Transition Pathway Initiative

TPI Sectoral Decarbonisation Pathways

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Simon Dietz, Beata Bienkowska, Valentin Jahn,
Nikolaus Hastreiter, Antonina Scheer, and Rory Sullivan

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TPI AT A GLANCE

SUPPORTERS

120
SUPPORTERS

$40
TRILLION
COMBINED AUM

COMPANIES

479
COMPANIES

16
SECTORS

46
COUNTRIES OF LOCATION

$10
TRILLION
OF TOTAL MARKET CAP

SECTORAL BENCHMARKS

2
BENCHMARKS FOR ENERGY
Electricity, Oil & Gas

3
BENCHMARKS FOR TRANSPORT
Autos, Aviation, Shipping

5
BENCHMARKS FOR INDUSTRIALS AND MATERIALS
Aluminium, Cement, Diversified Mining, Paper, Steel

1. THE TPI SECTORAL DECARBONISATION PATHWAYS

In a world where we are faced with multiple interpretations of what the low carbon transition should look like (often with the intention of slowing rather than accelerating the rate of change, and often to argue for less ambitious action by companies), it is imperative that we as investors make decisions based on credible, rigorous analysis that is explicitly focused on the goal of net zero and that reflects the economic, technical and societal realities of the low carbon transition. The TPI sectoral decarbonisation strategies provide that authoritative analysis.

TPI's sectoral decarbonisation pathways are widely used by investors and investor networks – notably by Climate Action 100+, the largest global investor collaboration on climate change – to assess whether companies are aligned with the goals of the Paris Agreement, specifically the goal of keeping global temperature rise below 1.5 degrees Celsius. This analysis informs investment decision-making and underpins these investors' engagement with companies across the range of high impact sectors.

TPI's pathways are derived from scenarios developed by the International Energy Agency (IEA) and are available to use by everyone via the TPI online tool.

TPI's sectoral decarbonisation pathways meet the demand from all stakeholders – investors, companies, civil society organisations – for a credible, rigorous framework for assessing corporate climate change performance. They are recognised by investors as the authoritative translation of the IEA's scenarios into credible performance benchmarks for industry sectors and for individual companies.

Adam Matthews, Chair, Transition Pathway Initiative (TPI)

Key features of TPI sectoral decarbonisation pathways:

1. **We create sector-specific methodologies based on the Sectoral Decarbonisation Approach**. This approach allocates an absolute, economy-wide emissions budget into sectoral budgets, reflecting the unique challenges faced by different sectors arising from the low-carbon transition, including where emissions are concentrated in the value chain and how costly it is to reduce them.
2. **We benchmark emissions in most sectors against three scenarios that are derived from modelling by the IEA.** Where necessary, we supplement IEA data with data from other models and databases, such as those of the Intergovernmental Panel on Climate Change.
3. **TPI benchmarks cover the majority of lifecycle emissions in each sector**, while also taking into account issues of data availability. Where relevant, we consider non-CO_2 emissions, for example methane in the oil and gas benchmarks.
4. **TPI benchmarks extend to 2050**, allowing investors to see a company's transition pathway in the short, medium, and long term.
5. **In nearly all sectors, company emissions are normalised against a physical activity output (e.g., cementitious product, electricity generation, or crude steel)**. This intensity metric allows for comparisons between companies.
6. **The benchmark methodologies can be adapted to new models and scenarios**. This means future scenario updates should be easy to incorporate, and alternative sources of scenario can be used instead.
7. TPI methodologies are **free to use, allowing public review and scrutiny.**

2. TPI sectoral decarbonisation pathways: overview of methodology

TPI benchmarks. For most sectors, TPI uses the following sectoral benchmark pathways[1] derived from IEA scenarios:

- **1.5 Degrees scenario**, which is consistent with the most ambitious aim of the Paris Agreement to hold "the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels". [1] This scenario is consistent with a carbon budget that limits the global mean temperature rise to 1.5°C with a 50% probability [2].
- **Below 2 Degrees scenario**, which is also consistent with the overall aim of the Paris Agreement to limit warming, albeit at the middle of the range of ambition. This scenario is consistent with a carbon budget that limits the global mean temperature rise to 1.65°C with a 50% probability or 1.8°C with a probability of 66% [3].
- **National Pledges scenario**, which is consistent with the global aggregate of emissions reductions pledged by countries up to at least mid-2020, depending on the sector. According to IEA, this aggregate is currently insufficient to put the world on a path to limit warming to 2°C, even if it will constitute a departure from a business-as-usual trend. It is consistent with a carbon budget that would lead to a global mean temperature rise of 2.6°C by 2100 relative to pre-industrial levels with temperatures continuing to rise thereafter [3].

How do we derive TPI benchmarks? TPI's Carbon Performance assessment is based on the Sectoral Decarbonization Approach (SDA) [4], created by CDP, WWF and WRI in 2015. The SDA translates greenhouse gas emissions targets made at the international level (e.g., under the Paris Agreement to the UN Framework Convention on Climate Change) into appropriate benchmarks, against which the performance of individual companies can be compared.

The SDA is built on the principle of recognising that different sectors of the economy (e.g., oil and gas production, electricity generation and automobile manufacturing) face different challenges arising from the low-carbon transition, including where emissions are concentrated in the value chain, and how costly it is to reduce emissions. Other approaches to translating international emissions targets into company benchmarks have applied the same decarbonisation pathway to all sectors, regardless of these differences.

Key inputs to calculating the benchmark pathways:

- A time path for carbon emissions that is consistent with meeting a particular climate target by keeping cumulative carbon emissions within the associated carbon budget.
- A breakdown of this economy-wide emissions path into emissions from key sectors (the numerator of sectoral emissions intensity).
- Consistent estimates of the time path of physical production from, or economic activity in, these key sectors (the denominator of sectoral emissions intensity).

