubes and graphene are twins

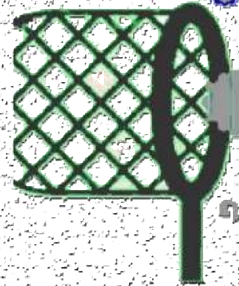
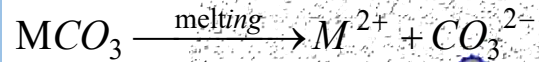
Mechanical properties: strength is more than 100 times that of steel, more than 11 times that of carbon fiber, and the strongest material known on earth.

The best known thermal conductor, 3-6 times that of diamond and 7-15 times that of copper.

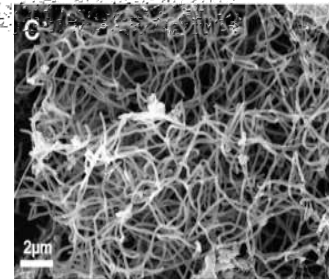
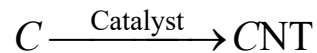
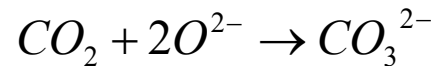
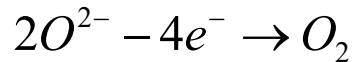
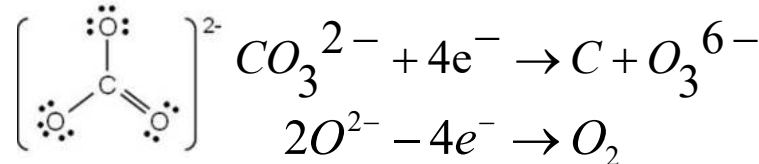
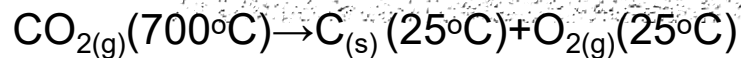
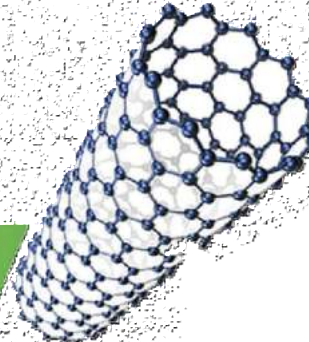
In theory, its electrical conductivity is second only to superconductors.

Superior lithium and hydrogen storage.

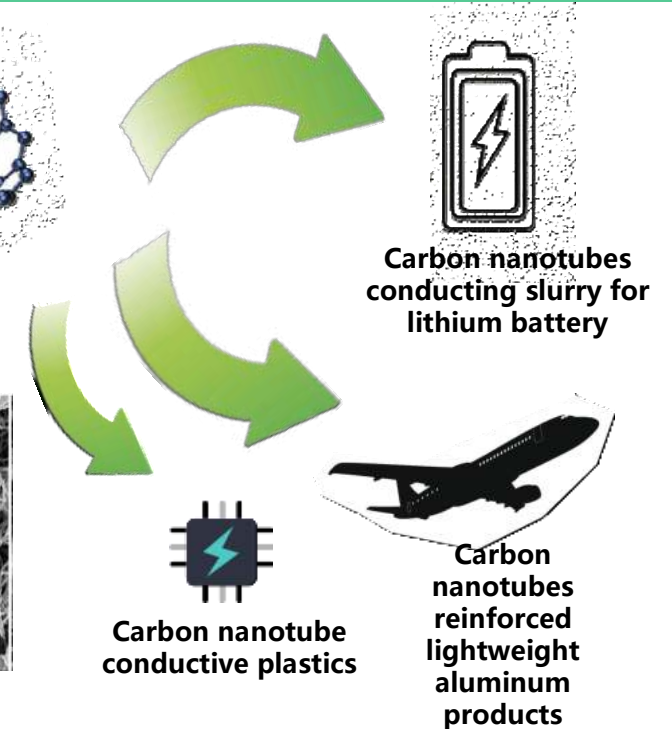
The current carrying density is thousands of times higher than that of copper.



CO₂



CNT: 5-150nm



1

**UNIQUE
TECHNOLOGY,
BUSINESS MODEL &
SOCIAL MISSION**

2

**ONE TON OF CNT
REDUCES 3.5 TONS
OF CO2 EMISSION**

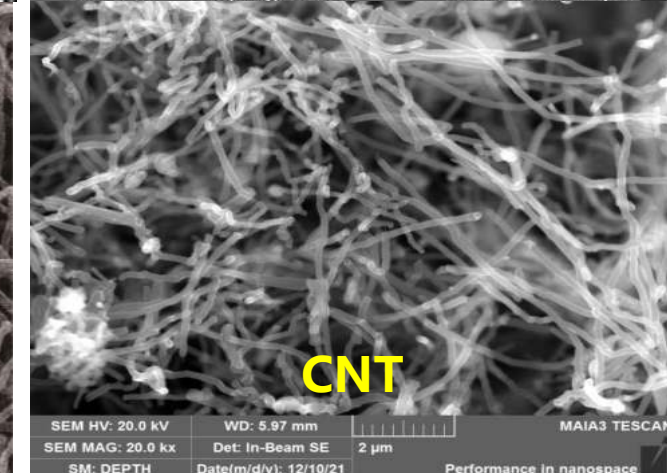
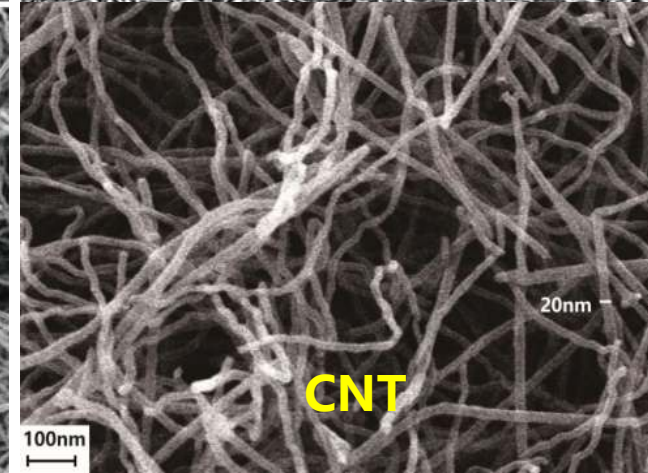
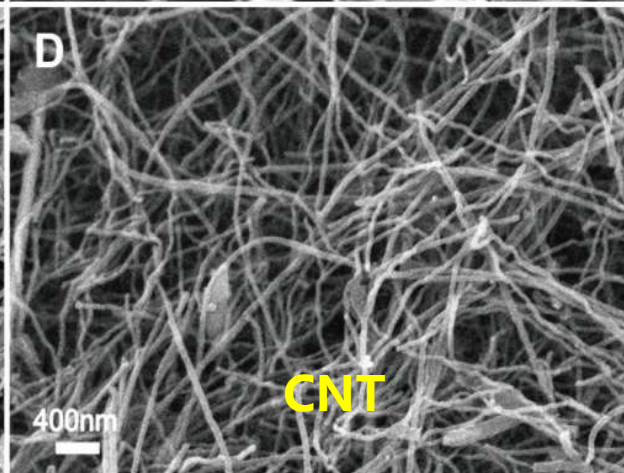
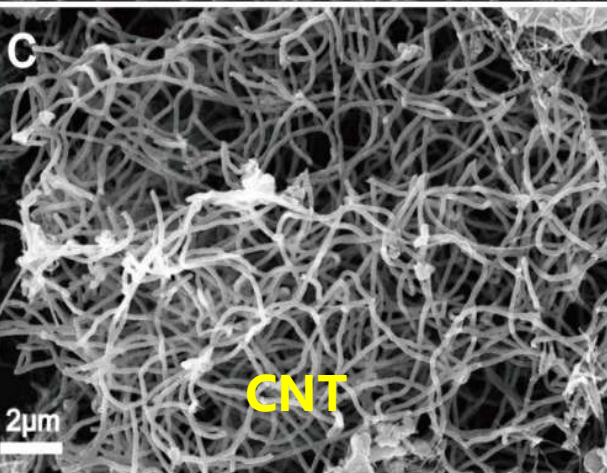
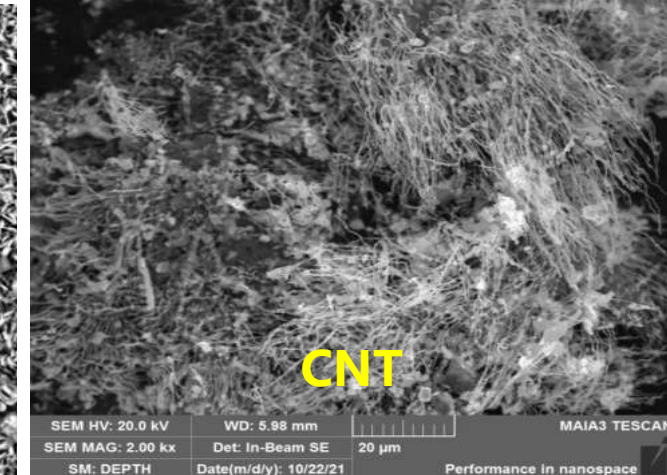
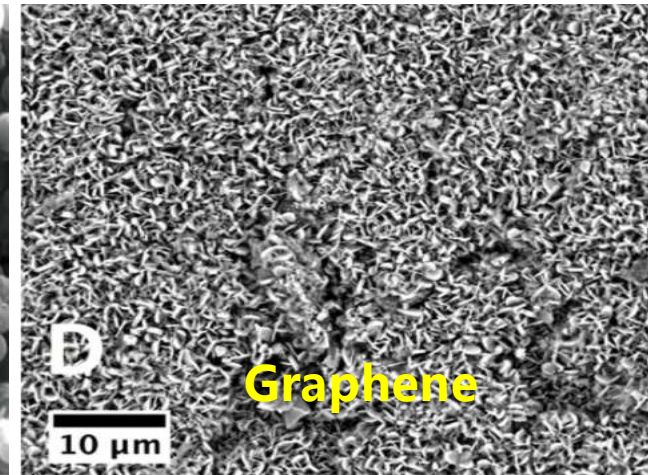
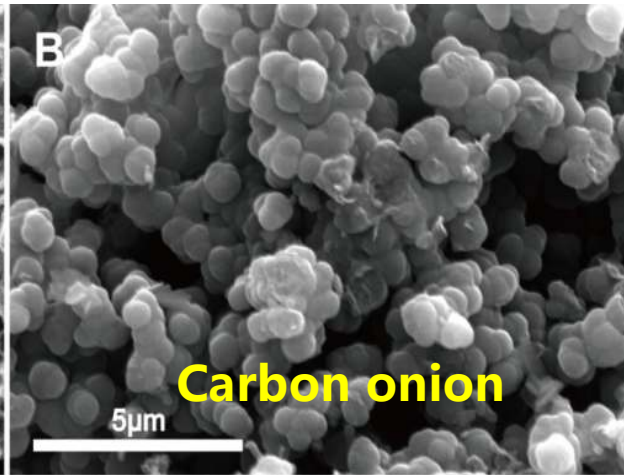
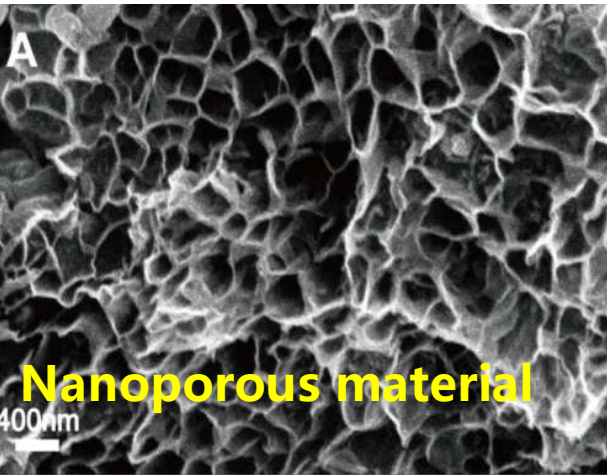
3

