NET ZERO INITIATIVE

FOR IT

Understanding the role of digital solutions in the global net zero effort

June 2024

Authors - Carbone 4
Clara Benedini, Manager
Pierre Maquet, Consultant
Benjamin Paulmier, Consultant
Zénon Vasselin, Manager

The team is grateful to

- Alexia Soyeux, César Dugast, Hélène Chauviré, Jean-Marc Jancovici, Julie Daunay, Laurent Morel, Mujahed Darwaza and Rodrigo Baranna for their help and supervision.
- Erwann Fangeat, Gauthier Roussilhe, Julia Meyer, Pernilla Bergmark, Maxime Efoui-Hess and Benjamin Ninassi from the scientific committee, for their expertise.
- Alain Marbach, Alexis Nicolas, Antoine Barbeau, Arnaud De Scorbiac, Aurore Vaudatin, Camille Richard, Caroline Gibert, Cédric Paolozzi, Christophe Lahaye, Clara Micarelli, Firmin Domon, Gregory Lebourg, Guillaume Portier, Isabelle Appé, Jean-manuel Canet, Johan Perier, Laurent Brugeilles, Lise Wilmer, Lorena Nava Guajardo, Nicolas Bordier, Olivier Rech, Olivier Renaud, Pascale Dubreuil, Philippe Tuzzolino and Tristan Nitot for their contribution.

Sponsor companies
Back Market
Bureau Veritas
Constellation
IJO
ISAI
OCTO Technology
Orange
OVH
Vusion Group

Sponsor companies are responsible for their own communications.

Page layout: Louise Badoche (Carbone 4)

Table of contents

Executive summary

This report is a guidance **to the Pillar B of the Net Zero Initiative (NZI) dashboard applied to the IT sector**. Pillar B aims to **quantify a company's positive impact** on the greenhouse gas emissions of its ecosystem. We focus here on the "**Avoided Emissions**" indicator, reflecting the contribution of a company's solutions to reduce their clients' direct and indirect emissions compared to a reference situation.

This report is divided in four parts:
Part 1: General Guidelines describe the IT sector's contribution to global carbon neutrality
Part 2: Characterisation of Solutions explains how IT solutions may decarbonize an activity
Part 3: General Methodology details issues to address in IT avoided emissions assessments
Part 4: Families of Solutions – Toolbox details guidelines for 4 families of solutions

PART 1 – THE IT SECTOR'S CONTRIBUTION TO GLOBAL CARBON NEUTRALITY

Summary of challenges of decarbonization in the IT sector

- The digital sector accounts for **~3% of global GHG emissions**[1], and its very fast growth makes the respect of global decarbonization targets even more challenging.
- The **digital consumption for its own sake (A)** and the **digital "solutions"** – aimed at *digitizing /connecting* other products and services – **(B)** share the same decarbonization challenge: **reducing their *absolute* emissions by 45% by 2030**[2]**.**
- **Like all others, IT companies must question the relevance of their product/service portfolio** in a transitioning world and reflect on the **compatibility of their business model** in a low-carbon future (see Box 1). **Technical progress does not avoid emissions by design.**
- Both (A) and (B) companies should also **fund emissions reduction and carbon sinks development** outside their value chain. **This fair contribution to global carbon neutrality cannot "compensate" nor "offset" an insufficient reduction of their own emissions.**

Summary of IT's role in decarbonization

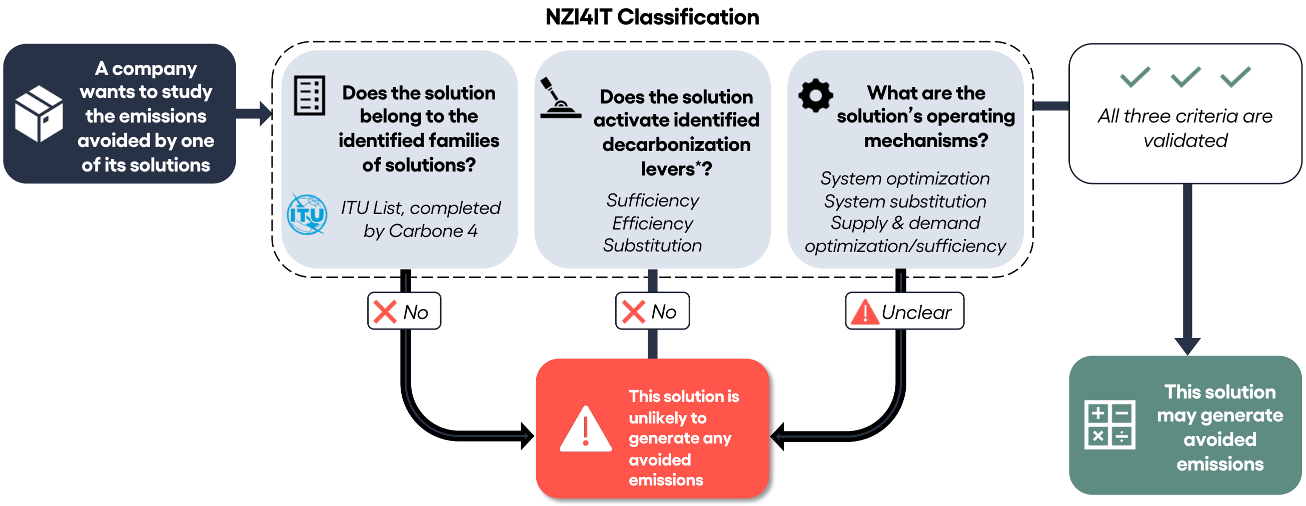
- Using **this guidance**, companies (B) selling **digital "solutions"** can assess if their products **help their customers to reduce their own emissions**.
- **The avoided emissions indicator is a short-term compass to fuel company strategic decisions,** allowing for instance to **target markets** for decarbonization.
- **Avoided Emissions are not fungible** with induced emissions and therefore **shall not** be used to **claim a hypothetic "carbon neutrality"** for the company nor its solutions.

[1] Source: The Shift Project, 2021 ; This figure includes production and use of terminals, data centers and networks.
[2] 'Guidance for ICT companies setting Science Based Targets', SBTi, 2019.

PART 2 – HOW CAN IT SOLUTIONS DECARBONIZE AN ACTIVITY?

Summary of the Characterisation of Solutions

- This method covers **both IT for Green** – IT decarbonizing other sectors – **and (IT for) Green IT** – IT decarbonizing itself – solutions.
- **To conduct an avoided emissions assessment,** companies must be able to **clearly understand** and define **how each solution acts upon a physical system**, and either optimizes, substitutes or reduces the need for it, using the following diagram:



- * **Enablement in itself is not a decarbonizing lever**: companies must clearly identify which of sufficiency, efficiency or substitution is "enabled" by a solution, and argue as to why the system could not get decarbonized without IT.

PART 3 – ISSUES TO ADDRESS IN IT AVOIDED EMISSIONS ASSESSMENTS

Summary of the General Methodology for the IT sector

- Claiming avoided emissions sends a **strong signal** to the market, requiring the company to pass successfully through the **6 Eligibility Gates** of NZI4IT, 6 conditions framing the legitimacy of avoided emissions claims.
- Quantifying avoided emissions for IT solutions can be extremely challenging and **requires precise data**, especially to prove that a substitution occurred.
- The guidance complements NZI Pillar B Guide about time and geographic perimeters for assessments:
  - **yearly ex-post analyses** are to be favoured over forecasts over a solution's lifespan.
  - **location-based** accounting remains mandatory for electricity consumption.
- **11 methodological cruxes** specific to the IT sector are explained and solved with complementary guidelines:
  - **Baseline issues**: **Reference situations must be updated regularly** to reflect the IT sector's quick evolutions over years. **Low-tech alternatives** must also be part of the market mix of the baseline.
  - **Rebound issues**: "Is there a real **substitution**?" – Rebound is **omnipresent in IT and should always be accounted for**. For *cloud* migrations, the **maximum level of specificity is**

required in the data collection: no avoided emissions extrapolations can be done on an entire customer base from a single customer case. The guidance also helps identify rebound effects.
  - **"Enablers" are redefined** through the concepts of sufficiency, efficiency and energy substitution, by distinguishing the **levels of maturity** of solutions.
- Communication on avoided emissions must **explicit the reference situation hypotheses** and shall not incite to overconsumption.
- Automatization, especially **Artificial Intelligence (AI) solutions cannot claim avoided emissions simply on the grounds that they replace a human job**.

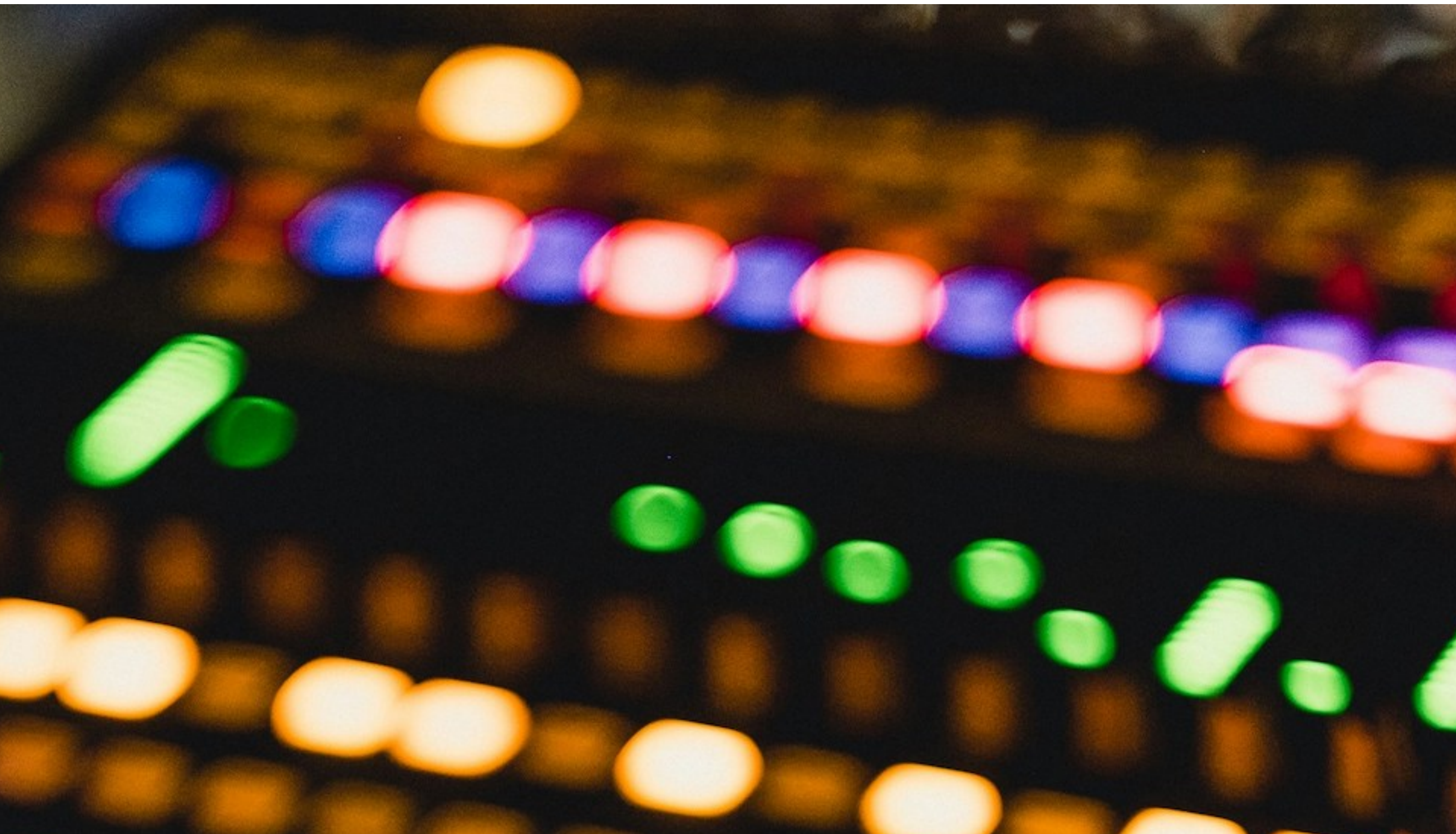
PART 4 – SECTORAL TOOLBOX TO ASSESS AVOIDED EMISSIONS FOR 4 IT SOLUTIONS

Summary of the toolbox content

The toolbox provides **detailed guidelines** to calculate the emissions of the **reference situation** and of the solution scenario, evaluate **rebound** effect, identify **necessary data** and **important parameters** for 4 families of solutions:

1. **Circularity**: repairs, refurbishment…
2. **Cloud & "Virtualization":** infrastructure sharing, cloud migration…
3. **Demand-Offer matching platforms**
4. **Demand-size optimization and sufficiency**

No Avoidance Factors were calculated, since the method requires a high level of specificity for any avoided emissions calculation, *i.e.,* getting specific customer & market data – not just extrapolated data – to perform the assessment.



PART 1

General Statement

I. Introduction

The digital sector – including device production, data sharing, computing and storage capacity – has seen its energy and resource consumption boom, while the opposite would seem to be required to limit global warming to less than 2°C above pre-industrial levels. Accounting for 2.1% to 3.9%[3] of global greenhouse gas (GHG) emissions and 2.5% of France's carbon footprint in 2020, it stands out for its upward trend, of +6% per year in France[4]. If the trend continues, the carbon footprint of the digital sector in France could increase by 45% between 2020 and 2030[5]. In a broader lifecycle analysis, GHG emissions represent only part of the environmental impact of digital technology: the sector is exerting increasing pressure on mineral and fossil resources, water use and waste[6]. Lastly, growing demand for electricity and non-recyclable critical metals could come into competition with the increased needs from the low-carbon transition[7].

The sector is sometimes promoted as a provider of solutions to the climate crisis, capable of reducing the greenhouse gas emissions of other sectors. **This calls for a further investigation of**

[3] Charlotte Freitag et al, *The real climate and transformative impact of ICT: A critique of estimates, trends, and regulations*, 2021.
[4] The Shift Project, *Lean ICT: pour une sobriété du numérique*, 2018 and *Impact environnemental du numérique : tendances à 5 ans et gouvernance de la 5G*, 2021; ARCEP-ADEME, *Evaluation environnementale des équipements et infrastructures numériques en France*, 2022.
[5] ARCEP-ADEME, *Environmental assessment of digital equipment and infrastructure in France*, 2022
[6] ARCEP-ADEME, *Evaluation environnementale des équipements et infrastructures numériques en France*, 2022; Green IT, *Le numérique en Europe : une approche des impacts environnementaux par l'analyse du cycle de vie*, 2020; AFP, *En Europe, une hostilité émergente contre les centres de données*, 2022; Marion Cohen and Antoine Gonthier, *Economie, ressources naturelles et pollutions*, 2020.
[7] CGDD, *Les ressources minérales critiques énergies bas carbone*, 2023; IRIS, *Un retour des stocks stratégiques de métaux critiques dans la dynamique de transition bas carbone?*, 2023; Carbone 4, *Guerre et transformation bas-carbone: d'une dépendance des énergies fossiles vers celle des métaux?*, 2022

the decarbonisation potential of digital technology and of the steps the sector should take to contribute to the net zero emissions objective.

These Guidelines extend the Net Zero Initiative (NZI) benchmark initiated by Carbone 4 by adapting it to the digital sector. Twenty organisations and experts from the sector including digital companies, specialised consultancies and investment funds, network operators, institutions, academics and NGOs pledged to use the NZI for IT Guidelines. Companies that sign the NZI for IT code of conduct acknowledge the relevance of its findings and use the proposed methodologies to adopt climate strategies commensurate with current environmental challenges.

II. Two categories of digital products and services with distinct climate issues

Digital solutions can be differentiated by their functions, forming 2 groups with different decarbonisation levers.

1. The first category (hereinafter referred to as "category A") refers to **solutions that promote a digital consumption for its sake**: this is the case for all screens that support entertainment, and in particular the viewing of online recreational videos, whether they come from streaming websites, mobile phone applications or video game consoles. This category A has seen very strong growth in recent years[8]. **These products have neither the aim nor the ability to contribute to the decarbonisation of other uses**. Like all other products & services, they should start by questioning the relevance and conditions of their development in a world constrained by the compliance with a 1.5°C or 2°C carbon budget. Furthermore, their *own* contribution to decarbonisation can only, and must only, be achieved through efforts to reduce their induced emissions (pillar A of the NZI reference framework).

2. The second category (hereinafter referred to as "category B") refers to **digital solutions** aimed at *digitising* or connecting another type of product, services or solution. Today's economy is heavily reliant on the support of these digital solutions, which enable players to communicate and operate increasingly faster (emails, automated processes, digitised transactions, etc.), a logic that decarbonisation calls into question.

   Category B, which is largely based on data production and processing, includes solutions for measuring, managing and optimising a number of physical flows. Examples include

[8] While data traffic is responsible for 55% of the global energy impact of digital technology, online video flows accounted for 80% of this traffic in 2018 and 80% of the increase in their annual volume. It should be noted that these video flows by type of use are made up of streaming platforms for films or series (34%), pornography (27%), Tubes on Demand (21%), and videos exchanged on social networks via smartphones (21%) - see The Shift Project, *Climate: the unsustainable use of online video*, 2019.

systems for optimising buildings energy consumption, eco-driving systems integrated into vehicles, and platforms facilitating access to soft or shared mobility. Under **certain conditions, the solutions in this category offer potential help in reducing greenhouse gas emissions.** For these solutions, the challenges of decarbonisation therefore go beyond Pillar A: there is also a challenge of avoided emissions, Pillar B of the NZI reference framework. The difficulty, however, lies in measuring the reduction in emissions they actually achieve.

The digital revolution is often presented or considered as the ally of ecology, due to the decarbonising potential of certain solutions belonging to category B[9]. However, when we look at the negative externalities associated with the sector as a whole (categories A and B), we see that its emissions and other pollution are significant and growing. In fact, **the emissions that could be avoided by certain category B solutions are over-compensated by the growth of certain uses (particularly in category A) that have no environmental virtue.**

III. How can digital companies contribute to global net zero?

Like any other sector, the digital sector must contribute to the pursuit of the goal of global net zero: any digital company, whether it produces category A or B goods and services, must be accountable for its climate strategy and follow science-based rules of action to limit its GHG emissions. To do so, the company can take a two-stage approach.

1. Firstly, a company should ensure that its solutions are compatible with a low-carbon world (forward-looking analysis and pillar B of the NZI framework),
2. Secondly, it must reduce its own emissions and contribute to the development of carbon sinks (pillars A and C of the NZI guidelines).

1. Ensuring that the purpose of one's activities is compatible with a low-carbon world: analysing the business model and Pillar B

The need to re-benchmark the various economic sectors within the physical limits of the planet means that each company must first question the purpose of its activities to ensure that they are compatible with a low-carbon world.

- Given the pressure that the sector is exerting on greenhouse gas emissions, mineral and water resources, as well as on the demand for electricity, **every digital company must ask itself the question of the relevance of the uses of its products in a transitioning world.** This analysis of the nature of its activities is the only way to ensure that they meet the imperative of sufficiency, i.e. "a situation in which limited resources are put at the service

[9] Remote working, collaborative platforms, e-commerce, so-called "dematerialized" uses (books, films, music), "intelligent" buildings and cities, etc., would all help to reduce our consumption of resources and the resulting pollution. See Marion Cohen and Antoine Gonthier, *Économie, ressources naturelles et pollutions*, 2020.

of reasonable needs"[10]. It implies upstream reflection on the **sustainability of the business model** in a low-carbon world.

- For companies marketing **category B** solutions that **help to reduce emissions from their ecosystem,** the analysis can go a step further: they can assess the ability of their existing or future solutions to contribute to decarbonising activities.

As we will see in Chapter 3, several tools can be used to assess the compatibility of a company's business model with a low-carbon world (for categories A and B), and to measure the emissions avoided by its products and services (for category B only).

2. Reducing one's own emissions and helping to develop carbon sinks

Once it has ensured that its products are aligned with a low-carbon world, a digital company, whether Category A or B, must reduce **the externalities of its products as much as possible.**

- **Reducing one's own emissions (known as *induced* emissions, or pillar A) must be a key part of the** climate strategy of digital sector companies. They must follow science-based emissions reduction trajectories aligned with those of their sector to meet the Paris Agreement.

  As mentioned above, category A solutions – whose purpose is a digital consumption per se (and video viewing in particular) – should focus their efforts on **reducing their induced emissions in absolute terms,** because of their growing emissions and inability to reduce emissions of other sectors**.**

  The key obstacle to an adequate reporting by companies in the sector lies in digital value chains that are intricate, geographically fragmented, and suffer from a **lack of transparency** from the sector's largest players[11].

- Finally, like all economic players, companies in the digital sector (categories A and B) must **help to reduce global emissions by contributing to developing global carbon sinks (pillar C of the NZI guidelines)**.

  However, with the exception of IT solutions dedicated to improving agriculture and/or forestry, digital technology has no immediate link with the value chains of the land and forestry sectors: its players can only contribute to the effort by funding carbon sequestration projects outside their value chain.

[10] Definition proposed by the economist Eloi Laurent in an interview with France Inter in September 2022.
[11] From an accounting point of view, it can be difficult to provide keys for converting the consumption of digital products and services into quantities of GHGs emitted. This is because it is difficult to identify relevant units of need (*functional units* in carbon accounting) that are close to the underlying physical reality (e.g. what physical quantities should be attached to the viewing of a streaming video in order to properly reflect the response to the need? Is the need simply a volume of data, a bit rate for a certain duration or something else?) because digital equipment is subject to numerous threshold effects that decouple its consumption of energy and materials from the quantity of services rendered. In fact, on a small scale, there is a non-linearity between the power consumption of network equipment and the data flows passing through this equipment. On a large scale, it seems reasonable to imagine that this effect will be eliminated, but then we come up against the problem of network infrastructures: capacity sizing is linked to the peak load and not to the average load. The 'weight of the peak' therefore adds emissions that are difficult to include in the carbon bill of VoD system users. Furthermore, the superimposition of invisible flows mobilised to provide a digital service obscures the physical reality that supports them (see Carbone 4, *Les matières de l'immatériel: exist-t-il des risques d'approvisionnement en matières premières pour les entreprises du numérique?* 2023). Finally, business models and the distribution of value do not encourage a systemic approach (e.g. *over-the-top* services or OTTs - see *Transitioning towards sustainable digital business models*, ECDF Working Paper Series #005, Hugues Ferreboeuf, 2022).

Remember that these contributions in no way "offset" the emissions of these companies, and **do not replace** the essential reduction actions under pillar A.

IV. Tools for a low-carbon strategy in the digital sector

To build an effective and ambitious climate strategy, companies of the digital sector must have the analytical tools to meet the objectives set out in the previous chapter. The following tools can already be used to help the sector's companies make an effective contribution to global net zero.

- **All digital players, category A and B, must first reflect on the purpose of their activities to ensure that they are able to operate within the physical limits of the planet and in compliance with the Paris Agreement.**
    - Companies marketing **Category A and B** solutions can analyse **the resilience of their business model and solutions portfolio** by projecting them into a low-carbon world using **forward-looking scenario analysis.** These aim to identify the risks and opportunities associated with the low-carbon transition, and are an exercise recommended by the CSRD [12,13].
    - **Category B companies** can also assess the relevance of a solution, or a portfolio of solutions, in a world in transition using **Pillar B** tools.
        - The Paris Agreement Compatibility Score (**SCAP**)[14] developed by NZI can be used to **assess the compatibility of existing products and services with a low-carbon world.** By analysing a solution or portfolio of solutions, it can answer two questions: do my solutions contribute to low-carbon practices, and do my solutions help to decarbonise the function I am addressing?
        - Category B companies can also carry out an analysis to **measure the emissions that their new solutions can help to avoid for customers and end users**. Digital solutions aimed at optimising systems (sensors feeding *machine learning* algorithms to optimise data centre cooling, for example), eliminating travel thanks to remote work, or better matching supply and demand (as-a-service solutions and usage economy platforms), are conducive to calculating avoided emissions. However, a **number of methodological challenges need to be rigorously addressed: quantifying rebound and indirect effects, and defining the** baseline **situation** are critical[15].

[12] *Corporate Sustainability Reporting Directive.*
[13] Scenario-based prospective analyses aim to identify the risks and opportunities of the low-carbon transition.
[14] NZI, *Proposal for a new climate indicator*, 2022.
[15] These aspects are dealt with in the Methodological cruxes part of the General Methodology section.

