Telefónica

Avoided emissions

METHODOLOGICAL FRAMEWORK

July 2025

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Glossary of acronyms

- **AR6:** Sixth Assessment Report of the Intergovernmental Panel on Climate Change
- **B2B:** Business-to-Business
- **B2C:** Business-to-Consumer
- **CO_2EQ:** Carbon Dioxide Equivalent
- **EV:** Electric Vehicle
- **GESI:** Global e-Sustainability Initiative
- **GHG:** Greenhouse Gas
- **GWP:** Global Warming Potential
- **GSMA:** GSM Association
- **ICT:** Information and Communication Technology
- **IPCC:** Intergovernmental Panel on Climate Change
- **IOT:** Internet of Things
- **ISO:** International Organization for Standardization
- **ITU:** International Telecommunication Union
- **KV:** Kilovolt
- **KWH:** Kilowatt-hour
- **LCA:** Life Cycle Assessment
- **LED:** Light-Emitting Diode
- **MB:** Megabyte
- **M2M:** Machine-to-Machine
- **NZI:** Net Zero Initiative
- **SBTI:** Science Based Targets initiative
- **SIM:** Subscriber Identity Module
- **TSO:** Transmission System Operator
- **W:** Watt
- **WBCSD:** World Business Council for Sustainable Development

1 Introduction

Telefónica Group is one of the world's leading telecommunications service providers, offering fixed and mobile connectivity services, as well as a wide range of digital services for individuals and businesses. It is present in Europe and Latin America, where it has around 390 million customers.

With the aim of creating, protecting and promoting fixed and mobile connections for its customers, Telefónica helps them to take control of their digital lives without losing sight of the fact that the most important connections are human ones, even though we live in a time when technology is more present than ever.

Telefónica Group is responsible for providing network infrastructure and connection capabilities to facilitate Business-to-Consumer (B2C) and Business-to-Business (B2B) communication in a wide range of applications with the capacity of changing people's everyday habits. In addition, the Group is also providing Machine-to-Machine (M2M) connections facilitating the deployment of the Internet-of-Things (IoT) communication through several solutions based on new technologies.

Previous studies carried out by other corporate entities and independent experts, such as "The Enablement Effect"[5] by GSMA or "Mobile carbon impact"[6] by GeSI identified that using this kind of connectivity solutions result in a net reduction in carbon emissions against a business-as-usual scenario. Telefónica has been working during the past years to address and quantify the net carbon impact attributable to the products and services provided. With this objective in mind, the company has prepared this document to detail the methodological framework developed for calculating its net carbon impact.

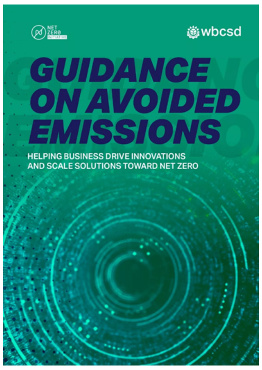
The objective of the company is to develop a solid and transparent method based on the already existing knowledge regarding the avoided emissions of digital solutions. The most relevant standards and recommendations on the subject have been identified and exhaustively reviewed, looking for harmonization with the state-of-the-art for the information and communication technology (ICT) sector.

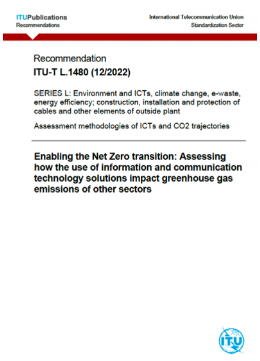
The next chapters detail the steps taken by Telefónica to evaluate the net carbon impact of its portfolio of digital services, from a company perspective. Chapter 2 contains an explanation of the main features of the methodological framework while, in chapter 3, the individual calculation of the avoided emissions by the different categories evaluated is detailed.

1.1. Main reference documents

As mentioned in the previous section, this framework has been carried out considering the already existing documentation applicable to avoided emissions of the ICT sector. After a first documentation review, two methodological documents have been selected as main references for the development of the current method.

These are "Guidance on avoided emissions: Helping business drive innovations and scale solutions toward Net Zero"[1] from the World Business Council for Sustainable Development (WBCSD) and the Recommendation "ITU-T L.1480 (12/2022) – "Enabling the Net Zero transition: Assessing how the use of information and communication technology solutions impact greenhouse gas emissions of other sectors"[2] from the International Telecommunication Union (ITU). It has been sought that an analysis performed with the methodological framework developed by Telefónica Group on this report, is fully compliant with the WBCSD´s requirements and partially compliant with the ITU's requirements. This partially compliance concept is one of the options contemplated in the Recommendation ITU-T L.1480.




ITUPublications
Recommendations

International Telecommunication Union
Standardization Sector

Recommendation
ITU-T L.1480 (12/2022)

SERIES L: Environment and ICTs, climate change, e-waste, energy efficiency; construction, installation and protection of cables and other elements of outside plant

Assessment methodologies of ICTs and CO2 trajectories

Enabling the Net Zero transition: Assessing how the use of information and communication technology solutions impact greenhouse gas emissions of other sectors

ITU

GUIDANCE ON AVOIDED EMISSIONS - WORLD BUSINESS COUNCIL FOR SUSTAINABLE DEVELOPMENT. Helping business drive innovations and scale solutions toward Net Zero

WBCSD and its member companies, in collaboration with the Net Zero Initiative (NZI) and an expert advisory group, set out to define a framework to consistently assess and account for the decarbonizing impact of companies' solutions, also known as avoided emissions. The guidance represents a critical step in incorporating avoided emissions into globally recognized carbon accounting standards.

As clearly defined in Net Zero target-setting frameworks, companies need to rapidly reduce their direct and indirect greenhouse gas (GHG) emissions to meet the goals of the Paris Agreement. As a result of the surge in sustainable solutions claims, there is a need to raise the bar of current avoided emissions claims to ensure their highest possible integrity and support businesses in making credible, consistent and transparent assessments and claims regarding avoided GHG emissions. It recognises that claims are currently being made in a less than credible way and seeks to standardise the calculation method to improve credibility.

RECOMMENDATION ITU-T L.1480 - INTERNATIONAL TELECOMMUNICATION UNION (ITU). Enabling the Net Zero transition: Assessing how the use of information and communication technology solutions impact greenhouse gas emissions of other sectors

This Recommendation provides a methodology for assessing how the use of ICT solutions impacts GHG emissions of other sectors. More specifically, the methodology provides guidance on the assessment of the use of ICT solutions covering the net second order effect (i.e., the resulting second order effect after accounting for emissions due to the first order effects of the ICT solution), and the higher order effects such as rebound effects. By providing a structured methodological approach, it aims to improve the consistency, transparency and comprehensiveness of assessments of how the use of ICT solutions impact GHG emissions over time.

Assessments may also declare themselves partially compliant to this Recommendation by complying to the majority of the requirements, if they are unable to fulfil all of them due to data gaps, a lack of transparency in databases, and so forth.

2 Methodological Framework

This report comprises a new evaluation method developed by Telefónica, aimed at identifying the GHG emissions avoided by the provision of a digital solution to its customers, in quantitative and objective terms. This method has been developed with the cooperation of the expert LCA consultancy company IK Ingenieria.

The main steps that need to be followed when analyzing a new solution are depicted in figure 1. First, the company and the solution eligibility are considered, in line with the three eligibility gates described in section 2.2. These three gates guarantee that the company is credible regarding its climate action, that the solution is aligned with the latest climate science and that its contribution towards climate change mitigation is legitimate.

Once the solution eligibility is proven, the solution scope and the reference scenario, to which it is to be compared, shall be defined. The reference scenario has to be the hypothetical situation in which the digital solution has not become operational, thus granting that the differential benefit being enabled by the digital solution is identified.

Following this, a consequence tree of the solution has to be created, identifying all the first, second, and higher order effects being triggered by the solution provision. Thinking about the digital service logic and identifying all the effects that happen around it, both negative and positive, is a key step to accurately define the solution's net carbon impact.

Finally, all those effects identified are evaluated at the solution level, obtaining an abatement factor for each user of this service of the company, which are, at the final stage, aggregated at the company level, considering the whole set of yearly users of the solution.

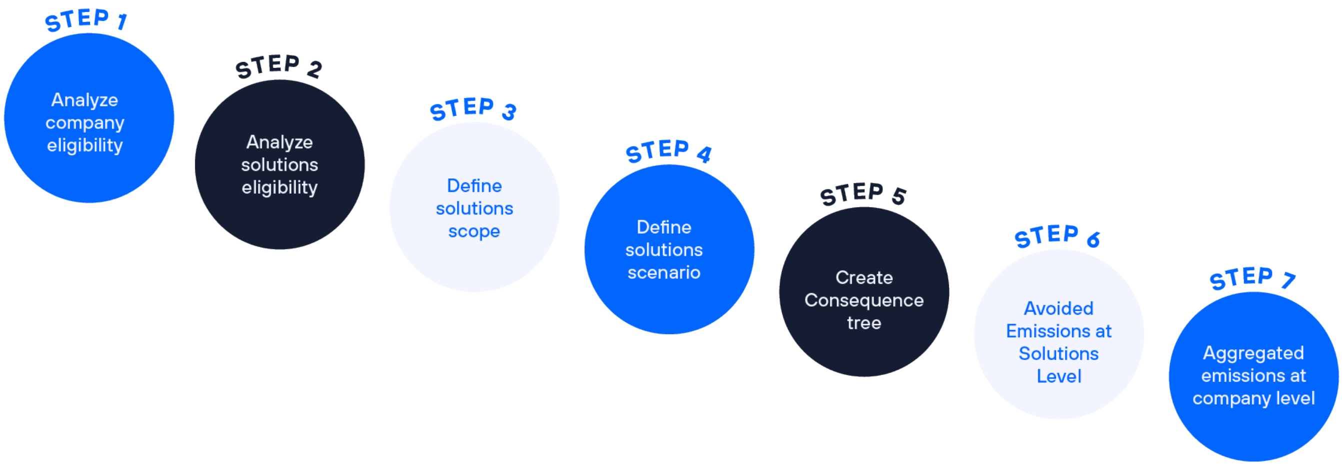


Figure 1.- The main steps of the methodological framework

This proposed approach is potentially applicable to any company service having an emission abatement potential. However, as the portfolio of solutions being currently provided by the Telefónica Group is quite extensive and the evaluation resources are limited, it has been decided to address first the most relevant solutions for the company, in order to have an overall picture of the emissions being avoided by the provision of these services. It is expected to have a growing list of evaluated services as the method evolves.

During the following sections, the evaluation procedure proposed in this methodological framework is explained, detailing the specific rules and recommendations to be followed when analyzing a certain digital solution from scratch.

2.1. DEFINITIONS

This document uses some terms that are previously defined elsewhere. All these terms are generally based on the two methodological reports mentioned in section 1.1 (Main reference documents), which are the Guidance on avoided emissions prepared by the World Business Council for Sustainable Development (WBCSD)[1] and the ITU-T L.1480 Recommendation[2] from the International Telecommunication Union. Also, there are additional references from the ISO 14040:2006[7], 14044:2006[8] and 14046:2014[9] standards from the International Organization for Standardization.

→ 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. [WBCSD]

→ LIFE CYCLE GHG EMISSIONS

The sum of GHG emissions resulting from all stages of the life cycle of a product. [WBCSD]

→ 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. [WBCSD]

→ ELIGIBILITY GATES

The three criteria (climate action credibility, latest climate science alignment and contribution legitimacy) that companies must abide by to be able to claim avoided emissions in line with the WBCSD guidance. [WBCSD]

→ ICT ENABLED SCENARIO

A situation with the studied ICT solution applied. ICT solution is a system encompassing ICT goods, ICT networks and/or ICT services that contributes to meeting a technical, societal or business challenge. [ITU-T L.1480]

→ REFERENCE SCENARIO

A reference case that represents the events or conditions most likely to occur in the absence of the assessed solution. 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. [WBCSD]

→ EMISSION FACTOR

A factor allowing GHG emissions to be estimated from a unit of available activity data (e.g., tonnes of fuel consumed, tonnes of product produced) and absolute GHG emissions. [ITU-T L.1480]

→ ENVIRONMENTAL IMPACT

Impact including positive and negative aspects on the environment. [ITU-T L.1480]

→ FUNCTIONAL UNIT

Quantified performance of a product system for use as a reference unit. [b-ISO 14040]

→ GLOBAL WARMING POTENTIAL (GWP)

Ratio of the warming of the atmosphere caused by one greenhouse gas to that caused by a similar mass of carbon dioxide. GWP is calculated over a specific time frame, generally 100 years. [ITU-T L.1480]

→ LIFE CYCLE

Consecutive and interlinked stages of a product system, from raw material acquisition or generation from natural resources to final disposal. [b-ISO 14040]

> *NOTE – Recommendation ITU L.1410 defines the life cycle of ICT goods, networks and services.*

→ LIFE CYCLE STAGE

One of several consecutive and interlinked stages of a product system. [ITU-T L.1480]

→ ICT GOODS

Tangible goods deriving from or making use of technologies devoted to or concerned with:

- the acquisition, storage, manipulation (including transformation), management, movement, control, display, switching, interchange, transmission or reception of a diversity of data;
- the development and use of the hardware, software, and procedures associated with this delivery; and
- the representation, transfer, interpretation, and processing of data among persons, places, and machines, noting that the meaning assigned to the data is preserved during these operations. [ITU-T L.1480]

→ PRIMARY DATA

Quantified value of a unit process or an activity obtained from a direct measurement, or a calculation based on direct measurements at its original source. [b-ISO 14046]

> *NOTE 1 – Primary data need not necessarily originate from the product system under study because primary data may relate to a different but comparable product system to that being studied.*

> *NOTE 2 – In practice, primary data may be emission factors and/or activity data.*

> *NOTE 3 – Primary data includes site-specific data, i.e., data from one specific unit process within a site; and site-average data, i.e., representative averages of site-specific data collected from organizations within the product system which operate equivalent processes.*

→ SECONDARY DATA

Data obtained from sources other than a direct measurement, or a calculation based on direct measurements at the original source. NOTE –

Such sources can include databases, published literature, national inventories and other generic sources. [b-ISO 14046]

→ **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. [ITU-T L.1480]

NOTE 1 – First order effects include GHG and other emissions, e-waste, use of hazardous substances and use of scarce, non-renewable resources.

NOTE 2 – First order effects are sometimes referred to as environmental footprints.

NOTE 3 – This definition has been amended from [ITU-T L.1410].

NOTE 4 – Recommendation ITU-T L.1480 only addresses GHG emissions.

→ **SECOND ORDER EFFECT**

The indirect impact created by the use and application of ICTs which includes changes of environmental load due to the use of ICTs that could be positive or negative. [ITU-T L.1480]

NOTE 1 – Second order effects can be either actual or potential.

NOTE 2 – This definition has been amended from [ITU-T L.1410].

→ **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. [ITU-T L.1480]

NOTE 1 – Rebound effects include effects occurring through financial gains, savings in time and space, and others.

NOTE 2 – Higher order effects could be associated with both second and first order effects.

NOTE 3 – This is amended from [ITU-T L.1410] where it is referred to as other effects and is also referred to as higher order effects in some academic literature.

→ **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. [WBCSD]

→ **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. [WBCSD]

2.2. COMPANY AND SOLUTION ELIGIBILITY

According to the “Guidance on avoided emissions”[1] from the WBCSD, not all claims regarding avoided emissions can be considered legitimate. To limit any misuse of avoided emissions, companies should first ensure their company and solution are eligible to make an avoided emissions claim by following three eligibility gates detailed in their guidance. This first eligibility check ensures the highest possible integrity of avoided emissions claims.

GATE 1 – CLIMATE ACTION CREDIBILITY

This gate considers the company eligibility scope and defends that the company must set and externally communicate a consistent climate change strategy in relation to the latest climate science, providing robust GHG footprint measurement and including science-based informed targets covering scopes 1, 2 and 3. Of course, reporting transparently all the progress on a regular basis is also a requirement to comply with this gate. Companies should not make avoided emissions claims without working on the reduction of the mentioned scopes in line with the latest climate science.

GATE 2 – LATEST CLIMATE SCIENCE ALIGNMENT

This gate aims to the solution eligibility scope and defends that the solution analyzed must have mitigation potential according to the latest climate science and recognized sources, being not directly applied to those activities which involve exploration, extraction, mining and/or production, distribution and sales of fossil fuels. To date, the latest climate science sources of information recognized by the WBCSD, are the IPCC Sixth Assessment Report (AR6)[3] and the EU Taxonomy.

GATE 3 – CONTRIBUTION LEGITIMACY

This gate aims to the solution eligibility scope and defends that the solution should have a direct and significant decarbonizing impact. A company should calculate and report on the system-wide emissions savings of the considered solution, justifying why the reduction is directly attributable to its solution and that the expected impact is significant.

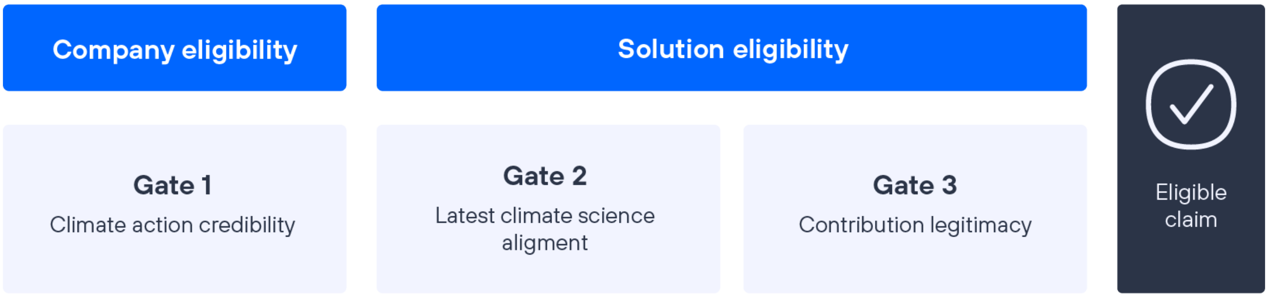


Figure 2. .- The three gates to ensure the eligibility of avoided emissions claims. Source: Guidance on avoided emissions by the WBCSD.

On these definitions, it is clear that the company is eligible for the gate 1 on climate action credibility. Telefónica measures on an annual basis its corporate carbon footprint, including in the calculation scopes 1, 2, and 3. The detail on these results, the reduction objectives and its annual evolution is disclosed in its corporate Climate Action Plan[4].

Figure 3 .- Telefónica's strategic decarbonization levers for the climate transition

The company's Executive Committee approved the global goal of achieving net zero emissions by 2040 across the value chain. To achieve this, Telefónica is committed to reducing emissions by 90% and neutralising residual emissions through the purchase of carbon removal credits, preferably through nature-based solutions.

These net zero emissions targets have been validated under the new Science Based Targets (SBTi) standard, going beyond the Paris Agreement. The established reduction targets are not only compatible with network expansion and service quality, but also help the company competitiveness.

In the Climate Action Plan, Telefónica details how they align the business model with the most ambitious scientific climate recommendations. In the Plan, GHG emissions are quantified, showing their SBTi validated targets and defining specific actions to achieve them, both for the company's activities and for the collaboration with customers and suppliers.