**WORLD' S 1ST
INDUSTRIAL
PRODUCTION OF
CNT FROM CO2
EMISSIONS**

4

**DISRUPTIVE
INNOVATION AT
SCALE**

To Produce Different Carbon Nanomaterials by Morphology Control

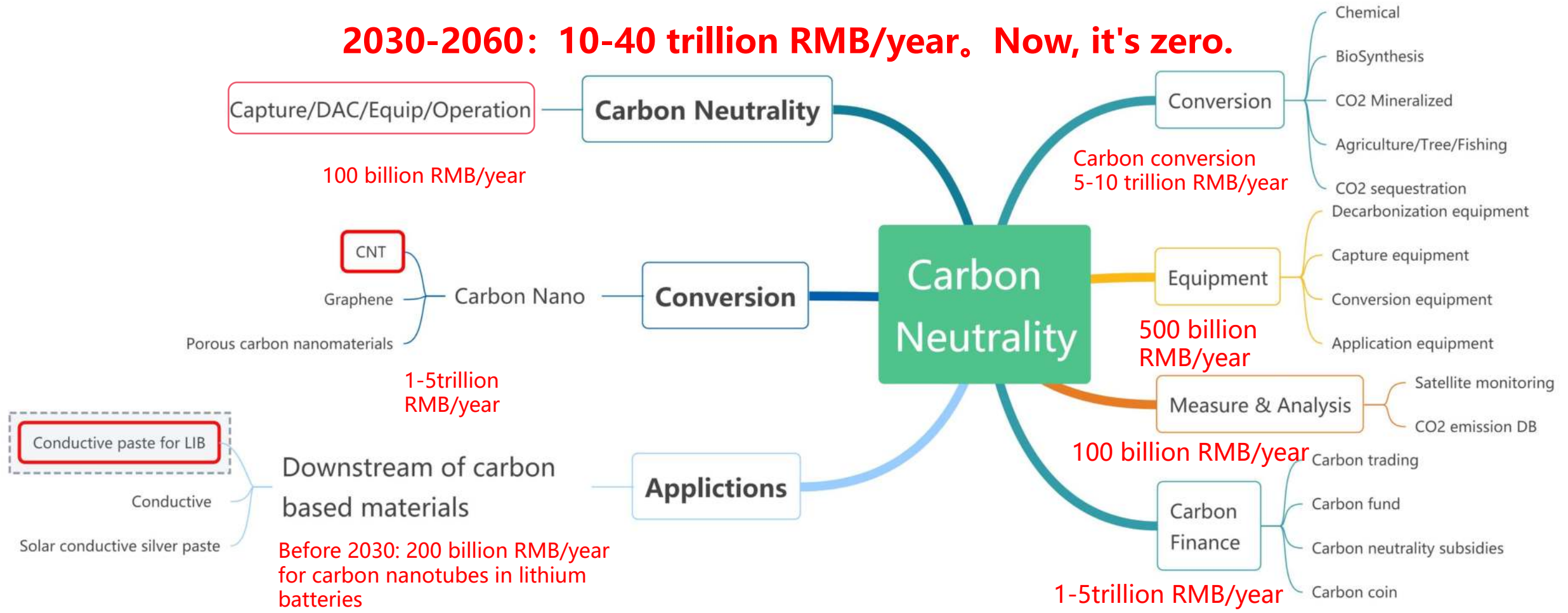


Different Carbon Nanomaterials by morphology control, formula, and processing

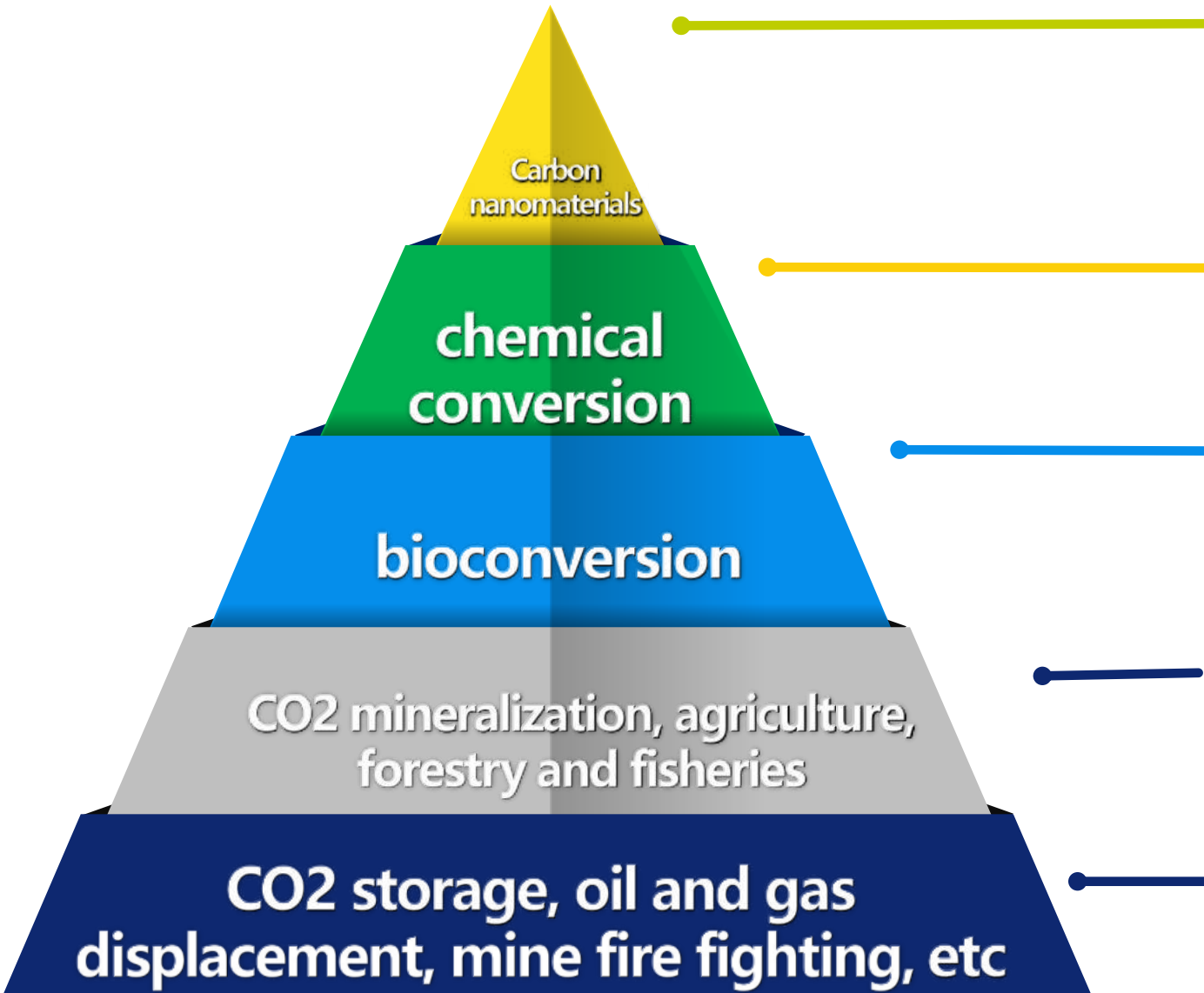
CNT produced by industrial scale furnace since Nov. 2020