These tools open up two possibilities for digital businesses:

- modify their existing products and services to make them more suitable for a low-carbon world, through new uses or new markets ;
- consider and direct their production towards the creation of new products and services that will be resilient in this global transition, and will replace those that are less relevant or at high risk of transition.

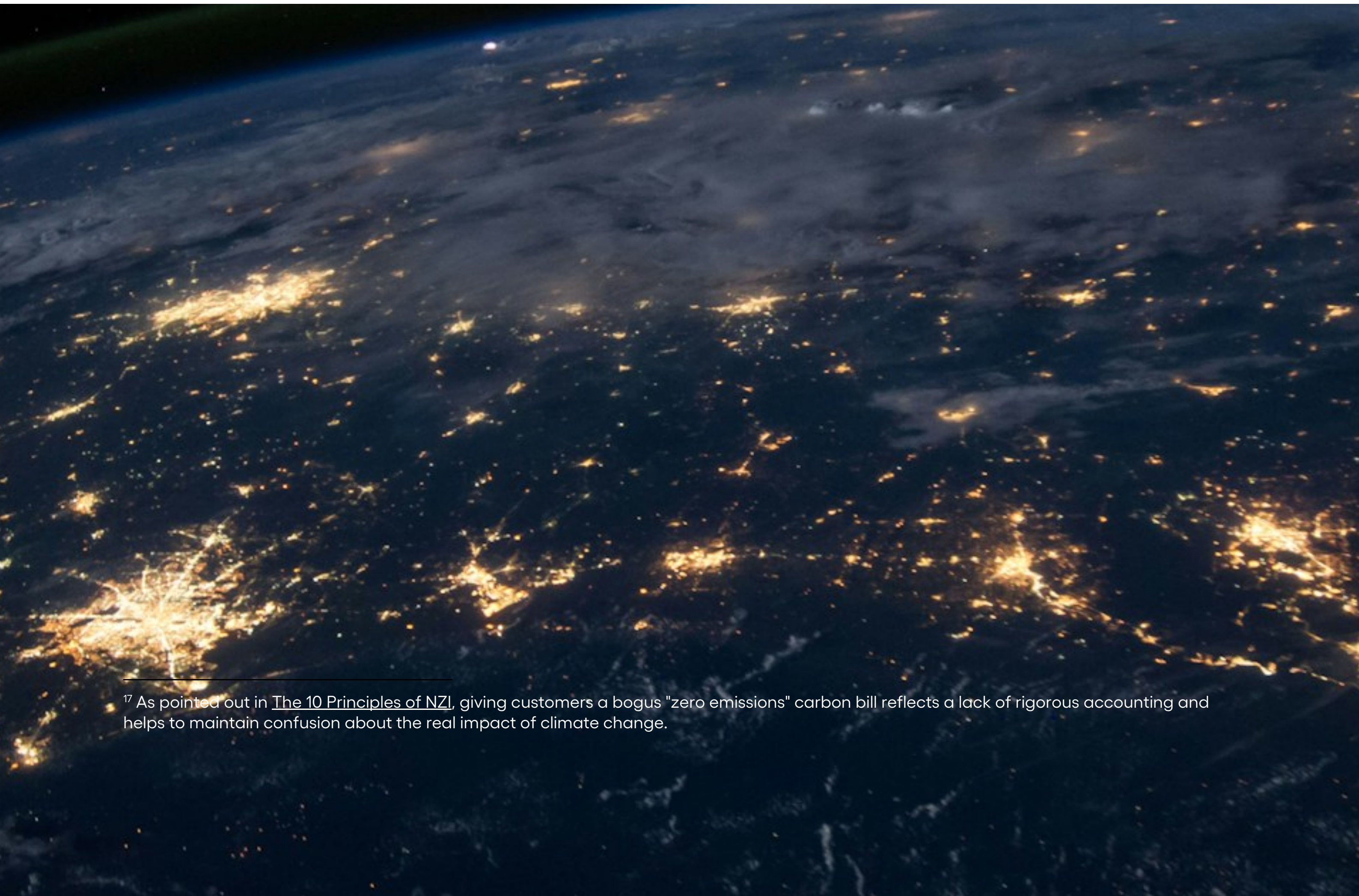
- Secondly, **companies (categories A and B) must take an interest in measuring and reducing the negative externalities of their products and services**. As a reminder, according to the SBTi, the majority of companies - and the economy as a whole, all sectors combined - must reduce their emissions by at least 90% by 2050 compared with 2020 in order to limit global warming to 1.5°C compared with the pre-industrial era[16].
    - To reduce its externalities, the company must seek to **reduce its own emissions** (pillar A).
    - To do so, it needs to **use standard science-based methodologies** appropriate for digital technology. This will enable it to measure its carbon footprint, disclose its commitment to reduction targets and adopt an appropriate reduction action plan.
    - But it is not enough. **Analysing the purpose of the digital solutions is also necessary. It can consist in** checking the compatibility of its portfolio of products with a low-carbon world, and/or assessing the decarbonisation potential in its products' customer sectors (pillar B).

- Companies (**categories A and B**) can also **fund projects that contribute to reducing emissions and developing carbon sinks outside their value chain (pillar C).**
    - Digital companies must support projects outside their value chain that are consistent with their financial resources and/or their level of current or past emissions (for example via an internal carbon price compatible with a 1.5°C objective).
    - Under no circumstances can these contributions be considered a compensation for induced emissions and give way to declarations of carbon neutrality.
    - If companies do not adopt a global reduction trajectory compatible with the Paris Agreement, their investments in "offsetting" are tantamount to an attempt to grant themselves a right to exist in a low-carbon world without having made the necessary transformations. These practices are formally condemned by the GHG Protocol and the NZI.

- **For all category A and B digital companies, communication must be unambiguous, sincere and faithful to** their effective efforts to reduce their environmental impact and their low-carbon transition strategy. This means respecting the four principles listed below.

[16] SBTi, *Net Zero Standard V.1.1*, April 2023

1. **A company should refrain from declaring hypothetical "climate" virtues or benefits associated with its products and services if it has not conducted specific studies** using appropriate methodologies that can attest to these emission reductions. It is up to any company that has produced a solution to demonstrate any positive environmental impacts using scientific methods.
2. Given the collective interest in accessing the data of digital players to measure the environmental impacts of the sector and inform decision-making, companies must **demonstrate a reasonable level of transparency** to facilitate inventories of the carbon impacts of their activities.
3. For products and services that have no emission reduction or avoidance potential, it is **important to be transparent about their impact over their entire life cycle**, and under no circumstances to communicate that they are "green", messages that help to make invisible the pressures exerted by these solutions on mineral resources and the climate[17].
4. Finally, **declarations of emissions avoided** by Category B digital solutions must be **grounded in appropriate calculations,** account for **rebound effects and describe the reference situation**.



[17] As pointed out in The 10 Principles of NZI, giving customers a bogus "zero emissions" carbon bill reflects a lack of rigorous accounting and helps to maintain confusion about the real impact of climate change.

PART 2

Characterisation of Solutions

I. Introduction

As defined in Part 1, digital companies at the service of others (category B) must question their business strategy regarding climate change:

- analysing if their products **help today's world decarbonization**, using **Avoided Emissions as the key indicator**.
- questioning the fitness of their products in tomorrow's low-carbon world, using the **Paris Agreement Compatibility Score** (see Box 1) as key indicator.

Box 1: the Paris Agreement Compatibility Score

The Net Zero Initiative has defined another indicator complementary to the avoided emissions indicator, the **Paris Agreement Compatibility Score (PACS)**, meant to measure the relevance of a product or service in a low-carbon world that has transitioned following a 1.5°C or Well-Below 2°C trajectory.

If the baseline has completely shifted towards a virtuous situation, a product may not make enough of a difference to avoid emissions anymore; however, that does not necessarily mean it is not relevant in a low-carbon world.

Conversely, a solution that avoids emissions at a given time thanks to a particularly emissive baseline is not necessarily compatible with the aforementioned trajectories and thus not necessarily relevant in the long-term.

To discover more, read the Net Zero Initiative proposal to create a new climate indicator.

Avoided Emissions (AE) are a short-term compass to fuel company strategic decisions, helping determine which product to deploy in which market to accelerate decarbonization.

Rigorously calculating AE requires high quality data and a **profound understanding of the underlying physical mechanisms** leading to the reduction of greenhouse gas emissions.

Calculating AE seems the only way to properly prove and quantify the climate benefits of an IT solution. But before launching any calculation process, it is recommended to conduct a first qualitative assessment. In this regard, the following chapter proposes an approach to **characterize the relevance of IT solutions in terms of avoided emissions**.

A **characterisation framework** is described hereafter to help companies identify categories of solutions that might lead to avoided emissions. It covers most relevant families, but as IT evolves rapidly, other examples may probably emerge in the future.

This framework can also be used by companies as **brainstorm material** for innovation purposes or to help **portfolio analysis**:

- *What kind of **new products** could both contribute to my company's strategy and avoid emissions?*
- *Is my company's current products portfolio **compatible** with our ambition regarding avoided emissions?*

II. NZI4IT Characterisation process

Before carrying out any calculation, companies can investigate the three following questions to start characterizing the relevance of solutions that may lead to avoided emissions:

Does my solution belong to a family of solutions that could avoid emissions?

Which decarbonization levers does my solution activate for my clients?

What are my solution's operating mechanisms to avoid emissions?

Figure 1 recapitulates the corresponding characterisation process. Each of these questions – each step of the process – sheds light on the IT solution from a different angle. If, despite these three spotlights, the source of impact of the IT solution remains blurry, then this solution is very unlikely to generate any quantifiable avoided emissions. The company then ought to stop the avoided emissions assessment and related communication.

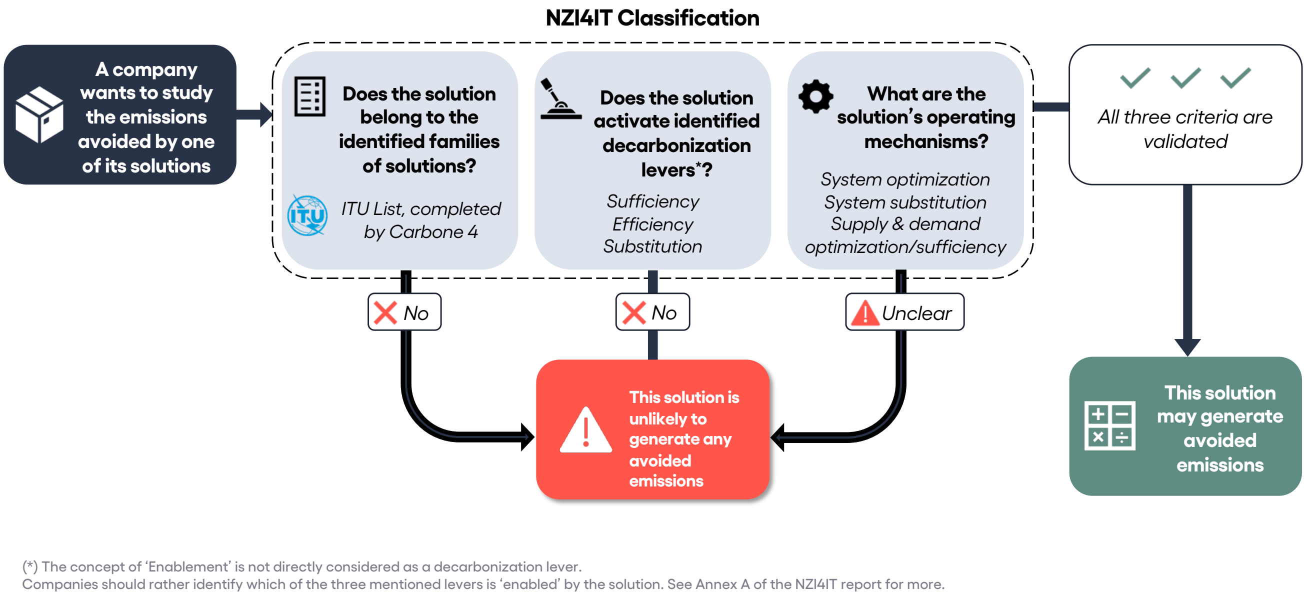


Figure 1: The NZI4IT characterisation process for IT solutions

1. Does my solution belong to a family of solutions that could avoid emissions?

Based on the ITU L.1480 characterisation[18], with the support of the NZI4IT advisory board and sponsors, a list of promising families of solutions was established[19]. It consolidates all products that could claim avoided emissions thanks to their mode of action. The ITU characterisation has been built to reflect the decarbonization needs of all sectors. Those needs have then been translated into what seemed the most relevant technological levers and into practical solutions.

Thus, if a company's solution does not refer to any of the families in Table 1, it means that the solution is unlikely to have any decarbonizing effect. However, this is not reciprocal: finding a company's solution in this table does not necessarily means that this solution avoids emissions. Avoided emissions depends both on the solution and on the market – key to design the reference situation – so one cannot claim avoided emissions by studying only the solution itself.

[18] ITU-T. (2022). Enabling the Net Zero transition: Assessing how the use of information and communication technology solutions impact greenhouse gas emissions of other sectors. International Telecommunication Union Standardization sector. Recommendation ITU-T L.1480.
[19] Also note that the ongoing work 'Evaluation environnementale des effets directs et indirects du numérique pour des cas d'usage' by ADEME will tackle the subject.

System monitoring and optimization	System substitution	Supply or demand monitoring and optimization
Optimization of grids	Virtual meetings	Improved metering and forecasting of electricity supply and demand
Production efficiency	Remote work	Improved energy system through demand side management
Intelligent building energy and resource management	Substitution of ICT systems and uses?	As-a-service and sharing solutions
Route optimization		Circularity (industry, transport, IT, …)
Precision agriculture		Optimized use and sharing of buildings
Precision forestry		Eco driving
Ecosystems protection[20]		Shared mobility
Optimization of ICT systems		Systems or programs encouraging user sufficiency for ICT use

Table 1: Identified families of solutions that could avoid GHG emissions.

2. Which decarbonizing lever does my solution activate for my clients?

To verify the studied solution helps the client decarbonize its activities, Table 2 defines the three decarbonization levers.

Lever	Definition	IT for Green examples	(IT for) Green IT examples
Sufficiency[21]	Questioning our energy & material needs and prioritize the most essential ones.	Eco-designed hardware & software, video encouraging energy saving habits	Refurbished IT equipment, sleep mode for idle IT systems, default video resolution on streaming platforms
Efficiency	Reducing the amount of energy or materials needed to meet a given need.	Route optimization	Upgraded CPU architecture, Virtualization
Substitution	Switching from one system to another, or from high to low-carbon energy.	Online meetings	Virtualization

Table 2: Decarbonization levers that may lead to avoided emissions.

[20] The Recommendation ITU-T L.1480 only refers to "Forest protection". The NZI4IT methodology recommends including all natural ecosystems in this category to ensure the most representative view of existing solutions.
[21] See for example on sufficiency: Santarius, T., Bieser, J.C.T., Frick, V. et al. Digital sufficiency: conceptual considerations for ICTs on a finite planet. Ann. Telecommun. 78, 277–295 (2023). https://doi.org/10.1007/s12243-022-00914-x

These levers can cover different contexts and be activated in different ways. “Digital sufficiency” for instance can be applied at the hardware, software, and user levels[22].
Verifying that the studied solution effectively activates a decarbonization lever in Table 2 ensures that it has a **tangible** effect on its operating ecosystem. “Enablement” is not a decarbonization lever by itself (see Annex A for more).

3. How does my solution contribute to avoiding emissions?

This final step helps identify how, where and when the IT solution acts on the system. Indeed, understanding where the emissions are avoided in the value chain is necessary to prepare the calculation and ensure the decarbonization potential is real. To clarify this context, the interactions of the solution with its operating ecosystem must be characterized.

First, the solution’s operating mechanism (on the system) must be identified, as it is responsible for the activation of the lever(s) identified in the previous step of the characterisation process.

When communicating on avoided emissions, being clear on the mechanism at work is essential.

Mechanism	Definition
System monitoring and optimization	Improving the efficiency of a system by optimizing it, thanks to improved physical flow measurements and algorithm-based forecast. *Examples: predictive maintenance, connected water heater, etc.*
System substitution	Replacing one system by another while providing the same final service to the user. *Example: Online meetings replacing physical meetings.*
Supply & demand monitoring, optimization, and sufficiency	Improving the match between supply and demand for a given need, leading to a more responsible demand and overall reduction in emissions. *Examples: online sharing economy platforms, sufficient ‘pas-as-you-go’ phone packages, etc.*

Table 3: Mechanisms allowing a potential generation of avoided emissions.

Two further aspects should also be analysed: *scale* and *time*. These considerations are closely related to the level of specificity, illustrated in Box 5: they characterize the level of precision retained for the avoided emissions assessment[23].

Regarding *scale*, six levels have been selected: individual / household / firm / sector / national / global.

Regarding *time*, two levels may be considered: short-term and long-term.

[22] More information on digital sufficiency is provided by: Santarius, T., Bieser, J.C.T., Frick, V. et al. Digital sufficiency: conceptual considerations for ICTs on a finite planet. Ann. Telecommun. 78, 277–295 (2023). https://doi.org/10.1007/s12243-022-00914-x
[23] More information the level of specificity can be found in: *Net Zero Initiative, Le Guide Pilier B, Calculer et valoriser ses émissions évitées, Carbone 4, 2022.*

Box 2: Consolidation of Avoided Emissions

Avoided Emissions is not an indicator that can be easily consolidated at every scale. Indeed, two different solutions may take their avoided emissions from the same potential. The avoided emissions resulting of the combination of both solutions will therefore be inferior to the separate sum of the two.

The scale and the consolidation rules for the avoided emissions indicator must thus be determined to avoid such overlap. The reference situations of each solution shall also be consistent and share common quantified structuring hypotheses.

Figure 2 illustrates the overall characterisation process for a company providing connected thermostats aiming at reducing energy consumption in buildings.

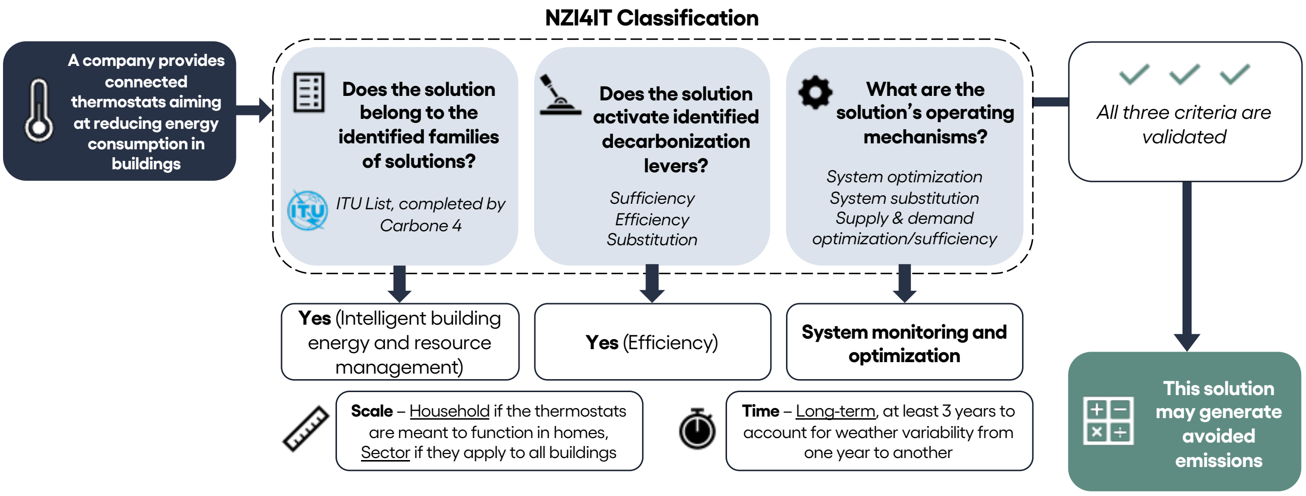


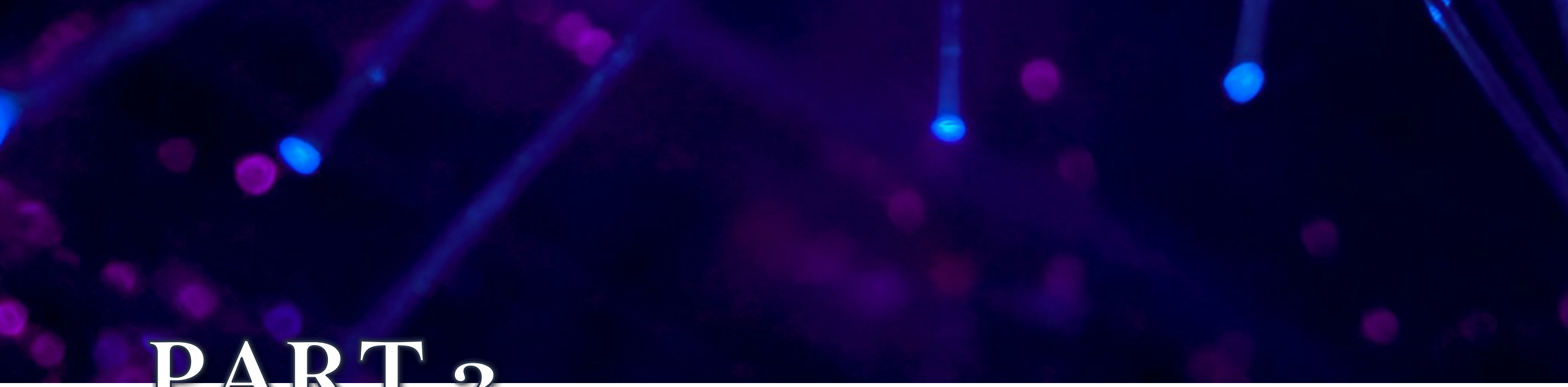
Figure 2: The NZI4IT characterisation process for a connected thermostat solution

Once the decarbonizing lever, mechanism, scale level and time level have been identified, the solution is characterized.

III. Outcomes and next steps

By reflecting on the key issues presented above, companies should have a better idea of whether their products could avoid emissions or not. If the solution passes the three "tests" presented in Figure 1, an avoided emissions calculation may follow. Besides, all the answers that were found throughout this characterization process will be useful for the calculations and may help companies to carry out their own assessment.

In the end, it should be noted that **calculating** the emissions avoided by their solution stands as the **only reliable basis** for corporate communication. It is also the only precise way to know if emissions are indeed avoided.
To this purpose, NZI4IT provides calculation steps in the **Methodology** and **Toolbox** sections.



PART 3

General Methodology

I. Eligibility gates

Throughout their lifecycle, IT solutions have several **social and environmental impacts other than GHG emissions:** local pollution caused by raw material extraction, resource depletion, water usage[24] to name a few. Furthermore, IT solutions have spread through all sectors of the economy, including those that can be considered noxious for human health and/or the environment.
To avoid promoting harmful products or practices, and to solve certain methodological issues encountered when assessing the avoided emissions of an IT solution, **this guide provides eligibility gates that must be validated before starting an assessment.** Gate 3 is a direct application of the gates mentioned in the WBCSD x NZI guidance on avoided emissions.

- **Gate 1: Do no significant harm (DNSH)**
  Solutions that cause significant damage to environmental indicators other than climate are not eligible for avoided emissions claims. The criteria defined by the EU Taxonomy may be used as a reference.

- **Gate 2: Excluded sectors**
  Solutions that directly hinder one or more of the United Nations' sustainable development goals (SDGs) are not eligible for avoided emissions claims. In particular, solutions applied to one of the following activities are excluded:
    - Fossil fuel exploration or extraction[25] (goals 7 and 13),
    - Tobacco industry (goal 3),
    - Gambling (goals 1 and 3),
    - Pornography (goals 3 and 5),
    - Weapons trade (goal 16),
    - High frequency trading.

- **Gate 3: Climate action credibility**
  Any company claiming avoided emissions must have set and communicated a climate strategy aligned with latest climate science, as described in the WBCSD x NZI guidance on

[24] *Green IT, Le Numérique en Europe : une approche des impacts environnementaux par l'analyse du cycle de vie, 2021.*
[25] With the exception of solutions aiming solely at reducing waste (e.g. methane leaks), where the company is able to prove they do not induce increased demand.

Avoided Emissions. The company must communicate its carbon footprint yearly using a robust framework (e.g., GHG Protocol, BEGES) and commit to its reduction pathway, aligned with the Paris agreement goals.

- **Gate 4: No immediate rebound effect**
  Solutions that directly increase the demand or create new demand for the need it answers to are not eligible for avoided emissions claims. Likewise, solutions that explicitly encourage users to increase their usage of said service are not eligible for avoided emissions claims.

