Sustainable1

Trucost Environmental Model

V3.0 BETA Methodology

CONFIDENTIALITY: EXTERNAL

S&P Global Sustainable1 – September 2026

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Terms and Definitions

Term	Description
Business Activities	A standardized sector classification covering 1000+ unique economic activities, including ~750 granular (detailed-level) activities and ~250 overarching (summary-level) activities.
Carbon Dioxide Equivalent (CO2e)	A metric used to compare the emissions of different greenhouse gases based on their global warming potential (GWP) relative to carbon dioxide (CO2). Greenhouse gas totals are usually calculated in metric tons of CO2e.
Data Source Flag	An identifier used to indicate the original source of a data point in the dataset, taking into account collected company environmental disclosures and various modeling approaches.
Direct Operations	Business operations that occur at locations or sources owned or controlled by the company.
Ecosystem Services	Services, such as climate regulation and water filtration, that are naturally provided by ecosystems to the benefit of local and/or global populations.
Environmental Damage Cost	A monetary value representing the negative environmental externality (to society) associated with a given environmental emission (or resource use) in a given location.
Environmental Indicator	Categorization of the individual environmental pollutants (and resource use) covered in the assessment of a company's environmental impacts.
Environmental Intensity Factor	A quantity of pollutant emission (or resource use), measured in standardized units (e.g. metric tons or cubic meters), normalized by a quantity of output (e.g. revenue or production volume). Intensity factors represent the environmental emission (or resource use) intensity of an activity. They are typically used to estimate the environmental impacts of a company either from their direct operations or the supply chain (indirect).
Externality	The indirect impact of an economic activity affecting third parties not directly involved in the activity, and not reflected in market prices.
Geographic Segment Distribution Dataset (GeoSeg)	Internal S&P Global dataset of company revenue split by the countries (or regions) into which it sells its goods and services.
Global Warming Potentials (GWPs)	GWPs are numerical values that quantify the relative contribution of different greenhouse gases to global warming over a specified time period, typically 100 years. These values help to assess the impact of emissions from various sources by transforming outputs into one equivalent unit.
Greenhouse Gases (GHGs)	Gases that trap heat in the atmosphere and contribute to the greenhouse effect, such as carbon dioxide, methane, and nitrous oxide.
Gross Domestic Product (GDP)	The total market value of all final goods and services produced within a country over a specific period, serving as a key measure of economic activity and growth.

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Impact Scope	Categorization of the origin of an environmental impact within a company's value chain, including both upstream (i.e. supply chain) and downstream (e.g. product use/end-of-life) origins.
Input-Output Tables (IOTs)	Tables describing the sale and purchase relationships between producers and consumers within an economy.
Natural Capital	The stock of renewable and non-renewable natural resources (e.g. plants, animals, air, water, soils, minerals) that combine to yield a flow of benefits to society.
North American Industry Classification System (NAICS)	A standardized system used to classify business establishments by industry across North America.
Scope 1 GHG Emissions	The GHG emissions from sources that are owned or controlled by a company - for example, emissions from combustion in owned or controlled boilers, furnaces, vehicles, etc.
Scope 2 GHG Emissions	The GHG emissions from the generation of purchased electricity, heat, steam, or cooling, consumed by a company.
Scope 2 Location-Based GHG Emissions	The Scope 2 GHG emissions based on the average emissions intensity of the grid where the energy is consumed.
Scope 2 Market-Based GHG Emissions	The Scope 2 GHG emissions based on the specific energy contracts or certificates a company has chosen.
Scope 3 GHG Emissions	All other indirect GHG emissions emitted beyond a company's direct control, both upstream in the supply chain and downstream. For example, emissions from the production of purchased materials, and from the use of sold products and services.
Scope 3 Downstream GHG Emissions	The GHG emissions related to a company's sold goods and services (i.e. after the point of manufacture/sale).
Scope 3 Upstream GHG Emissions	The GHG emissions related to the indirect emissions that occur in the production and transportation of the goods and services a company purchases from its suppliers.
Social Capital	The networks, together with shared norms, values and understanding that facilitate cooperation within and among groups.
Social Cost of Carbon (SCC)	The valuation of the marginal cost of each additional metric ton of GHGs emitted in the atmosphere and over its lifetime.
Statistical Classification of Economic Activities in the European Community (NACE)	The European Union's standardized system for classifying economic activities, used for statistical, regulatory, and business purposes.
Supply Chain Operations	Business operations that occur within a company's upstream value chain, at locations or sources owned or controlled by another entity.
Supply Chain Tier	Categorization of suppliers based on their proximity to the final product of the company. For example tier 1 relates to the direct suppliers of a company, tier 2 suppliers supply tier 1, tier 3 suppliers supply tier 2, and so on.
Trucost Environmental Model V3.0	The Trucost Environmental Model is used to estimate the environmental impacts of companies across direct operations and the entire supply chain. This documentation provides details on the third version of the model (E-Model 3.0).

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Introduction and Context

Objective

S&P Global Sustainable1 (S1) measures company environmental impacts across key dimensions such as Greenhouse Gas (GHG) emissions, air pollution, water use, land use, and waste disposal. The Trucost Environmental dataset provides comprehensive environmental profiles for over 30,000 companies. This data serves multiple purposes: evaluating environmental impacts (and the associated externalities), managing climate and environmental risks, and conducting peer and portfolio analyses from an environmental perspective.

The Trucost Environmental dataset underpins a range of S1 products and solutions. The Trucost Environmental Model is used to estimate company direct and supply chain environmental impacts in the absence of as-reported (disclosed) data, and these estimates inform the S&P Generated data received by clients. Table 1 provides a hypothetical example for Scope 1 GHG emissions where the S&P Generated total value is higher because S1 has estimated a quantity for methane, which is in addition to the disclosure for carbon dioxide and nitrous oxide.

Table 1 Scope 1 GHG Emissions – S&P Generated vs As Reported

Greenhouse Gases	**Quantity (metric tons CO2e)**	
	As Reported	**S&P Generated**
Carbon Dioxide	1,000,000	1,000,000
Methane		20,000
Nitrous Oxide	350	350
Total	**1,000,350**	**1,020,350**

Maintaining a robust and up-to-date model approach is therefore essential to ensure it accurately reflects current economic activity and the evolving environmental impact landscape.

Business Case

Trucost Environmental Model Version 3.0 (E-Model 3.0) has been developed to improve the granularity, accuracy, and breadth of S1's environmental data sets. This latest model delivers a significant upgrade from its predecessor, with a series of major methodological improvements implemented alongside enhanced functionality. The main benefits of the updated methodology are summarized in Table 2 below.