Carbon Neutral Economic Development

2030-2060: 10-40 trillion RMB/year. Now, it's zero.



Carbon Dioxide Conversion Pyramid, A Feasible Carbon Neutrality Path



Maximum value added

The highest added value of CO₂ conversion products, the product value of 10,000 to million RMB/ton of CO₂ is reduced to carbon nanomaterials and oxygen, the most thorough conversion unit of carbon nanomaterials contains about 4 units of CO₂. The amount of conversion is 100 thousand tons to 10 million tons

Higher added value

Chemical conversion products involve various fields, the product value of thousands to thousands of RMB/ton, involving hydrogen and other chemical products, may need to be converted in the chemical park of 100,000 tons to tens of millions of tons

High value added

Microorganisms, enzymes and microalgae to convert CO₂. The converted products involve food, starch, feed, cosmetics, pharmaceuticals, fertilizers and other bioactive substances, with a product value of 100 to 10,000 RMB/ton. The amount of conversion can be 100 thousand tons to 10 million tons, or even 100 million tons

Most widely used

CO₂ mineralization is one of the most widely used carbon dioxide conversion products (cement, ash ballast), the simplest conversion, China's application prospect: 100 million tons per year, product value of 100 to 1,000 RMB/ton. Improve the concentration of CO₂ in the crop environment, through photosynthesis, help crop yield, early maturity, etc., play the role of gas fertilizer, instead of pesticides and fertilizers. Carbon sequestration of 100 million tons

A lot of CO₂ can be sequestered

CO₂ flooding of coalbed methane, oil flooding and mine fire fighting can absorb a large amount of CO₂, improve the efficiency of coalbed methane and oil mining, and reduce disasters and accidents in the process of coal mining

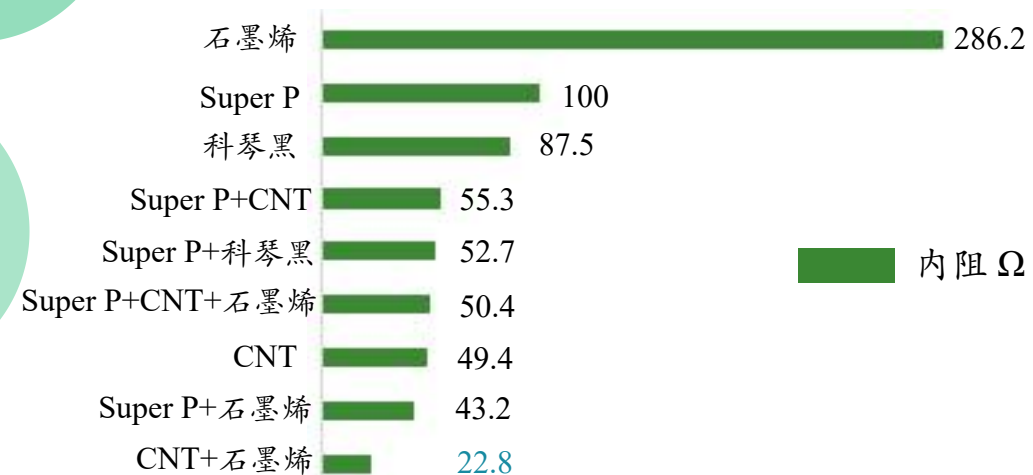
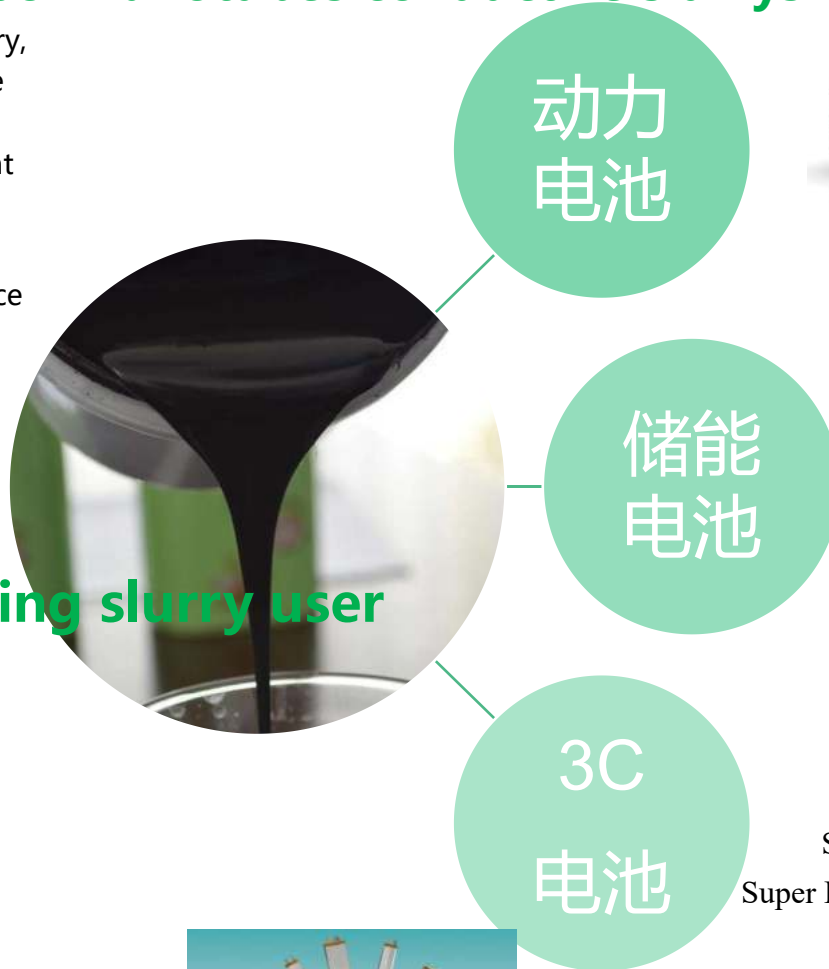
Key Product: Conductive slurry of carbon nanotube for lithium-ion batteries

The main advantages of carbon nanotubes conductive slurries

- Reduce the internal resistance of lithium battery, improve the gram capacity and high-rate discharge power density
- Increase the energy density, reduce the amount of conductive agent and binder
- Extend service life
- Improve low temperature discharge performance
- Reduce the battery temperature during fast charging and discharging
- Ultra-high temperature and ultra-low temperature environment