- **Gate 5: No incentive to renewal**
  Hardware solutions that are designed to be difficult to repair, that incite renewal of other equipment, or that are cheaper to buy new than to repair are not eligible for avoided emissions claims.

- **Gate 6: No misleading communication**
  Solutions that are qualified as "carbon-neutral", "green", or any other term implying that increasing consumption of the solution has no negative effect on the environment, or alleged positive environmental effects, are not eligible for avoided emissions claims. The communication surrounding the solution must be aligned with the **Net Zero Initiative's ten principles** and any ICT sector specific NZI communication principles newly published**.**

II. Global guidance on avoided emissions

If all eligibility criteria are met, an avoided emissions assessment may begin, following the methodology defined by the **Net Zero Initiative Pillar B guidance**. A recap of the different steps of an assessment is given by figure 3.

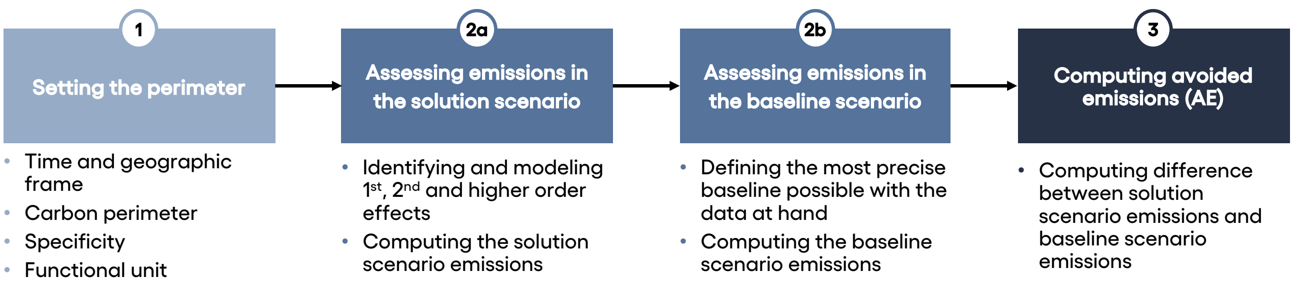


Figure 3 – Steps of an avoided emissions assessment

1. Guidance on time perimeter – ex ante / ex post analyses

Avoided emissions are usually computed on the complete lifespan of the studied solution. Each year, embedded avoided emissions are calculated for the newly sold products, in a flow-based approach – like induced emissions for car sellers for instance –.
For IT solutions however, there is a high uncertainty about continuous use over a long timespan, even for hardware products, considering the pace at which the sector evolves. Hence, it is recommended to assess avoided emissions using a stock-based approach instead of a flow-based approach.
Rather than considering the emissions over a solution's complete lifecycle, companies should assess the ex-post emissions of their solutions each year – or at longer regular intervals if justified – by looking at the solution's level of usage during the year.

A forecast of avoided emissions along lifespan may also be used to fuel basic strategic analyses as long as no marketing communication are made on this same basis (see Box 3).

Example

NZIProperty, a real estate company, fully completes its private cloud migration within a year in 2021, decommissioning all of the servers it used to have on premises. NimbusTech, the cloud provider, wishes to assess the avoided emissions of their cloud solution for this specific customer.

To define the solution scenario, NimbusTech could try to predict how NZIProperty will use their solution over its lifespan, a prediction that is strongly prone to uncertainty. NimbusTech instead should assess how the solution was used in 2022 in an ex-post analysis, having access to detailed data of NZIProperty's use of their services during the year.

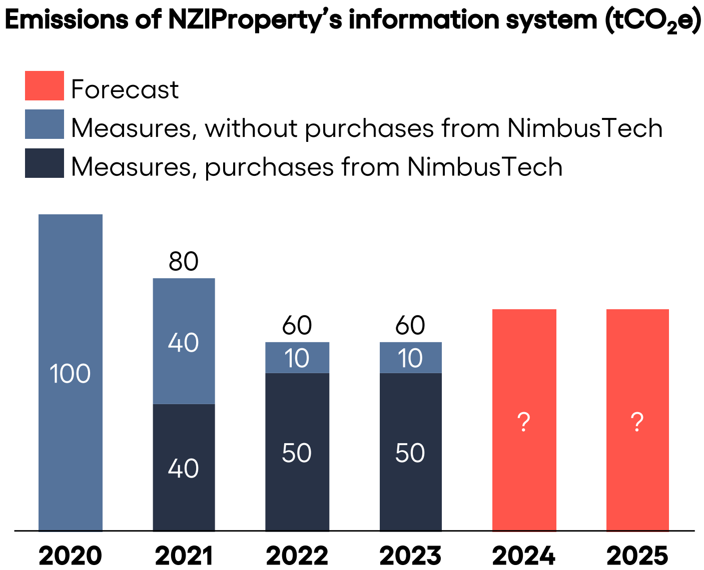


Figure 4 - Illustration of NimbusTech's attempt at evaluating their solution's avoided emissions over its lifecycle – To ensure the avoided emissions assessment is robust, NimbusTech must restrain its perimeter to measured ex-post values

Box 3: Lifespan assessments

Ex-ante assessments looking at the solution's full lifespan may seem more adapted for certain solutions (e.g., hardware).

When this is the case, the integral of the solution's emissions over its lifespan shall be assessed, with regular updates of the solution scenario (e.g., every 3 years).

The ex-ante predictions must match the ex-post measurements. If time shows that avoided emissions were overestimated by a given value during the first 3-year span, this value must be deducted from the predicted avoided emissions of the following span.

2. Guidance on geography

The induced emissions of IT solutions rely strongly on the emissions factor of the electric grid they are connected to. As per global NZI Pillar B guidance, geography must be taken into account when assessing the avoided emissions of a solution, with a strong emphasis on the carbon intensity of the concerned grids. Accounting for emissions linked to **both combustion and upstream of electricity** is necessary.

Using the GHG Protocol's **location-based** method to compute emissions associated with electricity consumption is **mandatory** to provide results closest to the physical reality.
Calculation based on real-time or **hourly reporting** of the carbon intensity of the grid may also be used with a location-based approach, especially for "Demand side optimization" IT solutions – typically "smart grid" solutions –.

III. Methodological cruxes

Once the perimeter of the assessment has been set, the baseline and solution scenario emissions can be calculated. The following section provides guidance on 11 methodological cruxes or "pain points" specific to the IT sector that may occur whilst following the generic avoided emissions methodology.

1. Baseline issues

Defining a credible baseline is a customary crux for avoided emissions calculations. Reference situations are, by construction, counterfactual: they rely on hypotheses aiming to describe **what would have happened without the solution.**

Defining a credible reference scenario can be particularly tricky when looking at IT solutions, as many key metrics of the sector are subject to frequent, fast, and significant changes (data traffic, microprocessor performances, usages, number of connected users, breakthrough innovations, etc.).

This section aims to solve certain issues one may encounter when attempting to settle on a satisfying baseline for the avoided emissions calculations of an IT solution.

Crux 1: Generally speaking, how should technical progress be treated?

The IT sector being prone to fast and frequent changes, it may be essential to clearly define **how quickly technical upgrades get absorbed in the baseline**. Detailed customer surveys are often a possible answer to ensure the truthfulness of an avoided emissions claim, as highlighted by the methodological cruxes covered in this guide.

Considering the difficulty to access or collect such data, the following proxy may be used: when assessing a given IT solution, the baseline for a given year N includes the level of usage of said solution at year N-1; any increased usage must be studied to decide whether it corresponds to rebound or substitution. **Emissions are assessed at the level of usage of the current year rather than during the product's entire lifecycle, as illustrated by Figure 5.**

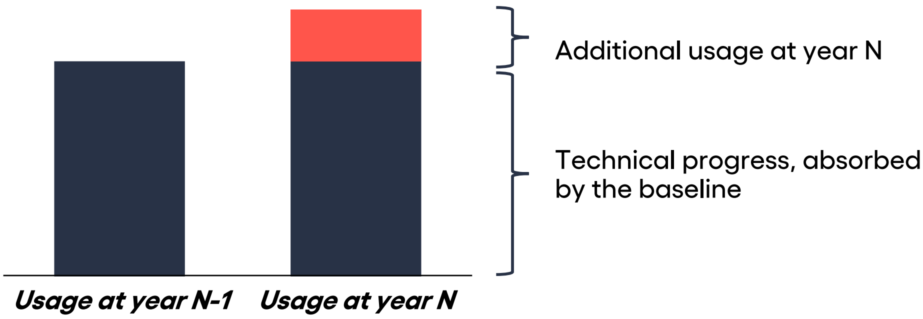


Figure 5 – Illustration of the inclusion of technical progress in the baseline

Increased usage (the red part in figure 5) is presumed as rebound effect and contributes negatively to the solution's potential avoided emissions claim unless:

- A peer reviewed third-party study has proven otherwise,
- Or the sum of the emissions of *{1st order effects of the solution + emissions of the sector or environment it applies to}* are proven to have decreased. Finding the right perimeter of the application domain may raise questions. This exception would mean that the increased usage somehow caused a substitution in the ecosystem, for instance if a company won market share over other companies in a decreasing or stable market.

Example 1: Telecommunication and work-home commutes
VirtualMeet Corporation provides a videoconference tool and wishes to claim avoided emissions based on reductions in emissions for workplace-home travels from its users. In 2023, users spent

a total of 60 billion minutes on the platform, versus 50 billion in 2022. When assessing the solution's potential avoided emissions in 2023:

- On the basis of 50 billion minutes, the solution is compared to the market average of videoconferencing tools, and may add to its avoided emissions tally if and only if the solution is less carbon-intensive than its competitors.
- On the basis of the additional 10 billion minutes, no customer data or external paper is available to confirm this growth in usage is not rebound. The emissions of *{VirtualMeet's carbon footprint + average work-home commute emissions per employee*[26]*, globally + average home heating emissions per capita, globally + average emissions of purchased IT equipment for home offices, globally}* are compared between 2022 and 2023. If there was an increase, no avoided emissions can be claimed.

Example 2: Move to Cloud

NimbusTech provides cloud storage services. In 2022, its customer base stored 10 exabytes of data, versus 12 in 2023. When assessing the solution's avoided emissions in 2023:

- On the basis of 10 EB, the solution is compared to its competitors.
- On the basis of the supplementary 2 EB, if no customer survey data is available, compare *{NimbusTech's carbon footprint (Pillar A) + Global emissions of the cloud storage sector}* in 2022 and 2023. If there was an increase, no avoided emissions can be claimed.

Crux 2: Unsustainable trends of the digital sector

Following current projections, the IT sector carries unsustainable trends: strong increases of data volumes, number of devices per user, software, technical and/or cultural obsolescence (devices becoming less 'fashionable').

Taking these into account in the baseline may facilitate the possibility to claim avoided emissions even if the impact on global emissions increasing. Furthermore, the solution may itself contribute to the strong rise in IT usage, reinforcing the unsustainable trends.

Solutions should not benefit from an increasingly emissive context, especially if the solution is part of the problem. Lower increase avoided emissions (see Box 4) may be claimed, but under certain conditions only.

Example

In the near-future, a company provides a low-latency ultra-HD video encoding solution, perfect for live streaming services. While the use of this solution does reduce the overall number of bytes transferred over the network when it is released, it increases this metric when compared to today's standards, where live streaming video content is in much lower quality on average. It might even stimulate the growth of livestream data traffic (for example, households with slow internet speed will start watching high quality streams). This may lead to an increase in emissions linked to this usage.

However, if we follow the hypothesis that data traffic and average video quality will strongly increase, the well-compressed ultra-HD videos will avoid emissions compared to the projected average.

Solution

Trends of strong usage growth may be considered in the baseline, allowing an IT solution to claim lower increase avoided emissions, under the following conditions:

[26] Global emissions of the transports sector may also be include in the perimeter, to account for effects such as digital nomadism (or any increased traveling for employees allowed by the existence of virtual meetings).

- The company must not be responsible for these trends (e.g., by commercializing products or services that encourage increased consumption)
- The company must clearly communicate on the 'lower increase' nature of the avoided emissions, and be transparent on the necessity for sufficiency.
- The baseline is updated yearly, to avoid overestimating avoided emissions, or the usage growth projections are provided by a peer-reviewed independent scientific publication.

Box 4: Avoided emissions of the "lower increase" type (AELI)

Adapted from the NZI Pillar B Guide

Depending on the reference situation, avoided emissions can represent:
The **effective reduction** of emissions in comparison to a previous more emissive situation ;
The **lower increase** of emissions in comparison with a fictional counterfactual scenario that would have generated more emissions.

This difference between the two types of avoided emissions is taken into account in the Net Zero Initiative reference framework. Thus, two subcategories of avoided emissions are established:

Avoided emissions (AE): the difference in emissions between the situation with a solution and a counterfactual reference situation. They are broken down into two types:
Avoided emissions of the "reduction" type (AE_R): the share of avoided emissions (AE) corresponding to a real reduction of emissions in comparison with the previous situation.
Avoided emissions of the "lower increase" type (AE_{LI}): the share of avoided emissions (AE) corresponding to an increase in emissions in comparison to the previous situation, but lower than the reference scenario.
The ex-ante predictions must match the ex-post measurements. If time shows that avoided emissions were overestimated by a given value during the first 3-year span, this value must be deducted from the predicted avoided emissions of the following span.

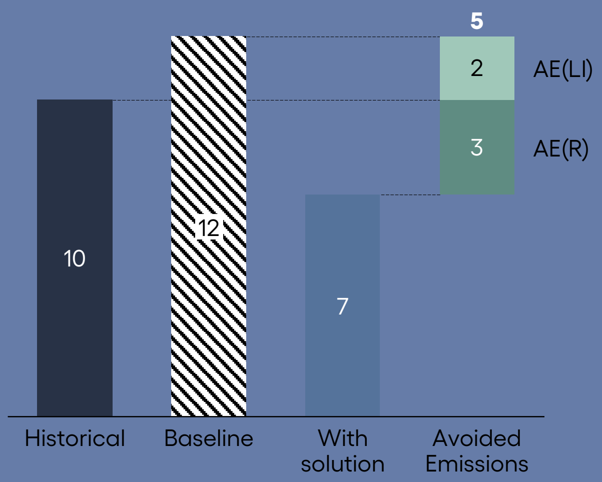


Figure 6 – The two types of avoided emissions: Reduction (AE_R) and Lower Increase (AE_{LI}) Avoided Emissions. Note that AE = AE_R + AE_{LI}

Crux 3: Low-tech alternative available

An IT solution may answer a need that is already satisfied, to a certain extent, by a non-digital solution (or a less complex IT solution).

Example 1

A company provides VR headsets with a lower product carbon footprint than its direct competitors. If the customer buys the headset for entertainment purposes, is the baseline:

- *the average of other VR headsets on the market?*
- *a more 'classic' game controller?*
- *going out for a walk, which also satisfies the need to relax?*

If the headset is bought for professional training purposes, is the baseline classic in-person training programs?

Example 2

A company provides a videoconferencing tool: is the baseline the average of its competitors' tools? or classical phone calls (that also satisfy the need of communicating, albeit sometimes in a less practical way)?

Solution

The baseline is dependent on the specificity level of the assessment (see Box 5). Particular caution is preferable when the studied solution is usually regarded as hi-tech: AI, Robotics, Blockchain, VR, etc. Table 5 highlights the distinctions to be made according to the chosen specificity.

Box 5: Specificity levels

The Net Zero Initiative distinguishes three visions that reflect the available levels of precision:

More statistical

Market average: Life cycle emissions of the market average

Company-specific: Life cycle emissions of the average solution of the company's catalog of products

Solution-specific: Life cycle emissions of the specific solution

More specific

Figure 7: Different levels of precision for calculating the emissions of a solution

This gradation applies both to the reference and the solution situations as illustrated in Table 4 below:

		Solution situation		
Reference situation	Specificity level	Solution specific	Company specific	Statistical
	Solution specific	Very high	High	Medium-high
	Company specific	High	Medium	Medium-low
	Statistical	Medium-high	Medium-low	Low

Table 4: Overall specificity level as a function of reference situation and solution specificity levels

Specificity	Guidelines	Example
Low	If no precise data is available concerning the customer base's situation and usage of the solution, one may: - Be conservative and choose the low-tech alternative as the baseline, - Consider the average carbon footprint of the solutions answering the need on the market, eventually by using hypotheses on the proportions in which said solutions are used to answer the need. Either way, **full transparency on the hypotheses used and the perimeter** to which the studied solution **is mandatory** in any communication concerning the solution's avoided emissions. It must also be stated that the assessment was made with low data quality.	*CyberCardio Inc. provides virtual reality (VR) games and dedicated equipment allowing users with an equipment to workout in a playful way, at home.* *Less tech-intensive alternatives include traditional home gym equipment (e.g. treadmills) and outdoor runs.* *If CyberCardio Inc. has no precise data on its customer base's situation, it shall choose outdoor running as the baseline for its assessment, or use a third-party study that provides figures on the proportion of cardio workouts done with gym equipment/with VR tools/with no equipment.* *It is likely that the product does not lead to avoided emissions.*
Medium	Gather data through customer surveys to build a pondered baseline, in order to estimate the proportion of users who, without buying the solution, would have: - kept the status quo - bought a low-tech alternative - bought a hi-tech alternative. Transparency on the number of participants who took part in the study and on the hypotheses used is mandatory. **Survey samples must be representative and extrapolations must be limited and justified.**	*CyberCardio Inc. collected data from a **representative sample** of its customer base, which highlights what their customers would have done without buying their product.* *50% would have bought a classic treadmill, 30% would have bought an equivalent VR solution, and 20% would have gone for outdoor runs at their local park (with the trip of going to the park and back having a certain average emission factor).* *CyberCardio Inc. builds a pondered baseline using these statistics and communicates clearly on how it was built, which may or may not lead to avoided emissions.*
High	Precisely ask the considered customer what would have been done without the solution and use the answer as the baseline for this unitary case. Communicate adequately on the solution, with disclaimers on the strong dependency on context for avoided emissions: the solution reduced emissions for a given customer, but this may not always be the case for the entire customer base.	*CyberCardio Inc. sells its solution to a Company A for their office gym. Company A affirms they would have bought a similar solution otherwise, whose LCA proved to be more emissive.* *CyberCardio Inc. claims avoided emissions for this specific case.*

Table 5 – Guidelines for low-tech alternatives according to the level of specificity

Crux 4: A/B testing or Before/After situations

An IT solution may take advantage of A/B testing or before/after measures to define a baseline scenario. It can, however, benefit from an important change of context, challenging the relevance of avoided emissions.

Example

An AI solution for maritime route optimization is sold to a shipping company A. Before that, the company used a traditional transport management system software, with no embedded intelligence. Is the baseline the average of route optimization software currently on the market (difficult to say how well they would perform with company A), or company A's previous scenario?

Solution

The "before" situation can be a suitable baseline only if the given solution is new on the market – a temporality criterion may be specified for given families of solutions –, or if the specificity is granular enough to assess that the customer would have kept the status quo without the solution. Otherwise, the baseline should take into account the market average savings permitted by the given solution.
A/B testing gives a suitable baseline under the same conditions.

Crux 5: Shifting baseline

Diversification of competition, regulatory or macroeconomic changes may force shifts in the baseline to keep it meaningful. The updates of avoided emissions calculations must be frequent enough to include such shifts.

Example

A company provides a new, innovative solution which avoids emissions by reducing usage of a certain activity, with no rebound effect. Two years later, the solution has fully penetrated the market and has become the standard (or regulation imposed it as the standard), although calculations made during the initial AE assessment did not predict such an impact.

Solution

Update calculations once a year rather than once every 3 to 5 years, as the digital sector evolves fast. Apply changes to the baseline if regulation or global market trends have changed.

Crux 6: "Clandestine passenger" syndrome

An IT company may not see an interest in refining the measure of their induced emissions with the most precise data possible if the current situation allows them to claim avoided emissions.

Example

Company A provides a new IT solution that applies to car mobility. Competitors emerge and studies show that this type of solution allows the reduction of emissions in the automobile sector by 4 gCO_2eq/passenger.km on average. Company A's solution is more emissive than the market average, reducing emissions by 2 gCO_2eq/passenger.km when compared to a situation without such a solution.

Company A chooses to compute its avoided emissions using the market average in the solution scenario (4 gCO_2eq/passenger.km), and has no incentive to upgrade its data precision, as it would reduce the avoided emissions it can claim by a factor of 2.

Solution

Whenever claiming avoided emissions, communicate an indicator on the specificity of the assessment: low, medium or high. If low specificity is used for the solution scenario, communicate transparently on the fact that the avoided emissions may be over-estimated.

Crux 7: Machines replacing humans

An IT solution may replace humans for a particular job or task. One may be tempted to claim avoided emissions because part of the commuting no longer occurs for the considered company. However, this commuting may simply be transferred to other locations (e.g. a new workplace, in a different company).

Example

An NLP model suppresses the need for human translators at a given company. The people who were employed as translators no longer work at the company, resulting in a reduction of the company's "Workplace" emissions. However, the former translators are likely to start a new position elsewhere, inducing similar workplace emissions; and at the global scale no emissions reductions are observed.

Solution

IT solutions that directly substitute human activity cannot claim avoided emissions simply on the grounds that they delete a given job position.

If a company wants to claim avoided emissions because it developed an Artificial Intelligence (AI) or automatization solution that replaces human labour, it must be able to prove that this automatization have improved the carbon footprint on the system, by properly identifying decarbonizing levers and mechanisms at stake, as highlighted by the Characterisation of solutions section. The calculation perimeter shall include the emissions of the activity of the replaced human person in both reference situation and solution scenario, even if the replaced person has left the company.

For example, a welding robot allowing to reduce methane leaks coming from a pipeline thanks to more precise welding than a human operator may be eligible for avoided emissions, but an AI translation software is not.

2. Substitution and rebound issues

It must be clearly identified whether a solution replaces an existing usage or simply adds a new one. If a solution gives way to a completely new usage, it may **only lead to lower increase avoided emissions at best** – if the reference scenario includes this new usage, and the solution is more efficient than its competitors acting upon said usage –, and **simply be considered as added emissions at worst** – if the reference scenario does not include this new usage or if the solution is less efficient than its competitors –.

Crux 8: Level of detail required to prove that a decarbonizing substitution occurred

When aiming to act on the substitution lever (see Characterisation of solutions section), solution providers must be able to justify as thoroughly as possible that their solution replaces an existing usage, rather than stack on top of it.

Example 1

A cloud provider sells it services to a company that currently has its information system hosted on premises. How can it ensure the on-premises machines get decommissioned?

Example 2

Videoconferences may substitute some physical meetings, but also induces supplementary conferences: part of the solution's effect is substitution, whilst another is addition.

Solution

Whenever the solution aims at replacing or inducing replacement of a 'recurring' object (e.g., a database snapshot, a meeting, a meal) and not a 'unique' object (e.g., a heating management system, an Active Directory, Identity Access Management, etc.), the maximum level of specificity is required to prove substitution.

This implies having access to precise customer data, surveys, and computing whether or not emissions are avoided on average. Another possibility is to build on publications by **independent** research institutes that advocate substitution.

Crux 9: Identifying higher order effects and their amplitude

An IT solution may induce several higher order effects, both inside and outside its value chain, which can be challenging to identify and measure. Taking these effects (and particularly rebound) into consideration when calculating avoided emissions is crucial ; as leaving them out may imply forgetting about a large portion of the solution scenario emissions as long as the functional unit is conveniently chosen.

Example 1

*A footwear company uses a virtualization solution which allows much more energy-efficient and scalable applications. Its convenience incites the company to build more applications, increasing data traffic and computations (**direct convenience rebound, inside the IT value chain**).*

*Thanks to all this newly acquired computational power and data, the company manages to target new customers and start selling (and thus producing) more shoes, emitting more along the way (**indirect 'economy-wide' rebound, outside the IT value chain**).*

Example 2

Videoconferencing solutions have several higher order effects: increased energy consumption for residential heating, increased purchases of monitors and personal devices, digital nomadism and more.

Solution

At the beginning of the assessment, go through a checklist of potential higher order effects as illustrated in Figure 8, and quantify each one. The definitions of economic, time and space rebound are aligned with the ITU's L1480 recommendation[27]. Potential convenience rebound effects must also be studied, if the assessed solution makes a task less tiring for example, which can induce an increase of executions of the said task. Table 6 provides examples of different types of rebound effects.

When data lacks to precisely quantify, customer surveys or conservative hypotheses can be used to evaluate high order effects.

