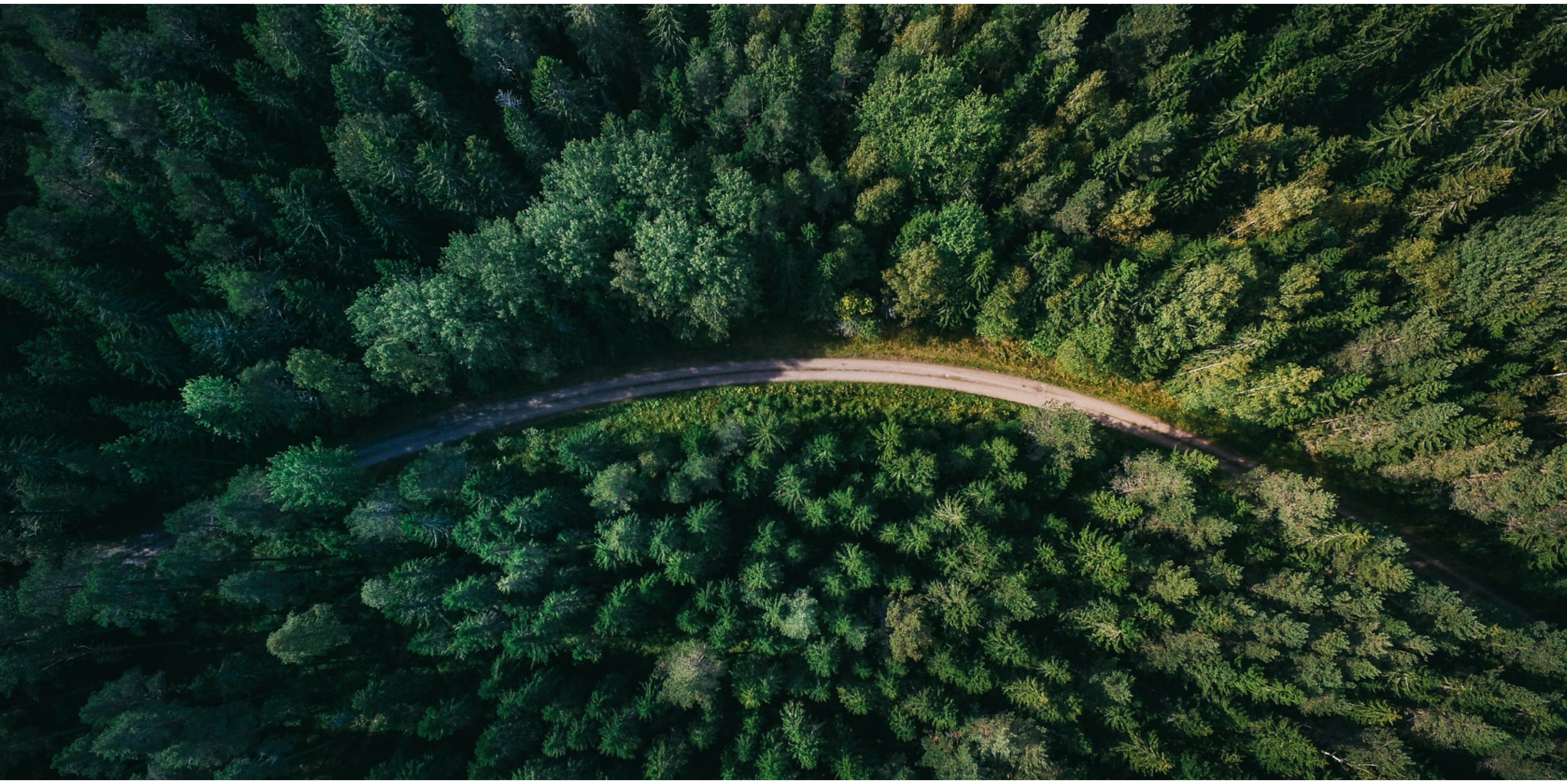
Structural effects in decarbonisation trajectories

Background note on structural effects



Climate Action Accelerator
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Executive Summary

The Climate Action Accelerator ("the Accelerator") supports partner organisations in the development of their climate and environmental roadmaps. All partners of the Accelerator commit to reducing their direct and indirect greenhouse gas emissions in line with the Paris Agreement. Roadmaps of partner organisations cover solutions related to reducing greenhouse gas emissions as well as broader environmental impacts.

