A Proposed Method for Measuring Paris Alignment of New Investment

December 2020

CLIMATE POLICY INITIATIVE

Supported by

Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety

AUTHORS

Valerio Micale

Cooper Wetherbee

Rob Macquarie

Paul Rosane

ACKNOWLEDGMENTS

The authors wish to thank the following for their helpful comments, including, in alphabetical order by affiliated organization: Sarah Zugel (BMU), Valeria Ehrenheim (Carbon Tracker Initiative), Ian Cochran and Alice Pauthier (I4CE), Rohit Vadakattu (ICF), Alex Clark (Oxford University), Gireesh Shrimali (Stanford University), Padraig Oliver (UNFCCC), Rodney Boyd. We also wish to thank the following for their cooperation and valued contributions, including, in alphabetical order, Barbara Buchner, Donovan Escalante, Angela Falconer, Tom Heller, Federico Mazza, Chavi Meattle, Baysa Naran, Atta Oraee, Labanya Prakash and Amanda Shutze (CPI). Thanks also to Elysha Davila, Caroline Dreyer, Julia Janicki, Alice Moi, and Josh Wheeling (CPI) for contributions to this brief's review, layout, and graphic design processes. Front cover photo by Flickr user jose|huerta.

ABOUT CPI

CPI is an analysis and advisory organization with deep expertise in finance and policy. Our mission is to help governments, businesses, and financial institutions drive economic growth while addressing climate change. CPI has six offices around the world in Brazil, India, Indonesia, Kenya, the United Kingdom, and the United States.

SECTOR

Climate finance

REGION

Global

KEYWORDS

Paris Alignment, Decarbonization Pathways, Emissions, Climate Finance Flows, Tracking, Methodologies, Impact

RELATED CPI WORKS

Improving Tracking of High-GHG Finance in the Power Sector

Paris Misaligned: An Assessment of Global Power Sector Investment

CONTACT

Valerio Micale
valerio.micale@cpiglobal.org

Cooper Wetherbee
cooper.wetherbee@cpiglobal.org

CONTENTS

1. INTRODUCTION

In 2015, world leaders negotiated the Paris Climate Agreement, a landmark accord to strengthen the global response to climate change by committing to keep temperature rise to less than 1.5-2°C above pre-industrial levels. The Paris Agreement also established the need for a collective, systemic effort to achieve such goals, identifying the financial system as a fundamental force to drive a zero-carbon economic transition which is "aligned" with the Agreement.

For the financial sector, this means adjusting business models (Carney, 2020) to ensure that all investment and financing decisions appropriately take climate change into account and aim to actively contribute[1] to achieving the goals enshrined in the Paris Agreement (I4CE, CPI, 2019). Institutional alignment strategies should therefore be developed in conjunction with each institution's climate risk management approach and existing climate action initiatives. Climate risk should be evaluated and managed across investment due diligence in all three of its forms:

- **Physical risk:** The potential negative impacts of climate change on real assets, including chronic risks such as sea level rise, and acute risks such as extreme weather events.
- **Transition risk:** The potential negative impacts of changing policies, regulations, market conditions, and public perception on the profitability of polluting assets, whose continued operation is incompatible with the transition to a low-carbon, climate-resilient economy.
- **Liability risk:** The potential risk that businesses or citizens may seek compensation through the legal system for losses suffered due to unmitigated climate change risks.

Growing awareness of these risks is highlighting the importance of climate goals for commercial financial actors, while these risks are simultaneously becoming financially material for investors. In both cases, financial institutions must build an understanding on the compatibility of their investment decisions with forward-looking scenarios outlining the transition to a decarbonized economy.[2]

1 Both public and private financial institutions are committing to aligning their activities with the Paris Agreement. As outlined in IIGCC's work on Paris Alignment, a key tenant is supporting the transition through active contributions and management strategies.

2 This is particularly relevant for transition and liability risks: the higher the contribution of invested assets to temperature increases, the higher their exposure to the risk of political, market, and reputational responses whereby they could suddenly lose their value and become stranded. For example, future policy is likely to discriminate among assets according to their contribution to the problem, such as emissions.

Accordingly, assessing and monitoring the consistency of investments[3] with scenarios driving various levels of temperature rise (emissions/temperature pathways) is set to become a fundamental part of risk assessment and due diligence practices, as already recognized by multiple ongoing initiatives, such as the Task Force on Climate-related Financial Disclosures (TCFD).[4] For policymakers and regulators, these will be important tools to understand how countries, sectors, and financial systems are contributing to shaping a sustainable or unsustainable future.

A broad interpretation of Paris alignment for financial institutions involves their holistic commitment to make investments and overall organizational practices consistent with the achievement of the Paris goals, both in mitigation and adaptation, through the integration of Paris targets across the investment decision chain, from strategy and sourcing through to due diligence. Institutional engagement must be comprehensive across multiple business areas, able to deliver on a long-term horizon, and ambitious in the scale of action taken (I4CE and CPI, 2019).

In this paper we focus on a narrower definition of Paris alignment focusing on the outcomes of the investment allocation process, which measures the consistency of new investments - those that produce immediate changes in the real economy - with Paris-aligned, or Paris-misaligned temperature trajectories. The aim of this approach is to provide metrics that can support the broader integration of Paris goals within the organization.

1.1 PURPOSE OF THIS PAPER

In this paper we propose a method to help financial institutions and policymakers understand the extent to which their new investments within specific (high-impact) sectors are aligned with different temperature pathways, and whether they are on track with the goals of the Paris Agreement.

Financial sector alignment requires an increase in finance for clean investment and a phase-out of finance for high-emissions activities and assets. A better understanding of both the implications that current investment has on carbon emissions and the likelihood of limiting the projected increase in global temperatures is required to fully evaluate investors' Paris alignment progress.

The quantitative method we propose derives from existing science-based approaches. These are adapted to compare the level of carbon intensity observed in actual new investments with the level of carbon intensity of investment in new assets needed in a specific country or region[5] under different temperature pathways.

3 In line with CPI's Global Landscape of Climate Finance, this paper defines "investment" as primary financial commitments into productive assets at the project level – excluding secondary transactions that involve money changing hands but no physical impact, and also research and development spending assumed to be recovered through the sale of resulting products. Financial commitments provided by certain instruments such as guarantees, insurance, government revenue support schemes and fiscal incentives, or "intermediate output" investments in manufacturing or equipment sales, are not counted due to data limitations and the potential for double-counting.

4 The TCFD highlights that 2ºC scenarios provide a common reference point for measuring alignment with the objectives of the Paris Agreement on Climate Change, which can support investors' evaluation of the potential magnitude and timing of transition-related implications for individual organizations (TCFD, 2017).

5 "Needed" considering projected demand in excess of projected output from existing assets already operating in a country.

The focus on new investment complements existing methodologies by providing a practical approach to track financial actors' contributions to changes in the real economy. Indeed, existing carbon-intensive assets - whether they change ownership or not - will keep operating as long as allowed by local legislators, and as long as they are competitive and economically convenient for investors (e.g. they are already "locked-in"). Conversely, investment in new projects impacts the real world, either by displacing existing carbon-intensive technologies or by locking-in additional carbon-intensive assets.

This method can help investors, policymakers, private responsible investment initiatives, and coalitions of financial regulators make more informed investment decisions and improve policy design. Questions that the proposed method would help answer include:

- Are new investment decisions aligning with Paris-compatible decarbonization pathways in key sectors (e.g. energy, agriculture, building)?
- How does this alignment status vary across different financial actor groups?
- Are investor groups, governments, financial regulatory authorities putting in place the right incentives to correct or adjust investment practices in line with Paris goals?

1.2 OUTLINE

In Section 2, we provide an overview of existing approaches currently used to assess the alignment of portfolios with Paris Agreement goals, and the added value of the method proposed in this paper.

Section 3 introduces a two-step approach to assess the alignment of primary investment flows for high-carbon sectors, complemented by specific data sources for the power sector and the transport sector.

Finally, Section 4 concludes with recommendations on the next steps needed to strengthen the analysis, as well as potential applications of the approach that can be useful to investors and policymakers.

This paper is connected with two additional CPI studies: One tracking financial flows beyond climate (i.e. low-carbon) finance to cover high-emissions investment transactions, such as dirty finance for coal-fired electricity generation,[6] and another study applying the approach proposed herein to evaluate the alignment of global power sector investment.[7]

6 See Paper 1: Improving Tracking of High-GHG Finance in the Power Sector.
7 See Paper 3: Paris Misaligned: An Assessment of Global Power Sector Investment

2. EXISTING APPROACHES FOR MEASURING PARIS ALIGNMENT AND ADDED VALUE OF THE PROPOSED METHOD

With respect to existing approaches, our proposed method for the first time applies science-based approaches to the assessment of alignment of new investment. We go beyond trends for the individual entity to cover key sectors and financial actor categories. As such, the approach can help individual investors, regulators, and sustainable finance initiatives.

Current research methods evaluating the alignment of investment with Paris Agreement goals and various temperature pathways can be organized into two main categories:

1. **Taxonomy-based approaches,** which define criteria to determine whether investment in specific technologies or sectors contribute positively to Paris goals (climate-positive) or negatively (climate-negative), or where they sit on the spectrum, as under a 'shades of green' approach (Cicero, 2020). Attribution can be based on assumptions for technology/sector types, and/or technology-specific / sector-specific carbon performance thresholds.
2. **Science-based approaches**, which translate current or projected allocation of investments in a portfolio into activity-related metrics, carbon metrics, or carbon intensity metrics. These metrics are then compared with carbon budgets available for the portfolio (e.g. according to its market share), for different temperature increase pathways.

The difference between these two approaches is summarized in Table 1.

Table 1: A comparison between taxonomy-based and scenario-based approaches

	TAXONOMY-BASED APPROACHES	SCENARIO-BASED APPROACHES
Technical focus	Climate solutions (e.g. renewable energy, energy efficiency)	Economic/productive sectors (e.g. power sector, transport sector)
Geographical focus	Can be country-specific or global	
Alignment benchmark	Based on project-specific thresholds, or benchmarks.	Flexible, it can be based on project specific thresholds, or aggregated thresholds established at the technical focus of reference.

Outcome	Binary: aligned or not aligned	Provides a temperature scenario that investment examined is compatible with.
Example outcome	The investment in a power plant project in Brazil is aligned with Brazil's national contribution and/or international efforts on climate goals.	Investment in the Brazilian power sector by one specific entity, or a broader investor group, is compatible with a 3C country-specific scenario pathway, and with a 2C scenario global pathway.

Climate-related investment taxonomy approaches are addressed in the accompanying paper on tracking high-emissions finance.

This paper focuses on science-based approaches that compare current trends with projected needs along system-wide temperature pathways. We reviewed existing broadly used practical methods from academic research, international financial institutions, and consulting work, particularly the Arabesque S-Ray Temperature Score (Arabesque, 2020) 2 Degrees Investing Initiative / PACTA (2DII, 2019; FinanceMap, 2020), and the Science-Based Targets Initiative (SBTi, 2018, 2019, 2020a, 2020b, 2020c). Table 2 presents a summary of these.

Table 2: Summary of approaches for science-based portfolio alignment methodologies for emissions mitigation pathways.[8]

PROVIDER	SECTORS	METRICS	CURRENT METRICS ESTIMATE	SCENARIO METRICS ESTIMATE	PATHWAY ALLOCATION
Arabesque	Power, Industry, Transport and Other	Emission Intensity Ratio (EIR) =	The GVA would usually be calculated as GVA = pre-tax profits + depreciation + labor expenses	Intensity ratio calculated for every sector and IEA scenarios (B2DS, 2DS, RTS). GDP calculated using 2010 PPP USD.	Comparison between sector-specific company-level EIR and Sector-specific EIR under different pathways. This will determine temperature pathway of current company EIR.
	Theoretically applicable to any sector and country	Annual emissions variation = %	%annual variation in emissions calculated for the last 3 years.	%annual variation in emissions calculated to achieve net 0 by mid-2060s.	Comparison between company-level %annual growth and company-level %annual reductions to understand change in pace required.
2D Investing (PACTA) / Finance Map	Power (Gas, Coal, Nuclear, Hydro, RE), automotive (ICE, hybrid, electric), oil and gas (oil, gas production), coal mining, aviation, shipping, cement, and steel sectors	Sector-specific activity-based metrics (MW, barrels, CO_2)	1. Activity-based metrics for sector-specific assets sourced from several datasets. 2. Activity-based metrics from assets is assigned to companies based on ownership shares 3. Companies assigned to financial instruments based on ownership shares.	1. Activity-based metrics calculated for every sector and IEA scenarios (B2DS, SDS, SPS CPS) 2. Activity-based metrics for relevant sectors and scenarios is assigned to companies and financial instruments based on market share (based on activity)	Comparison between current sector-specific activity-metrics attributed to company/instrument and sector-specific activity-metrics assigned to company/instrument. This will determine temperature pathway of current activity-metrics.

8 A more detailed overview of Paris alignment approaches, including approaches focusing on climate risk, is available in Annex I.

SBTi – absolute contraction approach	All sectors or specific sectors depending on contraction approaches	Emissions = tCO_2	Scope 1 + Scope 2 GHG emissions	1. Sector-specific or global pathways scenarios for 1.5C and 2C calculated based on IAMC scenarios. A short time span is considered using this approach. 2. %annual reduction in emissions under the scenario are simply applied as such to the initial company's emissions to determine its target.	Target for year X is determined
SBTi – sectoral convergence approach	Power, Iron and steel, Aluminum, Cement, Pulp and paper, Passenger and Freight transport, Service and commercial buildings	Emission intensity = Emissions = tCO_2		1. Intensity ratio calculated for every sector and for the B2DS IEA scenario. 2. Emissions metrics for the relevant sectors for the B2DS IEA scenario is assigned to companies and financial instruments based on: - convergence of intensity to sector intensity under B2DS scenario - emissions calculated using the market share expected at the time of the determined target.	Target for year X is determined

A deeper review of these approaches is provided in Annex I, while a more detailed analysis of Methodologies Assessing a Portfolio's Alignment with Zero-Carbon Trajectories or Temperature Goals" has recently been published by Institut Louis Bachelier (2020).

However, most of these initiatives possess the following characteristics:

- **They provide a snapshot of how aligned an entity's portfolio of assets owned is, in a specific moment in time.** These approaches look at the emissions (or emissions reductions) from an existing portfolio or stock of assets, attributable to a specific entity at the time of the assessment, for example through direct ownership of the asset (e.g. by a company), or indirect support through investment/financing towards listed or unlisted equity or loans benefiting entities owning such assets. By linking ownership of assets with their emissions, these methods can prompt divestments and reduce access to finance for carbon-intensive assets.
- **They support decision making at the individual investor level.** They help determine the alignment of specific corporates, relying on self-reported emissions and requiring third-party verification. Alignment is then determined using market share and emissions per activity or per economic output.
- **When they determine the degree of alignment at the sectoral level, they use a global geographical scope.** This approach is in line with the challenge represented by climate change, where impacts occur globally, independent of where they are originated.