Table 2: Main Benefits of the Environmental Model V3.0 [BETA]

Feature	**Overview**
Transparency	Methodology design, assumptions, and key decision points are documented across all major model components, supporting a transparent, traceable, and consistently applied modeling approach. Detailed source referencing is provided for every input model factor.
Applicability	Full refresh of all underlying data sources, for each model component, integrating the latest and best-available sources to reflect current context.

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Granularity	Enhanced granularity in key areas of the dataset, including expanded business activities (from 464 to 1000+), breakdown of Scope 3 upstream GHG emissions (by category), and additional environmental indicators, including new land use metrics, break out of water consumption and water withdrawal indicators, and expanded coverage of major air and water pollutants.
Coverage	• Expanded coverage of environmental estimations, and core factor coverage across every single business activity (including CO2, CH4, N2O, land use, water use, waste, etc.) • Additional fuel emissions factors for expanded fuel coverage, now covering 50+ individual fuels, including biofuels, across a broader set of GHG and air pollutant indicators.
Accuracy	• Weighted-average factors for higher-level parent industries (for use where granular level industry information not available), regionalized based on technology mix for key industries such as electricity generation and steel manufacturing. • Implementation of new related-metric-model to estimate key related metrics in the absence of full disclosure (e.g. estimate PM2.5 based on disclosed PM10, estimate water consumption based on disclosed water withdrawal). • Production-based modeling: Added a database of GHG intensity factors per unit of physical production (e.g. tons of cement manufactured), enabling the estimation of company emissions based on reported physical production data, for selected industries.
Timeliness	The model incorporates real-time sector-specific price indices and inflation adjustments, where relevant, enabling estimates to better reflect current market conditions and changes in product pricing, year-over-year.
Regionalization	The model considers geographic specificity of environmental impacts, specifically in relation to Scope 2 GHG estimates (based on regional electricity grid mix) and environmental damage costs. The environmental damage costs now reflect important differences in environmental externalities, including those associated with regional variations in water stress, population density and ecosystem service value.
Flexibility	The model architecture has been designed to support efficient maintenance, updates, and enhancement. Its modular structure facilitates the integration of new datasets, methodologies, and analytical capabilities as they become available.

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Data Sources and Collection

S1 uses a range of publicly available external data sources, alongside various internal S&P data sources, to inform E-Model 3.0. Table 3 highlights some of the primary sources.

Table 3: Key data sources for E-Model 3.0

E-Model 3.0 Component	Use Case	Primary Data Sources
Revenue-based Direct Intensity Factors	US environmental pollutant release totals per business activity	United States Environmental Protection Agency Flow Sector Attribution (EPA FLOWSA) database[14]
	US gross output per business activity	United States Bureau of Economic Analysis (BEA) GDP-By-Industry tables[12]
Production-based Direct Intensity Factors	GHG emissions per metric ton of production	• United States Environmental Protection Agency (EPA) U.S. Cement Industry Carbon Intensities[15] • International Energy Agency (IEA) Average GHG emissions intensity for production of selected commodities[6]
Fuel Emission Factors	Air pollutants and GHG emissions from fuel use	• UK National Atmospheric Emissions Inventory (NAEI)[10] • United States Environmental Protection Agency (EPA) GHG Emission Factors Hub[16] • UK Department for Energy Security and Net Zero (DESNZ) Greenhouse gas reporting: conversion factors 2021 [2]
Employee-Commuting Intensity Factors	Calculating Employee-Commuting Intensity Factors	U.S. Department of Transportation (DOT) Federal Highway Administration (FHA) National Household Travel Survey: Summary of Travel Trends[13]
Supply Chain Intensity Factors	Supply Chain Intensity Factors	• United States Bureau of Economic Analysis (BEA) 'Make' and 'Use' tables [11] • Organization for Economic Cooperation and Development (OECD) Inter-Country Input-Output Tables [8] • United States Environmental Protection Agency Flow Sector Attribution (EPA FLOWSA) database[14]

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Methodology Summary

1. Model Dimensions

The key dimensions of the Trucost Environmental Model V3.0 are shown in Figure 1. The following sections cover the different dimensions of the model, including environmental indicators, impact scopes, regions and business activities.

