Utilities - HK/China

Carbon Watch: An overview of China National Emission Trading Scheme

Industry Overview

02 February 2024

Equity
HK/China
Utilities

Gary Tsang >>
Research Analyst
Merrill Lynch (Hong Kong)
+852 3508 6825
gary.tsang@bofa.com

Cissy Guan >>
Research Analyst
Merrill Lynch (Hong Kong)
cissy.guan@bofa.com

Charlotte Xia >>
Research Analyst
Merrill Lynch (Hong Kong)
charlotte.xia@bofa.com

Carbon Watch: Monitoring carbon and impact to power

Carbon Watch is our new series tracking China's carbon policy and its impact to the power sector. China National Emission Trading Scheme is still at the nascent stage of development covering <5% of carbon emissions in 2023. We estimate carbon cost for thermal power operator like Huaneng could reach RMB0.6-1.5bn p.a. in 2026-27E, or 0.4-1.1% of current average benchmark thermal tariff. But longer term higher carbon cost will make thermal power less competitive compared to renewable power.

CNETS: An introduction and outlook on scope and price

CNETS is the trading platform for cost-effective control and reduction of carbon emissions. Currently, CNETS only covers thermal power generators. Cement and aluminum may be included in 2024, and iron & steel in 2025. Allowances are allocated for free using emission intensity benchmark and based on actual power output. The benchmark could be tightened by 1-2% p.a. going forward, and may take 3-4 years before leading IPPs need to pay for emission. Industry expert sees CNETS carbon price at RMB70/ton in 2024, RMB120/ton in 2026, vs RMB55/68 per ton in 2022/23.

Comparing China and EU emission trading systems

EUETS covers the power, industrials and transportation sectors with trading volume at 6.2x of emissions (2022), way higher than CNETS at <5% of emissions in 2023. EUETS distributes allowances through both free allocation and auctioning (mainly through auction for its power sector). EUETS is a cap-and-trade system where carbon prices are affected by economic growth, weather, and the relative prices of gas and coal. CNETS is based on emission intensity. Market confidence, reduction targets and relative pace of actual vs. benchmark emission intensity reduction will impact carbon price.

CCER: Overview and its connection with CNETS

CCER market is for voluntary emission reduction projects (mandatory in CNETS). CCER is issued to projects engaging in GHG emission mitigation or atmosphere GHG removal. Currently 4 technical standards are approved for CCER issuance, i.e. forestation carbon sink, concentrated solar power, offshore wind, and mangrove vegetation creation. MEE may include other technical standards and requires approved projects to be economically inviable if without CCER. 5% of emission is allowed to be offset with CCER in CNETS.

Green power, green electricity certificate and CNETS

GEC is unlikely to be qualified to offset CNETS emissions, consistent with international convention due to greenwashing concern. GEC price may drop to near zero after full renewable power inclusion, same as the case in the US and EU. Industrial sector carbon emission is measured through a) combustion of fossil fuel; b) decomposition of carbonate; c) implied emission from power and heat purchased. Going forward, industrial sectors can purchase green power to reduce emission from power purchased.

[Global Energy Weekly: Sell the range, buy the dip in carbon 02 October 2023]

CNETS: China National Emission Trading Scheme

EUETS: EU Emission Trading System

CCER: China Certified Emission reduction

GHG: greenhouse gases

MEE: Ministry of Ecology and Environment

GEC: green electricity certificate

IPPs: independent power producers

NDRC: National Development and Reform Commission

NEA: National Energy Administration

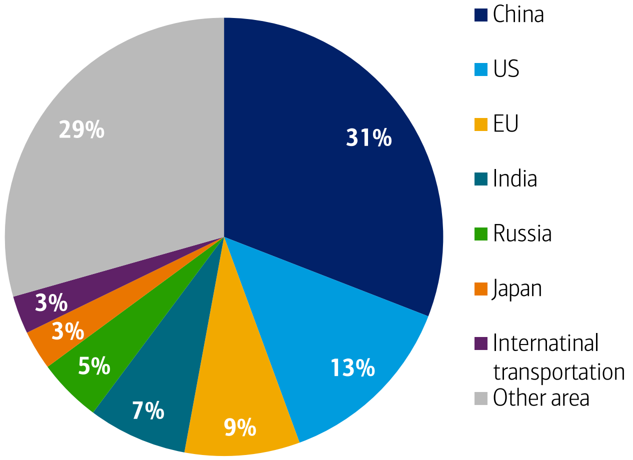
NBS: National Bureau of Statistics

China carbon goals – 2025, 2030, 2060

China's dual carbon goal was first announced in 2020, which targets peak carbon dioxide (CO_2) emissions before 2030 and to reach carbon neutrality by 2060. China State Council published action plan for 2030 carbon peaking in Oct 2021, targeting to reduce carbon emissions per unit of GDP by 18% by 2025 and by more than 65% by 2030, compared to 2020 levels. According to 14th Five-Year Plan (FYP) mid-term assessment published in Dec 2023, CO_2 emission intensity reduction is lagging target.

Thermal power generators account for almost one-third of carbon emission in China, followed by iron and steel (15%) and cement (11%).

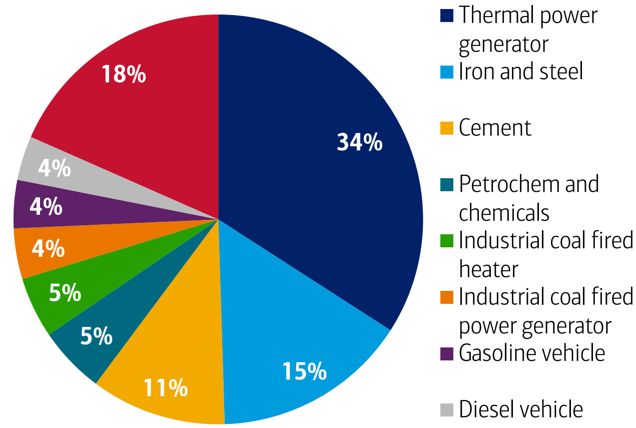
Exhibit 1: China accounts for 31% of global carbon emission
2021 global carbon emission by nation



Source: Our World in Data

BofA GLOBAL RESEARCH

Exhibit 2: Thermal power (including captive power plants) account for c.43% of China's carbon emission
China carbon emission by sectors in 2022



Source: NetEase Research Institute

BofA GLOBAL RESEARCH

What is China National Emission Trading Scheme (CNETS)?