2.1 ADDED VALUE OF THE PROPOSED METHOD

The approach proposed in this paper (illustrated in Chapter 3) can complement these existing methods, providing more comprehensive information to stakeholders than other existing methodologies. In particular, the method has the following added value:

1. **The proposed method focuses on the alignment of new investments made at a given point in time (e.g. in a single year) rather than of existing assets (e.g. those owned in a portfolio). This holds investors responsible for the anticipated emissions of newly commissioned assets they finance, and thus for their impacts on the real economy.** By focusing on portfolio-level alignment, existing portfolio approaches look at simple ownership – at the time of assessment – of already existing and deployed assets independently of who originally financed them. However, these methods break the link between the asset created and the original finance provider once the asset is sold. By contrast, examining the alignment of recent investments that commission and create new assets allows us to assess financial actors' direct contributions to different temperature pathways. The latter approach enables us to attribute responsibility for changes in the real economy to specific actors and groups - a key tool to enable climate-smart financing decisions and policies that will drive progress toward Paris targets (Caldecott, 2020; 2DII, 2020). Focusing on recent investments driving development of new assets also calls attention to current investment practices, rather than past practices that may be outdated.
2. **In addition to enabling the assessment at the individual entity level, the proposed method empowers us to identify key trends among market sectors and types of financial actors.** This will help drive a broader understanding of progress toward Paris alignment, which would be useful to investors, policymakers, regulators, and financial regulators in particular.
3. **Our method reflects the interactions between carbon budgets and projected, sector-wide locked-in emissions in its assessment of the temperature pathways of new investments.** The proposed approach evaluates each additional new investment (tracked using transaction-level datasets) in the context of existing and planned emissions in the same sector (tracked through asset-level datasets). This enables us to determine whether the incremental new investment is sufficiently ambitious to keep resulting sector-wide emissions within the required carbon budget.
4. **Our assessment examines the alignment of investment activity with target country- and region-specific temperature pathways.** Geographic granularity allows us to consider local and regional economic development needs, priorities, and resource constraints driving country- and region- specific greenhouse gas (GHG) emission budgets. This in turn permits more targeted assessments than can be obtained by evaluating alignment at an aggregate, global level. Alignment between investments and country-specific sectoral pathways is independent from whether investment activity originates from local or foreign investors. For example, finance to projects in China must be aligned with China's temperature pathways, independently of whether it originates from foreign or domestic sources.

Table 3: Complementarities between proposed and existing methods.

	ASSET TARGETED	LEVEL OF ANALYSIS	LEVEL OF ALIGNMENT	PROJECTED LOCKED IN EMISSIONS
New method	New assets commissioned	Individual entity; aggregated financial actor categories; aggregated sector-level impact; aggregated country-level impact.	Sectoral pathways; country-specific pathways.	Variable in the assessment of new investment alignment.
Existing methods	Existing portfolios of assets	Individual entity	Sectoral pathway; global pathways.	Not factored in.

2.2 APPLICATION OF THIS METHODOLOGY

The method can inform:

- **Investors about the alignment of planned new investments with different temperature pathways. This information may also be a useful tool for day-to-day investment decision-making, especially when used in conjunction with sustainable investment taxonomies from organizations like the European Commission (EU-TEG, 2020) and Climate Bonds Initiative (2020).**
- **Policymakers, private responsible investment initiatives, and coalitions of financial regulators on progress in aligning the financial sector with Paris targets by measuring how, and to what magnitude, new investment choices can impact countries' decarbonization trajectories on a periodic basis (e.g.** year-to-year). This can help decision-makers monitor the most recent trends and determine where regulatory or policy changes or incentives can be most effectively applied to drive adoption of new investment practices that can support the financial system's transition.

3. PROPOSED METHODOLOGY

This chapter introduces an approach to assess alignment of new investments with different temperature pathways. General principles would then be tailored and adjusted to reflect the specificities of key sectors in the transition toward a zero-carbon economy. We more specifically discuss the application of this approach to the power and transport sectors.

3.1 PROPOSED GENERAL APPROACH TO ASSESS TEMPERATURE PATHWAYS

For each specific country or region, in a given sector (e.g. power, transport), we first 1) define carbon intensity[9] limits (or thresholds) required for new investment to align with different temperature pathways. We then 2) calculate the carbon intensity of new investments. Carbon intensity of new investment is linked to the underlying assets financed by this new investment. Comparing these carbon intensity figures allows us to identify the temperature pathway with which new investment is aligned. These two steps are summarized in greater detail below.

3.1.1 STEP 1: DETERMINING A CARBON INTENSITY THRESHOLD REQUIRED FOR VARIOUS TEMPERATURE PATHWAYS

The first step defines the levels of carbon intensity associated with different temperature pathways – based on pathway-specific carbon budgets[10] – for a given sector in a given country. These calculations provide a benchmark or threshold to evaluate alignment of new investment.

Under the proposed methodology, carbon intensity thresholds are estimated as the level of carbon intensity required among future investment to realign overall country- or region-specific carbon intensities to each of the different temperature scenarios, factoring in locked-in emissions from existing assets. This approach reflects the reality that any additional investment in a specific carbon-intensive sector will have to compensate for emissions locked in the system in order to meet Paris-compatible emissions budgets. A less strict measure of alignment would permit the lock-in of more emissions than the system can afford.

Estimating the carbon intensity proceeds in 4 sub-steps.

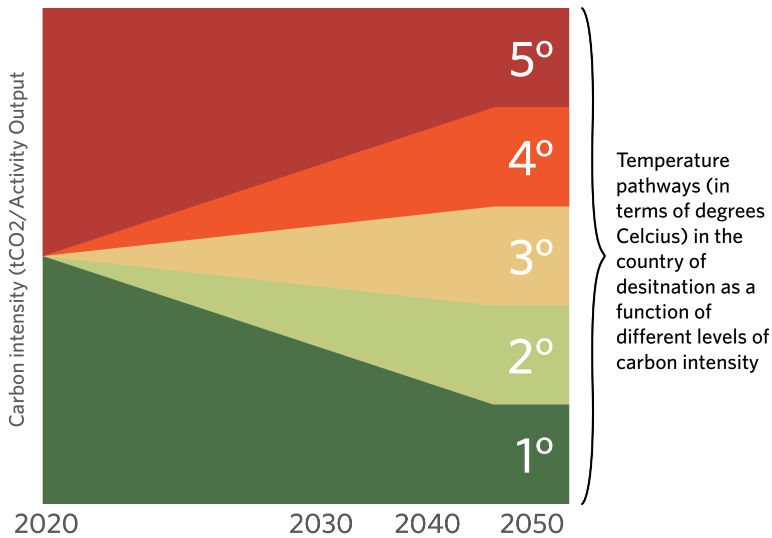
9 Carbon intensity is defined as the ratio between level of emissions (e.g. CO2) per unit of output from a specific activity (e.g. MWh, or kWh in the case of a power sector.

10 Carbon budgets reflect the total amount of CO2 emissions allocated to a sector and/or a region over a period of time. CO2 scenarios are usually built on these carbon budgets, allowing a temporal distribution of emissions that the total carbon budget accounts for.

Sub-step 1: Select GHG emission and activity level scenarios corresponding to a range of global temperature rises, for a specific sector and/or geography. Several institutions provide scenario models, including the International Energy Agency's (IEA) World Energy Outlook (2020), IIASA's IAMC 1.5°C Scenario Explorer (2020), the En-ROADS initiative (Climate Interactive, 2020), and the U.S. EIA's Annual Energy Outlook (2020a), among many others.[11] An overview of scenario models is provided by Institut Louis Bachelier (2020), and by Germanwatch, NCI, and WRI (2020). For a model to be useful in measuring the alignment of investment with Paris goals, it should have three main features:

1. Implicit global temperature rises are no greater than 2°C and ideally lower than 1.5°C, reflecting the requirements and ambitions of the Paris Agreement.
2. Global scenarios are disaggregated into pathways for smaller geographical units – at least for regions, and preferably for countries.
3. Available data points for activity levels, related demand (i.e. energy generation needs), and volume of emissions at regular time intervals representing different milestones along the pathway (e.g. 2025, 2030, 2035, 2040).

Figure 1: Determining the carbon intensity of the asset fleet relative to various emissions pathways



Sub-step 2: Estimate the level of activity/output and the amount of GHG emissions for which assets currently in the system are projected to be responsible at the time of a specific milestone (e.g. 2025, 2030, etc.). This allows our analysis to factor in the impact of "locked-in" assets that are still expected to be in operation at the chosen milestone year. The starting point (Figure 2) is the estimate of the level of emission and activity/output and related carbon intensity of **(S) current installed and operating assets**[12]**.**

To estimate these metrics for **assets that will still be locked-in (SI)** in a given scenario year (e.g. 2030), the following **adjustments (Δ)** are then applied:

11 The models mentioned provide a reference for either global alignment pathways, or alignment for specific sectors and countries/regions, based on assumptions about burden sharing among sectors of the economy and countries which lead to different outcomes/scenarios.

12 For assets here we refer to tangible assets which are functional to the production of outputs or services. Examples of these assets can include capacity for the generation of electricity, a car fleet for the supply of transport services etc,

- Assets expected to be **decommissioned or retired**[13] are removed.
- Assets currently **under construction** that will be in operation by the same milestone are added.

Figure 2: Determining the level of carbon intensity of additional investments and underlying assets required to align country/region specific carbon intensity with different temperature pathways.

Definitions

IC. Activity output from assets/capacity in the pipeline associated to the new investment

S. Activity output/supply generated by current operating assets/capacity

Δ. Activity output/supply adjustment reflecting time aspects

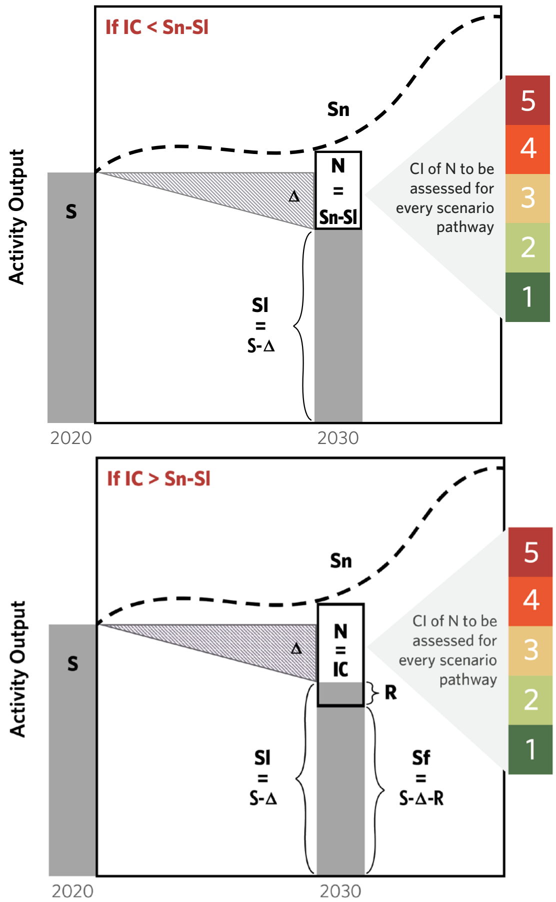
SI. Activity output/supply from currently operating assets in the year of comparison after considering adjustments (D)

Sn. Activity levels nees, usuallu a function of market demand

N. Additional Activity Output required to meet total Activity needs

R. Activity outpu/supplu adjustment reflecting replacement by new commitments

Sf. Asset replacements (R=SI+IC.D)



Sub-step 3: Calculate the level of extra activity/output required to meet future demand, which can be satisfied by financing additional assets in the future. As mentioned, the proposed approach factors in the impact of locked-in assets, after which we assess additional supply required. Looking again at Figure 2, activity/output needed from **additional future assets (N)** is estimated in two different ways, depending on circumstances:

- **Top figure:** N as the gap between total activity/output levels driven by demand (Sn), and activity/output from locked-in assets (Sl), or **N = Sn - Sl**. We would use this approach when the projected level of activity from the new assets under assessment (IC), is smaller than the gap between demand needs and supply from locked-in assets (**IC<Sn-Sl**). We expect this to be the most frequent scenario, compatible with assuming a growing economy and limited demand side interventions, or technology shifts, in the scenarios used.
- **Bottom figure:** N as the projected level of activity from new invested assets under

13 Decommissioning and retirement are here meant conservatively, based only upon "technical" retirements of assets once they reach the end of their useful operating life. While economic and policy conditions may contribute to accelerated retirements of existing assets, especially in the power sector, our model does not project these types of decommissioning ex-ante, as they are dependent on complex and varied conditions within each country, which were out of scope for this paper.

assessment (IC), or **N = IC**, used to partly fill a gap in supply (Sn-Sl) and to replace excess supply (R). This would occur when output from the new invested assets under assessment (IC) is larger than the gap between supply needs and supply from locked-in assets (**IC>Sn-Sl**).[14] This could be due to strong demand-side policies being approved at the country level that keep down the need for new assets, or fuel-based demand curve constraints. In the event of new investments leading to an overrun of scenarios' activity levels,[15] we assume that some locked-in assets are displaced, and their activity levels (Sl) are reduced by **R = Sl+IC-Sn**, to **Sf = Sl – R**.[16]

Sub-step 4: Estimate carbon intensity of new investment required to comply with the GHG emissions scenario used for comparison at the time of specific milestone. This is calculated as the ratio between:

- The residual amount of emissions that can be emitted under a specific temperature scenario, after emissions from locked-in assets are subtracted (Sl or Sf depending on the scenarios), which can be negative or positive, and
- The activity/output required from additional future assets (N).[17]

For sectors in which assets with long lifetimes enable significant lock-in, strict carbon intensity requirements under ambitious temperature pathways may generate a negative carbon intensity threshold, implying that development of new carbon-free assets should also be accompanied by the retirement of existing high-carbon generation stock, or investment of carbon sequestration technologies (e.g CCS) to meet emissions reduction trajectory, as also highlighted by similar work on the 2°C capital stock for electricity generation (Pfeiffer et al. 2016).

While those technologies are critical to reach alignment, we recommend that these negative carbon intensity targets be used if and when data on new investments also include investments in such carbon-negative activities. Where such data are not available, carbon intensity thresholds should be assumed as no lower than 0.[18]

14 There are two further cases falling within this scenario, with no impact on the treatment of variables 1) when (supply need (Sn) is higher than supply from locked-in capacity (Sl), but the additional output from new investment (IC) is larger than the gap between supply need and supply from locked-in capacity (or Sl<Sn<Sl+IC), or 2) when (supply need (Sn) is lower than supply from locked-in capacity (Sn<Sl)

15 Note that – coherently with the approach here proposed which defines carbon intensity thresholds at the country/sector level – the potential overrun of scenario's activity levels is also assessed in aggregate terms, at the sectoral/country level, rather than at the level of single investment. Taken alone projects are almost always, individually, within the carbon budget. If the overrun of scenario activity levels had to be determined using such a siloed approach, it would lead to an emission overshoot and a higher than desired absolute level of emissions, e.g. in those cases where aggregate levels of activity/output are higher than what is planned by the trajectory/carbon budget.

16 Different assumptions can then be used to determine which locked in capacity would be replaced based on technical, economic, or political considerations (e.g. oldest active assets, most polluting assets, most expensive assets).

