Carbon in Reverse:

Global carbon emissions forecasting points to historic peak

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18 JUNE 2025

For the first time in modern history, this analysis reveals that global CO_2 emissions are likely to have reached their peak or are <u>very close</u>.

Summary

As the implications of climate change move from theoretical to financial, institutional investors are under increasing pressure to understand when, and whether, global carbon emissions will peak. While most models focus on long-term scenarios or lack the granularity to detect inflection points, this analysis applies a novel statistical approach to pinpoint a likely historic moment in global emissions.

Using a weighted Bayesian Ridge regression analysis of global fossil-fuel carbon emissions from 2000 to 2024 across major economies, this paper introduces a method to accurately forecast emissions to 2030. For the first time in modern history, this analysis reveals that global CO_2 emissions are likely to have reached their peak or are very close.

Global CO_2 emissions are expected to plateau with peak emissions of 36.90 ± 0.61 $GtCO_2$ per year expected around 2027, followed by a gradual decline of 0.12 $GtCO_2$ per year through 2030. This peak emerges from developed economies' deep emissions cuts more than offsetting developing world growth, with structural declines in the carbon-intensity of economic growth in China and the rest of the world tipping the global balance toward decline.

For investment teams, this insight reframes climate risk, not just as a future problem, but as a current inflection point. With emissions projected to plateau for the first time outside of an economic crisis, market dynamics, carbon pricing signals, and transition risk exposures will shift. This paper provides the data and context necessary for long-term asset managers, risk officers, and policy strategists to align with the next phase of the energy transition.

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Introduction

Global carbon emissions continue to increase. The Global Carbon Project (GCP), the world's most authoritative source for carbon cycle data, reported that global industrial carbon emissions reached 37.4 $GtCO_2$ in 2024, marking a 0.8% increase[1]. This upward trajectory has persisted virtually uninterrupted since 2000, with only temporary dips during the COVID-19 pandemic and the 2008 financial crisis.

The north-south emissions divide

The emissions picture reveals a striking geographic split. Most advanced economies have successfully reduced their fossil fuel emissions over the past decade. Yet global emissions keep rising because of one critical factor: the rapid industrialization of China and India. These two giants have more than offset the progress made by developed nations.

But this dynamic may be shifting in ways that could reshape the global climate trajectory.

Signs of a structural shift

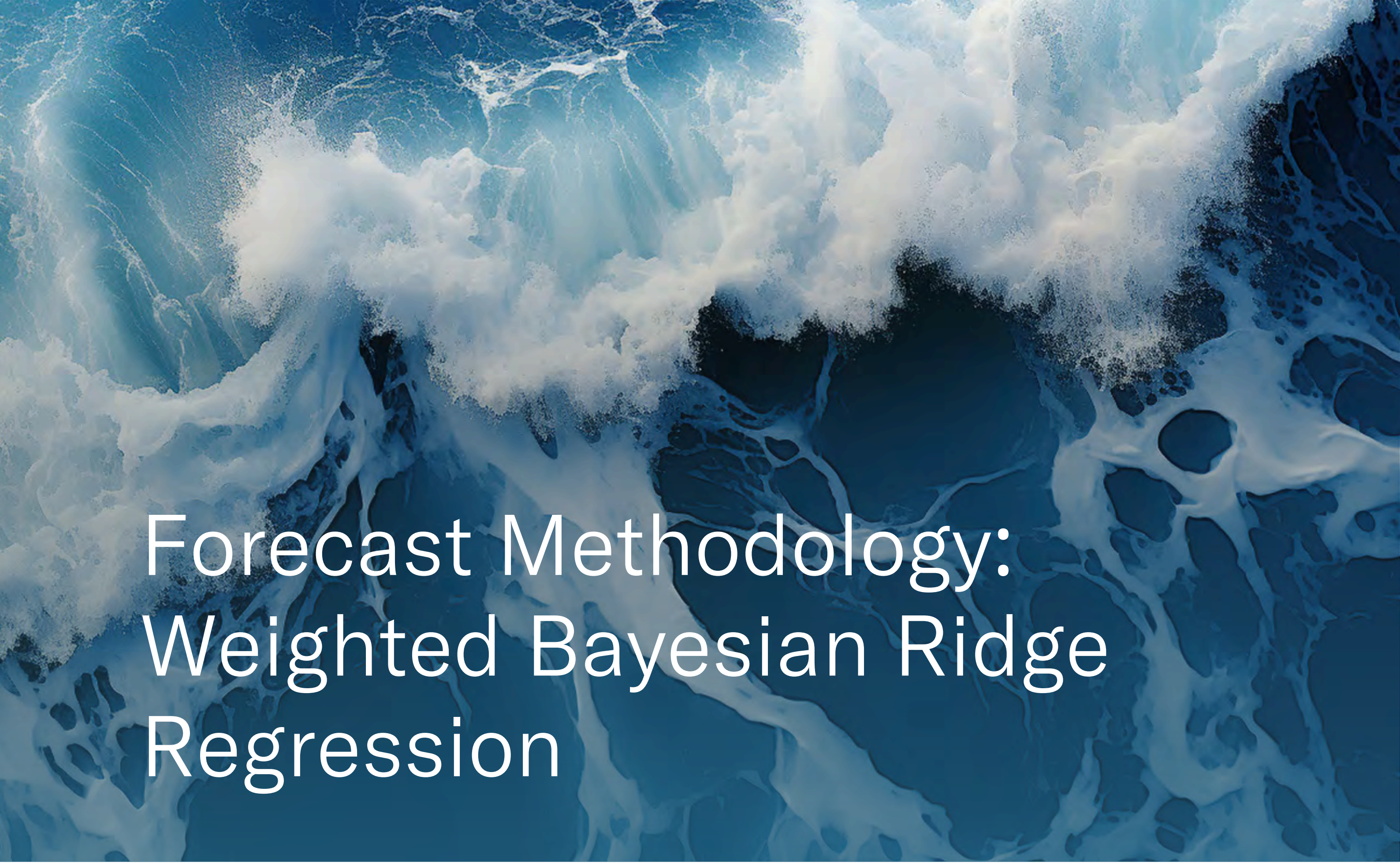
China has invested heavily in clean energy infrastructure, and recent analysis suggests this massive deployment may finally be paying dividends[2]. Early indicators point to China potentially beginning to reverse its carbon emissions, a development that would fundamentally alter the global emissions landscape.