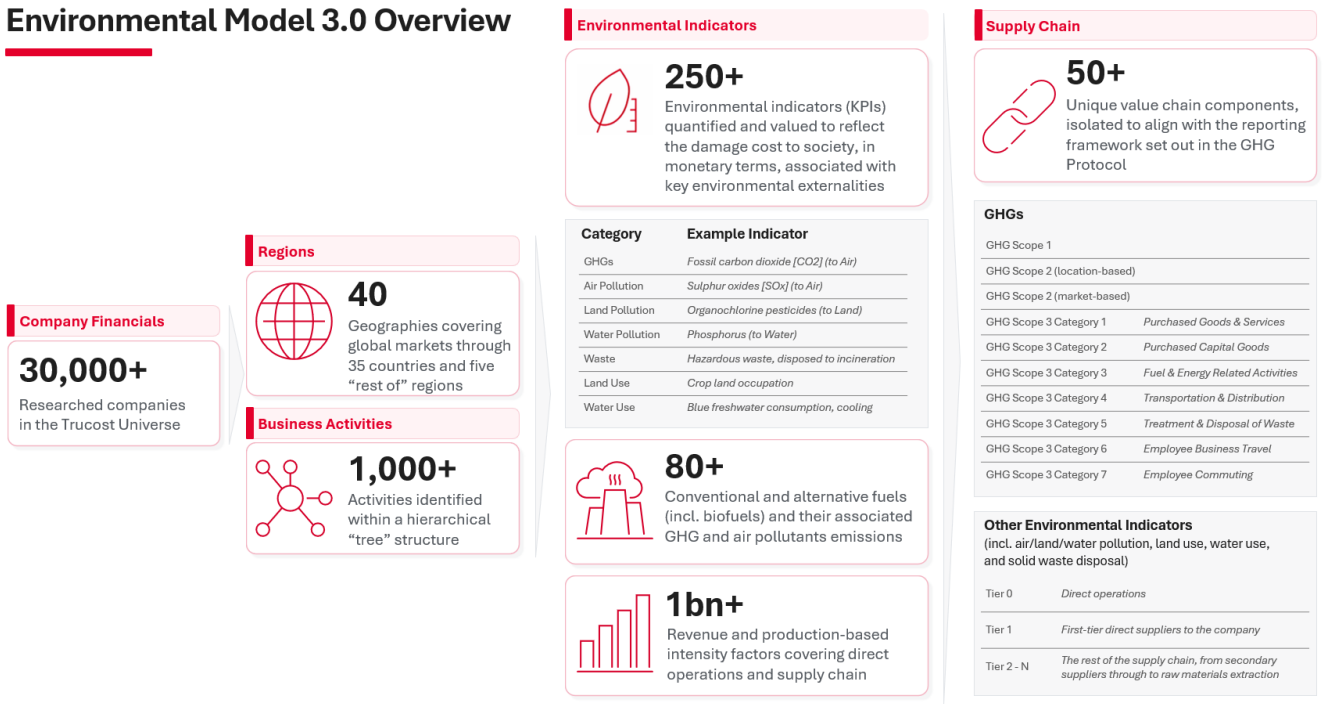


Figure 1: E-Model 3.0 Overview [BETA]

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1.1. Company Financials and Environmental Disclosures

S&P Global Environmental Data analysts (analysts) collect financial data for the initial modeling of environmental metrics:

- Consolidated revenues, EBITDA and EBIT are collected from S&P Global Market Intelligence in local currency. These values are standardized in USD based on the average daily London spot rate over the fiscal year in question. This ensures there is consistency across the Market Intelligence and Sustainable1 data.
- The analysts then segment company revenues by business activity.

Separately, environmental disclosure data is also collected by analysts to inform the creation of environmental profiles. The latter includes, but is not limited to, the list of sources below:

- Company Annual Reports or 10K Reports
- Corporate Sustainability Reports / Environmental Reports
- Climate Disclosure Project (CDP) Responses
- Company Websites
- Company Communication

Analysts use estimations to sense-check all disclosure, and determine whether the disclosure can be incorporated into a company's profile. All companies that go through the research process are considered fully researched companies covering approximately 30,000 public companies.

1.2. Regions

E-Model 3.0 incorporates information on each company's revenue split by geography, taken from S&P Global Geographic Segment Distribution Dataset (GeoSeg). This internal S&P Global dataset uses a data modeling approach to disaggregate company-disclosed geographic revenue segments across underlying countries (or regions), using Gross Domestic Product (GDP) as a weighting factor, where necessary. Integrating GeoSeg allows for the regionalization of estimated environmental data at the company level and improves accuracy as follows:

- Scope 2 GHG emission estimates reflect regional variations in electricity grid mix.
- Damage costs reflect regional variations in key geographic contexts, such as population density and water stress.

1.3. Business Activities

E-Model 3.0 includes over 1,000 unique business activities, which are organized in a hierarchical tree structure covering up to nine levels. This allows for accurate categorization of a company's revenue data, enhancing the accuracy of S1's modeling capabilities.

The business activities are based on both the North American Industry Classification System (NAICS) and Statistical Classification of Economic Activities in the European Community (NACE) – the granular levels are more closely aligned with NAICS, and the higher levels are more closely aligned with NACE.

S1 bases its Business Activities on NAICS and NACE because they are closely related systems that cover the economic activities of North America and Europe, from which the majority of the external data sources also derive. NAICS also aligns with the previous version of the environmental model (version 2.0)[7] and the input-output tables used in the underlying supply chain calculations. In addition, both classifications are relatively well aligned with the key drivers of environmental impacts.

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1.4. Environmental Indicators

The model covers over 250 unique environmental indicators (which we also refer to within this document as environmental key performance indicators [KPIs]). These environmental KPIs represent a vast array of individual chemical pollutants, greenhouse gases, solid waste types, and environmental-related resource use, specifically water withdrawal and consumption, and land use.

Chemical pollutant emissions cover emissions to air, land, and water of various categories of pollutants, including heavy metals, nutrients, pesticides, other organics, and smog-forming pollutants. Solid waste types include hazardous and non-hazardous waste disposal to landfill and incineration, as well as high-level radioactive waste and mining tailings.

Water use is subcategorized according to lifecycle use – withdrawal, consumption or discharge. Waste is subcategorized according to type such as hazardous, non-hazardous, radioactive or mining.

1.5. Supply Chain Tiers and Impact Scopes

To provide a transparent view of a company's total footprint, all environmental emissions (and resource use) are categorized based on where in the value chain the impact occurs. The impacts are classified into two primary areas in this BETA release:

- Direct Operations: Impacts generated directly by the company's own activities
- Upstream Supply Chain: Indirect impacts generated by the company's suppliers.

1.5.1. Greenhouse Gas (GHG) Emissions

For greenhouse gases, our impact scope structure is based on the best-practice reporting methods of the Greenhouse Gas (GHG) Protocol (see Figure 2). To ensure alignment with this reporting framework, we apply specific intensity factors to calculate Scope 1 (direct), Scope 2 (upstream electricity), and individual Scope 3 (upstream other supply chain) categories.

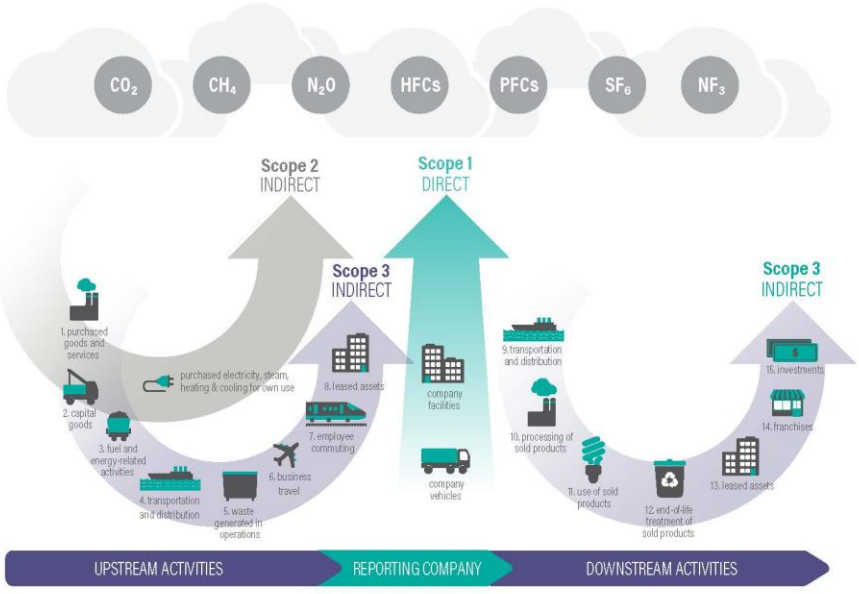


Figure 2: Overview of GHG Protocol Scopes and Emissions

Source: Greenhouse Gas (GHG) Protocol, 2011[5].