Lithium battery company- Carbon nanotube conducting slurry user

BYD, CATL, ATL, 孚能科技、天津力神、欣旺达、亿纬锂能、中创新航(中航锂电)、鹏辉能源、新能源科技、珠海光宇、万向、卡耐新能源、北京国能等



表：不同类型和配比导电剂内阻

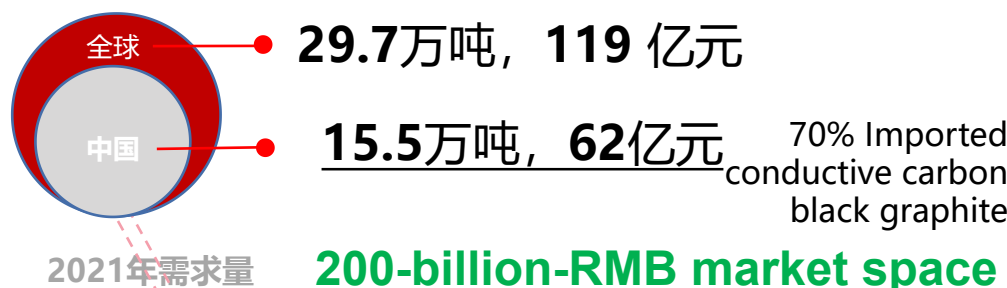
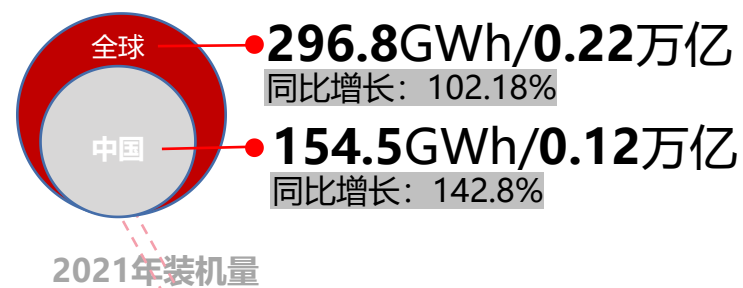
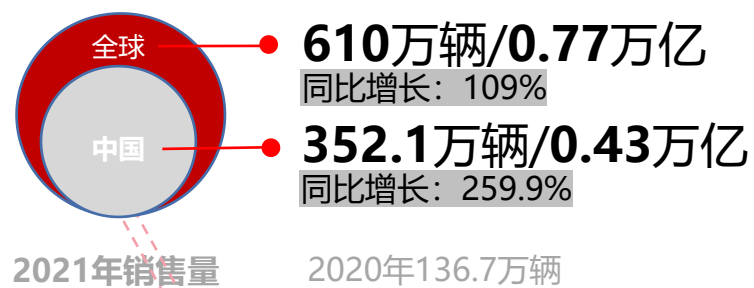
Market Analysis of New Energy Vehicles, Lithium Batteries and Their Conductive slurries (2030)

new energy vehicles

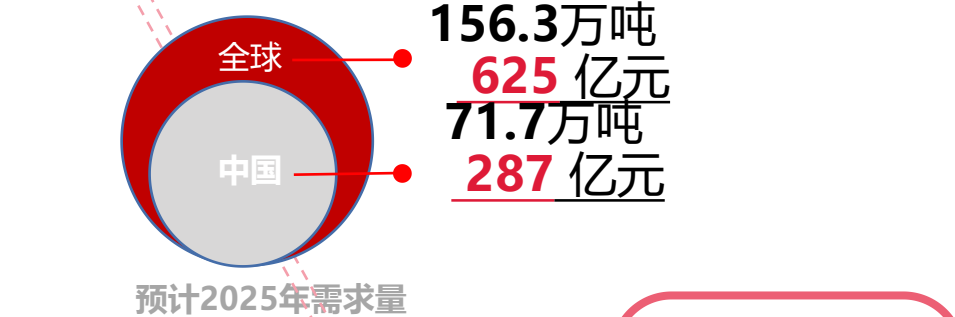
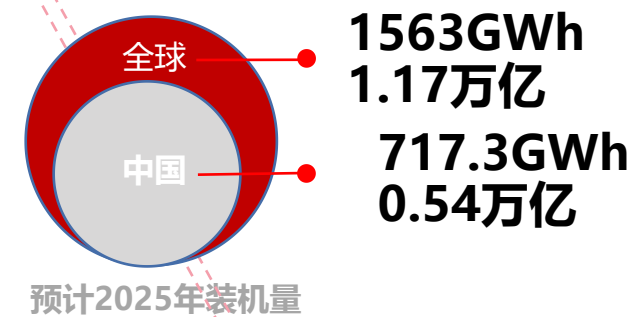
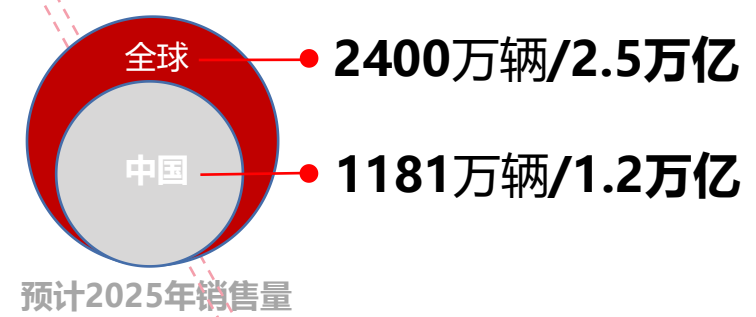
power battery

conductive agent

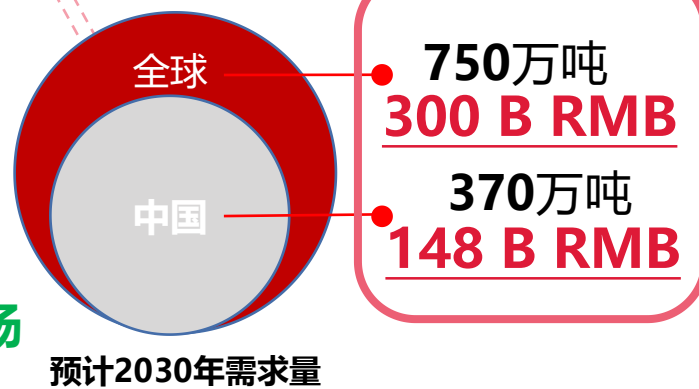
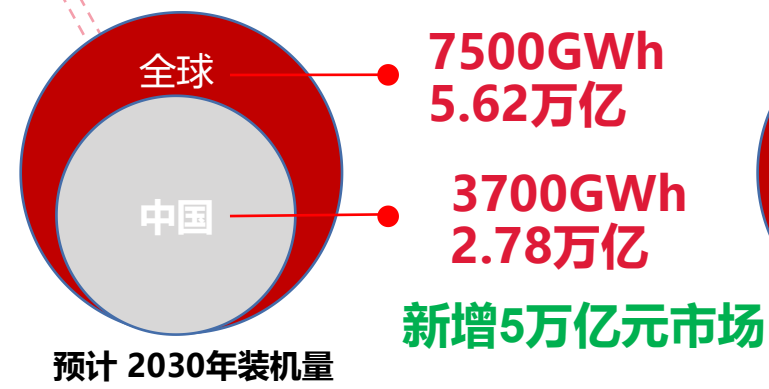
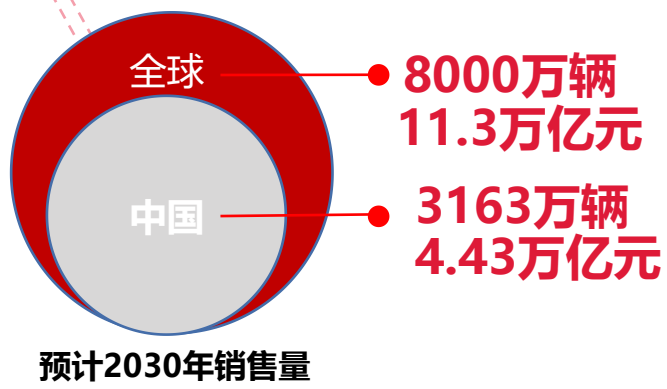
Current Carbon Institute track