17 Or in algebra: $CI\ Threshold = CI_{N,T} = \dfrac{(Sn.T x CI_{Sn.T})-(S^* x CI_{S^*})}{N.T}$

Where:

$CI_{N.T}$ is the required level of carbon intensity for additional future assets we are trying to determine

$N.T$ is the level of activity/output required from additional future assets (Sn-Sl or IC depending on setting in sub-step 3)

CI_{S^*} is the level carbon intensity expected from current assets, adjusted by projected variations at the time considered (Sl or Sf depending on setting in sub-step 3);

S^* is the level of activity expected to be produced by current assets, adjusted by projected variations at the time considered (Sl or Sf depending setting in sub-step 3);

$CI_{Sn.T}$ is the level carbon intensity expected from total assets at the time considered;

$Sn.T$ is the level of activity expected to be produced by total assets at the time considered;

T is the temperature pathway used as reference for the calculation e.g. 2°C or 3°C.

18 Or in algebra: CI Threshold = max ($CI_{N,T}$,0):

3.1.2 STEP 2: ASSESSING ALIGNMENT OF NEW COMMITMENTS WITH DIFFERENT TEMPERATURE PATHWAYS

In this second and final step, we compare:

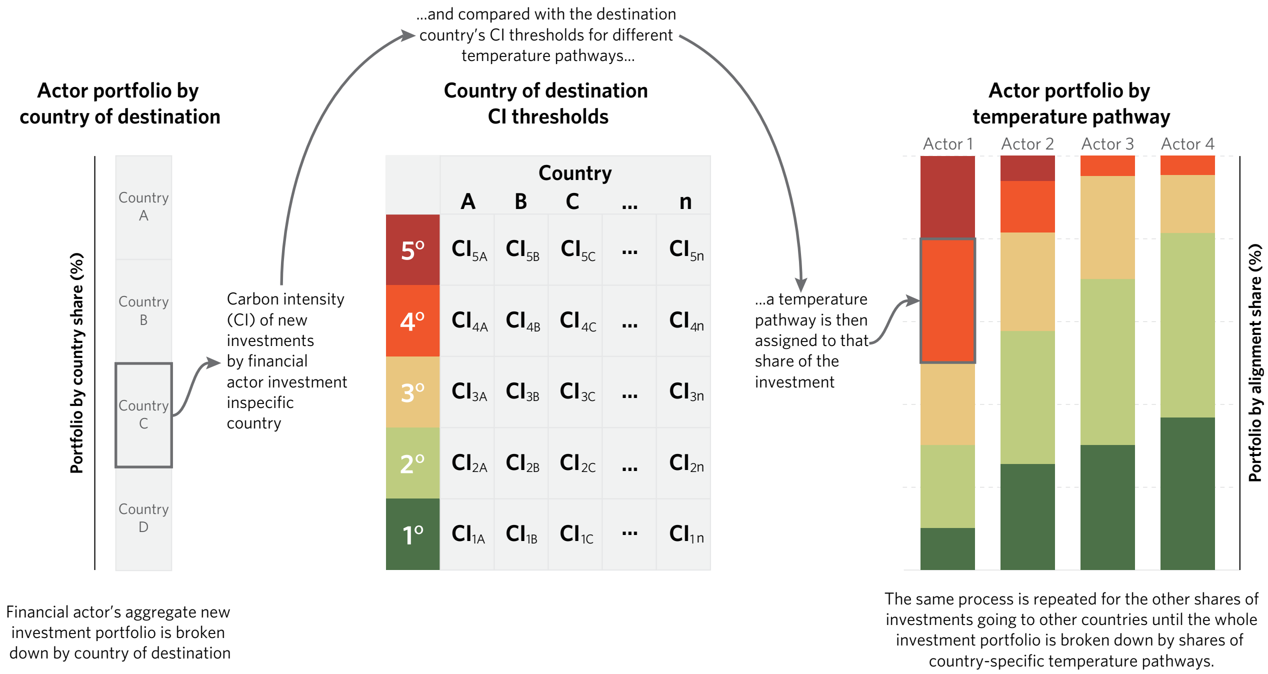
- **The target carbon intensity thresholds for additional future investments, previously calculated for different temperature scenarios**, in each specific country/region (or alternatively global level), and sector of reference (Step 1), with
- **The carbon intensity of new investments under assessment**, and underlying assets financed going to the same country/region and sector.

Assessment can be performed at the level of analysis required (e.g. single financial actor, class of financial actor, country of destination, country of origin) to evaluate the alignment new commitments.

As seen in Figure 3, assessment includes the following sub-steps:

- We first estimate the carbon emissions and expected productive output (e.g. electricity generation) associated with new individual investments. This may require analysis of datasets containing both the details of the financial transaction and the technical aspects of the underlying asset. One example of a comprehensive source for this type of information on low-carbon investment is CPI's Global Landscape of Climate Finance (CPI, 2019).
- Next, we calculate the carbon intensity per unit output of investment aggregated at the level of individual countries and regions. This is accomplished by dividing total emissions by total productive output for each geography. Carbon intensities can also be calculated specifically for commitments made by certain categories of financial actors (e.g. development finance institutions), or even to a single institution, to focus on the alignment of commitments by a given group or actor rather than by country or region.
- We then link the calculated carbon intensity of new investment with the corresponding carbon intensity thresholds previously calculated for the country and sector examined to determine the associated temperature scenario, and the resulting overall alignment status of investment for the given region, country, or actor type.

Figure 3: Determining alignment of carbon intensities from new sector-specific investments with country- or region-level pathways, as aggregated at the financial actor level (e.g. Investor n).



Box 1: Additional explanation of the reasoning behind the current approach

Importance of locked-in capacity. Simply looking at the alignment between the carbon intensity of new financed assets in a sector and the carbon intensity of the entire asset fleet in the same sector means ignoring the role that locked in capacity plays in shaping future emissions, or optimistically and unrealistically assuming a perfect and instantaneous substitute between new assets and existing assets. This ultimately provides a distorted incentive favoring the financing of new carbon intensive assets.

Use of carbon intensity. Carbon intensity has been chosen as a preferred approach, mostly for practical reasons. It is one of the most commonly used metrics for technical criteria to assess alignment, including the EU Taxonomy (EU-TEG, 2019). It allows us to look at trends at different levels of aggregation (spanning from country, to financial sector within a country, to the individual institution) while at the same time avoiding an estimation of the level of absolute activity and emissions that should be allocated to an entity, which would require us to construct an additional set of assumptions.

Carbon intensity alone, detached from the determinants used to construct it, can appear to ignore absolute level of emissions, or absolute number of new assets being built. For example, a country or an investor may have reduced its intensity, but may have also increased its overall output, thus increasing emissions. In the approach proposed here, however, the carbon intensity thresholds are not only the function of target emissions and levels of activity, but also the function of how asset finance, in aggregate, depletes carbon budgets.[19]

Importance of dynamic adaptability. Dynamic adaptability is the flexibility to keep project pipelines aligned with policy objectives over time, to be relevant in the long term, and adjusted to changing external conditions such as shifting economic, demographic, technological, or climatic trends (OECD, 2018). In the context of alignment with Paris goals, this would mean that projects that are aligned today, in 2020, may not be aligned in 2021 as the entire baseline moves. The approach proposed here makes sure that dynamic elements are embedded in the assessment of the alignment to Paris goals. Thresholds used to estimate the Paris alignment status of new asset investment would only be valid for the year of assessment, and factor in the most recent developments. For example, today's commitments would use the most recent scenarios and account for the emissions of assets locked in as per today. Similarly, future assessment would dynamically factor in today's new investments under future locked-in capacity. Dynamic adaptability ensures that policymakers can receive timely feedback, giving them the chance to adjust estimates – and goals – as more information becomes available.

19 Carbon intensities of locked-in assets, are adjusted to reflect the total impact of new financed assets on their possible replacement.

3.2 SOURCES AND SPECIFIC APPROACHES USED FOR THE POWER SECTOR

The key output metric in the power sector is the **electricity generated** by plants (e.g. TWh). After estimating the magnitude of greenhouse gas emissions produced from generation (e.g. MtCO2), it is possible to calculate the **carbon intensity** as a ratio of total power sector emissions to total electricity output.

3.2.1 ASSET DATASET AND ADJUSTMENTS

IEA figures were used to estimate baseline capacity in 2018, with project-level asset datasets used to apply cumulative net capacity change (retirements and new built) relative to 2018 benchmark for 2025, 2030, 2035, and 2040. The project-level dataset was sourced from the S&P World Electric Power Plant Data Base (2017), which provides global coverage of individual plants' locations, capacities, fuel types, and technology (i.e. prime mover) types.[20] The dataset also provides information on the ages of existing plants, the retirement years of decommissioned plants, and the projected online years of plants under construction at the time of data collection, the vast majority of which were assumed to start commercial operations by 2025.[21]

To account for future plant decommissioning, we assembled decommissioning assumptions from a wide variety of sources, taking into account asset lifespan by technology type, current generation fleet age, and relicensing processes that enable plants to continue operating beyond the initial projected asset life. These sources include Lawrence Berkeley National Labs (Mills et al., 2017; Wiser et al., 2019), US EIA (2011; 2017; 2019), US DOE-ONE (2020), Nature (Cui et al. 2019), and NEA (2015). Because some plants in the database have remained operational despite being past their assumed service life, we used another set of assumptions to determine whether these plants received additional capex and/or licensing renewals to enable longer-term operations for another full asset life cycle. More details are provided in Annex II.

It should be noted that our retirement assumptions were developed in the context of a technology- and price-agnostic business-as-usual scenario, in which assets retire not because of policy changes or short-term market pressures, but rather because they reach the end of their usable life as a source of reliable power generation.[22]

20 While the dataset was 3 years old at the time of our analysis, its asset data reflected the global generating fleet in 2018, making it compatible with our methodology for measuring the alignment of 2018 power sector financing commitments.

21 The Platts database is known to lag the most recent corporate disclosures on asset decommissioning; this makes our decommissioning estimates slightly conservative relative to the real world. However, many of these "missing retirements" are retired relatively quickly by our model, as the plants in question are often close to the end of their projected useful life.

22 This is not because CPI expects that no such policy- or economics-driven retirements will occur (indeed, many such retirements have occurred in recent years and this trend is expected to continue, especially among aging coal plants in advanced economies). Rather, this is to provide the most conservative, consistent backdrop possible on which to measure new generation needs through 2050. This is because the primary objective of our analysis is to map emissions headroom (i.e. the allowable increase or required decrease) between current power sector emissions and future emissions under each IEA scenario to new generation needs, in order to back calculate the target emissions intensity of new generation built in each country to achieve the respective IEA emissions scenarios. For a discussion of potential policy strategies countries can apply to drive accelerated decommissioning of existing high-carbon assets, refer to Paper 3: Paris Misaligned: An Assessment of Global Power Sector.

3.2.2 SCENARIO DATASET

We used data from the IEA's 2019 World Energy Outlook (IEA, 2019b) to define power generation scenario pathways. This publication is to date the most used source of power sector and country-specific decarbonization pathways. The three IEA scenarios are organized in the Sustainable Development Scenario (SDS), Stated Policy Scenario (SPS) and Current Policies Scenario (CPS).[23] Those are used to define 4 different temperature pathways to which the carbon intensity of current flows can be assigned:

- **<1.8 °C scenario** – based on the Sustainable Development Scenario (SDS); would be the only Paris Agreement-aligned scenario.
- **<3.2 °C scenario** – based on the Stated Policies Scenario (SPS); even if aligned with National Determined Contributions (NDCs), would overshoot Paris Agreement targets.
- **>3.2 °C scenario** (within current policies) – based on the Current Policies Scenario (CPS); temperature rise greater than 3.2 °C, assuming that carbon intensity would remain within thresholds estimated under the scenario.
- **>>3.2 °C scenario** (misaligned with policies) – based on the Current Policies Scenario; projected temperature increase far greater than 3.2 °C, assuming that carbon intensity would go even beyond thresholds estimated under the scenario.

Country-specific pathways are available for United States, Brazil, South Africa, Russia, China, India, Japan, with EU member states treated as a single bloc. This makes more than 75% of IEA's 2018 tracked global energy generation emissions available at the highest possible level of geographical granularity. For the remaining countries for which country-specific pathways are not available, we looked at the narrowest possible region of reference that could be retrieved using IEA region definitions.[24]

More details on the IEA's scenarios for the power sector are available in Annex III.

3.2.3 FINANCIAL COMMITMENTS DATASET

Our database of financial commitments to new power generation assets in 2018 is a hybrid constructed from granular project-level data and aggregate estimates. The preference is for granular data where it is available: the emissions intensity of new commitments can be estimated with much greater accuracy with verifiable details about physical assets, while information on the institutions providing finance and instruments used lets us estimate the alignment of particular types of financial flows.

23 Note that the WEO has been criticized because the SDS scenario does not sufficiently represent the importance of limiting temperature rises to 1.5°C and is considered optimistic about negative-emissions technologies after 2050 (Price of Oil, 2020; FixtheWEO, 2020). Consequently, the IEA has been encouraged to make a 1.5°C-aligned scenario the central focus of the 2020 WEO, which has ultimately been integrated in its most recent publication (IEA, 2020e), as a new Net Zero Emissions by 2050 (NZE2050) scenario, unfortunately not in time for this publication. Uncertainty over temperature increases (Sherwood et al., 2020; Roston, 2020) requires the adoption of conservative approaches to scenarios, as a consequence more stringent pathway data will be substituted into our models once they become available. Further, some critics consider IEA country-specific pathways as intrinsically political. This consideration has much to do with the idea of "burden sharing", or the political debate opposing the "atmospheric rights" and global challenge represented by climate change, with the "right to emit" that developing countries claim. A debate dating back to the dawns of the UN Framework Convention on Climate Change, which set up the basis for the Kyoto protocol, and led to the concept of "common but differentiated responsibility and respective capabilities" (UNFCCC, 1992). Our take on this aspect specifically favors the use of country specific pathways for two reasons: 1) debate on political appropriateness of principles for burden sharing, while being divisive, tends to lead to comparable outcomes (Averchenkova et al., 2014), 2) both global and local scenarios have political implications hence neither approach addresses the problem 3) regional pathways incorporate objective elements such as technical and financial capabilities of countries which are worth including.

24 E.g. the pathways of Kosovo and other European States which are not part of the European union are associated to pathways for the region: (Europe) – (European Union).

More specifically:

- Renewable energy transactions data were sourced from Bloomberg New Energy Finance, Climate Funds Update, Convergence, CPI's surveys of development finance institutions (DFIs), and the OECD's Creditor Reporting System. These transactions are already tracked in CPI's Global Landscape of Climate Finance.
- High-emissions power plant transactions data were sourced from IJGlobal, the World Bank's Private Participation in Infrastructure dataset, Boston University's China's Global Energy Finance dataset, Global Energy Monitor's Global Coal Public Finance Tracker, and the OECD's Creditor Reporting System.

While investments in energy efficiency, demand response, battery storage, and grid modernization are crucial for Paris alignment, this paper restricts the scope of inquiry to investment in generation due to the limited availability of investment data and alignment scenario benchmarks in these areas.

To estimate the alignment of total investment, it is important to ensure full global data coverage, which we accomplish by consulting IEA estimates of total power sector investment worldwide to helps fill gaps in our asset-level transactions database (IEA, 2019a). However, the IEA estimates lack any details regarding the sources of finance, in terms both of institutions and geographic origin, and are therefore only used to provide estimates of the magnitude of flows for which we are missing granular destination data. Since the datasets used to track finance for high-emissions power plants are focused on project finance, we do not have transaction-level data on projects being financed through corporate balance sheets (see Paper 1: *Improving Tracking of High-GHG Finance in the Power Sector*).