The roadmap includes an emission reduction trajectory starting from the baseline year until the target year (e.g. 2030 or 2035). This estimated reduction pathway is based on the selected solutions and the intensity with which they will be implemented. In addition, decarbonisation effects at a societal level, that are expected to take place independently of the actions of an individual organisation, are considered. The Accelerator calls the latter "structural effects".

This document outlines the general approach to structural effects taken by the Accelerator, explains the underlying methodology, and presents the data sources and calculation results for each relevant category.

The table below shows an overview of the structural effects applied as well as the cumulative effect for each category at the 2030 and 2035 milestones, relative to a 2025 baseline.

Category	Annual structural effect	Cumulative to 2030 (5 yrs)	Cumulative to 2035 (10 yrs)
Electricity from the grid	1.4%/year	6.8%	13.1%
Professional travel	2%/year	9.6%	18.3%
Air freight	3%/year	14.1%	26.3%
Procurement – Manufactured goods	3%/year	14.1%	26.3%
Procurement – Services	2%/year	9.6%	18.3%

These cumulative percentages represent the share of emissions in each category that is expected to be reduced through structural, economy-wide trends alone — independent of any specific action taken by the partner organisation. They are applied to the relevant emissions categories within the roadmap's baseline to derive the portion of the reduction trajectory attributable to structural effects, as distinct from the reductions driven by the organisation's own selected solutions.[1]

[1] Structural effects compound annually rather than accumulating linearly: each year's reduction applies to the emissions remaining after prior years' reductions, not to the original baseline. Cumulative reduction is therefore calculated as $1 - (1 - \text{annual rate})^n$, where n is the number of years elapsed. This yields a slightly lower cumulative figure than simple multiplication (e.g., 3%/year over 10 years gives 26.3% cumulative reduction, not 30%).

What are structural effects and how are they applied?

Structural effects are applied to emission reduction trajectories in order to cater for the fact that regardless of individual choices of an organisation, societies as a whole have started to decarbonise. In other words, even if an organisation did not make any effort to reduce its greenhouse gas emissions, electricity production is increasingly based on low-carbon energy,[2] more fuel-efficient planes are operated, and low-carbon energy is deployed in manufacturing processes. In other words, the emission *intensity* of certain activities is reduced – regardless of climate action of individual organisations.

These structural effects are added to the calculation of the expected emission reductions that result from low-carbon choices of the organisation. When applying structural effects, the Accelerator considers the change in *emission intensity* of a certain activity, not the total emissions of a given activity. For example, the Accelerator applies a structural effect of 2 % annually for air travel. For any given number of flights, the emission intensity (i.e. the emission factor) is therefore expected to be reduced by 2% annually, in addition to any action to reduce travel emissions by the organisation.

It is important to note that any climate and environmental roadmap developed in collaboration with the Accelerator includes solutions to reduce both absolute emissions and the emission intensity at an organisation level. The structural effects, stemming from global decarbonisation efforts, are simply added to the effects from direct climate action by the individual organisation.

Structural effects do not take into account rebound effects by definition as they only consider the emission intensity of an activity. At an organisational level, it is crucial to minimise such rebound effects in order to achieve the goals of the Paris agreement collectively. This is precisely the role of climate and environmental roadmaps: the solutions identified and agreed upon have the goal to make efficient use of resources, avoid waste and put the organisation on a pathway to sobriety, whilst fulfilling its social mission.