Meanwhile, the corporate world is showing its own signs of change. For the first time, the global listed equities footprint has declined by 2.5%[3], suggesting that even the private sector may be reaching an emissions inflection point.

Filling the forecast gap

If China, the world's largest emitter, has genuinely peaked, what does this mean for global emissions? The GCP doesn't provide forecasts, so this research aims to bridge that gap by forecasting emissions through 2030.

[1] https://globalcarbonbudget.org/fossil-fuel-co2-emissions-increase-again-in-2024/
[2] https://www.carbonbrief.org/analysis-clean-energy-just-put-chinas-co2-emissions-into-reverse-for-first-time/
[3] https://www.emmi.io/newsroom/white-paper-nov-2024



Forecast Methodology: Weighted Bayesian Ridge Regression

Model architecture

This analysis employs a Bayesian Ridge regression model with polynomial features to capture non-linear trends in emissions data. The Bayesian approach provides several advantages: uncertainty quantification through full probability distributions for predictions rather than point estimates, built-in regularization that protects against overfitting through prior distributions, and interpretability through clear confidence intervals for all predictions.

Carbon training data

For this analysis, the last 24 years of emissions data (2000-2024) were used. The choice of carbon data has important implications and the decision reflects several key insights about the nature of carbon emissions.

Embedding long-term structural trends

Carbon emissions are deeply intertwined with the economy, energy infrastructure, and technological deployment, all of which evolve over decades, not years. A 24-year window captures the full China industrialization cycle from rapid growth between 2000-2012 to subsequent moderation, the complete U.S. shale gas transition and coal-to-gas switching, the entire lifecycle of renewable energy from expensive niche to cost-competitive mainstream, and multiple economic cycles including the 2008 financial crisis and recovery. Using shorter training windows (~10 years) would miss these structural transformations, potentially biasing projections based on incomplete transitions.

The stickiness of carbon-economic relationships

Carbon emissions exhibit strong 'stickiness' due to several long-term structural factors:

- infrastructure lock-in, with power plants operating for 30–50 years
- slow-changing economic systems, and
- gradual turnover of capital stock such as vehicle fleets, buildings, and industrial equipment.

Persistent carbon intensity trends also play a role, as CO_2 per unit of GDP evolves slowly based on efficiency improvements and changes in the fuel mix.

Avoiding short-term bias

Shorter windows risk overweighting temporary phenomena such as economic shocks where recessions cause temporary dips, weather variations where cold winters or hot summers affect energy demand, policy cycles where elections and policy changes create volatility, and COVID-19 effects that linger even when excluding 2020-2021 data. A 24-year window smooths these perturbations while still capturing genuine trend changes.

Recency weighting scheme and COVID-19

Our analysis uses 24 years of emissions data with graduated weighting: 5x for 2022-2024, 2x for 2010-2019, and 1x for 2000-2009, excluding 2020-2021 pandemic data from model fitting.

Multiple weighting schemes were tested, all showing emissions peaking but with different timing. Recency weighting is justified because recent data better reflects current technology costs, policies, and the shift toward service economies. Without it, the model overweights China's 2000-2010 coal boom, skewing projections unrealistically high.

> Carbon emissions are deeply intertwined with the economy, energy infrastructure, and technological deployment, all of which evolve over decades, not years.

Global Emissions Forecasts: The Peak has Arrived

Year	Predicted Emissions ($GtCO_2$/yr)	±1σ Uncertainty	68% Confidence Interval	95% Confidence Interval
2025	37.01	0.56	[36.45, 37.57]	[35.91, 38.11]
2026	36.97	0.59	[36.39, 37.56]	[35.82, 38.13]
2027	36.90	0.61	[36.28, 37.51]	[35.69, 38.10]
2028	36.78	0.64	[36.13, 37.42]	[35.52, 38.03]
2029	36.61	0.67	[35.95, 37.28]	[35.30, 37.92]
2030	36.41	0.70	[35.72, 37.11]	[35.05, 37.77]

Global emissions are expected to plateau at 36.90 ± 0.61 $GtCO_2$ per year by 2027, followed by a gradual 0.12 $GtCO_2$ decline per year through 2030. The 95% confidence intervals suggest high confidence in this plateauing pattern. This represents the first projected multi-year plateau and decline in global emissions outside of economic crises.