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1.5.2. Broader Environmental Indicators

For all other (non-GHG) environmental indicators (such as water use and waste disposal), impacts are systematically structured into three distinct supply chain tiers:

- Tier 0: Direct operations.
- Tier 1: First-tier direct suppliers to the company.
- Tier 2-N: The rest of the extended supply chain, from secondary suppliers through to raw material extraction.

1.6. Environmental Damages

The world's largest companies depend on natural capital for their operations yet cause trillions of dollars in environmental costs that are not accounted for each year. Hidden environmental costs represent some of the most significant negative externalities in the global economy, the indirect impact of economic activities affecting third parties not directly involved in the activities, and not reflected in market prices.

Familiar examples of these negative externalities are widespread, from air pollution in dense city centers causing respiratory disease to industrial waste discharged into rivers and streams damaging aquatic ecosystems. While regulatory and investor pressure has led some sectors in different regions to address their environmental externalities, many remain unaccounted for around the world. The largest of these is anthropogenic global warming caused by greenhouse gas (GHG) buildup in the atmosphere, which scientists have linked to increasingly destructive weather patterns and rapid biodiversity loss globally.

S&P Global Sustainable1 assigns a monetary value to these externalities for each company in the Trucost Environmental dataset at business activity and regional level. Assigning a monetary value linked to environmental impacts contributes to efforts to measure natural capital in economic terms that resonate with capital markets participants. In doing so, the dataset can help investors, policymakers and other stakeholders more accurately measure the full costs of sectors and business activities in specific regions: not only the materials, labor, taxes and other operating costs contained in financial statements but also the equally real costs to nature and human health.

More information on environmental damage costs can be found in the S&P Global Report: Unpriced Environmental Costs: The Top Externalities of the Global Market (2024)[9].

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2. Calculation Layers

The model builds a unified and comprehensive environmental profile for each company by integrating data across its specific functions, operations and supply chain. The environmental profiles include:

- **Granular Emission Quantities:** Environmental impacts broken down by specific business activities, regions, and impact scopes.
- **Environmental Damage Costs in USD**: Localized financial estimates of the environmental harm caused by a company's operations.
- **Aggregated Metrics:** High-level, standardized metrics (such as Scope 1, Scope 2, and total indirect upstream supply chain impacts) alongside transparent data source flags.

The E-Model 3.0 methodology follows a strict hierarchy of data sources, prioritizing company reported disclosures first and relying on sophisticated estimation models when reported data is unavailable.

2.1. Model Structure

The calculation engine derives the total environmental profile of a company, including quantity of emission (or resource use) and associated environmental impact. The model is comprised of different modules, as seen in Figure 3. Note that items are numbered by priority order from higher (1) to lower (6).

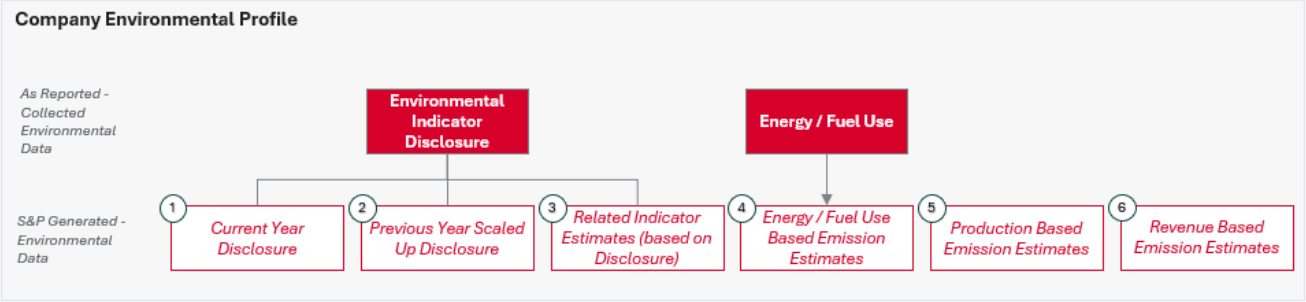


Figure 3: Overview of Environmental Profile Calculation Structure

The following sections provide more details on each calculation layer to derive the environmental profile. The model logic is built in Python; Appendix 1 shows the decision logic flow-chart.

2.1.1. Reported Company Disclosures (Current Year)

The most accurate information available is the environmental data directly reported by a company. S1 actively sources environmental performance metrics - such as greenhouse gas (GHG) emissions, water use, pollution, and waste - from publicly disclosed sources e.g. annual reports, sustainability reports, ESG reports, company websites, and third-party datasets such as the CDP.

- **Quality Control:** To ensure accuracy, rigorous data control procedures are applied, including specialist reviews, automated outlier detection, and year-over-year comparisons. S1 also engages with researched companies annually to verify datapoints and gather additional context.
- **Standardization:** All collected data is standardized into uniform units and mapped to consistent indicators. This ensures comparability across companies and aligns the reported data seamlessly with S1's estimation models.

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The reported data is compiled, cleaned and units are standardized. The data is then allocated to business activity, region, tier, and scope level of the supply chain, using the available estimated quantities at the granular level (see Section 3.).

In the absence of disclosed environmental performance data, S1 uses the other model calculation layers, tagged as lower priority, to calculate a complete environmental profile for a company. To support this, S1 also collects information on a company's revenue breakdown (by business activity) and production data (where relevant).

2.1.2. Scaling Previous Year Disclosure

If a company disclosed data in a previous year but has not disclosed data for the current year, E-Model 3.0 extrapolates the prior year's quantities to estimate the current year's impact. The previously reported quantity is scaled by analyzing changes in the company's operations between the years. S1 applies the following ratio based on estimated data to adjust historical disclosed data for the current year:

$$Scaled\ Quantity_{Current\ Year} = Disclosed\ Quantity_{Previous\ Year} \times \frac{Estimated\ Quantity_{Current\ Year}}{Estimated\ Quantity_{Previous\ Year}}$$

Notes:

- To maintain accuracy, this extrapolation is only applied for up to two years following an original disclosure**;** provided there is no drastic change in the company's operating structure (e.g. its revenue breakdown by business activity).
- The previous year and latest year estimates used to scale the value within the ratio are selected based on best available, according to the priority of the model calculation layers: fuel use based estimates, production based estimates and revenue based estimates.

