RYDER SCOTT | 20th ANNUAL RESERVES CONFERENCE

DEB RYAN

HEAD OF EMISSIONS INSIGHT

S&P Global Commodity Insights

Deb Ryan, Head of Emissions Insight at S&P Global Commodity Insights' Denver office, brings over 20 years of experience to her role. Her background encompasses emissions, carbon markets, and the upstream oil industry, with a focus on emissions analytics and global commodity markets. Deb holds a Bachelor's degree in Chemical Engineering and a Master's degree in Petroleum Engineering from Curtin University in Australia, as well as an MBA from Penn State University in the US. She has developed expertise in emissions analytics, carbon markets, and engineering, and has made significant contributions to S&P Global. Additionally, she teaches "Carbon Markets for Business" at the University of Colorado Denver.

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S&P Global
Commodity Insights

Future Price Drivers: Carbon Intensity & Carbon

Ryder Scott 20th Annual Reserves Conference

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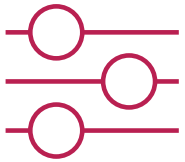
September 2024

‘The new pragmatism’ is characterized by 3 key themes, which define the 2024 S&P Global Commodity Insights scenarios and net-zero cases

A recalibrating world

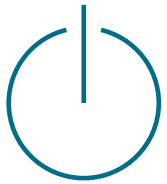
- What will follow the crisis and upheavals of the early 2020s?
- How will the geopolitical and macroeconomic landscape evolve?
- What is the role of the superpower?
- How will global energy markets effectively balance their pursuits of energy access and security?

Changing perspectives and values



- How will social values, policy and politics adapt?
- How will younger generations influence the future?
- Will markets ever drive (or even allow) companies to act for the “greater good”?

The nascent energy transition



- How long will the “triage” period last?
- How will energy demand and supply trends evolve in emerging economies?
- A revolution in AI promises to change the world, but will predictions come true?

Source: S&P Global Commodity Insights.

Future outcomes for global energy markets show a wide divergence in energy demand, supply and GHG emissions

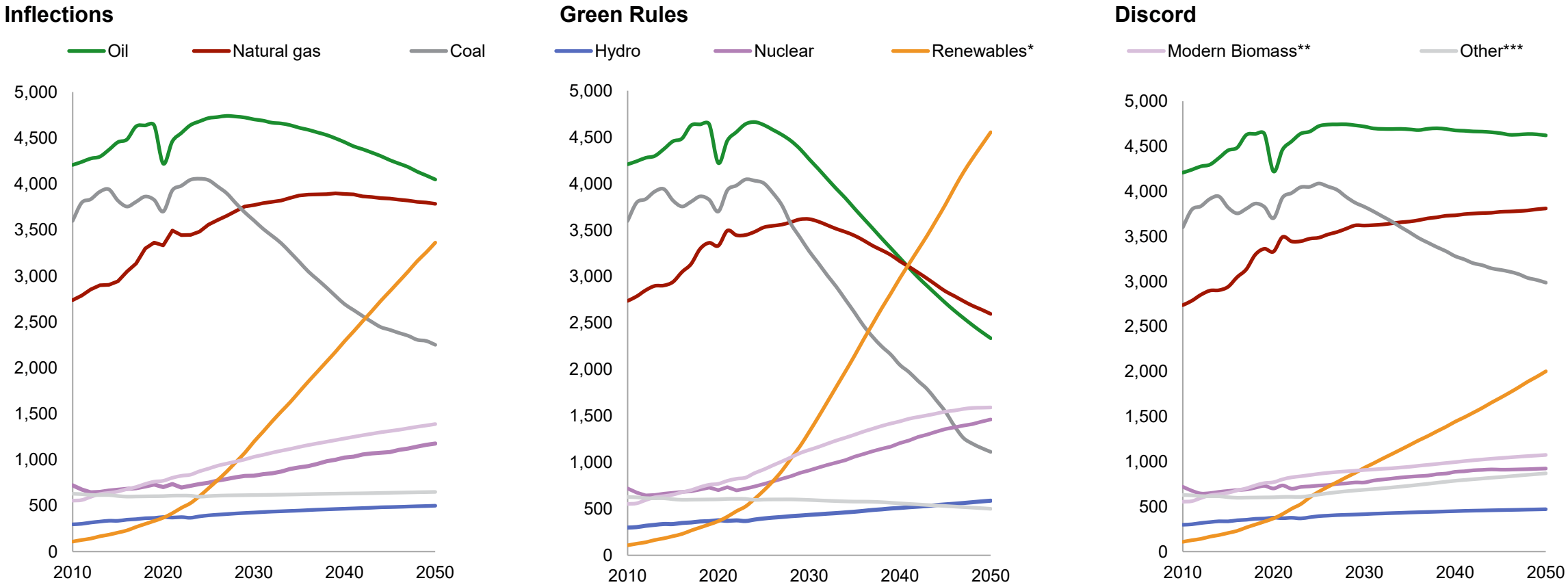
S&P Global Commodity Insights Energy and Climate Scenarios and net-zero cases: Key metrics

	Global GDP (CAGR 2023–50)	2050 TPED (change vs. 2023)	2050 fossil fuel % of TPED	GHG emissions (change vs. 2023)	Global temperature (est. change by 2100)
Inflections (base case)	2.5%	+15%	59%	-24%	2.4°C
Green Rules	2.6%	-3%	41%	-56%	1.8°C
Discord	2.0%	+10%	68%	-9%	3.1°C
Net-zero cases					
Accelerated CCS (ACCS)	2.5%	-12%	32%	-100%	1.5°C
Multitech Mitigation (MTM)	2.5%	-17%	22%	-99%	1.5°C

Data compiled July 2024.
CAGR = compound annual growth rate; TPED = total primary energy demand.
Commodity Insights considers a country or region to have effectively reached "net-zero" emissions once GHG emissions have fallen to less than 1% of their 2023 level and remain at that level over the course of a year.
Source: S&P Global Commodity Insights.

Global energy markets are on the cusp of change, with significant structural reordering expected over the coming decades

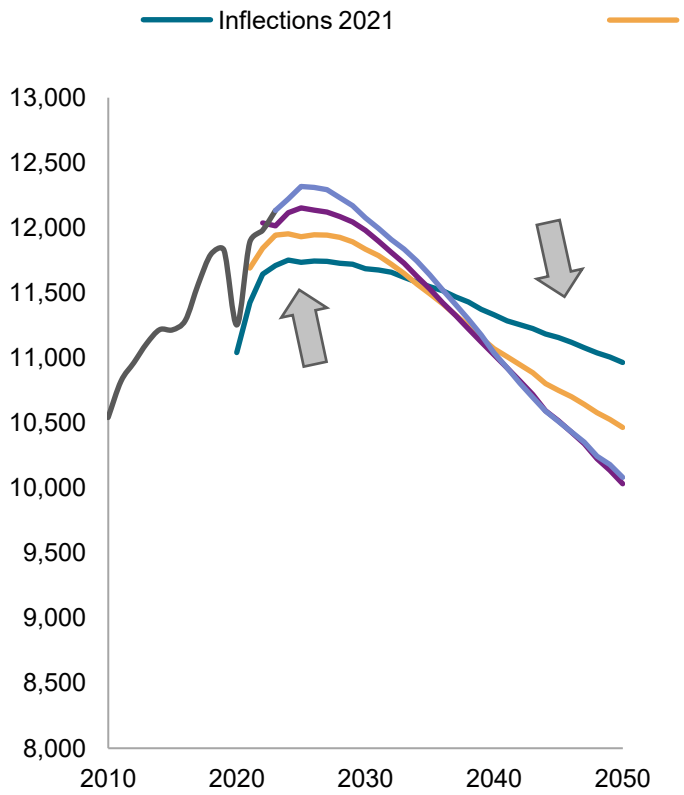
Total global primary energy demand by fuel, 2010–50 (MMtoe)



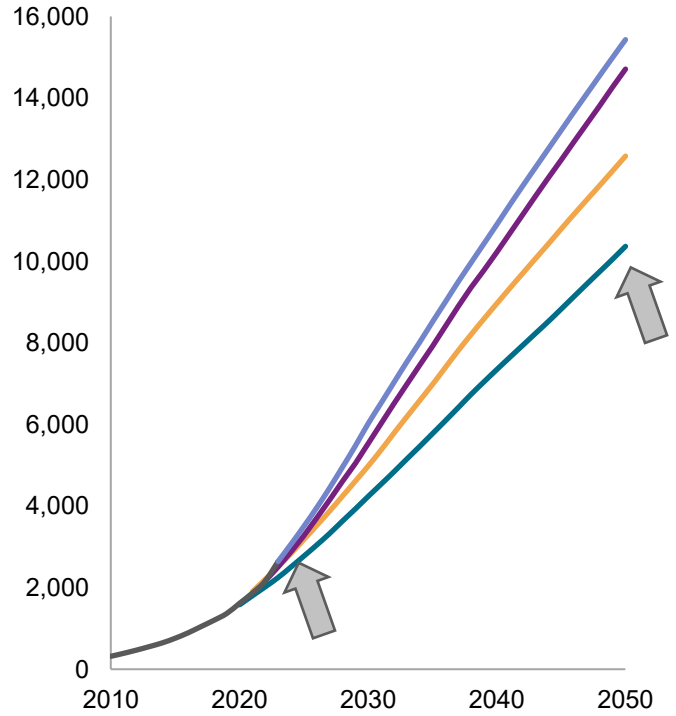
Data compiled July 2024.
MMtoe = million metric tons of oil equivalent.
* Includes solar, wind, geothermal and ocean energy. ** Includes biofuels and biomass (industry, electricity, district heat and refining). *** Includes solid waste, traditional biomass, ambient heat, net trade of electricity or heat.
Source: S&P Global Commodity Insights.

