

The Avoided Emissions Platform

Guiding principles and methodological basis

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Versions

Date	Version	Updates
May 2024	V0	<i>Preliminary Draft</i>
August 2024	V1	<i>Restructuration, sectoral developments Power & Alternative Fuels</i>
December 2024	V2	<i>Feedback integration, development of allocation recommendations</i>
March 2025	V3	<i>Final feedback consolidation</i>

Disclaimer

“The members of the Initiative are committed to fully comply with EU and relevant antitrust laws. In particular, they shall not discuss, communicate or exchange any commercially sensitive information. They shall also refrain from discussing topics related to pricing, production or market strategy. In the course of discussions or meetings, they shall voice their concerns if any activities or discussions may contravene these rules.”

Acknowledgment

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- Hervé Lefebvre, from ADEME

Their expert review was invaluable in consolidating and validating our generic and sectoral approaches.

**For more information on the methodology to calculate avoided emissions, join the
Avoided Emissions Platform (berard.hugo@quantis.com)**

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PURPOSE OF THE DOCUMENT

The document aims to gather all principles related to the framework of the Avoided Emissions Platform (AEP), and the environmental footprinting choice and rationale proposals.

This document is built upon existing framework, such as the “Guidance on avoided emissions, helping business drive innovations and scale solutions toward net zero” (WBCSD, 2023), the “Pre-investment Considerations: Diving Deeper into Assessing Future Greenhouse Gas Impact” (Prime Coalition, 2023), or the “Net Zero Initiative, calculer et valoriser ses émissions évitées” (NZI, 2022). Key concepts of avoided emissions are described in such global methodological guidelines. The objective of this document is to provide the technical background that has been used to develop the avoided emissions database. Therefore, the document does not aim at presenting extensively the general concepts underlying avoided emissions.

1. Preliminary definitions

Environmental Footprint (EF) Methodology	<ul style="list-style-type: none"> • A quantitative measure of the environmental impacts a product or service has throughout its life cycle. It takes into account the resources used to produce the product and its subsequent generation of gases, liquid and solid wastes. • Set of rules and procedures to be used to assess the environmental footprint of a product using a Life Cycle Assessment (LCA) approach. • It covers notably the scope to be considered, the functional unit, system boundaries, reference flows, calculation formulas, data requirements, default assumptions and limitations.
Life Cycle Inventories (LCI)	<ul style="list-style-type: none"> • "Building blocks" of the environmental impact assessment, they describe a list of all inputs and outputs required for the production of a given activity (e.g., production of 1 kg of Material X, consumption of Y kWh of electricity in each country, etc.), which are presented in the form of a dataset. • These datasets are composed of activity data (see "Activity data"), and can be derived from several sources, either company-provided or generic. • The environmental impacts of each of these building blocks are combined with the product's characteristics to obtain the environmental impact of a given product. • Synonym: Environmental datasets
Environmental Footprint (EF) Impact Assessment Tool	<ul style="list-style-type: none"> • Assessment tool that generates the environmental footprint of a product within its life cycle phases, based on characteristics (material type and quantity, type of processes etc.) and environmental datasets, according to the Environmental Footprint Impact Assessment Methodology. • The typical output of an impact assessment tool is a set of environmental footprint indicators (and possibly an aggregated footprint that combines those different indicators through normalization and weighting) by functional unit. • Synonyms: Environmental Footprint Tool, Environmental Assessment Tool, Life Cycle Assessment Tool

Climate change Indicator	<ul style="list-style-type: none"> The quantifiable representation of the climate change category with a corresponding unit. Example: <table border="1" data-bbox="480 365 1278 544"> <thead> <tr> <th data-bbox="480 365 746 454">EF Impact category</th> <th data-bbox="746 365 1050 454">EF Impact category indicator</th> <th data-bbox="1050 365 1278 454">Unit</th> </tr> </thead> <tbody> <tr> <td data-bbox="480 454 746 544">Climate change, total</td> <td data-bbox="746 454 1050 544">Global warming potential (GWP100)</td> <td data-bbox="1050 454 1278 544">kg CO₂ eq</td> </tr> </tbody> </table> 	EF Impact category	EF Impact category indicator	Unit	Climate change, total	Global warming potential (GWP100)	kg CO ₂ eq
EF Impact category	EF Impact category indicator	Unit					
Climate change, total	Global warming potential (GWP100)	kg CO ₂ eq					
Functional Unit (FU)	<ul style="list-style-type: none"> Provides quantitative and qualitative characteristics to the function of the product or service. It does so by defining the following questions: “What?” “How much?” “How long?” “How well?” “Where?” Example: Provide low voltage electricity at the point of consumption during one hour in a given country. The FU allows for fair comparisons between products that have the same function. 						
Reference Flow	<ul style="list-style-type: none"> The amount of output within a product system required to satisfy the function described in the functional unit. Example: to fulfil the function of providing 1 kWh electricity from a solar PV, the reference flow is the share of PV amortized per kWh produced over its lifetime 						
System boundary	<ul style="list-style-type: none"> The description of what is included or excluded from the analysis. Example: The system boundary of a ‘cradle-to-grave’ analysis includes all life cycle activities of a product - from raw material extraction to the use and disposal methods 						
Generic Data	<ul style="list-style-type: none"> Generic data covers Environmental datasets that are not directly collected, measured, or estimated by the company carrying out the assessment, but sourced from a third-party life-cycle-inventory database or other sources e.g., from published production data, government statistics, or industry associations), literature studies, engineering studies and patents, and can also be based on financial data, and contain proxy data, and other generic data. In the case of the first version of the Tool, generic data can be used to replace certain company-specific data if, for the given 						

	<p>case, it is more accurate and complete than the available data (i.e. supplier-operated processes).</p> <ul style="list-style-type: none"> • Synonym: harmonized data, secondary data
Default data	<ul style="list-style-type: none"> • Default data refer to industry-average parameters (e.g. product manufacturing scenarios, end-of-life scenarios, default transport distances...)
Product Type	<ul style="list-style-type: none"> • Any goods or services (ISO 14025:2006) • Synonym: Product
Co-product	<ul style="list-style-type: none"> • When the same system or unit process generates more than one product.
Reference scenario	<ul style="list-style-type: none"> • The reference scenario is a hypothetical trajectory reflecting how emissions would evolve over time if the solution was not used (WBCSD, 2023)
Solution scenario	<ul style="list-style-type: none"> • The solution scenario corresponds to the scenario that integrates the development of the assessed solution (product, service, technology, project that leads to a global decrease of GHG emissions). Also called “low-carbon scenario”.
Climate solution	<ul style="list-style-type: none"> • Any strategy, technology, policy, or action designed to reduce greenhouse gas emissions, mitigate climate change impacts, or enhance the planet’s ability to adapt to climate change.

2. Framework of the methodological principles

2.1 Objectives

Goal: In order to compensate for the absence of common standards and tools already available on the market, several organizations have decided to partner up to create a database of avoided emissions factors (datasets). Such datasets will allow users to evaluate the volume of avoided emissions associated with a given activity (solution or technology). This document presents a common environmental impact methodology for building an Avoided Emissions Platform, ultimately usable as a basis by data providers for ESG ratings, corporates, academics, financial actors, and other stakeholders.