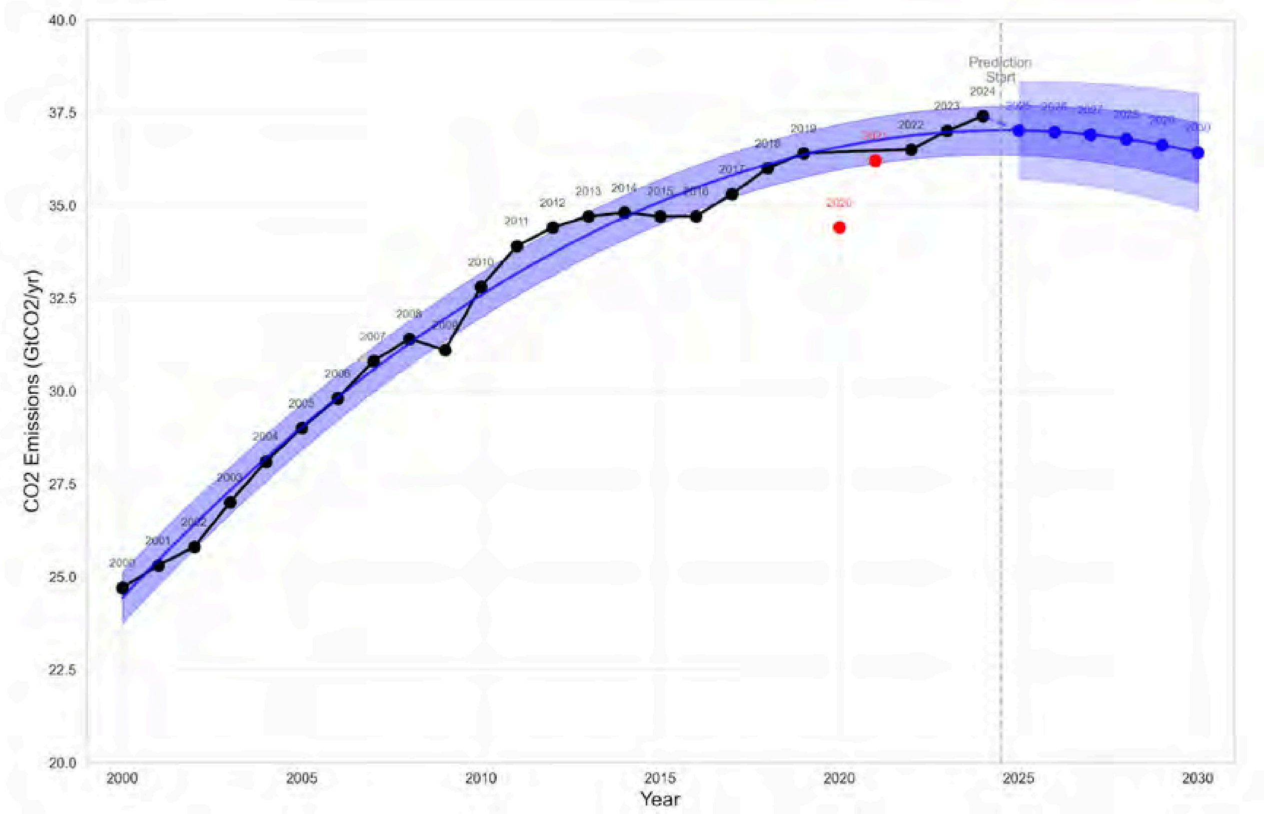


Figure 1: Global emissions from 2000 to 2040 with 5 years of forecasts from 2025 to 2030

Historical data and model fit

The black dots represent observed emissions data from 2000-2024 (excluding COVID years, shown as X markers). The light blue shaded region shows the model's 95% confidence interval, demonstrating an excellent fit to historical data with increasing uncertainty projected into the future. The model captures the rapid growth of the 2000s, the slight moderation in the 2010s, and the recent acceleration in the early 2020s.

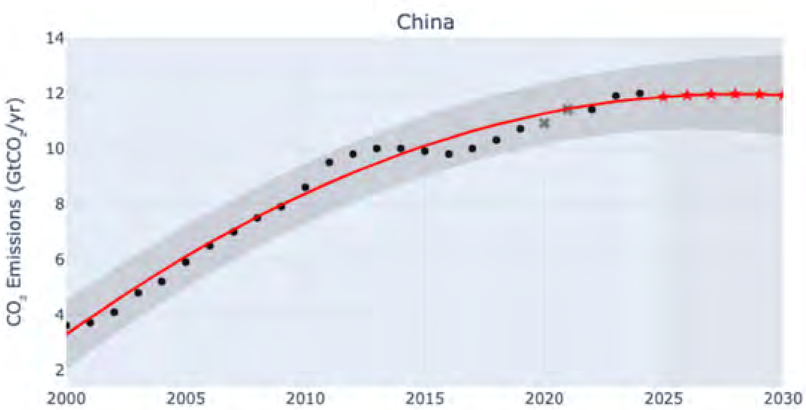
The prediction period (2025-2030)

The grey shaded "Prediction Period" highlights the key findings. The blue dots show the projected emissions, which reveal a remarkable pattern: emissions peak around 2027 at approximately 37.8 $GtCO_2$/yr before beginning a gradual decline. This is visualized by the flattening and slight downward curve of the confidence interval.