To account for this and any further, specific gaps in data coverage (e.g. due to a lack of information from particular countries), we include aggregate flows from unknown sources in our dataset, representing the residual investment in fossil fuels not tracked at the project level. Investment in nuclear energy, for which we were not able to access project-level transaction data, is also included in these aggregated flows from unknown sources.[25]

However, doing so introduces two caveats into our methodology. First, the lack of granular information on these IEA 'residual' flows precludes an accurate assessment of alignment accuracy for some actors (notably corporates) and countries originating investment. This is addressed in our presentation of alignment results in *Paris Misaligned: An Assessment of Global Power Sector Investment*.

Second, IEA estimates do not represent exactly the same type of flow as our granular data on commitments, so an additional assumption is involved. IEA figures reflect ongoing expenditures based on the capital costs of projects under construction or refurbishment, smoothed evenly over the relevant years – in other words, disbursements rather than new commitments. We assume that disbursements in 2018 to projects committed in previous years are a reasonable – although conservative - benchmark for commitments made in 2018 to future assets.

25 The WEI only provides the total investment for three fossil fuel types (coal, oil and gas) in aggregate, by region. We disaggregated these regional figures into investment figures for specific fuel types based on the relative estimated cost of new capacity additions recorded from 2017 to 2018. For this, we used World Energy Outlook electricity generation capacity statistics by fuel type, adjusted them with known power plants retirements from Platts, and multiplied by average capital costs from our observed project-level data. Finally, we deducted the total value of financial commitments recorded in our project-level dataset to coal, oil and gas projects in a given region from the IEA aggregate figure for the same fuel and region combination.

3.2.4 CAPACITY, GENERATION AND EMISSIONS ESTIMATES

To calculate the electricity generation from current capacity for specific countries and regions and related emissions, we applied assumptions to our asset-level and aggregate finance data, covering the technical and emission characteristics of various generation of technologies and fuel types.[26]

The first set of technical assumptions by technology type includes capacity factors and heat rates[27] for both new and retiring units. Heat rate and capacity factor assumptions were derived from a review of several sources, including the U.S. Energy Information Administration's (EIA) annual average tested heat rates file (2016), Lazard's 2019 Levelized Cost of Energy report (2019), and research by the California Energy Commission (Nyberg, 2014). Regarding emissions, only on-site estimates from fossil fuel combustion for electricity generation (Scope 1 emissions) are here considered, in line with emissions pathways used in IEA scenarios. The emissions rate assumptions by fuel type were taken from the standard fuel-specific CO2 mass/mmbtu rates widely available from US EIA (2016), US EPA (2014), IEA (2020b), and a variety of other industry and government sources.[28] Annex IV contains detailed technical assumptions by technology and fuel, for both new and retiring plants.

Information on the plant capacity or the technology and fuel type used by new financed renewable and high-emissions power plants have mostly been derived from the project-level datasets we consulted. However, we also had to estimate installed generating capacity for 19% of transactions (weighted by value in USD) in the renewables data, and 3% of high-emissions transactions for which information was not available.

As in the Global Landscape of Climate Finance, estimates were derived using average installation costs, from REN21 or IRENA (2020) in the case of renewable plants, while costs were estimated from project-level data for high-emissions plants, using Lazard's most recent Levelized Cost of Energy report (2019) to sense-check cost figures and adjust cost estimates where small sample sizes of project-level data resulted in unrepresentative implied installation costs. Where data cleaning did not return a clear technology or fuel type, we carried out desk research to label all plants under a list of standardized technologies and fuel types, available in Annex IV.

26 Because retiring units generally use older technology and operate well below full capacity in their final years before retirement, assumed heat rates are higher (i.e. less efficient) and capacity factors are lower for retiring units than for new units. For example, retiring combined cycle plants are assumed to have been operating at a heat rate of 7500 btu/kWh prior to their retirement, and at an annual capacity factor of 30%, as older units are less efficient and more expensive to operate, and therefore are only economic to operate in relatively few hours. By contrast, new combined cycle plants using newer technology are expected to function as highly-utilized baseload generation, and are therefore assumed to have a capacity factor of 65% in addition to a lower heat rate (higher thermal efficiency) of 6300 btu/kWh.

27 Heat rate is the standard measure of efficiency for thermal power plants, and reflects the amount of energy input (fuel) required to produce a given energy output (electricity).

28 Standard fuel-specific CO2 mass/mmbtu rates provided by the source were converted into tons CO2/mmbtu. We then calculated a per-MWh emissions rate for all technology-fuel type combinations by multiplying the btu/kWH heat rate for each technology by the tons CO2/mmbtu emissions rates (including the required unit conversions).

3.3 SOURCES AND SPECIFIC APPROACHES USED FOR THE TRANSPORT SECTOR (LIGHT ROAD VEHICLES)

The following paragraphs illustrate sources used to assess alignment for the transport sector's light road vehicles. Activity metrics considered for the sector is the **vehicle-miles traveled**, by cars (e.g. VMT). After estimating related emissions (e.g. gCO2), it is then possible to calculate the **carbon intensity** as a ratio between vehicles emissions and vehicle-miles traveled (e.g. gCO2/mile). The following methodology is based on U.S. assumptions and data availability. All estimations and calculations below are made for light road vehicles[29] with no further breakdown. This is due to inconsistent classification methods across institutions and geographies.

3.3.1 ASSET DATASET AND ADJUSTMENTS

The composition of the 2017 light road fleet comes from the National Household Travel Survey (2017). The survey assesses household vehicle ages by vehicle types. Household vehicles representing a majority of the total light road fleet, we applied the distribution by model year to the whole light road fleet.

A vehicle scrappage rate was then estimated by comparing the 2017 fleet composition (by vintage year) to the number of light road vehicles sold in each vintage. This scrappage rate was then used to estimate the gradual decommissioning of the 2017 fleet. More details on the approach used are available in Annex IV.

3.3.2 SCENARIO DATASET

GHG emissions scenarios come from the IEA ETP 2017 (2017). These scenarios correspond to Well-To-Wheel (WTW) light road CO2 emissions[30] between 2014 and 2050. The four GHG emissions scenarios correspond to different temperature increase trajectories:[31]

– **<1.8 °C scenario** – based on the Beyond 2 °C Scenario (B2DS, 50% chance of limiting global warming to 1.8°C by 2100), would be the only Paris-aligned scenario

– **<2 °C scenario** – based on the 2 °C Scenario (50% chance of limiting global warming to 2°C by 2100)

29 Highway vehicles under 10,000 lbs.

30 It means both on-road CO2 emissions (Tank-To-Wheel, TTW) and the CO2 emissions of the fuel lifecycle (Well-To-Tank, WTT) are included. Other indirect CO2 emissions (such as vehicle manufacturing) are not included.

31 Transport sector trajectories from IEA's ETP (IEA, 2017) are slightly different from power sector trajectories in IEA's WEO (IEA, 2019b)

- **<2.7 °C scenario** – based on the Reference Technology Scenario, taking into account countries' current commitments and NDCs pledges to limit emissions.
- **>2.7 °C scenario** - a scenario where temperature will go well beyond 2.7 °C. Travel demand forecasts (in distance traveled by the total fleet of light vehicles) are also based on IEA ETP 2017 scenarios: each CO2 emissions scenario has a corresponding level of demand for travel. Achieving the most ambitions CO2 emissions pathways (2DS and B2DS) involves equally ambitious reductions in travel demand. Using these demand scenarios assumes that some strong policies will allow travel demand to decrease accordingly. By using them, we therefore restrain our analysis to the technological compliance of the light road fleet.

3.3.3 FINANCIAL COMMITMENTS DATASET

Our dataset of 2018 private (households and businesses) financial commitments to new Electric Vehicles - both Plug-in Hybrid (PHEV) and Battery (BEV) – combine two sources from the U.S. Department of Energy. Unit sales by model type come from the Argonne National Laboratory (2020), and vehicle prices by model type from Fuel Economy (2020a).

Investment figures were split between private and governments expenditures, using again Fuel Economy (2020a) for governmental model-specific incentives. Internal Combustion Engines' vehicles sales were derived from light road vehicle sales data from the U.S. Bureau of Economic Analytics (2020).

Government's expenditures on new vehicle acquisitions are estimated separately using the U.S. General Services Administration (GSA) federal fleet data (2020).

3.3.4 MILES PER VEHICLE AND EMISSIONS ESTIMATES

The fleet activity can be estimated by looking at the **distance** vehicles travel each year. Vehicles' annual mileage decrease as they get older, at a rate estimated with NHTSA 2017 data.

The second parameter required to assess the impact of the fleet dynamically is the **fuel efficiency** of its vehicles. The fleet fuel efficiency is estimated by model year because of the U.S. Environmental Protection Agency's (EPA) 'real world' miles per gallon (mpg) estimates (2020). PHEV and BEV fuel efficiencies are estimated for each model using data from the U.S. EPA (2019).

Finally, the CO2 **emissions factors** used for light road transport in this methodology are Well-To-Wheel (WTW) CO2 emissions based on annual light road fuel consumption (U.S. DOT, 2018) and WTT emission factors (Argonne National Laboratory, 2019). Indeed, a CO2 cost can be associated to each volume of fuel used (Gasoline, Diesel, Electricity, etc.) for its production, transportation (WTT), and on-road use (TTW). For PHEV and BEV, the Well-To-Wheel emissions are updated based on the evolution of the electricity generation carbon intensity, to better grasp the potential carbon intensity of such vehicles. We assess the forecasted carbon intensity of these vehicles using multiple U.S. generation mix scenarios from the IEA (2019b) and the GREET model (Argonne National Laboratory, 2019).

4. CONCLUSIONS AND NEXT STEPS

4.1 CONCLUSIONS

Financial sector alignment requires an increase in finance for clean investment and a phase-out of finance to high-emissions activities and assets. A better understanding of the implications that current investment has on carbon emissions and the likelihood to limit the projected increase in global temperatures is required to fully evaluate investors' Paris alignment progress.

A number of approaches are currently being developed between taxonomies and science-based methods focussing on alignment of portfolios with Paris goals.

The quantitative method proposed in this paper derives from existing science-based methodologies and complements them by:

1. Focusing on the alignment of **new investments**, attributing responsibility at the time of the commissioning, and creation of the asset, rather than to their ownership.
2. Enabling the assessment at **individual entity level**, while identifying specific trends among **impact sectors** and **financial actor categories**
3. Assessing alignment of investment activity using country- and **region-specific temperature pathways**

The method provides a practical approach to track financial actors' contributions to changes in the real economy. The aim is to support investors, policymakers, private responsible investment initiatives, and financial regulator coalitions, with more informed investment decisions and policy design.

4.2 NEXT STEPS

In the accompanying paper, *Paris Misaligned: An Assessment of Global Power Sector Investment*, we apply the alignment methodology described in this paper to assess how current investment pipeline in the power and U.S. transport sectors will contribute to drive emission pathways in recipient countries. The paper specifically explores the role of different financial actor categories.

In addition, *Paris Misaligned* goes even further, examining more broadly the current status of investments and initiatives that financial actors are putting in place to measure, address, and scale up their efforts as they plan to meet the Paris alignment challenges.

Looking strictly at the methodology – on top of the benefits and complementarities already highlighted in Chapter 2 - we believe that there are further developments that can expand analytical tools available to investors and regulators, by building from the analysis and learning explored here.

4.2.1 EXPANDING THE APPROACH TO OTHER SECTORS

Following testing of the proposed methodology, the approach could be expanded and adapted to other emission-intensive sectors and datasets. This would require expanding the investment datasets currently in use by CPI in the *Global Landscape of Climate Finance* to cover finance in additional sectors. Alignment methodologies could be prioritized as follows:

Mitigation methodologies:

- First, by adapting the proposed alignment methodology if emissions and **activity-specific outputs** are quantified under decarbonization scenarios and can be tracked or estimated from current investments and stocks. Initial emission-intensive sectors could include other IEA sectors for which country-specific decarbonization scenarios exist, such as oil and gas, coal mining, aviation, shipping, chemicals, cement, and steel.
- For sectors in which activity-specific outputs are not available, or are less uniform (e.g. energy efficiency) new alignment methodologies could be established using **carbon intensity per unit of revenue generated** or by attributing Paris-aligned investment needs to entities, based on sector-specific market shares.

Adaptation methodologies:

- By establishing specific alignment methodologies for **adaptation projects** assessing investment needs as a function of country-specific exposure to physical climate risks.

4.2.2 HELPING FINANCIAL INSTITUTIONS ASSESS THE IMPACT OF THEIR NEW INVESTMENTS

Carbon intensity thresholds could be incorporated into tools available to individual investors and financiers to help them assess the impact of their activities and new investments:

Ex-post, as an assessment of their yearly efforts to achieve Paris-aligned temperature pathways on a year-to-year basis; and

Ex-ante, as a due diligence tool complementing existing taxonomies to assess the impact of potential investments under consideration.

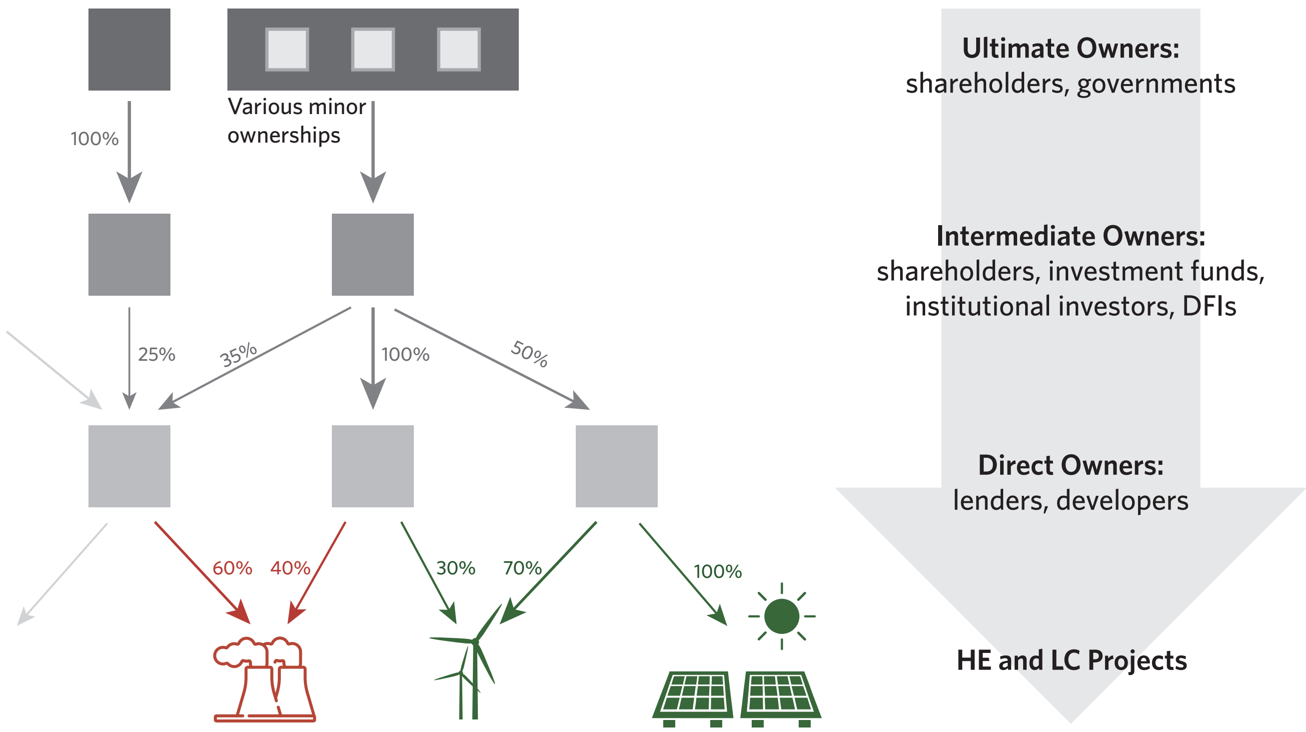
4.2.3 ATTRIBUTING HIGH-CARBON PRIMARY FLOWS UPSTREAM IN THE INVESTMENT DECISION CHAINS, USING OWNERSHIP STRUCTURES.