By applying structural effects, the Accelerator is not suggesting that technological improvements or efficiency gains only will provide the emission reductions necessary to achieve a 1.5° pathway. Indeed, the vast majority of emission reductions stem from the solutions and actions of the organisation, not from structural effects.[3]

The Accelerator applies structural effects to emissions from electricity from the grid, air travel, air freight, and procurement of goods and services.[4]

[2] Ember 2025, Global Electricity Review 2025, available online: https://ember-energy.org/latest-insights/global-electricity-review-2025/ (last accessed 8.4.2025).

[3] See, for example, roadmaps of MSF OCG, MSF OCP, Alima. Available at www.climateactionaccelerator.org.

[4] The Accelerator currently does not apply structural effects to road freight due to the unavailability of data on historical emissions per tonne-kilometre and due to the fact that the decarbonisation of the sector is still at an early stage (e.g. electrification of trucks). IEA, The Future of Trucks. Implications for energy and the environment, 2017, p. 93, https://iea.blob.core.windows.net/assets/a4710daf-9cd2-4bdc-b5cf-5141bf9020d1/TheFutureofTrucksImplicationsforEnergyandtheEnvironment.pdf

Methodology

There is currently no streamlined and internationally accepted methodology in place for the application and calculation of structural effects in the context of emission reduction trajectories. In practice, leading organisations do apply them.[5]

The Accelerator uses historical data to determine the structural effects that are applied to decarbonisation trajectories. It is assumed that a similar decarbonisation pathway will continue over the next couple of years. We even observe that decarbonisation, notably of the energy system, is in fact accelerating. The Accelerator does not use climate scenarios (e.g. from IEA, IRENA, World Energy Council) to estimate the structural effects, but may use them to put the hypotheses on structural effects in perspective.[6] Given this methodology, the Accelerator considers that the applied structural effects are conservative and that the actual structural emission reductions might be higher in reality as the decarbonisation of whole sectors and economies accelerates.[7]

In the previous version, the structural effects were mainly based on data on historical emission reductions over the last four years. In order to balance out the effects of the Covid-19 pandemic, this timeframe was extended to seven years for this updated version. If available, data for the previous ten years is provided for illustrative purposes. All figures are rounded to one decimal and all percentage values are rounded down for the purpose of determining structural effects. If the sources consulted for this document had revised their historical data, those updated values were integrated.

The presented data is largely based on analysis of the IEA (International Energy Agency) on historical, projected and required emission reductions for different sectors, as well as from EMBER (which aggregates data from the IPCC, other agencies, incl. IEA data), and the UN SDG indicator tracking database. In certain cases, additional data analysis was performed by the CAA, the methodology is provided in the respective section. All calculations are available upon request.

The Accelerator uses the compound annual growth rate (CAGR). The CAGR is the mean annual growth rate over a period of more than one year. This metric smooths out fluctuations in annual growth and reduction rates across the specified period, making it a useful tool for comparing trends over time.

Depending on data availability, the Accelerator may apply structural effects based on global data or – if possible – use adapted values for specific regions (e.g. for electricity use) or sourcing countries.

[5] https://www.england.nhs.uk/greenernhs/publication/delivering-a-net-zero-national-health-service/
[6] Carbone4, Découplage et croissance verte, 2021, https://www.carbone4.com/publication-decouplage
[7] https://ourworldindata.org/co2-gdp-decoupling. Whilst emissions per GDP decrease, absolute greenhouse gas emissions are still growing, mainly due to continued growing demand of goods and services.

Continuous improvement approach

Given the lack of an internationally streamlined methodology and the lack of data, the application of structural effects comes with large uncertainties. To take this into account, the Accelerator chose to use conservative estimates and base projections on historical data. In addition, the Accelerator considers its approach to structural effects as a continuous improvement exercise and will update and refine the document as we learn along the journey.

If you would like to provide comments or suggestions for further improvement, please contact us (contact@climateactionaccelerator.org).

Electricity from the grid

Structural effect applied by the Accelerator for the trajectory calculation:

- **Global: Annual reduction of 1.4% (previously -1.2%/year)**
- Structural effects may also be applied on a regional level, depending on the partner organisation and data availability.