In the last eight years, Telefónica has already achieved to reduce 52.1% of its GHG emissions (84.8% of Scopes 1 and 2 since 2015 and 31.3% for Scope 3 since 2016).

About the specific solution´s perspective, for all Telefónica's solutions for which claims for avoided emissions are being made, the corresponding solution's mitigation potential is clearly identified and described in the solution-specific section called "Solution eligibility". This content can be found in the third chapter of this report and facilitates the determination of whether these assessments and claims are sound in the context of the company's overall portfolio. This analysis ensures compliance with Gate 2 – Latest Climate Science Alignment, by verifying that the solution aligns with recognized scientific sources, and Gate 3 – Contribution Legitimacy, by demonstrating that the solution has a direct and significant decarbonization impact.

2.3. DEFINITION OF THE SOLUTION SCOPE

The first step undertaken when trying to identify the avoided emissions by a digital solution, has to be to define the solution's scope. To define the boundaries of an ICT solution, the composition and associated processes of the items involved in deploying the solution shall be identified, considering all the stages of its entire life cycle. These stages generally entail raw material acquisition, production, transport, usage and end-of-life treatments. Within these life cycle stages, different aspects can be identified having a potential contribution towards the net carbon emissions of the solution itself.

Some examples of this could be the raw materials requirement or the manufacturing efforts for creating the new devices or components required to enable the solution or electricity/data transfer requirements during the use stage of the ICT goods or platforms. Apart from this, the evaluated digital solutions always have, at least, one enabling effect. This can be considered as the positive contribution of the solution towards the net GHG emissions. Note that one solution can have more than one enabling effect.

From the technological perspective, it is important to acknowledge how the solution works and if some additional items are also required for the proper implementation of its enabling effects, that are accordingly required to be included within the solution scope. It is paramount that the enabling effects accounted for the solution are only the ones being enabled by the technology addressed, meaning that positive effects coming from other technologies already implemented should not be accounted for.

From the time perspective, there are different approaches accepted in the relevant bibliography depending on the reference document consulted. This calculation framework promotes the year-on-year approach to quantify the avoided emissions, which is also commonly known as ex-post assessment. This means that the evaluation is conducted looking to an already past situation. This approach requires less estimates, given the fact that most of the information about the solution performance could already be available from the company registers at the end of the reporting year.

This approach also fits perfectly into the common yearly reporting basis of the general key performance indicators of the company. It has to be noted that the assessment is always hypothetical in the sense that either the ICT solution or the reference scenario is contrafactual as they cannot, by principle, exist at the same time[2].

It is also worth to be noted that the avoided emissions from the implantation of a certain digital solution also directly rely on the geographical scope considered when setting the solution's scope. This is logical, as many of the aspects that need to be evaluated, such as the energy utilities, the transport means or the use of the telecommunication networks, may have different environmental effects depending on the country on which they are consumed. Moreover, the activity data that defines the effects on the GHG emissions caused by the implementation of the solution, are also geographically dependent. Some examples about this are the number of users for a solution, or the data related to the customer behaviour in a certain country. Accordingly, the results of the solutions evaluated are split by relevant geographical scopes. The geographical scopes considered for each solution evaluated, are clearly defined when documenting the work done.

As it is explained in the "Guidance on avoided emissions" from the WBCSD[1], avoided emissions shall not be communicated externally, without specifying which percentage of the total company revenue the solutions generating those avoided emissions represent.

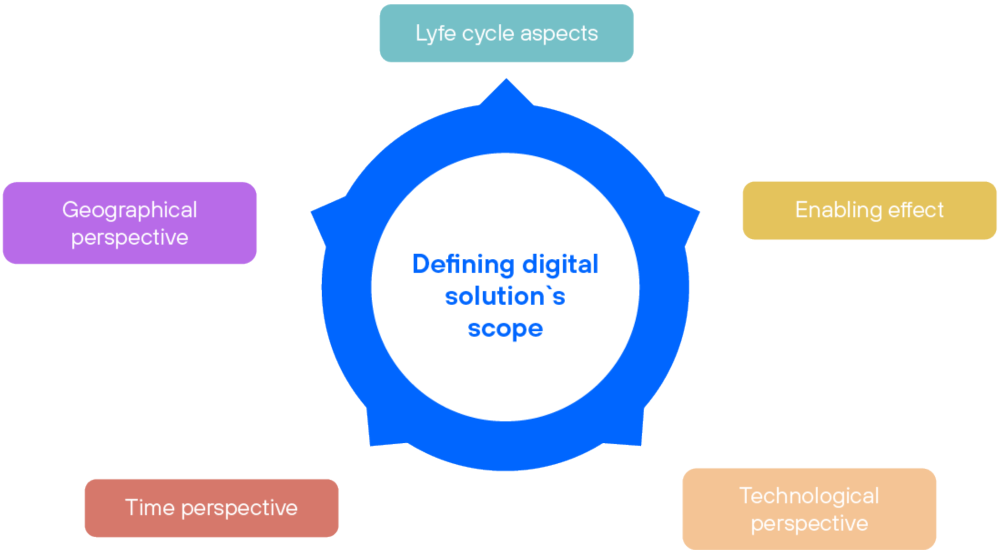


Figure 4 .- Defining digital solution's scope

2.3.1. FUNCTIONAL UNIT

The exercise of calculating the avoided emissions potential for a certain solution always involves comparing the solution itself with a baseline scenario. This scenario is a reference case representing the events or conditions most likely to occur in the absence of the assessed ICT solution. It is the scenario against which a solution is assessed, to determine its avoided emissions potential.

Consequently, the emissions calculation shall be consistent between this reference scenario and the ICT solution enabled scenario, for the comparison to be sound. To achieve this, using the same declared functional unit is a must when modelling both situations, allowing to calculate GHG emissions with equivalent scopes.

The functional unit is the reference which defines what precisely is being studied and quantifies the function being delivered by the product system. All the data collected for the materials procurement, manufacturing, distribution, installation, use, maintenance and end of life of the solution evaluated, are referred to this functional unit.

A digital solution is a broad concept. Therefore, from the methodological perspective it has been decided to reduce the functional unit to a clear concept, applicable to most of the potential comparative situations. In all the solutions evaluated using this methodology, the functional unit considered is:

To perform the function of the evaluated solution during a full-year period for one single connection

This functional unit can be applied consistently to multiple situations. For example, in a teleworking solution, the evaluation of 1 year provision of connectivity to a single home is assessed. In addition, the increased requirements of energy consumption at home for heating and cooling purposes is also analyzed, but always considering this same one-year period for a single connection. Conversely, compared to the reference situation without the teleworking capacity, the evaluation entails all the second and higher order effects related to the avoided commuting and the consolidation of physical offices. Higher order effects expected to occur in the future, like the one mentioned in this example, are always annualized, to reflect only the yearly share of those effects in the comparison performed.

For IoT based solutions, one single connection is related to a different concept, but using the same functional unit is meaningful. For example, in the fleet management solution, one single connection refers to just one vehicle being managed during a year by the solution. In any case, this reference is also easily applied to make a comparison with the reference case, in which the vehicles do not have this M2M connection in place and thus do not have the same efficiency in their routes.

In this way, the functional unit of the analysis is defined to be applicable both to the ICT solution enabled scenario and to the reference scenario. Additionally, the company shall use emission factors accounting for the solution's entire life cycle and not only for direct emissions related to the solution's operating phase.

Finally, using a functional unit associated to a single connection or user enables the company to determine a yearly carbon abatement factor for each enabling technology, which is easily upscaled towards the overall base of connections being provided by Telefónica to its customers for a one-year exercise. Thus, using this functional unit also facilitates the calculation of a total net carbon impact for each solution and the sum of total avoided emissions for the company itself.

2.3.2. CARBON IMPACT ATTRIBUTION

Any digital solution is generally enabled by the addition of different components that are commonly provided by different actors, contributing to a different extent to the outcome of the mentioned solution. The main contribution levels are described in a research paper by P. Bergmark, V. C. Coroamă et al[10] in the following three layers:

- **A-level:** The main ICT solution itself, which directly leads to an induced effect.
- **B-level:** Dedicated building blocks (equipment or software), developed specifically for the A-level service.
- **C-level:** General-purpose building blocks (equipment or software) required by the A-level service.

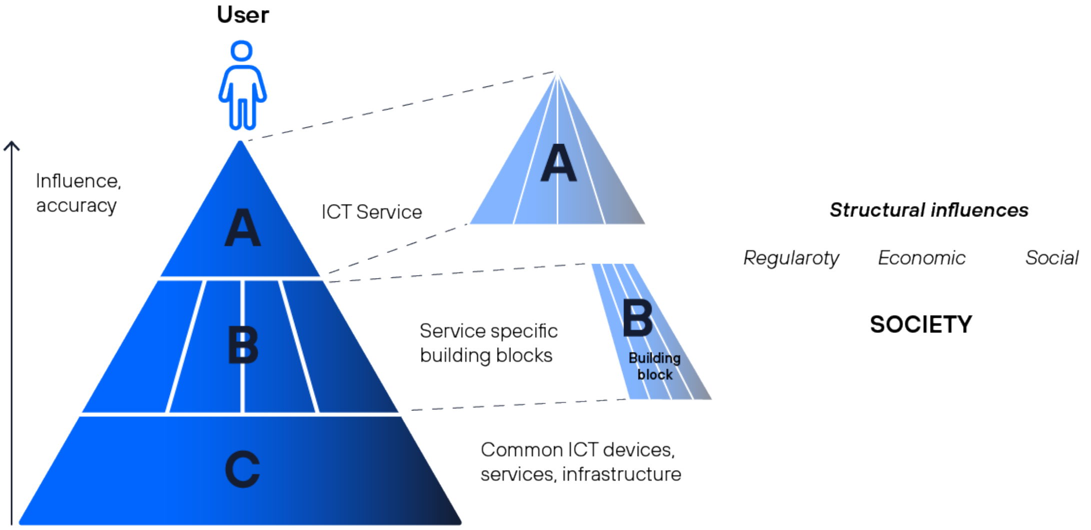


Figure 5 .- Contribution levels within a digital solution
Source: P. Bergmark, V. C. Coroamă et al[11]

This fact triggers a situation where the net carbon impact effect achieved by a digital solution can be claimed by different contributing actors. Therefore, an allocation or attribution procedure for the avoided emissions is required to avoid misleading results.

As stated in section 5.5.4 of the Guidance on Avoidance Emissions from the WBCSD[1], "no allocation of avoided GHG emissions should be pursued, as avoided GHG emissions should be quantified at the level of the enabled decarbonization effect of the considered solution. This approach does not entail that claims should be unique. Double counting may occur when two entities in the same value chain account for the avoided emissions from a single solution. Double counting avoided emissions between companies is considered acceptable because it is recognized that each entity within a value chain has different levels of influence over emissions and reductions."

On the other hand, ITU-T L.1480 Recommendation[2] considers the allocation between organizations in section 13.2, and has a full annex devoted to allocation between actors, namely Appendix V. In this document it is stated that "allocation between companies is complex and may involve several layers of contributions (including providers of generic and specific components, as well as the integrated solutions). Moreover, it may include several roles such as the innovator, the developer, the service owner and the operator. For the time being, such allocations are considered too challenging, meaning that the company shall make clear whether it contributes to a generic component, a specific component or the integrated solution, clarifying its role within the solution". In this standard, the "touch it and it's yours" principle is proposed, allowing to avoid doing any allocation.

Aligned with these references, Telefónica details its role in each calculated solution, considering the net carbon impact potential for each of them. This approach is based on the fact that, depending on the specific solution, the level of contribution or the role performed by Telefónica may be considered in different layers of the solution itself.

2.4. REFERENCE SCENARIO DEFINITION

Apart from the scope of the digital solution that is being analyzed, a reference scenario has to be defined to set the comparison allowing to calculate the avoided emissions. This reference scenario has to represent the events or conditions most likely to occur in the absence of the assessed digital solution. The baseline situation can be composed of several different activities, leading to delivering the same function to the customer than the digital solution itself. These activities can have a climate change associated potential or can be harmless. Besides, the potential can be positive or negative, but obviously, solutions displacing activities with high carbon emissions associated, have the highest carbon abatement potential.

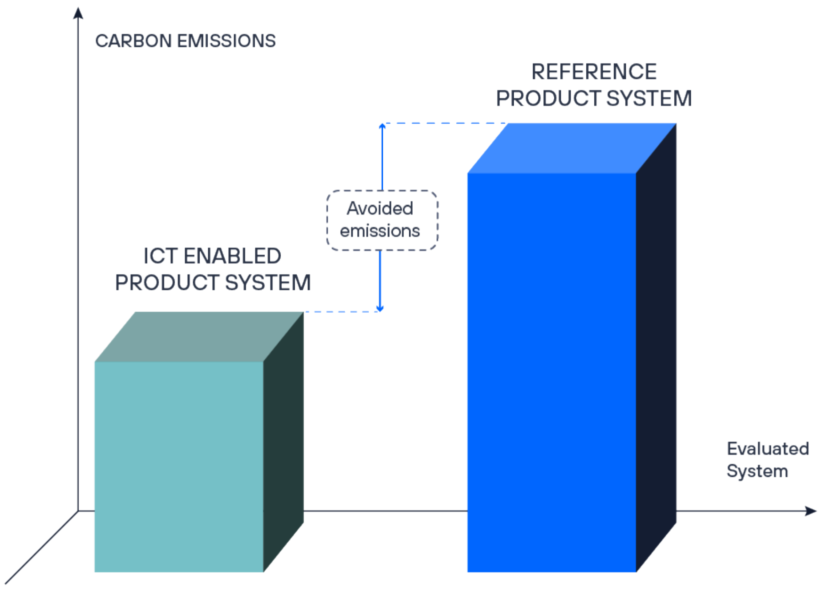


Figure 6 .- Reference scenario Vs ICT Enabled scenario

To define this hypothetical baseline situation, it is key to consider the same functional unit than the one defined for the ICT enabled situation. In this way, the environmental effects addressed for the reference scenario allow establishing a meaningful comparison towards the ICT enabled case in the same terms.

For example, when defining the reference scenario for a smart lighting digital solution, capable of gathering real-time data on the luminaire environment to take decisions on the illumination profile, the reference scenario has to exclude these smart capabilities but should include previous technological developments that are not linked to the new solution and are likely to be found in the market. In this example, the reference situation considers non-smart LED lamps, because the introduction of the LED technology is not linked to these smart capabilities of the digital solution assessed, and it is the technology most likely to be found nowadays. In the same way, the power of the lamp evaluated in the reference case has to be the same as the power considered for the ICT enabled case. Making the evaluation selecting different LED lamp powers for this example, would lead to a misleading comparison.

It has to be noted that the scope of the reference scenario shall be as similar as possible to the scope of the ICT enabled situation. Defining the baseline lays the groundwork to identify the different activities between both situations, which leads in the long term to calculating the avoided emissions. A broad understanding of the whole process is usually required to correctly identify these activities. It may be useful to think about the end user, to ascertain all the items involved in the reference situation. Note that there is no need to evaluate common first, second, or higher order effects that happen in both situations, because as it is planned to compare both scenarios, commons effects would not have any differential influence in the avoided emissions potential. In cases where several developments are equally likely, more than one reference scenario may be considered and mixed, if the analyst considers that this exercise reflects better the reality of the solution being evaluated. When modelling this mix of scenarios, a quantitative statistical approach has to be taken, if feasible.

2.5. DEFINITION OF A CONSEQUENCE TREE FOR THE SOLUTION

Calculating the emissions avoided by a digital solution implies comparing the carbon impacts caused by the solution to an alternative reference scenario, where this digital solution would not be in place. In this context, it is capital to identify the first, second, and higher order effects of the digital solution, allowing the identification of differences between the reference scenario and the ICT solution enabled scenario, in the long run that defines the extent of the emissions avoided.

A consequence tree is an analytical basis for identifying the whole set of effects induced as consequence of the deployment and use of the ICT solution. The use of this tool follows a systematic approach in which a deliberation on the digital solution is performed, identifying all the effects that directly or indirectly happen after its adoption. Each consequence that has a carbon effect has been included. These identified consequences are then classified as either first, second, or higher order effects, considering the directness of their effect, following these definitions.

→ FIRST ORDER EFFECTS

Effects related to the direct environmental consequences associated with the physical existence of the digital solution and its associated components, including hardware and software. This includes all the carbon impacts related with the different stages of the solution's life cycle, such as raw materials acquisition, production effort, energy consumption during use, transport or end-of-life treatment, among others. These are considered the direct impacts caused by the solution implementation.

→ SECOND ORDER EFFECTS

Effects outside the direct boundaries of the solution but related to the usage and application consequences of the digital solution. Carbon impacts related with any effect which can be either actual or potential, such as reduction of travel, transportation optimization or the shift to teleworking reducing office energy use, among others. Second order effects could be positive or negative towards the carbon emissions.

→ HIGHER ORDER EFFECTS

Effects associated with any change in the behaviour of the users and others affected in the mid and long-term. This includes indirect behavioural changes induced by the deployment and use of the ICT solution. These effects can also be positive or negative in terms of carbon impact.

After the identification step, the first, second, and higher order effects are divided into separate branches of a graphical representation, that summarises the process and facilitates understanding of the induced consequences by the solution being analyzed. The following figure shows a general example of this kind of plot.

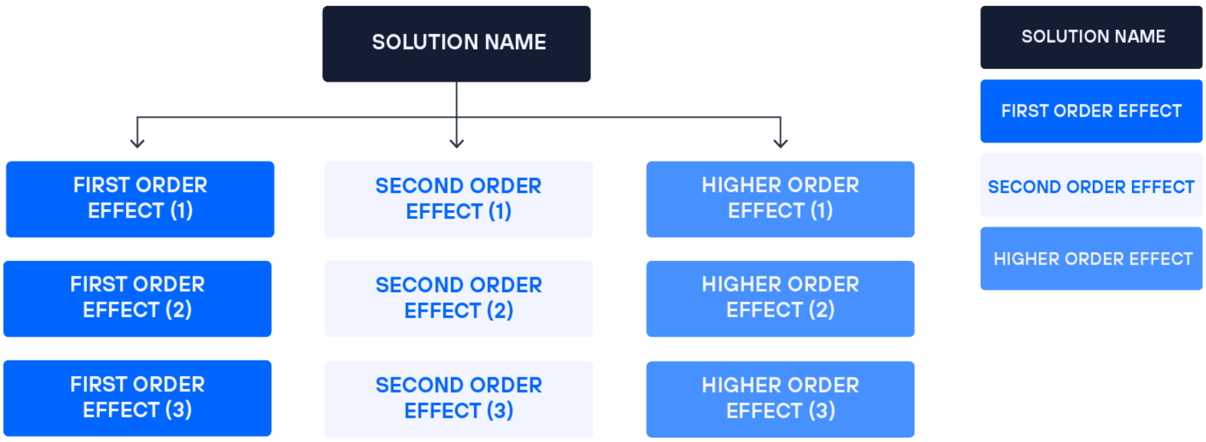


Figure 7 .- Example of a consequence tree example for a digital solution

The identification of effects may be an iterative process, and additional relevant effects may be identified during the assessment.