Recent years have seen higher-than-expected fossil fuel demand — but also higher renewable capacity build; GHG emissions are higher, but will decline faster

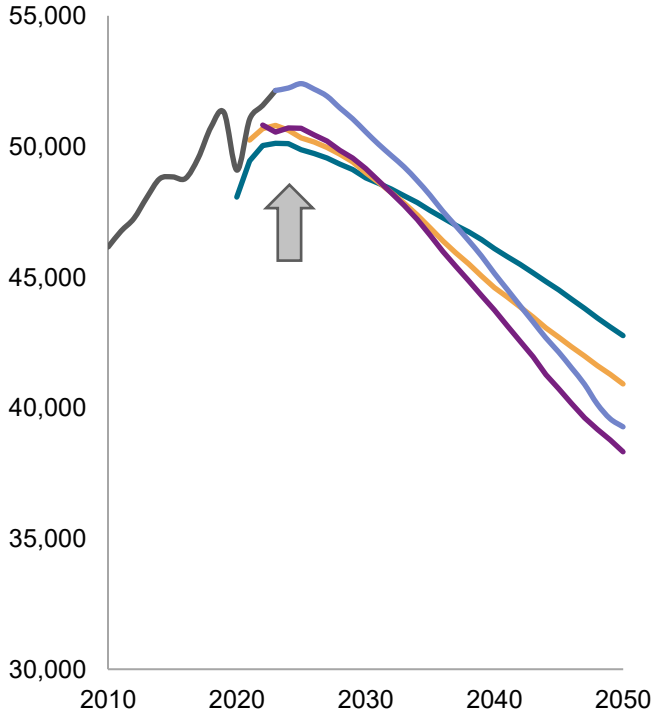
Global fossil fuel demand, 2010–50 (MMtoe)



Global renewable power capacity, 2010–50 (GW)



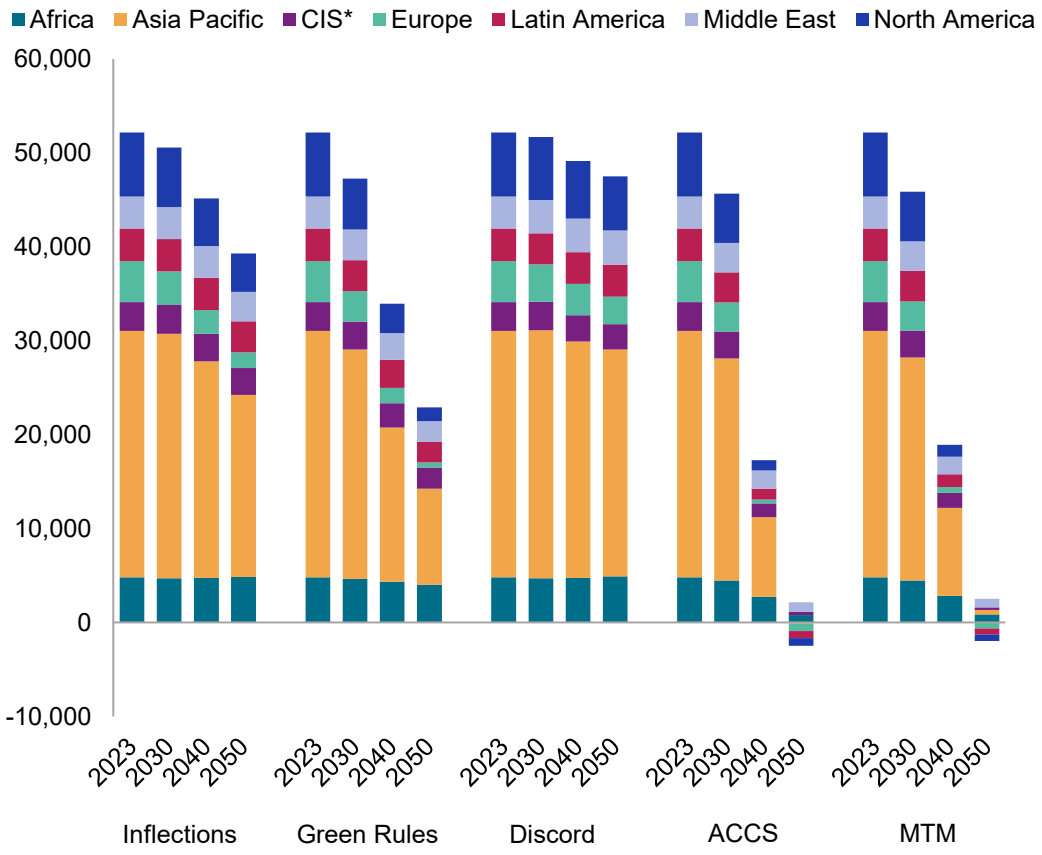
Global GHG emissions, 2010–50 ($MMtCO_2e$)



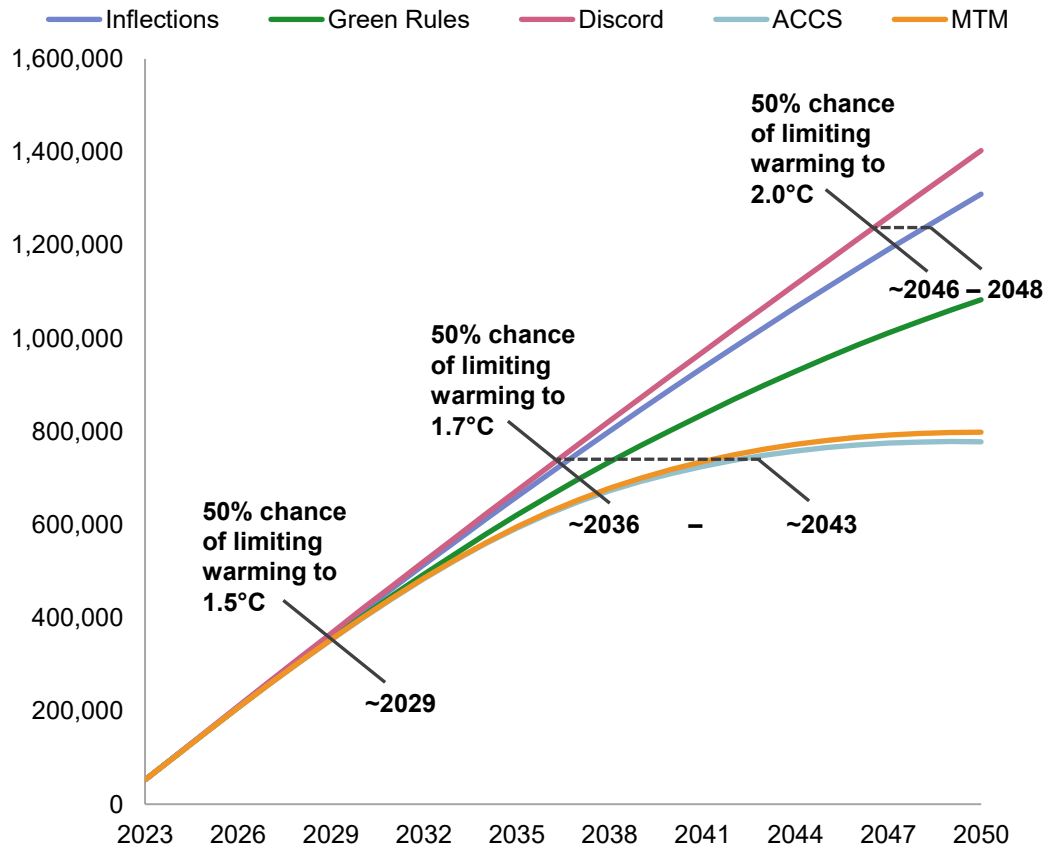
Data compiled June 2024.
$MMtCO_2e$ = million metric tons of CO_2 equivalent.
Source: S&P Global Commodity Insights.

Global GHG emissions decline under all outlooks, but cumulative emissions continue to rise, threatening carbon budgets by the end of this decade

Global GHG emissions by region, 2023–50 ($MMtCO_2e$)



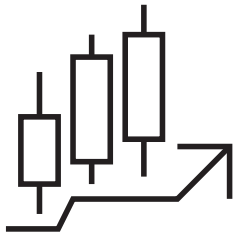
Global cumulative GHG emissions, 2023–50 ($MMtCO_2e$)



Data compiled June 2024.
* CIS = Commonwealth of Independent States.
Sources: S&P Global Commodity Insights; Global Carbon Project.

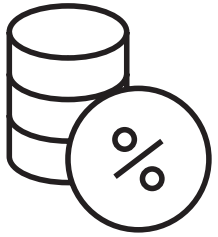
Emissions pricing creates financial incentives to help meet growing world energy demand and achieve net zero commitments in the most efficient manner

Three pathways for emissions intensity to translate into prices – all interlinked



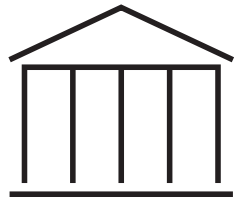
Voluntary

- Low emissions commodities



Financial

- Borrowing costs
- Stock price



Regulatory

- Carbon or methane tax
- Cap-and-trade

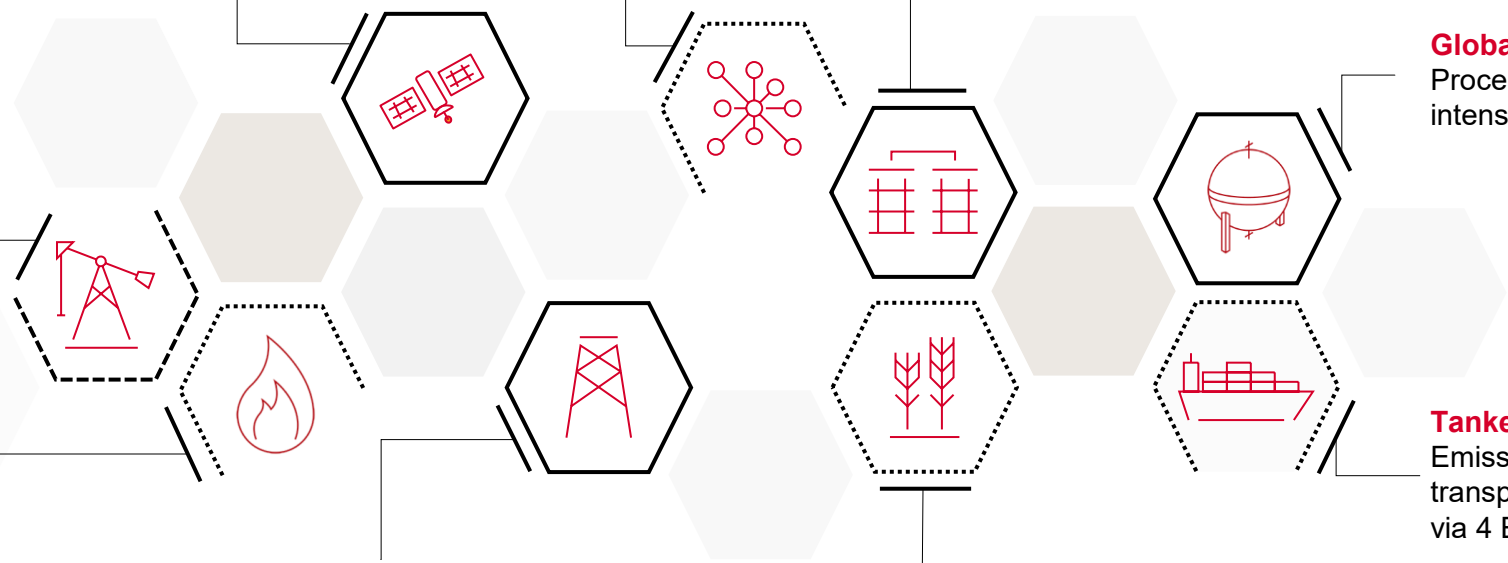
To understand the decarbonization story, we need to understand how all the commodities connect to cover all supply chains

Methane remote sensing
Advancing our own in-house remote sensing methane assessments

Petrochemical emissions
Advancing estimates for over **450** individual products

Refining emissions
Facility level estimates for over 90% of global refineries and expanding regional carbon intensity assessments of gasoline, diesel and jet fuel

Upstream emissions
Unprecedented level of granularity down to individual wells or assets and expanding coverage of major crude grades



Global LNG emissions
Processing emissions intensity at the facility level

Tanker shipping.
Emissions from the transport crude or fuel oil via 4 EU shipping routes