Background

- Decarbonisation of electricity production accelerated over the last seven years, compared to progress made over the last decade.
- The share of renewables in total power sector spending (including network infrastructure) was over 45% in 2020, and a further increase in renewable energy investments took place until 2025 where 65% of the total investments for energy were directed to clean energies.[8]
- Although growth in renewables is positive and accelerating, developing countries are lacking behind.[9]

Methodology

- The structural effects are based on the average intensity reduction of the last seven years to take the trend towards accelerated decarbonisation of the emissions intensity of electricity production into account, whilst balancing out exceptional circumstances for certain years, notably during the Covid-19 pandemic.
- Where possible, the Accelerator will apply structural effects at regional level, instead of using the global indicator, depending on data availability of the partner organisation.

Rationale

- Emission intensity of global electricity production decreased on average by 1.4% annually between 2017 and 2014.
- In the previous decade (2007-2017) the annual decrease was only 0.6%, further showcasing the increase in emission reduction from electricity production over the last years.
- Given the expected increase in efforts to decarbonise electricity production globally over the next years, this represents a conservative assumption.

Historical emissions	World	Europe	Africa	Middle East	Asia
Compound annual change in carbon intensity from electricity production in %, 2017 - 2024	**-1.4%**	**-3.5%**	**-1.1%**	**-0.7%**	**-1.6%**
Compound annual change in carbon intensity from electricity production in %, 2007 - 2017	-0.6%	-1.63%	-0.64%	-0.004%	-0.57%

Source: CAA calculations, based on data from Ember.[10]

[8] IEA, World Energy Investment 2025, https://www.iea.org/data-and-statistics/charts/global-investment-in-clean-energy-and-fossil-fuels-2015-2025
[9] IEA, IRENA, UNSD, World Bank, WHO, Tracking SDG 7: The Energy Progress Report, 2025
[10] https://ember-climate.org/data/data-explorer/. Last accessed 10 December 2025.

Aviation

Structural effect applied by the Accelerator for the trajectory calculation:

- **Professional travel: Annual reduction of 2% (no change)**
- **Air freight: Annual reduction of 3% (previously -1.4%)**

Background

- **Sustainable aviation fuels (SAF):** The development of sustainable aviation fuels is still in its early stages, currently accounting for just 0.1% of jet kerosene consumption.[11] The Accelerator has not included projections for increased SAF use in its assumptions for structural effects.

Methodology

- For this updated version, the analysis is based exclusively on the evolution of UK DEFRA (now Department for Energy Security & Net Zero) emission factors. The IATA (International Air Transport Association) data used in the previous version has not been updated in recent years and was therefore no longer included in this version.
- Contrary to the previous version, a longer timeframe (2018–2025) is considered to determine structural effects, in order to balance out the impacts of the Covid-19 pandemic. Emission factors temporarily increased due to lower occupancy rates during the pandemic. Using 2021 as the comparison year would have artificially inflated the percentage reduction.
- Emission factors without radiative forcing (RTF) were used to avoid inadvertently incorporating fluctuations resulting from methodological changes in the application of radiative forcing. In addition, no data without radiative forcing is available prior to 2016 from DEFRA. Therefore, no comparative data for the previous decade is available.

Rationale

- Professional travel: Between 2018 and 2023, emission factors increased due to lower occupation rates during the COVID-19 pandemic. Between 2024 and 2025, emission factors decreased due to[12]
  - post-pandemic normalisation of passenger load factors (moving from 2021 to 2023 data),
  - updated and more representative aircraft data, and
  - improved calculation methodologies using tools such as EUROCONTROL's Small Emitters Tool (SET).

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[11] IEA, 'Aviation', https://www.iea.org/reports/aviation. Accessed 20 November 2025.