In section 3 of this document, several digital solutions deployed by the Telefónica Group are evaluated following this methodological framework. As mentioned in the Recommendation ITU-T L.14802, "In cases where the assessment involves several ICT solutions or ICT solution scenarios, these could be covered within the same or in separate consequence trees depending on what is practical", Telefónica Group has covered the evaluation of each of its digital solutions with a particular consequence tree, leading to at least one consequence tree per solution. The definition of these consequence trees is available in the specific "First, second, and higher order effects" chapter for each of the evaluated solutions.

2.6. CALCULATION APPROACH

Once the digital solution scope, the reference scenario and the consequence tree are defined, it is time to calculate the avoided emissions at the solution level. To achieve that goal, it is necessary to gather all the relevant information regarding the first, second, and higher order effects identified within the solution scope. This inventory completion stage can be time-consuming. As a general rule, the most specific high-quality data available on the scenarios has to be used, but it may be necessary to refer also to secondary sources when information on either the solution or the reference scenario is not available from these primary data sources.

Depending on the avoided emissions framework, different modelling approaches may be recommended. Some of them recommend the consequential approach for decision-making purposes but acknowledge the possibility of using the attributional approach as an interim approach if consequential data is not available.

The **consequential approach** focuses on assessing the environmental consequences of a specific decision or change. It aims to model what would happen in the system if the solution is implemented, including both direct and indirect effects —such as changes in behaviour, market responses, or technology shifts— that go beyond the immediate boundaries of the product or service.

In contrast, the **attributional approach** looks at describing the environmental profile of a product or service as it is, by quantifying the inputs and outputs directly associated with it within a defined system boundary. It does not aim to model broader changes or future scenarios, but rather provides a snapshot of current impacts based on average or specific data.

Other frameworks propose a hybrid approach where consequential thinking is used to define the reference and solution scenarios, and where the life cycle assessment of both follows an attributional approach[1]. This last one is the approach taken by Telefónica in the present framework.

As depicted in figure 7, the net avoided GHG emissions for a certain solution are calculated as the difference between the emissions in the reference scenario compared to the ICT-enabled one. To that purpose, starting from the reference scenario, the carbon emissions caused or avoided by each consequence tree effect need to be calculated. By the time the emissions of the individual effects from the tree have been calculated, the net avoided emissions are calculated using the following formula.

Net avoided emissions = Enabling effects – Solution emissions – Rebound effects

At the final stage of the assessment, when the unitary avoided emissions at the solution level have been calculated, considering the specific functional unit defined for the comparison, it is the time to sum up the aggregated enablement effect at the company level. This process results in the total CO_2eq emissions that the company helps to avoid, considering all the digital solutions evaluated during a full year period.

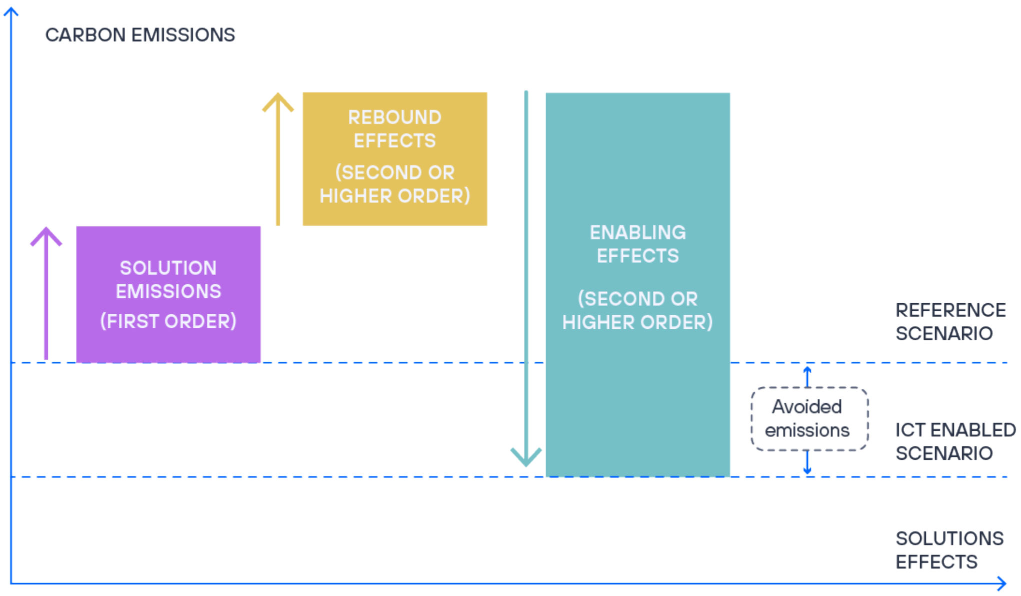


Figure 8 .- Net avoided emissions calculation approach for a digital solution

To do this, it is essential to identify the user base impacted or enabled by each ICT-based scenario during the assessment period. When aggregating emissions at the company level, it is also important to define appropriate functional units that allow for linking the per-unit avoided emissions with the company's total number of users or IoT connections. Without this, it would not be possible to accurately aggregate emissions at the company level.

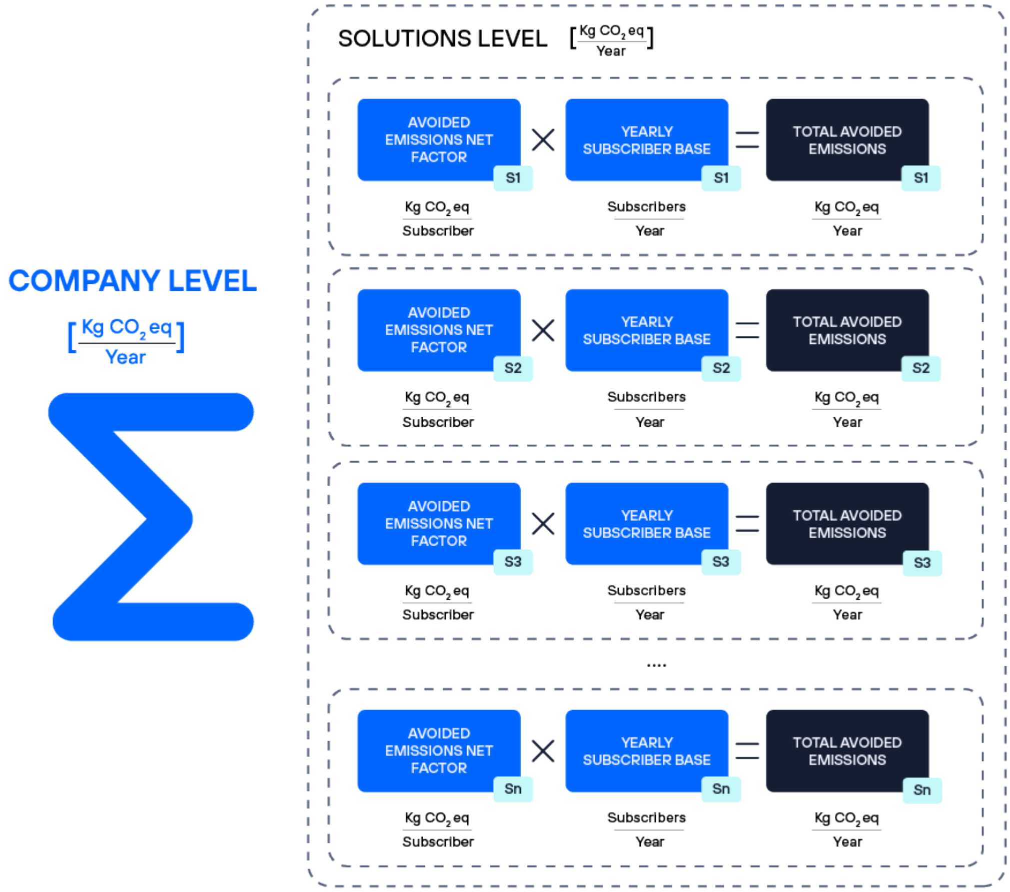


Figure 9 .- Emissions aggregation at the company level

It is, therefore, a good advice to consider the user perspective when selecting the functional unit for the analysis. In the IoT related digital solutions, it is sometimes more useful to define the functional unit considering the impact per connection, allowing to link the unitary impact to the total base of installed connections, which is usually the information known by the company about the solution deployment.

2.7. DATA QUALITY, SPECIFICITY AND UNCERTAINTY ASSESSMENT

In any kind of calculation method, the quality of the data used is directly related to the reliability of the outcome. Section 5.5.5 of the Guidance on Avoidance Emissions from the WBCSD[1] prioritizes the use of certain information sources recommending the use of direct measures, company's internal sources, supplier data, external studies conducted by credible organizations or regulations and standards. But it does not limit the use of any specific source.

Additionally, Recommendation ITU-T L.14802 proposes to perform a qualitative analysis of data quality, documenting the data sources and using different quality categories, primary data, secondary data and proxy data. In this method, the main data sources used when modelling the baseline and the ICT enabled scenarios for all the evaluated digital solutions are collected and classified in a dedicated section. This classification considers relevant attributes of the source, such as the quality of the source, the entity, the publication date, or the geographical validity.

The target is to achieve that the data points used are as higher quality level as possible, prioritizing primary and representative data when available, over lower quality data sources.

Regarding the uncertainty, the Guidance on Avoidance Emissions from the WBCSD[1], recommends including an uncertainty analysis in the final evaluation report, but it is not a compulsory requirement. In this method, a qualitative description of the uncertainty of the results, listing key assumptions and limitations associated with the calculation of the avoided emissions potential, is provided. The sensitivity of the results is directly related to the potential use of imprecise input data in the calculation model. Therefore, the uncertainty of the results is evaluated taking into consideration the influence of input data coming from low quality sources in the avoided emission results for each solution.

In addition to data quality and uncertainty, the WBCSD encourages the evaluation of the specificity level of the avoided emissions claim. For that purpose, the following scoring matrix is proposed, in which the specificity for both the reference scenario and the digital solution scenario are evaluated, achieving a score that could go from low to very high.

		Solutions (S)		
Reference scenario (R)	Specificity level	Solution Specific (1)	Company Specific (2)	Statistical (3)
	Solution Specific (1)	Very high	High	Medium-high
	Company Specific (2)	High	Medium	Medium-low
	Statistical (3)	Medium-high	Medium-low	Low

Figure 10 .- Specificity levels matrix for avoided emissions claims. Source: Guidance on Avoided emissions[1]

Please note that calculating a low specificity model is not necessarily bad, as specificity is not the same concept as quality. The choice of the level of specificity depends on the nature of the solution sold and on the objective pursued by the company through its calculations. Very high and high specific analyses are related to the evaluation of user specific situations. However, Telefónica is aiming to calculate the avoided emissions at the company level, combining the efficiencies for multiple users. Therefore, the solutions evaluated with this method, have mostly medium specificity level. In any case, the specificity of the avoided emissions model for each solution is disclosed in the "data quality, specificity and uncertainty" section of the evaluation.

The avoided emissions results calculated with this methodology for the fiscal year 2024 are 17.4 million tons of CO_2e, considering Spain, Brazil and

Germany, representing approximately 23% of the total revenues of the Company in these markets*.

The avoided emissions figure has also been reported in the Sustainability Report included in the Consolidated Management Report 2024 of Telefónica and verified by the third-party PricewaterhouseCoopers (PwC) under limited assurance in accordance with generally accepted professional standards.

* *The scope of this analysis differs from that of the Taxonomy report and is therefore not comparable. Differences in the scope of solutions, services, and included segments require a specific adaptation to each reporting methodology.*

3 SOLUTIONS PROVIDED BY TELEFÓNICA WITH POSITIVE NET CARBON IMPACT

Information and Communication Technologies (ICT), in essence, cover all the technologies enabling users to access, modify, transmit and use any kind of information in a digital format. These technologies are integrated in a lot of areas of vital relevance. All the potential uses and tools around this wide concept are known as ICT solutions or digital solutions, including but not limited to enabling communication between individuals, managing and analyzing data, facilitating decision-making processes or enhancing operational efficiency and business performance.

Telefónica is enabling the digital transformation of its B2B and B2C customers with a unique portfolio of solutions, answering to the different market needs. However, not the whole ecosystem of solutions provided by the company have direct influence towards the greenhouse gas emissions. Starting from the full portfolio, an identification of the most relevant solutions for the company has been required first. This identification of solutions is performed considering only the ones in which Telefónica is contributing with a key role. The relevance of the ICT solution towards the company and the materiality of their potential induced effects have been also considered during this selection process.

All the selected solutions have been evaluated from the "solution eligibility" perspective detailed in chapter 2.2, guaranteeing that each evaluated service complies with gate 2 (Latest climate science alignment) and gate 3 (Contribution legitimacy) within this procedure. More details about this selection are provided in the description of each solution that can be found in the next chapters.

This process leads to a list of services with notable potential and business relevance, making it particularly interesting for Telefónica to evaluate them from a quantitative point of view. This list of services is further described within the third chapter of the methodology. The set of selected solutions is broken down into two separate families, namely "Connected living solutions", related to facilitating the communication towards B2C clients and "Internet-of-Things", linked to specific solutions aimed at the B2B segment.

3.1. CONNECTED LIVING SOLUTIONS

Some habits and small gestures of our connected life can reduce the carbon impact throughout our lives. Routines that are being incorporated into our daily lives, sometimes without realizing it, thanks to combining connectivity and digital solutions.

Digitalization promoted by new technologies has proved to be an ally in tackling climate change. It boosts energy efficiency in industry and households and promotes a connected life with more sustainable habits, such as teleworking, online training, e-shopping or car-pooling, that help decarbonization. The connectivity provided by Telefónica is contributing to the digitization of companies, institutions and citizens and translates into new digital practices that drive sustainability.

This chapter focuses on connected living solutions that change people's habits, enabling them to generate less CO_2 emissions. It is worth mentioning that in the attempt of obtaining the soundest avoided emissions figures as possible, Telefónica conducted during the years 2022 and 2023 different surveys with its B2C clients, to identify the real use being performed by Telefónica's users on the evaluated connected living solutions. The outcome from these surveys is one of the main data points used when evaluating the connected living set of solutions, meaning that the enabling effect calculated is considering the real effect towards the company client's universe.

3.1.1. Teleworking

2020's pandemic transformed work environments through remote work. Although it has been a gradual return to in-office work in the wake of the health crisis, it is evident that teleworking has become more prevalent than before 2020, especially in hybrid models where people work from home a few days a week. The provision of connectivity by Telefónica, allow employees to work from home instead of travelling to their usual working place, reducing office commuting and the associated carbon emissions.

It is important to highlight that in this case Telefónica does not claim exclusive contribution to this digital solution. The company has the role of connectivity provider within this solution.

3.1.1.1. Solution eligibility

Teleworking is compliant with the solution eligibility proposed in section 2.2, as it is a capable service of having a direct and significant impact in the decarbonization process. In support of this affirmation, the Intergovernmental Panel on Climate Change (IPCC) in its Sixth Assessment Report (AR6)[3] make various references to how teleworking boosts this decarbonization mentioned above.

AR6 from the IPPC confirms that, within the transport sector, digitalization has facilitated teleworking, which has led to a decrease in travel demand. The shift towards a digital economy enables employees to perform their tasks and access information from remote locations.

Several case studies suggest that well-implemented teleworking policies can cut transport emissions by up to 20% in certain cases, though their overall impact on the entire transport system is unlikely to exceed 1%. Moreover, the IPCC report states that teleworking can reduce the per capita transport emissions by 0.3%.

3.1.1.2. Reference scenario definition and system boundaries

The reference scenario defined for the teleworking solution is a situation where the worker has to attend daily to its physical working place. In this situation, the worker is required to use a certain transport mode to travel the distance from his/her home to the company and return home daily, which is the main effect avoided by the teleworking solution.

For both the baseline and the ICT enabled situation, the functional unit considered is the following one:

One user working during a full-year period

The system boundaries of the reference scenario involve the user travelling to the working place back and forth using a vehicle that may vary from one user to another. The energy requirements to condition the temperature at the working place are not being included in the calculation, considering that this energy consumption is shared between many individuals. In big companies, the energy allocated per worker could be considered negligible compared to a home working case, in which the energy requirements get increased. In addition, leaving this effect out is a conservative situation towards the final avoided emissions calculation.

From a geographical perspective, the reference case has been set considering several countries, in which Telefónica has deployed this solution. These countries are Spain, Brazil and Germany.

3.1.1.3. First, second, and higher order effects of the solution

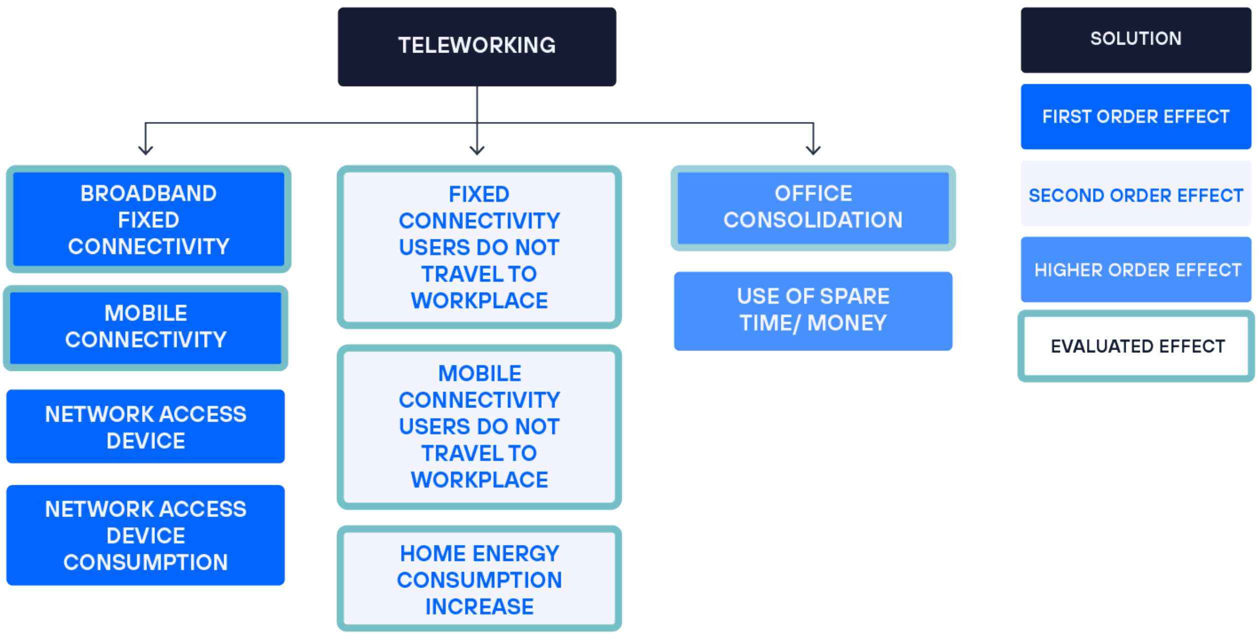


Figure 11 .- Teleworking solution consequence tree

Teleworking as a connected living solution has several environmental effects, which can be grouped into different levels that can go, according to the methodology, from first order effects to second and higher order effects. More details on this classification are explained in section 2.5 of this methodological report.