2.1.3. Estimating Related Environmental Indicators

In some cases, if a company reports data for one specific environmental metric, we can use that information to more reliably estimate a closely related metric. We use two main approaches to ensure that these estimates are accurate and avoid double-counting.

Related, Ratio-Based Estimates

For specific indicators - such as water usage and particulate matter (air pollution) - E-Model 3.0 uses reported data to estimate missing data for related indicator. For example, if a company reports its fine particulate emissions (PM2.5) but not its coarse particulate emissions (PM10), S1 applies a standardized ratio based on the estimated quantities of the two metrics, to gap fill the missing indicator.

Preventing Double Counting: Zero-out Logic

To ensure a company's environmental impact is not overstated, the model includes safeguards to prevent double counting. If a company has already reported data for a specific metric, the model does not generate overlapping estimates for the same metric, or a broader, related category (and vice versa).

For example, if a company reports specific data for waste sent to a landfill and waste sent to incineration, the estimate for the same metric, as well as the additional estimate for the indicator "unspecified waste" will not be generated. Conversely, if a company reports a bulk figure for "unspecified waste" the estimation of separate line items for landfill and incineration waste indicators will not be performed, as those impacts are already captured in the broader reported number.

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2.1.4. Fuel-based Estimates

If a company discloses fuel use split by fuel type – for example, natural gas or coal - fuel emission factors (EFs) are applied on the fuel use quantities to estimate the likely direct (operational) emissions to air resulting from fuel combustion.

The reported fuel data is compiled, cleaned and units are standardized, then S1 applies fuel EFs to calculate the resulting environmental impacts. The direct estimated emissions are then allocated to business activity, region, tier, and impact scope level using the available estimated quantities at the granular level (see Section 3.).

Note that if the result of the above calculation is zero, the model assumes that no material emissions occurred for that specific activity, and this will be reflected in the model outputs. Additionally, if a significant portion of a company's emissions are expected to originate from non-fuel sources, then the process emissions are prioritized instead of the fuel data, through the data point collection process. The assumption is based on the company's operational activities.

2.1.5. Production-based Estimates

Where production data is material and available, the environmental profile is estimated based on physical production quantities (such as metric tons of cement). The company's total production volumes are distributed across its business activities and regions (based on revenue splits). S1 then applies product-specific, production-based intensity factors at the most granular level (see Section 3.2.) to estimate the environmental profile of the company.

2.1.6. Revenue-based Estimates

This model calculation layer is the lowest level in the calculation hierarchy, and is the baseline estimation model when disclosure, fuel or production data is unavailable. It involves estimating environmental impacts using the company revenue data split by business activity and region. The company revenue split by business activity and region is compiled, then revenue-based intensity factors (as detailed in Section 1. 3.1.) are applied at the most granular level to estimate the associated environmental impacts. Revenue-based estimates have the greatest coverage within the researched universe, and can provide an estimate for every material environmental indicator at all levels of the value chain.

2.2. Generating Granular Insights

To provide actionable insights, top-level company data must be broken down ('allocated') into specific business activities, regions, and impact scopes.

2.2.1. Operation Layers and Data Allocation

To enable a detailed analysis of each company's environmental footprint, S1 allocates disclosed environmental data (company level – environmental indicator or total CO2e) and fuel-use based GHG estimations, across specific business activities and geographic regions covering the company operations. This allocation is performed systematically using a structured framework:

- Disclosures are distributed across a company's business activities and regions based on corresponding, granular production and revenue estimates.
- When direct granular estimates are unavailable to perform the allocation, the model systematically applies relevant proxy environmental indicators or standardized fallback options to ensure a complete and representative distribution across all operational layers, tiers and scopes of the supply chain.

2.3. Applying Environmental Damage Costs

Once a physical quantity of environmental impact is calculated and allocated, the environmental damage cost in monetary terms is applied, to quantify the impact to society and the environment. These costs are regionalized, factoring in the specific regions (and, for air pollutants, the likely emission origin) to accurately reflect the localized harm to human health and the environment.

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2.4. Final Output

The final step of the methodology is to aggregate the highly granular calculations into the accessible, usable data points displayed in the product. These final outputs include:

- **Detailed Metrics:** Total environmental emission quantities, intensities, and associated environmental damage cost, broken down across direct operations and the broader supply chain.
- **Standardized Reporting Metrics:** Aggregated global metrics, such as total Scope 1 and Scope 2 emissions.
- **Data Source Flags:** Clear indicators on every data point to identify which calculation layer has been applied to generate each data point. Table 4 provides the individual data source flags used in E-Model 3.0. Note that if aggregated outputs are the combination of more than one source, the resulting aggregated data source flag would be a combination of the data source flags in this table.

Table 4 E-Model 3.0 Data Source Flags

Estimate (from multiple sources)
Estimate (from extrapolation)
Estimate (from energy-use model)
Estimate (from production model)
Estimate (from revenue model)
Disclosure (from multiple sources)
Disclosure (from personal communication)
Disclosure (from Annual Report/10K/Financial Accounts)
Disclosure (from Environmental/CSR)
Disclosure (from CDP)

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3. Environmental Intensity Factors

When a company does not disclose its environmental data, E-Model 3.0 fills the gap using environmental intensity factors. An intensity factor is the quantity of a pollutant emitted, or resource used (e.g., metric tons, metric tons of CO2e, m2, m3) by a performed activity normalized by a specific unit of economic (revenue) or physical output (unit of production).

Where relevant, the model adjusts for materiality, ensuring that specific environmental indicators (e.g. mining tailings) are only applied to the business activities for which they are relevant. S1 utilizes three primary modeling approaches: revenue-based intensity factors, production-based intensity factors, fuel emission factors.

3.1. Revenue-based Intensity Factors:

This approach estimates environmental impacts based on the revenue generated by a company's individual business activities, applying industry-average impacts per million USD of economic output. The estimation of emissions or resource use is performed across three key operational layers:

3.1.1. Direct Operations

To estimate direct operational impacts, the direct intensity factors are created by mapping and normalizing aggregated environmental pollutant flows against gross industry output.

- The aggregated industry level emission data by year relies heavily on U.S. industry emissions totals, supplemented by a large range of additional sector-specific datasets. Financial denominators are adjusted for inflation using the U.S. Bureau of Economic Analysis (BEA) price indices to ensure consistency across all modeled years (2005 onwards).