200-billion-RMB market space



A market of 10 trillion RMB was added

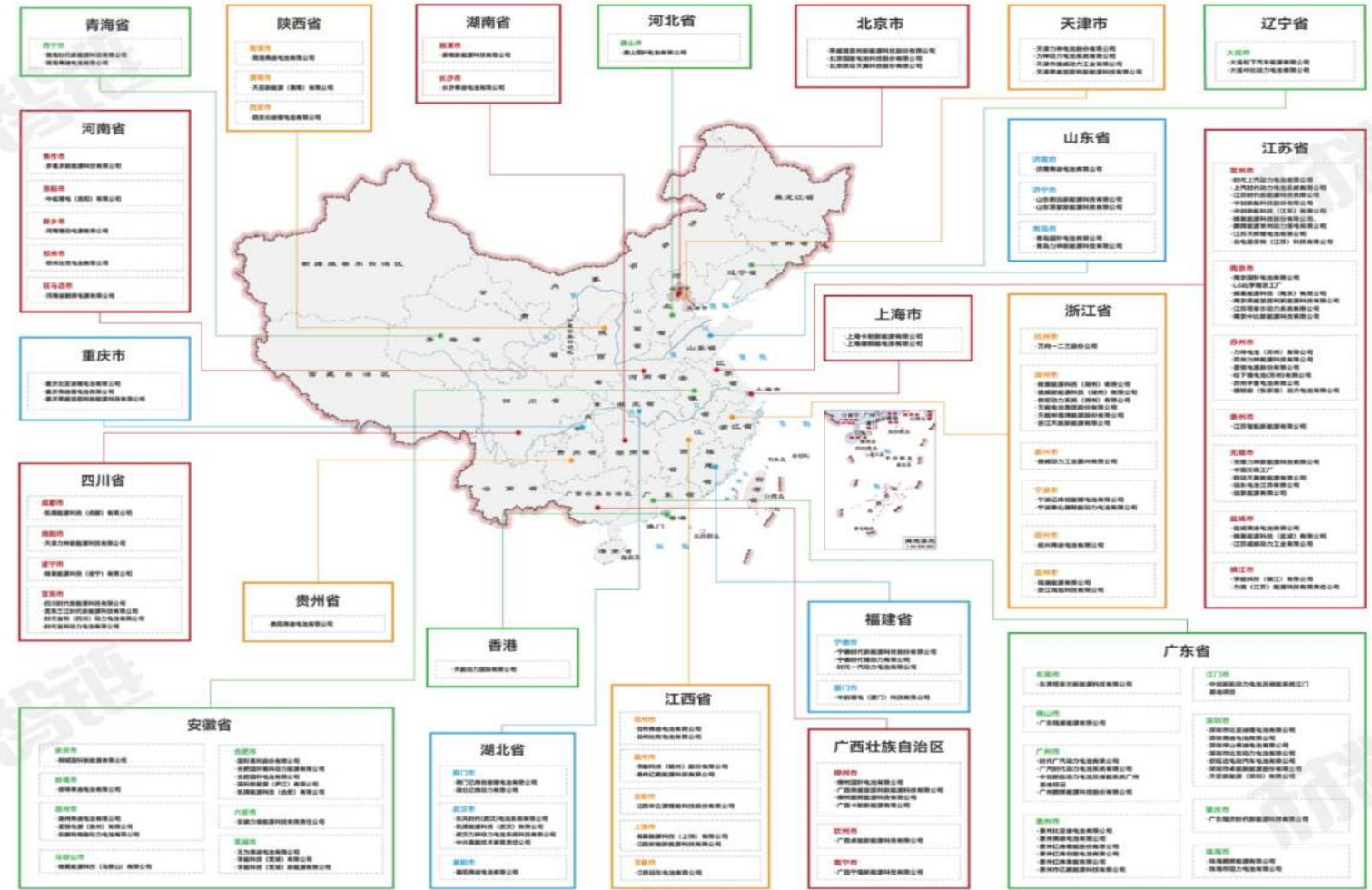


Docking more than 186 new lithium battery projects nationwide (in 2025)

In the future, in the foreseeable medium and long term, China's lithium battery market will be mainly distributed in coastal and economically developed areas; In the lithium battery market layout, will occupy a certain lithium battery market, at the same time in the carbon neutral development to seize the first opportunity.

Data up to the end of December 2022

Province	Planning base	GWh	Province	Planning base	GWh
Jiangsu	31	577.8	Jilin	2	50
Guangdong	15	252.8	Qinghai	3	40.5
Zhejiang	19	405.5	Hunan	3	38
Hubei	14	540.1	Henan	3	73
Sichuan	13	438	Shanghai	2	61
Anhui	12	196	Gansu	4	20.5
Fujian	10	417	Neimeng	2	30
Jiangxi	12	210	Guangxi	10	184
Chongqing	5	87	Hebei	2	44
Shandong	11	179.6	Tianjin	2	29
Shanxi	2	57	Yunnan	3	26
Guizhou	1	30	Taiwan	1	1.27
Beijing	1	2	Ningxia	1	2
Liaoning	2	50			
Total			186		4042.07



National capacity planning of conductive slurry can not meet the development needs of lithium battery industry

- ◆ The planning capacity information of major lithium battery enterprises such as CATL, BYD, EVE, CALB, REPT, SUNWODA, GREAT POWER, LISHEN, FARASIS, etc. obtained from public data.
- ◆ GGII: In 2021, CNT will account for 27% of the conductive slurry market, and it is expected that CNT will account for 61% in 2025. The long-term trend of replacing carbon black and conductive graphite is clear.

Planning capacity of major lithium battery enterprises	Power battery GWh (in 2025)
CATL	712.2
BYD	487
EVE	337.5
CALB	260
REPT	244
SUNWODA	186
GREAT POWER	50
LISHEN	40
FARASIS	39
Total GWh	2355.7

The amount of CNT and its conductive slurry	Count
CNT Permeability (%)	60%
CNT conducting slurry for power batteries (GWh)	1413.42
Amount of CNT conducting slurry (ton/GWh)	1,000 (average)
The above lithium battery enterprises CNT slurry consumption (ton)	1,413,420
Total national planning capacity (GWh)	4042.07
National amount of CNT conductive slurry (ton)	2,425,242

Note: The data comes from the analysis of the planned production capacity of domestic lithium battery industry to 2025 by the report of Guosheng Securities and the open market information of GGII, Qidian Research Institute

Our general planning CNT conductive slurry production capacity is more than 400,000 tons, the output value of nearly 20 billion RMB. Within five years, the supply of conductive slurry was in short supply.

Batteries are Critical for Carbon Neutral

Portable Energy Storage

Electronics



Drone



Electrical Vehicles



Electric planes



Globe: 1.4 billion cars/trucks
70kWh/car
China:400 million cars

100 TWh batteries
China: 28 TWh
Now Globe 1TWh/a
100 years to replace

\$100/kWh
\$10Trillion total
\$0.1Trillion/yr

Energy Storage, even bigger market

Renewable electricity cost: 1-3 cents/kWh in the long term



Technology gap: grid scale energy storage across multiple time scale

minute	hour	day	week	month	season
World electricity (2019): 23,000 TWh China 8,500 TWh	<u>72hr storage</u> 200 TWh batteries China 70 TWh		Now, 1TWh per year It will cost 200 years		<u>\$100/KWh</u> \$20Trillion
	96h 94TWh				

China' s EV battery + energy storage requires 97-120 TWh, and the world' s EV battery + energy storage requires 300 TWhs.

Courtesy: Prof. Yi Cui, Stanford Univ.

What is driving the market

What is driving the market (regulation, consumers, etc)

China

International

Materials are the next frontier of decarbonization

- Europe has begun to redefine rules with the goal of purchasing and using low-carbon materials with full lifecycle carbon emissions.
- For commodity producers, now is the time for action regarding decarbonization.
对日用品生产商，现在是时间采取行动开始减碳了。
- For commodity customers, now is the time to find alternatives to achieve net-zero emission targets
对日用品消费者，现在是时间去发现可替代的方案，去实现零碳排放的目标。
- **Strong Scope 3 goal is driving the demand for low-carbon materials**