2.2 Fundamental methodological principles

Some fundamental methodological principles are proposed:

- A **science-based** footprinting, based on **Life Cycle Assessment (LCA) principles**, with climate change being the only impact assessed. Life Cycle Assessment is recognized as the leading methodology for environmental impact evaluation. The main strengths of this tool are the following:
 - Metrics-based approach, allowing impact evaluations and/or comparisons to be made on a quantified and credible scientific basis.
 - Life-cycle oriented, allowing users to consider various product stages, to highlight potential ‘burden shifting’, or unintended consequences
- The methodology must guarantee an **identical scope for both “baseline” and “solution” scenarios**. In particular, the construction of baseline scenarios should comply as far as possible with the World Business Council for Sustainable Development (WBCSD), European Investment Bank (EIB) and the Greenhouse Gas (GHG) Protocol¹ guidelines to ensure the robustness of the exercise. Some adaptations will be needed to meet the specific objectives of the AEP and the related needs of assessed solutions, which is detailed in sectoral methodologies.
- The methodology should ensure that the most significant sources of emissions are captured. Depending on the nature and granularity of the data, **emissions data will need to be collected and modelled**, using sources such as the International Energy Agency (IEA), ecoinvent, the ADEME Base Empreinte, Environmental Product Declarations (EPDs), Product Category Rules (PCRs), and scientific literature.
- Particular attention will be paid to the **scope of validity of emission factors**, in order to select or construct the most relevant data regarding the customer context (geographical, technological, time frame, specific energy or input mix, etc.).
- As far as possible, the description of scenarios (and their quantitative implementation in the tool) will consider the **evolving parameters over the lifetime of products and services, such as technology efficiency, energy supply mixes etc.** This prospective

¹ <https://www.wbcscd.org/resources/guidance-on-avoided-emissions-helping-business-drive-innovations-and-scale-solutions-towards-net-zero/>
https://www.eib.org/attachments/lucalli/eib_project_carbon_footprint_methodologies_2023_en.pdf
<https://ghgprotocol.org/guidance-0>

vision will be based on the most credible possible assumptions, which will be explained and sourced.

- A system **usable by non-LCA experts** thanks to a common generic database and a user-friendly, easily accessible tool interface.

2.3 Deliverables

To reach the objective, a phased methodological development is proposed to deliver a first version of the tool, which demonstrates the operational aspects of the methodology for numerous avoided emission factors by end of 2024, with improvement of the methodology and the development of other avoided emissions factors for new solutions beyond 2024.

This document presents the methodological guidelines that will be applied to the different solutions. Some deviations might occur for defined sectors and / or solutions. These deviations are presented in the sector sections alongside details about assumptions and calculations for each of the covered sector.

2.3.1 Product coverage

A first batch of solutions split into 8 macro sectors has been defined to be developed during the first year of development and before the launch of the web-based platform. It represents a list of 60 low-carbon solutions which will be enlarged in the next years of development. For each solution, several KPIs (Key Performance Indicator) could be available. For instance, for the power sector, three KPIs will be available: kg CO₂eq / kW, kg CO₂eq / kW / year, or kg CO₂eq / kWh.

Please refer to the sectoral methodologies for details about the specific solutions covered in the first year, including their scope, data sources and assumptions, and KPIs proposed.

3. Avoided emissions factors: methodological propositions and rationale

3.1 Overall principles

3.1.1 Purpose

Avoided emissions refer to the reduction in greenhouse gas (GHG) emissions that result from implementing specific actions, technologies, or policies preventing emissions from occurring in the first place. These emissions are "avoided" because they would have been released into the atmosphere under a reference scenario but were prevented due to proactive measures. Thereby, any strategy, technology, policy or action designed to reduce GHG emission or mitigate climate change impacts compared to a reference situation (likely to occur without the strategy, technology, policy or action deployment) according to latest climate science is called a "Climate solution". In a sense, calculating avoided emissions of a climate solution *a priori* enables to checking actual potential.

Actions to enhance the planet's ability to adapt to climate change can also be regarded as climate solutions, however they are not in the scope of the AEP which rather focuses on technologies, products or practices targeting GHG emission reduction compared to reference scenarios.

Avoided emissions can be used in several contexts, notably corporate sustainability reporting (to demonstrate the positive impacts of their business and / or their sustainability initiatives), or project evaluation and funding (to incite investments in low carbon solutions). Therefore, they can be seen as a measurement of a company's contribution in commercializing solutions that decarbonize various sectors and value chains, or a quantitative measure to facilitate channel funding for the transition. It is also important to note that avoided emissions are not a way to offset GHG emissions from the company's own inventory (Scopes 1, 2 & 3), neither a direct contribution to one company's decarbonization targets.

The same four-step approach as WBCSD described in Figure 1 below (WBCSD, 2023) is followed to calculate the avoided emissions of the assessed solutions. Moreover, guidance on an additional, optional step of horizontal attribution is developed by the AEP (see section 4.8).

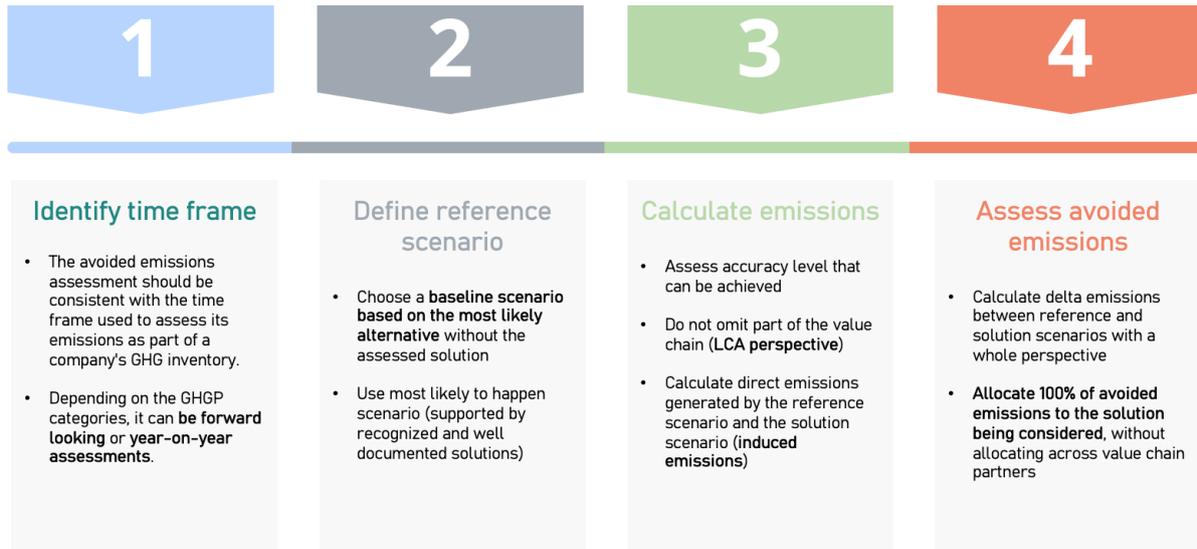


Figure 1: Four steps approach to generate avoided emissions for the assessed solutions

The calculation of avoided emissions fundamentally relies in the difference of GHG emissions between a reference scenario (sometimes labelled as baseline) and a solution scenario which corresponds to the implementation of the low carbon solution. Both reference scenario and solution scenario are dynamic, i.e. accounting for GHG emission intensity evolution over time (see Figure 2). Therefore, the avoided emissions generated by a given solution today (e.g. avoided emissions over 2024) might be different than the ones calculated in the future (e.g. avoided emissions over 2032). The choice of the reference scenario (prospective or normative) will deeply influence the evolution of the avoided emissions through time.