Notes:

- For greenhouse gases (GHGs), factors are based on an average across the five most recent years of data, in order to smooth out year-on-year volatility. For all other environmental indicators, we calculate factors based on the most granular data available, which is generally – but not always – the most recent. Any missing material factors are gap filled to ensure a complete coverage for each business activity.

- Direct operations are labelled as Tier 0 of the company value chain.

- Direct operations revenue-based intensity factors are also generated for the higher levels in the business activity hierarchy. The factors are based on the average intensity of the underlying granular business activities weighted by their gross output data.

3.1.2. Supply Chain

Estimating a company's complete supply chain footprint requires looking beyond just the immediate suppliers. S1 utilizes advanced macroeconomic Input-Output modeling to trace financial spend relationships across the entire supply chain, then aggregating the direct operational intensities of the sectors contributing to the spend of the target scope and activity, to derive the final supply chain intensity factor at the required activity and scope level.

- Using U.S. BEA (and OECD) Input Output tables, the model calculates the (attributable) environmental impacts of a company's direct (Tier 1) suppliers and propagates those calculations through the rest of the supply chain (Tier 2 through N), isolating all of the individual supply chain components aligned with the GHG Protocol reporting framework.

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Below is a hypothetical example of a supply chain intensity factor calculation for the business activity *Monetary authorities and depository credit intermediation*, representing indirect CO2 emissions in the first tier of the supply chain associated with spending on *Food services and drinking places*:

> *Food services and drinking places* produces **20** metric tons of CO2 for every 1 million USD of revenue generated.
>
> *Monetary authorities and depository credit intermediation* spends **0.01** million USD on *Food services and drinking places* per million USD of revenue that is generated.
>
> The supply chain intensity factor representing indirect CO2 emissions in the first tier of the supply chain associated with purchases on Food services and drinking places is calculated as follows: **20** × **0.01** = **0.2** metric tons of CO2

- Regional adjustments are applied within the supply chain model to better account for the likely location of supplier spend. This is particularly relevant when estimating Scope 2 GHG emissions (as well as the damage costs associated with environmental externalities across the supply chain). The example below demonstrates how Scope 2 GHG emissions estimates are further regionalized based on [i] the economic relationships described in the OECD Inter-Country Input-Output Tables[8] and [ii] country-specific electricity grid (GHG) emission factors calculated based on the electricity grid mix in different regions (Ember, 2026)[3].



Figure 4: Example of regionalization of the Scope 2 GHG factors, based on the Input-Output Tables [IOTs]

- Additional sector granularity is introduced wherever there is significant variation in the spending patterns (and associated environmental impacts) of each underlying activity. For example, within electric power generation, transmission and distribution and within (diesel and electric) rail transport. This is critical to ensure supply chain estimates accurately reflect the specific activities undertaken by each company.

3.1.3. Employee Commuting

To account for employee commuting emissions, national transport demographic data from the U.S. Department of Transport[13] is used to estimate the average GHG emissions associated with each employee commute (based on typical employee commuting

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patterns and associated GHG emissions by transport mode). This was then combined with data on the average number of persons employed by each industry (per unit revenue) to derive a series of intensity factors representing the estimated quantity of GHGs emitted via employee commuting, in each industry, per unit of revenue generated.

3.2. Production-based Intensity Factors

Where available, physical production quantities are generally a more stable, more accurate measure of company output than revenue, thereby making them a more accurate proxy for environmental impacts. S1 uses company-reported production quantities to estimate environmental impacts, for key productive industries (e.g. cement manufacturing), based on industry average production based intensity factors, calculated in terms of the quantity of pollutant emission (or resource use) per unit of production.

- Production-based intensity factors representing the Scope 1 and Scope 2 GHG emissions associated with a number of key products (incl. cement, iron, copper, and gold ores) are based on a meta-analysis of multiple sources. These factors cover major GHG emissions (of carbon dioxide, methane, and nitrous oxide) per metric ton of production.

- Production-based intensity factors for all other environmental indicators (beyond the major GHGs), across all other components of the value chain, are inferred based on the ratio observed between the corresponding revenue-based intensity factors for each environmental indicator and Scope 1 carbon dioxide.

3.3. Fuel Emission Factors

When a company discloses its physical fuel use (e.g., liters of diesel) but not the resulting emissions, S1 applies standardized fuel emission factors to the reported combusted fuel quantities. These factors represent the mass of emissions, of GHGs or other air pollutants, released per unit of combusted fuel.

- **Primary Fuels:** Emission factors for all major fuels are developed based on detailed underlying emissions data available for commonly used fuels, including coal, natural gas, gasoline, diesel, and other fossil-based transportation fuels.

- **Alternative Fuels & Blends:** Supplementary emission factors for various alternative fuels (and fuel blends) are based on a meta-analysis of the available literature, covering the emissions profile of hydrogen boilers, typical biofuel characteristics, and average blending rates. Emission factors are derived (or estimated) for all material pollutant emissions, where possible, based on the information available in the literature or various proxy data for similar fuel types.

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4. Environmental Damage Costs

The impact quantities in the Trucost Environmental dataset (metric tons, m2, or m3 of indicator emitted/used) are monetized, where applicable, using S&P Global Sustainable1's core database of environmental damage costs, to estimate the associated magnitude of natural capital cost. These costs are not directly observable in the market due to their varied forms, such as localized chemical pollution, noise pollution and visual nuisance, among many others.

The environmental damage cost factors convert unpriced company impacts on natural capital into monetary terms, enabling comparison and assessment of business practices in a systematic way based on value creation and destruction. The costs are based largely on peer-reviewed academic studies and datasets, covering the major environmental externalities associated with each type of economic activity.

The monetary value ('damage cost') is applied in units of USD millions per standard unit to the environmental indicator data, at the most granular level. The environmental valuation methodology includes seven categories of impact: GHGs, air pollution, land pollution, water pollution (including chemical pollution, oil spills and eutrophication), waste (including hazardous, non-hazardous, and nuclear waste), land use, and water use.

The following steps were applied to compile environmental damage costs:

1. **Understanding and quantifying drivers of change:** S1 identified a set of appropriate indicators to measure the extent of environmental impacts. This involved a thorough materiality assessment to identify the major drivers of impact across the entire corporate value chain, leveraging existing research and bespoke consultancy work.