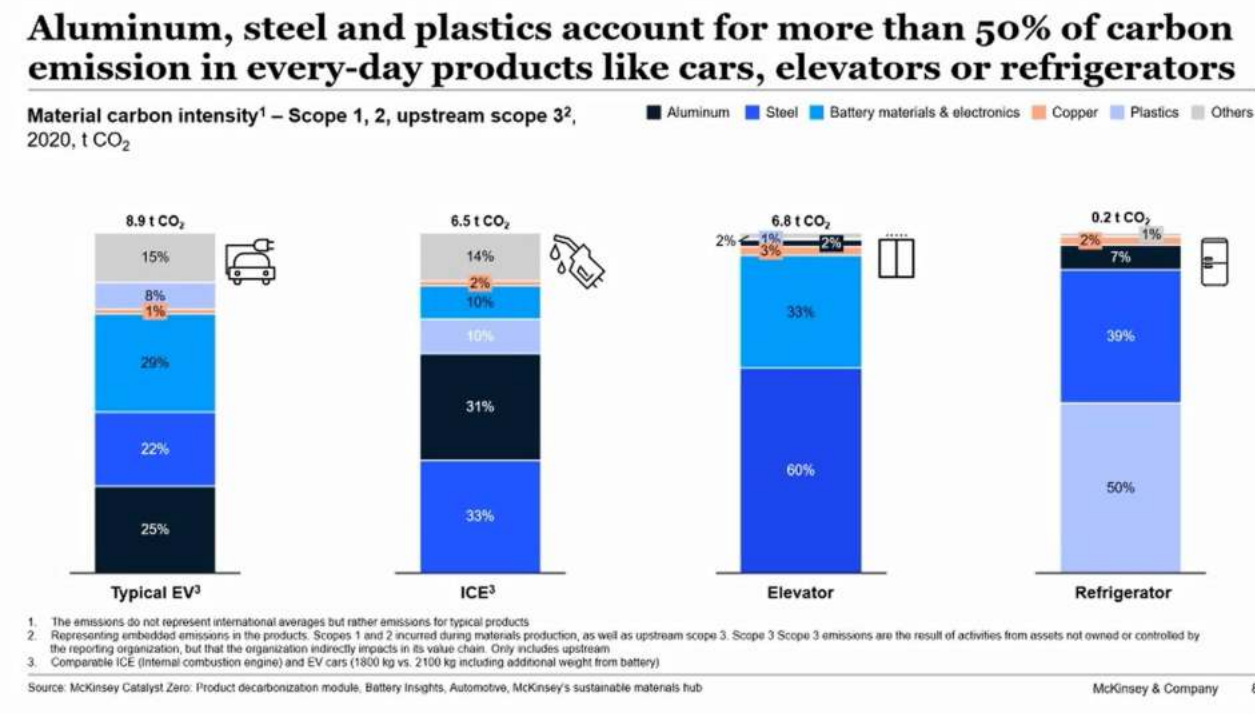
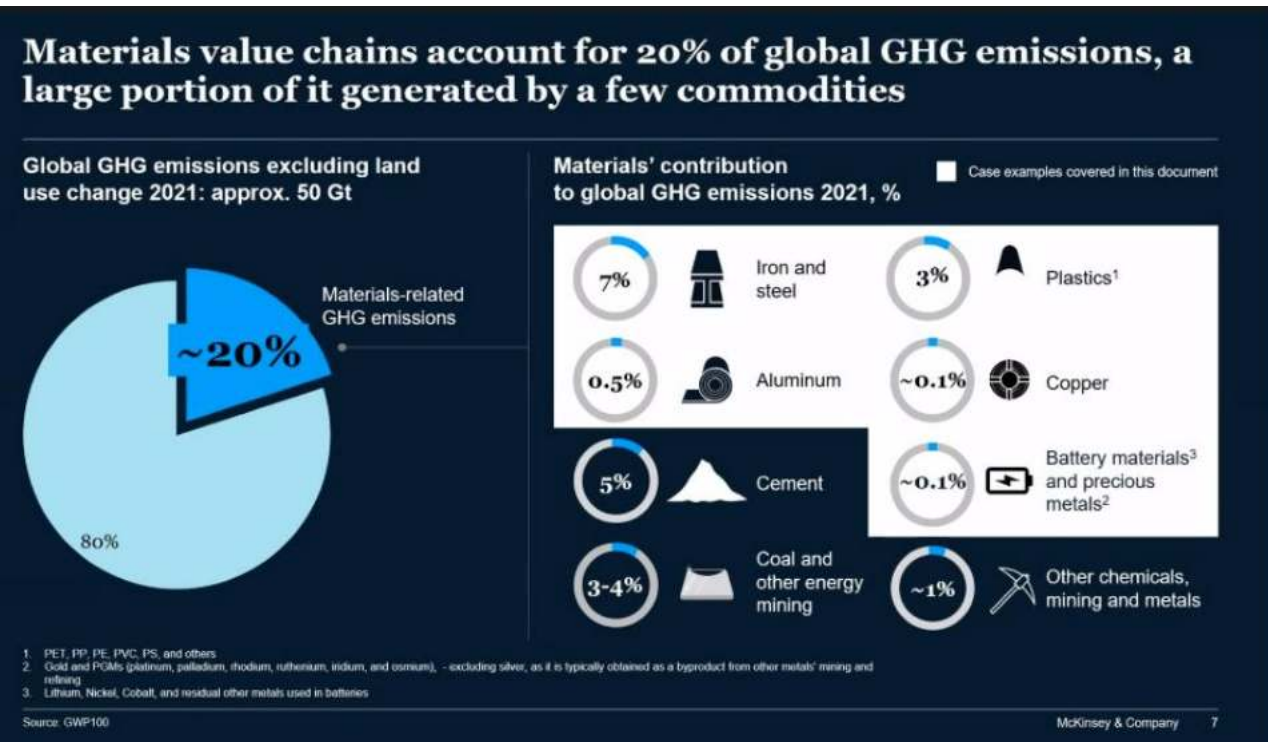
广范畴3排放（Strong Scope 3）目标正在驱动对低碳材料的需求

GHG Protocol Corporate Value Chain (Scope 3) Standard: Product life cycle emissions are all the emissions associated with the production and use of a specific product, from cradle to grave, including emissions from raw materials, manufacture, transport, storage, sale, use and disposal. 范畴3排放就是产品全生命周期温室气体排放，是与特定产品的生产和使用相关的所有排放，从摇篮到坟墓，包括原材料、制造、运输、储存、销售、使用和处置。温室气体主要包括二氧化碳、甲烷和氮氧化物等。这里我们仅考虑二氧化碳排放。

Materials are the next frontier of decarbonization

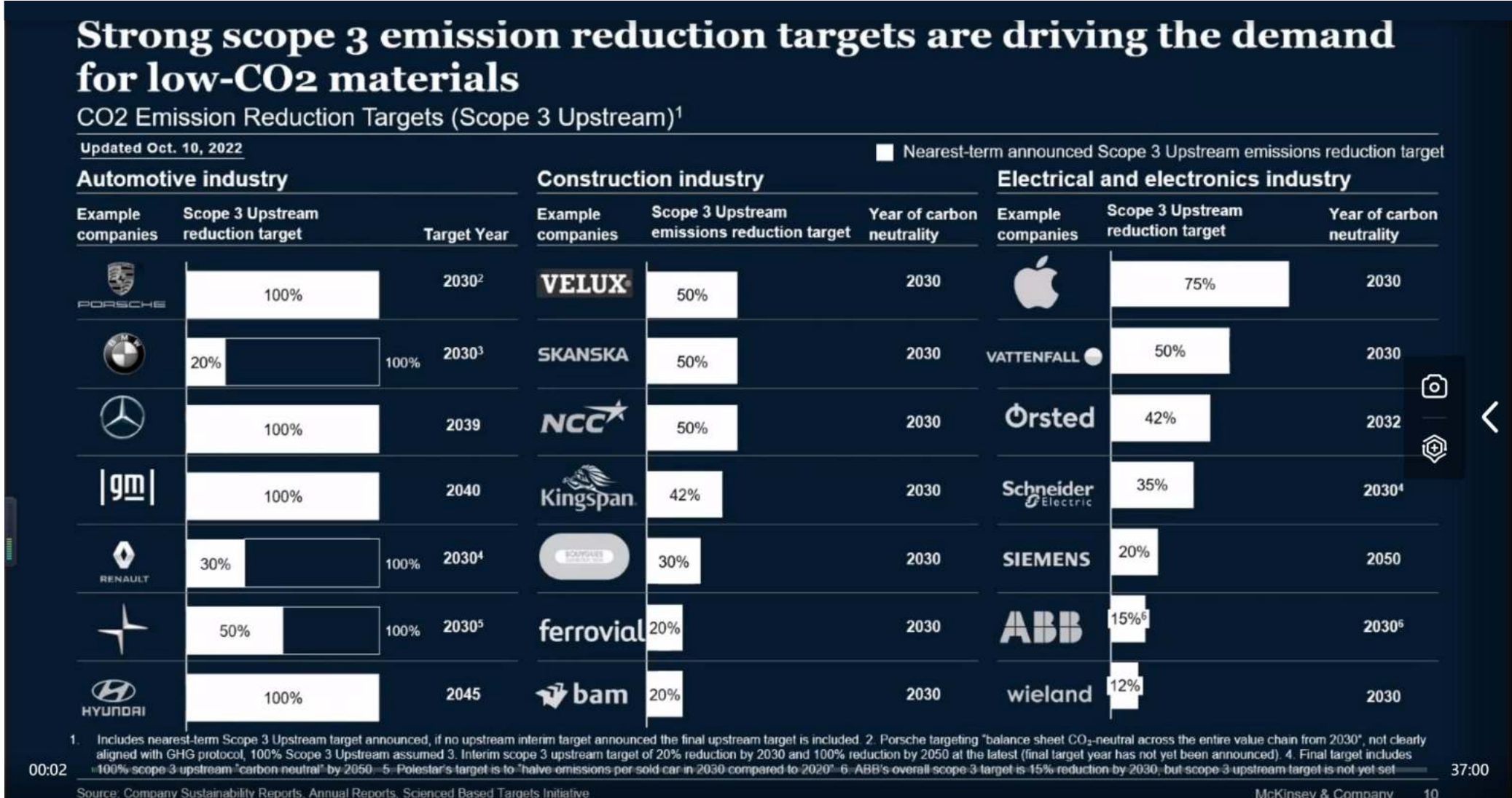
材料价值链贡献了全球温室气体排放的20%
大部分来自几个大宗原材料

铝、钢铁和塑料链贡献了日用品碳排放的50%，
如燃油汽车、电动汽车、电梯、冰箱



Many international brands have set goals and timeline for achieving Scope 3 carbon emissions targets

众多国际品牌提出了的达到范畴3碳排放目标的比例及时间表



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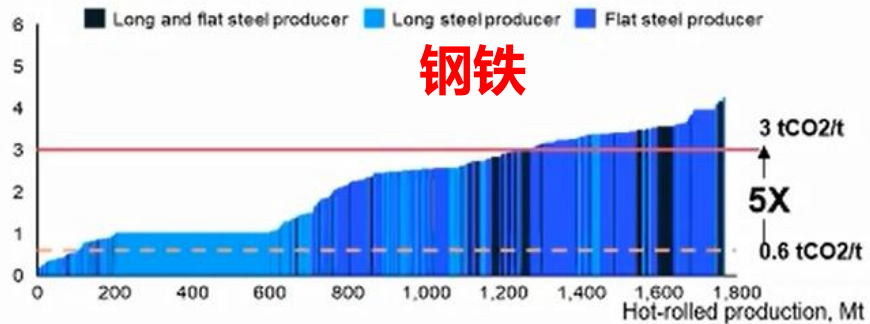
Courtesy: McKinsey