[1] The current benchmarks replace the ones stated in the Methodology note v3.0: *Below 2 Degrees, 2 Degrees and Paris Pledges.*

The benchmarks used by TPI represent emissions intensities, but they are created based on an absolute economy-wide emissions budget that is allocated into absolute sector-specific emissions budgets. In this way, the benchmark intensities can be understood as consistent with a particular scenario's absolute emissions levels.

The role of IEA modelling in deriving TPI benchmarks. The IEA modelling underpins the TPI benchmarks. Its economy-energy model simulates the supply of energy and the path of emissions in different sectors burning fossil fuels or consuming energy generated by burning fossil fuels. The model rests on assumptions about key inputs, such as economic and population growth.

In low-carbon scenarios, the IEA model minimises the cost of adhering to a carbon budget by always allocating emissions reductions to sectors where they can be made most cheaply, subject to some constraints as mentioned above. These scenarios are therefore cost-effective, within some limits of economic, political, social, and technological feasibility.

The adjustments we make to CO_2 emissions and activity data from the IEA are sector specific. Most adjustments fall into three different categories.

First, the IEA only models CO_2 emissions, so we include additional non-CO_2 emissions in sectors where they are relevant. For example, in the oil & gas sector we add methane emissions and in the aluminium sector we add perfluorocarbon emissions.

Second, we need to ensure consistency between our benchmarks and the assessment boundary chosen in our company assessments. For example, in some industrial sectors (paper, aluminium, and steel) we account for the fact that many companies generate electricity themselves instead of buying electricity from the grid. We exclude related electricity consumption from our benchmarks to avoid double counting between Scope 1 and 2 emissions. Where necessary, we also adjust the activity metric. For example, in aviation we supplement IEA activity data in revenue passenger kilometres with freight projections from ICAO in revenue tonne kilometres to enable the assessment of airlines with freight businesses.

Third, we need to ensure consistency between our benchmarks and the metrics disclosed by companies. For example, in the cement sector, companies typically disclose "specific net emissions" from cement manufacturing in line with the definition of the Global Cement and Concrete Association. Hence, we exclude emissions from on-site power generation and emissions related to the combustion from waste fuels from the benchmarks.

Sectors assessed on different benchmarks. In autos, different benchmarks are used to reflect additional sources of uncertainty, notably the extent to which shifting demand for different transport modes will affect what is required of companies. They are based on data provided by the International Council on Clean Transportation (ICCT) and the carbon budgets associated with these benchmarks.

In airlines and shipping, we use an International Pledges benchmark instead of National Pledges, because the pledges in these sectors are primarily set out by international bodies, the International Civil Aviation Organisation (ICAO) and the International Maritime Organisation (IMO), respectively, rather than by national commitments.

In aluminium and paper, we use Below 2 Degrees, 2 Degrees and Paris Pledges benchmarks, which are based on the IEA's 2017 scenarios due to the limited sectoral coverage of IEA's recent scenarios.

Source of data for scenarios: The main data sources are modelling work by the IEA: the World Energy Outlook reports [3] [6], the Energy Technology Perspectives reports [7] [8], and the Net Zero by 2050 report [2]. Other data sources include the Intergovernmental Panel on Climate Change [13], the International Council on Clean Transportation [9], and the International Civil Aviation Organisation. [10] [11]

3. SUMMARY OF THE TPI PATHWAYS

Table 1. Summary of key metrics on Carbon Performance benchmarks across sectors

Cluster	Sector	Scope of emissions	Benchmarks	Sectoral Carbon Performance measure
Energy	Electricity utilities	1 from owned electricity generation	1.5 Degrees scenario Below 2 Degrees scenario National Pledges scenario	Carbon intensity of electricity generation
	Oil and gas	1, 2, 3 (cat 11)		Carbon intensity of primary energy supply
Transport	Automobiles	3 (cat 11)	2 Degrees (high efficiency) 2 Degrees (avoid shift, improve) Paris Pledges scenario	New vehicle carbon emissions per kilometre
	Airlines	1	1.5 Degrees scenario Below 2 Degrees scenario International Pledges scenario	Carbon emissions per revenue tonne kilometre
	Shipping	1		Carbon emissions per tonne kilometre
Industrials and materials	Cement	1	1.5 Degrees scenario Below 2 Degrees scenario National Pledges scenario	Carbon intensity of cementitious product
	Diversified mining	1, 2,3 (cat 10, 11)		Carbon emissions per tonne of copper equivalent
	Steel	1, 2		Carbon intensity of crude steel production
	Aluminium	1, 2	Below 2 Degrees scenario 2 Degrees scenario Paris Pledges scenario	Carbon intensity of aluminium production
	Pulp and paper	1, 2		Carbon intensity of pulp, paper, and paperboard production

ELECTRICITY UTILITIES

Benchmarks in electricity (derived from IEA scenarios):

- **1.5 Degrees** scenario
- **Below 2 Degrees** scenario
- **National Pledges** scenario

Measure of emissions intensity:

Scope 1 emissions from owned electricity generation in tonnes of CO_2 equivalent per megawatt-hour.

Assessed emissions:

Generation is the primary source of emissions in the power sector. If assessed electricity utilities engage in activities other than power generation, such as natural gas distribution, emissions from generation alone are required for the purposes of the assessment. Otherwise, Scope 1 emissions can be an appropriate proxy for generation emissions. Emissions of greenhouse gases other than CO_2 from the power sector are generally considered negligible.