→ FIRST ORDER EFFECTS

- Broadband fixed connectivity: The users of this solution must have access to connectivity, to enable remote working from environments such as homes or commercial establishments. This first order effect corresponds to the impacts coming from the use of Telefónica’s fixed telecommunication networks, such as copper or fiber technologies.

- Mobile connectivity: Following the same logic, the users of this solution must have access to connectivity, to enable remote working from environments such as homes or commercial establishments. This first order effect corresponds to the impacts coming from the use of Telefónica's mobile telecommunication networks, such as 4G/5G technologies.

- Network access devices: In order to access the network, a specific device is always required to act as interface. This first order effect corresponds to the life cycle impacts (manufacturing, transport, end-of-life) associated to smartphones, personal computers or similar devices. This effect has not been quantified for this solution as it has been considered that users would already own this kind of interface devices in the reference situation.

- Network access devices consumption: In order to access the network, a specific device is always required to act as interface. This first order effect corresponds to the electricity consumption associated to smartphones, personal computers or similar devices. This effect has not been quantified for this solution, as it has been considered that users would already be using these devices in the reference situation.

→ SECOND ORDER EFFECTS

-Fixed connectivity users do not travel to workplace: The users of the fixed connectivity to access this digital solution are exempt from using any mode of transport to travel to their workplace. Travel related emissions are consequently reduced, which is the main avoided effect.

- Mobile connectivity users do not travel to workplace: The users of the mobile connectivity to access this digital solution are exempt from using any mode of transport to travel to their workplace. Travel related emissions are consequently reduced, which is the main avoided effect.

- Home energy consumption increase: All the users of the teleworking solution spend more time at home compared to the reference scenario, increasing their home temperature conditioning requirements. This results in an increase of the consumption of energy utilities, such as electricity or natural gas, increasing GHG emissions accordingly.

→ HIGHER ORDER EFFECTS

- Office consolidation: The normalization of teleworking can be expected to trigger a different mindset in company management strategies. Fewer office requirements would lead to office consolidation in the long-term, generating a reduction of, for example, the thermal conditioning or lighting requirements at the workplace. This effect not only considers closing physical offices as a whole, but also flexible approaches of using the office space, such as hot-desking. In this office space management approach, individual employees are not permanently assigned to a desk or office, which can reduce the total number of workplaces being a determinant factor towards overall office energy consumption[11].

- Use of spare time/money: Teleworking is an example of increased efficiency service, where the solution optimizes time and costs due to a direct lower travel requirement. Associated to this effect, customers can use their spare time and money to perform other activities, which can generate associated emissions reducing the avoided emissions of the ICT enabled scenario. This effect has not been quantified for this solution, as it is difficult to narrow the activities most likely to be performed by the users with their newly acquired spare time or money. As this directly depends on personal decisions of the user, there is not enough evidence to evaluate from a quantitative perspective if the effects caused by this higher order effect could be positive or negative from a climate change perspective.

3.1.1.4. Calculation logic

The avoided emissions logic for this solution is calculated according to the following diagram. The first group of effects have a positive contribution, avoiding emissions, while the second group contains effects generating additional GHG emissions compared to the baseline scenario.

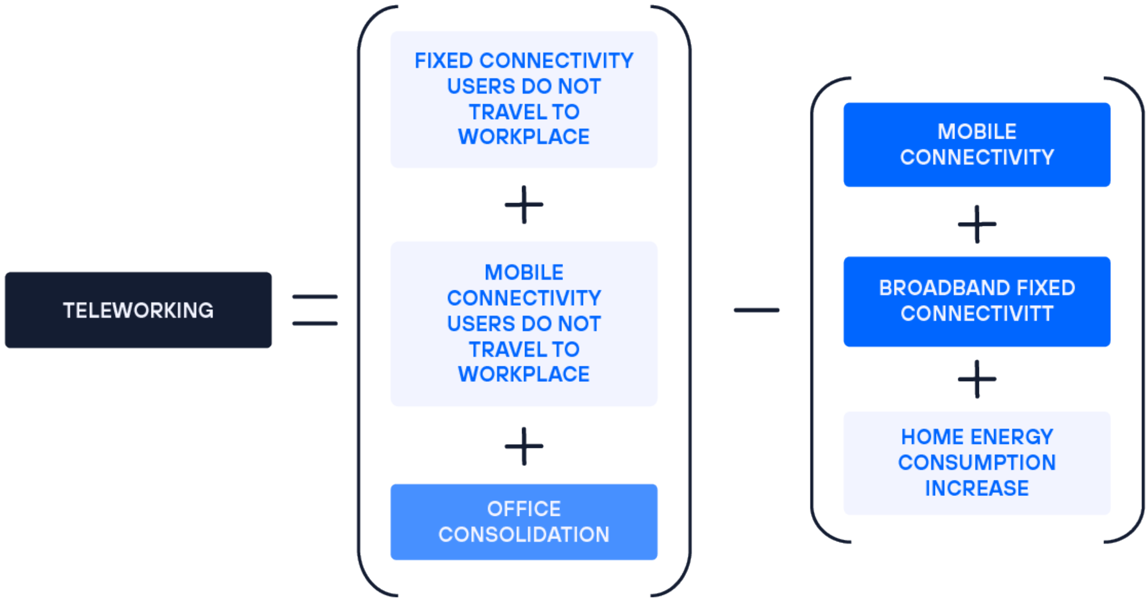


Figure 12 .- Calculation logic for teleworking solution

3.1.1.5. Data quality, specificity and uncertainty

The main sources of information for each data item used to create the evaluation model for this solution are contained in the following table, where an evaluation of the source quality is performed.

DATA ITEM	DATA SOURCE	SOURCE QUALITY	REFERENCE YEAR	GEOGRAPHICAL SCOPE
Telefónica's B2C Broadband fixed connections	Telefónica – Yearly activity data	Primary	2024	Country specific
Telefónica's B2C Mobile connections	Telefónica – Yearly activity data	Primary	2024	Country specific
Post-paid (contract) B2C mobile connections	Telefónica – Yearly activity data	Primary	2024	Country specific
Smartphones in the active mobile connections	Telefónica – Yearly activity data	Primary	2024	Country specific
Broadband fixed access emission factor	Telefónica - ITC networks LCA	Primary	2022	Country specific
Mobile access emission factor	Telefónica - ITC networks LCA	Primary	2022	Country specific
Share of fixed connections using connectivity for teleworking	Telefónica – Survey to customers on connected living habits	Primary	2022-2023	Country specific
Share of mobile connections using connectivity for teleworking	Telefónica – Survey to customers on connected living habits	Primary	2022-2023	Country specific
Total number of people working simultaneously from home (only fixed)	Telefónica – Survey to customers on connected living habits	Primary	2022-2023	Country specific

DATA ITEM	DATA SOURCE	SOURCE QUALITY	REFERENCE YEAR	GEOGRAPHICAL SCOPE
Average days per year working from home - fixed connection	Telefónica – Survey to customers on connected living habits	Primary	2022-2023	Country specific
Average days per year working from home - mobile connection	Telefónica – Survey to customers on connected living habits	Primary	2022-2023	Country specific
Average distance to workplace (round trip)	Telefónica – Survey to customers on connected living habits	Primary	2022-2023	Country specific
Average transport emission factor	IDAE - Instituto para la diversificación y el ahorro de la energía // DEFRA - UK Government GHG Conversion Factors for Company Reporting // Ferramenta do Programa Brasileiro GHG Protocol // Umwelt Bundesamt - Vergleich der durchschnittlichen emissionen einzelner verkehrsmittel des linien und individualverkehrs im personenverkehr in Deutschland	Secondary	2024	Country specific
Additional energy consumption per household when WFH	DEFRA - UK Government GHG Conversion Factors for Company Reporting // Eurostat // Ecoact - Homeworking whitepaper	Secondary	2018-2024	Country specific
Electricity mix emission factors	Emission factors used by Telefónica in its 2023 corporate CF calculation // REE // MCTI // STR // DEFRA	Secondary	2023-2024	Country specific

DATA ITEM	DATA SOURCE	SOURCE QUALITY	REFERENCE YEAR	GEOGRAPHICAL SCOPE
Carbon impact related to office space	ADEME - Etude sur la caracterisation des effets rebond induits par le teletravail	Proxy	2020	France
Expected long-term office space reduction	McKinsey Global Institute - Empty spaces and hybrid places: The pandemic's lasting impact on real state	Proxy	2023	European
Average workstation size	Cushman & Wakefield - Office space across the world.	Proxy	2017	Country specific

Tabla 1.- Teleworking - Data quality evaluation

From the uncertainty perspective, associated to the data quality used for this solution, there are only three data sources with "proxy" quality, which have a slightly lower data quality than the rest. All of these sources have been used to calculate the office consolidation higher order effect, which accounts to less than 4% of the total calculated avoided emissions for this solution, in all the evaluated countries. Therefore, it can be stated that the expected avoided emission results uncertainty is presumably low as these low-quality data are only related to a minor effect, so no further analysis is necessary.

The secondary sources used are mostly recent and coming from credible organizations such as the different public organisms publishing the transport related emission factors for each country, or Eurostat to calculate the additional energy consumption per household.

Main additional assumptions are:

- No heating is considered in Brazil for home conditioning.

- 8-hours working day assumed.

- Only 182 out of 365 days are considered to require home heating, according to the homeworking whitepaper.

- Only 122 out of 365 days are considered to require home cooling, according to the homeworking whitepaper.

- Broadband fixed access emission factor is calculated as a weighted average of the different fixed network impacts available at Telefónica. This includes fiber and copper technologies. The weighting is made considering the real penetration for both technologies on each evaluated country.

The analysis of the model created for this solution has medium specificity level, according to the specificity evaluation matrix.

	DIGITAL SOLUTION			
REFERENCE SCENARIO	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

Tabla 2.- Teleworking - Specificity of the solution

3.1.2. PUBLIC TRANSPORT APPLICATIONS

Use of public transport applications concerns the use of public transport availability information providing systems by individuals, increasing their use of public transportation systems over private transportation methods. Public transport apps tell you the optimal route to get from one point to another and show you in real time how much time is left for your bus/train to pass-by or what kind of incidents may appear in the different transport networks. These facilities encourage citizens to use these sustainable modes of transport, compared to using their more polluting private vehicles such as internal combustion-based cars. Telefónica's connectivity allows clients to access to text or app-based real-time information about public transport services.

It is important to highlight that, in this case, Telefónica does not claim exclusive contribution to this digital solution. The company has the role of connectivity provider within this solution.

3.1.2.1. Solution eligibility

The use of public transport applications is compliant with the solution eligibility proposed in section 2.2, as it is a capable service in having a direct and significant impact in the decarbonization process. In support of this affirmation, the Intergovernmental Panel on Climate Change (IPCC) in its Sixth Assessment Report (AR6)[3] make various references to how using public transport boosts this decarbonization mentioned above.

First, the IPCC report confirms that the use of public transport not only contributes to the reduction of GHG emissions, which is crucial in the fight against climate change, but can also have a significant impact on public health benefits. By reducing the number of private vehicles on the road, public transportation helps lower air pollution levels, decreasing the risks of different diseases.

More specifically, the case studies demonstrate that, focusing on emissions related to transportation, increased use of public transport could reduce emissions per capita by 0.7%. This reduction is particularly important in urban areas, where transportation is a major contributor to overall GHG emissions.

3.1.2.2 Reference scenario definition and system boundaries

The reference scenario defined for the use of public transport APPs solution is a situation where the user does not have access to online public transport applications, facilitating finding information about optimal routes, costs, ticket booking, time schedules or other kind of useful data encouraging the use of public transport networks, over its own transport mode to cover a certain distance.

In this situation, Telefónica's users would not be encouraged in the same way to use the public transport as the users in the ICT enabled scenario. In this reference scenario, the carbon emissions avoided through the usage of public transport services thanks to the apps, facilitated by Telefónica's connectivity, do not take place.

For both the baseline and the ICT enabled situation, the functional unit considered is the following one:

One user using public transport means during a full-year period

The system boundaries of the reference scenario involve the user making all his/her travels during a full-year period without having access to online information services that facilitate the use of public transport. Note that in the reference situation, the user would also use the public transport networks to a certain extent, as the access to these services is not limited to the users of public transport applications. Only the effect of the increased public transport use is considered in the avoided emissions calculation.

From a geographical perspective, the reference case has been set considering several countries, in which Telefónica has deployed this solution. These countries are Spain, Brazil and Germany.

3.1.2.3. First, second, and higher order effects of the solution

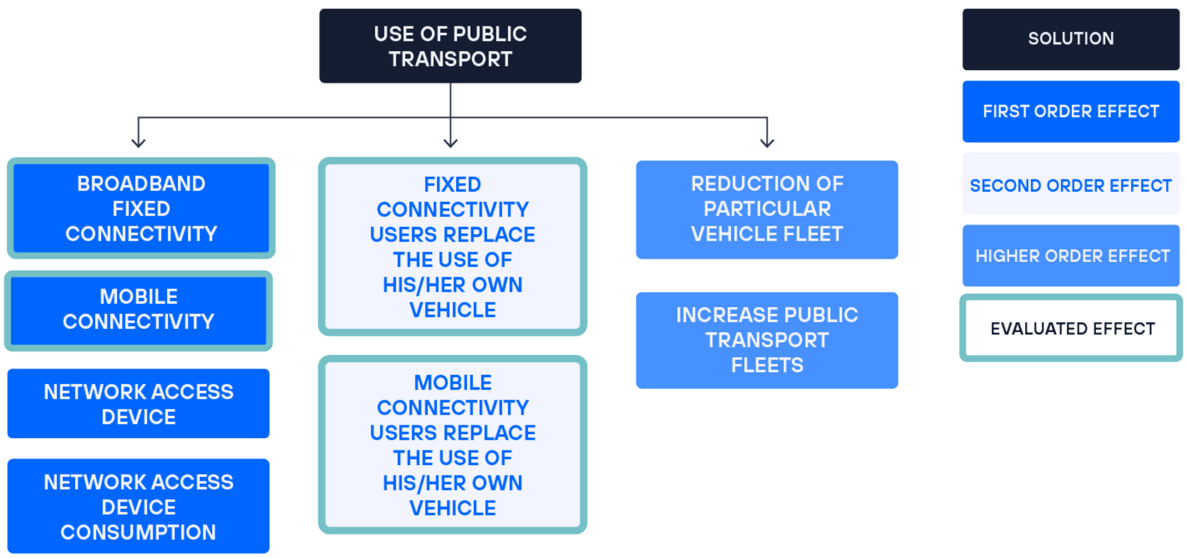


Figure 13.- Use of public transport solution consequence tree

Use of public transport applications as a connected living solution has several environmental effects, which can be grouped into different levels that can go, according to the methodology, from first order effects to second and higher order effects. More details on this classification are explained in section 2.5 of this methodological report.

→ FIRST ORDER EFFECTS

- Broadband fixed connectivity: The users of this solution must have access to connectivity, to enable the use of the public transport applications. This first order effect corresponds to the impacts coming from the use of Telefónica's fixed telecommunication networks, such as copper or fiber technologies.

- Mobile connectivity: Following the same logic, the users of this solution must have access to connectivity, to enable the use of the public transport applications. This first order effect corresponds to the impacts coming from the use of Telefónica's mobile telecommunication networks, such as 4G/5G technologies.

- Network access devices: In order to access the network, a specific device is always required to act as interface. This first order effect corresponds to the life cycle impacts (manufacturing, transport, end-of-life), associated to smartphones, personal computers or similar devices. This effect has not been quantified for this solution, as it has been considered that users would already own this kind of interface devices in the reference situation.

- Network access devices consumption: In order to access the network, a specific device is always required to act as interface. This first order effect corresponds to the electricity consumption associated to smartphones, personal computers or similar devices. This effect has not been quantified for this solution, as it has been considered that users would already be using these devices in the reference situation.

→ SECOND ORDER EFFECTS

- Fixed connectivity users replace the use of their own vehicle: The users of the fixed connectivity to access this digital solution replace the use of their own vehicles towards public transport, which in most cases is a more sustainable way of travelling. Travel related emissions are consequently reduced, which is the main avoided effect.

- Mobile connectivity users replace the use of their own vehicle: The users of the mobile connectivity to access this digital solution, replace the use of their own vehicles towards public transport, which in most cases is a more sustainable way of travelling. Travel related emissions are consequently reduced, which is the main avoided effect.

→ HIGHER ORDER EFFECTS

- Reduction of particular vehicle fleet: If the use of public transport is encouraged and facilitated, some users may conclude that owning a car is no longer required. This potential reduction of vehicle fleets may lead to a reduction in the resource consumption due to avoiding the production of new cars. Note that this effect has not been quantified for this solution, due to lack of quantitative information about this future outcome.

- Increase public transport facilities: In the same way as happens in the previously explained higher order effect, the potential increase in the use of public transport may have a direct impact on the need to increase the volume of public transport fleets. Due to a lack of quantitative evidence on the potential relationship between public transport APPs use and the increased requirement of public transport facilities this effect has not been considered in this analysis.

3.1.2.4. Calculation logic

The avoided emissions logic for this solution is calculated according to the following diagram. The first group of effects have a positive contribution, avoiding emissions, while the second group contains effects generating additional GHG emissions compared to the baseline scenario.

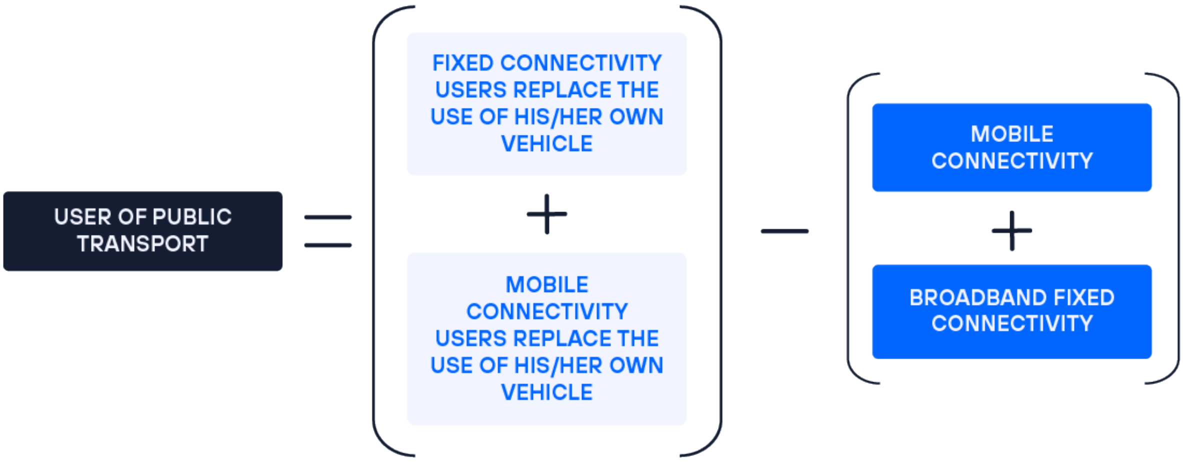


Figure 14.- Calculation logic for use of public transport solution

3.1.2.5. Data quality, specificity and uncertainty

The main sources of information for each data item used to create the evaluation model for this solution are contained in the following table, where an evaluation of the source quality is performed.