[12] Thrust carbon, '2025 DEFRA Emissions Factors Update: What This Means for Business Travel', https://thrustcarbon.com/insights/2025-defra-emissions-factors-update-2 , Accessed 14 April 2025

- On average emission factors for international travel decreased by 2% annually during the same period.[13]
- Air freight: : Between 2018 and 2025, emission factors for international air freight decreased by 2.9% annually.[14]

	International flights: CO_2 per passenger-kilometer	Freight: CO_2 per tonne-kilometer
Compound annual rate 2018 – 2025[15]	-2%	-2.9%

Source: Accelerator calculations based on DEFRA conversion factors.

[13] UK Department for Energy Security and Net Zero, 'UK Government GHG Conversion Factors for Company Reporting: Emission Factors Dataset', https://www.gov.uk/government/collections/government-conversion-factors-for-company-reporting, accessed 20 November 2025.
[14] UK Department for Energy Security and Net Zero, 'UK Government GHG Conversion Factors for Company Reporting: Emission Factors Dataset', https://www.gov.uk/government/collections/government-conversion-factors-for-company-reporting, accessed 20 November 2025.
[15] The climate impact of aviation extends beyond CO_2 and includes non-CO_2 effects such as contrails and nitrogen oxides (NOx). Contrails are high-altitude ice clouds that both reflect incoming solar radiation and trap outgoing heat. On balance, their effect is one of net warming, though this varies by time of day, season and geography. (Source: IATA). For this analysis, radiative forcing effects were excluded from the calculation of emission reductions over the period in question, since the focus here is on relative change rather than absolute climate impact.

International Maritime Transport

As of January 2026, no structural effect will be applied by the Accelerator (Previously -1,5%/year)

Background

- Industry goals
    - The International Maritime Organisation (IMO) updated its greenhouse gas reduction strategy in July 2023 and committed to reducing CO2 emissions per transport work, as an average across international shipping, by at least 40% by 2030, compared to 2008 and to reach net zero by or around 2050.[16] (Compared to the 2018 target of reducing emissions by 40% by 2030 and 50% by 2050, baseline 2008).
- Legislation
    - The Fuel EU maritime regulation will oblige vessels above 5000 gross tonnes calling at European ports to reduce the greenhouse gas intensity of the energy used on board by 2% from 2025 onwards, by 6% from 2030 onwards, reaching 80% reduction by 2050.[17]
    - In January 2024, the EU's Emissions Trading System (EU ETS) will be extended to cover CO2 emissions from all large ships (of 5 000 gross tonnage and above) entering EU ports, regardless of the flag they fly.[18]
- Historic carbon intensity
    - Improvements in carbon intensity of international shipping have not followed a linear pathway and more than half have been achieved before 2012. The pace of carbon intensity reduction has slowed since 2015, with average annual percentage changes ranging from 1 to 2%.[19]

Methodology

- For the updated version of the structural effects and in line with the other categories, the evolution of DEFRA maritime freight emission factors was taken into account.
- Previously, the Accelerator based the structural effect for maritime transport on data from IMO's fourth Greenhouse Gas Study that claimed an average annual percentage reduction between 1 to 2% since 2015 and accordingly applied a structural effect of 1.5% per year. This reduction is not reflected in DEFRA emission factors between 2018 and 2025.

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[16] https://www.imo.org/en/MediaCentre/PressBriefings/pages/Revised-GHG-reduction-strategy-for-global-shipping-adopted-.aspx

[17] European Council, Fit for 55: increasing the uptake of greener fuels in the aviation and maritime sector, https://www.consilium.europa.eu/en/infographics/fit-for-55-refueleu-and-fueleu/. Accessed 25 July 2023.

[18] https://climate.ec.europa.eu/eu-action/transport-emissions/reducing-emissions-shipping-sector_en, last accessed 23/08/2023.

[19] IMO, Fourth IMO Greenhouse Gas Study, 2020, https://wwwcdn.imo.org/localresources/en/OurWork/Environment/Documents/Fourth%20IMO%20GHG%20Study%202020%20Executive-Summary.pdf

Rationale

- Between 2018 and 2025, emissions from maritime transport decreased only by 0.02%. Whilst an accelerated reduction in emission intensity is expected due to the European legislation on energy efficiency, the Accelerator will not continue applying a structural effect to maritime transport as of January 2026.