NGL emissions
Creating capability to deliver key NGL emission intensity

Electricity. Generation facility emission estimates, regional grid intensities and forecasts... **critical input for scope 2 emission analysis**

Agriculture. Adding GHG emissions metrics to fertilizer, biofuels, and biomass energy plants, sugar plants and more

Expanding list of commodity carbon intensity assessments to enable carbon-differentiated trading

Higher frequency carbon intensity assessments enable the market to incorporate carbon into commodity valuations

Crude

- 162 Field CI assessments & 162 price premiums
- 41 Grade CI assessments & 41 price premiums
- 162 Crude Shipping CI assessments & 162 price premiums

Refined Product

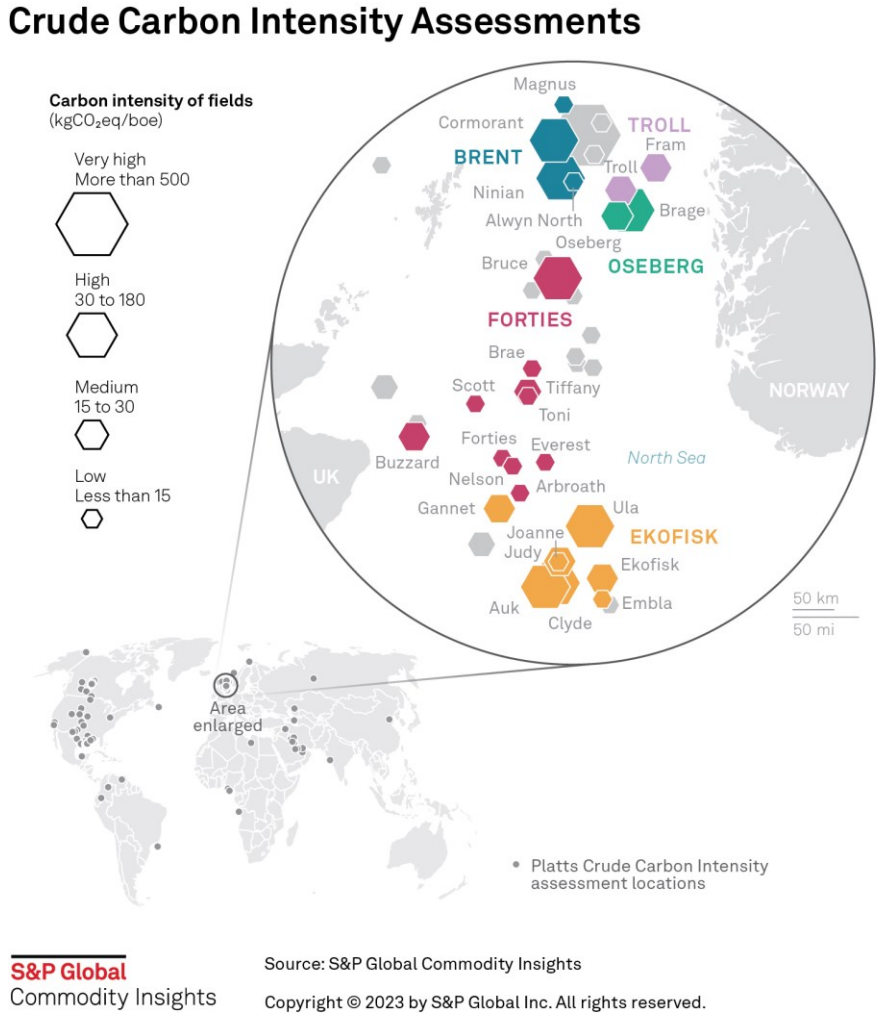
- 3 regional gasoline CI assessments & 3 price premiums
- 3 regional diesel CI assessments & 3 price premiums
- 3 regional jet fuel CI assessments & 3 price premiums

LNG

- 7 production-weighted Australia CI assessments & 7 price premiums

North American Gas & Power

- 13 gas CI assessments & 13 price premiums



The EU Methane Rule will roll out gradually, but the initial requirements for importers will come into force as soon as next year

July 2024

The EU Methane Rule comes into force.

January 2027

For new contracts, EU importers must prove exporters or producers in third countries measure, monitor, report, and verify methane emissions at the source level.

May 2025

EU importers must report whether and how exporters or producers in third countries measure, report, and reduce methane emissions.

August 2028

For new contracts, EU importers must report the methane intensity of gas sold using a standardized methodology (to be set by August 2027).

August 2030

EU importers must demonstrate that any gas sold is below a maximum methane intensity value or face financial penalties (to be set by August 2029).

Notes: New contracts are those concluded after the passage of the EU Methane Rule.
Sources: EU Regulation to reduce methane emissions in energy sector (europa.eu); L_202401787EN.000101.fmx.xml (europa.eu).

SPGCI is leveraging satellite-based imagery to assess methane and flaring emissions from Oil & Gas facilities around the world, with additional cross commodity applications

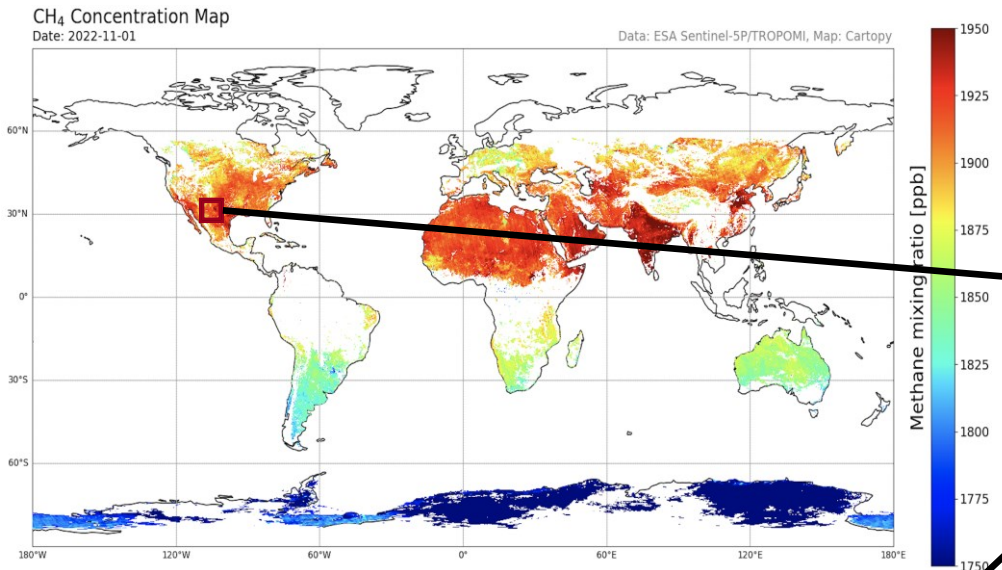
Internal Satellite Approach

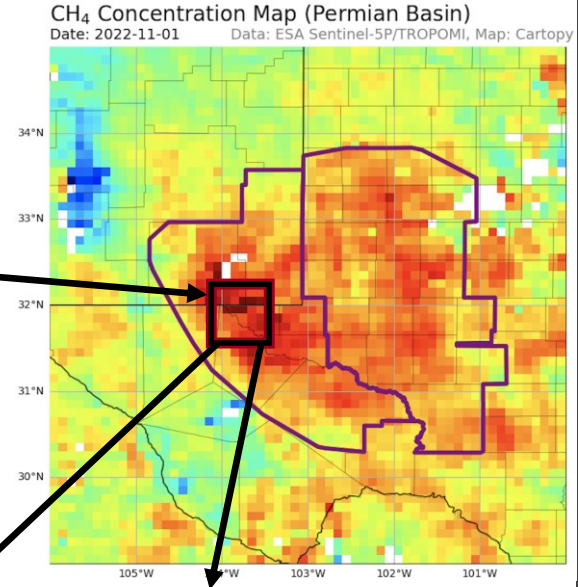
Satellite Imagery Data

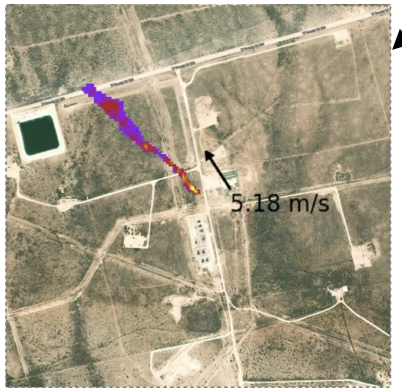
Internal Business data

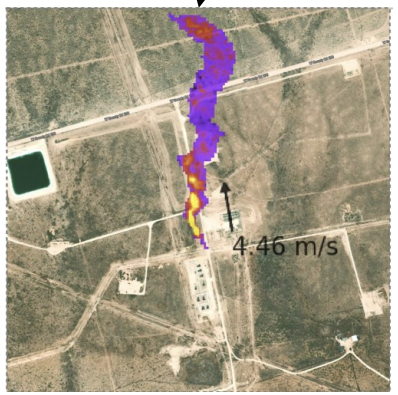
Weather data

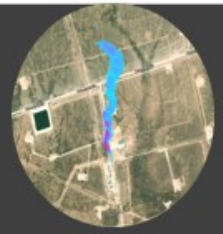
GIS data





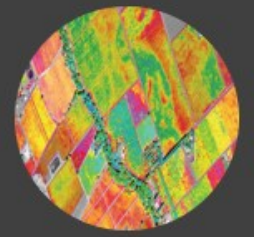





Methane emissions monitoring


Validate location of Petrochem and Refinery facilities


Renewable energy detection and land usage


Agricultural crop classification and yield prediction


Well pad and equipment detection


Wellhead flaring monitoring

S&P has been characterizing natural gas CIs at key North American locations

Natural gas carbon intensity assessment locations

Source: S&P Global Commodity Insights

- **Compare regional differences**
- **Benchmark certified supply chains against**
- **Benchmark RNG or alternative supplies against**
- **Allows differentiated market to develop further**

Understanding North American natural gas emissions requires connecting data from across the supply chain

Methane Data Science – Satellite data analyzed monthly for 19 US regions

Key data sources:

Energy Studio IMPACT™
S&P Vantage™

Emissions from **>6** million oil & gas assets

EDIN Midstream/Internal Models

Emissions from >1,000 gas processing plants

EDIN Midstream/Internal Models

Emissions from **>40,000** km of pipeline

Commodity Insights Analytics

>100 bcf/d flowing into **13** market hubs. Monthly data

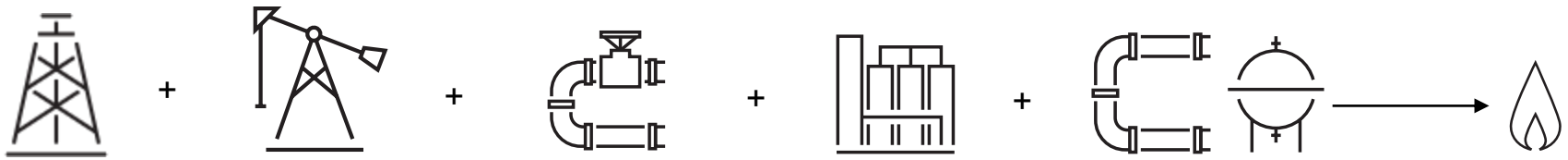
Emissions from **7** facilities exporting **>10** bcf/d