As mentioned previously, one of the benefits of measuring alignment by looking at commitments to new investment is the direct link it establishes between investors and new assets funded. This shifts the attention away from the mere ownership of the asset toward the actual moment of its creation, reframing the conversation around pre-emptive measures, such as exclusion lists, which rule out the financing of new low-carbon assets, or shutdown and/or emissions offsets (as opposed to sale) for existing high-carbon assets.

This approach could potentially be expanded to examine emissions impact, not only of direct investment, but also **upstream in the ownership chain**. Identifying the parties responsible for originating high-emissions finance could provide a broader view of the investment decision chain. This would allow policymakers, regulators, financial associations and private financial institutions to more effectively target and correct misaligned investment practices by bringing to light the roles of owners and shareholders in shaping investment decision-making, incentivizing stronger engagement (e.g. with asset/fund managers, board management etc.).

The approach would continue to use new primary investment datasets (e.g. CPI's *Global Landscape of Climate Finance*) along with the methodology introduced in this paper to assess alignment with different temperature pathways. However, it would go beyond primary investors by attributing investment flows and related temperature pathways to entities higher up in the ownership chain (e.g. parent company, fund holding equity share), using ownership structure data to track investment interests by firm (e.g. through datasets such as the Bloomberg Terminal).

Figure 4: Attribution of temperature pathways to investment decisions



Note: *Representative example of how temperature pathways can be attributed to investors on top of the investment decision chain based on ownership shares.*

4.2.4 STRENGHTENING TIES BETWEEN INSTITUTIONS AND REAL-LIFE INVESTMENT IN PORTFOLIO APPROACHES USING "HISTORIC OWNERSHIP," AS OPPOSED TO "CURRENT OWNERSHIP".

Current **portfolio approaches**, which rely on previously established science-based frameworks to understand the temperature pathway of stocks of assets attributed to corporates, could also adapt and integrate lessons from this methodology to **strengthen ties to tracked real-world investment data** (see Chapter 2 for an overview).

Attribution of asset-level activities, emissions, and Paris alignment to specific investor entities is currently based **on the ownership of an asset** at the **time of the portfolio assessment**.

Alternatively, "historic ownership" at the **time of financing** of the underlying asset (e.g. when asset reached financial closure) could be used as the main attribution approach.

The proposed approach would require tracking of project funders and owners at the time of financial close.

5. ANNEXES

5.1 ANNEX I: OVERVIEW OF PORTFOLIO ALIGNMENT METHODS

For the purpose of this paper, we looked principally into science-based approaches assessing carbon mitigation pathways from three main sources:

- Arabesque S-Ray Temperature Score: approach calculates the emission intensity of corporates based on reported GHG protocol's Scope 1 and Scope 2 emissions[32] and declared revenues and compares it with similar sector-specific metrics obtained from IEA scenarios in order to assign degree-based pathways.
- 2D investing / PACTA: approach looks at how corporates or investment portfolios are aligned with temperature pathways. Instead of having corporates submitting their Scope 1 and Scope 2 emissions, it looks at activity-based metrics from multiple datasets and assigns metrics to corporates and investors based on ownership shares. Metrics from each sector is compared with activity-based metrics for each sector sourced from IEA scenarios, attributed to the corporate based on market share.
- SBTi: approach aims at defining science-based decarbonization targets rather than assessing current temperature pathways. Two approaches are adopted:
  - absolute contraction approach: looks at **corporates' declared Scope 1 and Scope 2 absolute emissions. These are used as a starting point to apply annual reduction rates required in global pathways (based on Integrated Assessment Modeling Consortium (IAMC) scenarios), including – if applicable - sector-specific reduction rates. Target must be compatible with such reductions for the specific year of the target.**
  - sectoral convergence approach: looks at **emissions intensity based on corporate reported Scope 1 and Scope 2 emissions, and sector-specific level of activity. Absolute emissions pathways are then created looking at how planned activities at the time of the target will look like as they converge to the sector specific intensity defined in the IEA's B2DS scenario.**

The following paragraphs provide a more detailed overview of the approaches cited above, along with approaches assessing alignment of portfolios' resilience with adaptation pathways.

32 Emissions can be broken down into three categories by the Greenhouse Gas Protocol in order to better understand the source.
Scope 1 – All Direct Emissions from the activities of an organization or under their control. Including fuel combustion on site such as gas boilers, fleet vehicles and air-conditioning leaks.
Scope 2 – Indirect Emissions from electricity purchased and used by the organization. Emissions are created during the production of the energy and eventually used by the organization.
Scope 3 – All Other Indirect Emissions from activities of the organization, occurring from sources that they do not own or control. These are usually the greatest share of the carbon footprint, covering emissions associated with business travel, procurement, waste and water.

ARABESQUE

APPROACH 1: ALIGNMENT OF PORTFOLIOS WITH DIFFERENT EMISSIONS SCENARIOS

Scope	**Sectors** as aggregated by IEA sectors: **Power, Industry, Transport and Other**. The sectoral approach reflects the various levels of effort required by different sectors to reduce emissions and aligns with the approach in the SBTi. **Country**: No distinctions are apparently made at the country level.
Metrics	Emissions Intensity Ratio (EIR)
Current portfolio metrics calculation	EIR is calculated for each year at company level, using - Only **publicly reported emissions**. For each reporting company, their Scope 1 and Scope 2 GHG emissions are summed to get the total GHG emissions. Since emissions are usually self-reported, the summed emissions are cleaned to remove errors, and corrected if they have been reported in different units -**Company gross value added (GVA)** is taken as the annual revenue. The GVA would usually be calculated as GVA = pre-tax profits + depreciation + labor expenses, however not all companies (particularly companies in the United States) report their labor expenses separately, and thus this calculation cannot be performed without estimating these costs. Instead, revenue is used as a proxy, which, although not exactly equivalent to the GDP measure used to calculate the reference, is an acceptable trade-off between accuracy and precision. The sector GDP is given in PPP USD for 2010, and so the economic value added for each company is converted from the local currency to PPP USD for the current year and then adjusted to the 2010 base year. The EIR value is calculated monthly, using the most up to date emissions and revenue data available at that time. NB: It is assumed that a company is involved in only one of the four sectors.
Target metrics calculation / Benchmark	EIR calculated for 2030 and 2050[33] for each IEA scenario and sector using: - **Estimates of future GHG emissions from the IEA scenarios**, which outline future policy and technology pathways and the resulting changes in global mean temperature. Each scenario has an estimate of compatible global CO2 emissions, and partitions this between each sector (Power, Industry, Transport and Other). The scenarios assume that only existing or developing technologies are used and thus one of the major differences between them is the speed at which decarbonization occurs across the different sectors - The benchmark **gross value added calculated using sector-specific GDP** forecasts. These are estimated by partitioning the global OECD GDP forecast to 2050 into the four sectors (Power, Industry, Transport and Other) using global average GDP contribution to each sector from the UN national accounts over the last decade. Following the IEA scenario methodology, it is assumed that future GDP is constant across each of the emissions scenarios, and that the partitioning is constant over time. Based on the IEA scenarios from ETP 2017 (IEA, 2017): **B2DS**: Beyond 2°C Scenario – Global temperature rise is kept well below 2°C, and until 2060, the pathway is the same as that to limit global temperature rise to 1.5°C (with an overshoot) score **1.5°C** **2DS**: 2°C Scenario – Global temperature rise is kept below 2°C by 2100. This ambitious pathway leads to a global temperature rise of 1.7°C-1.8°C score **2°C** **RTS**: Reference Technology Scenario – Existing technologies and policies, resulting in a temperature rise of above **2°C** by 2100, and continued temperature rise after 2100 score **2.7°C** **> RTS** score > **2.7°C** **No disclosure:** in this case it is assumed that these companies are not making efforts beyond what is required by policy to reduce their emissions score **3°C**
Comparison current vs benchmark	Current portfolio metrics and benchmark metrics are then compared as per the following graph.

33 Two EIR benchmark time horizons are used to generate company scores, 2030 and 2050. The Temperature Scores assigned to companies equate to the end of century temperature (Table 1), since GHG's emitted today will remain in the atmosphere for many years to come. The 'near-term' 2030 reference point reflects the temperature pathway that the company is currently on, while the 2050 reference point shows the potential long-term implications of the company's current emissions, assuming that it makes no reductions.

APPROACH 2: ASSESSMENT OF YEAR TO YEAR VARIATION TOWARDS NET 0

Scope	Theoretically applicable to any sector and country
Metrics	Annual emissions variation
Current portfolio metrics calculation	For each reporting company, their Scope 1 and Scope 2 **GHG emissions** are summed to get the total GHG emissions. Since emissions are usually self-reported, the summed emissions are cleaned to remove errors, and corrected if they have been reported in different units. Annual variation of emissions in the last **three years** is then calculated.
Target metrics calculation / Benchmark	Annual variation of emissions required to achieve net 0 emissions by mid-2060's is also estimated.

Source: *Arabesque (2020)*

2 DEGREE INVESTING (PACTA)

ALIGNMENT OF PORTFOLIOS WITH DIFFERENT EMISSIONS SCENARIOS

Scope	The analysis covers climate-relevant **sectors** that are key to the transition to a low-carbon economy. These include **8 sectors** such as the **power (Gas, Coal, Nuclear, Hydro, RE), automotive (ICE, hybrid, electric), oil and gas (oil, gas production), coal mining, aviation, shipping, cement, and steel sectors**, which together account for approximately 80% of the CO2 emissions associated with a typical portfolio as well as 15-25% of a typical portfolio in terms of asset value. The real estate, agriculture and forestry sectors, despite being highly relevant in terms of climate, are not covered on a global level due to a lack of available data and may be covered by other tools (notably real estate in Switzerland). R&D investments are also not covered. In terms of **financial instruments**, the analysis covers listed equity, corporate bonds, and corporate loans. An additional analysis is possible for the Swiss real estate sector
Metrics	The model uses the following indicators as basis for comparison between portfolio and benchmarks: Power capacity by technology in megawatt (MW). Oil production in barrels per year. Gas production in billions of cubic feet per year. Coal production in tons of coal equivalent per year. GHG emissions pathways in the aviation, shipping, cement, and steel sectors. Nr of vehicles for automotive industry (TBC).

Current portfolio metrics calculation

First, securities are identified and assigned to the applicable 8 sectors (e.g. power) and broken down in individual technologies (e.g. share of coal energy, share of renewable energy) by matching

- **assets** as identified in the asset datasets indicating **companies** owning them (currently or in the near future as per plans),

and

- **share of companies** associated with **financial instrument** as identified in Bloomberg.

Key data providers for asset-level data are:

Data provider	Sector	Key data points
GlobalData	Power, oil & gas, coal mining	a. Power plant data, including installed capacity, technology, status (i.e. announced, active, decommissioned, etc.). b. Oil and gas field data, including annual production volume. c. Coal mine data, including annual production mass.
WardsAuto	Automotive	Production forecasts for light duty vehicles
RightShip	Shipping	Ship data, including ship type and GHG rating score.
FlightGlobal	Aviation	Passenger, cargo and combined aircraft data, including number of seats or tons transported, aircraft model, etc.
PlantFacts	Steel	Steel plant data, including production and CO2 emissions.
Cemnet	Cement	Cement plant data, including production and CO2 emissions

Target metrics calculation / Benchmark

IEA scenarios are used for their high degree of granularity, extensive geographic and sectoral coverage.

Scenarios used are:

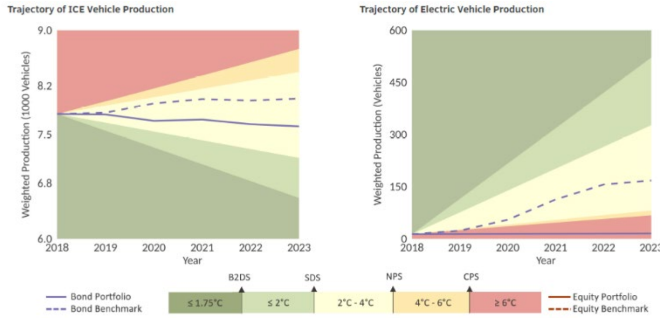
- Beyond 2° Scenario (B2DS) 1.75°C by 2100 (IEA, 2017)
- Sustainable Development Scenario (SDS) 1.7-1.8°C by 2100 (IEA, 2020a)
- Stated Policy Scenario (SPS) 2.7°C by 2100 (IEA, 2020a)
- Current Policy Scenario (CPS) 3.3°C by 2100 (IEA, 2020a)

Emissions and economic assets (as determined in scenarios) are allocated to financial assets using principally 2 approaches:

Market share approach (most used): where all sector level production and capacity trends are proportionally distributed across companies based on market share in the technology or sector. The market share is considered their share in the overall sector for low-carbon technologies, and their share in the specific technology for high-carbon assets. This different application is a result of the fact that taking the share in the sector for high carbon technologies might lead companies to be required to retire assets they don't have, whereas taking the market share in the technology for low-carbon technologies may lead companies to not have to build out low-carbon technologies if their current market share is zero and thus inflates the responsibility of existing 'leaders'. This approach is currently used in the PACTA model.
Economic efficiency / least cost approach (under development): This approach uses sector-level output variables, such as demand and price, as a constraint interacting with the production costs of individual companies, arguing that the 'marginal' product is produced at the lowest cost. The cost approach uses the cost structure of a company's existing, planned, and potential capital stock to estimate which assets meet a sector-wide output constraint under the assumption that low-cost assets will be deployed first. This logic has been applied by the Carbon Tracker Initiative for oil, gas, and coal production and capital expenditure (CTI 2014; 2016). It will be integrated into PACTA in 2020.

Comparison current vs benchmark

To understand how portfolio are aligned, a comparison is made between evolution of the assets / emissions in the next 5 years by the existing portfolio, and linear trend in a similar 5-years timeframe, towards assets / emissions assigned to that portfolio as per the approach described above. See figure below for an example.



OTHER CONSULTANTS/SERVICES PROVIDERS USING THIS APPROACH AND VARIATIONS

FinanceMap	Their portfolio alignment metric is based on PACTA methodology. FinanceMap then implements a method to move from these technology-level results to the Sector and Portfolio Paris Alignment (PA) Scores. Each Sector PA Score is a weighted average of the technology-level deviations for every technology within a sector. The technology deviation results are weighted both by the portfolio's exposure to each technology as well as the technology's importance to global emissions as determined by the IEA. FinanceMap uses the **IEA's 'Beyond 2 Degrees' Scenario (B2DS), which provides a pathway for a 50% chance of limiting warming to 1.750C and is the most ambitious available from the IEA as of October 2019**. While there are other climate scenarios with more ambitious temperature targets, the IEA's scenarios are the most granular and span the broadest number of sectors, allowing for a more robust analysis. As other equally useful scenarios become available and are integrated by 2Dii into PACTA, FinanceMap analysis will be updated accordingly.