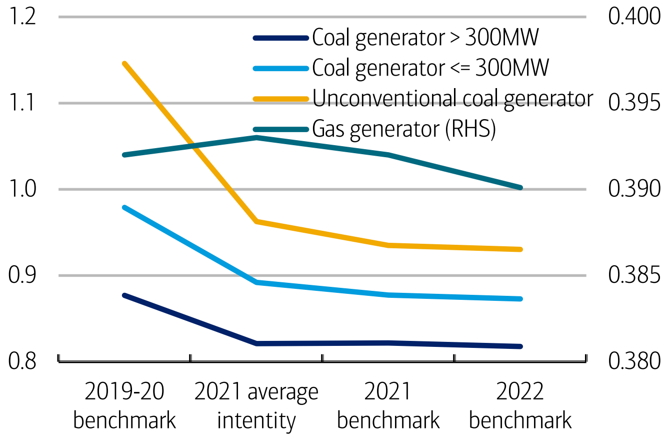
CNETS is designed to contribute to the cost-effective control and gradual reduction of carbon emissions. Currently, CNETS only covers thermal power generators, and the total allowance amount is basing on actual power generation and the tightening intensity benchmark of unit power generation emission, so that CNETS will not restrict power supply, but can incentivize more efficient generators.

One allowance gives the right to emit one tonne of CO_2, and currently allowances are allocated for free. For compliance period, companies must surrender enough allowances or emission reduction certificate to fully account for their emissions, otherwise fines are imposed. Companies can trade allowances with each other as needed. Spare allowances can be kept for use in the future or sell to other parties.

The benchmark is set to incentivize generators to improve efficiency and engage in heat supply and peak shaving. Currently CNETS allow different benchmark for different generators, i.e. is not forcing inefficient generators out of the market.

The benchmark tightened for the 2nd compliance period, to account for 1) technology advancement; 2) drop out of obsolete generators; 3) improvement of measurement accuracy, while making sure total emission allowance is equal to total emission.

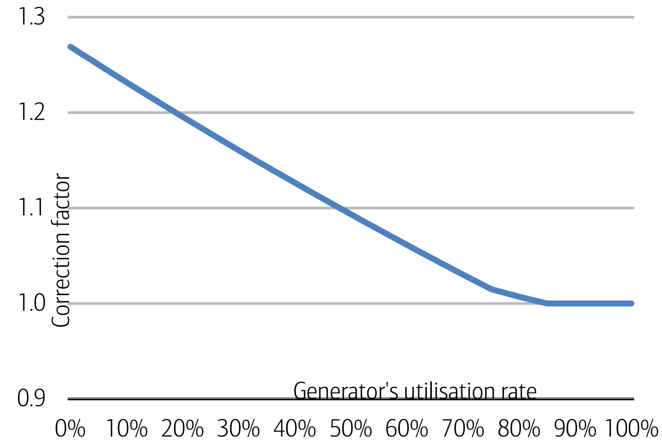
Exhibit 3: The intensity benchmark is set to incentivize efficiency improvement.
The intensity benchmark of unit power generation emission (tCO2/MWh)



Source: MEE, BofA Global Research

BofA GLOBAL RESEARCH

Exhibit 4: The correction factor is set to incentivize peak-shaving
The correction factor for coal generators utilization



Source: MEE, BofA Global Research

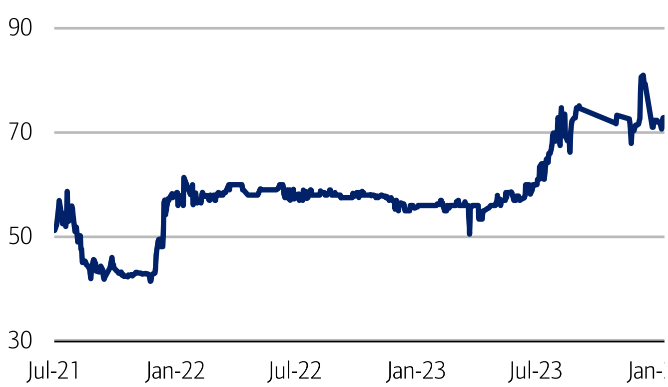
BofA GLOBAL RESEARCH

CNETS outlook, scope and carbon price

Our checks with industry expert Boyang Jin - China carbon team lead at Refinitiv LSEG (London Stock Exchange Group) - suggests:

- **Rate of benchmark reduction:** LSEG expects the power sector carbon emission benchmark will reduce by c.1-2% p.a. going forward, and it will take 3-4 years before leading IPPs will need to pay for emission.
- **Scope:** LSEG expects CNETS to include cements and aluminum sectors in 2024 and iron and steel in 2025, with the rest sectors, pulp and paper, petrochemical and chemical industry, to be included in 2025-26.
- **Carbon prices:** LSEG expects CNETS carbon prices to average at RMB70/ton and in 2024 RMB120/ton in 2026.
- **Auctioning:** CNETS is considering the inclusion of allowances auctioning, however, Ministry of Finance needs to establish a fund for use of proceeds first. LSEG reckons auctioning will not be launched before year end (YE) 25.