Supply chain segments:

Upstream oil & gas + **Gas processing** + **Transportation** (to market) + **Market Hubs** (e.g. Henry Hub) + **LNG**

Add up supply chain emissions from well to key location – energy allocation

Include Pre-production, Production, G&B, Processing, T&S – Emissions weighted by energy delivered to key locations



D&C | Production | Gathering & boosting | Gas processing | Transmission and storage | Key Locations

Emissions allocated to natural gas based upon energy ratio:

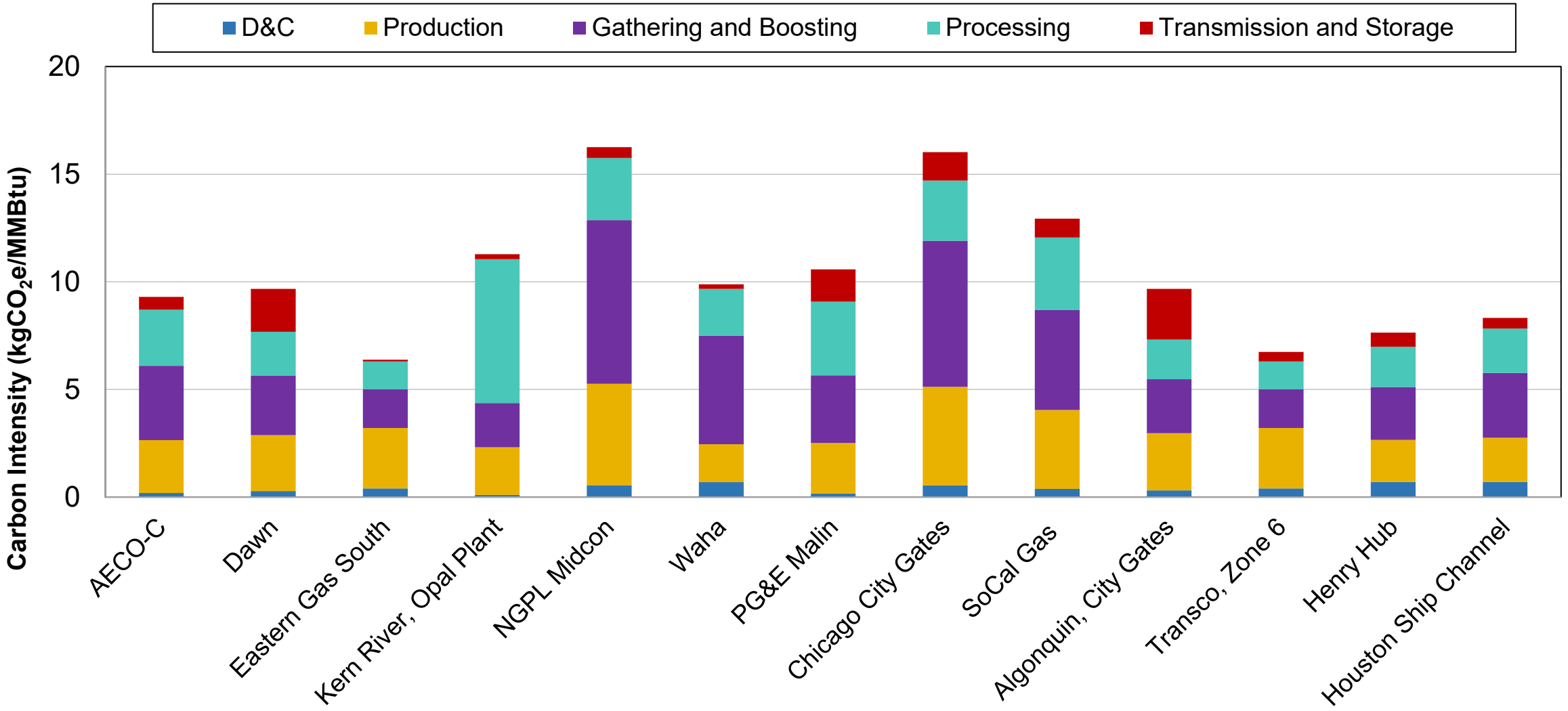
$$ER = \frac{MJ_{Natural\ Gas}}{MJ_{Natural\ Gas} + MJ_{Oil+NGLs+Condensates}}$$

$$CI_{Field/Basin} = \frac{gCO_{2e\,Field,D\&C+Prod}}{MJ_{MarketableGas}} + \frac{gCO_{2e\,Field,G\&B}}{MJ_{MarketableGas}} + \frac{gCO_{2e\,Field,Processing}}{MJ_{MarketableGas}} + \frac{gCO_{2e\,Field,T\&S}}{MJ_{MarketableGas}}$$

Need to understand full natural gas supply chain and map from producing basins to key locations

* MJ is represented on a lower heating value basis

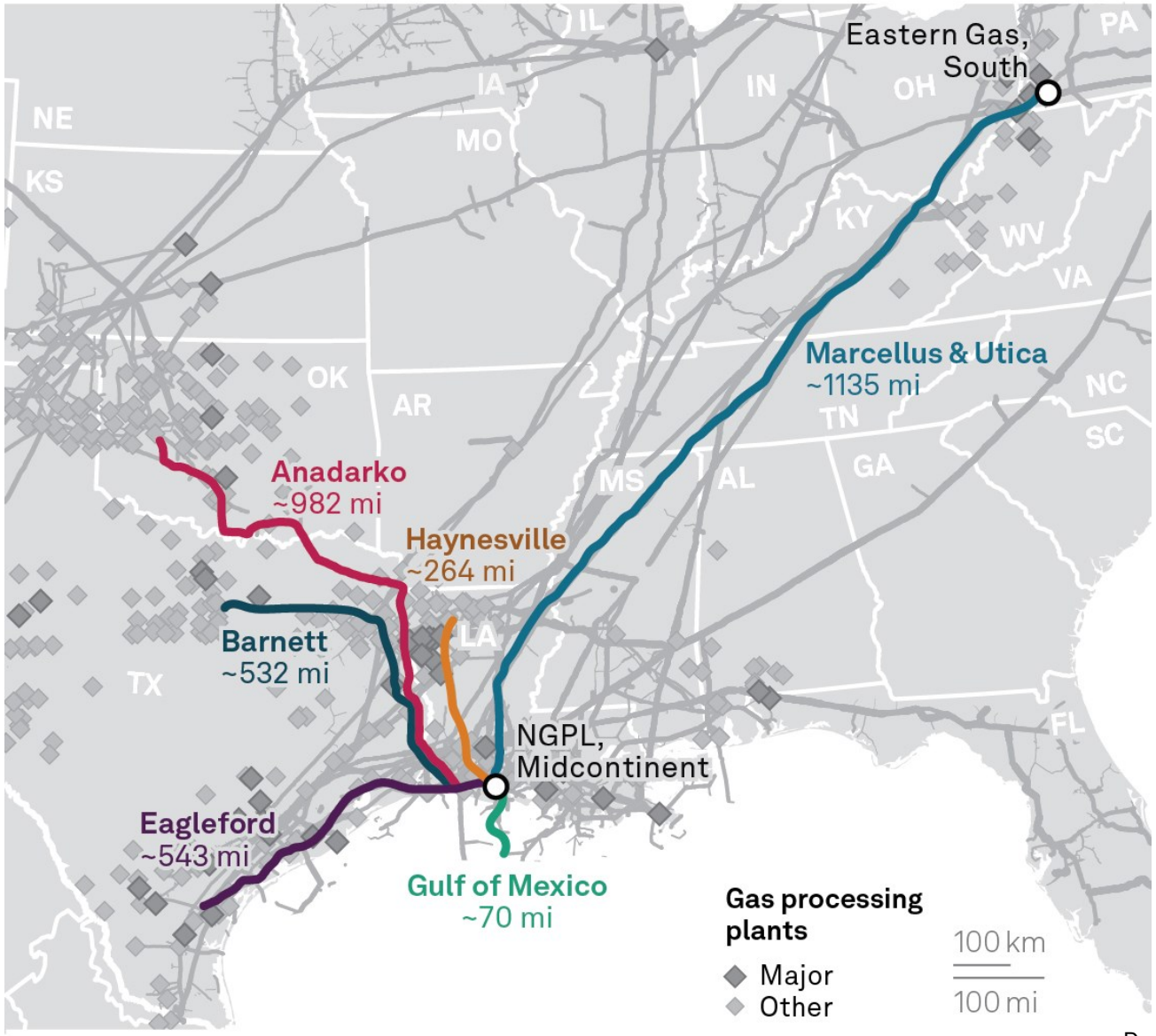
Trading location CI can vary from ~6 to 18 $kgCO_2e/MMBtu$ depending upon feed gas sources