Goals for low-carbon production are 4 to 11 times lower than the current carbon dioxide emissions from major raw materials

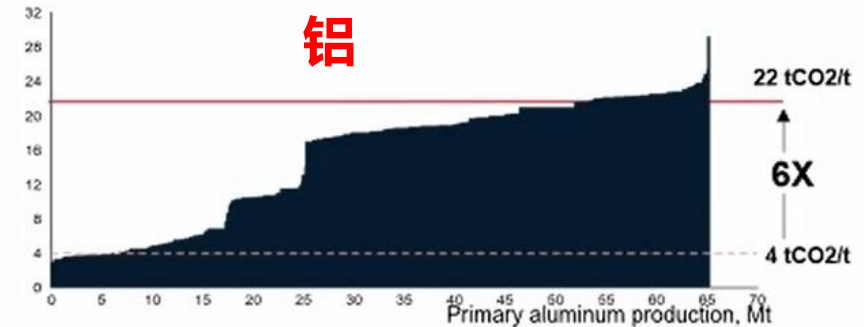
低碳生产的指标要比目前主要的大宗原材料生产的二氧化碳排放低4-11倍

Current materials CO₂ intensity, tCO₂/t of product¹, 2020

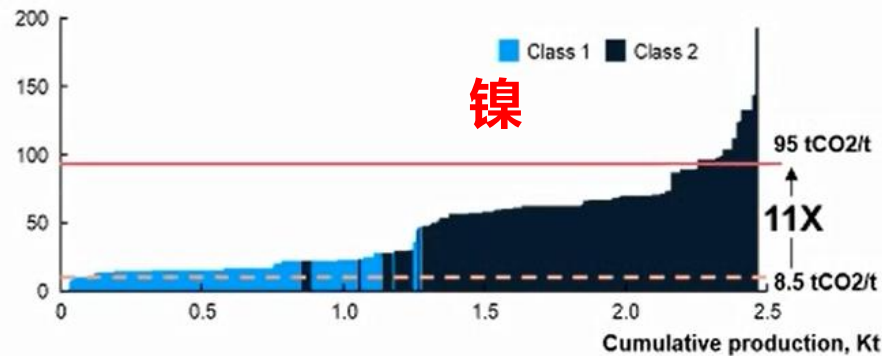
Steel, scope 1,2 & 3 emissions



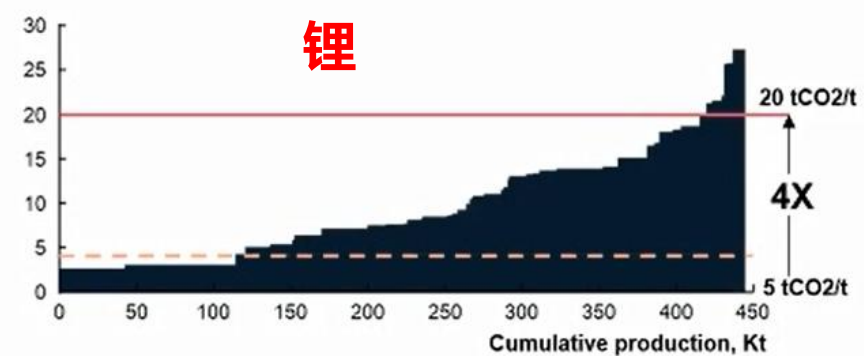
Aluminum, scope 1,2 & 3 emissions



Nickel, scope 1,2 & 3 emissions



Lithium, scope 1,2 & 3 emissions



1. Scopes 1, 2 and 3. For lithium, CO₂/t of lithium carbonate equivalent, for others, t per t of steel, aluminum and nickel

Source: McKinsey Basic Materials 2022, MetalSpans (CO₂ emissions model v52), MineSpans, McKinsey's sustainable materials hub

McKinsey & Company 9

中国的工业几乎都采用从矿石开采到冶炼的大宗原材料，都很难达到低碳材料的要求。
只有回收原材料的生产可能达到低碳材料二氧化碳排放的标准

What are challenges to creating and scaling up market

- ◆ Most materials are made from Oil, gas and coal, petrochemical based
- ◆ CCUS tech & products new, costs are higher than petroleum based products
- ◆ Carbon trading in China is not enough to offset the above cost differences
- ◆ Market mature needs time

Personal experience and observation, to create new market or market shares with new tech and products, it could take over dozen years, even longer to nourish.

How to develop & deliver technological solutions

- ◆ Identify related tech, 0 - 0.5, nourish it to 1 and 1.5, cooperate with universities and research institutes
- ◆ Find and follow the matured market
- ◆ Has to have long time plan to create a new market or knock off existing products
- ◆ Action instead of just thinking

We have to start at sometime, start from zero.

In China, it's too difficult to start from zero.

International, CCTV, CGTN, and domestic reports



新华社客户端
主流价值 从新看见

立即体验

碳中和的山西创新实践

2021-03-25 09:08:02
来源: 山西日报

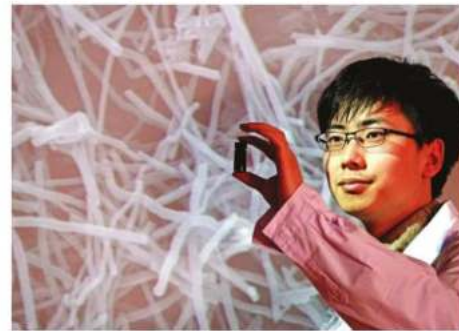
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社会

查看详情

视觉 7

碳中和的山西创新实践



1工作人员在展示放大5万倍的碳纳米管的纳米结构。

3月18日,山西清洁碳经济产业研究院的碳纳米管导电浆料生产线生产出了第一批锂电池导电浆料,提供给天津力神电池股份有限公司进行锂电池导电剂的试用。自此,山西清洁碳经济产业研究院自主研发、自主投资建设的碳捕集及转化装置将煤电烟气中的二氧化碳进行捕集、纯化,并转化生产出价值每吨近50万元的碳纳米管工业化系统已经运行了2个多月了。这套系统的碳捕集部分的能耗在目前国内已经运行的碳捕集系统中处于领先水平。

Fortune Magazine, Scientific American Magazine, CBC Canada, Wired UK, and others have reported on the Carbon XPRIZE and the award-winning teams

WIRE D LONG READS BUSINESS CULTURE GEAR SCIENCE SECURITY VIDEO

STEPHEN ARMSTRONG SCIENCE 09.04.2018 03:36 PM 2018/04/09

These startups are turning CO2 pollution into something useful

Solving climate change needs more than just reducing emissions—we're going to have to take back and transform the CO2 as well

To address [climate change](#), the [2016 Paris Agreement](#) saw 194 states and the European Union agree to limit the rise in global temperature to below two degrees Celsius over this century. With carbon dioxide levels still climbing, as [Nasa's monitoring shows](#), solving climate change needs more than just reducing emissions – we're going to have to take back the CO2 and technology can help.

C4X 中国C4X在碳捕集转化系统前探讨



XPRIZE

"China produces about one quarter of the world's CO2, which is around 90 million metric tonnes per year," according to [Wayne Song](#), who's leading the team from Suzhou, China. "Our solution is really aimed at cleaning up China first."



山西省电视台转型进行时采访宋维宁博士



WAYNE SONG
FOUNDER, C4X

中国国际电视台在美国怀俄明吉列市
采访碳X大赛XPRIZE及宋维宁博士

cgtn.com/america f Follow us @cgtnamerica

Key Personnel of the Team



Wayne Song, Ph.D.
Founder and CTO

- Educated and taught at McMaster Univ., Univ. of Toronto, Peking Univ., Tsinghua Univ., Univ. of West Virginia, Univ. of Maine, etc.
- Climate change, carbon neutrality, environmental protection, mechanics, materials, chemical engineering, civil engineering, and mechanical engineering, etc.
- 30 years of experience in technology industrialization, international cooperation, and 10 years of management experience in domestic and foreign listed companies;
- Published about 100 academic and conference papers, possessing over 30 Chinese and US patents.
- "Climate Trailblazer" , Global Climate Action Summit at the 2018 United Nations Global Climate Action Summit in San Francisco, United States (San Francisco, 2018).
- From 2016 to 2020, founded C4X team. 10 Finalists of Carbon Xprize 2016-2020, the only China-Canada team in the top ten of the world, and won a prize of \$500000.
- One of the key members of the R&D team for the first carbon based biomass composite materials in North America, as well as one of the founders of Dura Products, a Canadian listed company. Brought wood-plastic back to China in 1998, he was known as the first person in the Chinese wood-plastic composite industry.



22 CLIMATE TRAILBLAZERS 全球气候开拓者

The Climate Trailblazers reflect the global nature of the Summit, which aims to bring together the best in international climate change activity. Besides bringing their unique international experience to the Summit in September, the Climate Trailblazers will spread awareness of the Summit's ambitious goals within their own climate arenas in the lead up to the event. They will humanize the event as they will show through their actions that everyday people can do extraordinary things.