[27] ITU-T L.1480, Annex II : Checklist to support the identification of first, second and higher order effects.

In all cases, rebound **must always be included** in an avoided emissions calculation, and any communication on avoided emissions must explicitly mention which rebound effects were identified and quantified, with what hypotheses.
If applicable, any assessment should include the calculation of a **carbon tipping point**: how much can usage grow until efficiency gains are cancelled out?

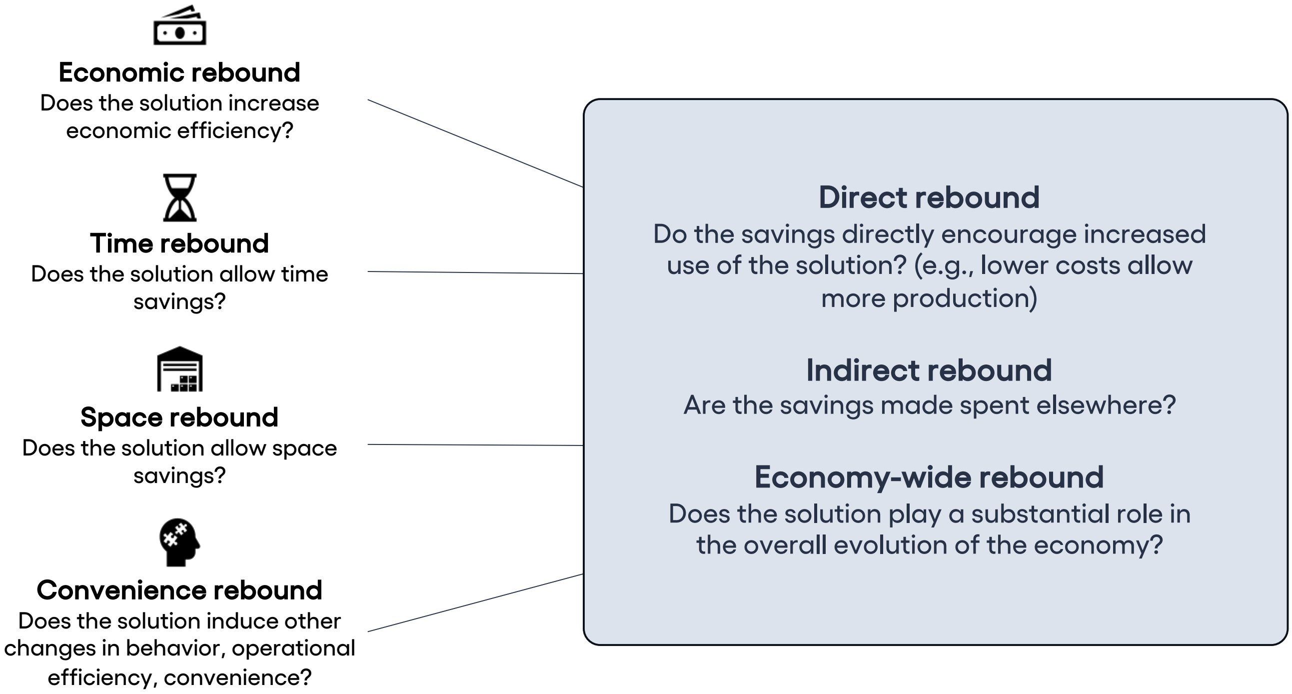


Figure 8 – Illustration of the different types of rebound to consider when assessing avoided emissions

	Direct	Indirect	Economy-wide
Economic	A cloud storage service allows a company to store its data cheaper than on-premises. The company keeps the same budget for data storage and starts collecting and storing more data.	A cloud storage service allows a company to store its data cheaper than on-premises. The company uses the savings to increase spendings elsewhere, which results in an increase in emissions.	A telecommunications company deploys a new faster data transmission technology that has repercussions on the entire economy, increasing overall resource consumption.
Time	A CRM software allows a company to save time on how they manage their business leads. Thanks to this time efficiency gain, the company treats more leads every day, grows faster and ultimately consumes more resources.	A software automatizes a tedious task, saving time for a company. The time saved is used elsewhere in an energy-consuming activity.	An IT solution drastically reduces latency of financial transactions, affecting the entire economy.
Space	A smart shelving solution helps save space in a warehouse. Saved space is used to increase activity.	A company migrates its on-premises machines to the Cloud. With the saved space, they engage in energy-intensive new activities.	N/A
Convenience	A company launches its e-commerce activity, providing a very convenient way for their customers to shop. This ultimately increases the company's production, resource and energy consumption.	N/A	A company provides no/low-code solutions to launch e-commerce websites easily. A large number of dropshipping companies are created as a consequence, with repercussions on the entire economy.

Table 6 – Examples of the different types of rebound effects of IT solutions

Crux 10: Different levels of maturity of an 'enabling' solution

Enablement itself is not considered as a decarbonation lever (unlike sufficiency, efficiency or substitution) by the relevant literature (see IPPC AR6 Work group III, 2022). Therefore, any solution identified as an 'enabler' cannot claim all of the avoided emissions within its value chain simply on the grounds that it allegedly allows decarbonation to occur (see Annex A: What about "enablement"? for more). How should 'enablers' be treated when assessing avoided emissions?

Example 1
Videoconferencing solutions make it possible for conferences previously held physically to be hosted online, potentially reducing the need for travel.

Example 2
5G allows IoT optimization systems to emerge.

Example 3
A city-owned bike rental app allows its users to know if bikes or parking spots are available at their local station, improving convenience and enabling some city inhabitants to switch to biking for their daily commute.

Solution
Treat 'enabling' solutions differently according to the level of maturity (or Manufacturing Readiness Level[28]), as highlighted by Table 7 below.

Maturity	Guidelines	Example
Low *MRL ≤8*	If the solution is in the research and development stage, provide an *ex-ante* calculation of its induced emissions with a carbon tipping point — the usage limit to remain below the emissions of the reference situation.	*Some telecommunication operators are working on a solution that would reduce the GHG emission intensity of data traffic by half. Communication surrounding the solution must specify that it **may** avoid emissions **only if data traffic does not double** (or more).*
Medium *MRL = 9*	If the solution is rather new on the market, analyse its position within its value chain and treat it like any other link of the chain. Follow the usual methodology for avoided emissions.	*A smart metering solution aims to enable diffuse curtailment[29] among its customer base, allowing connected water heaters to consume electricity when the grid is low-carbon.* *To claim avoided emissions, the solution must be **considered as a link of the curtailment value chain** and **account for potential rebound effects**, following the usual NZI methodology.*
High *MRL = 10*	If the solution has already penetrated the market, it should be considered as part of the baseline, and avoided emissions may be claimed only if the solution emits less than the market average, following the usual methodology for avoided emissions.	*A company provides a full suite of tools (file sharing, video calling, etc.) which allows users to work remotely. It may claim avoided emissions **only if the tool is less carbon-intensive than its competitors.***

Table 7 – Different levels of maturity for 'enabling' solutions

[28] As defined by the U.S. Department of Defense.
[29] Reduction of power production/consumption when there is too much/not enough electricity on the grid.

Crux 11: Lower increase avoided emissions for substitution products

Whenever a new solution replaces an existing one and increases overall usage, albeit in a more energy-efficient way, companies may claim Lower increase avoided emissions only if usage was bound to increase anyway.

Example 1
A company migrates its information system to a public cloud, and sees a strong increase in its IT activity, cancelling out energy efficiency gains. The cloud provider wishes to claim Lower increase avoided emissions, because of the global tendency to increase IT usage regardless of the hosting method. It may even claim avoided emissions for its entire customer base.

Solution
Lower increase avoided emissions can only be claimed if the maximum level of specificity has been used and has proven avoided emissions.

In the previous example, if the customer in question confirms when surveyed that he/she would still have increased usage without the solution, i.e. with its former on-premises machines.
Otherwise, communication around the solution may praise its energy efficiency but not claim avoided emissions. For example: "*Our solution reduces energy consumption* ***per FLOPS, per GB stored****, etc.*".

Crux 12: Influential players decarbonizing their own rebound

Leaders of the IT sector may have a strong influence on the development and global adoption of a new technology. A company should not be able to claim avoided emissions when decarbonizing the product or service it has itself set the standard for or created the need for.

Example
SmartoPhonu pioneers the development of a new generation of mobile phones with a unique innovative feature. A few years after launch, such phones are mainstream, with several players on the market. SmartoPhonu still holds a large share of the market, and strongly reduced the carbon footprint of the use of its phones this year thanks to design changes. Its products are now less carbon-intensive than its competitors.

Claiming avoided emissions in this situation is hazardous, as SmartoPhonu is partly responsible for the arrival of this new need on the market (the new feature it brought).

Solution
A temporality criterion may be added for players that hold a significant share of their markets. Unless the IT solution at stake was initially launched to reduce global emissions – i.e. it belongs to one of the identified families of solutions –, it cannot claim avoided emissions within the decade following its launch. Another possibility is to perform *ex-post* analyses after key dates that structure the solution's usage.

3. Guidance on allocation

As per the usual NZI Pillar B methodology, avoided emissions are meant to fuel the strategic decisions of a company, to act as an indicator to focus on products aligned with climate objectives, rather than to give way to any carbon finance projects. Allocation of avoided emissions is therefore usually not necessary at the end of an assessment.

If an allocation must be done, following NZI Pillar B's suggestion to compute the IT solution's share within its value chain according to its weight in the full system's Pillar A emissions is possible (as per Figure 9).

$$\%_{\text{allocation}} = \frac{\text{Life cycle emissions of the intermediate product}}{\text{Life cycle emissions of the final product}}$$

Figure 9 – Allocation method for avoided emissions, in the case of an IT solution being an intermediate product within a more complete system (final product)

PART 4

Families of Solutions – Toolbox

I. Introduction

This toolbox centralizes methodological guidelines on avoided emissions for the IT sector covered in the present report.

For each solution to avoid emissions the toolbox contains a **methodological sheet** setting out a rigorous method to calculate avoided emissions.

II. Contents of the toolbox

The Net Zero Initiative for IT toolbox focuses on 4 families of solutions that may avoid emissions of the IT sector (Green IT) or for other sectors (IT for Green).

Families of solutions are characterized by a certain level of homogeneity in the reference scenario for each solution-context pairing. Solutions within a same family are therefore treated in a similar way.

There may sometimes be overlap between several families of solutions. Referring to the Characterisation of solutions section can help identifying which decarbonizing levers are activated by a solution and facilitate reflection.

#	Family of solutions	Description	Example
1	**Circularity**	Solutions that reduce any sector's emissions by **extending the lifespan of equipment,** thanks to reuse, refurbishment, repairs, recycling and some forms of eco-design.	Reparation services Refurbishment factories Platforms selling second-hand or refurbished equipment
2	**Cloud & Virtualization**	Solutions that reduce the IT sector's emissions by **providing a substitution for or reducing the number of physical machines** owned, operated by or solicited by an organization, and/or the energy they consume.	Move to Cloud Moving one's own server fleet to colocation datacentre On premises virtualization
3	**Demand-Offer matching platforms**	Solutions that reduce the demand for physical products or services, by **promoting sharing and mutualization**.	Ridesharing platforms Tool sharing platforms
4	**Demand-side optimization and sufficiency**	Solutions that reduce any sector's emissions by **inducing a more responsible demand**, either by: - Subcategory 4.1: Displaying relevant climate information to the potential customers (decision on end-user's side), - Subcategory 4.2: Imposing by default a more sufficient/efficient consumption by the customer (decision on supplier's side).	**Subcategory A:** Eco-labelling of products Indicators on resource consumption Information mechanism on electricity grids Awareness raising tools **Subcategory B:** Smart metering Advertisement blockers Sufficient default settings for video streaming platforms (e.g. 360p by default)

Table 8 - Synthesis of families of solutions analysed and examples of concerned IT solutions

III. Specific issues to the IT sector

Growth trends
The IT sector is subject to significant growth trends. Whenever assessing avoided emissions, the methodological issues mentioned in the Methodology section must be kept in mind.

Data quality
To compute avoided emissions for a solution, **considerable data is necessary**. This can at time only be accessible by asking customers about their purchasing choices and their habits. **Obtaining reliable data through customer surveys with minimum bias can be complex.** This topic is modestly addressed in appendix C: "*How to create an effective customer survey?*".

Additionality
If a company computes specific avoided emissions for each of multiple customers and wishes to aggregate said avoided emissions at company level, it is necessary that the hypotheses in the various reference scenarios are coherent with each other and allow additionality.

IV. Solutions methodological sheets

Circularity

Solution 1 – Circularity

This family of solutions addresses any solution that extends the lifespan of IT equipment by giving it an extra lifecycle.
An IT equipment can reach its end-of-life because of physical, technical or cultural obsolescence, as described below:

- *Physical: the item no longer functions properly because of an incident (falls or other impacts, water damage, etc.) aging (worn out battery, processor, etc.), or manufacturing defects.*
- *Technical: the item no longer functions properly, because the operating system it is running on is no longer supported, and it is not compatible with the newer OSs being released.*
- *Cultural: the item still functions properly, but its owner gets rid of it (or stores it, not to be used again), for any reason (item no longer in fashion, no longer needed, etc.).*

Lifespan can be extended by repairing, refurbishing or re-selling equipment. Online platforms selling any type of second-hand equipment (IT or not) fall under this family.

Device protection mechanisms (such as phone cases), while not falling under the 'Circularity' category, also extend device lifespan, and may follow the same avoided emissions calculation method of comparing the impact of keeping a device for a longer lifespan than in the reference scenario.

Important note:

For companies selling new equipment and second-hand or refurbished equipment, avoided emissions calculations should **only** be possible if the business model does not encourage over-consumption and/or over-production.

The company must not give strong incentives to renewal of equipment, for example:
- If repairing an item costs nearly as much (or more) than buying a brand-new item,
- If the company hands out vouchers to be spent on new items when a customer hands in an old item for recycling purposes,

customers are encouraged to renew their equipment more frequently than needed.

Please also refer to the **Characterisation of solutions section** and **eligibility criteria** to find out whether the solution is eligible or not for avoided emissions calculation.

GENERAL APPROACH

To evaluate avoided emissions of a 'circularity' solution, **GHG emissions in a situation with the solution** and **GHG emissions in the same situation without the solution** (the reference situation) will be compared. The recommended functional unit is **years of use:**
Example: if Alice had 1 phone last for 5 years, which emitted 70 kgCO2e during its lifecycle, the metric to retain for the reference situation is 14kgCO2e/year of use.

If Alice had 2 phones lasting 3 years each and emitting 60 kgCO2e each, and Bob had 1 phone lasting 3 years and emitting 60 kgCO2e + Alice's first phone, refurbished, which lasted 2 years and emitted 15 kgCO2e, the metric to retain is:
*Total emissions = **195 kgCO2e,** total years of use = **11 years** → 195/11 = 17,7 kgCO2e/year of use.*
With a circularity solution: the lifespan of an item is extended when it begins its new lifecycle (e.g., when it is repaired, revalorized, traded, etc.).

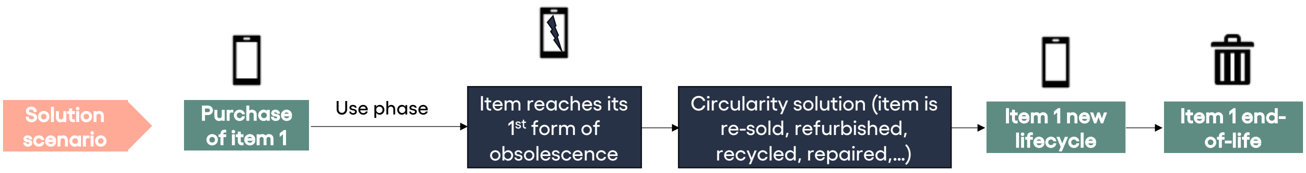


Figure 10 - Illustration of the situation with the solution. Figures are illustrative

In the reference situation: the consumer accesses alternatives on the market to satisfy the same lifespan. The consumer can buy a brand-new item, but a second-hand or refurbished item (elsewhere than in the solution scenario), repair the item (elsewhere than in the solution situation), or do nothing at all. The reference situation is thus the weighted average of the emissions of each possible alternative to the solution for the consumer, the weights being the likelihood of each alternative (i.e., the distribution of customers behaviour among the different alternatives).

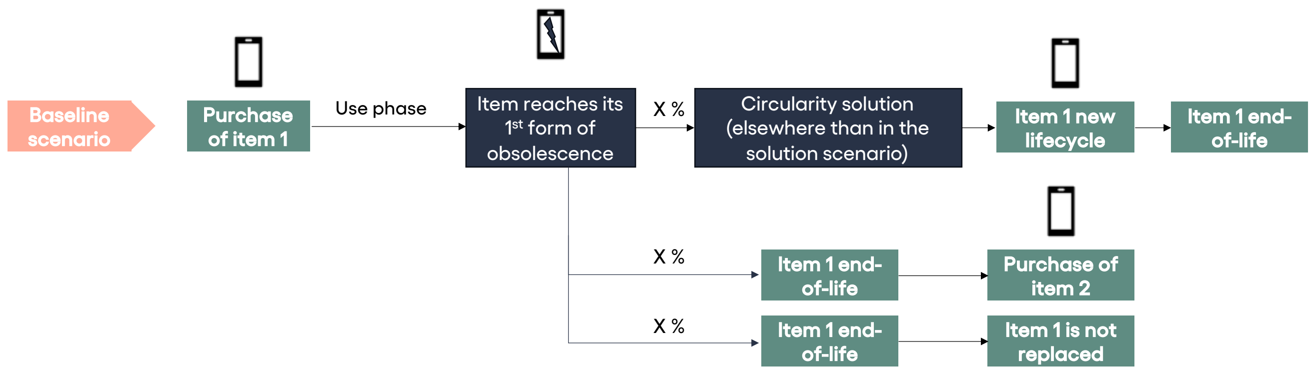


Figure 11 - Illustration of alternatives without the solution.
Figures are illustrative

POINTS TO ADDRESS

Direct rebound effect: if the alternative to buying a 'circular' product or service is **not buying anything**, there is a rebound effect. This rebound effect is considered in the alternative "Item 1 is not replaced". This alternative can be significant for certain devices, where **adoption rates wouldn't be as high** if it weren't for:

- a more affordable offer allowed by the existence of circularity solutions,
- the possibility to re-sell the purchased device thanks to a circularity solution if the user decides to get rid of it.

Example: a customer decides to buy an extra monitor for his workstation at home because of an attractive price tag on refurbished monitors.

If the assessed solution is concerned by this warning point, an estimation of this direct rebound effect should be **specifically assessed through a customer survey** (see Appendix for more).

Gray energy dilemma: If the older equipment, whose lifespan is being extended thanks to the circularity solution, consumes considerably more electricity than a new one would because significant efficiency gains have been made in more recent years, emissions in the solution scenario may be affected in a negative way.
Hence, **taking in consideration the emissions of the entire lifecycle of equipment** in both solution and reference scenarios is essential.

SOLUTION SCENARIO – CALCULATION

In the solution scenario, emissions over the item (that undergoes the circularity solution/process)'s entire lifespan must be considered.

Calculation in a company-wide average approach

To evaluate GHG emissions with repair, a lifecycle assessment (LCA) must be carried out. This must be calculated according to the type of repair and type of product repaired. All of the five steps below must be included in the calculation.

1) Manufacturing and logistics emissions of the brand-new equipment sold: use **company-specific average emissions per item, prior to the purchase by the final customer**.

If the company providing the circularity solution (named 'circular company' onwards) is **not the same as the company manufacturing the device,** the following options are possible, from most to less precise:

- use the average emissions of devices of the same range, by manufacturer,
- use the average emissions of devices of the same range sold on the market, all manufacturers included,
- use a conservative emission factor for the category of product being considered;

Then build the company-specific average emissions per item according to the company's catalogue of circular items.
Example: if the circular company repaired 5000 high-end phones from company A and 5000 high-end phones from company B, it shall use a weighted average of manufacturing and logistics emissions of company A and company B's high-end phones.

2) Use before repair emissions: use **company-specific average emissions of use before repair** (electricity consumed by the device itself and its surroundings, e.g. cooling systems must also be included for a server, etc.), according to the average lifespan of the type of device (and its range) before its first obsolescence.

If the circular company is not the same as the company manufacturing the device, averages for the market segment may be used, **following the same logic as for manufacturing and logistics emissions.** An extra level of precision may be reached if customers are being surveyed to know how long do they use the device before it reaches its 1st obsolescence.

3) Operations and logistics of the circularity solution: use **company-specific average emission of repair and logistics** around the circularity solution (spare parts, packaging and shipping the product, storage, energy consumption, etc.).

4) Use after repair emissions: follow the same guidelines as for the use emissions before repair, but adapt the lifespan of the new lifecycle:

- If the calculation takes place ex-post, use company-specific data to determine how long circular items last on average,
- If the calculation takes place ex-ante, use the following formula:

$$Lifespan_{2nd\ cycle} = Lifespan_{1st\ cycle} * \frac{Price\ of\ the\ circularity\ solution}{Price\ of\ the\ brand\ new\ equipment}$$

Using a monetary ratio encompasses all 3 types of obsolescence encountered. If technical obsolescence is planned (e.g., the considered hardware will no longer be supported after a certain date) **before this computed lifespan,** it must be considered as the 2nd cycle's lifespan.

If justified, an average between the guaranteed duration and the formula above may also be used. If no data is available to estimate the second cycle's lifespan, the guaranteed duration given by the circular company may be kept.

5) End-of-life emissions: use **company-specific average emissions of end-of life treatment** (incineration, landfill…). If the circular company is not the same as the company manufacturing the device, averages for the market segment may be used, **following the same logic as for manufacturing and logistics emissions.** Extra precision can once more be reached using customer surveys.

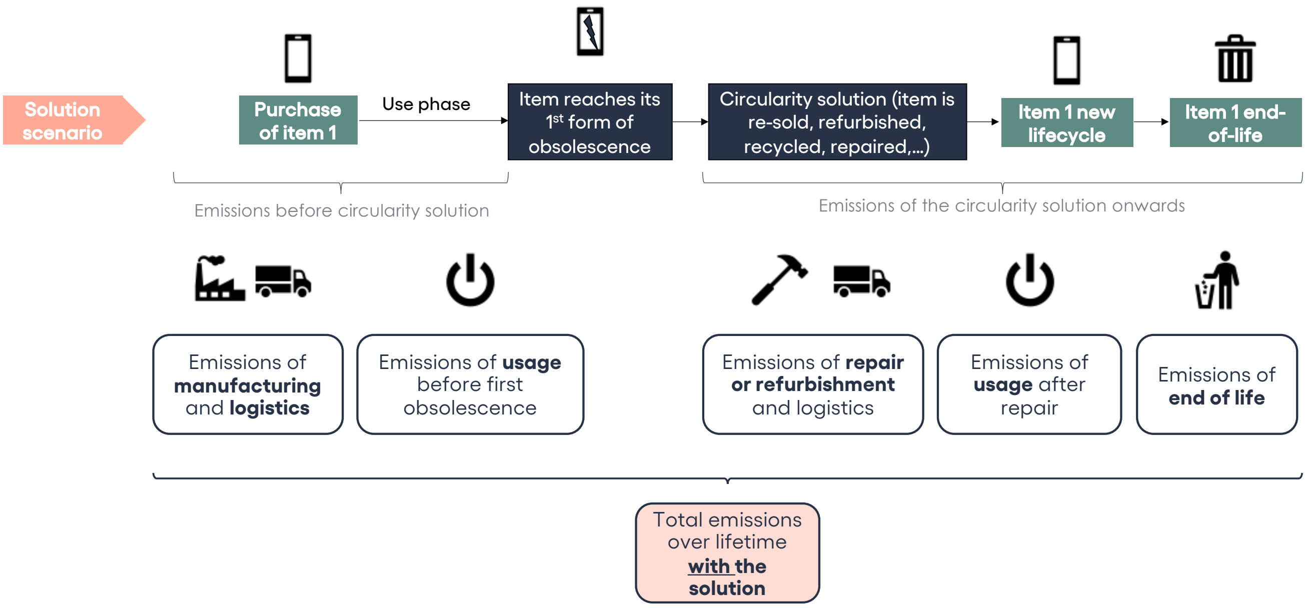


Figure 12 - Illustration of emissions to integrate into the calculation with each solution. Figures are illustrative

Calculating market average

For market average emissions calculations, instead of company-specific data, data are market averages: applicable for a company conducting the same types of repairs, for the same types of products, within the same market segment.