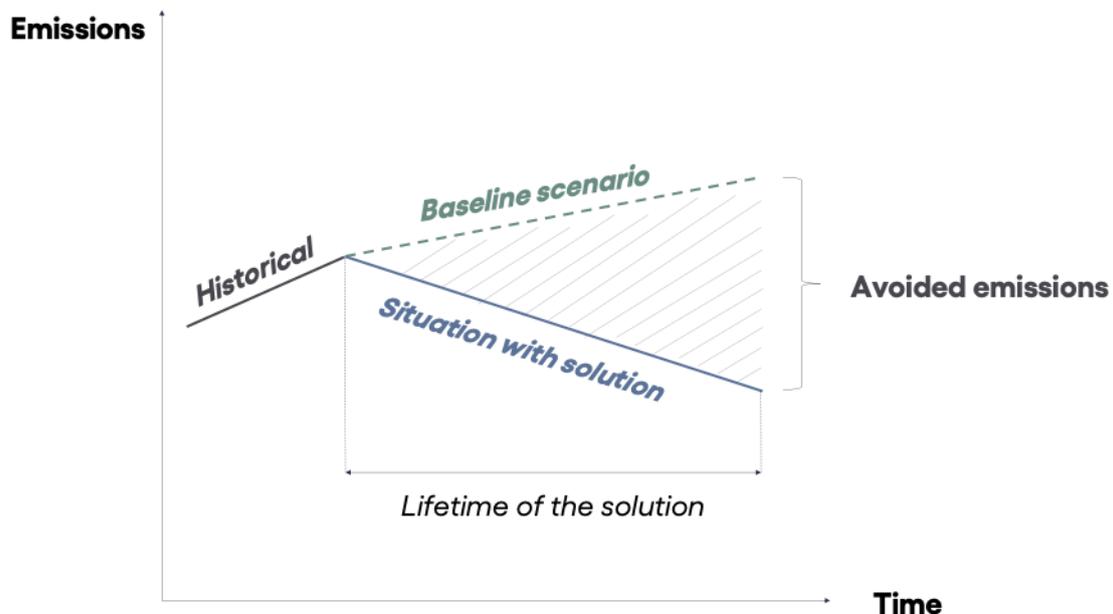


Figure 2: Illustration of the dynamic accounting of avoided emissions. Credits: NZI pillar B guidance

More detailed information is given in sections 4.4 and 4.5 on the modelling of the solution and reference scenarios, respectively.

3.1.2 General methodology

The avoided emission factor for a solution in year Y , related to its functional unit (FU), is calculated using the following equation:

$$AEF_Y = RE_{coeff} \times \left[\text{Baseline} \left(\frac{kgCO_2e}{FU} \right)_Y - \text{Solution} \left(\frac{kgCO_2e}{FU} \right)_Y \right] \times TVC_Y$$

The quantification of the avoided emissions up to a given year n will all follow the generic equation below:

$$AE = RE_{coeff} \times \left(\sum_i^n FU_i \times \left[\text{Baseline} \left(\frac{kgCO_2e}{FU} \right)_i - \text{Solution} \left(\frac{kgCO_2e}{FU} \right)_i \right] \times TVC_i \right)$$

With:

- AE/AEF : Avoided emissions/Avoided emission factor.
- i : corresponds to each year for which a solution is compared to a baseline, starting on the base year of the calculation (≥ 2024) and going up to 2050. Most of the time, base year corresponds to the time when the solution is put to the market.
- n : corresponds to the end year of the calculation, i.e. either the end of lifespan-related year when applicable, or 2050 by default.
- RE_{coeff} : Rebound effect (RE) coefficient. Refers to the discount coefficient applied to consider the rebound effect than can occur when expected gains from new technologies are balanced by an increase in the amount of consumption of the specified functional unit.
Note: Such effects are illustrated in the form of a coefficient in this generic equation to confirm their consideration, though factoring in rebound effects may not always allow for deriving such global coefficient. While it is likely applicable for most sectors where RE occur (e.g. buildings), for other solutions where a RE coefficient cannot be derived, it is not excluded to factor them in another way (e.g. implicit inclusion of an increased consumption in the FU).
- FU : Functional Unit (see definition section 4.2). refers to the unit (e.g. kWh electricity, sqm window...) on which the comparison between the performance of a solution (product or service) and the baseline is made. FU_i represents the amount of the solution that is provided on year i , given in the specified unit.
- $\text{Baseline} \left(\frac{kgCO_2e}{FU} \right)_i$: corresponds to the GHG emissions related to the baseline (reference scenario) for the delivery of the specified functional unit on year i . It may vary according to external decarbonation trends (e.g. IEA STEPS).
- $\text{Solution} \left(\frac{kgCO_2e}{FU} \right)_i$: corresponds to the GHG emissions induced by the solution for the delivery of the specified functional unit on year i .
- TVC_i : refers to the time-value of carbon on year i , stating that present GHG emissions are more harmful than future GHG emissions.

3.1.3 Proposition for the database

Cut-off of emissions after 2050

A general cut-off is applied after 2050, meaning that after this date, no avoided emissions are calculated. This only affects solutions with a lifespan above 25 years, and especially solutions that will go well beyond 2050 (buildings, new nuclear power, etc.). The rationale to apply this cut-off is based on several key points:

- From a pragmatic point of view, the reference scenarios used (e.g. STEPS) stop in 2050. There is no consensus and rare modelling about what happens after 2050. Trying to create a model that goes beyond 2050 would raise questions and acceptance issues.
- Modelling until 2050 already comes with significant uncertainty. Modelling after 2050 would require a strong justification that is not possible as uncertainty is very high when modelling that far ahead.
- The transition is mostly happening between today and 2050, as reflected through overall existing prospective scenarios up to the 2050 horizon, so most avoided emissions are captured with this cut-off. The further we go in time, the less decarbonizing the solution is compared with the reference which is improving. If a solution doesn't manage to demonstrate significant avoided emissions up to 2050, it should probably not be considered as a climate solution.
- It is conservative and avoids over-estimating avoided emissions.
- Most solutions are not impacted significantly by this cut-off as they have a lifespan inferior to 30 years. In the long-term, a modelling after 2050 could be added once the cut-off becomes more problematic and if a robust prospective vision that goes beyond 2050 is available.

This cut-off will be reviewed each time the database is updated, and it will be discussed whether it is necessary, and possible (with available prospective data) to update it or not.

- All the avoided emission factors are based on the previous equation. However, it is important to notice that the general equation is adapted to each solution, depending on methodological choices, available data, and sectorial specificities.
- i : this parameter is linked to each analysis and depends on the choice of the end user, with $2024 \leq i \leq 2050$.
- n : the end year of the calculation is set up to 2050 by default for cumulated avoided emissions over years. When avoided emissions are calculated for one year, n equals the assessment year (i.e. $i = n$).
- RE_{coeff} : The rebound effect is directly related to i) the sector the solution belongs to, ii) the solution itself. Whenever this factor is applied, some explanation will be provided on the relevant sectoral section.
- FU : Several FU can be set up for one solution. For instance, for green hydrogen (H_2), one FU could be “supply 1 MJ fuel” and another one “supply and use 1 MJ supply and use 1 MJ fuel for the same projected existing and new end uses as green/blue/pink H_2 in a given year”. The first FU would limit the comparison of green H_2 to other “colours” of H_2 only, whereas the second FU introduce the notion of existing and new end uses

and therefore open the door to a comparison with other energy vectors than H₂. This is further detailed in paragraph 4.2, while the retained FU per sector in the AEP tool are detailed in the dedicated sectorial methodology.

- *Baseline* $\left(\frac{kgCO2e}{FU}\right)_i$: the choice of the baseline scenario depends on many parameters, including data availability for deriving current and projected uses and related demands for the reference products or services.

Finally, the database will be updated on a regular basis (frequency to be confirmed) to keep aligned with the latest prospective scenario versions and background emission factor databases evolutions.