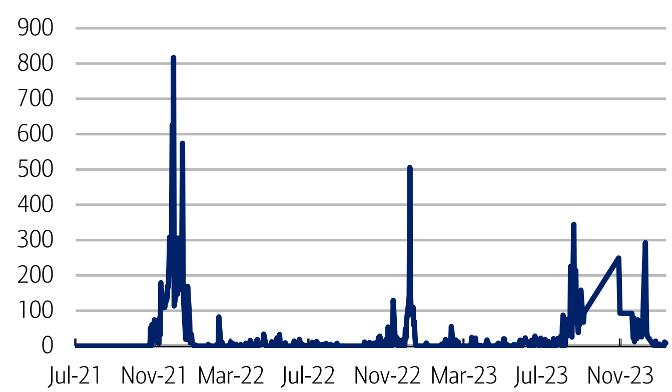
Exhibit 5: CNETS carbon price (RMB/ton)
LSEG expects CNETS carbon price at RMB120/ton in 2026



Source: Wind

BofA GLOBAL RESEARCH

Exhibit 6: CNETS carbon daily trading value (RMB mn)
Trading value only picks up when clearing day comes close



Source: Wind

BofA GLOBAL RESEARCH

Potential carbon costs to thermal power generators

While there are still many uncertainties, we use Huaneng power as an example to estimate the potential carbon cost and the impact to power tariff:

Exhibit 8: Potential carbon costs in 2026-27E for Huaneng Power
The RMB0.15-0.39c/kWh translates to 0.4-1.1% of average power tariff

	2026E	2027E	Comment
Coal-fired power output (bn kwh)	389	383	BofA forecast
Carbon emission (g per kwh)	726	726	Huaneng ESG report
CO2 emission (mn ton)	282	278	
Free quota as % of total emission	97.0%	95.5%	1.5ppt reduction a year
Free quota issued	274	266	
Charged quota (mn tons)	8	13	CO2 emission minus free quota
Carbon price (Rmb/ton) - 2024E	70	70	LSEG forecasts for 2024
Carbon price (Rmb/ton) - 2026E	120	120	LSEG forecasts for 2026
Carbon cost (Rmb mn) - low	**593**	**876**	
Carbon cost (Rmb mn) - high	**1,016**	**1,501**	
Carbon cost (Rmb cents/kwh) - low	0.15	0.23	Cost per kwh of coal-fired power
Carbon cost (Rmb cents/kwh) - high	0.26	0.39	

Source: BofA Global Research estimates, company report

BofA GLOBAL RESEARCH

The potential carbon costs in 2026-27E could reach RMB0.6-1.5bn depending on multiple variables. On a per kWh basis, this translates to about RMB0.15-0.39cent. If we compare to China's average thermal benchmark tariff, that means a potential 0.4-1.1% increase which is relatively small. But longer term, the carbon costs could rise and hence lifting the thermal power costs (along with fuel costs), which will make thermal power less competitive to renewable power.

Exhibit 3: A comparison between CNETS and EUETS
CNETS is a less active market with all allowance allocated for free, and minimum penalty.

	CNETS	EUETS
Emissions covered	4.5bn ton p.a.	1.4bn ton p.a.
Trading volume	212mn ton in 2023 (+300% YoY)	8.7bn ton in 2022 (EUA secondary market only)
Industries	Power	Power, industrial, transportation
Allowance determination	A combination of top-down and bottom-up, based on emissions intensity	CAP-and-trade, delineated in accordance with climate policy
Allowance allocation	100% free allocation	Free + auctioning
Products	Sport trading	Spot, futures and derivatives trading
Carbon credits	CCER, Not more than 5% of the allowance	cannot be used for cancellation from 2021
Entities	Emission control entities	Emission control entities, trading institutions and individuals
Punishment	Less than RMB30,000	A fine of EUR100/ton

Source: Refinitiv LSEG

BofA GLOBAL RESEARCH

What is China Certified Emission Reduction (CCER)?

CCER certificate is issued to projects engage in activities that mitigate greenhouse gases (GHG) emission or remove GHG from the atmosphere, while are not covered by the compulsory emission reduction targets. MEE oversees CCER verification, issuance, and transaction, and stipulated that CCER-qualified projects must be 1) of authenticity, uniqueness, and additionality; 2) within the field supported by MEE technical standards and comply to other MEE stipulated rules; 3) commenced construction after Nov 8th, 2012. Companies regulated by compulsory emission reduction targets can purchase CCER to offset up to 5% of their emission.

Among the 1st batch released on Oct 24th, 4 technical standards were approved by MEE, i.e. forestation carbon sink, concentrated solar power, offshore wind, and mangrove vegetation creation, as they are among the least controversial fields with low project return, small market size high data quality and social benefit.

According to CEO of Shanghai Environment Energy Exchange:

a) **Additionality** means the project reduces carbon emission beyond benchmark level. Also, additionality requires the project to not be economically viable if without CCER, which means onshore wind and solar base are not qualified.

b) **Uniqueness** means the project can only apply carbon reduction certificate through one system, be it CCER, the international system CDM (Clean Development Mechanism), or third-party systems, like VCS (Verified Carbon Standard) and GS (Gold Standard).

c) The previous technical standards set by NDRC are obsolete, and projects need to apply for CCER qualification again.

What is Green Electricity Certificate (GEC)?

GEC is the only certificate for the environmental benefit of renewable electricity generation and consumption. GECs are issued to all on-grid electricity generated by wind, solar, biomass, geothermal, marine, and hydro projects. All GECs are tradable, except for the ones issued to hydro power projects commissioned before 2023.

NDRC is studying the mechanism to coordinate GEC with CNETS and CCER trading system. LSEG reckons the linkage not likely to happen, as:

1) It is not international convention to link GEC with emission trading system, and thus such linkage may hinder CNETS's integration with international ETSs (Emission Trading Systems).

2) GEC is regulated by NEA and CNETS is regulated by MEE. Any linkage may create difficulty for regulation.

Applications of GEC:

1) GEC can be used to fulfill provincial renewable energy consumption obligation. Since 2019, NDRC and NEA rolled out provincial renewable energy consumption obligation, as of the minimum requirement of provincial annual renewable power consumption as a percentage of total power consumption. The obligation has been stepping up. For example, Zhejiang's obligation has stepped up from 17.5% in 2019 to 21.6% in 2023.