Country-Level Analysis: The Anatomy of the Global Emissions Peak

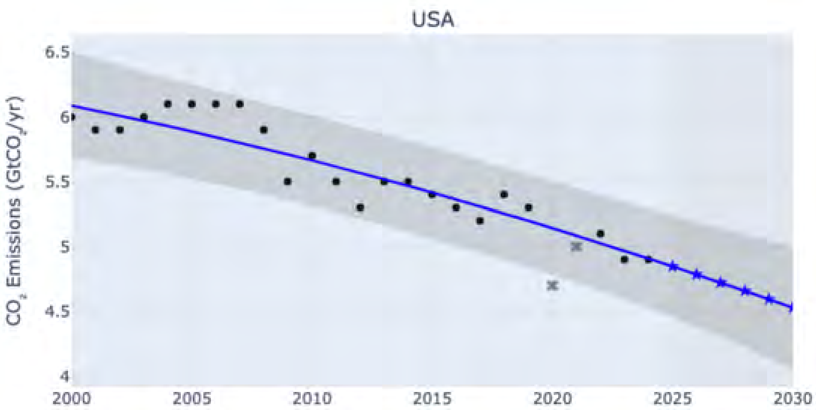
China: The plateau giant

This graph shows China's remarkable trajectory. After explosive growth from 2000-2012, emissions growth has moderated significantly. The projections (red line with gray confidence interval) suggest China has essentially plateaued at around 12 $GtCO_2$/yr. The narrowing confidence interval reflects high certainty in this stabilization, driven by China's structural changes towards a lower carbon economic growth.



USA: The steady decline

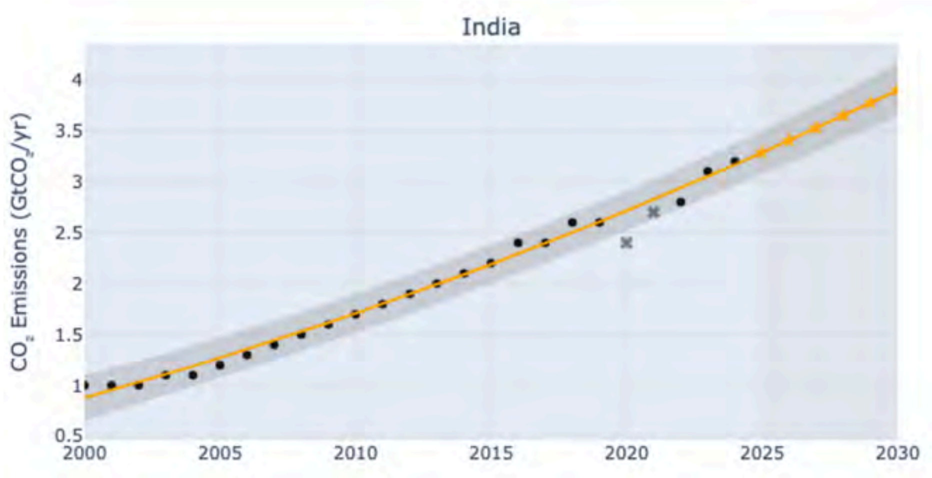
This graph illustrates America's consistent downward trend. From a peak of over 6 $GtCO_2$/yr in the mid-2000s, emissions have declined to under 5 GtCO2/yr. The projections show this trend continuing, reaching approximately 4.6 $GtCO_2$/yr by 2030. The smooth decline reflects structural changes in the US economy and energy system.



Charts: Disaggregates the global emissions into forecasting for the dominant six countries / regions.

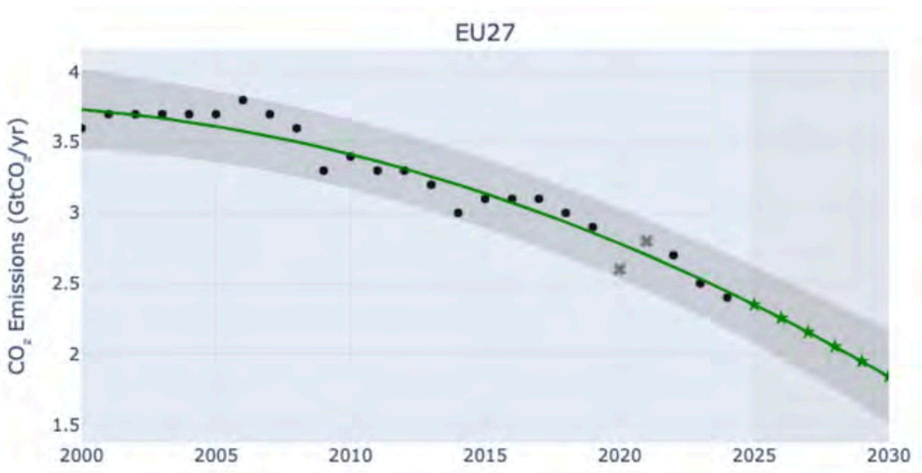
India: The carbon growth story

This graph shows India's steadily rising emissions, from 1 $GtCO_2$/yr in 2000 to 3.2 $GtCO_2$/yr in 2024. Unlike China, India shows no signs of plateauing, with projections reaching 4.0 $GtCO_2$/yr by 2030. The upward curve reflects India's ongoing industrialization and development needs.