3.2 Functional units and reference flows

3.2.1 Purpose

The avoided emissions factors developed for the AEP project shall reflect the abovementioned objectives (section 3): they must **use a science-based approach**, allowing the meaningful comparability of products that provide similar functions / final use. The chosen approach is Life Cycle Assessment (LCA): it is a science-based, comparative analysis and assessment of the environmental impacts of product systems. This environmental assessment method is characterized by two constitutive and unique features: the analysis from ‘cradle-to-grave’ and the ‘functional unit’. The functional unit is described in this section, and the system boundaries in the next one.

3.2.2 Proposition for the database

The standard definition of a functional unit (FU), common in LCA science, consists in describing the function(s) or service(s) provided (“what”), the extent of the function or service (“how much”), the expected level of quality (“how well”) and the duration/lifetime of the product (“how long”). It is a quantified measure to which all inputs and outputs of a given system are normalized.

It is the basis of comparison of product systems (goods and services) if they provide the same or a very similar function. It describes quantitatively the function of the product systems to be compared. This unit must be quantitative and additive, in order to be able to compare different systems with each other, and best translate the function studied.

The chosen functional unit should allow the comparison of various products that have the same final use but not necessarily the same physical flows nor products. Therefore, the functional unit should be the same in both reference and solution scenarios (e.g. providing 1 kg of protein), where it can be fulfilled by different systems (e.g. insect-based protein and beef protein). Small differences between products (e.g. aesthetic ones) are commonly neglected in LCA, as long as they have only minor influence on the environmental impacts of the product system.

However, it should be noticed that the selection of a functional unit is a challenge since different functional units lead to different results for the same product system. Furthermore, other non-quantifiable issues like sensitivity to design, / aesthetic criteria, or user acceptance are not part of the definition of the functional unit *stricto sensu*. When it comes to avoided

emissions assessment, such non-quantifiable aspects might be relevant to consider, as they might drive the adoption of a solution and therefore it's total substitution to a given reference scenario.

In the database, the integration of multiple functional units has been considered when relevant. For instance, hydrogen or electricity production might be assessed both from a « energy » perspective, with a functional unit expressed in MJ or kWh, and from a « power » perspective, with a functional unit expressed in installed kW.

These different functional units can indeed answer different goals and is adapted for different data availability at user level: an operator willing to compute and report its avoided emissions over the current year is more likely to use an avoided emission factor by energy produced (kWh), while an installer or an actor comparing two potential projects with regards to their lifetime potential will be likely to adopt a perspective by capacity (kW) installed.

3.3 Life cycle stages and system boundaries

3.3.1 Purpose

The life cycle stages and system boundary of reference and solution scenarios for climate change impact calculation shall be defined. As stated in the previous section, one key characteristic of LCA is a “cradle to grave” approach. ‘Cradle-to-grave’ means that all the important steps in the life cycle of a product are included in the analysis, from extraction of raw materials until recycling or end of life. This comprehensive view allows LCA to avoid ignoring or devaluing issues that may occur in another step.

It must also be noted that the concept of ‘life cycle’ used in LCA is always connected to the physical life cycle, not the “marketing life cycle”. Primarily intangible activities, such as R&D and design, marketing, advertising, etc., are not in the scope of the assessed life cycles.

3.3.2 Proposition for the database

For each assessed scenario (reference and solution), the life cycle stages required are the following (Figure 3):

- Raw material acquisition and pre-processing
- Manufacturing
- Packaging + Distribution
- Use stage
- End of life

Based on these different steps, a “product tree” is built, that consists in modelling the assessed function. Geographical and temporal boundaries have also to be set up to provide the full picture of the assessed function (e.g. producing 1 kWh of electricity in France in 2024 do not corresponds to the same system than, producing 1 kWh of electricity in China in 2015).



Figure 3: life cycle stages

The split of the assessed system in different steps allows to run contribution analysis, meaning that the main contributing steps can be identified, in both the solution and the reference scenario (see Figure 4).

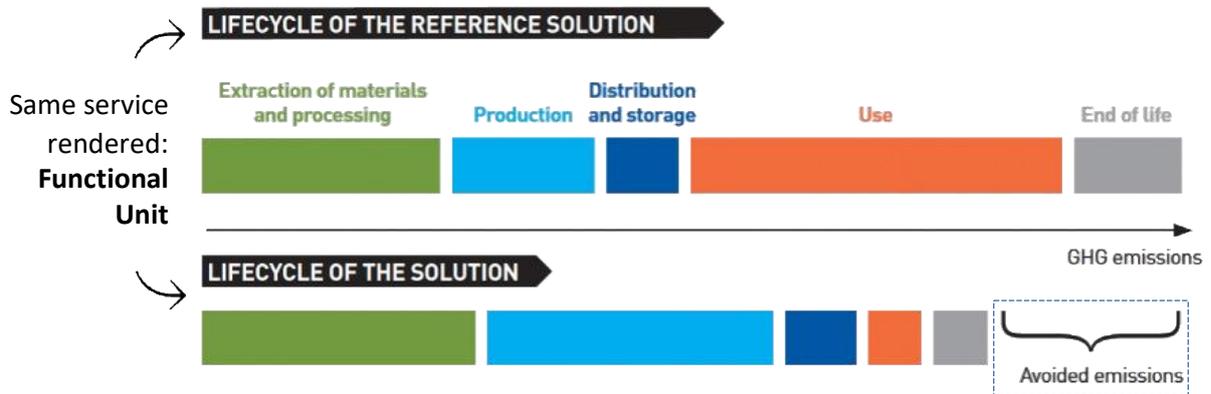


Figure 4: contribution analysis in the reference and the solution scenarios

When calculating avoided emissions, it might happen that the solution and the reference scenarios share some common steps. In this case, as the computation of the avoided emissions relies on the difference of two scenarios, all the identical modelling steps can be excluded from the scope. For instance, when comparing electric vehicles with conventional internal combustion engine, it might be not necessary to include the life cycle of the car seats, as the same car seats will be used on both scenarios.

3.4 Solution scenario

3.4.1 Purpose

The solution scenario is generally defined as the scenario that integrates the development of the assessed solution (product, service, technology, project that leads to a global decrease of GHG emissions). It is sometimes also called the “low-carbon scenario”. Modelling assumptions of the solution scenario are most of the time easily accessible and does not rely heavily in external assumptions (contrary to the reference scenario). The characteristics of the solution should be the same as the reference scenario: accurate, transparent and dynamic.

3.4.2 Proposition for the database

Eligibility criteria of solution scenarios have been proposed in different external guidelines, excluding (or not) fossil fuels direct and related activities. In our approach, we focus on the potential of decarbonization of the solution, wherever it could be applied. For instance, an energy efficiency solution that it applied to the fossil fuels sector, and which can be also applied to the biofuels sectors, is eligible to be labelled as an avoided emissions solution.

The solution assessed are described in the section 3.3.1 and are modelled with a life cycle perspective. Underlying data come from LCA databases (like the World Food LCA Database - WFLDB²), or from sectorial specific ones (like the IEA one for energy-related modelling³).

3.5 Reference scenario

3.5.1 Purpose

The definition of the reference scenario is shared by most practitioners. It is defined by WBCSD as “*a trajectory reflecting how emissions would evolve over time if the solution was not used*” (WBCSD, 2023). It aims to describe a “what If” scenario, in the case of the solution under assessment were not build.

The characteristics of the reference scenario are the following:

- Be as accurate as possible.
- Its underlying assumptions should be transparent.
- Be dynamic. It means that the characteristic of the scenario evolves through time.