2) Incremental renewable energy consumption, evidenced by GEC position will not be subject to provincial total energy consumption cap, as announced by NDRC, NBS and NEA in Aug 2022.

For renewable projects enjoying national subsidy, GEC trading income will be deducted from subsidy amount or belongs to the state (therefore no extra income and such project operators tend not to participate in GEC trading). For other renewable projects, project owner can pocket GEC trading income.

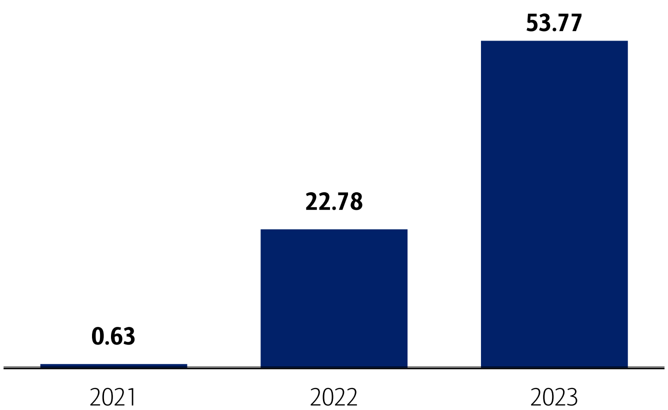
What is Green Power Trading?

Currently, green power trading mainly incorporates the mid-to-long term contracts for on-grid power from wind and solar projects and comes with green electricity certificates. Green power trading prioritizes wind and solar projects that is not included in national subsidy list or those voluntarily giving up subsidy. NEA progressively promotes the subsidized wind and solar project to participate in green power trading, any tariff premium to coal fire benchmark will be deducted from subsidy collection.

Apple has committed to achieve 100% green power consumption along the supply chain by 2030. Apple stated that 68 suppliers from China has committed to use 100% green power by 2030 for Apple products, in April 2023.

High-end export-oriented companies, multi-national companies' China production and operation centers, IDCs (Internet Data Centers) and Central SOE are driving the green power consumption in China. BNEF expects China green power trading volume to double in 2024 to more than 100bn kWh.

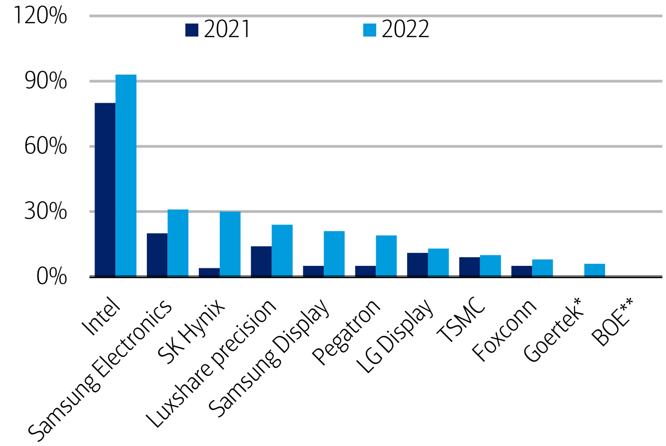
Exhibit 9: China green power trading volume accounted for only 1.2% of intra-province trading in 2023
China in-province green power trading volume (bn kWh)



Source: CEC

BofA GLOBAL RESEARCH

Exhibit 10: Green power consumption ratio
For leading consumer electronics supply chain companies



Source: Greenpeace
* Goertek didn't release 2021 data, and BOE didn't release both 2021 and 2022 data

BofA GLOBAL RESEARCH

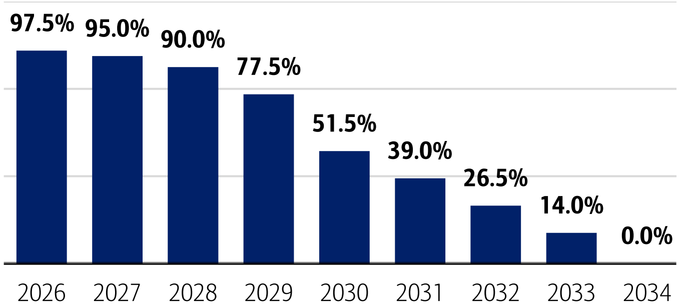
What is Carbon Border Adjustment Mechanism (CBAM)?

CBAM, signed by the European Parliament on May 10th, 2023, intends to equalize the price of carbon between domestic products and imports, and is set up to prevent carbon leakage, which occurs when companies based in the EU move carbon-intensive production abroad to countries where climate policies are less stringent, or when EU products get replaced by more carbon-intensive imports. CBAM currently covers the direct and indirect emission in goods from iron/steel, cement, fertilizer, aluminum, hydrogen industries and electricity.

Oct 1st, 2023 – Dec 31st, 2025 is the transitional period, when importers are required to report emissions embedded in their goods subject to CBAM without paying a financial adjustment.

Full CBAM regime will commence operation in 2026. Importers into the EU will be required to pay for the emissions embedded in their goods as if they were produced in the EU under the EUETS. Payment of CBAM charges will be facilitated through the purchase and surrender of CBAM certificates, which will be priced at the weekly averages of EUETS allowances auctions. Carbon cost paid at origin can be deducted. EU producers will initially receive free allowances up to a benchmark based on the average emissions of the best 10% of the industry's EU installations and will progressively receive less free allowances.

Exhibit 11: CBAM free allowances proportion gradually dropping
The percentage of free allowances industrials get to receive



Source: The European Commission
The benchmark is basing on the top 10% most efficient capacity in EU
BofA GLOBAL RESEARCH

CNETS chronicle: 2011-2023

2011-2019: 7 regional pilot carbon trading markets before national ETS

In Oct 2011, NDRC allowed 7 pilot carbon trading markets to research and formulate measures for emission allowance trading, so that China can achieve 2020 GHG emission goal at relatively low cost. The 7 pilot markets are Beijing, Shanghai, Chongqing, Guangdong, Hubei and Shenzhen. During 2013-14, the 7 pilot carbon markets launched, with covered sectors mostly include power, heat, petrochemicals, chemicals, refineries, cement, ceramics, and ferrous metals, where emission allowances are mostly allocated for free, basing on grandfather method, or emission intensity benchmark method.