Sources: *2DII (2019), FinanceMap (2020)*

SCIENCE-BASED TARGETS

APPROACH 1: ALIGNMENT OF PORTFOLIOS WITH DIFFERENT ABSOLUTE EMISSIONS SCENARIOS

Scope	All sectors or specific sectors depending on contraction approaches.
Metrics	= tCO2
Current port-folio metrics calculation	The targets must cover company-wide **scope 1 and scope 2 emissions**, as defined by the GHG Protocol Corpo-rate Standard (GGP, 2020) Can also cover **scope 3** emissions.

Target metrics calculation / Benchmark

SBTi scenarios are drawn primarily from the **Integrated Assessment Modeling Consortium (IAMC)**

The IAMC hosts an ensemble of more than 400 peer-reviewed emissions pathways, which have been compiled and assessed by the authors of the Intergovernmental Panel on Climate Change (IPCC) Special Report on Global Warming of 1.5˚C (SR15).[34]

Emissions reduction targets are aligned with the global, annual emissions reduction rate that is required to meet 1.5˚C or WB-2˚C.

Pathway Group	*Pathway Class*	*Pathway selection criteria and description*	*Number of scenarios*	*Number of scenarios*
1.5°C or 1.5°C-consistent	*Below-1.5°C*	*Pathways limiting peak warming to below 1.5°C during the entire 21st century with 50-66% likelihood**	*9*	*90*
	1.5°C-low-OS	*Pathways limiting median warming to below 1.5°C in 2100 and with a 50-67% probability of temporarily overshooting that level earlier, generally implying less than 0.1°C higher peak warming than Below-1.5°C pathways*	*44*	
	1.5°C-high-OS	*Pathways limiting median warming to below 1.5°C in 2100 and with a greater than 67% probability of temporarily overshooting that level earlier, generally implying 0.1–0.4°C higher peak warming than Below-1.5°C pathways*	*37*	
2°C or 2°C-consistent	*Lower-2°C*	*Pathways limiting peak warming to below 2°C during the entire 21st century with greater than 66% likelihood*	*74*	*132*
	Higher-2°C	*Pathways assessed to keep peak warming to below 2°C during the entire 21st century with 50-66% likelihood*	*58*	
** No pathways were available that achieve a greater than 66% probability of limiting warming below 1.5°C during the entire 21st century based on the MAGICC model projections.*				

After that further scenarios are further narrowed down based on the following:

a subset of these scenarios are removed due to **over-reliance on globally negative emissions** (e.g. bio-mass, CCS) in the second half of the century.

Paris Agreement asserts that emissions should **peak 'as soon as possible'**. As global emissions are still rising, a threshold is introduced here which defines a future window in time within which emissions need to peak: this threshold will remove scenarios that predicted a peak that is in the past, or earlier than the nearest time-step of 2020, as well as scenarios in which emissions peak in the 2025 time-step or later.

scenarios are removed if they depict an annual linear reduction (2020-2035) that is **less ambitious than the 20th percentile** of the envelope.

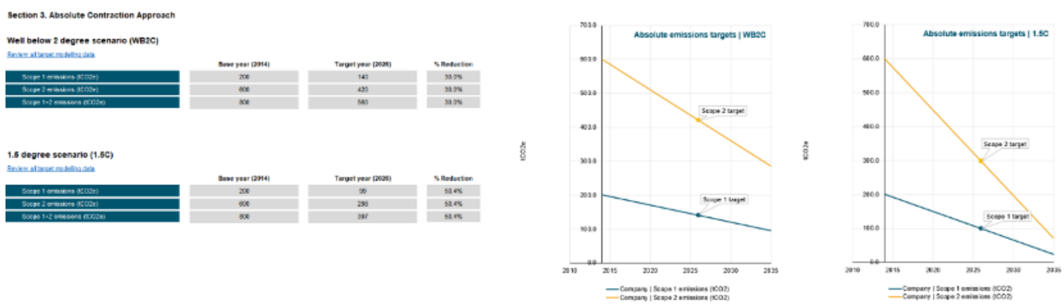
From an initial set of 177 scenarios from 25 models, the stepwise filter produces a final **1.5˚C envelope of 20 scenarios and a final WB-2˚C envelope of 28 scenarios.**

Linearization over a longer timespan can result in cumulative emissions more than 30% higher than prescribed. Thus, linear reduction rates are calculated based on the timespan 2020-2035, which aligns with the lifetime of a science-based target that is assessed by the SBTi and minimizes distortion.

The **contraction approach** Is then used to **allocate emissions trajectories** at a company level. Here all companies reduce their absolute emissions or economic emissions intensity (e.g., tonnes GHG per unit value-added) at the same rate, irrespective of initial emissions performance, and do not have to converge upon a common emissions value. The contraction approach can be used with **sector-specific** or **global** emissions scenarios.

Comparison current vs benchmark

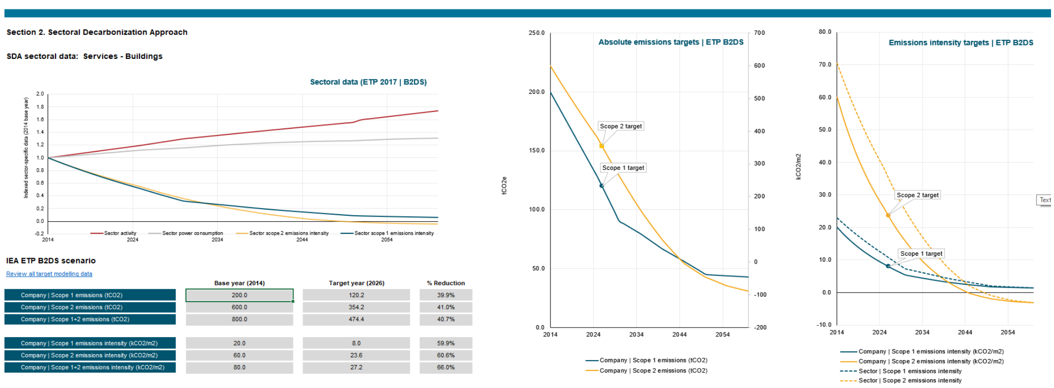
Emissions targets are provided for the year selected under 2 scenarios.



Sources: *SBTi (2018, 2019, 2020a, 2020b, 2020c)*

34 These scenarios vary depending on assumptions made about population, policy trajectories, and economic growth; technological advances and their cost-effectiveness and, of course, temperature outcomes. Many newer scenarios have been developed to reflect five different Shared Socioeconomic Pathways (SSPs), which represent diverse assumptions related to the achievement of sustainable development goals (SDGs), the extent of future fossil fuel reliance, and the degree of global coordination.

APPROACH 2: ALIGNMENT OF PORTFOLIOS WITH DIFFERENT EMISSIONS INTENSITY SCENARIOS

Scope	Under the **Sectoral Decarbonization Approach** (SDA) - intended to help companies in homogenous energy intensive sectors that can be described with a physical indicator – the following sectors are considered: Power generation (MWh) Iron and steel (metric tons of crude steel) Aluminum (metric tons of aluminum) Cement (metric tons of cement) Pulp and paper (metric tons of pulp and paper) Passenger and Freight transport (passenger-kilometer, tons-kilometer) Service and commercial buildings (square meters).
Metrics	= tCO2/activity level (e.g. MWh, tons, sqm) = tCO2
Current portfolio metrics calculation	Used for **scope 1 and scope 2 emissions** in the SDA tool, resulting in the following outputs for homogeneous sectors: scope 1 carbon intensity target, absolute scope 1 emissions reduction target, scope 2 carbon intensity target, absolute scope 2 emissions reduction target. In addition, a company can use multiple sector pathways in the SDA to also address scope 3 activities. Activity-level metrics for sector of reference.
Target metrics calculation / Benchmark	The **Sectoral Decarbonization Approach (SDA)** is based on the **Beyond 2°C scenario (B2DS)** developed by the International Energy Agency (IEA) as part of its publication, Energy Technology Perspectives (ETP) 2017 (IEA, 2017). The **convergence approach** Is then used to **allocate emissions trajectories** at a company level. Within each sector, companies can derive their science-based emission reduction targets based on their relative contribution to the total sector activity and their initial carbon intensity relative to the sector's intensity[35]. Here all companies within a given sector reduce their emissions intensity to a common value by some future year as dictated by a global emissions pathway (e.g., the emissions intensity of all electric power companies converges to a maximum of 29 g CO2e per kWh of electricity in 2050). The reduction responsibilities allocated to a company vary depending on its initial carbon intensity and growth rate relative to those of the sector, as well as the sector-wide emissions intensity compatible with the global emissions pathway. The convergence approach can **only be used with sector-specific emissions scenarios** and physical intensity metrics (e.g., tones GHG per ton product or MWh generated).
Comparison current vs benchmark	The new intensity targets for the years elected are then converted into absolute targets based on the sector market share. 

Sources: *SBTi (2018, 2019, 2020a, 2020b, 2020c)*

35 To avoid overallocation of target based on intensity, a company cannot project a future share which is smaller than the market share it has in the base year.

TRUCOST

EXPOSURE OF PORTFOLIOS TO PHYSICAL RISK SCENARIOS

Scope

The analysis draws on a database of 500,000 assets mapped to corporate owners across all regions and sectors. Asset cover (list not comprehensive):

Power Generation
Product Assembly
Delivery and Returns
Administration
Sales
...

Companies cover different sectors (list not comprehensive):

Energy
Materials
Consumer Staples
Consumer Discretionary
Information Technology
Industrials
Utilities
Real Estate
...

The methodology will also be expanded to incorporate supply chain and market climate change physical risks in early 2020 along with further enhancements to capture the financial consequences of climate change impacts at the company and portfolio level.

Climate hazards include:

Wildfire
Heatwave
Coldwave
Water Stress
River Flood
Hurricane
Coastal Flood

Metrics

Analysis looks at **assets and facilities owned** by a corporate subsidiary on climate change hazard maps.

Current exposure calculation

Weight of each asset within a subsidiary is determined based on activity share.
Weight of each company is based on portfolio weights.

Metrics for risk exposure are analyzed from several sources and converted and **normalized into a 1-100 score**.

Target exposure calculation / Benchmark

Corporate asset and headquarter locations are scored based on the level of **physical risk exposure in each scenario** and time period, and then aggregated to a corporate level physical risks score.

A composite physical risks score is also calculated for each company based on an average of all indicators, weighted for company specific sensitivity to each physical risk type.

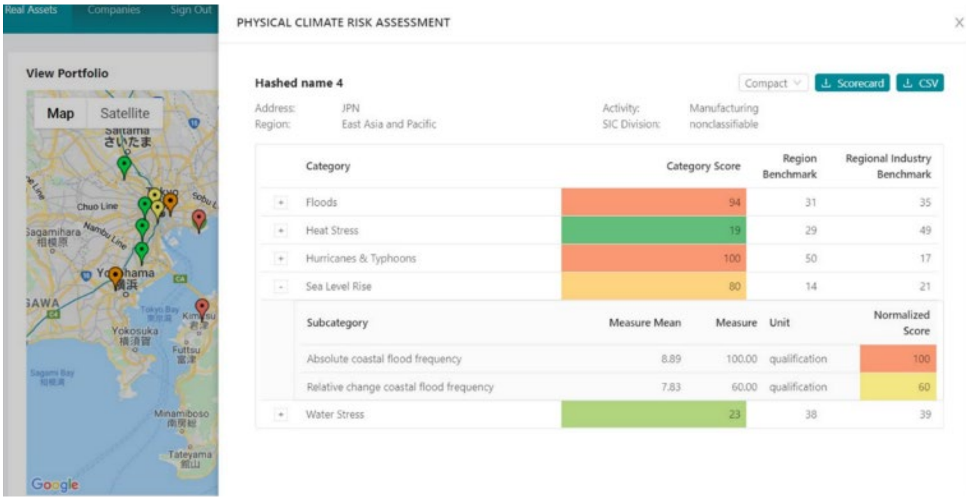
Identifier	Name	Business Activity	Country	Activity Share	Physical Risk Scores 2030						
					Drought	Flood	Heatwave	Coldwave	Hurricane	Coastal Flood	Composite Score
1	Site 1	Power Generation	China	15%	61	87	92	91	69	69	78
2	Site 2	Product Assembly	China	20%	78	81	92	76	50	60	73
3	Site 3	Product Assembly	China	10%	60	85	91	57	64	93	75
4	Site 4	Product Assembly	USA	10%	69	64	68	55	90	57	67
5	Site 5	Delivery and Returns	USA	5%	62	89	68	65	90	79	76
6	Site 6	Delivery and Returns	Germany	7%	73	69	64	69	81	83	73
7	Site 7	Delivery and Returns	UK	8%	75	76	78	62	78	68	73
8	Site 8	Power Generation	USA	15%	58	96	96	50	56	69	71
9	Site 9	Administration	Canada	4%	91	77	89	78	94	52	80
10	Site 10	Sales	France	6%	59	70	82	80	60	55	68

ID	Name	Sector	Portfolio Weight	Data Quality	Physical Risk Scores 2030						
					Drought	Flood	Heatwave	Cold wave	Hurricane	Coastal Flood	Composite Score
1	ABC Power Ltd	Energy	6.41%	A	33	95	87	40	39	59	59
2	XYZ Materials GmBh	Materials	5.13%	A	14	14	99	56	99	85	61
3	Universal Products Inc	Consumer Staples	2.56%	A	7	27	18	26	77	94	42
4	Electric Corp	Energy	1.28%	B	97	94	3	39	80	1	52
5	Consumer Products Inc	Consumer Discretionary	1.28%	A	58	94	90	40	69	89	73
6	ABC Tech Limited	Information Technology	2.56%	B	19	21	12	1	95	45	32
7	GHF Industrials Ltd	Industrials	1.28%	C	31	85	65	72	66	7	54
8	Materials Corp	Materials	3.85%	A	69	33	99	23	31	79	56
9	JKL Networks Inc	Utilities	1.28%	A	72	18	18	30	66	67	45
10	Real Estate Ltd	Real Estate	2.56%	C	38	88	13	26	70	54	48

Source: *Trucost (2019)*

427/MOODY'S

EXPOSURE OF PORTFOLIOS TO PHYSICAL RISK SCENARIOS

Scope	Climate Risk Scores available across a company's operations, benchmarked to facilities within a country Use cases include: Portfolio managers - Enhance the analysis of your portfolio and monitor risk as portfolio holdings change over time. Screen assets for their exposure to climate hazards, preacquisition. Asset owners - Evaluate the long-term risk exposure of your portfolio holdings and engage with asset operators to improve resilience and risk management. Banks - Identify the climate-related risks in commercial and residential mortgage portfolios. Incorporate climate risks into loan acquisition. Climate hazards include: Heat stress Wildfires (forthcoming) Extreme Rainfall Hurricanes & Typhoons Sea Level Rise Water Stress
Metrics	Exposure assessed for a single asset or a portfolio of assets depending on user assumptions.
Current exposure calculation	Metrics of risk exposure very granular - Inland and coastal flood risk assessed at the parcel level (90m x 90m). Numeric scores are then grouped into thresholds for straightforward communication of relative risk (note: normalization via distribution?).
Target exposure calculation / Benchmark	Models assess the projected exposure to climate hazards from 2030 to 2040 for each property. 