3.5.2 Proposition for the database

Prospective modelling can be based on a wide range of scenario types, depending on the complexity and uncertainty of the subject to be explored, the time horizon chosen and the resources available. These constraints / choices can have a direct impact on the outcomes of the different kinds of scenarios, ranging from low complexity and uncertainty for short term

² <https://quantis.com/who-we-guide/our-impact/sustainability-initiatives/wfldb-food/>

³ <https://www.iea.org/data-and-statistics/data-sets>

prediction to high uncertainty and / or complexity for long term modelling (Figure 5).

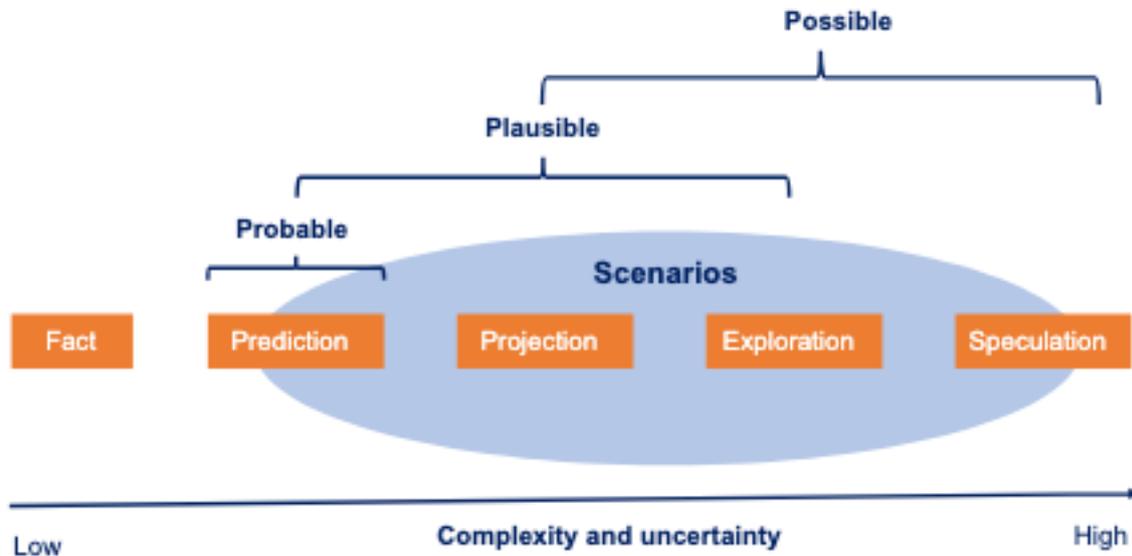


Figure 5: different approaches to designing scenarios (Wiebe et al., 2018)

We will distinguish two main categories of scenario, which differ according to the planning objectives:

- **Normative scenario definition:** The main objective is to answer the “what should happen” question. Normative scenarios sketch out a particular vision of the future which may be both desirable and / or feared (but generally desirable) and are conceived backwards, meaning that we go back in time to identify the paths to follow to reach that future. In other words, normative scenarios are based on an end-goal to reach (e.g. net zero by 2050) and describe the path to reach that goal. They do not try to predict what will happen but rather depict a direction to aim for.
- **Prospective scenario definition:** The main objective is to answer the “what can happen” question. Prospective scenarios are concerned with past and present trends and lead to likely futures. They use the realities, knowledge, and major trends of the present (e.g. current practices and regulation) to estimate the plausible continuation of these trends in the future.

Normative or prospective scenario?

As scenario availability (existence and accessible comprehensive data) and relevance can closely depend on the solution assessed, the decision tree in Figure 6 for selecting the most appropriate reference scenario is used for the present version of the database.



Figure 6: decision tree to choose the reference scenario

‘Local’ level refers to the specific geography (country, region...) addressed through the solution. For instance, the SNBC (Stratégie National Bas Carbone) could be used to build a reference scenario at the France granularity. ‘Global’ is about worldwide averages and trends. To stay ambitious but pragmatic / realistic, as far as possible (i.e. comprehensive and consistent data available to model the required reference scenario) **a prospective (exploratory) scenario shall be the basis of reference scenario**. Typical examples include IEA’s **Stated Policies Scenario (STEPS)**⁴ which describes the trend/outcomes in energy demand evolution up to 2050 as current policies are consistently applied from now on. STEPS was selected over APS (Announced Pledge Scenario) or Net Zero for AEP solutions using projections on energy sources and demand, as the goal is to capture the difference between a solution scenario and the situation that would occur otherwise, which reflects an ambitious but most realistic point of view based on credible projections and measures rather than intentions with no associated means. Consequently, resulting AEF encompass the less ‘ambitious’ but realistic (associated with the means deployed to comply with stated policies) aspects of STEPS, which translates into higher reference emissions and thus, higher avoided emission potential.

Choice of the substituted solutions: attributional or consequential approach

Two modelling approaches are generally considered when assessing environmental impacts with a lifecycle approach: attributional approach and consequential approach. The large majority of the LCAs today use the attributional modelling focusing on the total emissions during the life cycle of a product. Most of the commercial databases are also built on this approach (e.g. base ADEME, ecoinvent, DEFRA, etc.). In an attributional modelling approach, the effects of changes within a life cycle are not considered. In an avoided emissions calculation framework, this leads to compare the solution with the average reference element that is being substituted – for instance 1 kWh of low-carbon electricity with 1 kWh of average electricity produced over the same period of time. On the other hand, **the consequential approach** seeks to inform about the consequence of decisions by assessing the changes (either

⁴ <https://www.iea.org/reports/global-energy-and-climate-model/stated-policies-scenario-steps>

positive or negative) in total emissions which result from a marginal change in the level of output of a product. It tries to model the consequence of one additional unit of output rather than the average consequences of a product. Therefore, it relies on economic relationships, like historical trends in prices, or trends in consumption, market predictions representing relationships between demand for inputs, etc. In an avoided emissions calculation framework, this leads for instance to compare the addition of 1 kWh of low-carbon electricity with the 1 kWh that will be effectively displaced, which depends *inter alia* on the timing of its production, etc. There is no right or wrong choice between the attributional and consequential approaches, and the ISO standard does not offer specific guidance on how the goal of the study affects the scoping of the system boundary.

The proposed approach is **more aligned with the attributional approach**, in which it is accounted for market average mixes to reflect current and projected practices, and not marginal values. As underlined by 2.0 consultants (a consulting company focusing on consequential approach in LCA), “In consequential LCA modelling, long-term market trends and constraints play key roles for the identification of the long-term marginal suppliers of each product, that is, the suppliers that will change their production capacity in response to an accumulated change in demand for the product”. Such approach could hardly be implemented for the large-scale, long-term LCAs required by the AEP development; this can so far only be led on a case-by-case basis.

For instance, in our approach, in the power sector 1 kWh does not substitute to a marginal electricity mix when replacing other fuels (e.g. liquid), but an average mix representing current consumption is substituted.

Finally, it is important to note that by substituting average reference mixes (e.g. % fuel types replaced in year Y) derived from reference scenario data, it is not systematically inferred that the total reference demand (e.g. X GJ in year Y) would or could be supplied by the solution (e.g. X GJ solution cannot systematically be supplied in year Y). Reference demand data is rather used/intended to derive a representative average mix substituted per unit of solution (1 kg, 1 MJ...), than to assimilate the achievable substitutable amount to the total reference demand. Then, whether cumulative AE are computed (e.g. over 1 year, over lifespan...), the unitary AEF is multiplied by the cumulated amount of solution supplied.