EU27: The climate leader

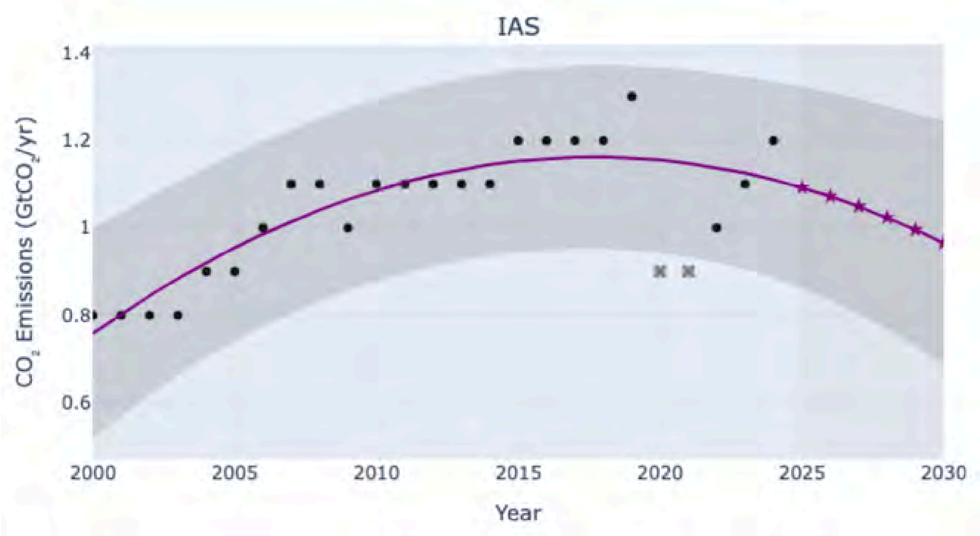
This graph demonstrates the European Union's (EU) continuous decarbonization. From nearly 4 $GtCO_2$/yr in the early 2000s, emissions are projected to fall below 2 $GtCO_2$/yr by 2030, a reduction of nearly 50% from peak levels. This steep decline proves that rapid decarbonization is possible in developed economies.



Charts: Disaggregates the global emissions into forecasting for the dominant six countries / regions.

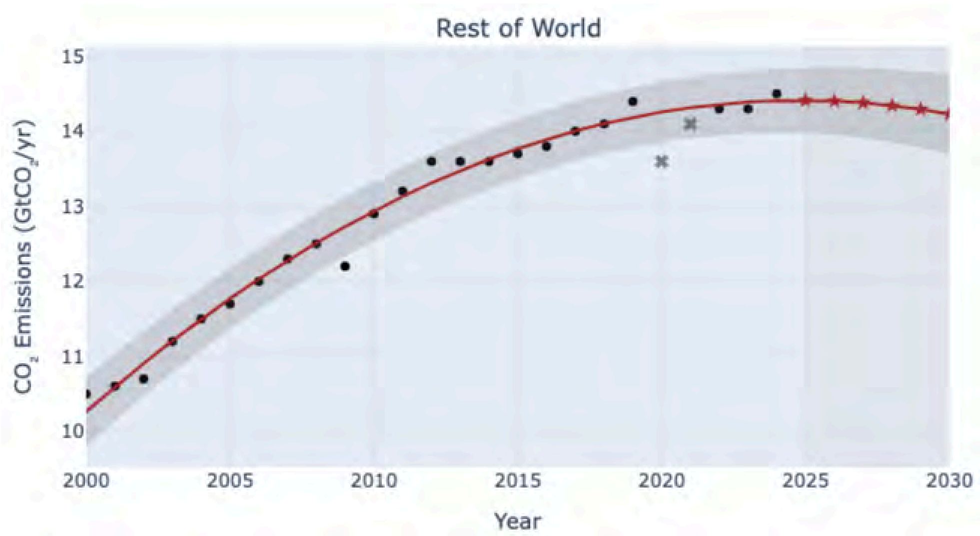
IAS: The minor player

This graph shows International Aviation and Shipping emissions remaining relatively stable around 1.1-1.2 $GtCO_2$/yr, with a slight decline projected. The wide confidence intervals reflect uncertainty in this sector's recovery and decarbonization pace.