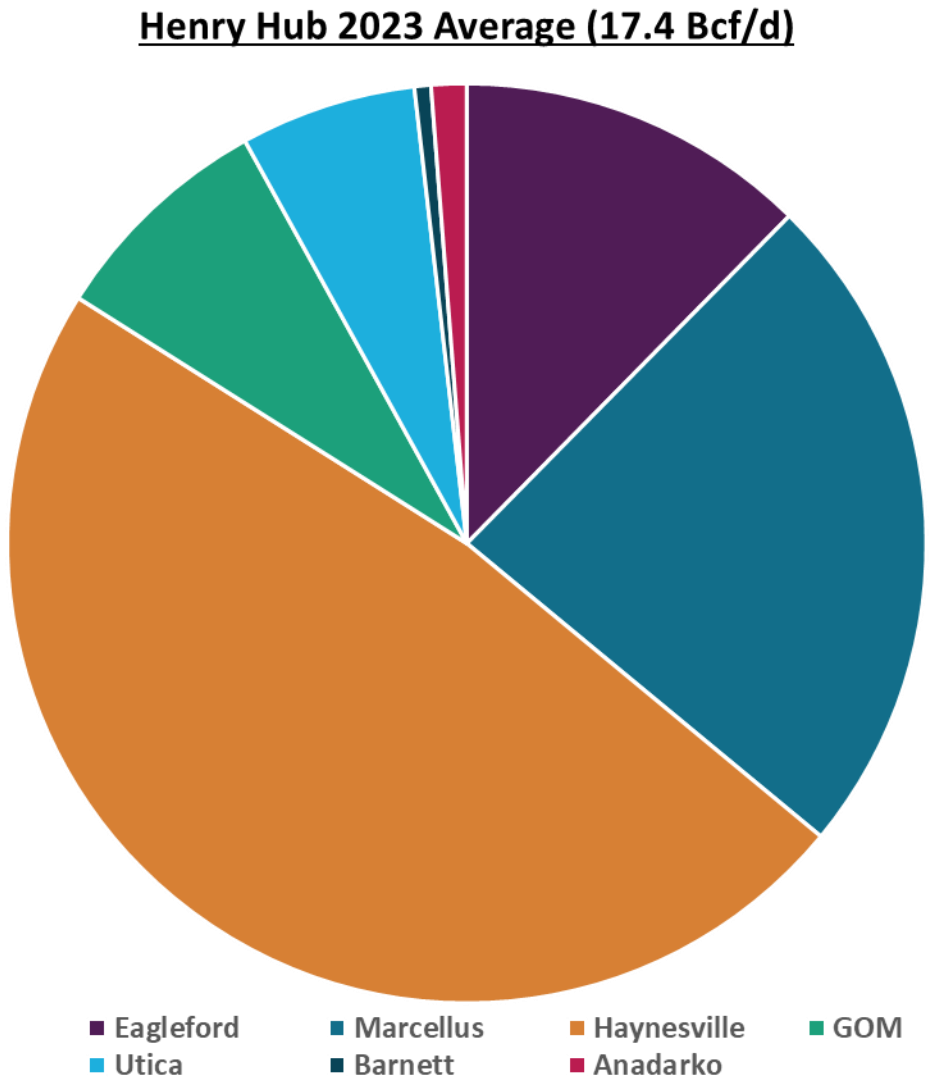


Source: S&P Global Commodity Insitghts

Henry Hub is sourced from multiple pathways

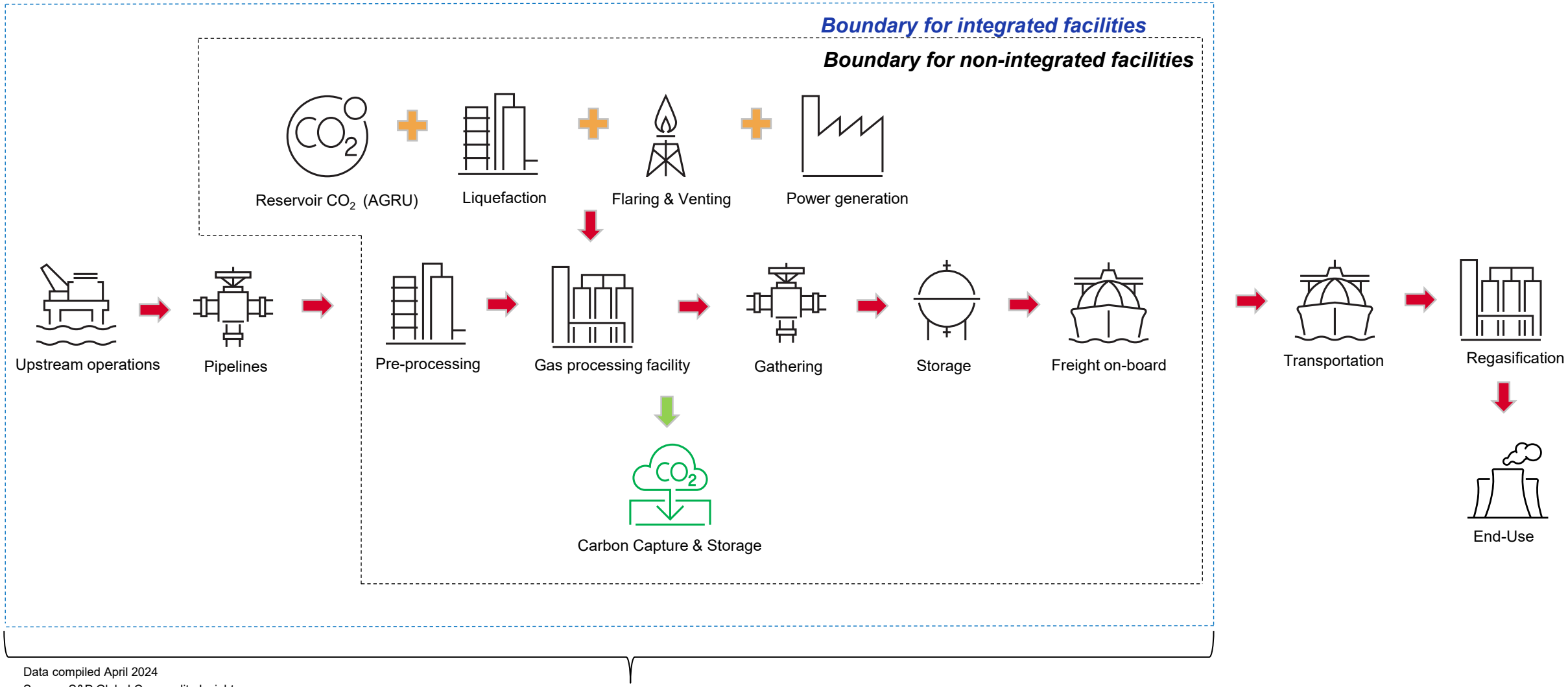
Assumed Henry Hub supply pathways





Source: S&P Global Commodity Insights

Understanding lifecycle emissions of the LNG supply chain for the market to accelerate decarbonisation and put a price on emissions



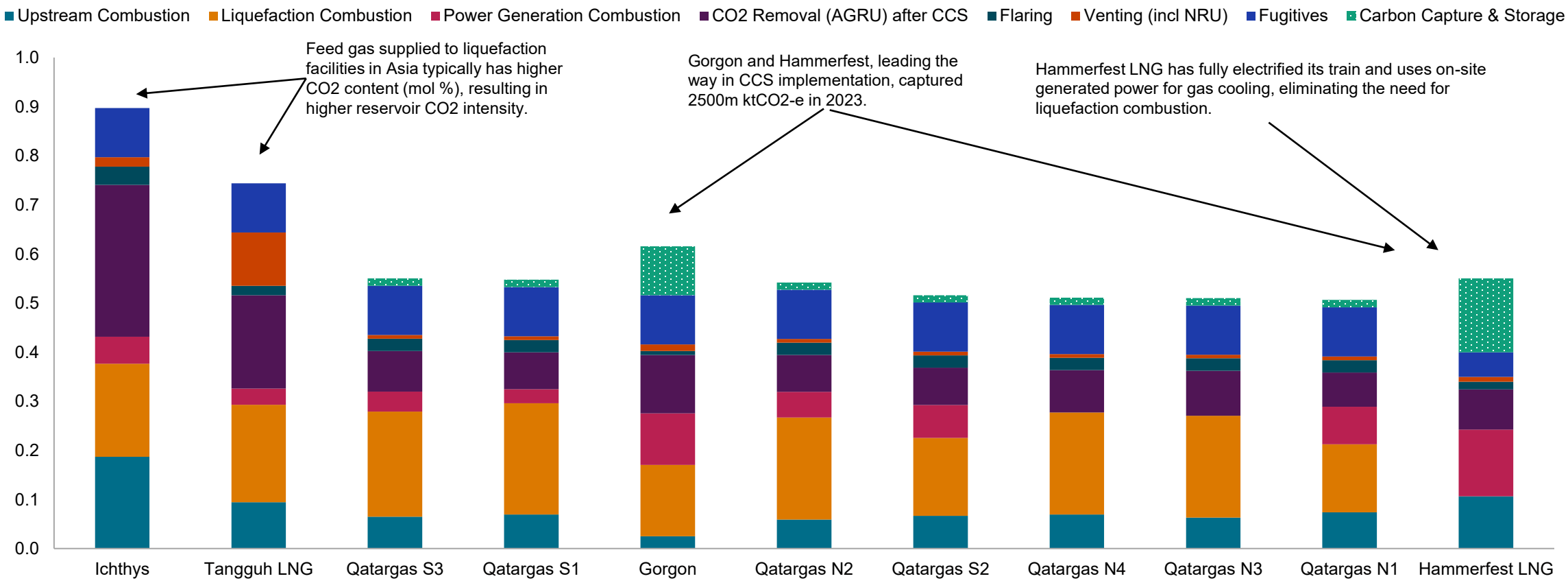
Data compiled April 2024
Source: S&P Global Commodity Insights.

LNG Production to Tank Emissions

S&P Global
Commodity Insights

Upstream feed gas composition and grid connectivity were found to greatly influence the carbon intensity of liquefaction facilities in a few markets

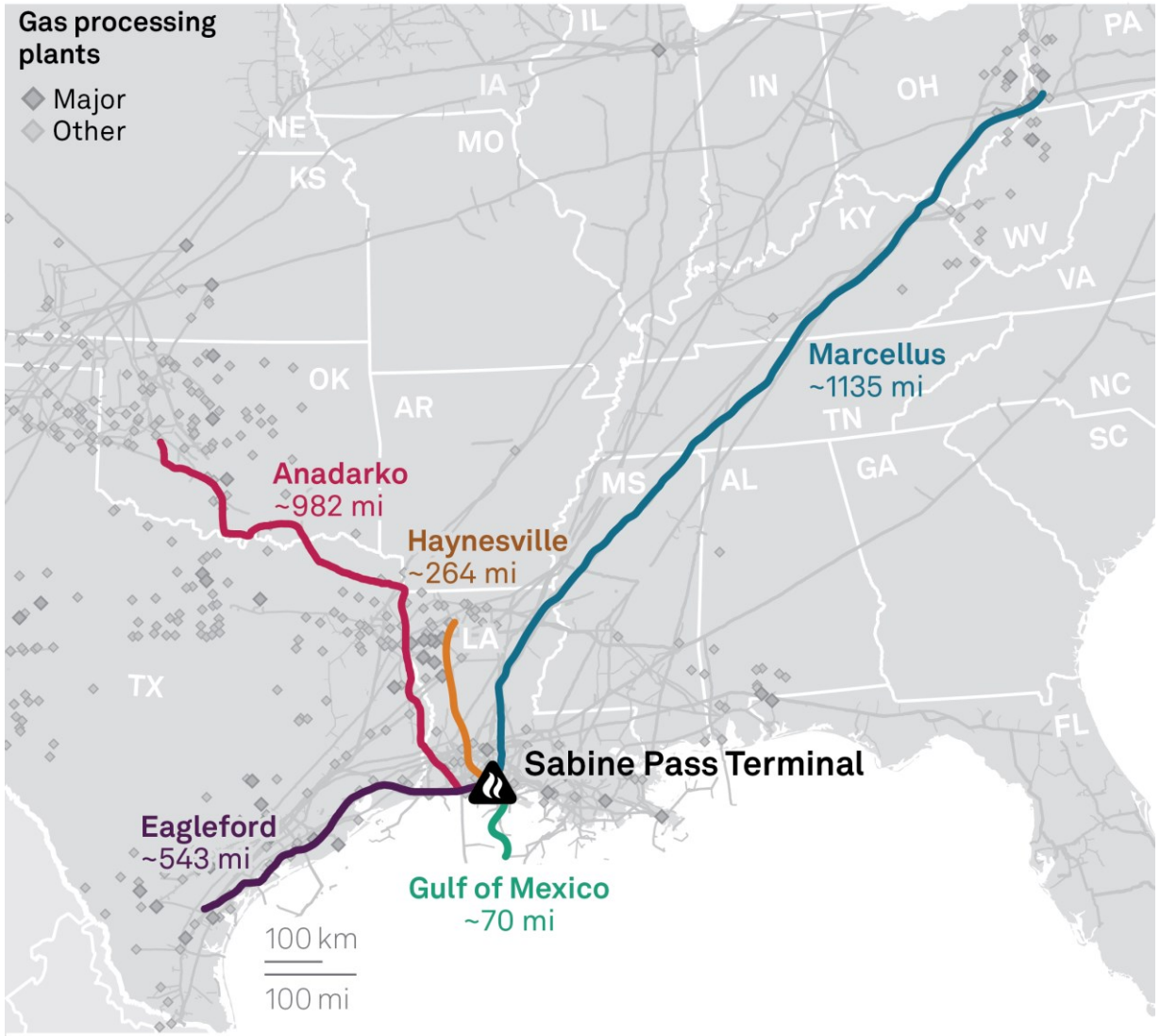
Carbon intensity of selected integrated facilities (tCO2/tLNG)



CCS = Carbon Capture & Storage; AGRU = Acid Gas Removal Unit.
Data compiled April 2024
Source: S&P Global Commodity Insights.