Specific case – Refurbishment

For refurbishment, the emissions to take in consideration span broader than for repairs, as there are usually more stakeholders: the person whose equipment is being refurbished and the person buying refurbished equipment are not necessarily the same.

For example, Alice can decide to hand in her phone to a refurbisher because she is getting a new one, and Bob purchases the refurbished phone (which used to be Alice's) when his own phone reaches its 1st obsolescence.

Emissions happening on both Alice and Bob's sides are necessary to take into account when assessing the emissions of the solution and reference scenarios. Doing so may prevent handing out avoided emissions in situations of clear rebound (e.g., both Alice and Bob changing their current phone simply because of more affordable offer on the market and the possibility to re-sell easily).

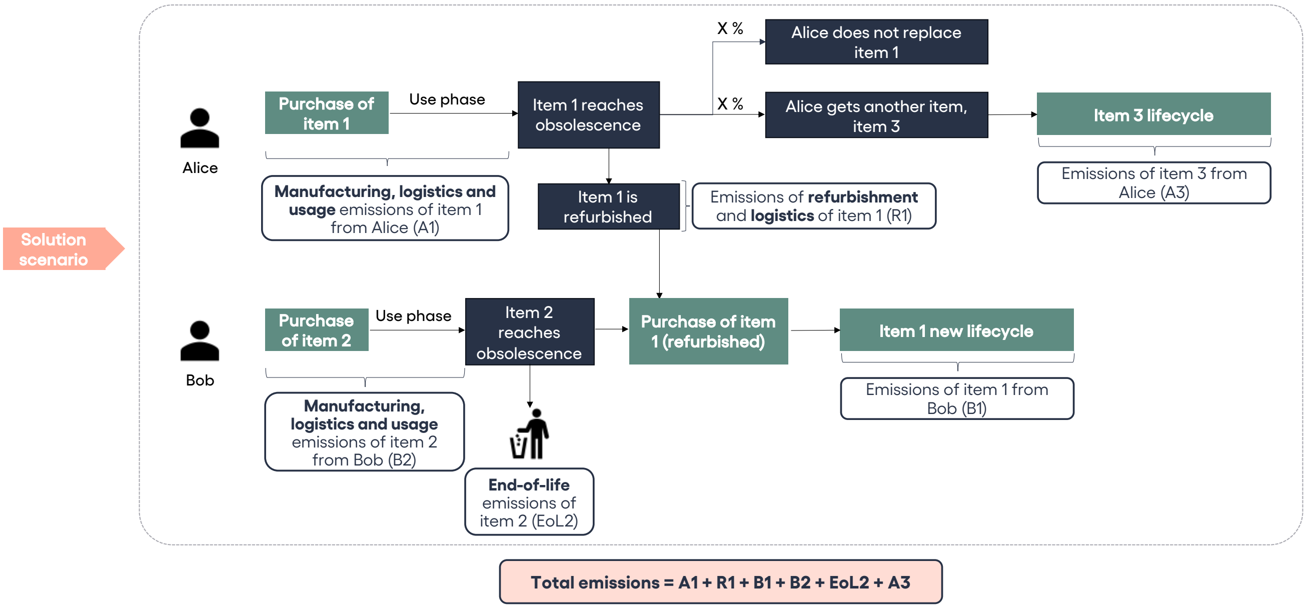


Figure 13 - Illustration of emissions to integrate for refurbishment solutions in the solution scenario. Figures are illustrative

This includes:
Manufacturing, logistics and usage emissions of both Alice and Bob's initial items (respectively; **A1** and **B2**)

- Refurbishment and logistics emissions for Alice's initial device (**R1**)
- End-of-life emissions of Bob's initial device (**EoL2**): an average end-of-life for the considered type of device may be used. These emissions are identical in the reference and in the solution scenario, we are not accounting for potential avoided emissions if item 2 were to get refurbished here: an avoided emissions calculation is done from the **purchased** refurbished item only, to avoid double-counting.
- Emissions of Bob's newly purchased refurbished device, which was once Alice's (**B1**): only account for the emissions happening after R1 emissions chronologically (use of the device by Bob, and an end-of-life considered to be average for the same reason as explained above)
- Emissions of Alice's replacement for item 1 if there is one (**A3**): from manufacturing to end-of-life. Data can be more or less precise but must be homogenous with the reference situation. If item 3 is a refurbished one, it is recommended to follow the method for Low-carbon label of refurbishment of electronics and electric equipment[30] to compute the emissions of purchased refurbished equipment.

The overall emissions of each item must be divided by said item's lifespan in order to obtain a result in $kgCO_2e$/year of use. Finally, the solution scenario emissions can be considered as the average of the results for all items, as highlighted by figure 15.

[30] Méthode de calcul des émissions évitées par le reconditionnement des équipements électriques et électroniques, Label Bas-Carbone, 2022.

REFERENCE SITUATION – CALCULATION

Calculations in a company-wide average approach

Similarly to the solution scenario, emissions for manufacturing, logistics, use and end-of life must be accounted for in the reference situation. One of three things can happen when the considered item reaches its first obsolescence in the reference scenario:

- It undergoes a circularity solution **elsewhere than in the solution scenario**,
- It reaches its end-of-life and is replaced by another item,
- It reaches its end-of-life and is not replaced.

The emissions to compute are the following:

<u>1) Manufacturing and logistics emissions of the considered equipment</u>: these emissions must be **exactly the same** as in the situation with solution.

<u>2) Use emissions before the considered item's first obsolescence</u>: these emissions rely heavily on the lifespan of the item, which can vary according to the situation. The following methods may be used to assess these emissions, from most to less precise:

- *For a unitary assessment*, with a customer survey, collect the determinants of the item's obsolescence. If it is **technical or physical**, the emissions of this phase are **identical** to those of the 'use phase before obsolescence' emissions of the solution scenario. If it is **cultural**, the circularity solution may have played a role in the shortening of the item's lifespan (see *Direct Rebound effect*); add a question in the survey asking the customer how much longer they would have kept their item if it weren't for the circularity solution. Compute use phase emissions accordingly.
- *For a company-wide approach*, thanks to customer surveys, determine the weighted average of the use phase emissions of the considered item's category by asking the same questions as above and applying the same rules (technical or physical obsolescence → same emissions as in solution scenario, cultural → use results of the survey).
- *If no customer data is available*, use a regional or global average lifespan for the item category considered, primarily by using scientific or institutional surveys, or by estimating the average item lifespan **whilst communicating clearly on the hypotheses**. The average lifespan must attempt to encompass physical, technical and cultural obsolescence.
  Example: as per the Daniel Research Group's 2018 study on Personal devices in the U.S., the average smartphone lifespan was 2.15 years in 2020.

The average lifespan kept for this phase is referred to as N_0 later on.

<u>3) Emissions following the considered item's first obsolescence (going all the way to the item's end-of-life</u>: compute a weighted average of emissions occurring:

- When the item goes through a circularity solution elsewhere (using a market average, or, if unavailable, the same emissions as the company's own emissions for the <u>operations and logistics of the circularity solution</u>, <u>use emissions after circularity solution</u> and <u>end-of-life emissions</u>). The considered lifespan of the second lifecycle is referred to as N_1 later on, and the emissions are referred to as E_1.
- When the item is replaced with another one (using a market average of <u>full lifecycle</u> emissions of items of the same price range as the initial item; **as well as the end-of-life emissions of the first item**). The considered lifespan of the new item is referred to as N_2 later on, and the emissions are referred to as E_2.

- When the item is not replaced (simply use the item's <u>end-of-life emissions</u>). In order to valorise the sufficient behaviour of the user, we amortize the emissions taking place upstream, for an additional period of N_3 years, corresponding to the duration of the lifespan extension of the item in the solution scenario. The emissions are referred to as E_3 later on.

The weights (probabilities of each of the three outcomes) must be determined through customer surveys, and are referred to as X_1, X_2 and X_3 later on.

The resulting emissions of steps <u>1)</u>, <u>2)</u> and <u>3)</u> **must be divided by the number of years of use of the reference scenario,** in order to obtain a metric that is comparable with the emissions computed for the solution scenario.

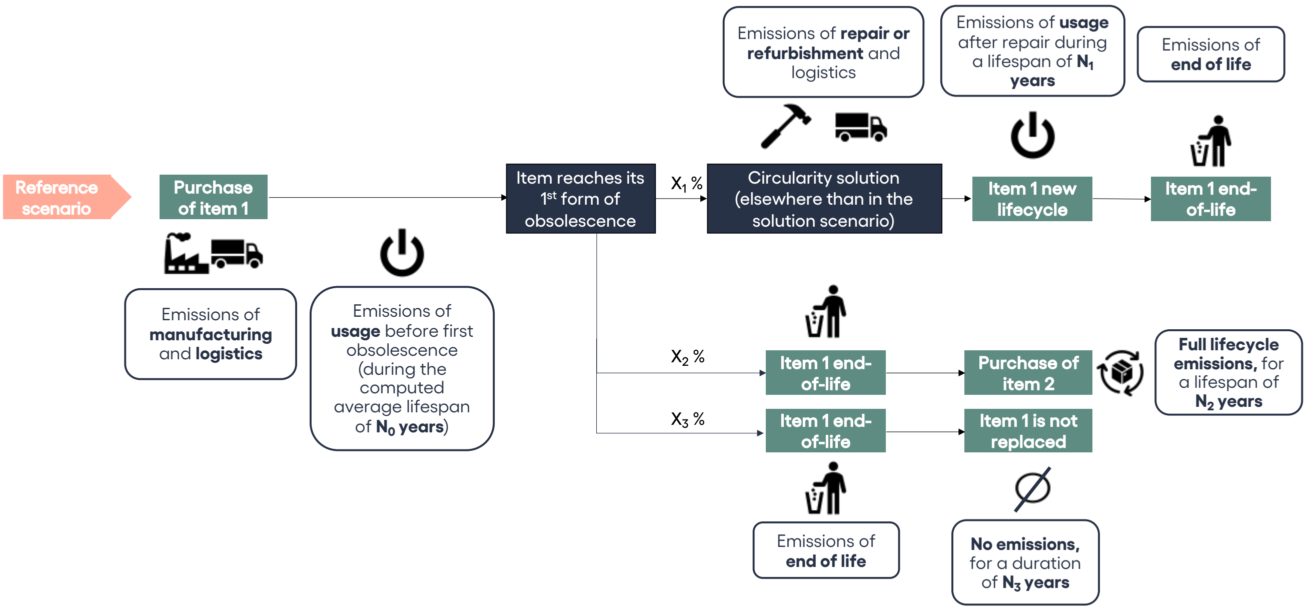


Figure 14 - Example for the reference scenario.
Figures are illustrative

Total emissions in the reference are the manufacturing and logistics emissions, use phase before 1st obsolescence emissions, and the weighted average of emissions happening after the 1st obsolescence (the sum of each alternative's emissions multiplied by the likelihood of the alternative happening). By calling the emissions before the item's 1st obsolescence E_0, and setting $X_0 = 1$, we have:

Reference scenario emissions per year of use = $\dfrac{\sum_i X_i E_i}{\sum_i X_i N_i}$

Calculations in market average approach

For market average emissions calculations, instead of using company-specific data, the data are market averages: the data is applicable for any company doing the same type of repair/refurbishment, for the same type of products, and in the same market segment.

AVOIDED EMISSIONS CALCULATIONS

Finally, avoided emissions are the difference between the emissions in the reference situation and in the solution. The resulting avoided emissions can be of **Lower increase** or of reduction, depending on the status quo and the projections made in the reference situation.

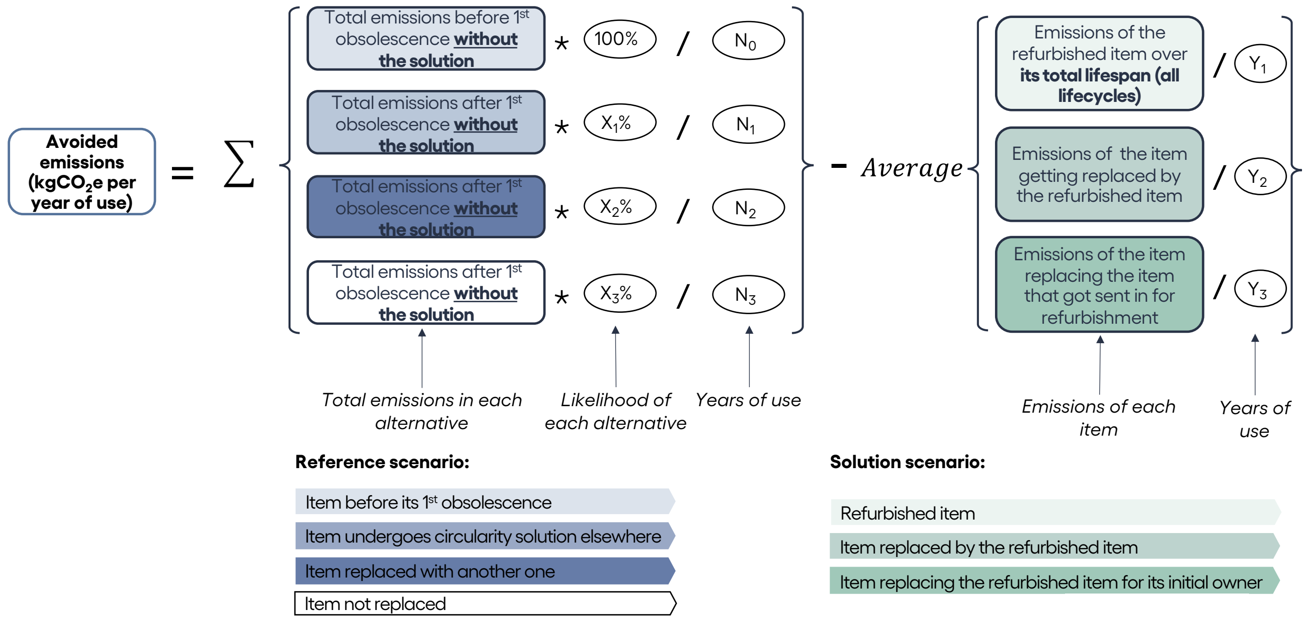


Figure 15 - Illustration of the calculation of avoided emissions for circularity solutions. Figures are illustrative

IMPORTANT PARAMETERS FOR THIS SOLUTION

Circularity solutions may or may not avoid emissions. This can depend on:

- lifespan extension after the circularity solution, the further a lifespan is extended, the more it avoids emissions, as the recommended functional unit is to compute emissions **per years of use.**
- emissions related to the solution's logistics, if the item needs to travel far, this will Impact avoided emissions.
- carbon footprint of the repaired part, if the repaired part represents a large part of the original item (thus a large share of production emissions) this larger share decreases the avoided emissions through repair compared to a smaller part (e.g.: replacing the screen and battery of a phone may emit almost as many emissions as buying a new phone versus only replacing a smaller part such as a button, which has a small carbon footprint in itself).
- the share of each alternative, the higher emissions of alternatives compared to the solution, the greater the avoided emissions. E.g.: repairing items belonging to consumers who normally don't opt for repair, avoids more emissions than repairing items for a conscious consumer, since the reference situation emissions are higher.

OVERVIEW OF THE NECESSARY DATA

Table 9 below sums up all aforementioned data necessary to collect before calculating avoider emissions. This data must be collected for one specific market segment, one specific geography and one specific of equipment (phone, laptop, server, home appliance, etc.).

Necessary data	Company-wide average approach	Market average approach
Years of use **before 1st obsolescence** *Note: may vary between solution and reference scenario if the solution is subject to rebound effect.*	Company specific data. This data can be collected through a **consumer survey.**	Market average data. This data can be collected through a **published consumer behaviour study.**
Years of use **after circularity solution**	Company specific data. This data can be collected ex-post, **or computed using the ratio of prices** between the brand new and the circular item.	Market average data. This data can be collected through a **published consumer behaviour study.**
Emissions in the situation with the solution: - Cradle to gate emissions - End-of-life emissions - Usage emissions - Repair logistics emissions	Company specific data. Cradle-to gate and end-of-life emissions data can be collected through **specific LCAs**. Usage emissions data can be computed from the lifespan of items and the local grid mix, using a **market average for the electricity consumption per year of use for the considered device**. Repair logistics emissions can be collected through a **carbon footprint** of the repair activity.	Market average data. Cradle-to gate and end-of-life emissions data can be collected through **average LCAs**. Usage emissions data can be collected through a **published consumer behaviour study**. Repair logistics emissions can be collected through **average LCAs of repair activities**.
Emissions in the reference situation: - Cradle to gate emissions for each alternative - End-of-life emissions for each alternative - Usage emissions for each alternative - Emissions of repair and logistics	Company specific data and market average data. Cradle-to gate and end-of-life emissions data can be collected through **average LCAs of each company-specific alternative.** Usage emissions for each alternative data can be collected through a **consumer survey**. Emissions of repair and logistics can be collected through **average LCAs of repair activities**.	Market average data. Cradle-to gate and end-of-life emissions data can be collected through **average LCAs of each market-average alternative.** Usage emissions for each alternative data can be collected through a **published consumer behaviour study**. Emissions of repair and logistics can be collected through **average LCAs of repair activities**.
Likelihood of alternatives	This data can be collected through a **consumer survey.**	This data can be collected through a **published consumer behaviour study.**

Table 9 - Overview of necessary data for avoided emission calculations for circularity solutions.

CALCULATION EXAMPLE

The example below considers Company A, selling refurbished smartphones, aiming to calculate a company wide average approach for its full catalogue of products[31].

Disclaimer: *the metrics shown here are arbitrary values and cannot be reused as-is. Reporting companies shall use their own metrics and hypotheses. In particular, use-phase emissions can strongly vary according to the customers' locations.*

SOLUTION SCENARIO		
Metric	**Computation**	**Value**
Average manufacturing and logistics emissions of a smartphone	Weighted average of manufacturing and logistics emissions of the models of smartphones sold by Company A	50 kgCO2e
Average use phase emissions of a smartphone before it gets sent in to company A for refurbishment	Weighed average of use phase emissions of the models of smartphones sold by company A (here estimated at 4 $kgCO_2e$/year) multiplied by the average lifespan of smartphones before they get sent in to company A (here estimated at 3 years)	3 x 4 = 12 $kgCO_2e$
A_1 = Average manufacturing, logistics and use emissions of a smartphone before it gets sent in to company A for refurbishment	Sum of the above	50 + 12 = 62 $kgCO_2e$
R_1 = Average emissions for refurbishment operations (including logistics)	To be computed by company A	5 $kgCO_2e$
B_1 = Average use and end-of-life emissions for a refurbishment phone	Collect the average lifespan of a refurbished phone thanks to customer surveys (here estimated at 2 years). End-of-life estimated at 5 $kgCO_2e$ here.	4 x 2 + 5 = 13 $kgCO_2e$
B_2 + **EoL_2** and **A_3** = Average lifecycle emissions linked to the purchase of a smartphone among company A's customer base (not necessarily brand new)	Customer survey. For example here, 70% of customers get brand new phones that emit 67 $kgCO_2e$ (50 for manufacturing and logistics, 12 for use, 5 for end-of-life) over a 3-year lifetime, and 30% of customers get refurbished phones that emit 18 $kgCO_2e$ (5 for refurbishment and logistics, 8 for use, 5 for end-of-life) over a 2-year lifetime.	0,7*67/3 + 0,3*18/2 = 18,3 $kgCO_2e$/year of use
Likelihood of a person getting new phone after handing in their previous for refurbishment	Customer survey	99%

Table 10 - Emission data for smartphones (solution scenario)

[31] To get a 1st idea, a simple comparison of manufacturing and refurbishment operations' emissions can be done.

Solution scenario emissions are the average of yearly emissions for each considered item.

For item 1, this corresponds to $A_1 + R_1 + B_1$ = 80 / 5 years = 16 kgCO_2e/year of use.
For item 2, this corresponds to $B_2 + EoL_2$ = 18,3 kgCO_2e/year of use.
For item 3, this corresponds to $0{,}99*A_3$ = 18,1 kgCO_2e/year of use.

$$\textbf{Solution scenario emissions} = \frac{16 + 18{,}3 + 18{,}1}{3} = \textbf{17,5 kgCO}_2\textbf{e/year of use}$$ [32].

REFERENCE SCENARIO		
Metric	**Computation**	**Value**
E_0 = Average manufacturing, logistics and use emissions of a smartphone before 1st obsolescence	Same manufacturing and logistics emissions as in the solution scenario, and use-phase emissions adapted to the new lifespan N_0 (3,1 years here).	50 + 3,1 x 4 = 62,4 kgCO2e
N_0 = Average lifespan of a smartphone before 1st obsolescence	On average, customers have stated that without company A, they would have kept their phone 0,1 years longer (than what truly happened in the solution scenario).	3,1 years
E_1 = Refurbishment, logistics, use and end-of-life emissions of a smartphone	Same as in solution scenario ($R_1 + B_1$)	18 kgCO2e
N_1 = Lifespan of smartphone after refurbishment	Same as in solution scenario	2 years
E_2 = Average full lifecycle emissions of a brand new phone + end-of-life emissions of the first smartphone	Use lifecycle assessments from manufacturers for considered models. Can also be considered as E_0 + 2 x E_3.	72,4 kgCO2e
N_2 = Average lifespan of a brand new phone	Hypothesis: same as N_0	3,1 years
E_3 = Average end-of-life emissions of a smartphone	Average of end-of-life emissions of the models of smartphones sold by Company A	5 kgCO2e
N_3 = Buffer value to amortize E_3 emissions	$N_3 = N_1$	2 years
X_1, X_2, X_3 = likelihood of alternatives to company A's refurbishment	Customer survey	X_1 = 19 % X_2 = 80 % X_3 = 1 %

Table 11 - Emission data for smartphones (reference scenario)

[32] Note: if items 2 and 3 follow the same pattern as item 1 (refurbishment, 80kgCO2e over a 5-year lifespan), the solution scenario emissions fall at 16kgCO2e, allowing more avoided emissions.

Reference scenario emissions = $\frac{\sum_i X_i E_i}{\sum_i X_i N_i}$ **= 20,7 kgCO₂e/year of use.**

Finally, comparing solution and reference scenarios, we obtain the avoided emissions for the average refurbished product sold by company A:

Avoided emissions = 20,7 – 17,5 = 3,2 kgCO_2e/year of use[33].

Solution 2 – Cloud & Virtualization

This family of solutions addresses any solution that aims to reduce the overall number of physical servers (and their electricity consumption) owned, operated by or solicited by an organization, which will later be referred to as the organization's 'server fleet'. A server fleet's climate impact may be reduced by:

- *Reducing the need for workloads and total IT power consumption (e.g., sufficiency, intelligent storage tiering)*
- *Reducing the amount of manufactured physical machines needed to satisfy the organization's workloads (e.g., virtualization, mutualizing resources, intelligent scheduling, scaling, etc.)*
- *Reducing the electricity consumption of IT equipment and its surroundings (e.g., more efficient CPU and storage, more efficient cooling, etc.)*

Colocation datacentres, virtualization and certain cloud services may contribute to the aforementioned emissions reductions only if rebound effect is contained.

Important note:

As of 2024, most of the largest cloud providers **strongly lack transparency** in their communication over their alleged avoided emissions, **using misleading vocabulary** ('carbon neutral' or 'carbon negative' companies, '100% carbon free' energy, etc.), leading to questionable claims.

As mentioned in the Net Zero Initiative's Pillar B guide, disclosing all hypothesis about the reference situation is required to claim any kind of climate benefit related to avoided emissions indicators. Notably, analysing and disclosing potential rebound effects (would the cloud customer have hosted the same amount of IT activity without my services?) is mandatory as part of the study of the reference situation.
Moreover, **computing emissions using location-based methods** for both reference and solution scenarios is also required, to ensure the highest level of physical proximity to physical reality.

Please also refer to the **Characterisation of solutions section** and **eligibility criteria** to find out whether the solution is eligible or not for avoided emissions calculation.

[33] This metric is illustrative and not meant to be re-used as-is.

GENERAL APPROACH

To evaluate avoided emissions of a ‘Cloud & Virtualization’ solution, **GHG emissions in a situation <u>with</u> the solution** and **GHG emissions in the same situation <u>without</u> the solution** (the reference situation) will be compared.

1. Functional unit

It is recommended to not use a functional unit more specific than **a year of functioning of the customer company’s global Information system (IS)**, as the solutions in this family are extremely prone to rebound. Ease of use of cloud services, for instance, may drive IT usage (number of terabytes stored, number of vCPUs used, number of features of an application etc.) upwards; as well as overall company growth[34] and absolute emissions.