From 2018, MEE took charge of the mission to address climate change and reduce carbon emission from NDRC.

2019-2020: The establishment of national ETS and its 1st compliance period

In Dec 2020, MEE released the plan for carbon emission allowance allocation for power sector, for the 1st compliance period of 2019-2020, and trial plan for emission trading regulation. It was 36 months after NDRC published the proposal to establish CNETS for the power sector in Dec 2017. Power generators were required to surrender allowances to fully account for their emissions for 2019-2020 by Dec 31st, 2021, or offset them with CCER.

Draft plan for emission trading regulation

CCER: Companies get to offset up to 5% of their surrender obligation with CCER.

Fine: RMB20-30k for companies failing to surrender emission allowances in time.

Shortfall in surrender will be deducted from the allowances for the following year.

2019-20 plan for national emission allowance allocation (power sector)
Release date: Dec 30th, 2020.

Coverage scope: power generators with annual CO2 emission exceeds 26k ton.

Allocation: For 2019-2020, all emission allowances are distributed for free.

Allowance for power generator = the power benchmark x on-grid power output x correction factor + the heat benchmark x heat supply volume.

The power benchmark, in ton CO2/ MWh.

The heat benchmark, in ton CO2/ Gj.

Correction factor: to level the playground for generators by adjusting for a) utilization rate; b) proportion of heat output; c) cooling methods.

Preferential treatment for gas-fired generator: gas-fired generator surrender obligation = minimum (verified emission, allocated allowance).

Regional carbon markets will no longer allocate emission allowances to companies included in national ETS.

2021-2022: The 2nd compliance period, benchmark is generous but tightened
MEE published consultation draft/ implementation plan for 2021-22 power sector emission allowance allocation in Nov 2022/ Mar 2023, and requires allowance surrender for the 2nd compliance period to be cleared by Dec 31st, 2023.

The benchmark is set to incentivize generators to improve efficiency and engage in heat supply and peak shaving. The benchmark edged down for the 2nd compliance period, to account for 1) technology advancement of power generation; 2) drop out of obsolete generators; 3) improvement of measurement accuracy, while making sure total emission allowance is equal to total emission.

In Jul 2023, MEE revealed more details on emission allowance clearing for 2021 and 2022, specifying spare allowances from previous compliance periods can be carried over to following periods.

The expansion of ETS coverage into industrials
In Mar 2022, MEE published a set of requirements on carbon emission reporting, dictating companies within petrochemicals, chemicals, building materials, ferrous metals, non-ferrous metals, paper and aviation sectors, with annual GHG emission exceeding 26k ton CO2eq (c.10k ton standard coal), to submit a 2021 emission report by Sep 2022. In Oct 2023, MEE reiterated such requirements for 2023-25 reporting.

The inclusion of methane into ETS seems a distant future
In Nov 2023, MEE released an action plan for methane emission control, with mostly vague, non-binding targets, and a focus on improving the capability of measurement and supervision.

Action plan for methane emission control

Target for the 14th FYP: The methane emission intensity for agriculture and animal husbandry should maintain or drop. The valorization ratio for urban residential waste and treatment ratio for urban sludge should improve. 6bn cubic meter of coal mine gas should be utilized by 2025.

Target for the 15th FYP: the utilization for coal mine gas should improve. Emission intensity for agriculture and animal husbandry should drop. Oil and gas exploration and production sector should aim to eliminate standing torches. The collection of associated gas from oil field should be international advance level.

To improve the monitoring of methane emission. To establish the measurement, reporting and verification system for methane emission. To promote leakage detection and reparation technology in oil and gas sector. To reduce standing torches in oil and gas exploration and production sector. To promote the valorization of livelihood dung. To scientifically control methane fermented from animal gut. To control methane emission from cornfield. To promote the sorting, reduction and valorization of residential waste.

History of EU-ETS to see where China is heading towards

Exhibit 13: The four stages of EU ETS
The covered region, industries, linear reduction factor, and allowance allocation

	Phase 1	Phase 2	Phase 3	Phase 4
Period	2005-2007	2008-2012	2013-2020	2021-2030
Stages	Pilot phase	Stabilization	Harmonizatoin & consolidation	Structural reform, further development
Region	EU27	EU27 + 3 nations*	EU28 + 3 nations*	EU28 + 3 nations*
Industry	Power, energy-intensive industries	Phase 1 + Aviation in EEA	Phase 2 + aluminim, chemicals, etc.	= Phase 3
Linear Reduction Factor	-	-	1.74%	2.2% - 4.4%*
Penalty*	EUR40/ton	EUR100/ton	EUR100/ton	EUR100/ton
Allowance	Almost 100% free	90% free + auction	Auction for power, benchmark for industries	Auction for power, benchmark for industries

Source: BofA Global Research
* 3 nations = Norway + Iceland + Liechtenstein
* FIT for 55 raises linear reduction factor from 2.2% in 2021-23, to 4.3% from 2024-27. and to 4.4% from 2028-30
* Penalty needs to adjust for inflation

BofA GLOBAL RESEARCH

Exhibit 12: Factors influences EU-ETS carbon price
EU-ETS is based on cap-and-trade system, thus different from CNETS

	Bullish	Bearish
Climate policy	Ambitious reduction targets	Cut reduction targets
Oil and commodities	Positive correlation	
Gas price	Positive correlation	
	Higher gas prices mean more coal power and rising demand for carbon allowances from power companies	Lower gas prices means decreasing demand for carbon allowances
Coal price	Negative correlation	
Market	Accelerated economic growth Reduced auctions Compliance period nears Active market	Brexit (UK-ETS) Increased auctions Inactive market
Weather	Cold weather pushes up electricity demand and carbon allowance demand; Low wind and PV output means more thermal power generation and rising carbon emissions	Warm winter Increased wind and PV power generation

Source: Refinitiv LSEG

BofA GLOBAL RESEARCH

Phase 1: 2005-2007, pilot phase, learning by doing

Phase 1 succeeded in establishing infrastructure needed to monitor, report and verify emissions, and free trade in emission allowances across the EU.