Source: *427 (2019, 2020)*

5.2 ANNEX II: ASSUMPTIONS ON DECOMMISSIONING AND EXTENSION OF PLANT'S SERVICE LIFE

Because some power plants in the database have remained operational despite being past their assumed service life, whether due to temporary service extensions or long-term operating license renewals, we used the following general set of retirement assumptions based on the relationship between a plant's current age (as of 2018, when the Platts dataset was assembled) and its assumed service life:

1. Plants whose current age is less than their projected retirement age (i.e. expected lifespan) are assumed decommissioned at their projected retirement age
2. Plants whose current age is greater than or equal to their projected retirement age, but under ten years greater, are assumed decommissioned 5 years from now (i.e. at an age of 5-15 years beyond their initial expected lifespan)
3. Plants whose current age is at least ten years greater than their projected retirement age, but under two times greater, are assumed decommissioned at twice their projected retirement age
4. Plants whose current age is greater than or equal to twice their projected retirement age, but under ten years greater, are assumed decommissioned 5 years from now (i.e. at an age of 5-15 years beyond twice their initial expected lifespan)
5. Plants whose current age is at least ten years greater than twice their projected retirement age are assumed decommissioned at triple their projected retirement age

The reasoning behind this set of assumptions is that plants that are known to have continued to operate beyond their projected useful lives may be past due for a scheduled decommissioning, which will happen in the next few years (Scenario 2 above). Or, long-lived plants may have received additional capex and/or licensing renewals to enable longer-term operations for another full asset life cycle (Scenario 3). Scenario 4 then represents a combination of Scenarios 2 and 3, where an asset receives a long-term life extension and continues operating in the short-term even when the end of this life extension period is reached. Finally, Scenario 5 effectively assumes that a plant has received two long-term life extensions and is decommissioned upon the end of the second extension. For the purposes of our analysis, no plant continues to operate beyond three times its initial projected service life.

Some plants in the Platts database were identified as currently in commercial operation but did not have in-service dates. As a result, the retirement year calculation methodology described above could not be applied to these units. Instead, these units' annual generation was calculated as a percentage of total annual generation for all operating plants. The capacities of all operating plants were then increased by this percentage, so that when these known-date plants retired, a proportional share of unknown-date plant capacity, generation, and emissions would be removed from the energy system as well. This approach does not account for potential heterogeneity in retirement patterns of unknown-date plants across different countries or fuel types. However, given the limited information available from which to project unknown-date retirements, and the relatively minimal share of total operational generation represented by these plants (<1%), the approach provides a broadly useful framework to ensure that plant retirement figures reflect all decommissioned plants, rather than only plants for which a specific retirement date can be projected based upon the date of initial operation.

5.3 ANNEX III: IEA SCENARIOS FOR THE POWER SECTOR

Scenario options – For the power sector we used IEA's pathways scenarios:

- **Sustainable Development Scenario (SDS)** – reflects major changes that would be required in policies to reach the energy-related goals of the United Nations Sustainable Development Agenda. Including (a) An early peak and rapid subsequent reductions in emissions, in line with the Paris Agreement (Sustainable Development Goal [SDG] 13); (b) Universal access to modern energy by 2030, including electricity and clean cooking (SDG 7); and (c) A dramatic reduction in energy-related air pollution and the associated impacts on public health (SDG 3.9). This trajectory is consistent with reaching global "net zero" carbon dioxide (CO2) emissions in 2070, limiting temperature increase to below 1.65 °C above pre-industrial averages with a 50% probability, or below 1.8 °C with 66% probability.

- **Stated Policies Scenario (SPS)** – reflects (a) The impact of energy-related policies that governments have already been implemented; (b) An assessment of the likely effects of announced policies, as expressed in official targets and plans, including commitments in Nationally Determined Contributions under the Paris Agreement; and (c) A dynamic evolution of the cost of energy technologies, reflecting gains from deployment and learning-by-doing. This trajectory is consistent with limiting the temperature increase to below 2.7 °C above pre-industrial averages with a 50% probability, or below 3.2 °C with 66% probability.

- **Current Policies Scenario (CPS)** – reflects the impact of energy-related policies that have already been implemented, leaving out future policies trajectories.

Geographical granularity – IEA's country-specific scenarios are available for 7 key high impact countries such as United States, Brazil, South Africa, Russia, China, India, Japan. European Union Member States' scenarios are treated as one block, as the decarbonization targets and strategies and incentive systems are all determined at the supranational level. Other regions covered by IEA include World, North America, Central and South America, Europe, Africa, Middle East, Eurasia, Asia Pacific, South East Asia, OECD, non-OECD, Developing Economies, and Advanced Economies.[36]

Data retrieved - For each scenario and country/regional combination, the following information is retrieved from IEA's outlook:

- **Electrical Capacity** (GW) deployed for the years 2025, 2030, 2035, and 2040;

- **Electricity Generation** (TWh) for the years 2025, 2030, 2035, and 2040; this is defined as the total amount of electricity generated by power only or combined heat and power plants including generation required for own-use. This is also referred to as gross generation;[37]

- **Emissions** from the Power Sector (MtCO2) for the years 2025, 2030, 2035, and 2040; CO2 emissions from electricity generation are the product of the carbon intensity of the fossil fuel mix the reciprocal of fossil fuel based thermal electricity generation efficiency,

36 Information on the individual regions covered by the IEA, are available at pp. 780-82 in IEA's WEO IEA (2019b).
37 See pp. 774 pf IEA WEO (IEA, 2019b).

the share of electricity from fossil fuels and total electricity output (IEA, 2020c);

- **Carbon intensity** of the power sector (MtCO2/TWh or tCO2/MWh) is then calculated for the years 2025, 2030, 2035, and 2040 as a ratio between Emissions from the Power Sector and Electricity Generation. Emissions and electricity generation are used by the IEA for data comparison(IEA, 2020d). Note, however, the IEA also publishes different carbon intensity estimates based on models simulating hourly electricity demand and supply, which capture the effects of demand-side flexibility in the estimate of CO emissions associated with electricity supply.[38]

5.4 ANNEX IV: POWER PLANT TECHNICAL ASSUMPTIONS BY FUEL AND TECHNOLOGY TYPE

Figure IV.1: Capacity factor, heat rate, and asset life by technology - existing units

Type	CF% at decomm	Heat rate, btu/kWh	Expected asset life, years
All others	30%	9,000	40
CCGT	30%	7,500	35
Coal	40%	11,000	55
CT	10%	10,000	40
Geothermal	65%	21,000	75
Hydro	35%	-	75
Nuclear	88%	11,000	50
Other thermal	40%	11,000	45
Solar PV	18%	-	30
Wind	25%	-	30

Figure IV.2: Capacity factor, heat rate, and asset life – new units

Type	CF% once operational	Heat rate, btu/kWh	Expected asset life, years
Biomass	75%	-	40
CCGT	65%	6,300	35
Coal	75%	10,000	55
Cogen	80%	12,000	40
CSP	40%	-	30
CT	10%	9,300	40
Geothermal	65%	21,000	75
Hydro	40%	-	75
Natural gas*	47%	2,000	35
Nuclear	90%	10,500	50
Oil	75%	10,000	40
Other thermal	75%	9,500	40
Solar PV	25%	-	30
Wind	35%	-	30

38 See pp. 326 pf IEA WEO (IEA, 2019b).

Figure IV.3: Carbon dioxide emissions rates by fuel type

Fuel	Emissions rate, pounds CO2 per mmbtu	Emissions rate, metric tons CO2 per mmbtu
Bioenergy	150	0.068
Coal	220	0.100
Natural gas	117	0.053
Oil/Other	161	0.073

5.5 ANNEX V: US TRANSPORT SECTOR ASSUMPTIONS – DYNAMIC FLEET SIZE

The general idea is quite simple. As years go by some vehicles will be scrapped and will disappear from the fleet. Older vehicles have greater chances to be decommissioned than the newest ones. It is therefore necessary to first assess the distribution of the Y0 vehicle fleet by model year (the model year of a vehicle is the year it was sold as a new car).

SCRAPPAGE RATE

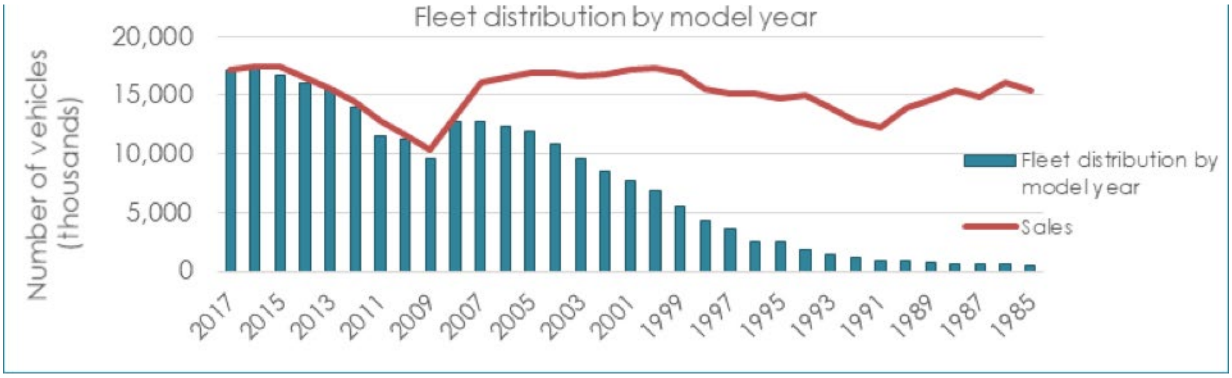


Figure 3- US light road fleet distribution by model year in 2017 (blue)(NHTSA, 2017; FHWA, 2018). US light road fleet sales 1985-2017 (red) (BEA, 2020)

The composition of the fleet reflects both the scrappage rate and the sales volumes of each model year. The composition of the light road fleet comes from a 2017 National Household Travel Survey. The survey assessed household vehicle ages by vehicle types. Household vehicles representing a huge majority of the total light road fleet, we applied the distribution by model year to the whole light road fleet. In order to access the scrappage rate, we then divided the fleet distribution by the sales volume.

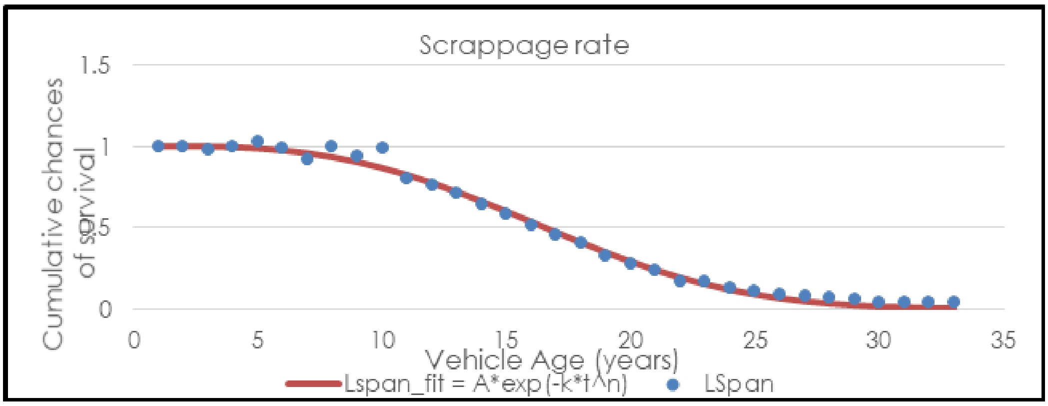


Figure 4 - US empirical Scrappage rate (blue dots) and fitted Scrappage rate model (red).

To obtain the scrappage rate model we fitted the following equation to the empirical scrappage rate, by minimizing the root mean square deviation (RMSD) of the residuals:

$$\min \mathrm{RMSD}(\widetilde{S_i} - S_i) \qquad S_i = A * e^{-k*i^n}$$

Where:

i, is the vehicle age

S_i, is the estimated scrappage rate

~Si, is the observed scrappage rate

A, k, n are parameters calculated through the regression. A is the initial survival rate and is set to 1. k and n determine the scrappage rate.

FLEET DEPLETION

Future evolutions of the Y0 fleet are then obtained by applying the scrappage rate (Si) to the respective vehicle vintages (or model year) composing the existing fleet composition (Figure 5). One underlying assumption is that the scrappage rate function induced by historical data is also valid in the coming years.

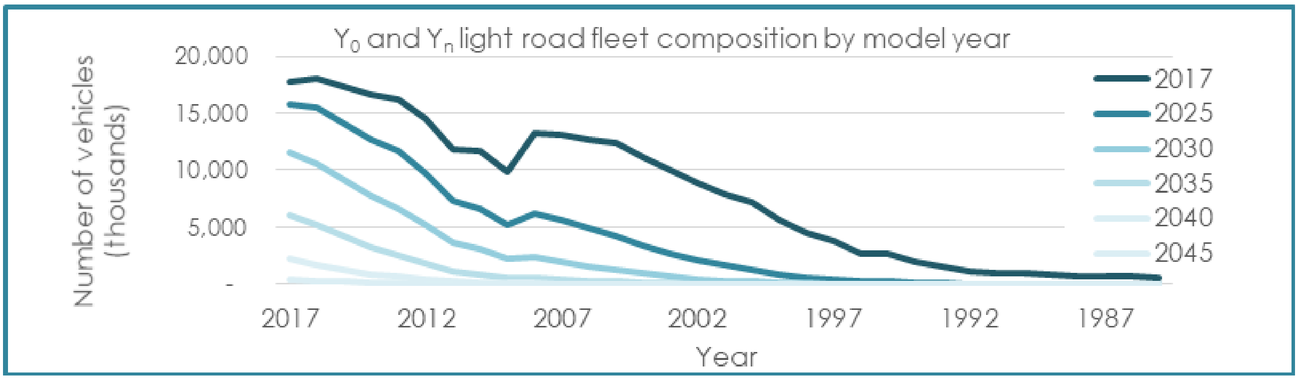


Figure 5 - US light road distribution by model year in 2017 (Y0, darkest blue) and scenario years (Yn, lighter blue).

The fleet depletion - as the evolution of the number of vehicles from the Y0 fleet – can then directly be calculated for each scenario year Yn.

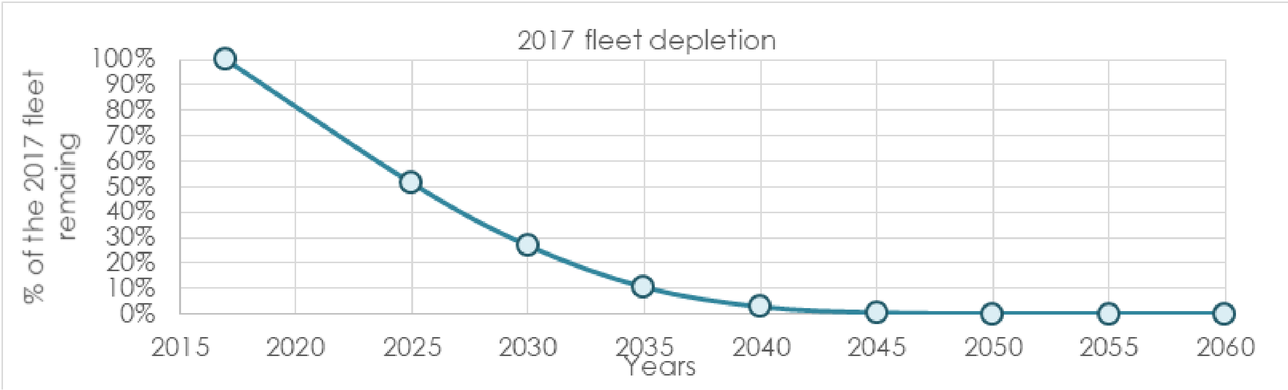


Figure 6 - US 2017 (Y0) light road fleet depletion in remaining percentage of Y0 fleet.