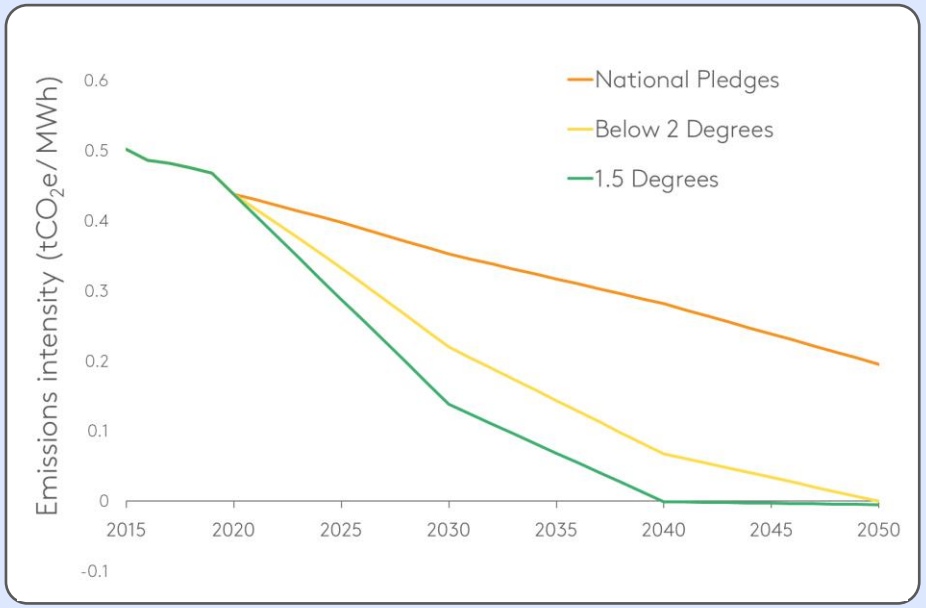
Sector activity metric:

The TPI methodology currently focuses on the emissions intensity of owned electricity generation, excluding power that is purchased by the utility and re-sold to customers. Heat generation is also excluded from both the benchmarks and the company assessments.

Core sources of scenario data:

IEA Energy Technology Perspectives 2020 [7], World Energy Outlook 2020 and 2021 [3] [6], Net Zero Emissions by 2050 [2].

Figure 2. Benchmark global carbon intensity paths for the electricity sector



For more information, see our electricity utilities methodology note.

OIL AND GAS

Benchmarks in oil and gas (derived from IEA scenarios):

- **1.5 Degrees** scenario
- **Below 2 Degrees** scenario
- **National Pledges** scenario

Measure of emissions intensity:

Scope 1, 2 and 3 category 11 (use of sold product) greenhouse gas emissions from energy products sold externally in grams of CO_2 equivalent per megajoule of energy sold.

Assessed emissions:

The vast majority of oil and gas lifecycle emissions stem from the use of companies' sold products, i.e., burning oil and gas to provide energy for buildings, electricity generation, industry and transport. Therefore, the scope of the benchmarks includes emissions from the entire energy system, excluding process emissions.

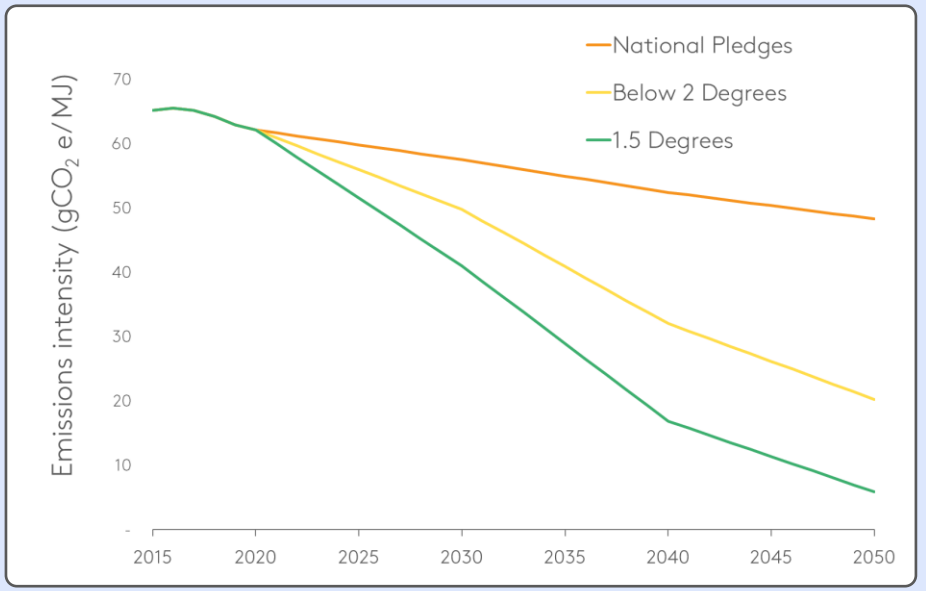
Sector activity metric:

The benchmarks are based on aggregate energy supply, which is defined as the total net calorific energy supply from all energy sources, i.e., hydrocarbons, biomass, waste, nuclear and renewables. This is an appropriate measure of activity against which to benchmark oil and gas companies, because they are primarily engaged in the supply of energy. While they are mainly involved in the sale of hydrocarbons, they increasingly supply electrical energy generated from renewables, fossil fuels and biofuels. Finally, some oil and gas companies are also involved in the sale of hydrocarbons for plastic and petrochemical production, as well as other non-energy uses. Hydrocarbons destined for non-energy use are excluded from the benchmarks, in terms of both primary energy used for non-energy outputs and emissions.

Core sources of scenario data:

IEA Energy Technology Perspectives 2020 [7], World Energy Outlook 2021 and 2021 [3] [6], Net Zero by 2050 [2].

Figure 3. Benchmark global carbon intensity paths for the oil and gas sector



For more information, see our oil and gas methodology note.

AUTOMOBILES

Benchmarks in automobiles:

- **2 Degrees (High Efficiency)** scenario
- **2 Degrees (Shift-Improve)** scenario
- **Paris Pledges** scenario

Measure of emissions intensity:

The average tank-to-wheel (TTW) emissions intensity of a company's fleet of new vehicles in grams of CO_2 per kilometre.