DATA ITEM	DATA SOURCE	SOURCE QUALITY	REFERENCE YEAR	GEOGRAPHICAL SCOPE
Telefónica's B2C Broadband fixed connections	Telefónica – Yearly activity data	Primary	2024	Country specific
Telefónica's B2C Mobile connections	Telefónica – Yearly activity data	Primary	2024	Country specific
Post-paid (contract) B2C mobile connections	Telefónica – Yearly activity data	Primary	2024	Country specific
Smartphones in the active mobile connections	Telefónica – Yearly activity data	Primary	2024	Country specific

DATA ITEM	DATA SOURCE	SOURCE QUALITY	REFERENCE YEAR	GEOGRAPHICAL SCOPE
Broadband fixed access emission factor	Telefónica - ITC networks LCA	Primary	2022	Country specific
Mobile access emission factor	Telefónica - ITC networks LCA	Primary	2022	Country specific
Share of fixed connections using connectivity for teleworking	Telefónica – Survey to customers on connected living habits	Primary	2022-2023	Country specific
Share of mobile connections using connectivity for teleworking	Telefónica – Survey to customers on connected living habits	Primary	2022-2023	Country specific
Average public transport journey length	Telefónica – Survey to customers on connected living habits	Primary	2022-2023	Country specific
Weekly trips by public transport	Telefónica – Survey to customers on connected living habits	Primary	2022-2023	Country specific
Times that user decides to use public transport due to using apps	Telefónica – Survey to customers on connected living habits	Primary	2022-2023	Country specific
Mode of public transport more likely used	Telefónica – Survey to customers on connected living habits	Primary	2022-2023	Country specific
Mode of transport more likely used if public transport is not chosen	Telefónica – Survey to customers on connected living habits	Primary	2022-2023	Country specific

DATA ITEM	DATA SOURCE	SOURCE QUALITY	REFERENCE YEAR	GEOGRAPHICAL SCOPE
Average transport emission factors	IDAE - Instituto para la diversificación y el ahorro de la energía // DEFRA - UK Government GHG Conversion Factors for Company Reporting // Ferramenta do Programa Brasileiro GHG Protocol // Umwelt Bundesamt - Vergleich der durchschnittlichen emissionen einzelner verkehrsmittel des linien und individualverkehrs im personenverkehr in Deutschland	Secondary	2024	Country specific

Tabla 3 .- Use of public transport - Data quality evaluation

From the uncertainty perspective associated to the data quality used for this solution, there are no data sources with "proxy" quality. Therefore, it can be stated that the expected avoided emission results uncertainty is presumably very low, as all the effects are related to high quality data, so no further analysis is necessary.

The secondary sources used are mostly recent and coming from credible organizations such as the different public organisms publishing the transport related emission factors for each country.

Main additional assumptions are:

- 47 weeks yearly using public transport in a regular basis. This is calculated as 52 weeks per year minus 5 weeks of vacation, on which it is understood that the overall behaviour towards the public transport use is not the usual one at the usual place of residence.

- Broadband fixed access emission factor is calculated as a weighted average of the different fixed network impacts available at Telefónica. This includes fiber and copper technologies. The weighting has been made considering the real penetration for both technologies on each evaluated country.

The analysis of the model created for this solution has medium specificity level, according to the specificity evaluation matrix.

		DIGITAL SOLUTION		
REFERENCE SCENARIO	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

Tabla 4 .- Use of public transport - Specificity of the solution

3.1.3. E-learning

It is no longer necessary to travel to a university or school to study a specialization course or even a full university degree. Digital connectivity facilitates access to education without leaving home through online training. This service, in addition to helping to reconcile work, family and any personal circumstance, facilitates the access to learning and saves carbon emissions by avoiding commuting. As happened in the case of teleworking, increased energy consumption caused by the individual use of heating or air conditioning at home must be taken into account.

It is important to highlight that in this case Telefónica does not claim exclusive contribution to this digital solution. The company has the role of connectivity provider within this solution.

3.1.3.1. Solution eligibility

E-learning is compliant with the solution eligibility proposed in section 2.2, as it is a capable service in having a direct and significant impact in the decarbonization process. In support of this affirmation, the Intergovernmental Panel on Climate Change (IPCC) in its Sixth Assessment Report (AR6)[3] make various references to how e-learning boosts this decarbonization indicated above.

The sixth IPCC report mentions that the lockdowns due to COVID-19 led to a 5.8% reduction in CO_2 emissions from 2019 to 2020. One of the factors contributing to this reduction is energy consumption, as the decrease in demand across various sectors, such as teleworking and e-learning, resulted in a decline in emissions from the transportation sector.Specifically, the IPCC confirms that e-learning has a significantly positive impact on parameters related to health, air quality, energy and mobility.

3.1.3.2. Reference scenario definition and system boundaries

The reference scenario defined for the e-learning solution is a situation where the student has to attend, in a regular basis, to a physical learning place. In this situation, the student is required to use a certain transport mode to travel the distance between home and the learning place. This situation happens the number of days the learning course lasts weekly, which is the main effect avoided by the e-learning solution.

For both the baseline and the ICT enabled situation, the functional unit considered is the following one:

One user learning during a full-year period

The system boundaries of the reference scenario involve the user travelling to the learning place back and forth using a vehicle that may vary from one user to another. The energy requirements to condition the temperature at the learning place are not being included in the calculation, considering that this energy consumption is shared between many individuals. In most of the learning places, the energy allocated per student could be considered negligible compared to a home learning case, in which the energy requirements get increased. In addition, excluding this effect is a conservative situation towards the final avoided emissions calculation.

From a geographical perspective, the reference case is set considering several countries, in which Telefónica has deployed this solution. These countries are Spain, Brazil and Germany.

3.1.3.3. First, second, and higher order effects of the solution

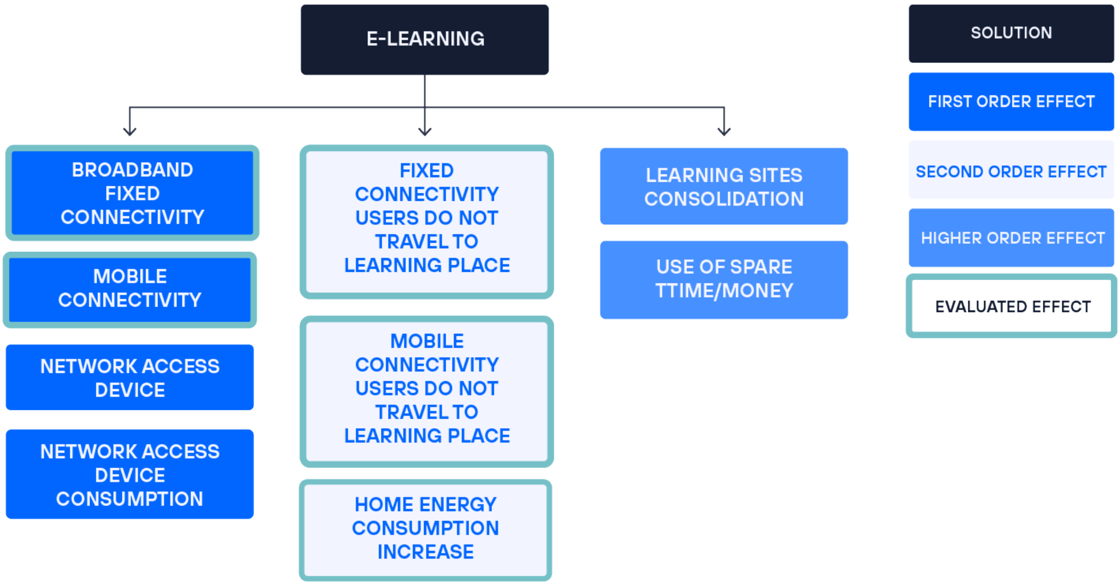


Figure 15.- E-learning solution consequence tree

E-learning as a connected living solution has several environmental effects, which can be grouped into different levels that can go, according to the methodology, from first order effects to second and higher order effects. More details on this classification are explained in section 2.5 of this methodological report.

→ FIRST ORDER EFFECTS

- Broadband fixed connectivity: The users of this solution must have access to connectivity, to enable remote learning from environments such as homes, offices or classrooms. This first order effect corresponds to the impacts coming from the use of Telefónica's fixed telecommunication networks, such as copper or fiber technologies.

- Mobile connectivity: Following the same logic, the users of this solution must have access to connectivity, to enable remote learning from environments such as homes, offices or classrooms. This first order effect corresponds to the impacts coming from the use of Telefónica's mobile telecommunication networks, such as 4G/5G technologies.

- Network access devices: In order to access the network, a specific device is always required to act as interface. This first order effect corresponds to the life cycle impacts (manufacturing, transport, end-of-life), associated to smartphones, personal computers or similar devices. This effect has not been quantified for this solution, as it has been considered that users would already own this kind of interface devices in the reference situation.

- Network access devices consumption: In order to access the network, a specific device is always required to act as interface. This first order effect corresponds to the electricity consumption associated to smartphones, personal computers or similar devices. This effect has not been quantified for this solution, as it has been considered that users would already be using these devices methodology in the reference situation.

→ SECOND ORDER EFFECTS

- Fixed connectivity users do not travel to learning place: The users of the fixed connectivity to access this digital solution are exempt from using any vehicle to travel to their learning place. Travel related emissions are consequently reduced, which is the main avoided effect.

- Mobile connectivity users do not travel to learning place: The users of the mobile connectivity to access this digital solution are exempt from using any vehicle to travel to their learning place. Travel related emissions are consequently reduced, which is the main avoided effect.

- Home energy consumption increase: All the users of the e-learning solution spend more time at home, increasing their home temperature conditioning requirements. This results in an increase of the consumption of energy utilities, such as electricity or natural gas, increasing GHG emissions accordingly.

→ HIGHER ORDER EFFECTS

- Learning sites consolidation: The normalization of e-learning can be expected to trigger a different mindset in learning institutions management strategies. Fewer space requirements would lead to learning sites consolidation in the long-term, causing a reduction of, for example, the thermal conditioning or lighting requirements at the learning place. To date it has not been possible to find quantitative data about this effect. Accordingly, it has been excluded from the calculation model.

- Use of spare time/money: E-learning is an example of increased efficiency service, where the solution optimizes time and costs due to a direct lower travel requirement. Associated to this effect, customers can use their spare time and money to perform other activities, which could have associated emissions reducing the avoided emissions of the ICT enabled scenario. This effect has not been quantified for this solution, as it is very difficult to narrow the activities most likely to be performed by the users with their newly acquired spare time or money. As this directly depends on personal decisions of the user, there is not enough evidence to evaluate from a quantitative perspective if the effects caused by this higher order effect could be positive or negative from a climate change perspective.

3.1.3.4. Calculation logic

The avoided emissions logic for this solution is calculated according to the following diagram. The first group of effects have a positive contribution, avoiding emissions, while the second group contains effects generating additional GHG emissions compared to the baseline scenario.

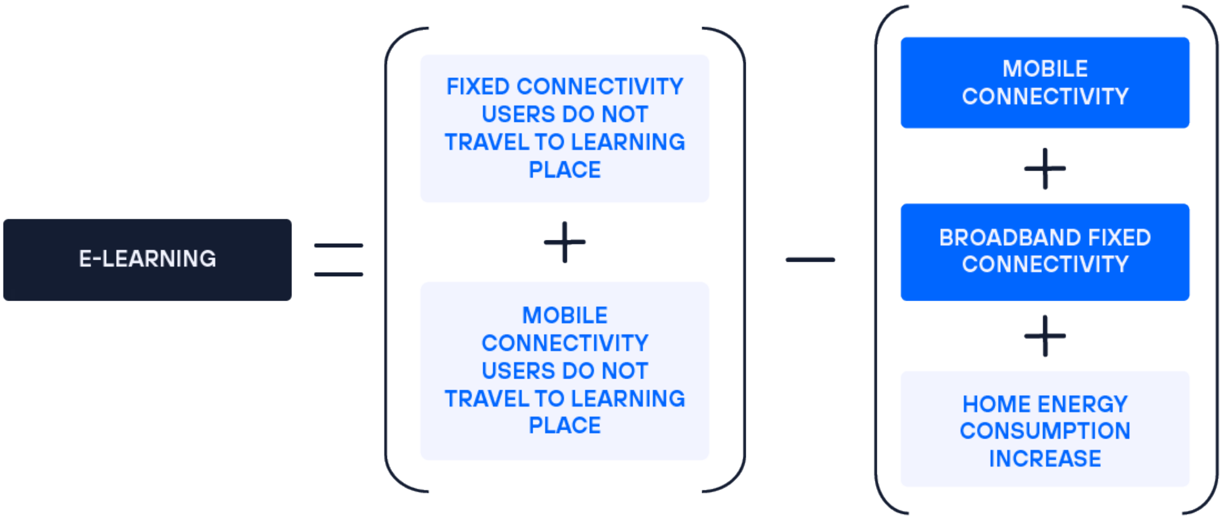


Figure 16.- Calculation logic for e-learning solution

3.1.3.5. Data quality, specificity, and uncertainty

The main sources of information for each data item used to create the evaluation model for this solution are contained in the following table, where an evaluation of the source quality is performed.

DATA ITEM	DATA SOURCE	SOURCE QUALITY	REFERENCE YEAR	GEOGRAPHICAL SCOPE
Telefónica's B2C Broadband fixed connections	Telefónica – Yearly activity data	Primary	2024	Country specific
Telefónica's B2C Mobile connections	Telefónica – Yearly activity data	Primary	2024	Country specific
Post-paid (contract) B2C mobile connections	Telefónica – Yearly activity data	Primary	2024	Country specific

DATA ITEM	DATA SOURCE	SOURCE QUALITY	REFERENCE YEAR	GEOGRAPHICAL SCOPE
Smartphones in the active mobile connections	Telefónica – Yearly activity data	Primary	2024	Country specific
Broadband fixed access emission factor	Telefónica - ITC networks LCA	Primary	2022	Country specific
Mobile access emission factor	Telefónica - ITC networks LCA	Primary	2022	Country specific
Usage share of fixed connection to study from home	Telefónica – Survey to customers on connected living habits	Primary	2022-2023	Country specific
Usage share of mobile connection to study from home	Telefónica – Survey to customers on connected living habits	Primary	2022-2023	Country specific
Share of e-learning connections avoiding trips	Telefónica – Survey to customers on connected living habits	Primary	2022-2023	Country specific
Total number of people studying simultaneously from home (only fixed)	Telefónica – Survey to customers on connected living habits	Primary	2022-2023	Country specific
Average days per year studying from home	Telefónica – Survey to customers on connected living habits	Primary	2022-2023	Country specific
Average distance to learning place (round trip)	Telefónica – Survey to customers on connected living habits	Primary	2022-2023	Country specific

DATA ITEM	DATA SOURCE	SOURCE QUALITY	REFERENCE YEAR	GEOGRAPHICAL SCOPE
Average transport emission factor	IDAE - Instituto para la diversificación y el ahorro de la energía // DEFRA - UK Government GHG Conversion Factors for Company Reporting // Ferramenta do Programa Brasileiro GHG Protocol // Umwelt Bundesamt - Vergleich der durchschnittlichen emissionen einzelner verkehrsmittel des linien und individualverkehrs im personenverkehr in Deutschland	Secondary	2024	Country specific
Additional energy consumption per household when LFH	DEFRA - UK Government GHG Conversion Factors for Company Reporting // Eurostat // Ecoact - Homeworking whitepaper	Secondary	2020-2024	Country specific
Electricity mix emission factors	Emission factors used by Telefónica in its 2023 corporate CF calculation // REE // MCTI // STR // DEFRA	Secondary	2020-2024	Country specific

Tabla 5 .- E-learning - Data quality evaluation

From the uncertainty perspective, associated to the data quality used for this solution, there are no data sources with "proxy" quality. Therefore, it can be stated that the expected avoided emission results uncertainty is presumably very low as all the effects are related to high-quality data, so no further analysis is necessary.

The secondary sources used are mostly recent and coming from credible organizations such as the different public organisms publishing the transport related emission factors for each country, or Eurostat to calculate the additional energy consumption per household.

Main additional assumptions are:

- No heating is considered in Brazil for home conditioning.

- Only 182 out of 365 days are considered to require home heating, according to the homeworking whitepaper.

- Only 122 out of 365 days are considered to require home cooling, according to the homeworking whitepaper.

- Broadband fixed access emission factor has been calculated as a weighted average of the different fixed network impacts available at Telefónica. This includes fiber and copper technologies. The weighting has been made considering the real penetration for both technologies on each evaluated country.

The analysis of the model created for this solution has medium specificity level, according to the specificity evaluation matrix.

		DIGITAL SOLUTION		
REFERENCE SCENARIO	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

Tabla 6 .- E-learning - Specificity of the solution

3.1.4. E-Shopping

The digitalization of our societies is allowing more and more people to opt for e-commerce for their everyday purchases through the use of online websites and app-based shopping services. Connectivity facilitates e-shopping, minimizing the need for in-person visits to physical retail locations. Although the delivery of these goods to the customer's home generates emissions, more emissions are avoided, since according to the respondents of Telefónica's surveys, around half of the shopping trips are made in private petrol or diesel cars. However, it can also generate a rebound effect, due to an increase in returns or purchases in general. In the end, whether it is a sustainable option depends on how each individual uses the service.

It is important to highlight that in this case Telefónica does not claim exclusive contribution to this digital solution. The company has the role of connectivity provider within this solution.

3.1.4.1. Solution eligibility

E-shopping is compliant with the solution eligibility proposed in section 2.2, as it is a capable service of having a direct and significant impact in the decarbonization process. In support of this affirmation, the Intergovernmental Panel on Climate Change (IPCC) in its Sixth Assessment Report (AR6)[3] make various references to how e-shopping boosts this decarbonization mentioned above.

On this subject, the sixth IPCC report remarks that online shopping, or e-commerce, has an impact on transportation emissions, as it reduces the need for customers to individually travel to stores. By shifting to home delivery, fewer trips are made by private vehicles, leading to a reduction in overall vehicle kilometers travelled, in this way, reducing transportation related emissions.

3.1.4.2. Reference scenario definition and system boundaries

The reference scenario defined for the e-shopping solution, is a situation where the user has to attend to a physical shopping place every time they want to acquire a product. In this situation, the shopper is required to use a certain transport mode to travel the distance from their home to the shop and return home, which is the main effect avoided by the e-shopping solution.

For both the baseline and the ICT enabled situation, the functional unit considered is the following one:

One user shopping during a full-year period

The system boundaries of the reference scenario involve the user travelling to the shopping place back and forth using a vehicle that may vary from one user to another. Compared to this reference scenario, the ICT enabled situation triggers some undesired effects from the environmental perspective, such as the shopping goods remote delivery and the increase in the return rates that is considered in the calculation of the avoided emissions.

From a geographical perspective, the reference case has been set considering several countries, in which Telefónica has deployed this solution. These countries are Spain, Brazil and Germany.