2. **Understanding the consequences of impacts:** S1 identified the likely end points of the impact – for example, water depletion (negative impact) can affect society (end point 1) through lack of drinking water and decreased food supply, and the environment (end point 2) through decreased water availability to sustain fauna and flora. Examples of impact metrics - or "valued attributes" - are changes in life expectancy or changes in species richness due to the emission of pollutants. Complex biophysical models were used to estimate these metrics, based on a thorough literature review, and adapted to reflect local conditions.

3. **Valuing impacts and dependencies in monetary terms:** S1 converted the impact metrics into monetary terms that reflect the costs and benefits to specific beneficiaries of the change in valued attribute. The output of this step was damage costs coefficients which reflect cost or benefit of specific practices and associated use of inputs and emissions on natural and social capital.

Further details on the calculation approach for specific environmental impacts are provided below:

- **GHGs:** Sustainable1 considers the impact of the GHGs covered in the GHG Protocol, plus any other major GHG contributors in each sector. The UN Intergovernmental Panel on Climate Change (IPCC) reports are used for the global warming potentials (GWPs). The valuation of the damage caused in monetary terms is calculated by multiplying each company's estimated GHG emissions in carbon dioxide equivalent (CO_2e) by the social cost of carbon (SCC) recommended by the Interagency Working Group on Social Cost of Greenhouse Gases (IWG).

- **Air, land and water pollutants:** S1 methodology values the impact of organic, heavy metal and other inorganic pollutants on human health and ecosystems.

    - For the impact on human health, S1 uses the Disability Adjusted Life Years (DALYs) quantification as set out by the World Health Organization (WHO, 2020) [17]. A DALY can be thought of as one year of life in full health, with a DALY value of less than one representing a year of life spent in sub-optimal health.

    - The impact on freshwater/seawater/terrestrial ecosystems is determined in terms of the percentage of ecosystem service value (ESV) lost, by pollutant and emission media. Ecosystem service value represents the monetary value linked to services, such as climate regulation and water filtration, that are naturally provided by ecosystems to the benefit of local and/or global populations (De Groot et al., 2012)[1].

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- For air pollutants, S1 has created different damage costs according to emission origin to fully account for the impact on human health:
    - Business activities have been assigned with an origin type – 'rural', 'urban' or 'peri-urban' - where the impact of the emissions will have a greater impact on human health in more population-dense urban or peri-urban settings. For example, hospitals has been assigned to 'urban', incineration of waste to 'peri-urban' and mining and quarrying to 'rural'.
    - Specially adjusted damage costs have been created for air transportation and sea transportation/ shipping, where emissions occur at high altitudes or far out at sea. As these activities occur far away from human settlements, they tend to result in less harm to human health.

- **Land use:** S1 methodology assesses the loss of ecosystem services due to the conversion of land from its natural ecosystem to an alternative land use or state, focusing on the ecosystem services that are provided by terrestrial ecosystems.

- **Water use:** S1 estimates the cost of using water, in different regions, at different levels of water scarcity, and for different use cases, accounting for the balance between water withdrawal and water consumption requirements.
    - Water availability can be affected when demand for water exceeds the volume available over a certain period of time, usually occurring in locations with low rainfall and high population density, or with strong agricultural and industrial operations. An unsustainable rate of water abstraction can affect access to water for local populations, provoke the intrusion of salt water in groundwater sources and, in more extreme situations, lead to the disappearance of water bodies and wetlands (European Environment Agency, 1997)[4].
    - The water withdrawal damage costs reflect the discounted future cost of groundwater depletion and the cost of water subsidies.
    - The water consumption damage costs additionally reflect the impacts of reduced freshwater availability on terrestrial ecosystems and human health.

- **Waste:** S1 methodology considers the impacts of hazardous, non-hazardous and nuclear waste, and their respective contributions to climate change, air and water quality degradation, environmental disamenity, and harm to human health, as well as the extent to which these contributions vary according to the waste disposal method.

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Monitoring and Review

E-Model 3.0 will be reviewed on an annual basis (as a minimum) and adjusted where required to reflect additional environmental issues as they emerge in the future. All new methodologies and any material changes to existing methodologies are reviewed and approved by an independent methodology governance committee.

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Assumptions and Limitations

The S&P Global Sustainable1 Environmental Model (E-Model 3.0) provides a standardized, scalable framework for quantifying corporate direct and supply chain environmental impacts. Modeling global corporate environmental footprints across hundreds of industries and geographies requires foundational assumptions when primary company disclosures are unavailable or inconsistent.

This section details the core assumptions applied in E-Model 3.0, along with the boundaries and limitations of the current BETA release.

Key Modeling Assumptions

1. **Geographic & Operational Distribution of Impact:**

    - **Revenue & Activity Location Proxy**: The model assumes that a company's geographic revenue distribution serves as a reliable proxy for the geographic location of its physical operations. While companies may generate revenue in regions distinct from their primary manufacturing locations, granular facility-level operational data is not consistently disclosed across the full global universe covered in E-Model 3.0. Geographic revenue segmentation provides a standardized, auditable, and globally consistent basis for identifying environmental impacts at a regional scale.

    - **Business Activity vs. Geography Prioritization:** Environmental intensity factors prioritize industry classification (business activity) over geographic location as the primary determinant of environmental impact. Regional adjustments (e.g., local electricity grid emission factors for Scope 2 GHG estimates) are applied where localized context is material.

    - **Disaggregation of Company Level Data:** The reported company-level physical production quantities are distributed across operating regions in proportion to geographic revenue shares. If a datapoint has been disclosed, but estimates do not exist at the required business activity and region level, then other proxy environmental indicators are used to split the value across the different layers of granularity in the allocation process.

2. **Industry Trend:**

    - **Industry Average Footprint:** Where company disclosures are absent, revenue and production-based intensity factors assume that companies behave similarly to the industry average trend.

    - **Materiality Thresholds:** To optimize computational efficiency and data quality, only material intensity factors are retained in the core E-Model database. Factors with negligible contribution to the total monetized environmental impact are excluded based on systematic materiality screening.

3. **Environmental Damage Costs**

    - Monetized environmental impacts are calculated by combining physical quantities (e.g., metric tons of CO2, cubic meters of water consumed) with damage cost factors derived from the Sustainable1 environmental valuation framework. To apply localized economic and epidemiological literature to a global corporate universe, the methodology employs several standardized assumptions:

        - **Social Discounting**: Intergenerational damages (such as persistent climate change impacts and long-term landfill leachate/degradation) are discounted to present value using a central social discount rate value. The social discount rate balances near-term economic trade-offs with the ethical necessity of preserving capital stocks for future generations.