Assessed emissions:

TPI's methodology for the auto sector focuses on the Scope 3 category 11 (use of sold products) emissions of auto manufacturers, as these emissions make up roughly 75% of lifecycle emissions. Scope 1 and 2 emissions from manufacturing are currently not included in the benchmarks, primarily due to data constraints. A modal shift from private cars to low-carbon alternatives is expected to play a role in decarbonising transport, but there is significant uncertainty over the scale of this shift. We therefore adopt two 2 Degree scenarios that each assumes a different level of modal shift. The High Efficiency scenario assumes that a greater share of emissions reductions in the auto sector results from improvements in vehicles' fuel efficiency, compared with Shift-Improve.

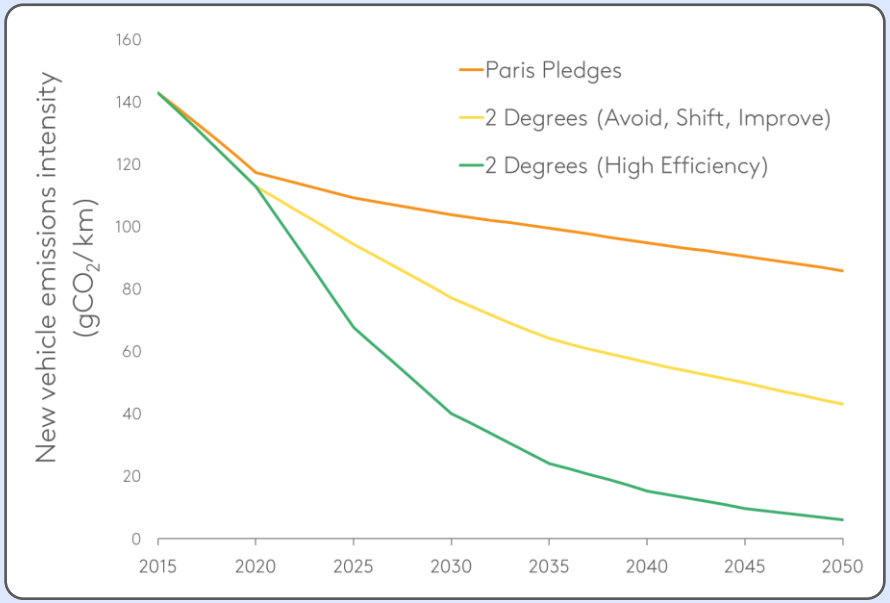
Sector activity metric:

The benchmarks consider the newly sold fleet of passenger vehicles rather than a company's entire fleet of currently used vehicles, in part to enable easier integration of company targets that focus on the fuel efficiency or emissions intensities of newly sold vehicles. The emissions intensity metric is taken on a per-kilometre basis using the New European Driving Cycle (NEDC). TPI combines regulatory data on test results for new cars in different jurisdictions with individual companies' regional sales figures.

Core sources of scenario data:

IEA Energy Technology Perspectives 2017 [8], Global Transportation Energy and Climate Roadmap 2012 [9].

Figure 4. Benchmark global carbon intensity paths for the autos sector



For more information, see our autos methodology note.

AVIATION

Benchmarks in aviation (derived from IEA scenarios):

- **1.5 Degrees** scenario
- **Below 2 Degrees** scenario
- **National Pledges** scenario

Measure of emissions intensity:

Tank-to-wheel (TTW) CO_2 emissions from conventional jet fuel in grams of CO_2 per revenue tonne kilometre (RTK).

Assessed emissions:

The majority of emissions in the airline sector arise from jet fuel combustion. Other emissions reported by airlines in Scope 1 relate to ground operations, but these usually make up less than 1% of total Scope 1 emissions. Airlines' Scope 2 emissions are also minimal. TPI assesses jet fuel emissions on a TTW basis because they represent the majority of emissions under airlines' influence.

Sector activity metric:

TPI's benchmarks include passenger and freight air travel in revenue tonne kilometres (RTK) assuming an industry accepted factor of 95 kilograms per passenger.

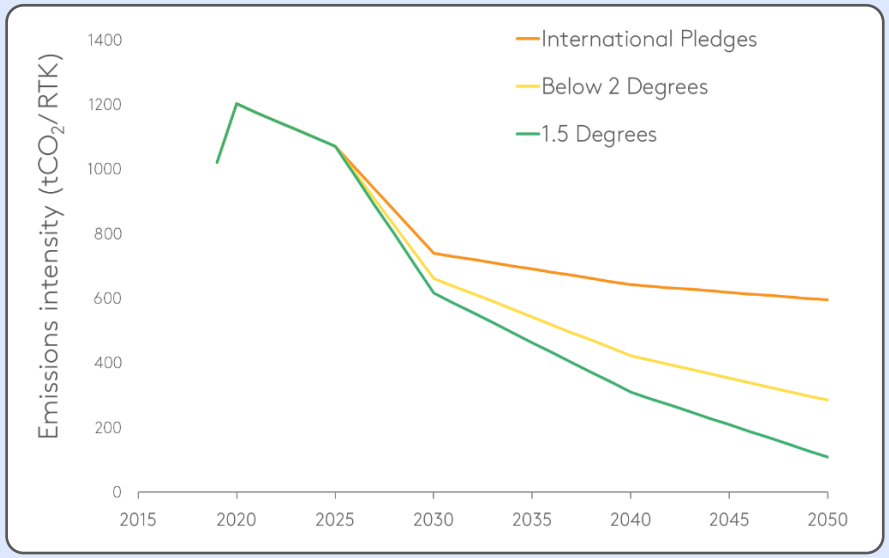
Core sources of scenario data:

IEA Energy Technology Perspectives 2020 [7], World Energy Outlook 2021 [3], and Net Zero by 2050 [4], ICAO Revenue Passenger-Kilometres Forecasts Scenarios 2021 [10], and The World of Air Transport in 2019 [11].