6. REFERENCES

2DII, 2020. 'Science-Based Targets' for Financial Institutions. Position deck & consultation. February. 2 Degrees Investing Initiative (2DII). Available at: https://2degrees-investing.org/wp-content/uploads/2020/02/2DII-Targets-Impact.pdf

2DII, 2019. PACTA Investor Briefing. Available at: https://www.transitionmonitor.com/wp-content/uploads/2019/12/PACTA2020_Investor_Briefing.pdf

427, 2019. Corporate Risk Screening. Available at: http://427mt.com/wp-content/uploads/2017/10/Corporate-Product-Sheet-Nov2019.pdf

427, 2020. Physical Climate Risk Application. Available at: http://427mt.com/wp-content/uploads/2017/10/App-Product-Sheet-Feb-2020-2.pdf

Arabesque, 2020. Temperature Score Methodology. Available at: https://arabesque.com/docs/sray/marketing/temperature/Temperature_Score_Methodology.pdf

Argonne National Laboratory, 2019. The Greenhouse gases, Regulated Emissions, and Energy use in Technologies (GREET) Model. Available at: https://greet.es.anl.gov/

Argonne National Laboratory, 2020 (access). Light Duty Electric Drive Vehicles Monthly Sales Updates. Available at: https://www.anl.gov/es/light-duty-electric-drive-vehicles-monthly-sales-updates

Averchenkova A., N. Stern. D. Zenghelis, 2014. Taming the beasts of 'burden-sharing': an analysis of equitable mitigation actions and approaches to 2030 mitigation pledges. Centre for Climate Change Economics and Policy Grantham Research Institute on Climate Change and the Environment. Available at: https://www.lse.ac.uk/granthaminstitute/wp-content/uploads/2014/12/Averchenkova-Stern-and-Zenghelis-policy-paper-December-2014.pdf

BEA, 2020 (access). Table 7.2.5U. Motor Vehicle Output. U.S. Bureau of Economic Analytics (BEA). Available at: https://apps.bea.gov/iTable/iTable.cfm?reqid=19&step=2#reqid=19&step=2&isuri=1&1921=survey

Caldecott, B., 2020. Achieving Alignment in Finance. In 'Aligning Finance for the Net Zero Economy', EIT Climate-KIC & UNEP Finance Initiative. September. Available at: https://www.climate-kic.org/wp-content/uploads/2020/09/200902_J932-CKIC-UNEP-ThoughtLeadershipSeries-DrBenCaldecott-1.pdf

Carney, M., 2020. The Road to Glasgow. Speech given at Guildhall, 27 February. Available at: https://www.bankofengland.co.uk/-/media/boe/files/speech/2020/the-road-to-glasgow-speech-by-mark-carney.pdf?la=en&hash=DCA8689207770DCBBB179CBADBE3296F7982FDF5

CBI, 2020. Climate Bonds Taxonomy. Climate Bonds Initiative (CBI). Available at: https://www.climatebonds.net/standard/taxonomy

Cicero, 2020. Shades of green fact sheet. Available at: https://www.cicero.green/our-approach

Climate Interactive, 2020 (access). En-ROADS. Available at: https://en-roads.climateinteractive.org/scenario.html?v=2.7.29

CPI, 2019. Global Landscape of Climate Finance 2019. Available at: https://climatepolicyinitiative.org/publication/global-landscape-of-climate-finance-2019/

Cui, R.Y., Hultman, N., Edwards, M.R. et al. Quantifying operational lifetimes for coal power plants under the Paris goals, 2019. Nat Communication 10, 4759. Available at: https://doi.org/10.1038/s41467-019-12618-3

DOE-ONE, 2020. What's the Lifespan for a Nuclear Reactor? Much Longer Than You Might Think. Department Of Energy, Office of Nuclear Energy (DOE-ONE). Available at: https://www.energy.gov/ne/articles/whats-lifespan-nuclear-reactor-much-longer-you-might-think

DOT and BTS, 2018. Transportation Statistics Annual Report 2018. U.S Department Of Transportation (DOT), Bureau of Transportation Statistics (BTS). Available at: https://doi.org/10.21949/1502596

EIA. 2011, Age of electric power generators varies widely. U.S. Energy Information Administration (EIA). Available at: https://www.eia.gov/todayinenergy/detail.php?id=1830

EIA. 2016, Carbon Dioxide Emissions Coefficients. U.S. Energy Information Administration (EIA). Available at: https://www.eia.gov/environment/emissions/co2_vol_mass.php

EIA. 2017, Natural gas generators make up the largest share of overall U.S. generation capacity. U.S. Energy Information Administration (EIA). Available at: https://www.eia.gov/todayinenergy/detail.php?id=34172

EIA, 2019a. How old are U.S. nuclear power plants, and when was the newest one built? U.S. Energy Information Administration (EIA). Available at: https://www.eia.gov/tools/faqs/faq.php?id=228&t=21

EIA, 2019b. Annual Electric Generator Report 2018, Table 8.2. Average Tested Heat Rates by Prime Mover and Energy Source 2008-2018. U.S. Energy Information Administration (EIA). Available at: https://www.eia.gov/electricity/annual/html/epa_08_02.html

EIA, 2020a. Annual Energy Outlook. U.S. Energy Information Administration (EIA). Available at: https://www.eia.gov/outlooks/aeo/

EPA, 2014. Emission Factors for Greenhouse Gas Inventories. U.S. Environmental Protection Agency (EPA), Available at: https://www.epa.gov/sites/production/files/2015-07/documents/emission-factors_2014.pdf

EPA, 2019. Model Year 2018 Green Vehicle Guide. U.S. Environmental Protection Agency (EPA), Available at: https://www.fueleconomy.gov/feg/EPAGreenGuide/pdf/all_alpha_18.pdf

EPA, 2020. The 2019 EPA Automotive Trends Report. U.S. Environmental Protection Agency (EPA), Available at: https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100YVFS.pdf

EU-TEG, 2020. Taxonomy: Final report of the Technical Expert Group on Sustainable Finance. European Union Technical Expert Group (EU-TEG) on Sustainable Finance (ed.). European Commission, Brussels. Available at:

https://ec.europa.eu/info/sites/info/files/business_economy_euro/banking_and_finance/documents/200309-sustainable-finance-teg-final-report-taxonomy_en.pdf

EU-TEG, 2019. Taxonomy Technical Report. European Union Technical Expert Group (EU-TEG) on Sustainable Finance (ed.). European Commission, Brussels. Available at: https://ec.europa.eu/info/sites/info/files/business_economy_euro/banking_and_finance/documents/190618-sustainable-finance-teg-report-taxonomy_en.pdf

FinanceMap, 2020 (access). FAQ. Available at: https://financemap.org/faq

FixTheWEO, 2020 (access). The IEA needs to change course. Available at: http://www.fixtheweo.org/

Fuel Economy, 2020 (access). U.S. Department of Transportation, Office of Energy Efficiency & Renewable Energy. Available at: https://www.fueleconomy.gov/

Germanwatch, NCI and WRI. 2020. Aligning Multilateral Development Banks' Operations with the Paris Agreement's Mitigation Objectives. Germanwatch, New Climate Institute (NCI), World Resource Institute (WRI). Available at: https://www.germanwatch.org/sites/germanwatch.org/files/Memo1%20-%20Mitigation.%20MDB%20Paris%20Alignment.pdf

GGP, 2020 (access). Corporate Standard. Greenhouse Gas Protocol (GGP). Available at: https://ghgprotocol.org/corporate-standard

I4CE, CPI, 2019. Aligning with the Paris Agreement - A CPI and I4CE Executive Summary. Institute for Climate Economics (I4CE) and Climate Policy Initiative (CPI). Available at: https://www.i4ce.org/wp-core/wp-content/uploads/2019/09/I4CE_CPI_ESjoint_Aligning_with_the_Paris_Agreement.pdf

IEA, 2017. Energy Technology Perspectives 2017. International Energy Agency (IEA), Paris. Available at: https://www.iea.org/reports/energy-technology-perspectives-2017

IEA, 2019a. World Energy Investment 2019. International Energy Agency (IEA), Paris. Available at: https://www.iea.org/reports/world-energy-investment-2019

IEA, 2019b. World Energy Outlook 2019. International Energy Agency (IEA), Paris. Available at: https://www.iea.org/reports/world-energy-outlook-2019

IEA, 2020a (access). World Energy Outlook. International Energy Agency (IEA), Paris. Available at: https://www.iea.org/topics/world-energy-outlook

IEA, 2020b. CO2 Emissions from Fuel Combustion: Overview, International Energy Agency (IEA), Paris. Available at: https://www.iea.org/reports/co2-emissions-from-fuel-combustion-overview

IEA, 2020c. CO2 emissions from fuel combustion 2020 edition – Database Documentation. International Energy Agency (IEA), Paris. Available at: http://wds.iea.org/wds/pdf/Worldco2_Documentation.pdf

IEA, 2020d. Electricity generation and power sector CO2 emissions in advanced economies, 1971-2019. International Energy Agency (IEA), Paris. Available at: https://www.iea.org/data-and-statistics/charts/electricity-generation-and-power-sector-co2-emissions-in-advanced-economies-1971-2019

IEA, 2020e.World energy Outlook 2020. International Energy Agency (IEA), Paris. Available at: https://www.iea.org/reports/world-energy-outlook-2020/achieving-net-zero-emissions-by-2050

IIASA, 2020 (access). IAMC 1.5ºC Scenario Explorer. Available at: https://data.ene.iiasa.ac.at/iamc-1.5c-explorer/#/workspaces

Institut Louis Bachelier, 2020. The Alignment Cookbook: A Technical Review of Methodologies Assessing a Portfolio's Alignment with Low-Carbon Trajectories or Temperature Goal. https://www.louisbachelier.org/wp-content/uploads/2020/07/rapport-0207-mis-a-jours.pdf

IRENA, 2020. Renewable Power Generation Costs in 2019. International Renewable Energy Agency (IRENA). Available at: https://www.irena.org/costs/Power-Generation-Costs/Wind-Power

Lazard, 2019. Lazard's Levelized Cost of Energy Analysis – Version 13.0. https://www.lazard.com/media/451086/lazards-levelized-cost-of-energy-version-130-vf.pdf

Mills, A., R. Wiser, J. Seel, 2017. Power Plant Retirements: Trends and Possible Drivers. Energy Analysis and Environmental Impacts Division, Lawrence Berkeley National Laboratory. Available at: https://eta-publications.lbl.gov/sites/default/files/lbnl_retirements_data_synthesis_final.pdf

NEA, 2015. Projected Costs of Generating Electricity - 2015 Edition. Nuclear Energy Agency (NEA). Available at: http://www.oecd-nea.org/jcms/pl_14756

NHTS, 2017. National Household Travel Survey 2017. U.S. Department of Transportation, Federal Highway Administration. National Household Travel Survey (NHTS). Available at: https://nhts.ornl.gov/

Nyberg, M., 2014. Thermal Efficiency of Gas-Fired Generation in California: 2014 Update. California Energy Commission, Energy Assessments Division, Supply Analysis Office. Available at: http://large.stanford.edu/courses/2016/ph240/wang1/docs/CEC-200-2014-005.pdf

OECD, 2018. Developing Robust Project Pipelines for Low-Carbon Infrastructure, Green Finance and Investment. OECD Publishing, Paris. Available at: https://doi.org/10.1787/9789264307827-en

OGP, GSA, 2020 (access). FY18 Federal Fleet Open Data Visualization. GSA, Data 2 Decision, Office of Governmentwide Policy (OGP). U.S. General Services Administration (GSA), Available at: https://d2d.gsa.gov/report/federal-fleet-open-data-visualization

Pfeiffer A., R. Millar, C. Hepburn, E. Beinhocker, 2016. The '2!C capital stock' for electricity generation: Committed cumulative carbon emissions from the electricity generation sector and the transition to a green economy. Applied Energy 179 (2016) 1395-1408. Available at: https://www.inet.ox.ac.uk/files/The_%E2%80%982%C2%B0C_capital_stock%E2%80%99_for_electricity_generation.pdf

Roston E., 2020. Top Scientists Just Ruled Out Best-Case Global Warming Scenarios. Bloomberg Green. 22 July 2020. Available at: https://www.bloomberg.com/news/articles/2020-07-22/top-scientists-just-ruled-out-best-case-global-warming-scenarios

SBTi, 2018. Criteria and Recommendations. Available at: https://sciencebasedtargets.org/wp-content/uploads/2017/02/SBTi-criteria.pdf

SBTi, 2019. Foundations of Science-based Target Setting. Available at: https://sciencebasedtargets.org/wp-content/uploads/2019/04/foundations-of-SBT-setting.pdf

SBTi, 2020a (access). Methods. Available at: https://sciencebasedtargets.org/methods-2/

SBTi, 2020b (access). SBTi-tool (V1.1). Available at: https://sciencebasedtargets.org/sbti-tool/

SBTi, 2020c. Science-Based Target Setting Manual. Available at: https://sciencebasedtargets.org/wp-content/uploads/2017/04/SBTi-manual.pdf

S&P Global Market Intelligence, 2017. World Electric Power Plants Data Base (WEPP). Available at:
https://www.spglobal.com/platts/en/about

Sherwood S. C., M. J. Webb J. D. Annan K. C. Armour P. M. Forster J. C. Hargreaves G. Hegerl S. A. Klein K. D. Marvel E. J. Rohling M. Watanabe T. Andrews P. Braconnot C. S. Bretherton G. L. Foster Z. Hausfather A. S. von der Heydt R. Knutti T. Mauritsen J. R. Norris C. Proistosescu M. Rugenstein G. A. Schmidt K. B. Tokarska M. D. Zelinka. 2020. An Assessment of Earth's Climate Sensitivity Using Multiple Lines of Evidence. Reviews of Geophysics, Volume 58, Issue 4, December 2020. Available at: https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2019RG000678

TCFD, 2017. Recommendations of the Task Force on Climate-related Financial Disclosures. June. Task Force on Climate-related Financial Disclosures (TCFD). Available at: https://www.fsb-tcfd.org/publications/final-recommendations-report/

Trucost, 2019. Understanding Climate Risk at the Asset Level: The Interplay of Transition and Physical Risks. Available at: https://www.trucost.com/publication/understanding-climate-risk-at-the-asset-level-the-interplay-of-transition-and-physical-risks/

UNFCCC, 1992. UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE. Available at: https://unfccc.int/sites/default/files/convention_text_with_annexes_english_for_posting.pdf

Wiser, R., Bolinger, M., 2019. Benchmarking Anticipated Wind Project Lifetimes: Results from a Survey of U.S. Wind Industry Professionals. Lawrence Berkeley National Laboratory. Available at: https://eta-publications.lbl.gov/sites/default/files/wind_useful_life_report.pdf

climatepolicyinitiative.org