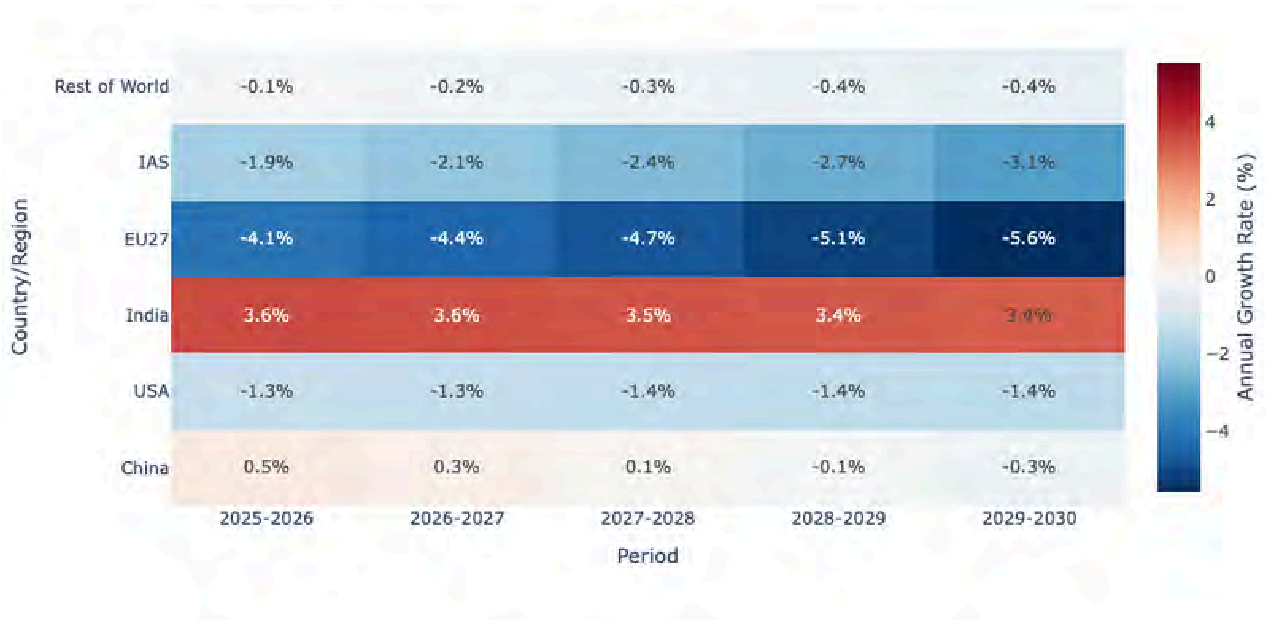
Rest of the World: The largest stabiliser

This graph aggregates all other nations, showing a plateau around 14.5 $GtCO_2$/yr with a gradual decline by 2030. The most dominant footprint, this decarbonisation has significant implications for the global carbon peak. It's important to note, however, that this stability masks diverse trends, as some nations grow while others decline, which collectively balance out.



Charts: Disaggregates the global emissions into forecasting for the dominant six countries / regions.

Predicted annual CO_2 emissions growth rates by country (2025-2030)



"... some nations grow while others decline, which collectively balance out."

The Critical Balance and Key Uncertainties

Global carbon emissions have reached a carefully balanced tipping point, with the arithmetic revealing striking precision in how different regions contribute to the overall trend. Combined reductions from the United States and EU27 total 0.93 $GtCO_2$ over the 2025-2030 period (USA: -0.37 $GtCO_2$, EU27: -0.56 $GtCO_2$), which more than offsets India's growth of 0.70 $GtCO_2$ over the same period. The EU + USA reductions exceed India's surging carbon growth by 0.23 $GtCO_2$.

The determining factor in achieving net global decline comes from China and the Rest of World, whose combined emissions are falling by 0.35 $GtCO_2$ (China: -0.08 $GtCO_2$, Rest of World: -0.27 $GtCO_2$). This additional decrease compounds the net reduction from developed economies, resulting in a total global reduction of 0.58 $GtCO_2$ over the 2025-2030 period, or approximately 0.12 $GtCO_2$ annually.

The global emissions peak reflects this delicate balance in action. While India's growth partially offsets developed economies' reductions, the combined declines from the EU, USA, China, and Rest of World ensure the overall downward trend. This marks a historic turning point where global emissions finally begin their descent.

It's important to understand that uncertainties grow with time, and the key factors that could undermine the global peak carbon are China and the Rest of the World. Both have flat to declining levels of carbon emissions by 2030, but given the uncertainties, could tip either way.

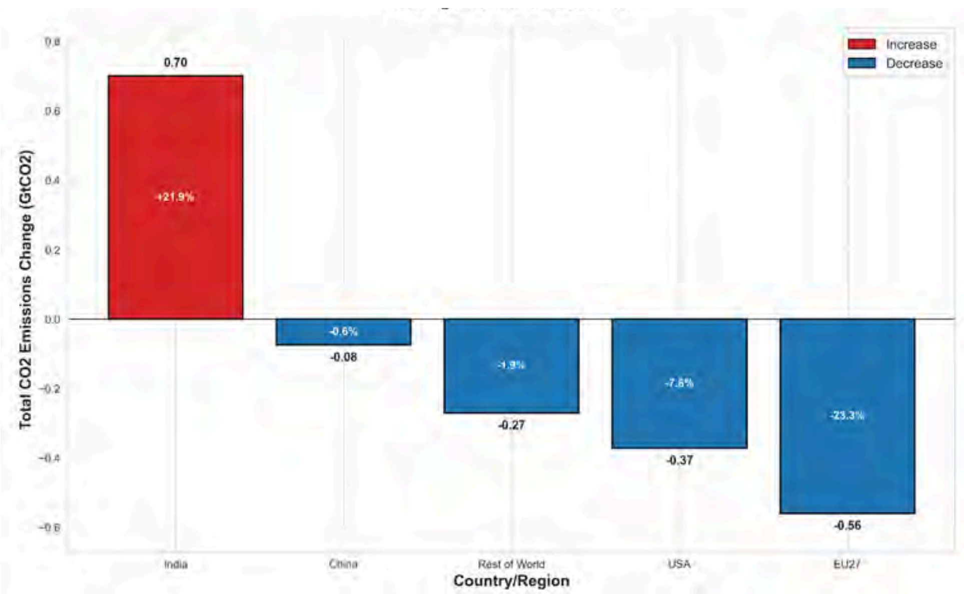


Chart: Total CO2 Change by Region (2025-2030). Change from 2024 Baseline.