Short-term impacts of Covid-19:

The pandemic dramatically increased company emissions intensities in 2020, while decreasing the sector's absolute emissions. This has led to readjusted carbon budgets for the sector. To reflect the impact of this shock, until 2025 all three scenarios follow the same intensity trajectory outlined in the IEA's *Net Zero Emissions by 2050* report [2].

Figure 5. Benchmark global carbon intensity paths for the aviation sector



For more information, see our aviation methodology note.

SHIPPING

Benchmarks in shipping (derived from IEA scenarios):

- **1.5 Degrees** scenario
- **Below 2 Degrees** scenario
- **National Pledges** scenario

Measure of emissions intensity:

Tank-to-wheel (TTW) CO_2 emissions in grams per tonne-kilometre.

Assessed emissions:

The majority of emissions in the shipping sector arise from fuel combustion. TPI uses Scope 1 tank-to-wheel (or in the case of shipping, tank-to-propeller) emissions. Other emissions reported by shipping companies in Scope 1 relate to land-based operations (e.g., at ports), but these are generally minimal (around 1–2% of total Scope 1 emissions). Shipping companies' Scope 2 emissions, which include emissions from purchased electricity, are also generally small for those companies focused on shipping transport (less than 1% of total Scope 1 and 2 emissions).

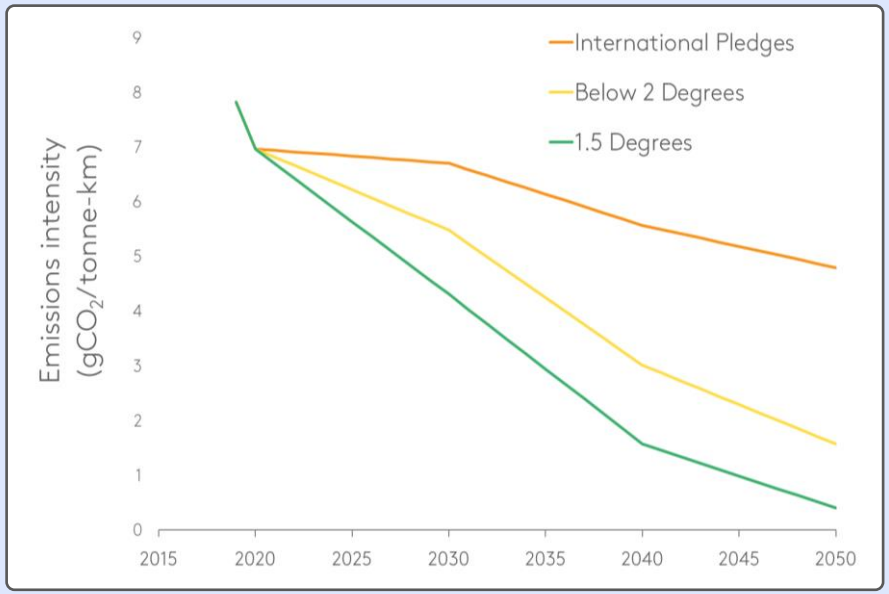
Sector activity metric:

TPI focuses on tonne-kilometres of the international freight shipping sector. This is a standard metric of transport activity in the shipping industry which represents the total number of tonnes transported multiplied by the distance transported.

Core sources of scenario data:

IEA World Energy Outlook 2021 [3], Energy Technology Perspectives 2020 [7], and Net Zero by 2050 [2].

Figure 6. Benchmark global carbon intensity paths for the shipping sector



For more information, see our shipping methodology note.

ALUMINIUM

Benchmarks in aluminium (derived from IEA scenarios):

- **Below 2 Degrees** scenario
- **2 Degrees** scenario
- **Paris Pledges** scenario

Measure of emissions intensity:

Scope 1 and 2 greenhouse gas emissions in metric tonnes of CO_2 equivalent per tonne of primary and secondary aluminium produced.

Assessed emissions:

Alongside Scope 1 emissions, Scope 2 emissions from purchased power are sufficiently important in the aluminium sector to be included in the benchmarks. Additionally, non-CO_2 greenhouse gases in the form of perfluorocarbons (PFCs) are considered, as they are emitted when alumina is smelted to produce primary aluminium.

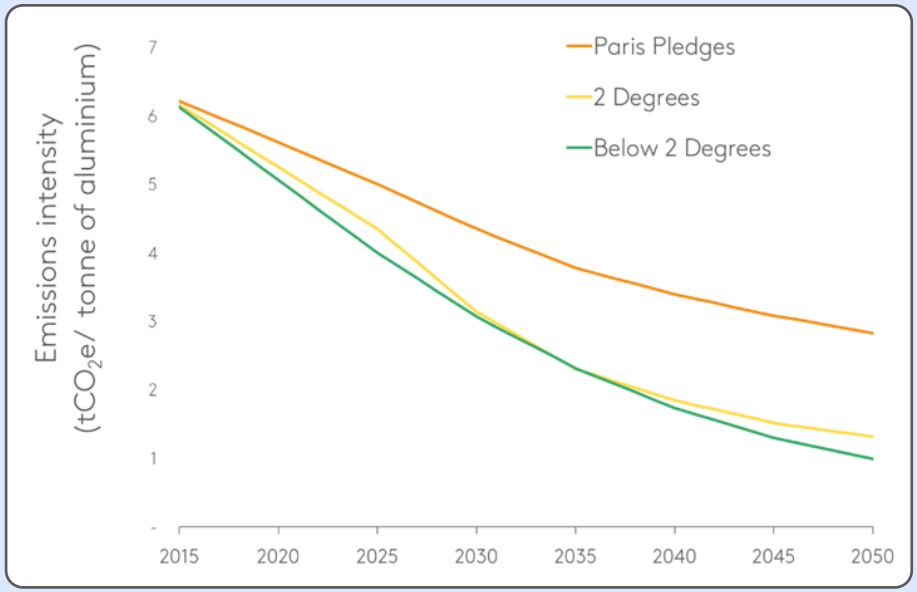
Sector activity metric:

TPI assesses the production of primary and secondary aluminium, including the processes of alumina refining, aluminium smelting and aluminium recycling.