Example: according to STEPS there would be 144 EJ (exajoules) of natural gas, biogas and biomethane demanded in 2030 to cover the end uses targeted by biogas and biomethane solutions. This does not imply the assumption that biogas and biomethane achievable volumes in 2030 could reach 144 EJ (which is not realistic); however, the related shares of natural gas (92%) versus biogas and biomethane (8%) are considered to derive the average gas mix substituted by 1 MJ of biogas or biomethane in 2030.

Note: Considering the abovementioned limitations regarding attributional approach with average market mixes (vs. consequential LCA approach that better reflect market effects and size dependence), and the underlying uncertainty of prospective scenarios used, it appears difficult to attribute avoided emissions to solutions from nearly monopolistic market players (e.g. a big electricity supplier in a given country). Indeed, solution-level AE assessment scale may not be appropriate for such players as the reference scenario at that level consists almost exclusively in their solutions already. This is further developed in the AEP’s Company protocol,

where recommendations to rework the functional unit and compute company level AE are provided.

3.6 Temporal allocation

Two ways of assessing avoided emissions are generally considered, whether on a forward-looking approach, or on a year-on-year one.

The forward-looking approach consists in calculating overall lifecycle emissions (from production until the end of life for both the reference and solution scenarios) in the year of sale of the solution. On the other hand, the year-on-year one is based on a temporal distribution of lifecycle emissions over time (on a yearly basis).

These two approaches are used broadly by the ecosystem of players computing avoided emissions. The year-on-year approach is generally considered to contain less uncertainties as it does not rely on assumptions regarding the evolution of the reference scenario over time and expected life expectancy. However, the forward-looking approach can provide useful metrics for players that no longer have access to their products once sold (manufacturers/installers vision), or for players seeking to assess the impact of a project or several projects over their lifetime to feed decision-making.

Note that the same distinction exists in methodologies of induced carbon emissions accounting: GHG Protocol requests to report under “Use of Sold Products” the anticipated use-phase emissions of the products sold at the year of the reporting (e.g. emissions of the cars for a car manufacturer over their expected lifetime). Other methodologies request to report the annual emissions of the stock of products sold in the past and still active on the year of reporting.

The AEP does not recommend one specific approach, as the retained approach can depend on the type of actor or the purpose for which avoided emissions are being calculated. Thus, the AEP aims at proposing, when relevant and possible, emission factors that suits both year-on-year and forward-looking approaches. An example is provided in Figure 6, and more details are furnished in sectoral methodologies.

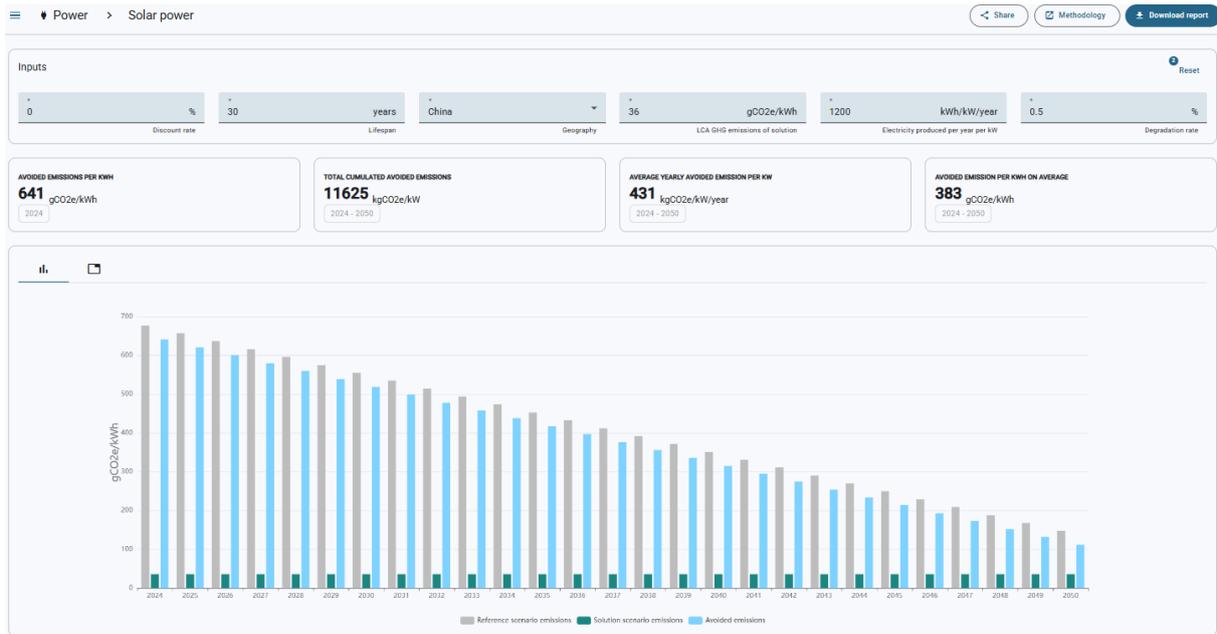


Figure 7: illustration of the platform (illustrative only) including year-on-year and forward-looking avoided emission factors

3.7 Market mechanisms

Scale effect

Macroeconomic scale-up describes the expansion from a product or company perspective towards a country or regional perspective, including dynamic effects of production structures (e.g. production of one lithium battery vs. one million lithium batteries). Macroeconomic scale-up approaches aim to link environmental burdens on the micro level (e.g. product, process data) with information on the macro level (e.g. national, regional or sector data). Process-based LCA is traditionally used to evaluate the environmental impacts of a specific process or product but hardly addressing macroeconomic effects. The implementation of a macro level perspective can also be relevant for biofuels, bioplastics and other agricultural products, as the total amount of products might be limited due to limited availability of natural resources. This point of attention has been highlighted in other approaches on avoided emissions, such as the Project Frame, where such scale up effect are described as “potential impact at the technology scale”.

Rebound effect

Rebound effects refer to the change of environmental impacts when the implementation of an improvement option liberates or binds a scarce production or consumption factor (e.g. money, time, space) which can offset the effect of the measures. Rebound effects can occur due to changes in production and consumption, e.g. when energy savings resulting from a more energy efficient option are cancelled out by increasing overall energy demand. Although rebound effects are already considered in some LCA case studies, it is far from being common practice. Assessing and quantifying the changes in production and consumption can become very complex and challenging as, for example, a regional perspective or personal behaviour must be included.

Ignoring rebound effects leads to either under- or over-estimations of the impacts of products. Hence, for a realistic assessment of the environmental impacts related to a decision, rebound effects should ideally be included in LCA. This modelling of the consequences of a decision is important for including a macro level perspective into LCA and for assessing potential positive effects of products/processes.

As a good option for practitioners to capture the complexity of production and consumption, the use of (future) scenarios within attributional LCA is recommended until robust and comprehensive macroeconomic scale up models are available that include rebound effects.

Growing demand case

For some specific sectors, it might be needed to integrate additional usages of the assessed solutions. This is particularly true for sectors with important increase rates, such as green hydrogen or renewable electricity, where prospective scenarios predict an important increase of the production. In such cases, part of the solution does not only substitute to the classical counterfactual scenario but also contributes to new usages. For instance, renewable electricity does not only replace average electricity mix, but it is also projected that in the years to come, electricity will be more used in the transportation sector (where it will replace fuels used in internal combustion engines, whether they are fossil or biobased), in the building sector (in heat pumps to replace classical gas boilers), etc. Those new demands, when relevant, important enough and clearly identified, are integrated in the calculation of the avoided emissions factors (see power sector for instance)

3.8 Allocation rules

3.8.1 Purpose

Horizontal allocation (also called “horizontal attribution”) describes the breakdown of overall avoided emissions by a product or a service among the different players of the value chain that enabled the solution. As several players are required (for instance from the key component manufacturer up to the operator), it is generally admitted that no actor can claim to be alone responsible for all the emissions avoided. One can either claim to *contribute* to the overall avoided emissions (i.e. without such claim being supported by a specific amount of avoided GHG) or claim for oneself a share of the avoided emissions derived from the relative importance of the player within the value chain. There is no consensus among players and methodologies between these two approaches.