Investment Implications

For investment teams, peak carbon changes the fundamental assumptions underlying climate risk assessment:

Shadow carbon pricing

The reversal of emissions reveals a significant shadow price of carbon operating globally. Although not formally imposed worldwide, it is being enacted through market mechanisms, national government policies, and corporate operational decisions, creating real economic costs for carbon-intensive activities.

Transition risk shift

Companies positioned for continued fossil fuel demand growth face accelerated stranded asset risks as the growth phase ends.

Regional divergence

Investment strategies must account for dramatically different regional trajectories, including India's continued growth, China's plateau, and declines in developed markets.

Conclusion: A Historic Pivot, But Not a Victory

This analysis provides strong evidence that global fossil CO_2 emissions have peaked or are on the cusp of doing so, marking a historic turning point in climate dynamics. However, this plateau occurs at levels far above those aligned with 1.5°C or even 2°C pathways.

This moment is critical, not as an endpoint but as a signal that further action is both possible and essential. The next phase must focus on accelerating emissions declines, embedding these structural shifts through policy, investment, and global coordination.

The peak must not be mistaken for success; it should be the beginning of a steeper path toward meaningful climate stability.

Institutional investors and policymakers must act decisively in this window of opportunity, accelerating capital allocation toward net-zero transitions, enforcing regulatory consistency, and integrating carbon risk into all levels of financial planning.

Technical notes

Data sources

Emissions data: All historical CO_2 emissions data (2000-2024) are sourced from the Global Carbon Budget 2024, published by the Global Carbon Project.

The latest data and analysis can be found at https://globalcarbonbudget.org/fossil-fuel-co2-emissions-increase-again-in-2024/ .

The full methodology is detailed in: Friedlingstein et al. (2025). Global Carbon Budget 2024. Earth System Science Data, 17, 965–1128. https://essd.copernicus.org/articles/17/965/2025/

All visualizations are based on fossil fuel CO_2 emissions data only, using polynomial Bayesian Ridge regression with recency weighting. The model excludes land-use emissions and non-CO_2 greenhouse gases. Country groupings follow Global Carbon Project definitions, with IAS representing International Aviation and Shipping.

Context and clarification

Why use Bayesian Ridge regression instead of more complex machine learning models?

Interpretability and uncertainty quantification were prioritised over marginal accuracy gains:

- Bayesian methods provide probability distributions, not just point estimates
- Ridge regression prevents overfitting on limited data (24 years)
- Polynomial features capture the non-linear plateau behavior
- The model's simplicity makes it auditable and reproducible

More complex models (neural networks, random forests) might fit historical data slightly better but would be "black boxes" for projection - simplicity is best here.

If emissions have peaked, does this mean climate change is solved?

Absolutely not. Peak emissions are necessary but insufficient for climate stabilization. The projections indicate that emissions will plateau around 36.9 $GtCO_2$/yr, still adding substantial amounts of CO_2 annually. The peak is a critical milestone showing that the energy transition is working, but emissions must not just peak but decline rapidly to limit warming to 2°C. We need to transform this plateau into a steep decline.

Context and clarification

The model shows emissions peaking, but what if China's emissions rebound or India grows faster than expected?

This is precisely why we use Bayesian methods with uncertainty quantification. The confidence intervals widen over time, acknowledging this uncertainty. For China, a recent analysis shows structural decline driven by massive renewable deployment. For India, even if emissions grow 50% faster than projected, this adds only ~0.4 $GtCO_2$/yr by 2030, significant but not paradigm-shifting.

How can you exclude COVID years but then use them to argue emissions can fall quickly?

Emmi excludes COVID years from model training because they represent an artificial, unsustainable reduction mechanism (economic shutdown). However, they remain valuable as proof of concept, showing that emissions can decrease by 6% in one year. The key insight is that purposeful policy could achieve similar reductions through the deployment of clean energy rather than economic contraction. It's the difference between using COVID as a predictor (inappropriate) versus using it as evidence of physical possibility (valid).

The 24-year window includes the 2008 financial crisis. Doesn't this bias the results toward lower emissions?

Actually, including 2008 makes the projections more robust, not biased. The 24-year window captures both the pre-2008 boom years (when emissions grew rapidly) and the recovery period. More importantly, recency weighting (5x for 2022-2024) means recent years dominate the projection. If anything, emphasizing recent years when emissions have been growing (2021-2024) makes the "peak emissions" finding more conservative and credible.

How sensitive are the results to the weighting scheme? What if you weighted all years equally?