3.1.4.3. First, second, and higher order effects of the solution

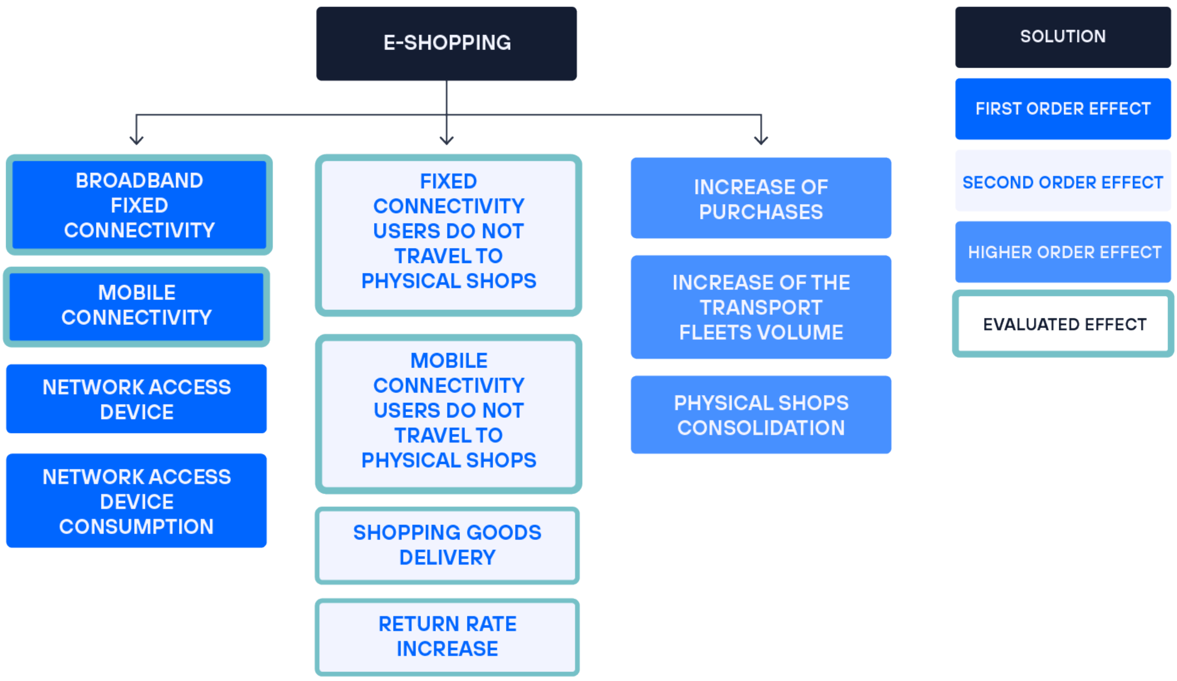


Figure 17 .- E-shopping solution consequence tree

E-shopping as a connected living solution has several environmental effects, which can be grouped into different levels that can go, according to the methodology, from first order effects to second and higher order effects. More details on this classification are explained in section 2.5 of this methodological report.

→ FIRST ORDER EFFECTS

- Broadband fixed connectivity: The users of this solution must have access to connectivity, to enable remote shopping from home or from any other outdoor locations. This first order effect corresponds to the impacts coming from the use of Telefónica's fixed telecommunication networks, such as copper or fiber technologies.

- Mobile connectivity: Following the same logic, the users of this solution must have access to connectivity, to enable remote shopping from home or from any other outdoor locations. This first order effect corresponds to the impacts coming from the use of Telefónica's mobile telecommunication networks, such as 4G/5G technologies.
- Network access devices: In order to access the network, a specific device is always required to act as interface. This first order effect corresponds to the life cycle impacts (manufacturing, transport, end-of-life), associated to smartphones, personal computers or similar devices. This effect has not been quantified for this solution, as it has been considered that users would already own this kind of interface devices in the reference situation.

- Network access devices consumption: In order to access the network, a specific device is always required to act as interface. This first order effect corresponds to the electricity consumption associated to smartphones, personal computers or similar devices. This effect has not been quantified for this solution, as it has been considered that users would already be using these devices in the reference situation.

→ SECOND ORDER EFFECTS

- Fixed connectivity users do not travel to physical shops: The users of the fixed connectivity to access this digital solution are exempt from using any vehicle to travel to physical shops. Travel related emissions are consequently reduced, which is the main avoided effect.

- Mobile connectivity users do not travel to physical shops: The users of the mobile connectivity to access this digital solution are exempt from using any vehicle to travel to physical shops. Travel related emissions are consequently reduced, which is the main avoided effect.

- Shopping goods delivery: As a consequence of remote shopping, a negative second-order effect arises from the necessity for all parcels to be transported to end users via delivery services. This increases fuel consumption and associated emissions from external delivery companies.

- Return rate increase: As a direct consequence of not being able to check physically the product before the purchase, it is considered that the product return rate increases, resulting in an increased delivery transport flow.

→ HIGHER ORDER EFFECTS

- Increase of purchases: In the long-term, making shopping easier for the customers, may lead to a situation in which the customers tend to buy more goods, increasing the delivery associated emissions. Unfortunately, there is no quantitative evidence around this subject to evaluate to which extent this effect could likely be a reality. Therefore, this higher order effect has not been evaluated so far.
- Increase of the transport fleets volume: A higher volume of parcel delivery requirements would directly affect the volume of the transport fleets associated to shopping businesses or private courier transport businesses. After researching, no quantitative evidence has been found around this subject to evaluate to which extent this effect could likely affect to this kind of companies. Therefore, this higher order effect has not been evaluated so far.

- Physical shops consolidation: The normalization of e-shopping, can be expected to trigger a different mindset in the management strategies for retailers. Fewer customers at the physical shops would lead to selling sites consolidation in the long-term, causing a reduction of, for example, the thermal conditioning or lighting requirements at the shops. After researching this effect during past years in which the e-shopping has already been in place, the analyst team has been unable to find quantitative data linking e-shopping with a reduction in the shopping centers. Therefore, this effect has not been evaluated so far.

3.1.4.4. Calculation logic

The avoided emissions logic for this solution is calculated according to the following diagram. The first group of effects have a positive contribution, avoiding emissions, while the second and third group contains effects generating additional GHG emissions compared to the baseline scenario.

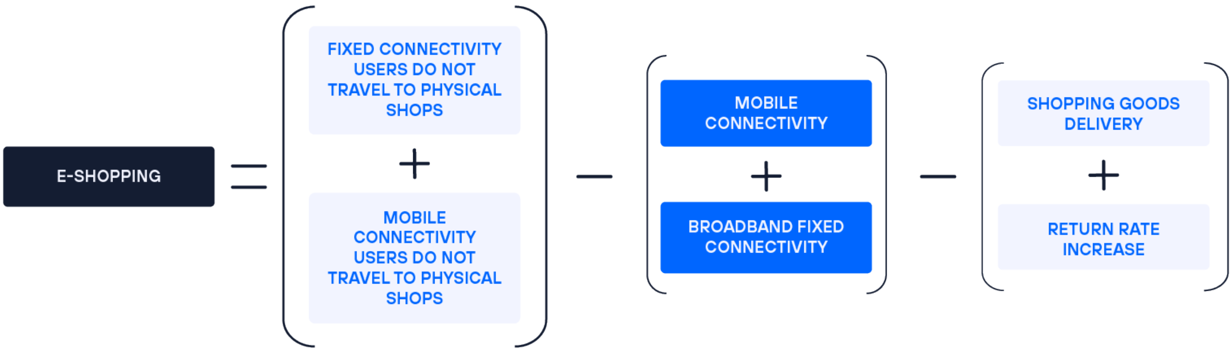


Figure 18 .- Calculation logic for e-shopping solution

3.1.4.5. Data quality, specificity, and uncertainty

The main sources of information for each data item used to create the evaluation model for this solution are contained in the following table, where an evaluation of the source quality is performed.

DATA ITEM	DATA SOURCE	SOURCE QUALITY	REFERENCE YEAR	GEOGRAPHICAL SCOPE
Telefónica's B2C Broadband fixed connections	Telefónica – Yearly activity data	Primary	2024	Country specific
Telefónica's B2C Mobile connections	Telefónica – Yearly activity data	Primary	2024	Country specific

DATA ITEM	DATA SOURCE	SOURCE QUALITY	REFERENCE YEAR	GEOGRAPHICAL SCOPE
Post-paid (contract) B2C mobile connections	Telefónica – Yearly activity data	Primary	2024	Country specific
Smartphones in the active mobile connections	Telefónica – Yearly activity data	Primary	2024	Country specific
Broadband fixed access emission factor	Telefónica - ITC networks LCA	Primary	2022	Country specific
Mobile access emission factor	Telefónica - ITC networks LCA	Primary	2022	Country specific
Usage share of fixed connection for e-shopping	Telefónica – Survey to customers on connected living habits	Primary	2022-2023	Country specific
Usage share of mobile connection for e-shopping	Telefónica – Survey to customers on connected living habits	Primary	2022-2023	Country specific
Average number of journeys avoided	Telefónica – Survey to customers on connected living habits	Primary	2022-2023	Country specific
Average shopping journey distance	Telefónica – Survey to customers on connected living habits	Primary	2022-2023	Country specific
Mode of transport used to go shopping	Telefónica – Survey to customers on connected living habits	Primary	2022-2023	Country specific

Average transport emission factor	IDAE - Instituto para la diversificación y el ahorro de la energía // DEFRA - UK Government GHG Conversion Factors for Company Reporting // Ferramenta do Programa Brasileiro GHG Protocol // Umwelt Bundesamt - Vergleich der durchschnittlichen emissionen einzelner verkehrsmittel des linien und individualverkehrs im personenverkehr in Deutschland	Secondary	2024	Country specific
Average emissions of delivery	OliverWyman - Delivery decarbonization pathway	Proxy	2023	Country specific for Spain and Germany. Proxy for Brazil
Most likely return rate. Additional journeys generated by returns	OliverWyman - Delivery decarbonization pathway	Proxy	2023	Country specific for Spain and Germany. Proxy for Brazil
Impact of current return rates on per parcel CO_2eq emissions	OliverWyman - Delivery decarbonization pathway	Proxy	2023	Country specific for Spain and Germany. Proxy for Brazil

Table 7.- E-shopping - Data quality evaluation

From the uncertainty perspective associated to the data quality used for this solution, there is only one data source with "proxy" quality, which have a slightly lower data quality than the rest, so an uncertainty analysis can be done. This data has been used to calculate two second order effects, namely shopping goods delivery and return rates increase.

These two effects together account to between 24% and 30% of the net calculated impact for this solution, depending on the country considered. Therefore, it can be stated that the expected avoided emission results uncertainty is medium for this service, as these low-quality data are related to a relevant effect, which in this case is the shopping goods delivery.

The secondary sources used are mostly recent and coming from credible organizations such as the different public organisms publishing the transport related emission factors.

Main additional assumptions are:

- Only 50.6% of the emissions per delivery for the "National Standard Case" declared in the OliverWyman's delivery decarbonization pathway report are considered in our model, to avoid double counting and overlapping with the reference case. This excludes the IT related emissions, because the ITC network impact has been already considered as an evaluated first order effect. In addition, this also excludes the transport of the product until the retailer and the impact associated to the shops and warehouses, as those effects would also occur in the reference scenario.

- For the Brazilian case, the average emissions of the delivery have been calculated as an average of the rest of evaluated situations, due to lack of data.
- Broadband fixed access emission factor has been calculated as a weighted average of the different fixed network impacts available at Telefónica. This includes fiber and copper technologies. The weighting has been made considering the real penetration for both technologies on each evaluated country.

The analysis of the model created for this solution has medium specificity level, according to the specificity evaluation matrix.

		DIGITAL SOLUTION		
REFERENCE SCENARIO	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 8 .- E-shopping - Specificity of the solution

3.1.5. Carpooling

Thanks to digitalization, apps and services connecting travellers with each other allowing them to share car rides, are available. In this way, carpooling applications avoid single occupant trips. If it is possible to replace two or more vehicles in which only one person travels with a single car that carries all of them, far fewer polluting emissions are produced. Connectivity is used to locate and book a place in a shared vehicle that has already planned to make the same trip.
It is important to highlight that in this case Telefónica does not claim exclusive contribution to this digital solution. The company has the role of connectivity provider within this solution.

3.1.5.1. Solution eligibility

Carpooling is compliant with the solution eligibility proposed in section 2.2, as it is a capable service of having a direct and significant impact in the decarbonization process. In support of this affirmation, the Intergovernmental Panel on Climate Change (IPCC) in its Sixth Assessment Report (AR6)[3] make various references to how carpooling solutions boost this decarbonization remarked above.

The previously indicated report from the IPCC, mentions that focusing on less GHG-intensive transport modes, could reduce the overall GHG emissions in the transport sector. Concretely, it refers for example, to smart and shared mobility by carpooling as a way of reducing the demand for transport. In this way, this could lead to reduced demand for energy and transport, which may decrease the GHG emissions.

Moreover, the IPCC's AR6 confirms that some studies show car sharing and carpool commuting can reduce the transport emissions between 1.1% and 1.2% per capita.

3.1.5.2 Reference scenario definition and system boundaries

The reference scenario defined for the carpooling solution is a situation where the user does not have access to online applications and services facilitating finding and booking a place in a shared car, that would take that route anyway, independently of sharing the travel or not. This kind of applications also facilitate to the user the action of finding people willing to share the vehicle owned by the user.

In this situation, Telefónica's users would not be encouraged in the same way to share a vehicle as the users in the ICT enabled scenario. In this reference scenario, the carbon emissions avoided through the usage of the carpooling services facilitated by Telefónica's connectivity do not take place.

For both the baseline and the ICT enabled situation, the functional unit considered is the following one:

One user travelling during a full-year period

The system boundaries of the reference scenario involve the user making all their travels during a full-year period without considering the option of sharing the vehicle with unknown people.

From a geographical perspective, the reference case is set considering several countries, in which Telefónica has deployed this solution. These countries are Spain, Brazil and Germany.

3.1.5.3. First, second, and higher order effects of the solution

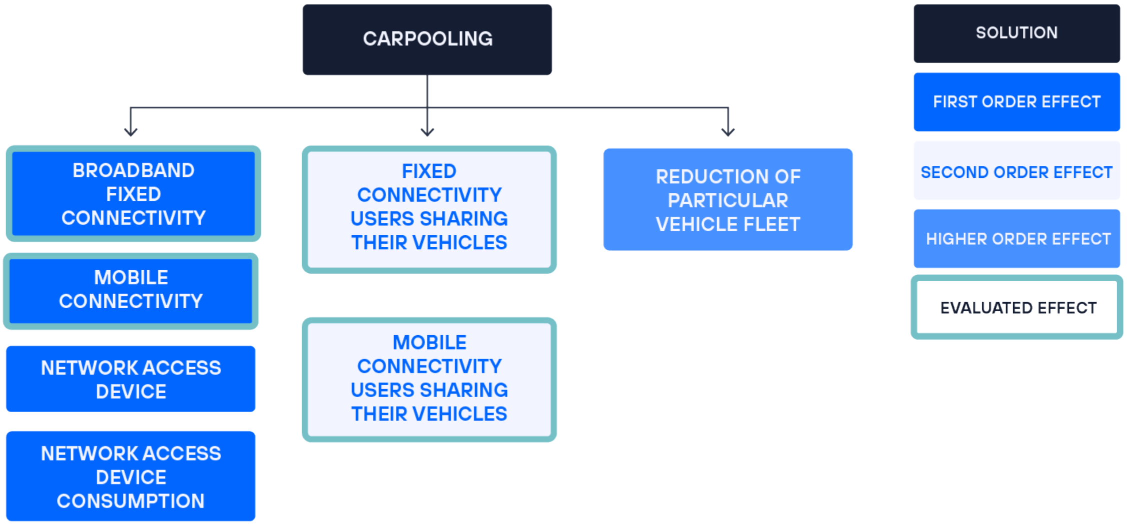


Figure 19 .- Carpooling solution consequence tree

Carpooling as a connected living solution has several environmental effects, which can be grouped into different levels that can go, according to the methodology, from first order effects to second and higher order effects. More details on this classification are explained in section 2.5 of this methodological report.

→ **FIRST ORDER EFFECTS**

- Broadband fixed connectivity: The users of this solution must have access to connectivity, making available the on-line information about carpooling related services, such as dedicated apps, timetables, or locations, from home or from any other outdoor location. This first order effect corresponds to the impacts coming from the use of Telefónica's fixed telecommunication networks, such as copper or fiber technologies.

- Mobile connectivity: The users of this solution must have access to connectivity, making available the on-line information about carpooling related services, such as dedicated apps, timetables, or locations, from home or from any other outdoor location. This first order effect corresponds to the impacts coming from the use of Telefónica's mobile telecommunication networks, such as 4G/5G technologies.

- Network access devices: In order to access the network, a specific device is always required to act as interface. This first order effect corresponds to the life cycle impacts (manufacturing, transport, end-of-life), associated to smartphones, personal computers or similar devices. This effect has not been quantified for this solution, as it has been considered that users would already own this kind of interface devices in the reference situation.

- Network access devices consumption: In order to access the network, a specific device is always required to act as interface. This first order effect corresponds to the electricity consumption associated to smartphones, personal computers or similar devices. This effect has not been quantified for this solution, as it has been considered that users would already be using these devices in the reference situation.

→ **SECOND ORDER EFFECTS**

- Fixed connectivity users sharing their vehicles: The users of the fixed connectivity to access this digital solution replace the use of vehicles on their own, towards sharing their transport with users requiring taking the same route, which is always a more sustainable way of travelling. Travel related emissions are consequently reduced, which is the main avoided effect.

- Mobile connectivity users sharing their vehicles: The users of the mobile connectivity to access this digital solution replace the use of vehicles on their own towards sharing their transport with users requiring taking the same route, which is always a more sustainable way of travelling. Travel related emissions are consequently reduced, which is the main avoided effect.

→ **HIGHER ORDER EFFECTS**

- Reduction of particular vehicle fleet: If the use of shared transport is encouraged and facilitated, at some point some users may decide that they do not need to own a car. This potential reduction of vehicle fleets may lead to a reduction in the resource consumption due to avoiding the production of new cars. Note that this effect has not been quantified for this solution, due to lack of quantitative information about this future outcome.

3.1.5.4.Calculation logic

The avoided emissions logic for this solution is calculated according to the following diagram. The first group of effects have a positive contribution, avoiding emissions, while the second group contains effects generating additional GHG emissions compared to the baseline scenario.