Core sources of scenario data:

IEA Energy Technology Perspectives 2017 [8], International Aluminium Institute, Perfluorocarbon (PFC) emissions dataset. [12]

Figure 7. Benchmark global carbon intensity paths for the aluminium sector



For more information, see our aluminium methodology note.

CEMENT

Benchmarks in cement sector (derived from IEA scenarios):

- **1.5 Degrees** scenario
- **Below 2 Degrees** scenario
- **National Pledges** scenario

Measure of emissions intensity:

Specific 'net' greenhouse gas emissions per unit of cementitious product, in metric tonnes of CO_2 equivalent per tonne of cementitious product.

Assessed emissions:

Net emissions are direct (i.e., Scope 1) emissions from cement production, including from burning fossil fuels to heat kilns, from the calcination process and from on-site use of the company's vehicles, but excluding emissions from on-site power generation, emissions from alternative fuels and raw materials, and emissions from off-site use of the company's vehicles.

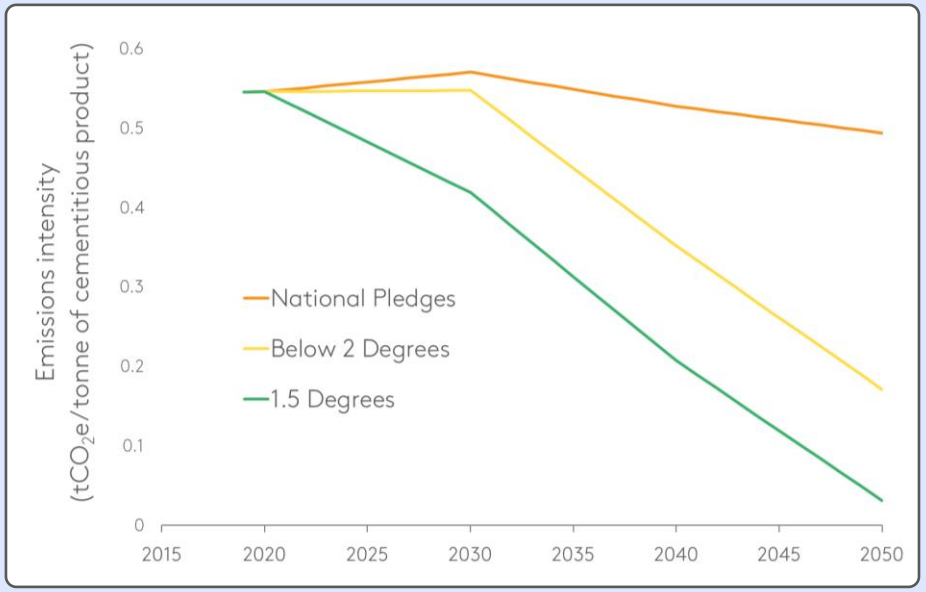
Sector activity metric:

The production measure, cementitious product, consists of all clinker produced by the reporting company for the purposes of making cement or direct clinker sale, plus gypsum, limestone, cement kiln dust, all clinker substitutes consumed for blending, and all cement substitutes. It excludes clinker bought from third parties.

Core sources of scenario data:

IEA World Energy Outlook 2021 [3], and Net Zero by 2050 [2].

Figure 8. Benchmark global carbon intensity paths for the cement sector



For more information, see our cement methodology note.

DIVERSIFIED MINING

Benchmarks in diversified mining (derived from IEA scenarios):

- **1.5 Degrees** scenario
- **Below 2 Degrees** scenario
- **National Pledges** scenario

Measure of emissions intensity:

Scope 1, 2 and 3 categories 10 and 11 (processing of sold products and use of sold products) greenhouse gas emissions from externally sold products in units of tonnes of CO_2 equivalent per tonne of Copper Equivalent (tCuEq).

Assessed emissions:

Depending on the product portfolio, Scope 3 emissions can make up to 95% of a mining company's total emissions. To capture material transition risk, TPI looks at both the operational Scope 1 and 2 emissions and downstream product use and processing emissions. Because mining companies also sell energy products, benchmark emissions include all energy- and process-related emissions across the economy. The cement and chemical sectors' process emissions are excluded, as they are not relevant for the mining industry.

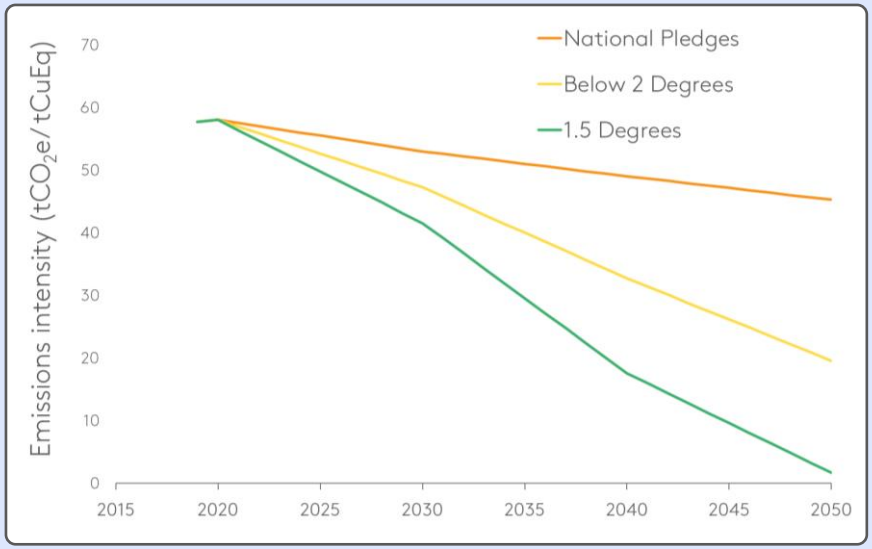
Sector activity metric:

The benchmark denominator includes three broad groups of products sold by mining companies: energy commodities (oil, gas and coal), ores of key metals (iron ore and bauxite), and other minerals (copper, nickel, gold, and 14 others). Historic production, as well as future forecast values are normalised using a Copper Equivalent metric. The approach allows the comparison of volumes of various materials and is well understood and used by the industry. To avoid impacts of price swings, TPI uses 10-year average price data to convert production values into a copper equivalent value.