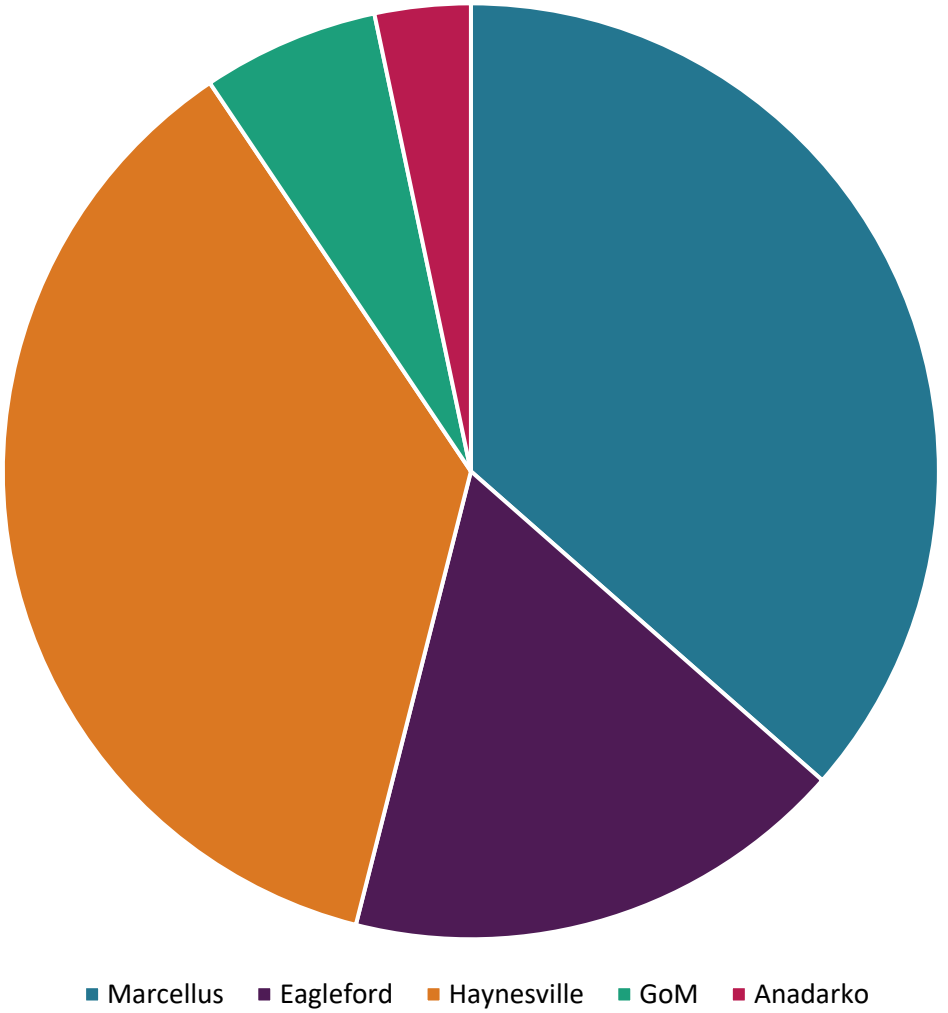
Sabine Pass LNG is source from multiple basins

Assumed Sabine Pass supply pathways

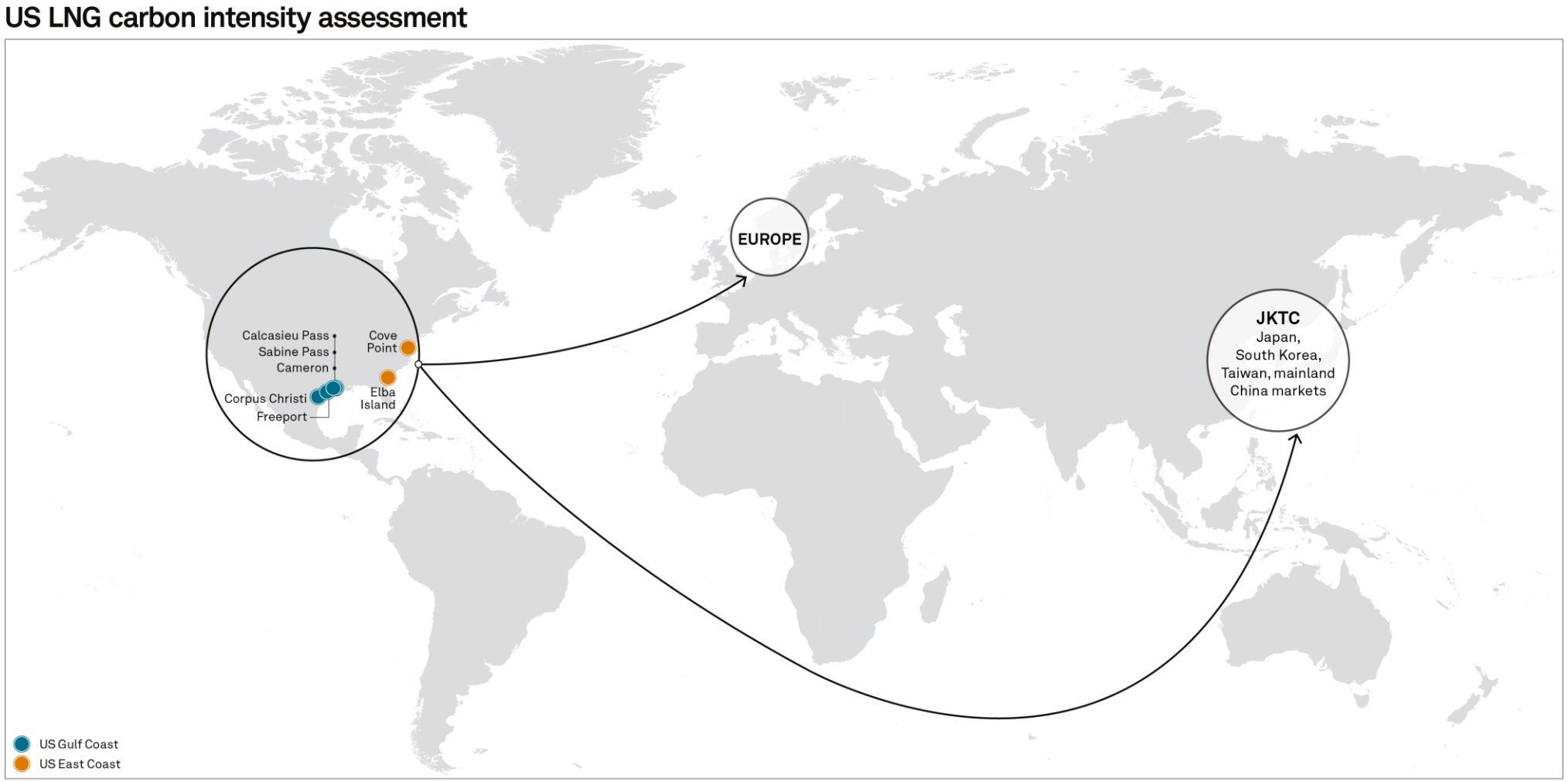


Source: S&P Global Commodity Insights

Sabine Pass LNG supply Sources (4.6 Bcf/d)



US LNG carbon intensity assessments for US Gulf Coast and US East Coast will be published in December 2024



Data compiled Aug. 8, 2024.
Source: S&P Global Commodity Insights: IC-2014024.

How the market will price carbon into commodity prices based on the carbon intensity of the commodity is still evolving

Offset approach

Buying carbon credits to offset emissions in the production, transportation process

Wide range of credit type and options on scope of emissions to offset; strong credibility required

Attribute approach

Carbon intensity becomes an attribute of the production (much like sulphur), allowing for price differentiation

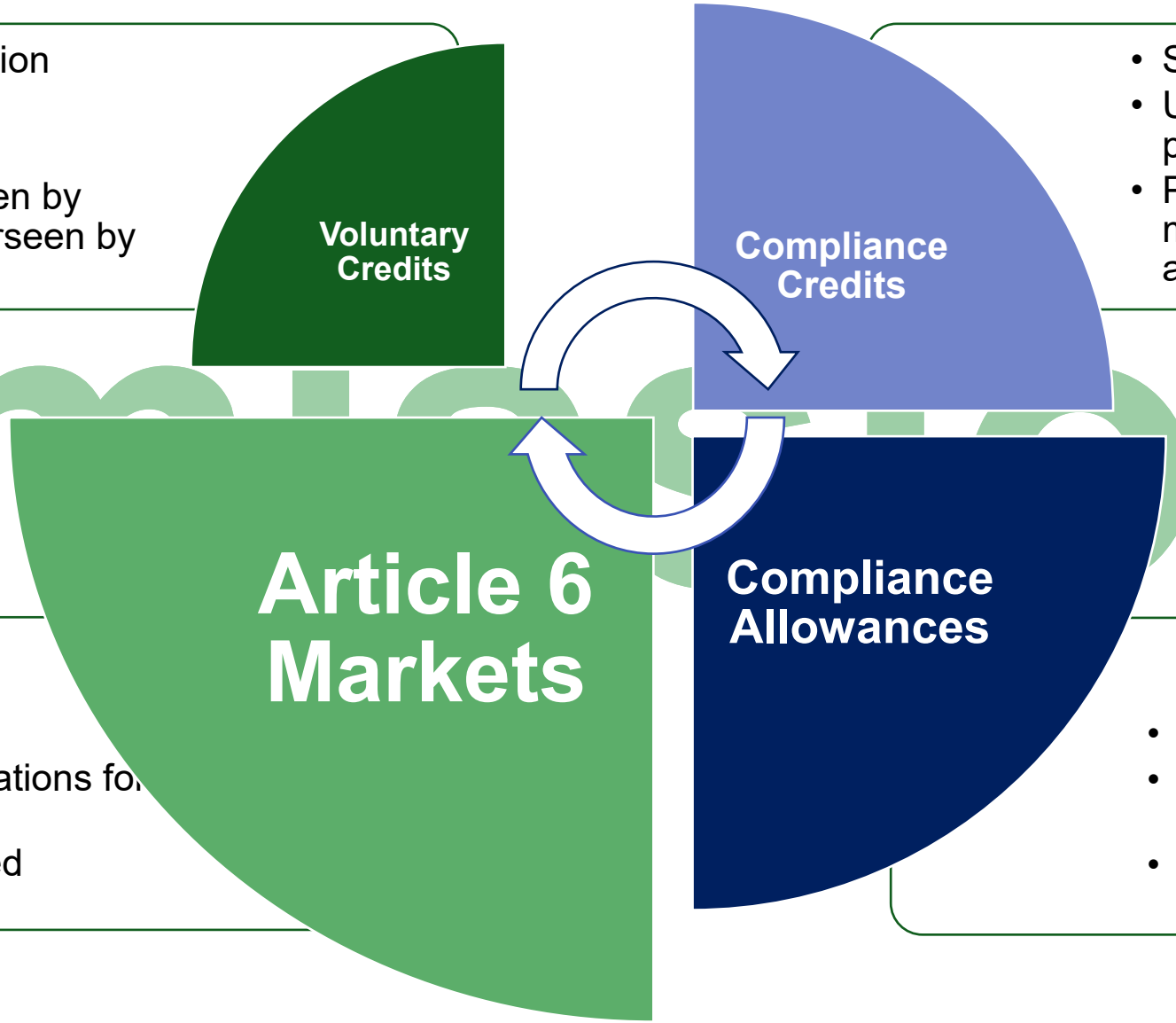
Producers may reduce operational carbon intensity

Carbon intensity becomes an attribute in financial lending, investing

What is the difference between a compliance and voluntary market?