6 NORTH AMERICA

2 EUROPE

3 ASIA

Dr. Wayne Song, one of the CLIMATE TRAILBLAZERS

3 CENTRAL & SOUTH AMERICA

4 AFRICA

4 AUSTRALIA & OCEANIA ASIA



DR. ROBERT BULLARD
Prof. Urban Planning & Environmental Policy at [Texas Southern University](#) Houston, Texas, USA



CHRIS CASTRO
Director of Sustainability at the [City of Orlando](#) Orlando, Florida, USA



KATE GREENBERG
Western Program Director for the [National Young Farmers Coalition](#) Durango, Colorado, USA



ANTHONY LEISEROWITZ
Director of the [Yale Program on Climate Change Communication](#) Hamden, Connecticut, USA



SAM TEICHER
Founder and Chief Reef Officer of [Coral Vita](#) Freeport, Bahamas



JENNIFER WAGNER
Executive Vice President of Corporate Development at [CarbonCure Technologies](#) Halifax, Canada



BASIMA ABDULRAHMAN
Founder and CEO of [KESK Green Building Consulting](#) Erbil, Iraq



TARIQ AL-OLAIMY
Co-Founder of [3BL Associates](#) Manama, Bahrain



DR. WAYNE SONG
CEO and General Manager of [Green Carbon Technology Co., Ltd.](#) and [C4X Technologies Inc.](#) Suzhou, China

San Francisco, USA, Sept. 12, 2018

Key Personnel of the Team

公司
高
管

Name	Title	Background
Dr. SM Xie	Partner	➤ 北大法律系，日本神户大学法学博士。法律、投资及海内外并购经验，执业律师
Dr. DH Li	Partner	➤ 清华本科、多伦多大学博士。25年国际多行业并购投融资经验
HW Wen	Manufacture	➤ 20多年大工业生产、安全和全面管理经验，全面控制、协调生产部门的人员管理及各项生产活动；制定生产计划及任务，安排和控制生产作业进度，跟踪生产情况，产品需求，生产过程，产值目标等
XB Cheng	Processing	➤ 30年新材料设备，模具，机械设计、生产经验； ➤ 丰富的生产经验，熟悉行业生产过程，原材料供应渠道，生产规程以及质量标准
LQ Zhang	QC	➤ 工商管理硕士，服务过十多家世界500强企业； ➤ 质量管理经验丰富；ISO、EICC相关质量和环境管理体系建立及全面管理
GX Ren	Administration	➤ 前中国银行某支行行长，20多年行政人事管理经验和山西省政府资源关系
Y Zhang	CFO	➤ 30多年财务工作经验，20多年外资经理以上职位，具备大中型外资制造企业从业背景；负责税务筹划、营运分析、成本控制及成本核算等
YG Wu	Sales	➤ 20年大型项目管理运营经验，负责市场开拓

技术
团
队

Name	Title	Background
G. Ozin	Advisor	➤ Father of Nanochemistry, Einstein Award of Science, FCAE, Canada, FRSC, Univ. Toronto
M Sain	Advisor	➤ Prof. Univ. Toronto, FCAE, Canada, FRSC, UK
Dr. HJ Wu	Advisor	➤ 美国加州州立大学客座教授，碳基材料专家

LCA Carbon Emission of Li-ion Battery

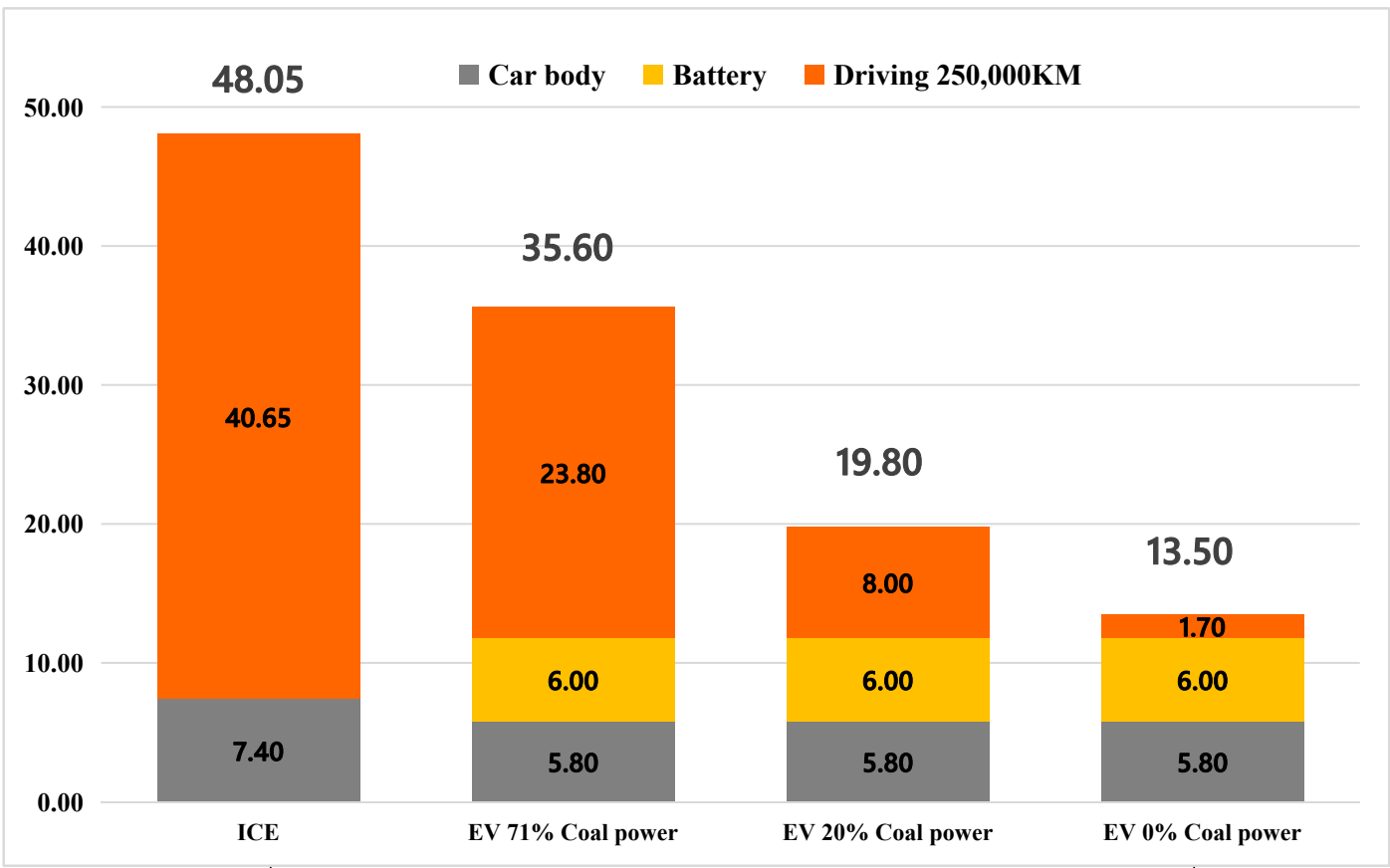
	GWh	Kt CO2e carbon/graphite	Kt CO2e Li-ion battery
	1	5.37	72.9
	100	537	7,290
CATL	711	3,820	51,820
China (2030)	3000	16,110	218,640

	KWh/EV	battery Energy consumption KWh
Tesla Model 3	82	25,837
Nissan LEAF	62	19,535
small EV	50	15,754

- ◆ By 2025, Chinese lithium-ion battery industry will reach a production capacity of over 3000GWh.
- ◆ The full lifecycle carbon emissions of battery production in the entire industry will reach 219 million tCO2e, second only to the carbon emissions of the aviation industry.
- ◆ The preparation of carbon nanomaterials by electrolysis of CO2 can reduce carbon dioxide emissions by 12% for the lithium-ion battery industry.

Comparison of LCA CO2 emissions of fuel vehicles and EVs (in tons)

- The carbon emissions of EVs decrease with the reduction of carbon emissions from the power grid;
- At present, 71% of the electricity in the power grid comes from thermal power, and carbon emissions reduction is still high;
- By 2050, the thermal power composition of the power grid will be reduced to 20%, and carbon emissions reduction will be significantly reduced;
- By 2060, the thermal power composition of the power grid may decrease to 0%, and the carbon emissions reduction throughout the entire life cycle of the power grid will reach its lowest point.



ICE: Toyota RAV4
 EV: Tesla model3 performance AWD, 82KWh



The carbon emissions of EVs decrease with the reduction of carbon emissions from the power grid

Note: Energy consumption based on 250,000 KM life time driving distance
 LCA=Life Cycle Assessment
 EV=Electric Vehicle
 ICEV-G=Internal Combustion Engine Vehicle using Gasoline
 Source: Wall Street Journal; 蔡蔚, 2022车用动力系统国际高峰论坛



Decarbonization - Challenges and Opportunities

去碳 - 机会和挑战

Dr. Wayne Song, CEO

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