The overall contribution approach can lead to overestimate the contribution of less decisive players with more modest contribution (two actors of the same value chain will have the same claim regardless of their respective additionality and criticality on the overall solution enablement). The allocation approach yields methodological questions (how to determine the proportion of impact that can be directly attributed to each player) as well as pragmatic question (how to calculate the allocation key once the methodology is selected).

3.8.2 Proposition for the database

Overall literature on avoided emissions does not reach a consensus on if and how a horizontal attribution should be performed. Some actors argue that avoided emissions should not require horizontal attribution, with the following main arguments:

- The full value chain is needed to avoid emissions.
- The absence of horizontal attribution is similar to the **scope 3 rationale** in GHG accounting (double counting is acceptable), which enables to be already compliant with company level calculation rules if intended.
- Horizontal attribution should be pursued in the long term but is **too complicated and uncertain** at this stage to be recommended.

Other actors promote horizontal attribution arguing that it is needed to:

- avoid double counting - in particular for financial players investing in several actors of the same value chain, who contribute to the same volume of AE.
- obtain a representative quantitative result for each actor.

The AEP sees the advantages as well as the challenges of horizontal attribution, and most importantly its complexity. Indeed, conducting horizontal attribution requires first to identify and select all the relevant actors of a value chain, which can go very far. Then, the attribution key between actors can be defined in various ways as developed in section 4.8.3. Facing the absence of consensus on the subject and the complexity of systematically computing attribution keys, the AEP supports the following approach:

- The overall avoided emissions of a solution should be available *before* potential allocation and that metrics will be provided in the database for all assessed low-carbon solutions.
- Avoided emissions may be allocated according to a systematic process, for which recommendations are provided in the next section:
 - Identify all actors of the value chain at the different intended levels
 - Select the dedicated links (key transition enablers)
 - Apply the relevant allocation key at intended levels of the value chain

In other words, the contribution to avoided emissions (i.e. metric before horizontal attribution) and the attributed avoided emissions (i.e. metric after horizontal attribution) should be seen as two different and complementary indicators. The first one illustrates if the product considered is part of a decarbonizing value chain, whereas the second one illustrates the specific decarbonizing role of the considered product.

3.8.3 Further recommendations for horizontal attribution

Guidance on recommended steps

Whether the user wants to apply horizontal attribution to the total avoided emissions, the AEP recommends the following approach:

- 1) **Identify all actors** of the value chain, starting by the **first level**, i.e. those representing the foreground activities/operations of the solution's life cycle.

The user may then iterate the procedure to identify subsequent levels of the value chain (i.e. the foreground activities of the previous level: sub-components for assembly, fuel supply for power generation...) whether they want to also consider allocation to those actors. Figure 8 illustrates possible value chain level breakdown.

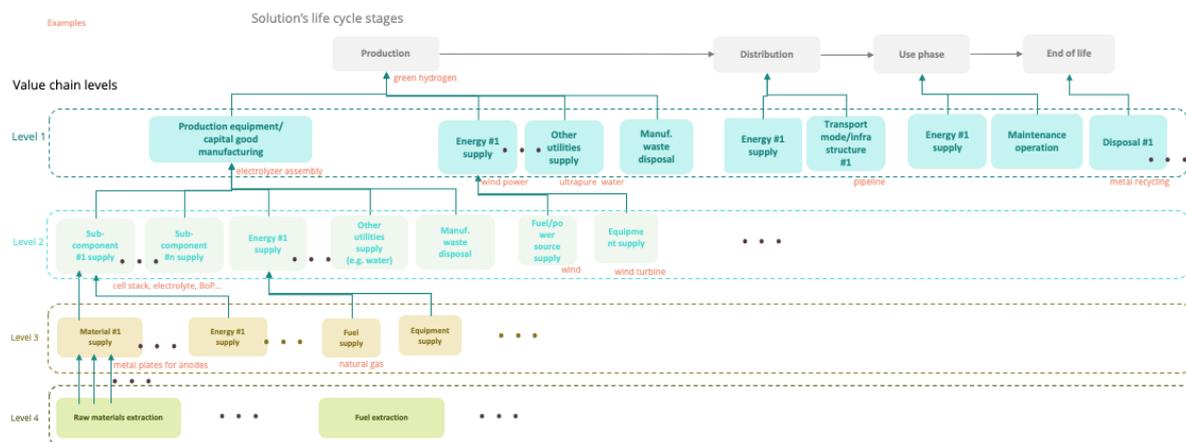


Figure 8: illustrative value chain levels related to a solution's life cycle (non-comprehensive view)

- 2) (Optional) select the **dedicated links** among the first level actors, which will be seen as **key enablers**
- 3) **Attribute** shares of avoided emissions based on a most relevant criterion that is deemed to reflect each key enabler's share of contribution to avoided emissions over the solution's lifecycle

Detailed recommendations per step

1) Identifying all actors of the value chain

First, all actors and components of the value chain that allow a climate solution to exist need to be identified. This list often includes numerous actors that are directly or indirectly linked to the solution. To help the user efficiently identify the key actors to account for, some indications are provided hereafter:

- The **functional unit** to which the AEF relates can be a good starting point that helps identify the appropriate actors or groups of actors, i.e. those enabling to actually fulfil the solution's function.

For instance, the functional unit of alternative fuels (hydrogen, biogas...) is to 'supply and use 1 MJ of (given fuel) under (appropriate conditioning specifications) for current and projected end uses in a given year' can help to comprehensively think of each actor group:

- actors that enable to supply the fuel (i.e. from raw materials supply to delivery, including conditioning, transport and storage steps, production equipment manufacturing...).
- actors that will further use the fuel (i.e. who are maintaining demand for it, thereby enabling the solution's deployment) as per current end uses.

- *actors that will likely use the fuel as per projected new end uses.*
- Further indications of actors to include can be derived from the differential **system boundaries**, i.e. activities that are identical (both in terms of nature – e.g. a steel plant – and amount per FU – e.g. same amount of amortized steel plant impact per kg of conventional vs. low-carbon steel) between reference and solutions scenario - resulting in compensated emissions when calculating the AEF. Such activities can be seen as not directly or critically enabling the transition, thus not eligible to AE claims. This positioning is aligned with Climate Dividends approach REF.

For example, tire supply activity is likely the same for both combustion and electric car manufacturing: this activity would thus not get a share of AE allocated.

2) Selecting “dedicated” activities

A second recommended step is to select only the links of the value chain that are **dedicated to the transition**, i.e. the activities (components, operations, services...) directly serving/enabling the transition. In other terms, such activities are part of the solution’s value chain and not equivalent to any activity of the reference scenario value chains.

Remaining “generic” activities that are not dedicated to the transition, should not be retained for the attribution.

Note: There again, the differential system boundaries can help identify the key enabling activities. Moreover, this should enable consistency with induced EF system boundaries – so, actors indeed factored in this EF – as activities that are identical in both reference and solution scenarios are often excluded from the calculation of both reference and solution emission factors (due to the AEF differential concept which would simply cancel emission from identical activities).

For instance, for the climate solution “electric car”, the car seat manufacturer is not considered dedicated to the transition (the car seat is a generic product that can also be used in internal combustion engine cars), thus cannot claim avoided emissions and should not be included in the links selected for horizontal attribution. In contrary, the battery manufacturer is considered to serve directly the transition (as the battery is a key component allowing vehicles to use electricity instead of fuel) and should thus be selected for the horizontal attribution.