The uncertainty intervals partially account for variability, but black swan events can't be predicted. However, this limitation applies equally to all scenarios:

- Wars or economic collapses would likely reduce emissions
- Breakthrough technologies (fusion, cheap carbon capture) would also reduce emissions
- The asymmetry we identify (emissions can fall fast but rise slowly) means disruptions are more likely to invalidate high-emission scenarios than low ones

About Emmi

Emmi is 'your net-zero investor toolkit' – we provide financed emissions data and climate risk analysis across all major public and private asset classes. These support climate-related reporting, and analysis that feeds into investment management processes.

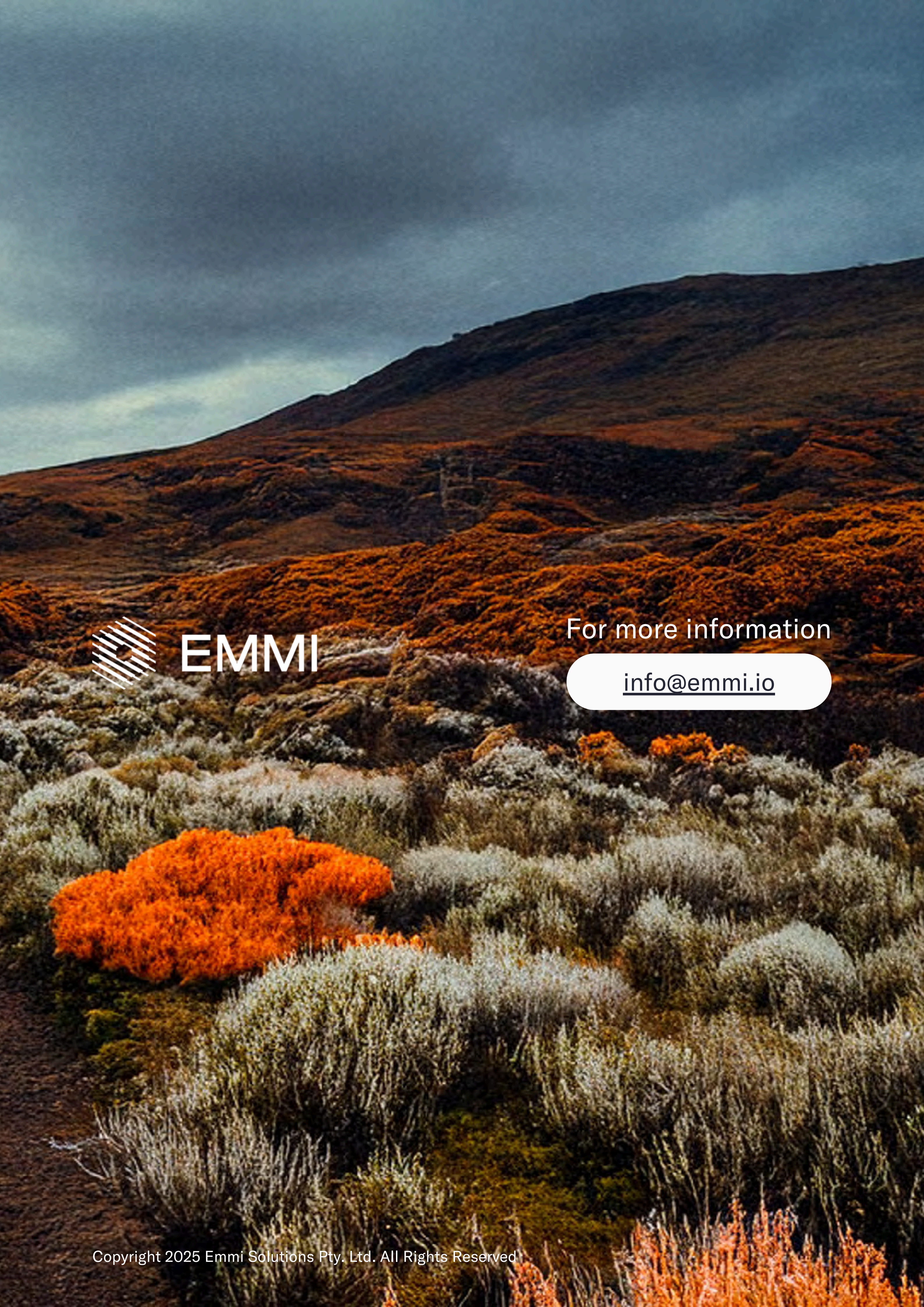
We use a combination of reported emissions, proprietary machine-learning models and algorithms to do this. Our tools translate emissions into financial implications, based on climate and pricing scenarios. This gives our clients actionable insights about their carbon exposure.

This diagnostics 'toolkit' is backed by our team of climate and finance experts.

Emmi believes that a low carbon economy is possible, and that properly incentivising and mobilising capital is the fastest and most cost-effective way to reach Net Zero and beyond.

Incorporating the cost of carbon into every decision will enable the finance sector, and its customers, to efficiently allocate resources towards this goal, which will accelerate decarbonisation.

To achieve this, and to meet regulatory requirements, there is a need for a broad spectrum of quality carbon emissions data and climate risk analysis. We have built Emmi to solve that problem.



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