Example: ModernMart, a retail company generating a revenue of 1 billion dollars in 2019, migrates its entire information system to NimbusTech, a cloud provider. The move-to-cloud is complete in 2024 and the company grew to 2 billion dollars of revenue.

ModernMart’s IS was responsible for 15 000 tCO2e in 2019 (fully on premises), and emissions gradually grew to 25 000 tCO2e in 2024. No avoided emissions may be claimed, unless the overall emissions of the ICT sector have decreased (see Methodology – Baseline issues – 1. How should technical progress be treated).

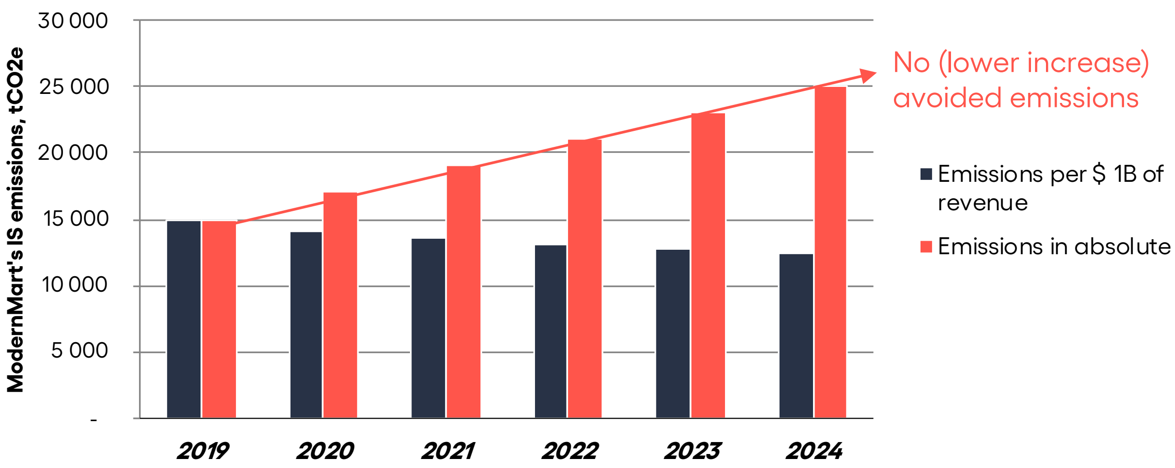


Figure 16 - Illustration of ModernMart’s emissions over the years. Figures are illustrative

[34] If an acquisition occurs, companies must do a *proforma* calculation.

2. Recommended specificity, timeframe and geography frame

Specificity

Most solutions within this family are prone to many methodological issues treated in the Methodology section:

- Crux 2 – Unsustainable trends: cloud and virtualization technologies contribute to the ever-growing amount of data stored, processed, transferred,
- Crux 3 – Low-tech alternatives for some services that do not necessarily require large amounts of data or a digitized treatment,
- Crux 5 – Shifting baselines (and Crux 1 – technical progress): cloud and virtualization technologies have matured over the past decades and must be included to some extent in reference scenarios,
- Crux 9 – Economic and convenience rebound brought by easy-to-use cloud services.

Furthermore, each deployment of a 'Cloud & Virtualization' solution is highly complex: the customer may choose between hundreds of managed services, policies and architectures for their new IS. Because of this complexity, **it is advised not to assess avoided emissions for a company's full customer base**, but rather focus on unitary customers. Table 12 below gives guidance on how to treat different specificity levels.

Level of specificity	Guidelines
High – for a specific customer	**Possible to compute avoided emissions**, following the methodology provided by the toolbox.
Medium – for a company's customer base	**Possibility to aggregate avoided emissions** of all customers for which a specific calculation was made, as long as all reference scenarios are coherent with each other. Forbidden to extrapolate the results of one specific customer calculation to the entire customer base.
Low – for a market average	**No avoided emissions calculations** – at most, a company may argue its solution is less carbon-intensive than its competitors (if all hypotheses are disclosed), but no numerical value may be claimed.

Table 12 - Illustration of specificity levels for Cloud & Virtualization solutions.

Timeframe

Ex-ante assessments may be done, following the instructions provided in the Methodology (lower increase avoided emissions only, yearly updates of the solution scenario deducting avoided emissions from the previously computed ones if necessary, and computation of a carbon tipping point). **Ex-post assessments following a year of use are preferable.**

Geography

In both reference and solution scenarios, emissions linked to electricity shall be computed using the **location-based method** and to account for upstream of energy. The country or countries in which IT activity is being hosted must be clearly identified.

3. Identification of decarbonizing levers, starting and arrival points

Before computing avoided emissions, it is recommended to precisely identify how the solution may decarbonize, what is the current situation of the company on the verge of buying the solution, and what is its target situation.

Decarbonizing levers

In both reference and solution scenario, greenhouse gas emissions from the server fleet may be modelled as follows (for a given site hosting IT activity):

$$GHG_{total} = GHG_{manufacturing+EoL} + GHG_{use}$$

$$GHG_{total} = N_{server} * EF_{server} + PUE * \left(CPU * Elec_{per\ CPU} + Storage * Elec_{per\ storage}\right) * EF_{grid}$$

With:

- N_{server} = average number of servers solicited during the year[35] (corresponding to the exact number of servers in the server fleet for an on-premises situation);
- EF_{server} = average emission factor for the manufacturing of a solicited server;
- PUE = Power Usage Effectiveness[36] of the concerned site, which should rely on real measured values (rather than a theoretical PUE for perfect weather and workload conditions);
- CPU = characterization of the quantity of processing/computing of the organization's workloads;
- $Elec_{per\ CPU}$ = estimation of the electricity required to perform one unitary computation on average;
- $Storage$ = total amount of data stored by the IS, taking into account replication;
- $Elec_{per\ storage}$ = electricity required to store one unit of data;
- EF_{grid} = emission factor of the electricity grid supplying power to the equipment.

Solutions of this family mainly aim to reduce:

a) N_{server} : by increasing the number of virtual machines per physical server, by handling seasonality better (reducing the need of dimensioning the server fleet in order to be able to handle the highest activity peak), etc.;
b) PUE : by optimizing cooling systems, by increasing efficiency of supporting equipment, etc;
c) $Elec_{per\ CPU}$ and $Elec_{per\ storage}$: by increasing the number of virtual machines per physical server and by applying more energy-efficient processes at every layer (virtualization, containerization, micro-services, intelligent data tiering policies, etc.);
d) EF_{grid} : by hosting activities in countries with low-carbon electricity.

CPU and $Storage$ are likely to increase due to rebound effect, and **tipping points are to be computed to ensure inflation is contained.** Solutions of this family must clearly identify which lever(s) among a), b), c) and d) supposedly reduces before beginning an assessment.

[35] If the studied solution mutualizes servers (e.g., public cloud), an allocation based on revenue or electricity consumption can be made to allocate a number of servers to a given customer; as stated in the *Solution Scenario – Calculation* section.
[36] As defined by the Green Grid, *PUE: A comprehensive examination of the metric* & ISO/IEC 30134-2.

Starting point
A characterization of the customer's initial IS must be done, identifying the following elements for each site where the company hosts some activities:

- Composition of the server fleet (servers, switches, firewalls, routers, disks, etc.);
- PUE and emission factor of the electricity grid mix;
- Current architecture and operating state of physical and virtual servers, to point out whether they are obsolete or not,
- Number of Terabytes stored by the IS and characterization of workloads.

Arrival point
A characterization of the target IS must be done, identifying the same elements as for the starting point, by asking the question:

- What are the main services being deployed (simple "lift-and-shift", additional file storage, object storage, Virtual Machines for computing, serverless computing, etc.), and can they be translated into an average server fleet?
- Is the deployment of the considered solution motivated by better efficiency or by the possibility to strongly scale IT activity upwards?
- For cloud solutions, is the target public, private or hybrid cloud?

Identifying both starting and arrival points will help build the reference and solution scenarios later on.

4. Additional constraints

Update frequency of avoided emissions claims
Solutions of this family being subject to shifting baselines and unsustainable trends such as exponential data growth (methodological cruxes n° 2 and 5), avoided emissions calculations for any given customer should undergo yearly updates.

If a customer witnesses avoided emissions for a given year, but the solution has contributed to added emissions beforehand or afterwards, communication from the solution provider cannot ignore the more emissive years and communicate solely on the year during which there were avoided emissions: any added emissions must be deducted from claimed avoided emissions. As stated throughout this guidance, **carbon tipping points** must be computed to contain rebound.

Lower increase avoided emissions
Lower increase avoided emissions (later referred to as AE_{LI}, as opposed to reduction avoided emissions, AE_R) may be computed only in the situation where the customer's initial IS disposed of a certain number of under-solicited physical machines, and **adopting the solution has led to a sufficiently small increase** in CPU and/or $Storage$.

In this sense, it may be argued that the observed growth of IT activity could and **would** have happened with the initial information system's fleet. It may correspond to the company's embedded growth, not rebound: adopting the solution did not drive nor particularly facilitate the increase of the number of workloads or stored data of the considered organization.

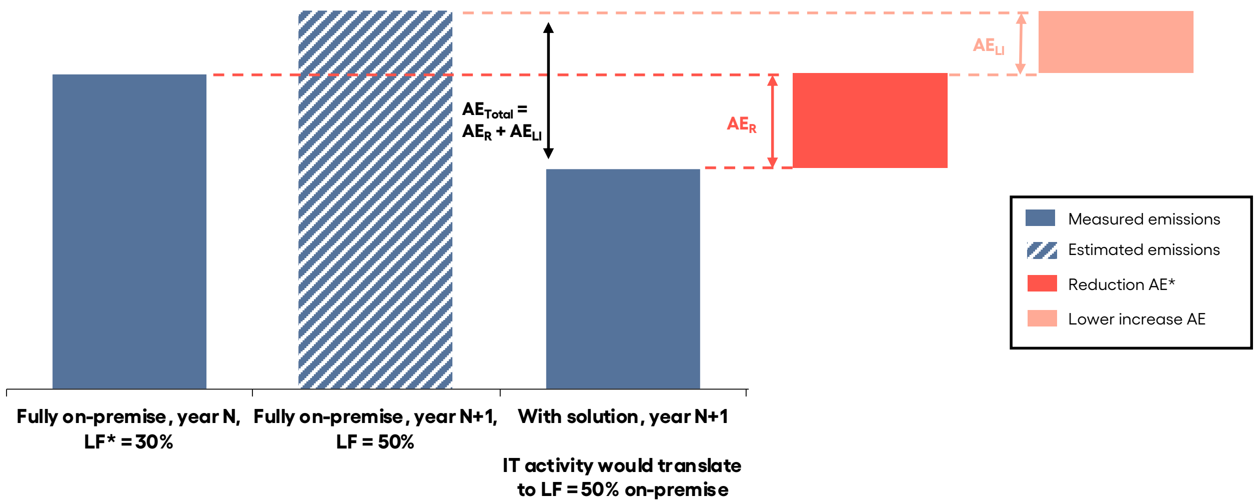
If the **average load factor** of the IS's most solicited machines **was below 80% before** adopting the solution, and observed IT activity growth after adoption **would have kept this factor under 80% had all IT activity been hosted on the initial IS**, lower increase avoided emissions may be claimed.

Above this threshold, the initial IS would likely have needed to scale up, and the IT activity growth is considered as rebound, driven (or facilitated) by the adoption of the solution.

In other words, lower increase avoided emissions calculations are possible **if the observed IT growth is likely to have happened without the solution and the initial IS was dimensioned large enough to handle such growth, without the need to scale up.**

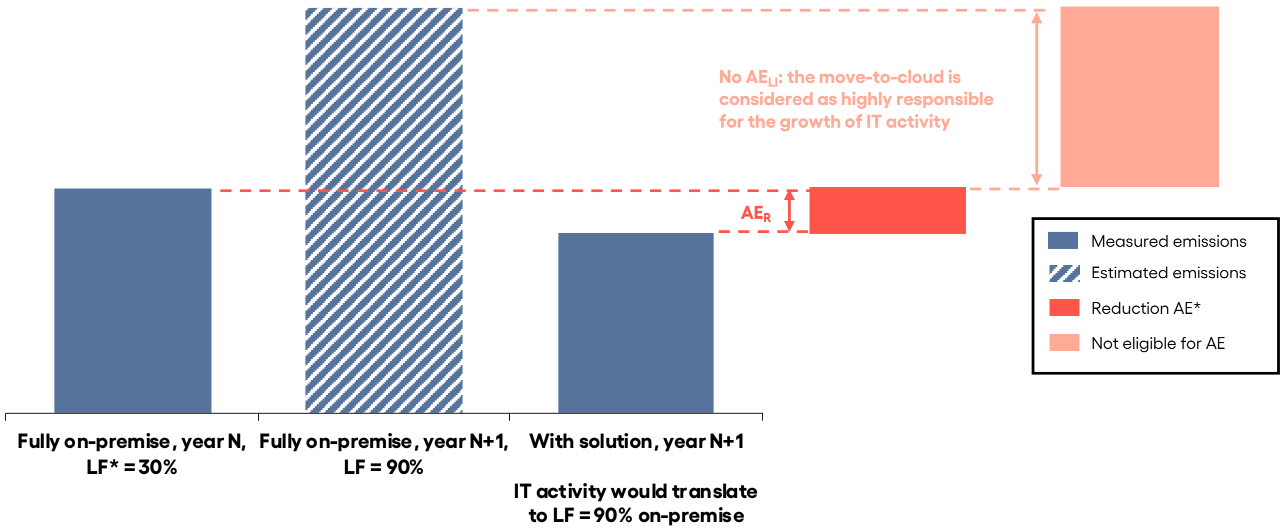
Figure 17 illustrates a situation where a customer migrating its fully on premises IS to a (public or private) cloud may give way to lower increase avoided emissions for the provider, thanks to a moderate growth of IT activity.

Figure 18 illustrates a situation where the growth of IT activity exceeds what would have been possible on premises and is therefore considered as rebound.



***LF: Load factor, **AE: Avoided emissions**

Figure 17 - Illustration of a situation where a customer adopting a move-to-cloud solution can lead to lower increase avoided emissions. The total avoided emissions is the sum of reduction and lower increase avoided emissions



***LF: Load factor, **AE: Avoided emissions**

Figure 18 - Illustration of a situation where a customer adopting a cloud solution cannot lead to lower increase avoided emissions; as growth exceeding a certain threshold is considered as rebound effect caused by the solution

Once specificity, geography, time frame, decarbonizing levers and starting and arrival points have been identified or chosen, the calculation of emissions may follow.

With a 'Cloud & Virtualization' solution: the studied solution may decarbonize a customer's IS by acting upon the aforementioned levers (N_{server}, PUE, $CPU * Elec_{per\ CPU}$, $Storage * Elec_{per\ storage}$, EF_{grid}). A clear understanding of underlying elements for the considered customer is necessary to pin down the emissions in the solution scenario:

- Solicited hardware (servers, switches, routers, storage disks, firewalls, etc.)
- Other equipment using energy (cooling systems, ventilation, lighting, etc.)
- Different layers of abstraction (hypervisors, containers, etc.)
- The electric grid(s) supplying power to the equipment

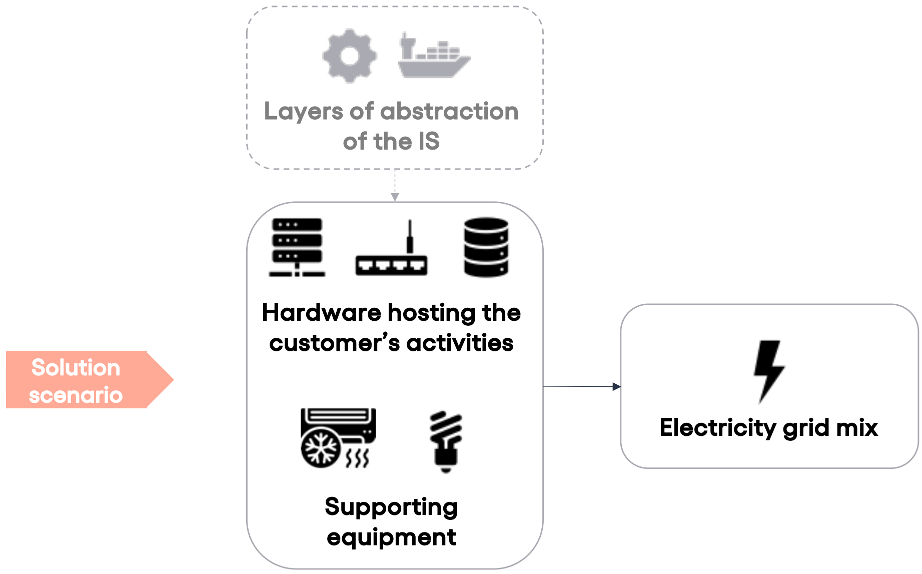


Figure 19 - Illustration of the situation with the solution

<u>In the reference situation</u>: The reference scenario is highly dependant on context: the customer's intentions when adopting the solution and also the nature of the solution itself. The following decision tree summarizes the possible contexts and associated reference scenarios. Every question appearing must be answered through a customer survey and cannot be extrapolated.

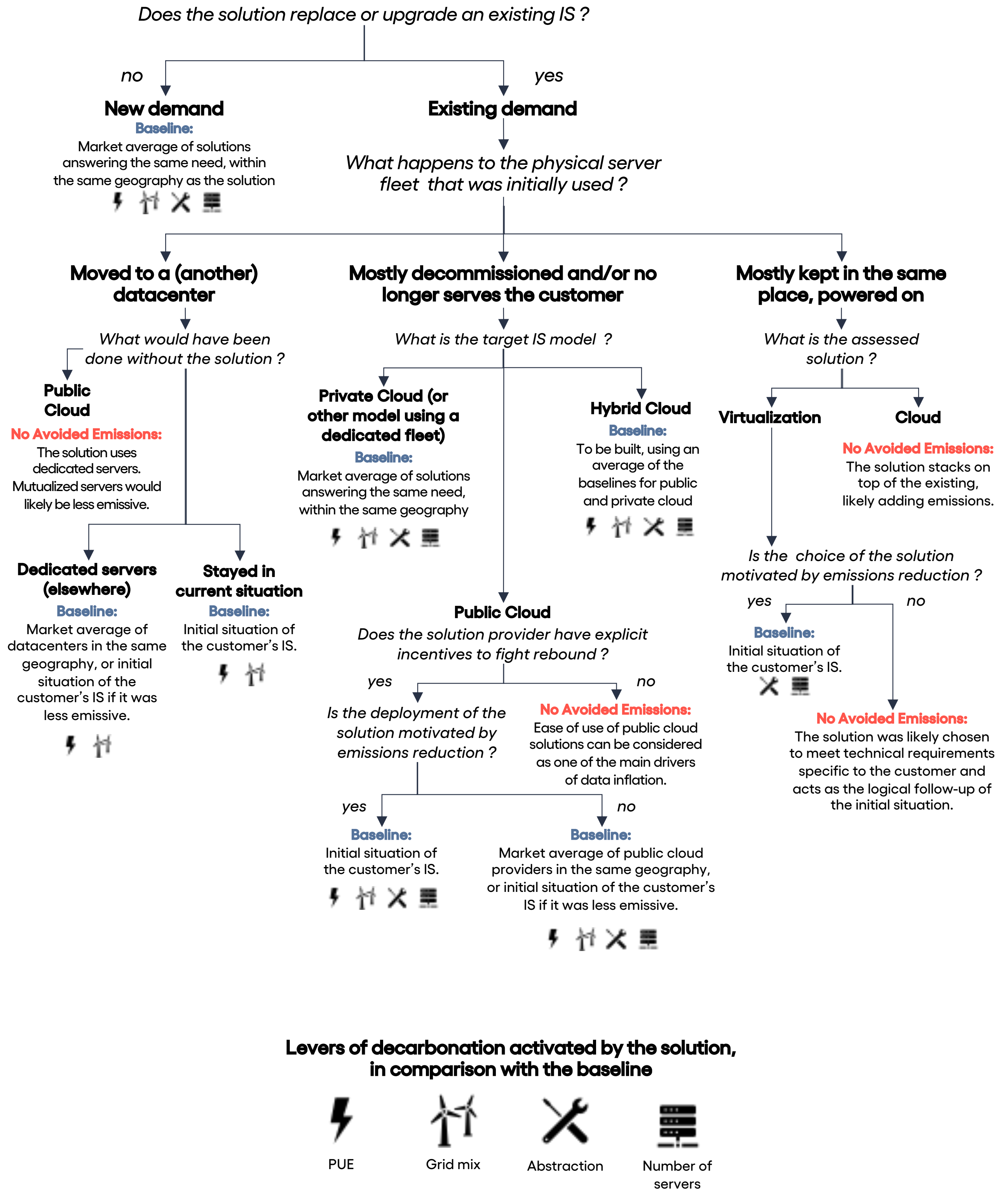


Figure 20 - Illustration of alternatives without the solution

POINTS TO ADDRESS - REBOUND EFFECT

Rebound effect: To check whether or not the considered solution is prone to rebound or other induced effects, companies should analyse the following dimensions:

- Direct and indirect economic rebound: whilst optimizing energy and hardware use for a given amount of data storage and/or processing, solutions within this family also tend to allow important cost savings when compared to their on premises or non-virtualized equivalents. Said savings may be reinvested directly to make the company IS grow, or within other branches of the company.

- Direct convenience rebound: many of the solution's mechanisms (such as auto scaling, load balancing, caching/content delivery networks, etc.) drastically simplify the operations a company must go through when scaling its IT activity upwards, reducing or suppressing the need to purchase and configure equipment.

  Customers may start increasing their volumes of data stored and processed simply due to the simplicity allowed by the provider's services.

- Economy-wide rebound: driving the amounts of data stored and processed upwards may have a significant impact on the economy as a whole, enabling data-driven business models to emerge, giving birth to new activities that can be more or less aligned with a low-carbon world. Providers should keep an eye on their customer's business models and avoid hosting activities for companies whose products are harmful for the environment.

Networks: the computed emissions for this family of solutions are mainly linked to datacentres. As a first approximation, emissions linked to network usage (inbound and outbound data for the IS) are considered as identical in the reference and in the solution scenario. However, if the considered customer's business model relies heavily on network use (B2C companies, streaming services, etc.), network-related emissions must also be considered (using metrics on electricity use per transferred gigabyte for example) as they may be prone to rebound.

Data-based customers: Companies whose business model heavily relies data (e-commerce, recommendation algorithms based on user behaviour, etc.) should be particularly vigilant with rebound effects, as their performance is closely linked to the amount of data they handle.

SOLUTION SCENARIO – CALCULATION

In the solution scenario, emissions of the customer's IS over a full year should be considered. If another functional unit is chosen, the reporting company shall disclose the arguments motivating this choice.

Calculation for a specific customer:

Because of the complexity of solutions within this family, this calculation provides global guidelines rather than a full detailed process. Any hypotheses made to compute emissions must be communicated. Emissions to compute are listed below:

1) Emissions of electricity consumption of the IT fleet hosting the customer's activities: for each site X, collect the **customer-specific IT equipment electricity consumption** over the year (referred to as $Elec_{IT\,use,\,site\,X}$ later on), and multiply it by the appropriate **location-based emission factor** (referred to as $EF_{site\,X}$ later on) that must include **upstream and combustion,** to compute these emissions.

One calculation must be done for each site hosting activities. For a given site X, these emissions will be referred to as $GHG_{IT\ use,\ site\ X}$ later on:

$$GHG_{IT\ use,site\ X} = Elec_{IT\ use,site\ X} * EF_{site\ X}$$

If the provider has access to the customer's IT power solicitation over time t (referred to as $P_{IT\ use,\ site\ X}\ (t)$ later on) and the local grid's emission factor at a precise rate (hourly or daily, for example); additional precision may be achieved:

$$GHG_{IT\ use,site\ X} = \int_{t=0}^{t=1\ year} P_{IT\ use,site\ X}(t) * EF_{site\ X}(t)\ dt$$

Customer-specific IT electricity consumption should be measured when possible; thanks to metrics provided by Power Distribution Units, or metrics on the average electric power allocated to said customer over the year. If this consumption is estimated, **full transparency on the estimation method must be disclosed** when communicating.

<u>2) Emissions of electricity consumption of supporting equipment (cooling, ventilation, lighting, etc.) allocated to the customer's activities:</u> for each site X hosting the customer's activities, these emissions are to be estimated thanks to the following formula:

$$GHG_{support,site\ X} = GHG_{IT\ use,site\ X} * (PUE_{site\ X} - 1)$$

Where $PUE_{site\ X}$ is the average **real**[37] Power Usage Effectiveness of site X over the year.