Core sources of scenario data:

IEA Energy Technology Perspectives 2020 [7], World Energy Outlook 2021 [3], and Net Zero by 2050 [2].

Figure 11. Benchmark global carbon intensity paths for the diversified mining sector



For more information, see our diversified mining methodology note.

PULP AND PAPER

Benchmarks in the paper sector (derived from IEA scenarios):

- **Below 2 Degrees** scenario
- **2 Degrees** scenario
- **Paris Pledges** scenario

Measure of emissions intensity:

Scope 1 and 2 greenhouse gas emissions from the production of pulp, paper and paperboard in tonnes of CO_2 equivalent per tonne of pulp, paper and paperboard sold.

Assessed emissions:

The assessment aims to cover most material emissions associated with the production of paper and related products. As Scope 2 emissions from purchased electricity constitute a significant share of an average paper producer's emissions, they are also included in the analysis.

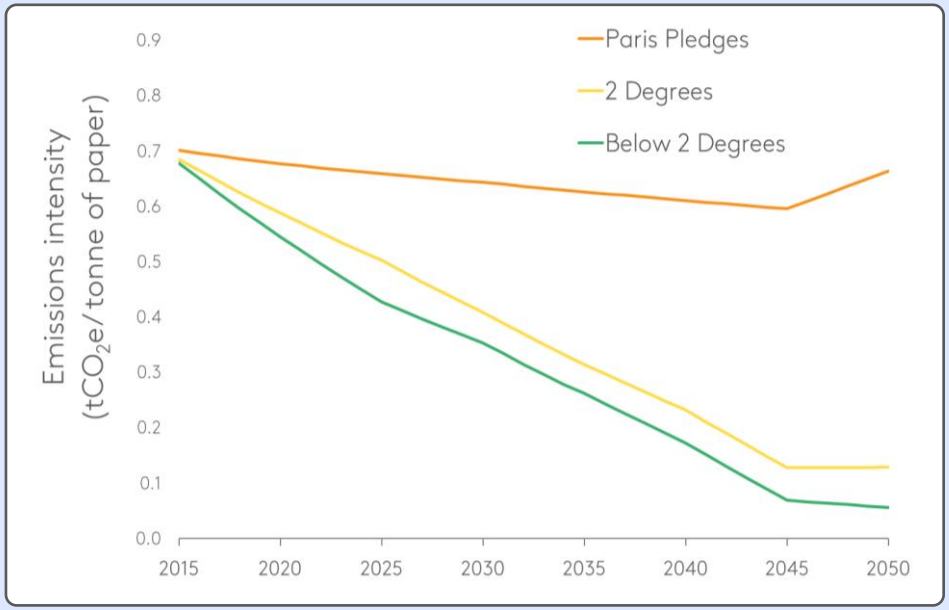
Sector activity metric:

The benchmark includes global production of externally sold pulp, paper and paperboard.

Core source of scenario data:

IEA Energy Technology Perspectives 2017. [8]

Figure 9. Benchmark global carbon intensity paths for the paper sector



For more information, see our paper sector methodology note.

STEEL

Benchmarks in the steel sector (derived from IEA scenarios):

- **1.5 Degrees** scenario
- **Below 2 Degrees** scenario
- **National Pledges** scenario

Measure of emissions intensity:

Scope 1 and 2 greenhouse gas emissions from primary and secondary steelmaking in metric tonnes of CO_2 equivalent per tonne of crude steel.

Assessed emissions:

The steel sector has significant Scope 1 emissions, largely from the burning of metallurgical coal in basic oxygen furnaces to produce primary steel. Scope 2 emissions are also significant: the second most common production route for steelmaking uses electric arc furnaces to melt scrap steel in what is known as secondary steel production.

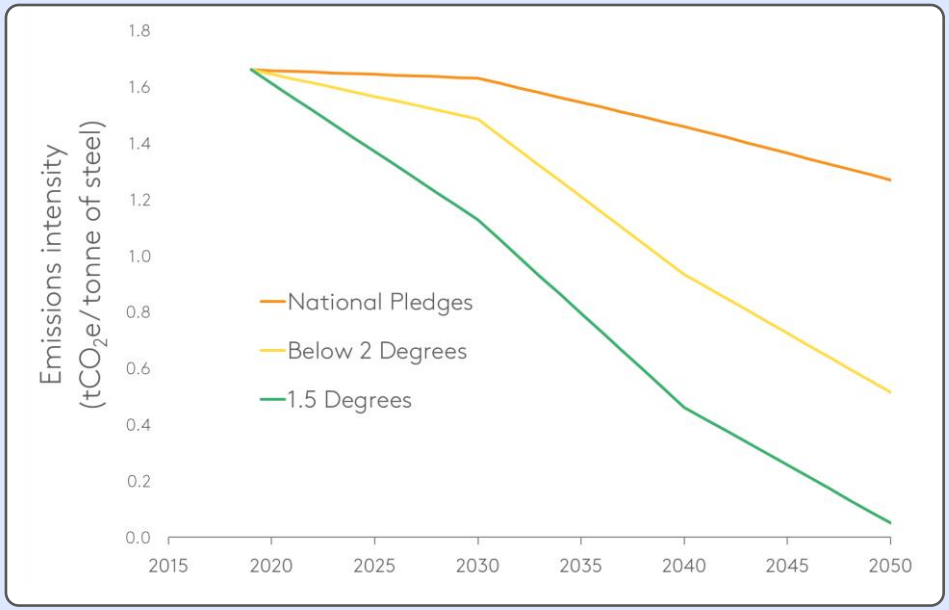
Sector activity metric:

The benchmarks for the steel sector consider crude steel production, meaning that finished products, such as stainless steel, are not included. This is primarily due to data constraints, since only crude steel production is projected in the IEA models used.