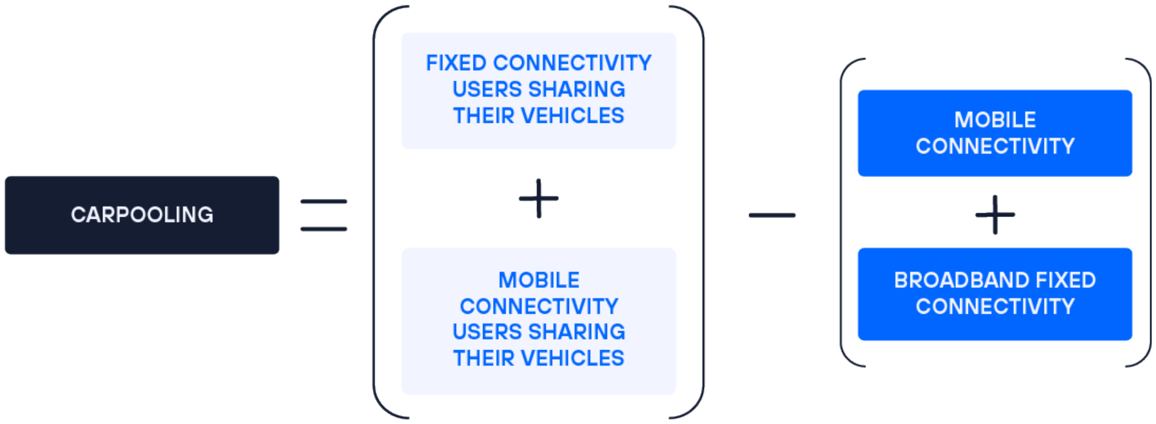


Figure 20 .- Calculation logic for carpooling solution

3.1.5.5. Data quality, specificity, and uncertainty

The main sources of information for each data item used to create the evaluation model for this solution, are contained in the following table, where an evaluation of the source quality is performed.

DATA ITEM	DATA SOURCE	SOURCE QUALITY	REFERENCE YEAR	GEOGRAPHICAL SCOPE
Telefónica's B2C Broadband fixed connections	Telefónica – Yearly activity data	Primary	2024	Country specific
Telefónica's B2C Mobile connections	Telefónica – Yearly activity data	Primary	2024	Country specific
Post-paid (contract) B2C mobile connections	Telefónica – Yearly activity data	Primary	2024	Country specific
Smartphones in the active mobile connections	Telefónica – Yearly activity data	Primary	2024	Country specific
Broadband fixed access emission factor	Telefónica - ITC networks LCA	Primary	2022	Country specific
Mobile access emission factor	Telefónica - ITC networks LCA	Primary	2022	Country specific
Share of fixed connections using connectivity for carpooling	Telefónica – Survey to customers on connected living habits	Primary	2022-2023	Country specific
Share of mobile connections using connectivity for carpooling	Telefónica – Survey to customers on connected living habits	Primary	2022-2023	Country specific
Number of trips travelled using carpooling connections	Telefónica – Survey to customers on connected living habits	Primary	2022-2023	Country specific
Average distance travelled using carpooling connections	Telefónica – Survey to customers on connected living habits	Primary	2022-2023	Country specific

DATA ITEM	DATA SOURCE	SOURCE QUALITY	REFERENCE YEAR	GEOGRAPHICAL SCOPE
Alternative transport if carpooling not used	Telefónica – Survey to customers on connected living habits	Primary	2022-2023	Country specific
Average transport emission factor	IDAE - Instituto para la diversificación y el ahorro de la energía // DEFRA - UK Government GHG Conversion Factors for Company Reporting // Ferramenta do Programa Brasileiro GHG Protocol // Umwelt Bundesamt - Vergleich der durchschnittlichen emissionen einzelner verkehrsmittel des linien und individualverkehrs im personenverkehr in Deutschland	Secondary	2024	Country specific

Table 9 .- Carpooling - Data quality evaluation

From the uncertainty perspective, associated to the data quality used for this solution, there are no data sources with "proxy" quality. Therefore, it can be stated that the expected avoided emission results uncertainty is presumably very low, as all the effects are related to high quality data, so no further analysis is necessary.

The secondary sources used are mostly recent and coming from credible organizations such as the different public organisms publishing the transport related emission factors for each country.

Main additional assumptions are:

-Broadband fixed access emission factor is calculated as a weighted average of the different fixed network impacts available at Telefónica. This includes fiber and copper technologies. The weighting has been made considering the real penetration for both technologies on each evaluated country.

The analysis of the model created for this solution has medium specificity level, according to the specificity evaluation matrix.

	DIGITAL SOLUTION			
REFERENCE SCENARIO	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 10 .- Carpooling - Specificity of the solution

3.2. IOT RELATED SOLUTIONS

The Internet-of-Things or directly "IoT" is a concept referring to objects with computing devices in them that can connect to each other and exchange data using telecommunication networks. The introduction of this technology has led to the creation of IoT networks, creating a new universe of connected appliances.

IoT is not just limited to machine-to-machine communication, but also involves human-machine interaction, as well as key procedures such as data collection and analysis for meaningful actions in the business environment. Telefónica is helping to drive smart industry and smart cities forward through digitization, through specific technological solutions based on asset connectivity and data analytics.

The connectivity provided by Telefónica as well as the development and operation of different tailormade B2B digital solutions and platforms, such as Kite Platform, is providing a key contribution towards driving business sustainability for Telefónica's B2B clients. This chapter focuses on those IoT related solutions facilitating the optimized performance of the business activities, enabling them to reduce their CO_2 emissions.

3.2.1. Smart cities: Smart parking

As the population of cities grows, there is a need to rethink mobility as it is known and focus on sustainability. For this reason, smart cities must work to improve the way citizens move around cities, with the aim of combating pollution and the excessive use of cars and other vehicles. One way to achieve improved mobility is through smart parking solutions, which make it easier to find parking in urban areas, improving traffic flow, favouring local commerce and the satisfaction of inhabitants and visitors. Moreover, the application of these solutions not only applies exclusively to urban areas, but can also be applied in car parks, airports, hospitals, shopping centres, natural spaces or park and ride facilities. These solution results in a reduction of the traffic congestion, and therefore a reduction in the fuel consumption.

It is important to highlight that in this case Telefónica does not claim exclusive contribution to this digital solution. The company has the roles of connectivity provider, data analytics solution owner & operator within this solution.

3.2.1.1. Solution eligibility

The use of smart parking solutions is compliant with the solution eligibility proposed in section

2.2, as it is a capable service of having a direct and significant impact in the decarbonization process. In support of this affirmation, the Intergovernmental Panel on Climate Change (IPCC) in its Sixth Assessment Report (AR6)[3] make various references to how smart city concepts boost this decarbonization mentioned above.

The IPCC in their last report, indicates that the information and communication technologies can play and important role for GHG emission mitigation. The IoT can be a very useful tool for planning, evaluating and integrating information rapidly, for example, IoT sensors collecting real-time data facilitating more efficient transport planning options.

More specifically, this kind of sensors can be used in smart parking solutions. Gathering real-time information on parking availability and integrating it into information systems that drivers can easily check avoids unnecessary kilometers reducing the associated GHG emissions.

3.2.1.2. Reference scenario definition and system boundaries

The reference scenario defined for the smart parking solution is a situation where drivers look for parking space without using any digital solution supporting this task. Smart parking sensors do not need to be manufactured, but the counterpart is that the parking spot finding process would take in general terms a longer time.

For both the baseline and the ICT enabled situation, the functional unit considered is the following one:

People leaving their car in one certain urban parking spot during a full-year period

The system boundaries of the reference scenario involve the user having to drive a certain time to find parking space. This time is higher than the one in the ICT enabled situation. From the perspective of one single parking spot, depending on the amount of people that use that spot, a total driving time reduction per sensor can be achieved. This reduction is associated with a reduction in the driving-related emissions. In the reference case, the vehicle speed when looking for car park is the same than in the ICT enabled situation.

From a geographical perspective, the reference case is set considering only Spain.

3.2.1.3. First, second, and higher order effects of the solution

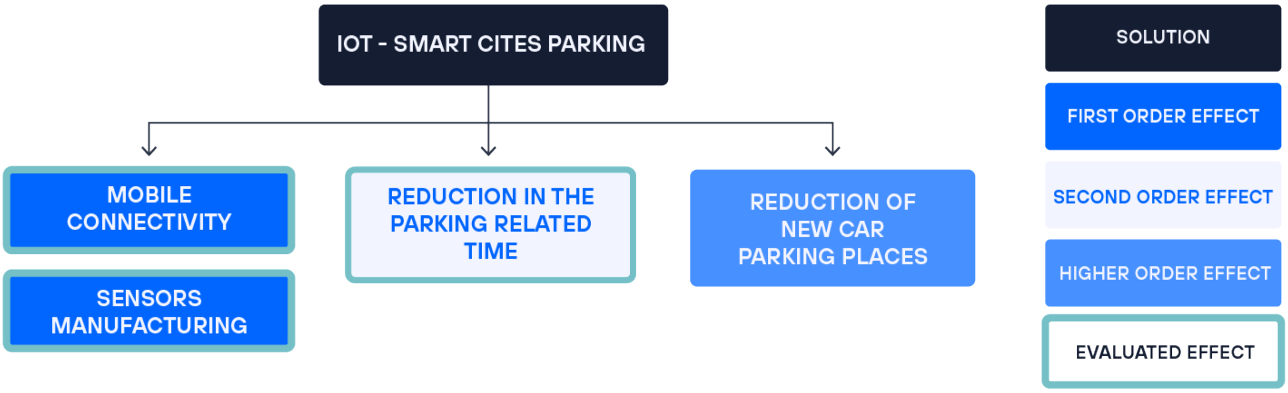


Figure 21 .- Smart parking solution consequence tree

Smart parking as an IoT solution has several environmental effects, which can be grouped into different levels that can go, according to the methodology, from first order effects to second and higher order effects. More details on this classification are explained in section 2.5 of this methodological report.

→ FIRST ORDER EFFECTS

- Mobile connectivity: The smart sensors involved in this solution must have access to mobile connectivity, enabling the parking occupation information to be transferred to the solution manager. This first order effect corresponds to the impacts coming from the use of Telefónica's mobile telecommunication networks. In this case, the devices involved in the solution work under Narrowband-IoT technologies, that have a much lower power consumption than common mobile technologies.

- Smart sensors manufacturing: Different kind of smart sensors and devices are required to deploy this service. Smart parking sensors can identify parking availability, facilitating to share this information in real-time with the drivers looking for a parking spot. The requirement of raw materials and manufacturing efforts for these devices is considered as a first order effect in this solution.

→ SECOND ORDER EFFECTS

- Reduction in the parking related time: Smart parking sensors are capable of monitoring car park space availability in cities. This information is fed back to vehicles and drivers, who can find parking space faster. This reduces the time spent driving looking for a parking spot, avoiding the associated fuel consumption and emissions to air.

→ HIGHER ORDER EFFECTS

- Reduction of new car parking places: As high order effect it can be considered that due to this solution, in the long-term, there would be a better organisation and efficiency of parking spaces. Accordingly, the need for new car parks could be reduced. Note that this effect has not been quantified for this solution, due to lack of quantitative information available about this future outcome.

3.2.1.4.Calculation logic

The avoided emissions logic for this solution is calculated according to the following diagram. The first group of effects have a positive contribution, avoiding emissions, while the second group contains effects generating additional GHG emissions compared to the baseline scenario.

Figure 22 .- Calculation logic for smart parking solution

3.2.1.5. Data quality, specificity, and uncertainty

The main sources of information for each data item used to create the evaluation model for this solution are contained in the following table, where an evaluation of the source quality is performed.

DATA ITEM	DATA SOURCE	SOURCE QUALITY	REFERENCE YEAR	GEOGRAPHICAL SCOPE
Telefónica's smart parking connections	Telefónica – Yearly activity data	Primary	2024	Spain
Mobile access emission factor	Telefónica - ITC networks LCA	Primary	2022	Spain
Parking sensor manufacturing	Specific device LCA conducted using technical datasheets of the device	Primary + Secondary	2024	Spain
SIM Cards manufacturing	Fraunhofer IZM – Comparative LCA for SIM and e-SIM cards	Secondary	2022	Europe
Average time spend looking for parking	Ecologistas en Acción - Cuentas ecológicas del transporte	Secondary	2016	Spain
Average time spend looking for parking	Ecologistas en Acción - Cuentas ecológicas del transporte	Secondary	2016	Spain
Average urban car speed	Dirección General de Transportes y Movilidad. Comunidad de Madrid - Estado de la movilidad de la ciudad de Madrid	Secondary	2022	Spain

DATA ITEM	DATA SOURCE	SOURCE QUALITY	REFERENCE YEAR	GEOGRAPHICAL SCOPE
Average parking time reduction	IEEE Technology and Society Magazine - Reducing parking space search time and environmental impacts: A technology driven smart parking case study	Secondary	2020	Global
Vehicle related emissions	DEFRA - UK Government GHG Conversion Factors for Company Reporting	Secondary	2024	UK
Smart parking connection usage	Telefónica – Own assumption based on expert judgement	Proxy	2024	Spain

Table 11 .- Smart parking - Data quality evaluation

From the uncertainty perspective, associated to the data quality used for this solution, there is only one data source with "proxy" quality, which has a slightly lower data quality than the rest, so an uncertainty analysis can be done. This data has been used to calculate the second order effect of the parking related time reduction. However, as this is the unique positive effect for this solution, it accounts to almost all the avoided effect, being the first order effects for this solution (devices and connectivity carbon impact) nearly negligible.

It has to be noted then that the avoided emissions declared for this digital solution are uncertain. The procedure followed to deal with this uncertainty level has been to be very conservative with the smart parking sensors usage, considering that only 4 vehicles per day are managed by the same parking sensor, which underestimates this digital solution's technical capacity. Calculating this solution's effect with real data from a use case could lead to a relevant increase in the avoided emissions.

The average urban car speed is calculated only using data from Madrid. To better reflect the Spanish situation, data from different urban situations has to be considered in future exercises. The rest of the secondary sources used are mostly recent and coming from credible organizations such as the smart devices manufacturer, public bodies and real use cases.

Main additional assumptions are:

- For the vehicle related emissions, an average between the emissions coming from diesel and petrol cars is assumed.

- To calculate the average urban car speed, the mean of the average speed of the urban structure network has been considered, according to each hourly period as disclosed by the Directorate for transport and mobility of Madrid.

- The monthly data traffic expected for the SIM cards used in this service is less than 100 MB/month. Accordingly, the Telefónica 4G network operation-related impacts have been adapted to better reflect the situation of this Narrowband-IoT technology.

- Real information about the average vehicle coverage of a sensor during a full year period from the Telefónica´s service is not available. Based on published information about use cases for this same solution, it has been identified that this type of sensor is implemented in areas with high parking demand, with a maximum dwell time in place. Estimating a conservative regulated parking schedule, from 8:00 to 20:00, in which the maximum parking time is 3 hours. This gives a minimum turnover of 4 vehicles per day, which is the number of vehicles for which each sensor would facilitate parking for. It has been considered that the solution is active every day of the year. Some use cases discuss situations where this is installed in loading and unloading zones, with a 30-minute rotation, which would give a much higher number of cars, but it has been decided to choose the 3-hours rotation conservative approach.

The analysis of the model created for this solution has medium-low specificity level, according to the specificity evaluation matrix.

		DIGITAL SOLUTION		
REFERENCE SCENARIO	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 12 .- Smart parking - Specificity of the solution

3.2.2. Smart cities: Smart lighting

Smart lighting is considered a key element to improve energy efficiency and reduce light pollution in cities. Many municipalities have already upgraded their lighting infrastructure to energy-efficient light-emitting diodes (LEDs). Along with IoT device integration, this enables efficient remote management of public lighting. Smart connected lighting nodes are point-to-point remote management systems, allowing individual control of the intensity of each luminaire, reducing lighting intelligently or even turning off luminaires when there is no presence. Thanks to the generation of data produced by IoT sensors and the application of predictive models using artificial intelligence, it is possible to know energy consumption with greater precision, perform more efficient maintenance and save energy.

It is important to highlight that in this case Telefónica does not claim exclusive contribution to this digital solution. The company has the roles of connectivity provider, data analytics solution owner & operator within this solution.

3.2.2.1. Solution eligibility

The use of smart lighting solutions is compliant with the solution eligibility proposed in section

2.2, as it is a capable service of having a direct and significant impact in the decarbonization process. In support of this affirmation, the Intergovernmental Panel on Climate Change (IPCC) in its Sixth Assessment Report (AR6)[3] make various references to how smart city concepts boost this decarbonization mentioned above.

The IPCC in their last report, indicates that the information and communication technologies can play and important role for GHG emission mitigation. The IoT can be a very useful tool for planning, evaluating and integrating information rapidly, for example, IoT sensors collecting real-time data facilitating more efficient street lighting systems.

Also known as smart lighting, this service uses sensors that can gather, evaluate, and integrate the information collection, improving the efficiency of the whole system by turning on and off or even dimming the lights only when it is necessary, avoiding energy wastage.

3.2.2.2. Reference scenario definition and system boundaries

The reference scenario defined for the smart lighting solution is a situation where the luminaire is an urban 30W LED lamp (the same as in the ICT enabled scenario) without a point-to-point smart management solution in place. The luminaire could have some kind of automatic programming like switching-off during daily time, but the performance of the lamp is not directly dependent on the surrounding light conditions of every specific spot.

For both the baseline and the ICT enabled situation, the functional unit considered is the following one:

One urban 30W LED lamp functioning during a full-year period

The system boundaries of the reference scenario involve the average yearly electricity consumption of a 30W LED lamp. Compared to this situation, the ICT enabled scenario provides a reduction in the individual power consumption, avoiding the electricity to be generated in the first place. In this baseline scenario, there is also a maintenance vehicle requiring to inspect periodically the status of the lamp. A reduction in the maintenance need has been considered in the ICT enabled scenario, as real-time information about the status of the luminaire can be obtained and analyzed, reducing the preventive travel.

From a geographical perspective, the reference case is set considering only Spain.

3.2.2.3. First, second, and higher order effects of the solution

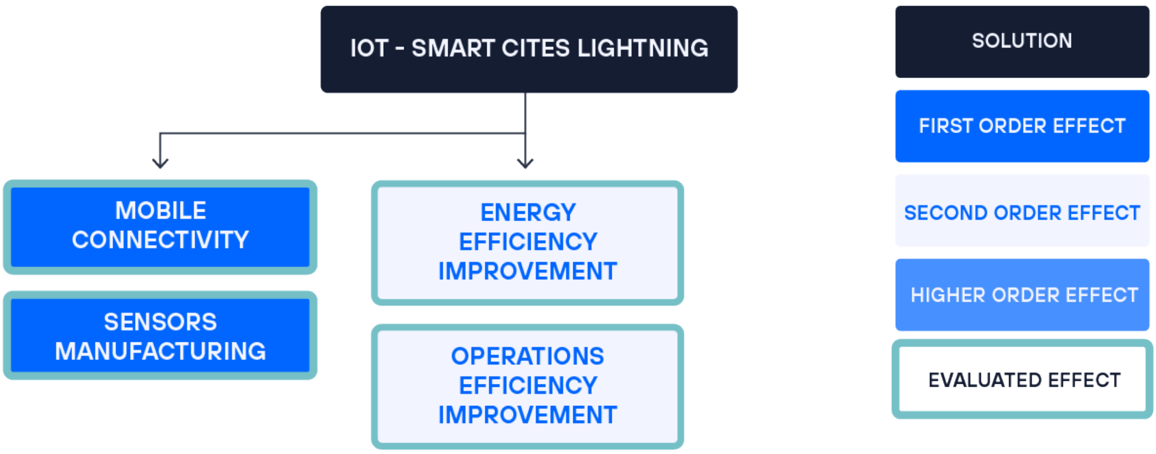


Figure 23 .- Smart lighting solution consequence tree

Smart lighting as an IoT solution has several environmental effects, which can be grouped into different levels that can go, according to the methodology, from first order effects to second and higher order effects. More details on this classification are explained in section 2.5 of this methodological report.