If the provider has access to $P_{IT\ use,\ site\ X}\ (t)$ and its own PUE at a daily or hourly rate, additional precision may be achieved:

$$GHG_{support,site\ X} = \int_{t=0}^{t=1\ year} P_{IT\ use,site\ X}(t) * (PUE_{site\ X}(t) - 1)\ dt * EF$$

<u>3) Manufacturing, transportation and end-of-life emissions of IT equipment:</u> these emissions (referred to as $GHG_{IT\ manuf.}$ later on) should always be properly measured if the customer has a dedicated IT fleet, using emission factors from provider LCAs to assess emissions of each piece of equipment dedicated to the customer.

For public cloud solutions, the provider may estimate the emissions allocatable to a specific customer A using the following proxy:

[37] Measured, as opposed to the 'theoretical' or 'target' PUE that would be achieved with perfect conditions for the uninterruptible power supply devices.

$$GHG_{IT\ manuf.,customer\ A,site\ X} = GHG_{IT\ manuf.,total,site\ X} * \frac{Elec_{IT\ use,customer\ A,site\ X}}{Elec_{IT\ use,total,site\ X}}$$

Where $GHG_{IT\ manuf.,\ total,\ site\ X}$ and $Elec_{IT\ use.,\ total,\ site\ X}$ refer to the total manufacturing, transportation, end-of life emissions and total electricity consumption of IT equipment operated by the provider for its customers[38] within site X; respectively. An economic allocation (using the ratio of what is charged to customer A and the provider's total revenue from the site).

4) Emissions of refrigerant fluid leaks: for each site X, these emissions (referred to as $GHG_{leaks,\ site\ X}$ later on) can be estimated by allocating part of the provider's total refrigerant leak emissions on site X in a similar way as with public cloud server manufacturing emissions, using a ratio of electricity consumed for the specific customer and the electricity consumption of the total customer base for the site.

5) All other emissions (optional): for each site X, emissions from the provider's backup generators, building construction, employee commuting, business travel, maintenance, etc. (referred to as $GHG_{other,\ site\ X}$ later on) can be allocated to the customer using the same ratio method used for refrigerant leaks if these emissions are taken into account in the reference scenario as well.

Finally, the emissions of all sites must be taken into account to obtain the emissions of the solution scenario:

$$GHG_{Sol.\ scenario} = \sum_{Sites} \left(GHG_{IT\ use,site\ X} + GHG_{support,site\ X} + GHG_{manuf.,site\ X} + GHG_{leaks,site\ X} \right)$$

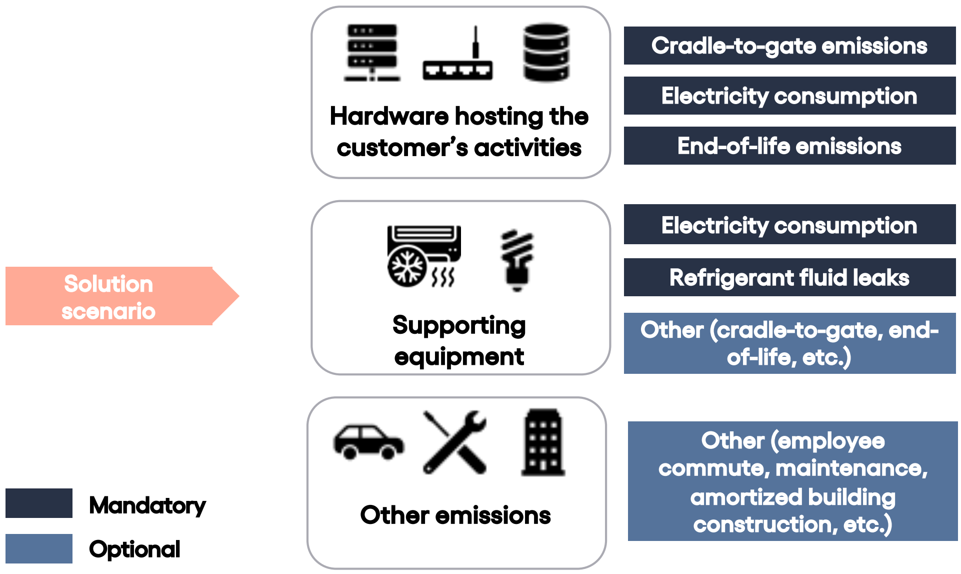


Figure 21 - Illustration of emissions to account for in the solution scenario. Figures are illustrative

[38] This excludes any consumption for 'internal' IT equipment, part of the provider's own fleet.

REFERENCE SITUATION – CALCULATION

Calculation for a specific customer:

When following the decision tree (Figure 20), any time the reference situation is 'the initial situation of the customer's initial IS', the emissions to be computed (and the method used to compute them) are **exactly the same as those mentioned in the solution scenario**:

- Emissions of electricity consumption from IT equipment,
- Emissions from other supporting equipment,
- Manufacturing, transportation and end-of life emissions of IT equipment,
- Emissions of refrigerant fluid leaks,
- Other emissions (if they are accounted for in the solution scenario).

If the decision tree (Figure 20) calls for the computation of a 'market average' of solutions answering the same need as the assessed solution, in a given geography, the emissions to account for are **the same as those mentioned in the solution scenario.** They may vary from those computed in the solution scenario if:

- The provider is able to argue that they have a better PUE than average. All assumptions made to estimate the average PUE of competitors are to be clearly stated in any communication surrounding avoided emissions.
- The provider is able to argue that, thanks to their virtualization services, mutualization mechanisms, etc., they are able to provide the same levels of computing power and capacity storage with less physical servers. All assumptions made to estimate the average number of servers that would be needed by competitors are to be clearly stated in any communication surrounding avoided emissions.
- The provider is able to argue that they power their machines with low-carbon electricity in higher proportions than those of the average local grid, thanks to physical PPAs or self-made renewable facilities, for example.

Note that, unless the customer clearly states that their choice would have been to host their activities in another location had it not been for the solution chosen, the grid mix emission factor is the same between the solution scenario situation and the market average scenario.

This does not reward any solution provider that would play a role in the development of new renewable electricity facilities. While these initiatives are encouraged, they fall out of scope of the avoided emissions of IT itself, and may follow guidelines provided by the NZI4Energy guide. One main warning point is that the provider deploying these facilities must not consume more electricity than it generates renewable electricity if they are to claim any avoided emissions by these means.

AVOIDED EMISSIONS CALCULATION

Finally, avoided emissions are the difference between emissions in the reference scenario and the solution scenario:

$$AE = GHG_{ref.\ scenario} - GHG_{sol.\ scenario}$$

IMPORTANT PARAMETERS FOR THIS SOLUTION

Cloud & Virtualization solutions may avoid or may add emissions. This heavily relies on:

- Characterization of CPU and storage, as stated earlier, solutions within this family are highly prone to (and may drive) rebound effect, which must be contained.
- Grid mix, to be considered using a location-based method.
  If a customer keeps the same amount of IT activity (no rebound) and moves its on premises IS (located in France, with a grid emission factor of 60 gCO2e/kWh) to a highly efficient private cloud solution in Ireland (grid emission factor of around 400 gCO2e/kWh) allowing him to have 3 times as few machines, all efficiency gains are cancelled out by the fact that the grid is 7 times more emissive, and emissions are increased (not avoided).

A rigorous calculation of these parameters is necessary for both solution and reference scenarios to be able to claim avoided emissions.

OVERVIEW OF NECESSARY DATA

The data mentioned below must be collected for the specific customer whose information system is being assessed.

Necessary data	Solution scenario or specific customer's initial IS situation	Market average of solutions answering a same need
Solicited power of machines	Measured data, from the power distribution unit for example. For public cloud solutions, total electricity consumption of machines within the datacentre.	To be considered identical to the solution scenario, unless published studies prove otherwise.
Electricity grid Emission Factors (EF	This data can be gathered thanks to ElectricityMaps' historical data.	This data can be gathered thanks to ElectricityMaps' historical data.
Measured PUE	Measured data, thanks to the total electricity consumption and the solicited power of machines.	This data can be collected using published studies and must be sourced.
Manufacturing emissions	Cradle-to gate and end-of-life emissions data of machines can be collected through **specific LCAs**.	Cradle-to gate and end-of-life emissions data can be collected through **specific LCAs**.
Refrigerant leaks	Refer to the quantity of refrigerant fluids bought in kg, for each type of fluid, over the year.	This data can be collected using published studies and must be sourced.
Data traffic (inbound and outbound)	Measured data.	To be considered identical to the solution scenario, unless published studies prove otherwise (e.g., the CDN of the provider is particularly efficient).
Economic or electricity consumption-based ratios	Gather customer-specific and global data on spendings or electricity consumption.	To be considered identical to the solution scenario.

Table 13 - Overview of the necessary data for avoided emissions of 'Cloud & Virtualization' solutions

CALCULATION EXAMPLES

Disclaimer: *the metrics shown here are arbitrary values and cannot be reused as-is. Reporting companies shall use their own metrics and hypotheses.*

Case 1: Customer A moves its on premises IT fleet to a datacentre, motivated by reducing its emissions. It decides to go with Provider X, who boasts a better PUE than its competitors in the region. No rebound effect in IT usage is observed.
Following the decision tree (Figure 20), the reference scenario is a market average of datacentres in the same geography. $GHG_{IT\ use}$ and $GHG_{IT\ manuf}$ are equal in the reference and solution scenarios, as customer A's IT usage and server fleet are unchanged. $GHG_{support}$ and GHG_{leaks} carry potential avoided emissions as highlighted by tables 14 and 15.

SOLUTION SCENARIO		
Metric	**Computation**	**Value**
$GHG_{IT\ use}$	Computed thanks to the measured values of power solicited by the IT fleet and local electricity grid mix emission factor.	50 tCO2e
$GHG_{support}$	Computed thanks to the PUE of Provider X's datacentre: $GHG_{support} = GHG_{IT\ use} * (\text{PUE-1})$ For this example, PUE = 1,3.	50 * (1,3 - 1) = 15 tCO_2e
GHG_{leaks}	Computed using Provider X's total refrigerant leak emissions (500 tCO_2e in this example) and customer A's weight in compared to Provider X's total customer base electricity usage in the datacentre (10% in this example).	500 * 0,1 = 5 tCO_2e

Table 14 - Emissions data for customer A (solution scenario)

REFERENCE SCENARIO		
Metric	**Computation**	**Value**
$GHG_{IT\ use}$	Same as in the solution scenario, as no variation is observed in IT usage and Provider X shares the same grid as its competitors in the region.	50 tCO2e
$GHG_{support}$	Computed thanks to the average PUE of datacentres in the region: $GHG_{support} = GHG_{IT\ use} * (\text{PUE-1})$ For this example, PUE = 1,5.	50 * (1,5 - 1) = 25 tCO_2e
GHG_{leaks}	Computed using the average ratio between $GHG_{IT\ use}$ and GHG_{leaks} in the region; estimated at 12,5 in this example.	50 / 12,5 = 4 tCO_2e

Table 15 - Emissions data for customer A (reference scenario)

Provider X's avoided emissions for customer A can therefore be computed by looking at the differences observed for $GHG_{IT\ use}$ and $GHG_{IT\ manuf}$ between the solution and reference scenarios:

Avoided emissions = (25 + 4) – (15 + 5) = 9 tCO_2e.

Case 2: Customer B decommissions some on premises data storage racks, and opts for Cloud Provider Y's scalable object storage service instead.

Customer B's former on premises machines used to store 2000 Terabytes (TB) of data in total. The overall emissions associated with this data was 60 tCO_2e/year.

Cloud provider Y has measured its own carbon footprint and estimated that Customer B's usage of the object storage service emits 10 $kgCO_2e$/TB/year.

Cloud provider Y computes a carbon tipping point if it wishes to claim avoided emissions: if customer B increases its spendings and starts hosting over 6000 TB, the overall emissions associated with their data storage will have increased compared to the reference situation, and **no avoided emissions may be claimed**.

Inversely, if customer B contains its rebound and hosts, for example, 4000 TB of data with the storage service, Cloud provider Y can claim avoided emissions:

Avoided emissions = 60 – 4 000*0,010 = 20 tCO_2e

Solution 3 – Demand and offer matching platforms (General approach)

This family of solutions addresses online platforms that allow users to share assets, in an effort to reduce said assets' overall emissions. Demand and supply matching platforms may help reduce emissions by:

- *Reducing production volumes, by sharing/mutualizing assets that are not used all the time, instead of having individual ownership (e.g., a platform that allows users to share housework tools between them);*
- *Reducing energy use of an overall category of assets, by allowing more people to benefit from unitary uses of the asset (e.g., a carpooling platform that allows two people to travel together in the same car for a given trip, rather than both using their car, consuming nearly twice as much fuel as a whole).*

A given demand and supply matching platform may act upon one or both of the levers mentioned above, avoiding production[39] and/or use phase emissions.

GENERAL APPROACH

To evaluate avoided emissions of a demand and offer matching platform, **GHG emissions in a situation <u>with</u> the solution** and **GHG emissions in the same situation <u>without</u> the solution** (the reference situation) will be compared.

1. Functional unit

This family of solutions potentially applies to a large number of sectors. It is recommended to choose a functional unit adapted to the sector being decarbonized, for instance:

- Transportation: $kgCO_2e$/trip, $kgCO_2e$/passenger.km, etc.
- Tools: $kgCO_2e$/use, $kgCO_2e$/hour of use, etc.
- Appliances and electronics: $kgCO_2e$/person/year, etc.

Companies shall disclose the arguments that lead them to the choice of a given functional unit.

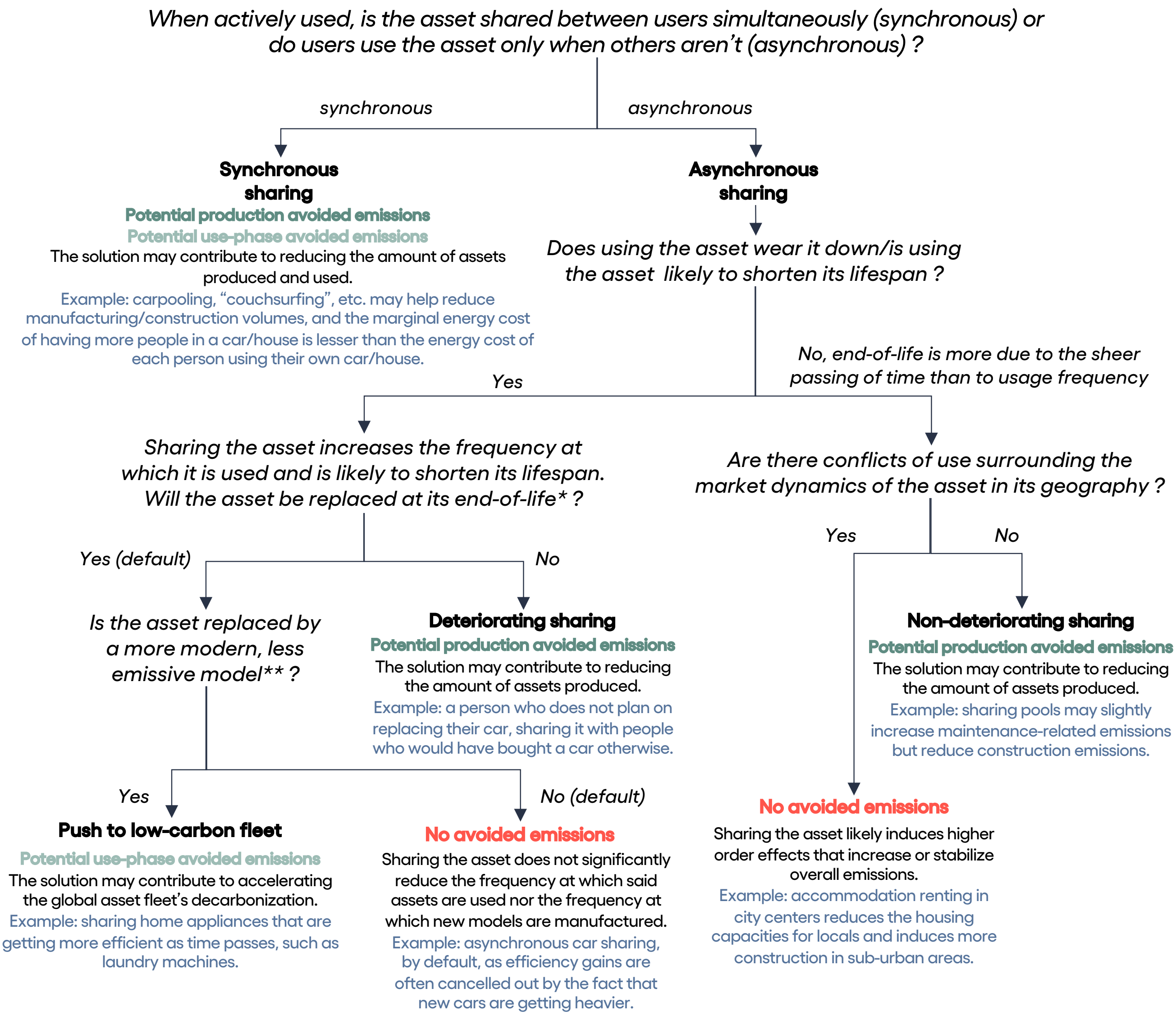
2. Identification of decarbonizing levers

Demand and offer matching platforms may reduce the emissions of:

- Manufacturing, transportation and end-of life of goods, which will later be referred to as '**production**' emissions;
- Energy consumption of goods (and any other emissions occurring in the timeframe where an asset is actively used), which will later be referred to as '**use-phase**' emissions;
- Or both.

[39] Includes manufacturing, transportation and end-of-life emissions.

This primarily depends on the nature of the shared asset, and the ways in which it is shared: the decision tree below helps to determine the lever(s) actioned by the solution to reduce emissions, and names four different sub-cases: Synchronous sharing, Push to low-carbon fleet, Deteriorating and Non-deteriorating sharing.



** This can be answered with customer surveys, either based on statistical behaviour or on a specific customer's behaviour.*
*** This can be answered with customer surveys, statistical upon the entire customer base or specific, or with market average data if the lowest level of specificity is used.*

Figure 22 - Illustration of situations in which the solution may avoid emissions. Figures are illustrative

With a Demand and offer matching platform: depending on the considered sub-case, different elements must be taken into account when looking at the solution scenario:

- **Synchronous sharing**: the shared asset's production and use-phase emissions, including the marginal energy cost associated with the extra users (for example, a small car carrying multiple passengers will consume more slightly more fuel than if there was only one passenger; use-phase emissions for the same trip cannot be considered exactly equal in the solution and in the reference scenario).

- **Deteriorating sharing and Non-deteriorating sharing**: the shared asset's production and use-phase emissions.
- **Push to low-carbon fleet**: the shared asset's production and use-phase emissions, its lifespan, and the production and use-phase emissions of the projected replacement for the asset.

Figure 23 - Illustration of the situation with the solution

<u>In the reference situation</u>: The reference scenario is highly dependant on the specificity level chosen for the assessment. The behaviour the customer would have had without the solution can be estimated:

- Thanks to the specific customer's own answer to a survey (maximum specificity).
- Thanks to the customer base's average response to a survey (medium specificity, requires a high enough response rate). This implies building a weighted average reference situation.
- Thanks to a peer-reviewed study on user behaviour with the considered asset.

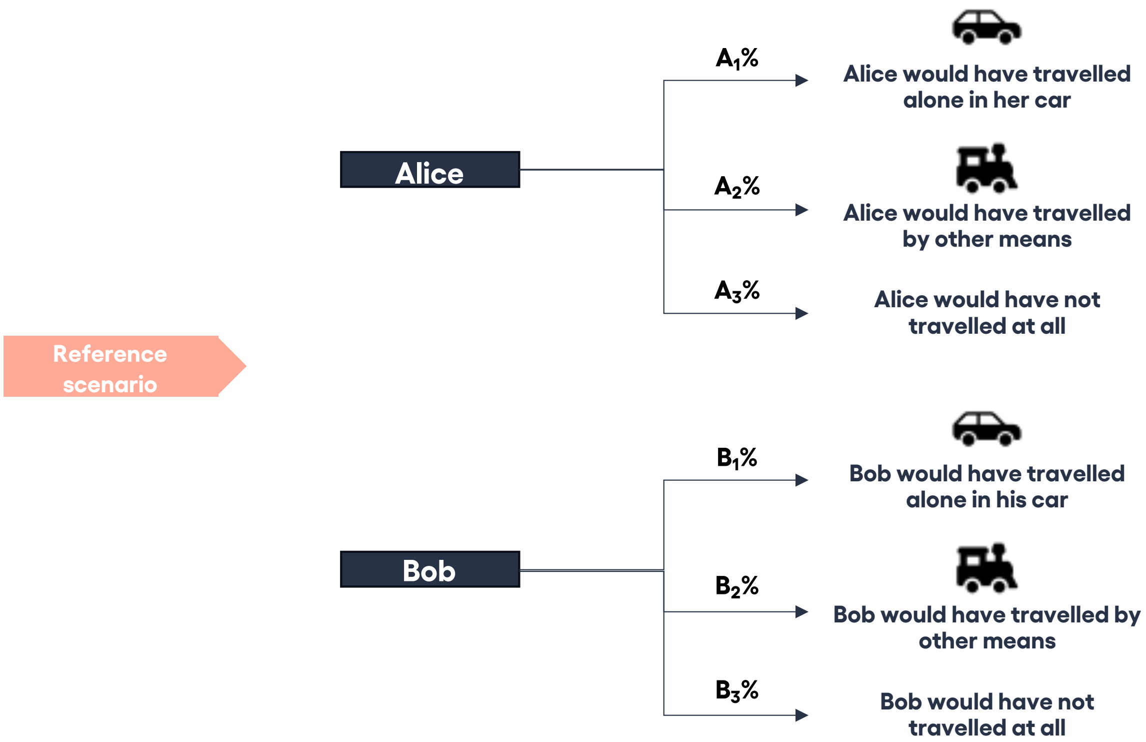


Figure 24 - Simplified illustration of the reference situation, for the example of carpooling

The basis on which the customer's behaviour in the reference scenario is built must be fully transparent, and **under no circumstance** can we estimate that 100% of customers would have chosen the alternative of buying their own personal asset without surveys or studies to back this claim.

POINTS TO ADDRESS

Rebound effect: To check whether or not the considered solution is prone to rebound or other induced effects, platforms should analyse the following dimensions:

- Direct and indirect economic rebound: using a shared asset is almost mechanically cheaper than owning one and using it individually. Monetary savings are bound to happen thanks to demand and offer matching platforms, and particular attention must be kept on economic rebound:

    - Are the lower prices driving adoption rate for certain assets/technologies?
    - Are the lower prices increasing the frequency of usage of certain assets/technologies?
    - Are the lower prices driving consumption of a given resource or emissive activity (such as traveling) upwards?

    These questions should always be treated and answered thanks to customer surveys and/or scientific papers.

- Direct convenience rebound: owning certain assets may prove to be cumbersome for some users. Similarly to economic rebound, questions on adoption rate and usage frequency must be asked.

    If the asset being shared is a transportation means, another convenience rebound is possible: for example, carpooling may prove to be less time-consuming to go from a given point A to a given point B than a low-carbon alternative such as a train or a bike. Because of this, demand for car trips from point A to point B may increase, and so may offer; if a person who initially planned to go from point A to point B by a lower-carbon mode sees that using their car and carpooling with it wouldn't cost them much and increase their comfort.

Shifting baselines: some behaviours have been initiated by the sharing economy and are today well-installed. Market averages **including the solution's competition** should be privileged when building low-specificity reference scenarios.

Example: an accommodation sharing platform cannot compare its services solely to hotels, which are often more emissive than renting somebody's apartment. Rather, each night must be associated with a complete catalogue of housing services within the same price range: hotels, camping, hostels, other platforms providing shared apartments, etc.

Solution 4 – Demand side optimization (General approach)

This family of solutions addresses mechanisms that reduce overall emissions (whether in the IT sector or outside of it), by inducing a less emissive behaviour or demand on the users' side. Two subcategories are distinguished:

- *Subcategory A: mechanisms that guide the customer or user towards the choice of a low-carbon product or behaviour. This can be achieved by **communicating relevant climate information** (such as the carbon footprint of a product, and suggestions for low-carbon alternatives), by **raising awareness**, or by **giving price incentives** for less emissive products or behaviours.*
- *Subcategory B: mechanisms that impose, by default, a low-carbon product or behaviour to customers. This can be achieved by **imposing energy-saving settings by default**, or by making use of environmental data (carbon intensity of the local electricity grid, weather conditions, etc.) to reduce emissions of used products.*

GENERAL APPROACH – SUBCATEGORY A

Providing a quantified indicator on avoided emissions for a subcategory A solution can be fastidious. Two situations are possible:

- The company providing the solution has measured data on customer behaviour. For example, a telecommunications operator deploys a 'pay-as-you-go' package that encourages customers to reduce their data consumption: the provider knows precisely how their customers behave with this offer, and can make use of market averages to build a reference scenario. Guidelines given for subcategory B products can be applied.