In the absence of reliable emissions data, phase 1 caps were set based on estimates. As a result, the total amount of allowances issued exceeded emissions and, with supply significantly exceeding demand, in 2007 the price of allowances fell to zero (phase 1 allowances could not be banked for use in phase 2).

Phase 2: 2008-2012, stabilization

Because verified annual emissions data from the pilot phase was now available, the cap on allowances was reduced in phase 2, based on actual emissions. However, the 2008 economic crisis led to emissions reductions that were greater than expected, which led to a large surplus of allowances and credits, which weighed heavily on the carbon price throughout phase 2.

Phase 3: 2013-2020, European harmonization and consolidation

Key features of phase 3:

1. Auctioning was the default method for allocating allowances. Market Stability Reserve, to stabilize carbon price, was introduced in 2019.
2. Harmonized allocation rules applying to the allowances still given away for free;
3. More sectors and GHG included.

Phase 4: 2021-2030, structural reform, further development

1. The launch of CBAM (Carbon Boarder Adjustment Mechanism)

2. The use of offsets with international emission reduction credits is no longer allowed.

Disclosures

Important Disclosures

BofA Global Research personnel (including the analyst(s) responsible for this report) receive compensation based upon, among other factors, the overall profitability of Bank of America Corporation, including profits derived from investment banking. The analyst(s) responsible for this report may also receive compensation based upon, among other factors, the overall profitability of the Bank's sales and trading businesses relating to the class of securities or financial instruments for which such analyst is responsible.

Other Important Disclosures

From time to time research analysts conduct site visits of covered issuers. BofA Global Research policies prohibit research analysts from accepting payment or reimbursement for travel expenses from the issuer for such visits.

Prices are indicative and for information purposes only. Except as otherwise stated in the report, for any recommendation in relation to an equity security, the price referenced is the publicly traded price of the security as of close of business on the day prior to the date of the report or, if the report is published during intraday trading, the price referenced is indicative of the traded price as of the date and time of the report and in relation to a debt security (including equity preferred and CDS), prices are indicative as of the date and time of the report and are from various sources including BofA Securities trading desks.

The date and time of completion of the production of any recommendation in this report shall be the date and time of dissemination of this report as recorded in the report timestamp.

Recipients who are not institutional investors or market professionals should seek the advice of their independent financial advisor before considering information in this report in connection with any investment decision, or for a necessary explanation of its contents.

Officers of BofAS or one or more of its affiliates (other than research analysts) may have a financial interest in securities of the issuer(s) or in related investments.

Refer to BofA Global Research policies relating to conflicts of interest.

"BofA Securities" includes BofA Securities, Inc. ("BofAS") and its affiliates. Investors should contact their BofA Securities representative or Merrill Global Wealth Management financial advisor if they have questions concerning this report or concerning the appropriateness of any investment idea described herein for such investor. "BofA Securities" is a global brand for BofA Global Research.

Information relating to Non-US affiliates of BofA Securities and Distribution of Affiliate Research Reports:

BofAS and/or Merrill Lynch, Pierce, Fenner & Smith Incorporated ("MLPF&S") may in the future distribute, information of the following non-US affiliates in the US (short name: legal name, regulator): Merrill Lynch (South Africa): Merrill Lynch South Africa (Pty) Ltd., regulated by The Financial Service Board; MLI (UK): Merrill Lynch International, regulated by the Financial Conduct Authority (FCA) and the Prudential Regulation Authority (PRA); BofASE (France): BofA Securities Europe SA is authorized by the Autorité de Contrôle Prudentiel et de Résolution (ACPR) and regulated by the ACPR and the Autorité des Marchés Financiers (AMF). BofA Securities Europe SA ("BofASE") with registered address at 51, rue La Boétie, 75008 Paris is registered under no 842 602 690 RCS Paris. In accordance with the provisions of French Code Monétaire et Financier (Monetary and Financial Code), BofASE is an établissement de crédit et d'investissement (credit and investment institution) that is authorised and supervised by the European Central Bank and the Autorité de Contrôle Prudentiel et de Résolution (ACPR) and regulated by the ACPR and the Autorité des Marchés Financiers. BofASE's share capital can be found at www.bofaml.com/BofASEdisclaimer; BofA Europe (Milan): Bank of America Europe Designated Activity Company, Milan Branch, regulated by the Bank of Italy, the European Central Bank (ECB) and the Central Bank of Ireland (CBI); BofA Europe (Frankfurt): Bank of America Europe Designated Activity Company, Frankfurt Branch regulated by BaFin, the ECB and the CBI; BofA Europe (Madrid): Bank of America Europe Designated Activity Company, Sucursal en España, regulated by the Bank of Spain, the ECB and the CBI; Merrill Lynch (Australia): Merrill Lynch Equities (Australia) Limited, regulated by the Australian Securities and Investments Commission; Merrill Lynch (Hong Kong): Merrill Lynch (Asia Pacific) Limited, regulated by the Hong Kong Securities and Futures Commission (HKSFC); Merrill Lynch (Singapore): Merrill Lynch (Singapore) Pte Ltd, regulated by the Monetary Authority of Singapore (MAS); Merrill Lynch (Canada): Merrill Lynch Canada Inc, regulated by the Canadian Investment Regulatory Organization; Merrill Lynch (Mexico): Merrill Lynch Mexico, SA de CV, Casa de Bolsa, regulated by the Comisión Nacional Bancaria y de Valores; Merrill Lynch (Argentina): Merrill Lynch Argentina SA, regulated by Comisión Nacional de Valores; BofAS Japan: BofA Securities Japan Co., Ltd., regulated by the Financial Services Agency; Merrill Lynch (Seoul): Merrill Lynch International, LLC Seoul Branch, regulated by the Financial Supervisory Service; Merrill Lynch (Taiwan): Merrill Lynch Securities (Taiwan) Ltd., regulated by the Securities and Futures Bureau; BofAS India: BofA Securities India Limited, regulated by the Securities and Exchange Board of India (SEBI); Merrill Lynch (Israel): Merrill Lynch Israel Limited, regulated by Israel Securities Authority; Merrill Lynch (DIFC): Merrill Lynch International (DIFC Branch), regulated by the Dubai Financial Services Authority (DFSA); Merrill Lynch (Brazil): Merrill Lynch S.A. Corretora de Títulos e Valores Mobiliários, regulated by Comissão de Valores Mobiliários; Merrill Lynch KSA Company: Merrill Lynch Kingdom of Saudi Arabia Company, regulated by the Capital Market Authority.