	Maritime transport: CO2e emissions per tonne-kilometre
Compound annual rate 2018 - 2025	-0.02%

Source: DEFRA

Procurement of Goods and Services

Structural effect applied by the Accelerator for the trajectory calculation:

- **Manufactured goods: Annual reduction of 3% per year (previously -3.4%)**
- **Services: Annual reduction of 2% per year (previously -2.3%)**
- **No structural effects are applied to food sourcing.**

Structural effects may also be applied at a regional level, if data on origin of products is available at the partner organisation.

Background

- The carbon intensity of procured goods & services depends on many factors, such as the type and composition of goods or services, the energy mix of the sourcing countries, the manufacturing process, etc.
- **Countries responsible for 46.3% of global GDP and 36.1% of global emissions have already decoupled economic growth and emissions in absolute terms**. Overall, **92% of global GDP and 89% of global emissions now are located in countries that have decoupled economic growth from emissions in either relative or absolute terms.[20]**
- Even more than for other categories, assumptions on structural effects for procurement therefore need to be considered as rough estimations.

Methodology

- Data availability on expected emissions per sector or type of good/service is very limited. Only generic indicators are available, such as emissions per GDP output, or emissions per manufacturing value added.
- Two indicators are used by the Accelerator to inform the structural effects for procurement:
  - Goods: emissions per manufacturing value added.[21]
  - Services: carbon emissions per GDP output
- No dedicated indicator to inform the structural effects for services is available. Using the carbon intensity of GDP output provides an – albeit not perfect – approximation.
- Given the trend towards accelerated decarbonisation across sectors and the increasing number of organisations that adopt science-based targets,[22] the Accelerator considers using historical data to determine the structural effect, as a conservative approach.
- In addition, it is assumed that a large share of manufactured goods is produced in China, where the rate of decarbonisation per manufacturing value added was even higher (a 6.3% decrease between 2015 and 2022),[23] further suggesting that the chosen approach is conservative.

[20] https://eciu.net/analysis/reports/2025/10-years-post-paris-decoupling-globally

[21] "[…] measures the carbon intensity of the manufacturing economic output, and its trends result from changes in the average carbon intensity of the energy mix used, in the structure of the manufacturing sector, in the energy efficiency of production technologies in each sub-sector, and in the economic value of the various output." https://sdg.tracking-progress.org/indicator/9-4-1-carbon-dioxide-emissions-per-unit-of-value-added/

[22] www.sciencebasedtargetsinititiative.org

[23] CAA calculations based on data from the UN SDG Indicator Database. https://unstats.un.org/sdgs/dataportal/database

- The global average is used to determine the structural effects. If reliable data on production countries for sourced goods is available at the partner organisation, the Accelerator will use structural effects per region, using the same calculation methodology.

Rationale

- **Between 2015 and 2022, emission intensity per manufacturing value added decreased globally by 3% annually.** During the Covid-19 pandemic, emission intensity increased slightly, but continues decreasing since 2021 again, albeit at a slightly lower rate compared to previous periods. In the previous decade (2005-2015), emissions per manufacturing value added decreased globally at a rate of 1% over the period – significantly lower than between 2015 and 2022.
- The carbon **emissions per GDP output** decreased globally on average by 2.1% over the period between 2015 and 2022, accelerating compared to 2005 to 2015, where the annual reduction was only 1.6%.

World	Average yearly change in carbon emissions per unit of manufacturing value added in %	Compound annual change in carbon emissions per unit of GDP in %
2015 – 2022	**World -3%** Africa -1.1% Asia -4.1% Europe -3% China -6.3% India -1.6%	**-2.1%**
2005 – 2015	**-1%**	**-1.6%**

Source: Accelerator calculations based on data from the UN SDG Indicator Database[24]

[24] https://unstats.un.org/sdgs/dataportal/database, Indicator 9.4.1