- The company has no measured data on customer behaviour. For example, for a solution displaying carbon indicators on a selection of products or raising awareness on climate change, it is likely impossible to quantify which changes in customer behaviour are attributable to the solution.

When no measured data on customer behaviour is available, it is recommended **not to claim quantified avoided emissions**, but companies can still (and are encouraged to) communicate on their **reasoning as to why the solution is contributes to decarbonization, qualitatively**.

To do so, companies can compute or gather several indicators:

- The induced emissions of the solution,
- The reduction of emissions caused by the change of behaviour the solution aims for,
- The conversion rate of customers adopting the low-carbon behaviour, and the number of customers.

For example, a solution providing connected price tags in a store aims at promoting low-carbon alternatives to products.

- The induced emissions the price tags are **1000 kgCO2e per year**;
- Throughout their suggestions, the price tags provide alternatives to certain products in the store that may **reduce the average shopping cart's carbon footprint by 10 kgCO2e**;
- The store sees **10 000 customer receipts per year** (10 000 shopping carts).

In order to defend the solution's contribution to reducing emissions, it must be able to induce enough behaviour changes to at least equal its induced emissions, i.e., it must affect **at least** $\frac{1000}{10} = 100$ **shopping** carts, which represents **1% of all purchases.**

The company may then argue as to why their product does indeed induce a change in behaviour among at least 1% of the store customers.

If the percentage of customers needing to change behaviour exceeds 100%, the solution does not, of course, avoid emissions, and if the percentage is particularly low, the solution has good chances of avoiding emissions and can be considered as relevant in the company's portfolio.

GENERAL APPROACH – SUBCATEGORY B

To evaluate avoided emissions of a demand-side optimization solution, **GHG emissions in a situation <u>with</u> the solution** and **GHG emissions in the same situation <u>without</u> the solution** (the reference situation) will be compared.

<u>Functional unit:</u> This family of solutions potentially applies to a large number of sectors. It is recommended to choose a functional unit adapted to the sector being decarbonized, for instance:

- Smart meter and connecter water heater: $kgCO_2e/kWh$ or $kgCO_2e$/year of functioning;
- Low-quality default settings for video platforms: kgCO2e/minute of watch time or kgCO2e/average view;
- Etc.

Companies shall disclose the arguments that lead them to the choice of a given functional unit.

<u>With a circularity solution:</u> thanks to the 'connected' aspect of the solution, measured emissions associated with the usage of a solution should be easily accessible in the situation with solution.

The lifecycle emissions of the solution itself and of the elements it applies to shall be included in calculations. For example, for a connected electricity meter that triggers household appliances to launch workloads when the electricity of the local grid is low-carbon, the full lifecycle emissions for all connected appliances must be taken into account. Figure 25 illustrates this situation:

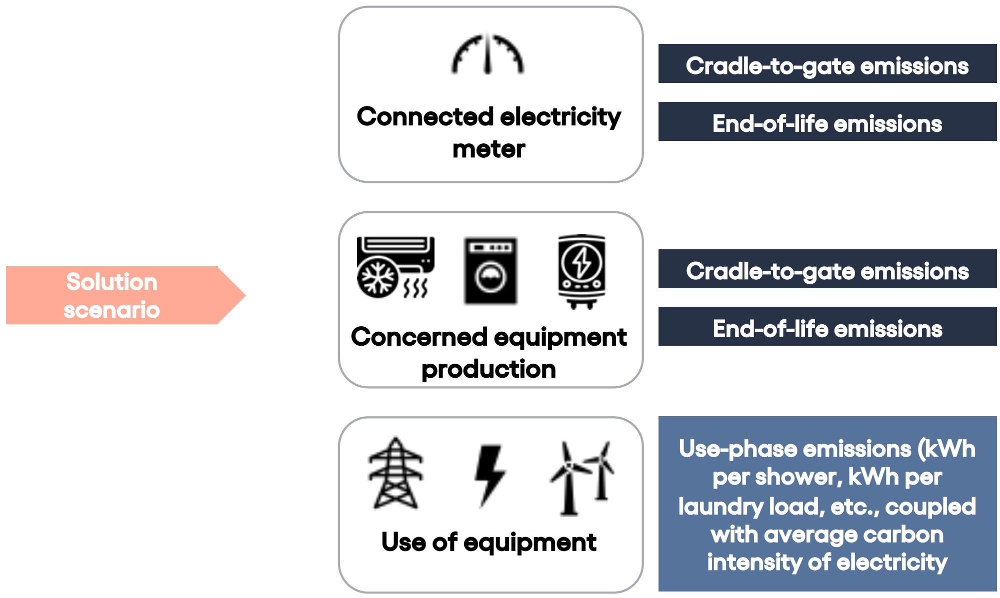


Figure 25 - Illustration of the situation with the solution. Figures are illustrative

In the reference situation: Unless the specificity level of the assessment allows otherwise, the reference situation should be representative of the market average for solutions satisfying the same need.

For example, with high specificity, a connected electricity meter coupled with a connected water heater may use a customer's previous situation (without connected equipment) as the reference scenario. Otherwise, the reference scenario should be that of the market average for water heaters, as illustrated by Figure 26.
For such and other "smart grid" solutions, calculation based on real-time or hourly reporting of the carbon intensity of the electricity grid with a location-based approach is allowed.

If access to a market average is difficult and if the reporting company has access to data on its average customer base, including those not using the assessed solution, the average situation of the customer base may be used. For example, a company providing connected appliances to professional real estate customers can analyse the average energy consumption of the concerned building stock, corrected of local climate variations and thermal insulation of buildings.

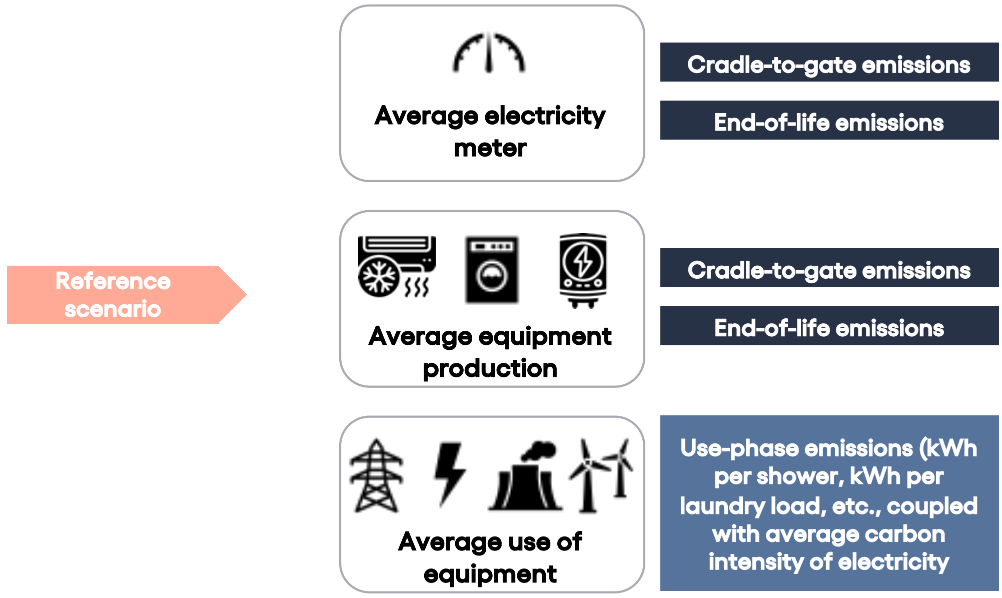


Figure 26 - Illustration of the reference scenario
Figures are illustrative

POINTS TO ADDRESS

Subcategory A

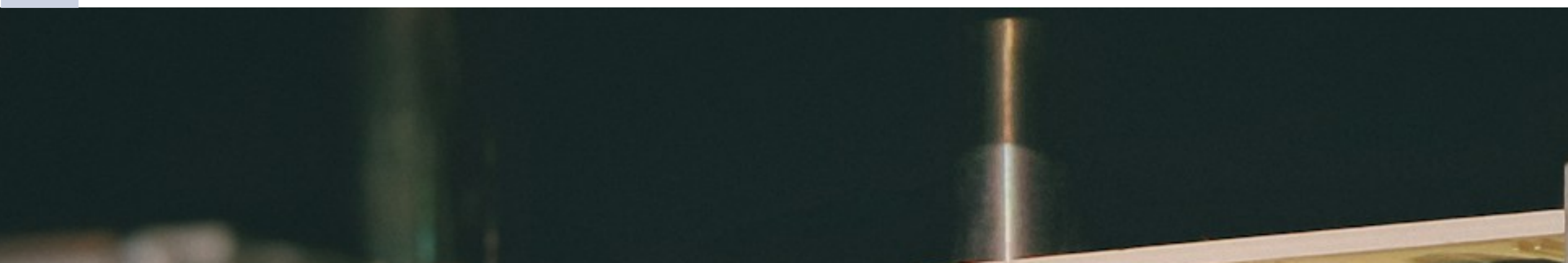
Direct behavioural rebound effect: for solutions that communicate climate indicators on products, a direct rebound effect may be observed where customers buy **additional** products because of their highlighted climate performance, instead of simply substituting their usual purchases with low-carbon purchases.

For goods that fulfil primary needs (e.g., groceries), this rebound may be ignored, as purchases are likely not additional, but customer surveys are required otherwise to ensure **substitution**.

Subcategory B

Direct rebound effect: for solutions that help reduce costs, energy consumption or increase convenience for customers may be prone to rebound and should be analysed by reporting companies if they identify one.

Another potential rebound effect is that of the incentive of premature renewal of equipment: replacing a fully functioning, rather new and efficient laundry machine with a newer, connected one may not be helpful to avoid emissions in the short and even long run. Whenever a solution replaces an existing one prematurely, these aspects must be taken into consideration by studying a correct timespan for both the reference and scenario , following the global NZI Pillar B guidance.



Annexes

Annex A - What about “enablement”?

It should be noted that the concept of “enablement” (or “enablement effect”) has not been included in the present report as a decarbonization lever *per se*. Indeed, unlike “sufficiency”, “efficiency” or “substitution”, this concept has no scientific basis and is thus not mentioned as a decarbonization lever by the relevant literature (for instance *IPCC AR6 WGIII - Climate Change 2022 - Mitigation of Climate Change*[40] does not mention the word “enablement” and only uses “enabler” as opposed to “barrier”). Therefore, where a solution would have primarily been considered as an “enabler”, NZI recommends avoiding this ambiguous wording but rather analyse more precisely the position of the solution in its value chain and identify clearly the decarbonization levers at work (see Table 2).

In fact, “enablement” can always be covered by one o

f these two situations:

- The solution is considered as the only part in a wider system allowing its decarbonization, meaning that without it, no further decarbonization process could occur.
- The solution is a new part of a system, providing a new function or improving/extending an existing one.

The first option is generally flawed, as the above-mentioned wider systems could have been improved in other ways (sufficiency, efficiency, …). In most cases, so-called “enablers” are only technological add-ons improving the total system efficiency.

Regarding the second option, the fact that a solution is a new part of a system does not mean that it has a decarbonization effect overall. Indeed, in most cases, similar systems already existed in the past, providing the same service but with less complexity. Most of the time, the “enablement” word does not relate to any proven decarbonization effect but only refers to the fact that the solution is new or that it solely allows the decarbonization to occur.

It is also important to mention that companies having activities such as R&D, or other developments far upstream the value chain, could be tempted to use this vocabulary as their action is very preliminary to actual decarbonization processes. In this case, the present report also recommends avoiding this wording, but rather to analyse the position of the solution in its value chain and identify which decarbonization lever in Table 2 is activated thanks to the solution.

Ultimately, it should be noted that an “enablement” claim will never have the same value than an avoided emissions calculation – see the level of evidence scale below –, which stands as the only reliable claim for corporate communication.

[40] M. Pathak, R. Slade, P.R. Shukla, J. Skea, R. Pichs-Madruga, D. Ürge-Vorsatz,2022: Technical Summary. In: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change[P.R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasija, G. Lisboa, S. Luz, J. Malley, (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA. doi: 10.1017/9781009157926.002.

Annex B - Examples and potential rebound effects

Examples are given below for each decarbonization lever.

Lever	IT for Green examples	(IT for) Green IT examples
Sufficiency	Eco-designed hardware & software, video encouraging energy saving habits	Refurbished IT equipment, sleep mode for idle IT systems, default video resolution on streaming platforms
Efficiency	Route optimization	Upgraded CPU architecture
Substitution	Online meetings	Virtualization

Examples are given below for each mechanism.

Mechanism	IT for Green examples	(IT for) Green IT examples
System monitoring and optimization	Thermostats	Optimized cache servers
System substitution	Phone calls & other virtual meeting systems	Edge computing
Supply & demand monitoring, optimization, and sufficiency	Ridesharing marketplace platforms	Load-balancing for computation

Examples of potential rebound effects are given below to help companies in this preliminary assessment of their solution.

Mechanism	Family of solutions	Potential rebound effects
System monitoring and optimization	Optimization of grids	Increased energy consumption
	Production efficiency	Increased production
	Intelligent building energy and resource management	Increased energy consumption
	Route optimization	Increased use of mobility
	Precision agriculture	Intensification of agricultural practices
	Precision forestry	Intensification of forestry practices
	Forest protection	Increased amount of stored data
	Optimization of ICT systems	Increased amount of stored data
System substitution	Virtual meetings	Increased meeting time and number of meetings
	Remote work	Increased heating at home, increased number of purchases of IT equipment
	Substitution of ICT systems	Increased amount of stored data
Supply or demand monitoring	Improved metering and forecasting of electricity supply and demand	Increased energy consumption

and optimization	Improved energy system through demand side management	Increased energy consumption
	As-a-service and sharing solutions	Increased production
	Circularity (industry, transport, IT, ...)	Increased production, Increased use of mobility, ...
	Optimized use and sharing of buildings	
	Eco-driving	Increased use of mobility
	Shared mobility	Increased use of mobility
	Systems or programs encouraging user sufficiency for ICT use	

Annex C - How to create an effective customer survey?

Objectives of conducting a customer survey

To help companies obtain useful data to compute avoided emissions, customer surveys, **working with statistical sociologists** to avoid statistical bias, are recommended.

Customer surveys can collect two types of data:

- **Data on customer behaviour for the solution and reference situations** (e.g., how customers intend to use the sold product or service, how long do they intend to keep it, what is the main factor motivating customers to get rid of their current solution and/or adopt a new one, etc.)
- **Data on alternatives and their likelihood for the reference situation** (e.g., what customers would have done if they hadn't bought this product or service). This also helps to quantify the **impact of the rebound effect of the solution** (e.g., the likelihood that the customer wouldn't have bought any product or service instead).

Data can then be used to accurately compute avoided emissions with a company-wide average approach.

How to formulate a customer survey: recommendations

General recommendations:

- use multiple-choice instead of open answers,
- randomly rank answers to prevent any bias,
- ask questions about specific purchases at the time of purchasing goods or services or later on (for example, with a survey sent by email),
- provide examples to help customers understand questions,
- avoid asking too many questions to have a good answer rate.

Annex D - Glossary

Carbon accountability

Activity data: A quantitative measure of a level of activity that results in GHG emissions. *From ITU-T L. 1410*. Example: the number of kWh of electricity consumed by a server.

Emission factor: A factor allowing to estimate the GHG emissions associated with an activity data. Example: 0,4 kgCO2e per kWh of electricity consumed.

Life cycle GHG emissions: The sum of GHG emissions resulting from all stages of the life cycle of a product or solution. *From Climate Avoided Emissions Guidance, WBCSD & NZI.*

Attributional approach: A method that estimates comparative GHG impacts as the difference in product GHG inventories (constructed using attributional. (LCA) between the reference solution and assessed solution. *From Climate Avoided Emissions Guidance, WBCSD & NZI.*

Consequential approach: A method that estimates comparative GHG impacts as the total, system-wide change in emissions and removals that results from a given decision or intervention. *From Climate Avoided Emissions Guidance, WBCSD & NZI.*

Functional unit: Unit chosen as a reference to quantify a product or solution's performance. Example: number of FLOPS for a processor.

Net Zero Initiative terms

Added emissions: Added emissions are defined as the negative impact on society when comparing the GHG impact of a solution to an alternative reference scenario where the solution would not be used. *From Climate Avoided Emissions Guidance, WBCSD & NZI.*

Avoided emissions: Avoided emissions are defined as the positive impact on society when comparing the GHG impact of a solution to an alternative reference scenario where the solution would not be used. *From Climate Avoided Emissions Guidance, WBCSD & NZI.*

Reduction avoided emissions: Share of avoided emissions corresponding to an actual reduction of emissions when compared to the previous situation.
Lower increase avoided emissions: Share of avoided emissions corresponding to an increase in emissions compared to the previous situation, but lower than in the reference scenario.

Modifying usage: A usage of an ICT solution that modifies an activity in the reference scenario. *From ITU L-1480*. Example: A team working on a project has weekly meetings, in-person, in the reference scenario. Using video calling, it now holds the weekly meetings virtually. The video calling app has modified usage.

Rebound usage: Usage of an ICT solution which is additional to modifying an activity in the reference scenario. *From ITU L-1480*. Example: The team working on the project now has bi-weekly virtual meetings. The additional time spent in meetings when compared to the reference situation is rebound usage.

Reference activity: The activity which the studied ICT solution modifies (e.g., by optimizing it or substituting it partially or entirely). *From ITU L-1480.* Example: in-person team meetings.

Reference scenario: A reference case that represents the events or conditions most likely to occur in the absence of the assessed solution. In this guidance, it is the scenario against which a solution is assessed to determine avoided emissions. "Reference Scenario" may be used interchangeably with "Counterfactual" or "Baseline" scenario in other avoided emissions guidelines. *From Climate Avoided Emissions Guidance, WBCSD & NZI.*

Baseline or reference scenario: The quantification of the emissions in a given reference scenario.

Situation with solution: A case that represents the events or conditions occurring (or most likely to occur) with the assessed solution.

Intervention accounting: An accounting method that quantifies systemwide impacts of a specific action or intervention on GHG emissions and removals relative to a counterfactual reference scenario that represents the conditions most likely to occur in the absence of the action or intervention. *From Climate Avoided Emissions Guidance, WBCSD & NZI.*

Inventory accounting: An accounting method for GHG emissions and removals over time within a defined inventory boundary relative to a historical base year. *From Climate Avoided Emissions Guidance, WBCSD & NZI.*

Allocation: The distribution of avoided emissions among the various players allowing said avoided emissions to exist.

Specificity levels: The level at which the potential avoided emissions are being assessed from the solution provider and end user's points of view. Examples: studying the effects of a specific product used by a specific client, studying the effects of a whole array of products used a specific client, studying the effects of a specific product used by a group of clients, etc.

Global Net Zero: Condition in which anthropogenic GHG emissions are balanced by anthropogenic removals over a specified period and within specified boundaries. In this guidance, we refer to Global Net Zero to describe the internationally agreed upon goal for mitigating global warming in the second half of the century. The IPCC concluded the need for net-zero CO2 by 2050 to remain consistent with a 1.5°C pathway. *From Climate Avoided Emissions Guidance, WBCSD & NZI.*

Eligibility gates: Criteria that companies must abide by to be able to claim avoided emissions in line with this guidance.

Effects

First order effect: Direct environmental effect associated with the physical existence of an ICT solution, i.e., the raw materials acquisition, production, use and end-of-life treatment stages, and generic processes supporting those including the use of energy and transportation. *From ITU L-1480.*

Second order effect: The indirect environmental effects happening outside an ICT solution's value chain or life cycle but resulting from the use of that solution. Can be negative or positive. Example: the variation of the number of cars on the road caused by the existence of a carpooling app.

Enablement: Providing a mechanism that allows systems or services, which would not operate without this mechanism, to avoid carbon emissions.

Net Second order effect: The resulting second order effect after accounting for emissions due to the first order effects of an ICT solution. *From ITU L-1480.*

Higher order effect: The indirect effect (including but not limited to rebound effects) other than first and second order effects occurring through changes in consumption patterns, lifestyles, and value systems. *From ITU L-1480.*

Rebound effect: Increased use of a solution as a consequence of its lower GHG emissions impact, which partly or fully cancels out the initial GHG emissions savings intended by the solution. *From Climate Avoided Emissions Guidance, WBCSD & NZI.*

Time rebound: Changes in emissions due to the use of saved time (may be direct or indirect).
Space rebound: Changes in emissions due to the use of saved space (may be direct or indirect).

Direct rebound: A rebound effect where increased efficiency, associated cost reduction and/or convenience of a product or service results in its increased use because it is cheaper or otherwise more convenient. *From ITU L-1480.*

Indirect Rebound: A rebound effect where savings from efficiency cost reductions enable more income to be spent on other products and services. *From ITU L-1480.*

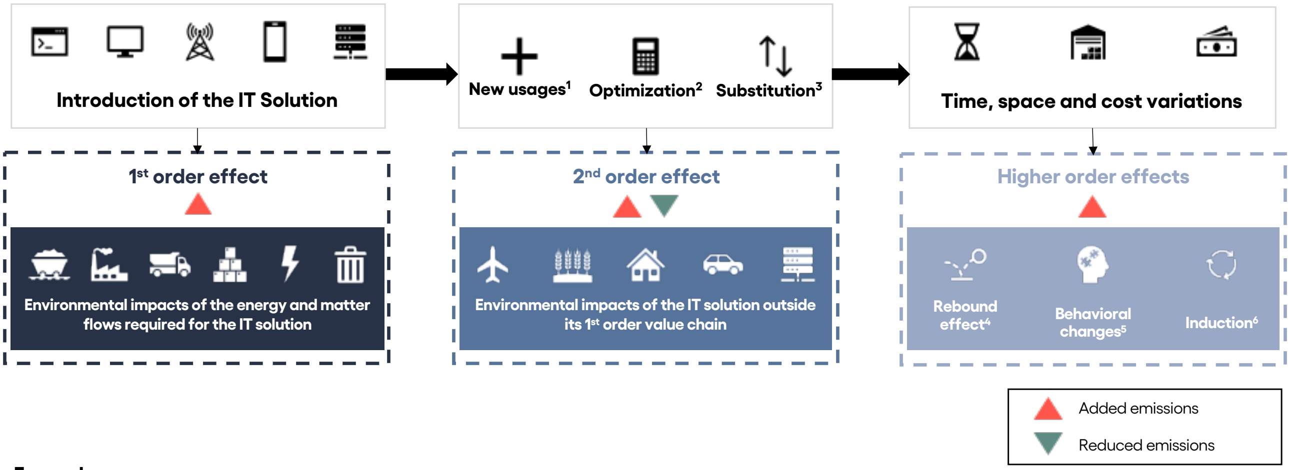
Induction: When an ICT application stimulates increased use of the application itself. *From ITU L-1480.*

Economy-wide rebound: Rebound effect where more efficiency drives economic productivity overall resulting in more economic growth and consumption at a macroeconomic level. *From ITU L-1480.*

IT definitions

IT Solution: A system encompassing IT goods, IT networks and/or IT services that contributes to meeting a technical, societal, or business challenge. *From ITU L-1480.*

Annex E - Illustration of an IT solution's overall effects



Examples

1. A flight cost comparison website can generate new usages – some people who weren't used to air travel will start using it.
2. Precision agriculture, smart buildings, carpooling apps can optimize resource consumption (water, electricity, costs, etc.) for a given usage.
3. Cloud solutions can replace an existing on-premise datacenter which gets decommissioned.
4. A certain activity costs less thanks to the ICT solution. The savings are used to increase the usage of said activity rather than keeping it at its previous level.
5. An app impacts a user's ways of thinking, changing how he/she spends time or money on goods/activities.
6. An online service rewards users for spending time on the service, which stimulates usage growth.

carbone4

Carbone 4 is the first independent consultancy specialised in low carbon strategy and adaptation to climate change.

Constantly on the lookout for low amplitude signals, we deploy a systemic view of the energy-climate issue and put all our rigour and creativity to work to transform our clients into leaders in the climate challenge.

Contact: contact@carbone4.com