This information: has been approved for publication and is distributed in the United Kingdom (UK) to professional clients and eligible counterparties (as each is defined in the rules of the FCA and the PRA) by MLI (UK), which is authorized by the PRA and regulated by the FCA and the PRA - details about the extent of our regulation by the FCA and PRA are available from us on request; has been approved for publication and is distributed in the European Economic Area (EEA) by BofASE (France), which is authorized by the ACPR and regulated by the ACPR and the AMF; has been considered and distributed in Japan by BofAS Japan, a registered securities dealer under the Financial Instruments and Exchange Act in Japan, or its permitted affiliates; is issued and distributed in Hong Kong by Merrill Lynch (Hong Kong) which is regulated by HKSFC; is issued and distributed in Taiwan by Merrill Lynch (Taiwan); is issued and distributed in India by BofAS India; and is issued and distributed in Singapore to institutional investors and/or accredited investors (each as defined under the Financial Advisers Regulations) by Merrill Lynch (Singapore) (Company Registration No 198602883D). Merrill Lynch (Singapore) is regulated by MAS. Merrill Lynch Equities (Australia) Limited (ABN 65 006 276 795), AFS License 235132 (MLEA) distributes this information in Australia only to 'Wholesale' clients as defined by s.761G of the Corporations Act 2001. With the exception of Bank of America N.A., Australia Branch, neither MLEA nor any of its affiliates involved in preparing this information is an Authorised Deposit-Taking Institution under the Banking Act 1959 nor regulated by the Australian Prudential Regulation Authority. No approval is required for publication or distribution of this information in Brazil and its local distribution is by Merrill Lynch (Brazil) in accordance with applicable regulations. Merrill Lynch (DIFC) is authorized and regulated by the DFSA. Information prepared and issued by Merrill Lynch (DIFC) is done so in accordance with the requirements of the DFSA conduct of business rules. BofA Europe (Frankfurt) distributes this information in Germany and is regulated by BaFin, the ECB and the CBI. BofA Securities entities, including BofA Europe and BofASE (France), may outsource/delegate the marketing and/or provision of certain research services or aspects of research services to other branches or members of the BofA Securities group. You may be contacted by a different BofA Securities entity acting for and on behalf of your service provider where permitted by applicable law. This does not change your service provider. Please refer to the Electronic Communications Disclaimers for further information.

This information has been prepared and issued by BofAS and/or one or more of its non-US affiliates. The author(s) of this information may not be licensed to carry on regulated activities in your jurisdiction and, if not licensed, do not hold themselves out as being able to do so. BofAS and/or MLPF&S is the distributor of this information in the US and accepts full responsibility for information distributed to BofAS and/or MLPF&S clients in the US by its non-US affiliates. Any US person receiving this information and wishing to effect any transaction in any security discussed herein should do so through BofAS and/or MLPF&S and not such foreign affiliates. Hong Kong recipients of this information should contact Merrill Lynch (Asia Pacific) Limited in respect of any matters relating to dealing in securities or provision of specific advice on securities or any other matters arising from, or in connection with, this information. Singapore recipients of this information should contact Merrill Lynch (Singapore) Pte Ltd in respect of any matters arising from, or in connection with, this information. For clients that are not accredited investors, expert investors or institutional investors Merrill Lynch (Singapore) Pte Ltd accepts full responsibility for the contents of this information distributed to such clients in Singapore.

General Investment Related Disclosures:

Taiwan Readers: Neither the information nor any opinion expressed herein constitutes an offer or a solicitation of an offer to transact in any securities or other financial instrument. No part of this report may be used or reproduced or quoted in any manner whatsoever in Taiwan by the press or any other person without the express written consent of BofA Securities.

This document provides general information only, and has been prepared for, and is intended for general distribution to, BofA Securities clients. Neither the information nor any opinion expressed constitutes an offer or an invitation to make an offer, to buy or sell any securities or other financial instrument or any derivative related to such securities or instruments (e.g., options, futures, warrants, and contracts for differences). This document is not intended to provide personal investment advice and it does not take into account the specific investment objectives, financial situation and the particular needs of, and is not directed to, any specific person(s). This document and its content do not constitute, and should not be considered to constitute, investment advice for purposes of ERISA, the US tax code, the Investment Advisers Act or otherwise. Investors should seek financial advice regarding the appropriateness of investing in financial instruments and implementing investment strategies discussed or recommended in this document and should understand that statements regarding future prospects may not be realized. Any decision to purchase or subscribe for securities in any offering must be based solely on existing public information on such security or the information in the prospectus or other offering document issued in connection with such offering, and not on this document.

Securities and other financial instruments referred to herein, or recommended, offered or sold by BofA Securities, are not insured by the Federal Deposit Insurance Corporation and are not deposits or other obligations of any insured depository institution (including, Bank of America, N.A.). Investments in general and, derivatives, in particular, involve numerous risks, including, among others, market risk, counterparty default risk and liquidity risk. No security, financial instrument or derivative is suitable for all investors. Digital assets are extremely speculative, volatile and are largely unregulated. In some cases, securities and other financial instruments may be difficult to value or sell and reliable information about the value or risks related to the security or financial instrument may be difficult to obtain. Investors should note that income from such securities and other financial instruments, if any, may fluctuate and that price or value of such securities and instruments may rise or fall and, in some cases, investors may lose their entire principal investment. Past performance is not necessarily a guide to future performance. Levels and basis for taxation may change.