- Voluntary Participation
- Open to Everyone
- Unlimited Volume
- Project-based, driven by methodologies overseen by private Standards

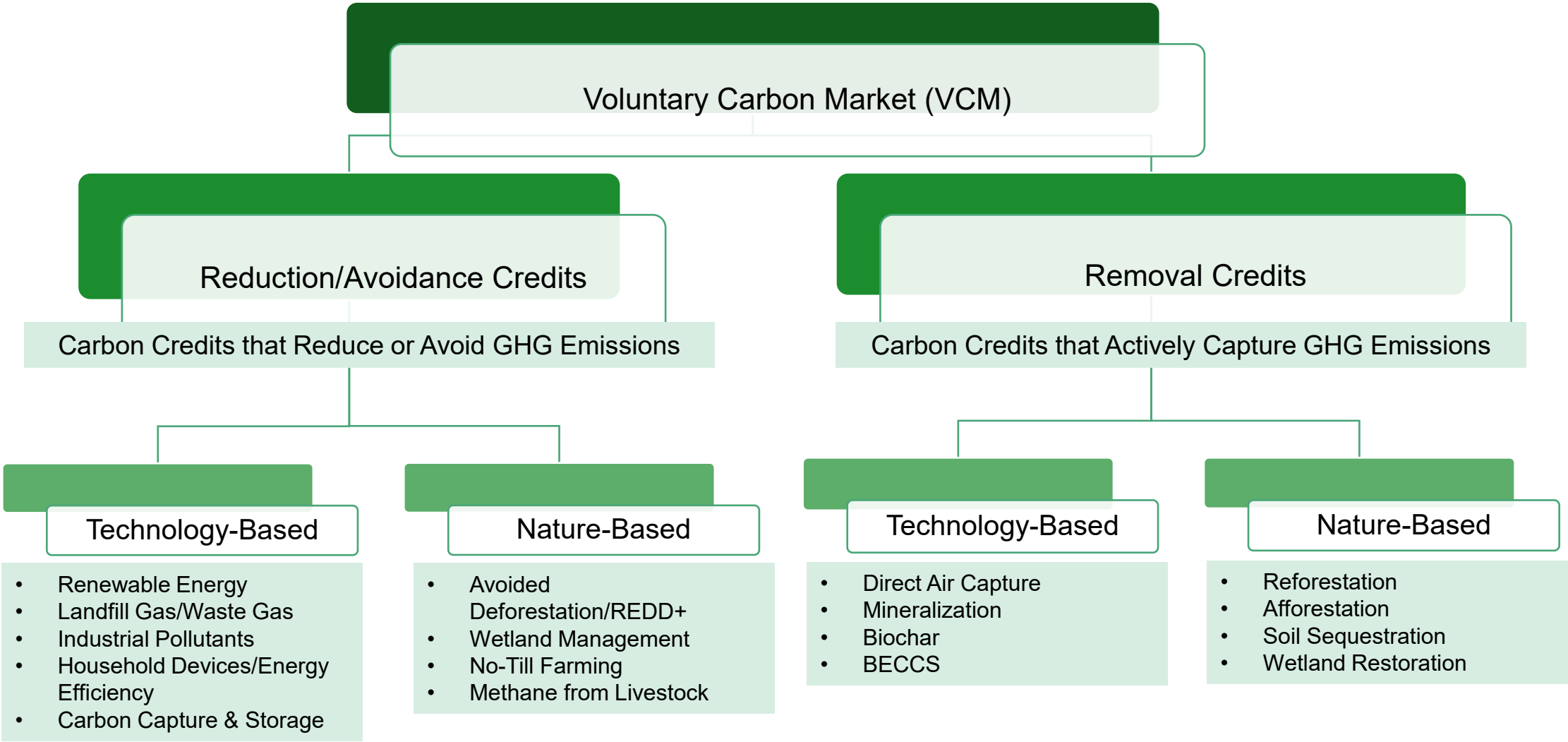
- Sector or Region specific
- Usually Mandatory participation + voluntary
- Project-based, driven by methodologies overseen by authorities



- Paris Agreement
- Include various iterations for Article 6.2 and 6.4
- Managed and traded nationally

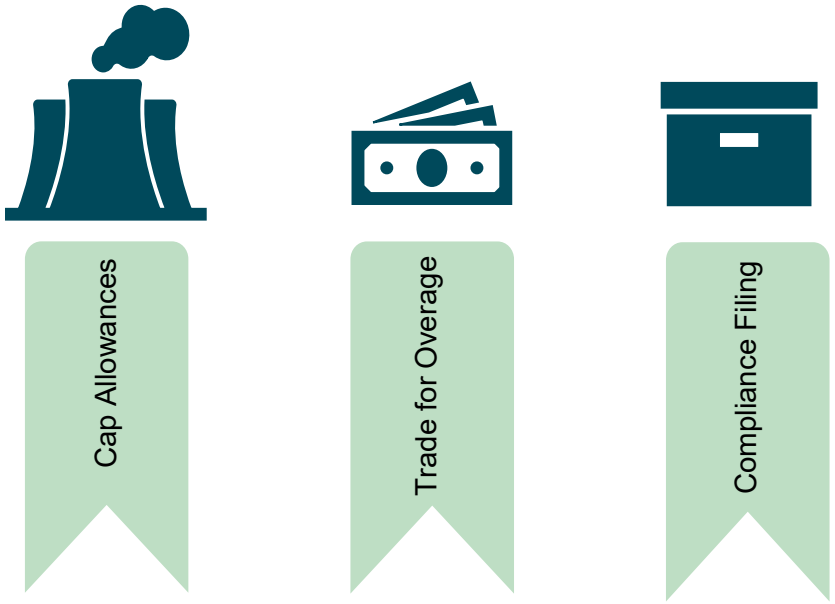
- Sector **AND** Region specific
- Mandatory participation, not voluntary
- Allowance-based, making availability finite

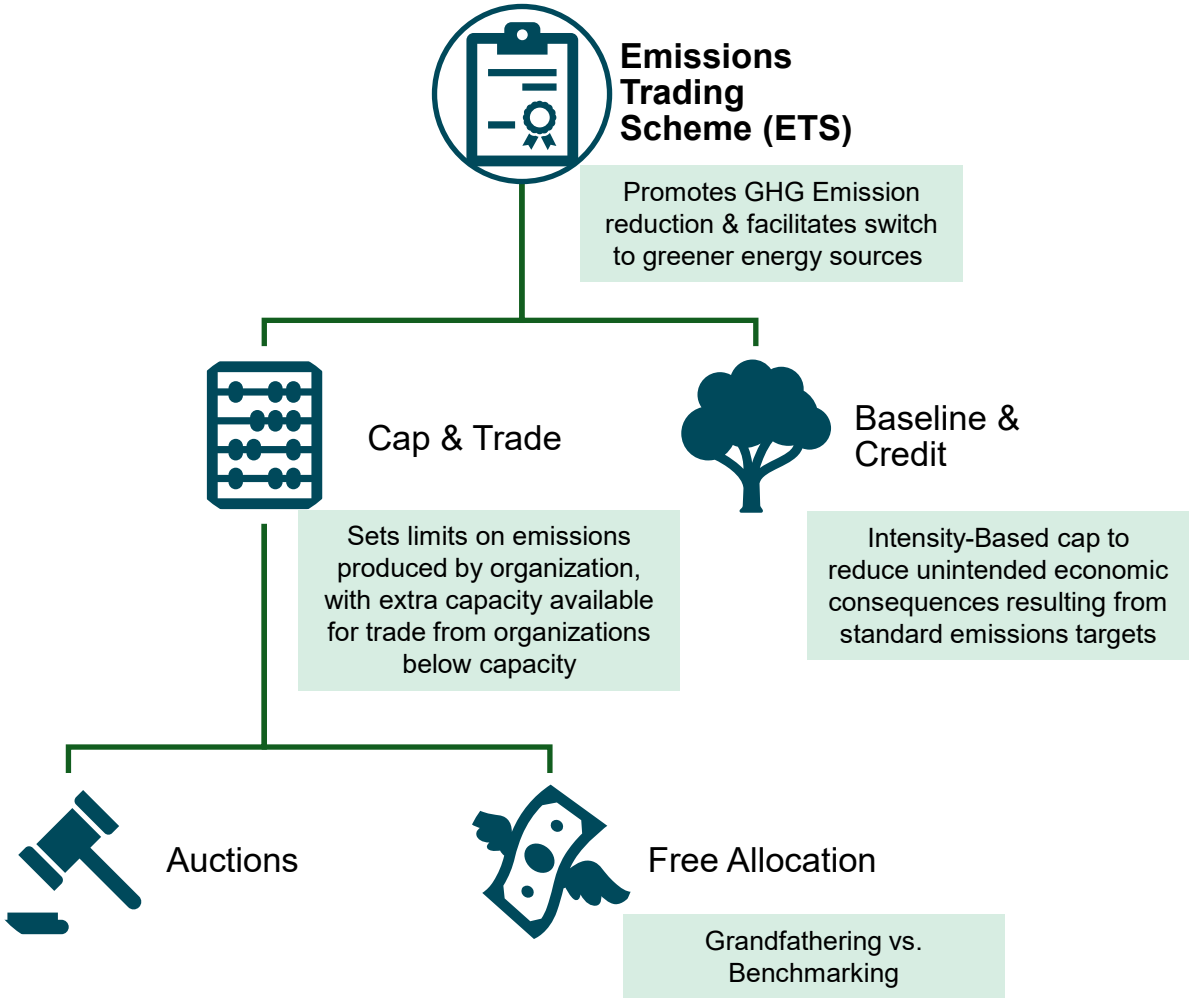
The Voluntary Carbon Market Is Layered And Complex