Core sources of scenario data:

IEA Energy Technology Perspectives 2020 [7], World Energy Outlook 2021 and 2020 [3] [6], and Net Zero by 2050 [2].

Figure 10. Benchmark global carbon intensity paths for the steel



For more information, see the steel methodology note.

About TPI

The Transition Pathway Initiative (TPI) was established in January 2017. It is a global initiative led by asset owners and supported by asset managers. As of February 2022, 120 investors globally have pledged support for TPI; jointly they represent over US$40 trillion in combined Assets Under Management and Advice.

Using publicly disclosed data, TPI assesses the progress that companies are making on the transition to a low-carbon economy, supporting efforts to mitigate climate change.

- TPI aligns with the recommendations of the Task Force on Climate-related Financial Disclosure (TCFD).
- TPI provides the data for the Climate Action 100+ Net Zero Company Benchmark.
- TPI publishes all of its pathways, methodologies, company assessments and data via an open-access online tool and on GitHub.

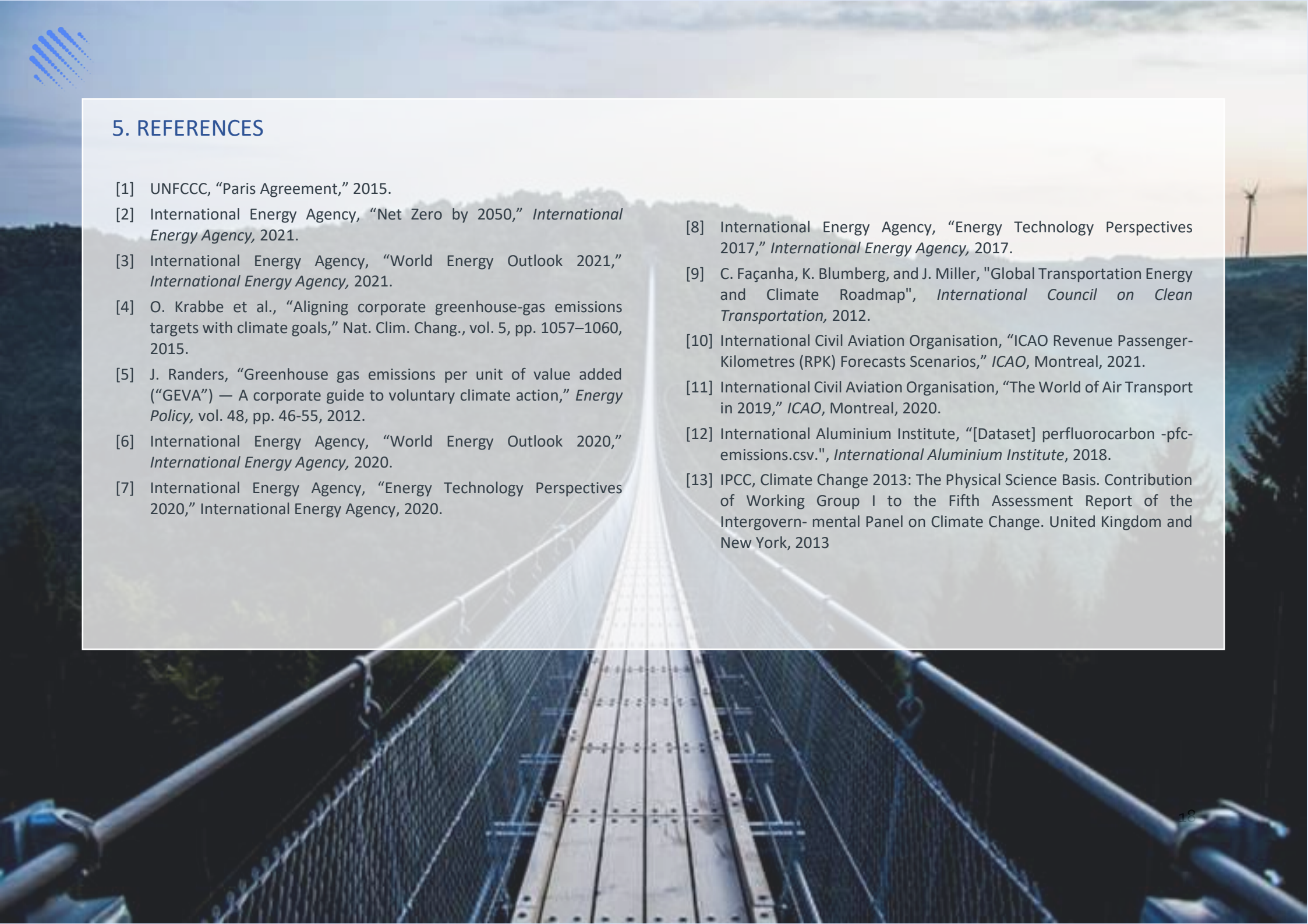
Strategic Relationships

The Grantham Research Institute on Climate Change and the Environment, a research centre at the London School of Economics and Political Science (LSE), is TPI's academic partner. It has developed the assessment framework, provides company assessments, and hosts the online tool.

FTSE Russell is TPI's data partner. FTSE Russell is a leading global provider of benchmarking, analytics solutions and indices.

Are you actively using the TPI sectoral decarbonisation pathways?

Tells us about your use cases. Please fill in the survey here.



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