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- **Income Elasticity and Purchasing Power Parity (PPP):** Environmental damage costs (e.g., health impacts from local air pollution, water scarcity costs) are adjusted across countries using PPP and an assumed standard environmental impact income elasticity.

- **Human Health Impacts (DALYs):** Human health damages resulting from toxic emissions and water contamination are evaluated using Disability-Adjusted Life Years (DALYs), and response models under steady-state environmental dispersion assumptions.

- **Ecosystem Services & Land, Water Use:** Land use and ecosystem degradation are valued based on the economic loss of ecosystem services (provisioning, regulating, and cultural) across terrestrial biomes and country-level baseline ecoregion distributions. Water consumption damages account for local catchment water stress, groundwater depletion rates, and local industrial water subsidy structures.

Main Methodological Boundaries & Limitations

Dimension	Methodological Scope & Boundary [BETA]	Impact on the Outputs
Regional Data Coverage	While E-Model 3.0 incorporates region-specific environmental data where available, the underlying datasets used to derive the factors currently exhibit significantly higher coverage and granularity in the United States and Europe.	In geographies where localized primary data is unavailable, proxy factors derived from North American or European datasets are utilized as baseline equivalents, adjusted with regional calibration factors.
	Environmental damage assessment is performed at the regional level rather than at exact facility locations.	Localized city-level characteristics or site-specific geographic coordinates environment characteristics (micro-climate, urban dispersion variations) are not captured.
Scope 2 Accounting	Estimates for Scope 2 GHG emissions apply regional and national grid average emission factors. Market-based accounting (reflecting contractual instruments) is limited to verified direct disclosures due to low global reporting coverage.	Scope 2 market-based accounting is purely based on company disclosures as part of the BETA release.
Outsourced Manufacturing Activities	Companies outsourcing their manufacturing activities, in the absence of disclosure, are modeled based on their primary business activities and spend profiles, without bespoke adjustments for varying degrees of vertical integration.	Asset-light companies modeled supply chain impacts will reflect industry trend average environmental impact rather than their specific outsourced activities intensities.
Granularity of Inflation Adjustments	Inflation adjustments are currently based on price index datasets, which may not capture all variations at the individual commodity level.	Revenue-normalized intensity factors reflect industry trends over short-term commodity price swings.

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Updates and Enhancements

Month/Year of Enhancement	Enhancement Description	Impact of change
September 2026	E-Model V3.0 BETA [original version]	Not applicable

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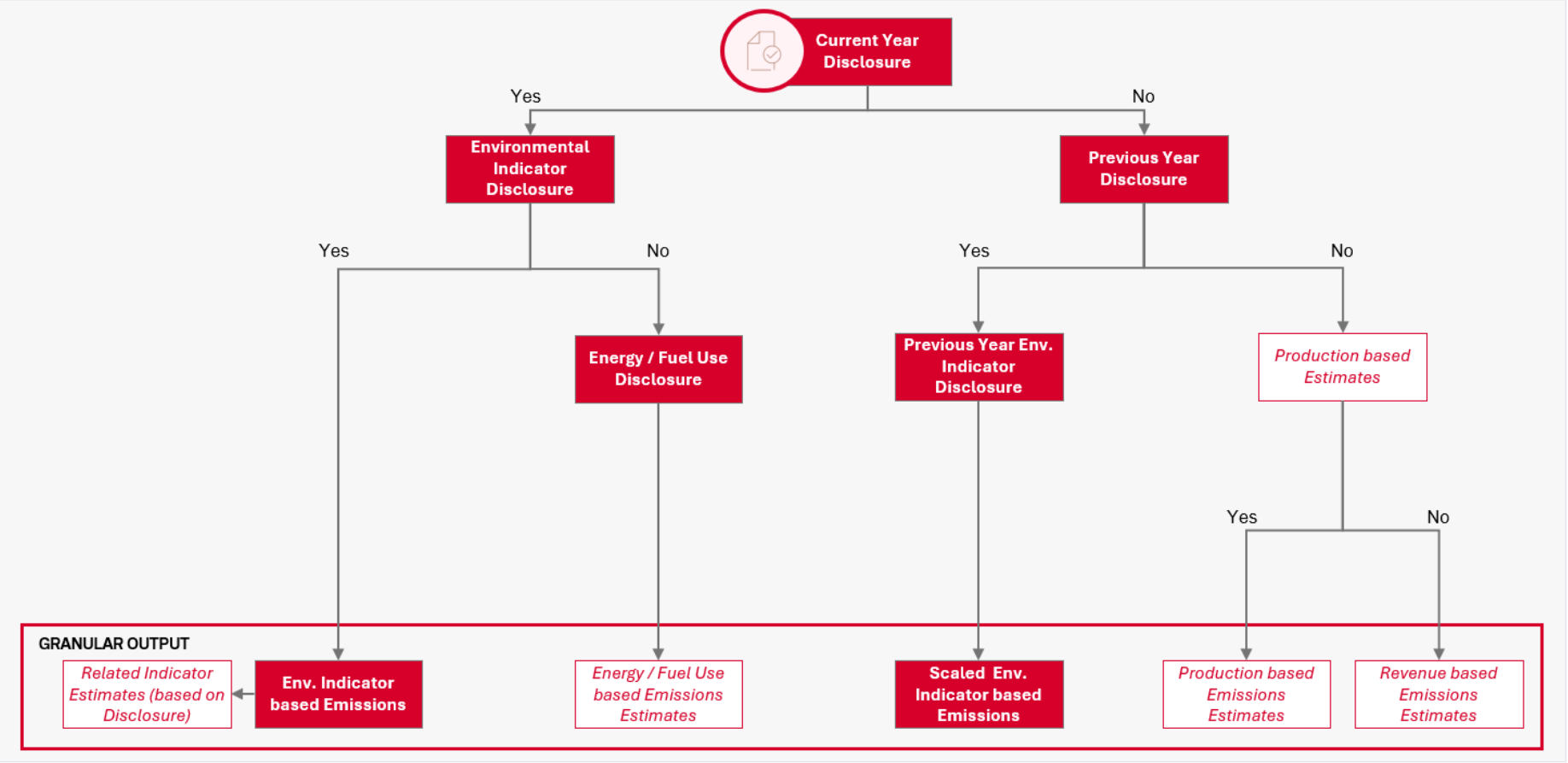
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Appendix

Appendix 1: E-Model 3.0 BETA Python Engine Module Logic Decision-Tree



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