Compliance Carbon Markets sit separately from Carbon Taxes

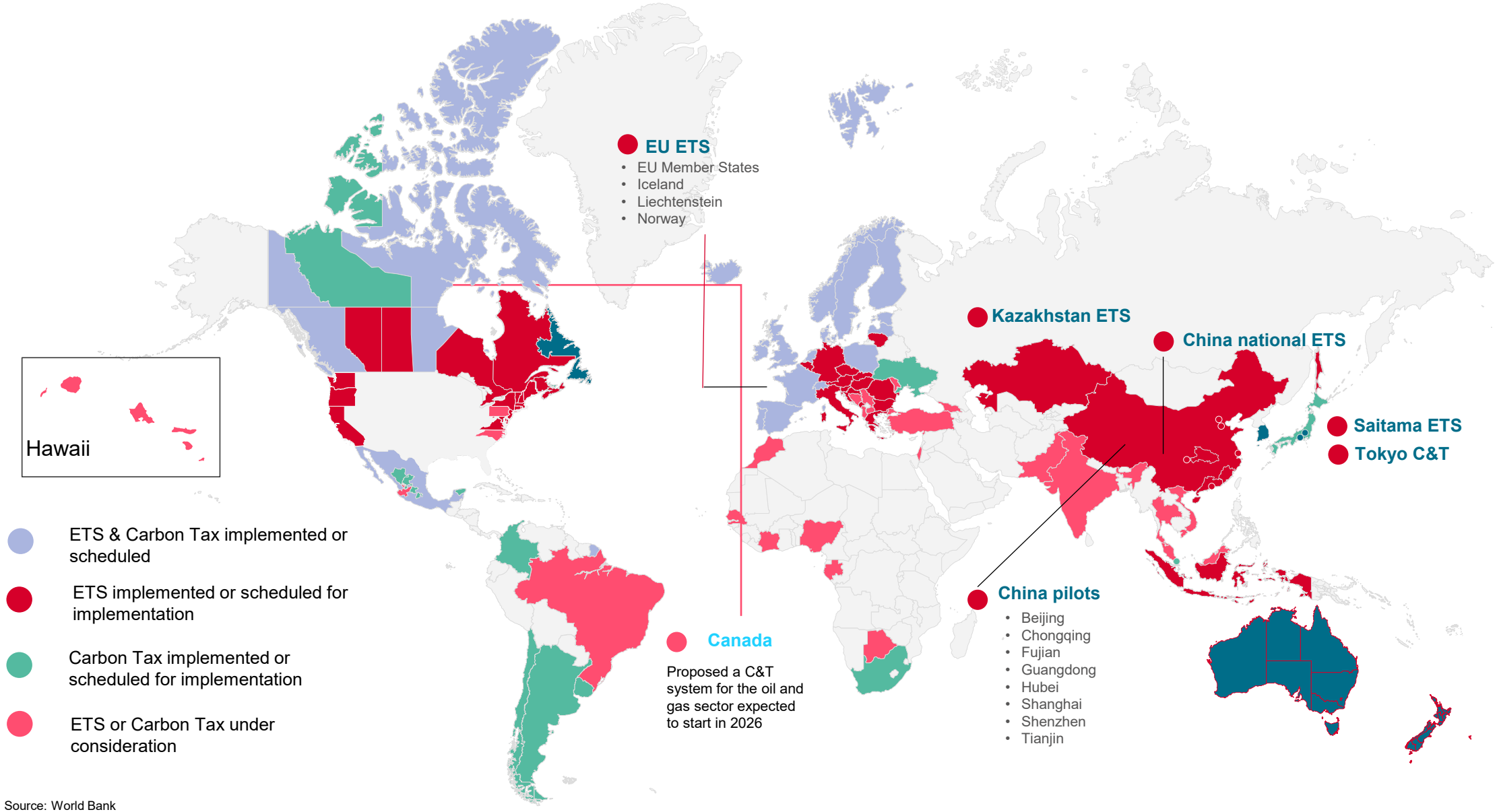
- A Carbon Tax is more efficient when damages from emissions grow slowly and steadily, and abatement costs rise quickly.
- An ETS is more efficient when damages from emissions grow rapidly and abatement costs rise slowly.





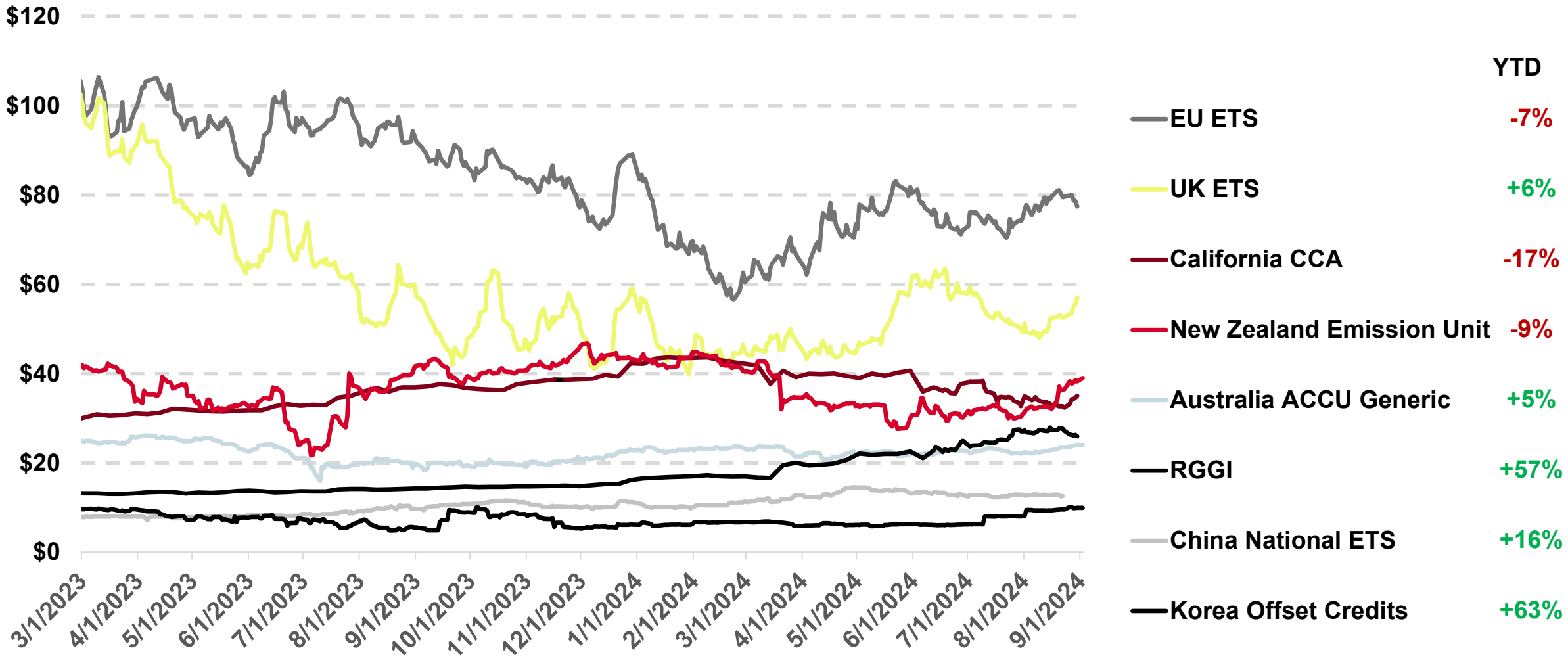
Source S&P Global Commodity Insight

>70 carbon price mechanisms in operation at the end of 2023; growing number of jurisdictions making plans to introduce an ETS or carbon tax



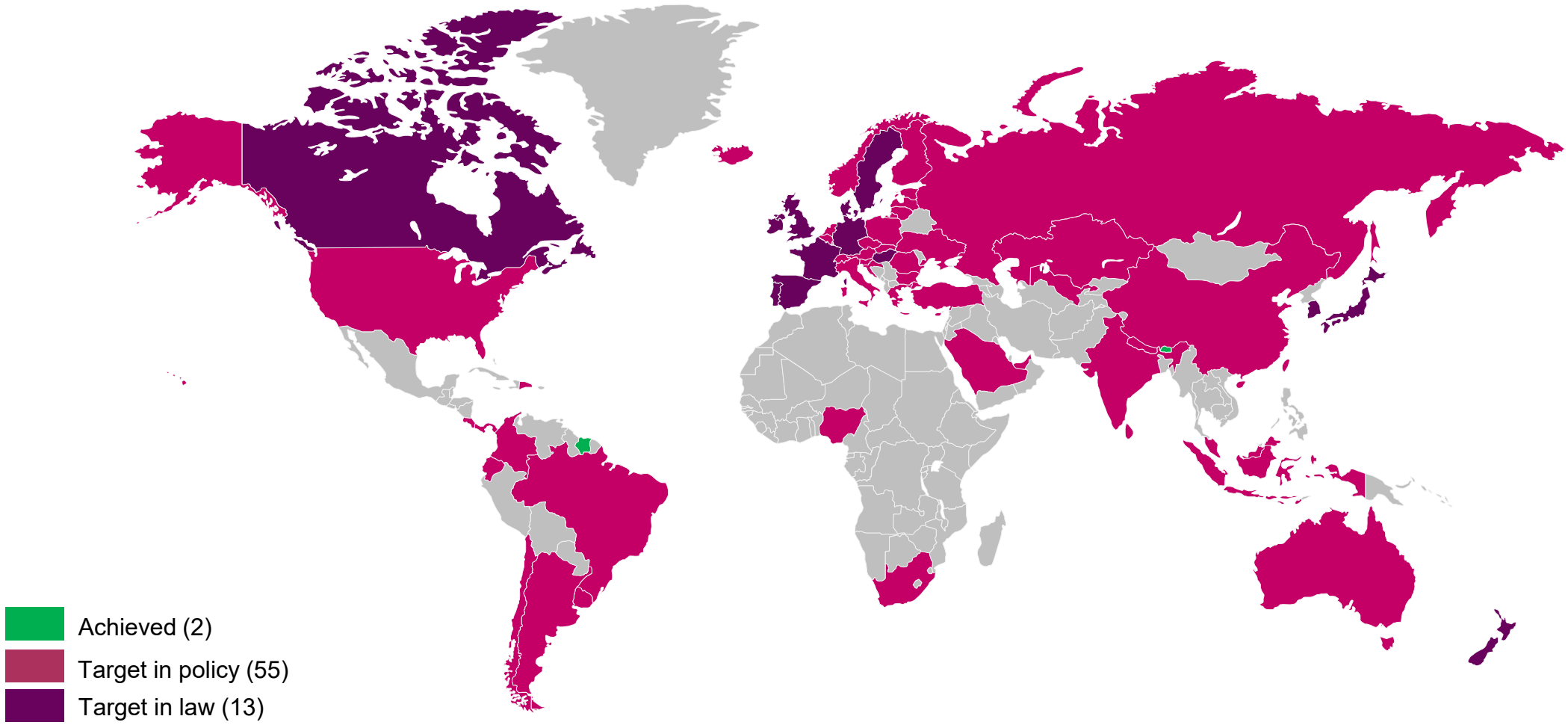
Source: World Bank

Compliance Carbon Markets: Prices Vary Widely; Down in EU / California / New Zealand and Up in UK / Australia / RGGI / China / Korea this year



Updated September 2024.
EU / UK / New Zealand / California CCA / Australia / RGGI / Korea prices from S&P; China prices from CNEEEX.

Rapid uptake of net zero pledges – need to understand the mechanisms to get there



Source: S&P Global Commodity Insights

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Thanks