This report may contain a short-term trading idea or recommendation, which highlights a specific near-term catalyst or event impacting the issuer or the market that is anticipated to have a short-term price impact on the equity securities of the issuer. Short-term trading ideas and recommendations are different from and do not affect a stock's fundamental equity rating, which reflects both a longer term total return expectation and attractiveness for investment relative to other stocks within its Coverage Cluster. Short-term trading ideas and recommendations may be more or less positive than a stock's fundamental equity rating.

BofA Securities is aware that the implementation of the ideas expressed in this report may depend upon an investor's ability to "short" securities or other financial instruments and that such action may be limited by regulations prohibiting or restricting "shortselling" in many jurisdictions. Investors are urged to seek advice regarding the applicability of such regulations prior to executing any short idea contained in this report.

Foreign currency rates of exchange may adversely affect the value, price or income of any security or financial instrument mentioned herein. Investors in such securities and instruments, including ADRs, effectively assume currency risk.

BofAS or one of its affiliates is a regular issuer of traded financial instruments linked to securities that may have been recommended in this report. BofAS or one of its affiliates may, at any time, hold a trading position (long or short) in the securities and financial instruments discussed in this report.

BofA Securities, through business units other than BofA Global Research, may have issued and may in the future issue trading ideas or recommendations that are inconsistent with, and reach different conclusions from, the information presented herein. Such ideas or recommendations may reflect different time frames, assumptions, views and analytical methods of the persons who prepared them, and BofA Securities is under no obligation to ensure that such other trading ideas or recommendations are brought to the attention of any recipient of this information.

In the event that the recipient received this information pursuant to a contract between the recipient and BofAS for the provision of research services for a separate fee, and in connection therewith BofAS may be deemed to be acting as an investment adviser, such status relates, if at all, solely to the person with whom BofAS has contracted directly and does not extend beyond the delivery of this report (unless otherwise agreed specifically in writing by BofAS). If such recipient uses the services of BofAS in connection with the sale or purchase of a security referred to herein, BofAS may act as principal for its own account or as agent for another person. BofAS is and continues to act solely as a broker-dealer in connection with the execution of any transactions, including transactions in any securities referred to herein.

Copyright and General Information:

Materials prepared by BofA Global Research personnel are based on public information. Facts and views presented in this material have not been reviewed by, and may not reflect information known to, professionals in other business areas of BofA Securities, including investment banking personnel. BofA Securities has established information barriers between BofA Global Research and certain business groups. As a result, BofA Securities does not disclose certain client relationships with, or compensation received from, such issuers. To the extent this material discusses any legal proceeding or issues, it has not been prepared as nor is it intended to express any legal conclusion, opinion or advice. Investors should consult their own legal advisers as to issues of law relating to the subject matter of this material. BofA Global Research personnel's knowledge of legal proceedings in which any BofA Securities entity and/or its directors, officers and employees may be plaintiffs, defendants, co-defendants or co-plaintiffs with or involving issuers mentioned in this material is based on public information. Facts and views presented in this material that relate to any such proceedings have not been reviewed by, discussed with, and may not reflect information known to, professionals in other business areas of BofA Securities in connection with the legal proceedings or matters relevant to such proceedings.

This information has been prepared independently of any issuer of securities mentioned herein and not in connection with any proposed offering of securities or as agent of any issuer of any securities. None of BofAS any of its affiliates or their research analysts has any authority whatsoever to make any representation or warranty on behalf of the issuer(s). BofA Global Research policy prohibits research personnel from disclosing a recommendation, investment rating, or investment thesis for review by an issuer prior to the publication of a research report containing such rating, recommendation or investment thesis.

Any information relating to the tax status of financial instruments discussed herein is not intended to provide tax advice or to be used by anyone to provide tax advice. Investors are urged to seek tax advice based on their particular circumstances from an independent tax professional.

The information herein (other than disclosure information relating to BofA Securities and its affiliates) was obtained from various sources and we do not guarantee its accuracy. This information may contain links to third-party websites. BofA Securities is not responsible for the content of any third-party website or any linked content contained in a third-party website. Content contained on such third-party websites is not part of this information and is not incorporated by reference. The inclusion of a link does not imply any endorsement by or any affiliation with BofA Securities. Access to any third-party website is at your own risk, and you should always review the terms and privacy policies at third-party websites before submitting any personal information to them. BofA Securities is not responsible for such terms and privacy policies and expressly disclaims any liability for them.

All opinions, projections and estimates constitute the judgment of the author as of the date of publication and are subject to change without notice. Prices also are subject to change without notice. BofA Securities is under no obligation to update this information and BofA Securities ability to publish information on the subject issuer(s) in the future is subject to applicable quiet periods. You should therefore assume that BofA Securities will not update any fact, circumstance or opinion contained herein.

Certain outstanding reports or investment opinions relating to securities, financial instruments and/or issuers may no longer be current. Always refer to the most recent research report relating to an issuer prior to making an investment decision.

In some cases, an issuer may be classified as Restricted or may be Under Review or Extended Review. In each case, investors should consider any investment opinion relating to such issuer (or its security and/or financial instruments) to be suspended or withdrawn and should not rely on the analyses and investment opinion(s) pertaining to such issuer (or its securities and/or financial instruments) nor should the analyses or opinion(s) be considered a solicitation of any kind. Sales persons and financial advisors affiliated with BofAS or any of its affiliates may not solicit purchases of securities or financial instruments that are Restricted or Under Review and may only solicit securities under Extended Review in accordance with firm policies.

Neither BofA Securities nor any officer or employee of BofA Securities accepts any liability whatsoever for any direct, indirect or consequential damages or losses arising from any use of this information.