After this step, a list of different links, components or actors that will get a share of the total avoided emissions of the solution is identified. Note that each of these links can then be divided into several sub-components and be the object of another horizontal attribution (see examples in section 4.8.4).

3) Applying the attribution key

The final step is to choose an attribution key to compute the share of total avoided emissions attributed to each link. Economic-based allocation (based on costs or added value) is frequently proposed to compute the breakdown of avoided emissions. For instance, it is the position of Carbon4 to the GFANZ public consultation, and it is also often used by the Climate Dividends Association.

However, such allocation approach may not properly reflect overall value chain actors’ efforts to avoid emissions for certain solutions. Typically, cost-based attribution seems relevant to solutions focusing on the general supply of a commodity that can be further used for various applications – power, hydrogen, electric car ... - and require investments in tailored

infrastructure (renewable power plant, electrolyser...). Conversely, for solutions describing a specific product with given end use – plant-based meat for human food, insect-based protein for animal feed -, it is complex to consolidate the contributions from all the actors across the value chain. In such case, an attribution key based on a physical criterion common to all sub-components may be more relevant (e.g. weight, protein content contribution). All in all, though it is acknowledged that economic-based allocation is not an ideal way to reflect decarbonation efforts, it remains a practically implementable and replicable approach that sounds relevant in some cases.

The AEP intends to further reflect on potential solution sub-categories if this happens to be applicable, that could help find the most suitable attribution key for each. As a preliminary note to illustrate the potential outcomes of this intended investigation, such sub-categories may consist in (but not restricted to): general commodity supply with cost-based allocation being relevant; products with specific end use for which a physical criterion (mass intensity or else) may be appropriate; services, practices and actions – e.g. building renovation, farm energy efficiency, data centre energy efficiency, incineration with energy recovery... - for which efficiency gain-related aspects could be considered.

Several attribution keys that can be used, along with their advantages and drawbacks, are developed in Table 1:

Table 1: possible attribution keys and their related pros and cons.

Attribution key	Pros	Cons
Stakeholder consensus	Weighting of all stakeholder insights/point of view Enables to factor in complementary adjustment factors to try refining the weight one wants to attribute to an actor deemed critical	Subjective/likely not based on tangible criteria or more complex to justify
Economic added value	Reflective of value brought to the market Can be summed up Illustrates the role of a specific actor	Uncertain estimation of added value? May not always be correlated to key role of components/operations?
Costs of capital goods and operations (CAPEX & OPEX)	Reflective of monetary efforts	Key components/operations may not be proportionally expansive vs. GHG reduction contribution Cost evolutions over time Potentially not summable
Induced GHG emissions	Directly accessible information (solution EF breakdown)	Key components/operations may not be proportionally GHG intensive while playing a critical role (e.g.

	based on physically relatable criterion	maintenance of a wind power plant) Improvement in induced GHG emissions means reduction of avoided emissions which is counter intuitive.
Weight of components	Based on physically relatable criterion	Not applicable/relevant to any solution (e.g. no meaningful relationship to consider weights of electrolyser vs filling station)
Arbitrary - criticality and importance judgement	Possible combination of criteria to not focus on 1 at the expense of other relevant aspects	Subjectivity, uncertainty

The stakeholder consensus would be the most ideal way to derive a relevant attribution key but is hard to achieve in practice and could result in discrepancies across calculations and the possibility to implement specifically maximizing or minimizing attribution shares. It would require stronger and transparent argumentation around the choices made, particularly if weighting factors are used in addition of an initial tangible criterion such as physical or economical.

The AEP tested attribution based on economic costs or investments – namely capital expenditures (CAPEX) and operational expenditures (OPEX) on example solutions (section 4.8.4) for which these costs seem to fairly capture the relative monetary efforts of each actor to enable the solution’s deployment. Moreover, these costs can generally be computed easily due to data availability. This enables to test the relevance of such cost-based attribution for specific cases, which will also help highlight the limitations or irrelevance of it for very different solution types.

Note: Comparing attribution shares based on different keys to evaluate the sensitivity to each actor can also be relevant to check that no important relevant bias is introduced when using the cost-based allocation key.

Communication

If a horizontal attribution is conducted, the AEP recommends reporting in any case the total avoided emissions of the whole system considered, before breaking down the % attributed to specific value chain actors. The way the attribution was conducted should also be disclosed and justified transparently, along with the related cost data sources, assumptions and limitations.

3.9 Time value of carbon

3.9.1 Purpose

Applying a discount rate to avoided emissions (time value of carbon) is suggested in some approaches when calculating avoided emissions factors, notably in the Climate Dividends approach (2022) or in the CDP & Breakthrough Energy “Emerging Climate Technology Framework” (2021). The main suggested rationale to introducing this parameter is that there is a more significant benefit from reducing greenhouse gas emissions immediately than reducing the same amount of emissions in the future. A value between [3%; 4%] discount rate is applied: *“The discount rate exists to recognize the uncertainty in the calculation (both in terms of future emissions of the Solution, and the evolution of the baseline/reference scenario) and the time value of carbon: emissions avoided or removed today are more important than those emissions avoided or removed tomorrow”*.

On the other hand, in most LCA approaches, there is no explicit differentiation of emissions at different times, as valuing present emissions against future ones can be seen as unethical.

3.9.2 Proposition for the database

In the case of the calculation of avoided emissions, applying a discount rate to future avoided emissions (resulting from the difference between a prospective reference scenario and a "solution" scenario) could help to consider the inherent uncertainty linked to prospective modelling. However, this uncertainty effect should be distinguished from differentiating climate change impact depending on the timing of the emissions.

Therefore, specific discount rates can be applied to specific scenarios to deal with uncertainties, depending on:

- Potential lack of “severity” or conservativeness of a scenario (a stated policy scenario might over-estimate avoided emissions).
- Inherent uncertainties of some solutions/sectors; for instance, there is more uncertainty in the future development of consumption patterns in the food and textile industries than there is in the evolution of the electricity mix in different regions of the world.

3.10 Limits

Table 10: levels of specificity for reference and solution scenario in AEF methodology

Reference Scenario	Specificity level	Solution Scenario		
		Solution specific	Company specific	Statistical
	Solution specific	Very high	High	Medium-high
	Company specific	High	Medium-high	Medium
	Statistical - country specific	Medium-high	Medium	Medium-low
	Statistical - world average	Medium	Medium-low	Low

Level of specificity of the platform's avoided emission factors

As for any database, the factors provided are generic and can be refined by users with more precise data. For instance, if a company selling a model of bicycle has conducted a robust



survey to estimate the actual modal shift enabled by its product, it is relevant to use that information to compute more specific avoided emissions than the one derived from country-average modal shift.

With its expert mode, the platform will authorize users to integrate specific elements (for instance load factor or carbon impact of their specific solution) so that the solution scenario can be as accurate as possible.

The positioning of the avoided emission factors is plotted in the table above, derived from WBCSD's specificity levels matrix for avoided emissions claims.

The concept of avoided emissions is focused on the climate change issue, and so only GHG emissions are considered for now. However, one major strength of the LCA approach is to be holistic, and to look at several environmental issues. Integrating other environmental impacts than climate change, such as biodiversity-related indicators (e.g. freshwater ecotoxicity or eutrophication impacts) or water use can enlarge the interpretation of results and provide useful insights to refine investments in the environmental transition.

**For more information on the methodology to calculate avoided emissions, join the
Avoided Emissions Platform (berard.hugo@quantis.com)**

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