→ FIRST ORDER EFFECTS

- Mobile connectivity: The smart sensors involved in this solution must have access to mobile connectivity, enabling the luminaire to gather and share information on the lighting conditions. This first order effect corresponds to the impacts coming from the use of Telefónica's mobile telecommunication networks. In this case, the devices involved in the solution work under Narrowband-IoT technologies, that have a much lower power consumption than common mobile technologies.

- Smart sensors manufacturing: Different kind of lighting control systems are required to deploy this service. Smart lighting sensors can identify light conditions and adapt the performance of the luminaire in a smart way, thus reducing consumption. The requirement of raw materials and manufacturing efforts for these devices is considered as a first order effect in this solution.

→ SECOND ORDER EFFECTS

- Energy efficiency improvement: Thanks to the new functions of the smart lighting devices, that can automatically control, or dim light requirements as needed, energy demand for street lighting is reduced.

- Operation efficiency improvement: Smart lighting devices can also automatically detect faults and burnt-out bulbs, facilitating the maintenance work and reducing travel associated emissions.

3.2.2.4. Calculation logic

The avoided emissions logic for this solution is calculated according to the following diagram. The first group of effects have a positive contribution, avoiding emissions, while the second group contains effects generating additional GHG emissions compared to the baseline scenario.

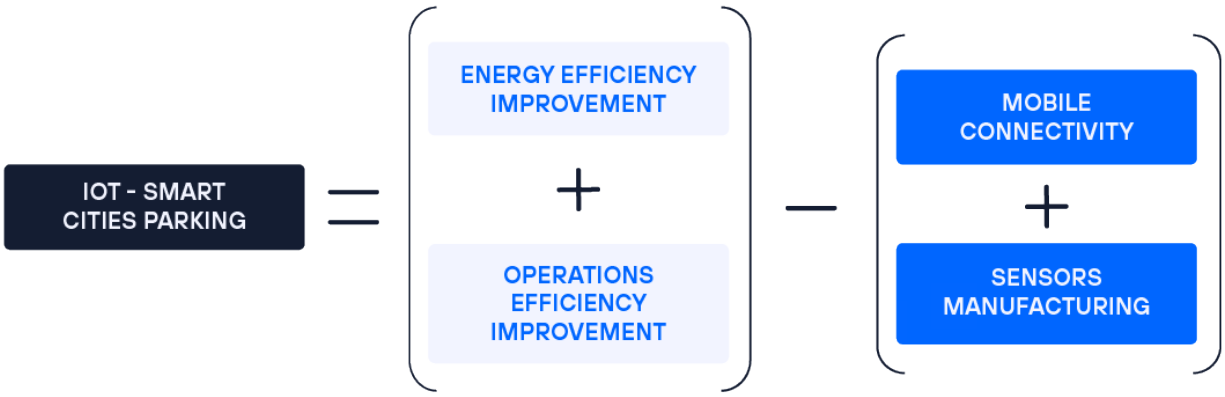


Figure 24 .- Calculation logic for smart lighting solution

3.2.2.5.Data quality, specificity, and uncertainty

The main sources of information for each data item used to create the evaluation model for this solution are contained in the following table, where an evaluation of the source quality is performed.

DATA ITEM	DATA SOURCE	SOURCE QUALITY	REFERENCE YEAR	GEOGRAPHICAL SCOPE
Telefónica's smart lighting connections	Telefónica – Yearly activity data	Primary	2024	Spain
Mobile access emission factor	Telefónica - ITC networks LCA	Primary	2022	Spain
Lighting sensor manufacturing	Specific device LCA conducted using technical datasheets of the device	Primary + Secondary	2024	Spain
SIM Cards manufacturing	Fraunhofer IZM – Comparative LCA for SIM and e-SIM cards	Secondary	2022	Europe
Average hours on per year	Journal of Physics: Conference Series - IoT-enabled smart lighting systems for smart cities	Secondary	2021	Global
Assumed energy consumption reduction	Joint Research Center - Update on the Status of LED-Lighting world market since 2018	Secondary	2021	Europe
Electricity mix emission factor	Red Eléctrica Española (REE)	Secondary	2023	Spain
Maintenance vehicle related emissions	DEFRA - UK Government GHG Conversion Factors for Company Reporting	Secondary	2024	UK

DATA ITEM	DATA SOURCE	SOURCE QUALITY	REFERENCE YEAR	GEOGRAPHICAL SCOPE
Yearly distance travelled by a maintenance vehicle	Telefónica – Own assumption based on the conditions of the lightning maintenance service for one town in Spain	Proxy	2024	Spain

Table 13 .- Smart lighting - Data quality evaluation

From the uncertainty perspective, associated to the data quality used for this solution, there are three data sources with "proxy" quality, which have a slightly lower data quality than the rest, so an uncertainty analysis can be done. All these sources have been used to calculate the maintenance operations efficiency improvement second order effect, which accounts to 20,9% of the total calculated avoided emissions for this solution. This means that a hypothetical ±20% deviation on the maintenance related impacts, leads to an approximate ±4.18% difference in the overall avoided emissions.

The procedure followed to deal with this uncertainty level, it has been to substantiate the assumptions made on real data from existing lighting maintenance contracts, trying to reduce the uncertainty of the assumption. The rest of the secondary sources used are mostly recent and coming from credible organizations such as the smart device manufacturer, the joint research center from the European Commission or other public organizations.

Main additional assumptions are:

- Breakdown of materials for the smart devices LCA is assumed based on a third-party verified environmental product declaration of a different smart metering solution.

- It is based on Telefónica's expert judgement that the most common power for the LED lamps used in public lighting is between 20W and 40W. 30W has been chosen as reference value for both scenarios.

- The monthly data traffic expected for the SIM cards used in this service is less than 100 MB/month. Accordingly, the Telefónica 4G network operation-related impacts have been adapted to better reflect the situation of this Narrowband-IoT technology.

- 12 hours daily every day is assumed as a usual average working time for this kind of luminaires.

- For the maintenance vehicle related emissions, a rigid road vehicle with maximum weight exceeding 3.5 tonnes (>3.5 - 7.5 tonnes) was assumed. The vehicle type used for this kind of maintenance is a small "bucket lorry".

- Yearly distance travelled by a maintenance vehicle has been estimated considering the conditions of the lighting maintenance service for a client in a town of Spain. 160 Km assumed daily to perform maintenance actions. 365 maintenance days a year assumed.

The analysis of the model created for this solution has medium-low specificity level, according to the specificity evaluation matrix.

	DIGITAL SOLUTION			
REFERENCE SCENARIO	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 14 .- Smart lighting - Specificity of the solution

3.2.3. Smart cities: Smart waste management

Improving the efficiency of waste collection is a key element as the population of cities is expected to grow. Waste management currently presents significant opportunities for improvement, both from an economic perspective and in terms of sustainability. Regarding collection planning, containers that have hardly been used are often emptied in such a way that resources are not efficiently managed. This is why digital solutions are an essential ingredient to improve the end-to-end process. With the smart waste management solution, it is possible to collect real-time information on the status of containers, using connected devices. This allow an efficient route planning based on the need for collection, which is essential for achieving a circular economy, reducing fuel consumption and preserving the environment.

It is important to highlight that in this case Telefónica does not claim exclusive contribution to this digital solution. The company has the roles of connectivity provider, data analytics solution owner & operator within this solution.

3.2.3.1. Solution eligibility

The use of smart waste management solutions is compliant with the solution eligibility proposed in section 2.2, as it is a capable service of having a direct and significant impact in the decarbonization process. In support of this affirmation, the Intergovernmental Panel on Climate Change (IPCC) in its Sixth Assessment Report (AR6)[3] make various references to how smart city concepts boost this decarbonization mentioned above.

The IPCC in their last report, indicates that the information and communication technologies can play and important role for GHG emission mitigation. The IoT can be a very useful tool for planning, evaluating and integrating information rapidly, for example, IoT sensors collecting real-time data improving the efficiency of waste management systems.

Smart waste management services use sensors to monitor container fill levels, optimizing collection routes and reducing unnecessary transport emissions by only collecting the containers when necessary, minimizing waste and energy use.

3.2.3.2.Reference scenario definition and system boundaries

The reference scenario defined for the smart waste management solution is a situation where the filling status of the waste containers is not monitored. This entails that waste management vehicles must follow established routes, that are independent of the filling status of the container. This situation is considered less efficient, because sometimes the vehicles would collect waste containers that are nearly empty.

For both the baseline and the ICT enabled situation, the functional unit considered is the following one:

One street waste container being managed during a full-year period

The system boundaries of the reference scenario involve a fleet of waste management vehicles having to perform a static collection route. This has some associated fuel consumption and related emissions that would be reduced in the event of establishing dynamic collection routes depending on the filling status of the container.

From a geographical perspective, the reference case is set considering only Spain.

3.2.3.3. First, second, and higher order effects of the solution

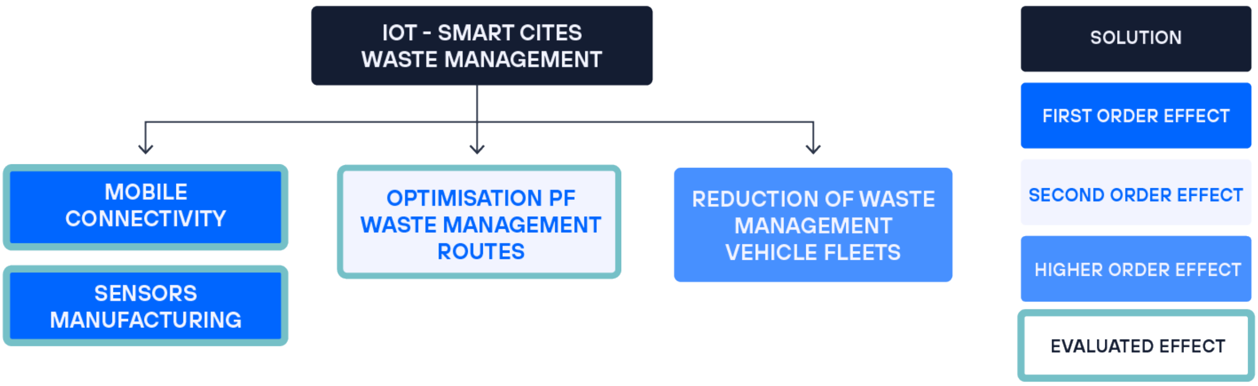


Figure 25 .- Smart waste management solution consequence tree

Smart waste management as an IoT solution has several environmental effects, which can be grouped into different levels that can go, according to the methodology, from first order effects to second and higher order effects. More details on this classification are explained in section 2.5 of this methodological report.

→ FIRST ORDER EFFECTS

- Mobile connectivity: The smart sensors involved in this solution must have access to mobile connectivity, enabling the waste container related information to be transferred to the solution manager. This first order effect corresponds to the impacts coming from the use of Telefónica's mobile telecommunication networks. In this case, the devices involved in the solution work under Narrowband-IoT technologies, that have a much lower power consumption than common mobile technologies.

- Smart sensors manufacturing: Different kind of waste management systems are required to deploy this service. Smart waste management sensors can identify the filling level of waste bins, optimizing the routes of waste collection vehicles. The requirement of raw materials and manufacturing efforts for these devices is considered as a first order effect in this solution.

→ SECOND ORDER EFFECTS

- Optimisation of waste management routes:

Better routing and co-ordination of waste management vehicle fleets can result in a reduction of the total distance travelled. This effect has an associated avoidance of fuel consumption and GHG emissions.

→ HIGHER ORDER EFFECTS

- Reduction of vehicle fleet: If the waste management gets optimized, at some point, public authorities may decide that they do not need the same quantity of vehicles to fulfil the same function. This potential reduction of waste management vehicle fleets may lead to a reduction in the resource consumption due to avoiding the production of new vehicles. Note that this effect has not been quantified for this solution, due to lack of quantitative information available about this future outcome.

3.2.3.4. Calculation logic

The avoided emissions logic for this solution is calculated according to the following diagram. The first group of effects have a positive contribution, avoiding emissions, while the second group contains effects generating additional GHG emissions compared to the baseline scenario.

Figure 26 .- Calculation logic for smart waste management solution

3.2.3.5. Data quality, specificity, and uncertainty

The main sources of information for each data item used to create the evaluation model for this solution are contained in the following table, where an evaluation of the source quality is performed.

DATA ITEM	DATA SOURCE	SOURCE QUALITY	REFERENCE YEAR	GEOGRAPHICAL SCOPE
Telefónica's smart waste management connections	Telefónica – Yearly activity data	Primary	2024	Spain
Mobile access emission factor	Telefónica - ITC networks LCA	Primary	2022	Spain
Waste management sensor manufacturing	Specific device LCA conducted using technical datasheets of the device	Primary + Secondary	2024	Spain
SIM Cards manufacturing	Fraunhofer IZM – Comparative LCA for SIM and e-SIM cards	Secondary	2022	Europe
Waste management vehicle related emissions	DEFRA - UK Government GHG Conversion Factors for Company Reporting	Secondary	2024	UK
Yearly distance travelled by a waste management vehicle	Telefónica – Own assumption based on previous experiences	Proxy	2024	Spain
Number of unique waste bins managed	Telefónica – Own assumption based on the waste vehicle fleet and the quantity of waste containers in a municipality of Spain Bilbao	Proxy	2024	Spain
Assumed efficiency improvement	Telefónica – Own assumption based on previous experiences	Proxy	2024	Spain

Table 15 .- Smart waste management - Data quality evaluation

From the uncertainty perspective, associated to the data quality used for this solution, there are three data sources with "proxy" quality, which have a slightly lower data quality than the rest, so an uncertainty analysis can be done. All these sources have been used to calculate the optimisation of waste management routes second order effect. However, as this is the unique positive effect for this solution, it accounts to almost all the avoided effect (88.5%), being the first order effects for this solution (device and connectivity carbon impact) accounting only to a minor portion of the effect.

It has to be noted then, that the avoided emissions declared for this digital solution are uncertain. The procedure followed to deal with this uncertainty level has been to substantiate the assumptions made on real data as far as possible, using the experience from partner enterprises, about the yearly distance travelled by a waste management vehicle, or public data provided by a Spanish municipality about the number of containers and vehicle fleet, trying to reduce as far as possible the uncertainty of the assumption.

Calculating this solution's effect with real data from a use case could lead to a relevant change in the avoided emissions. The rest of the secondary sources used are mostly recent and coming from credible organizations such as the smart devices manufacturer, or public bodies as the Department for Environment, Food & Rural Affairs of the UK government.

Main additional assumptions are:

- The monthly data traffic expected for the SIM cards used in this service is less than 100 MB/month. Accordingly, the Telefónica 4G network operation-related impacts have been adapted to better reflect the situation of this Narrowband-IoT technology.

- For the vehicle related emissions, a rigid road vehicle with maximum weight exceeding 3.5 tonnes (>3.5 - 7.5 tonnes) is assumed. The vehicle type used for this kind of service is a standard waste management lorry.

- It is assumed that a waste collection truck travels around 25,000 kilometers a year, as an average of the range between 20,000 and 30,000 kilometers per year. These numbers vary according to the specific conditions of the municipality and the type of collection service offered, depending on several factors, such as the size of the city, the frequency of collection, the amount of waste to be collected and the efficiency on the routes. In some large towns or cities with a more intensive collection system, this figure could easily increase to 40,000 kilometers or even more.

- Reviewing the information available from the city council of Bilbao, it is estimated that the number of unique containers managed by one single vehicle could be around 100.

- According to the expert opinion of Telefónica's smart waste management solution professionals, it is estimated that the most common route efficiency improvement for this service is around 15%-20%. However, in some specific cases, such as in rural areas or on the outskirts of large cities, efficiency values of around 50%-66% can also be achieved. In these types of scenarios, the collection service trucks must travel many more kilometers between towns to collect a reduced number of containers. Therefore, intelligent route management can significantly reduce the number of kilometers a truck travels. An estimate of 17.5% efficiency improvement is assumed conservatively as a common value when defining the routes followed by the vehicles managed by this kind of platform. It is known that in some specific areas, the efficiency could be significantly higher.

The analysis of the model created for this solution has medium-low specificity level, according to the specificity evaluation matrix.

	DIGITAL SOLUTION			
REFERENCE SCENARIO	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 16 .- Smart waste management - Specificity of the solution

3.2.4. Fleet management

The fleet management solution is a distinctive product in the market that uses advanced telematics to operationally manage fleets of vehicles in real time and simultaneously, provides a more strategic vision of the whole transport fleet. As a result of telematics, relevant information on the vehicles is obtained, enabling an efficient management in different logistics areas and achieving operational improvements and significant savings. The fleet management solution consists of a reduction of the fuel consumption and associated emissions due to optimised vehicles routes, both for freight and/or person transport vehicles.

It is important to highlight that in this case Telefónica does not claim exclusive contribution to this digital solution. The company has the roles of connectivity provider, data analytics solution reseller & operator within this solution. The data analytics solution considered for the Telefónica portfolio is Geotab, which is considered as the world leader in fleet management solutions.

3.2.4.1. Solution eligibility

The use of fleet management solutions is compliant with the solution eligibility proposed in section 2.2, as it is a capable service of having a direct and significant impact in the decarbonization process. In support of this affirmation, the Intergovernmental Panel on Climate Change (IPCC) in its Sixth Assessment Report (AR6)[3] make various references to how fleet management boosts this decarbonization mentioned above.

The IPCC in their last report, mentions that the information and communication technologies can play and important role for GHG emission mitigation. The IoT can be a very useful tool for planning, evaluating and integrating information quickly. For example, IoT sensors collecting real-time data enhancing the efficiency in fleet management services.

Fleet management using IoT sensors facilitates monitoring vehicle performance, optimizing routes, and tracking fuel consumption, thus reducing emissions by ensuring vehicles are used efficiently and only when needed, minimizing unnecessary travel and energy wastage.

3.2.4.2. Reference scenario definition and system boundaries

The reference scenario defined for the fleet management solution is a situation where a fleet of freight or workforce transport vehicles is managed without having real-time information on the vehicle location and performance. In traditional fleet management processes, routes and freights are optimized to some extent, but the same level of efficiency of the ICT enabled solution cannot be achieved.

For both the baseline and the ICT enabled situation, the functional unit considered is the following one:

One professional vehicle used to transport freight or people being managed during a full-year period

The system boundaries of the reference scenario involve the GHG emissions for one single professional vehicle during a full-year period, based on the average emissions of a regular freight fleet or workforce fleet, and an estimated average yearly distance travelled for each situation. The vehicle emissions per km are the same as the ones considered for the ICT enabled scenario, meaning that the benefit comes from the reduction of the Km travelled. In this baseline situation the smart devices and associated SIM cards do not need to be manufactured.

From a geographical perspective, the reference case has been set considering several countries, in which Telefónica has deployed this solution. These countries are Spain, Brazil and Germany.

3.2.4.3. First, second, and higher order effects of the solution

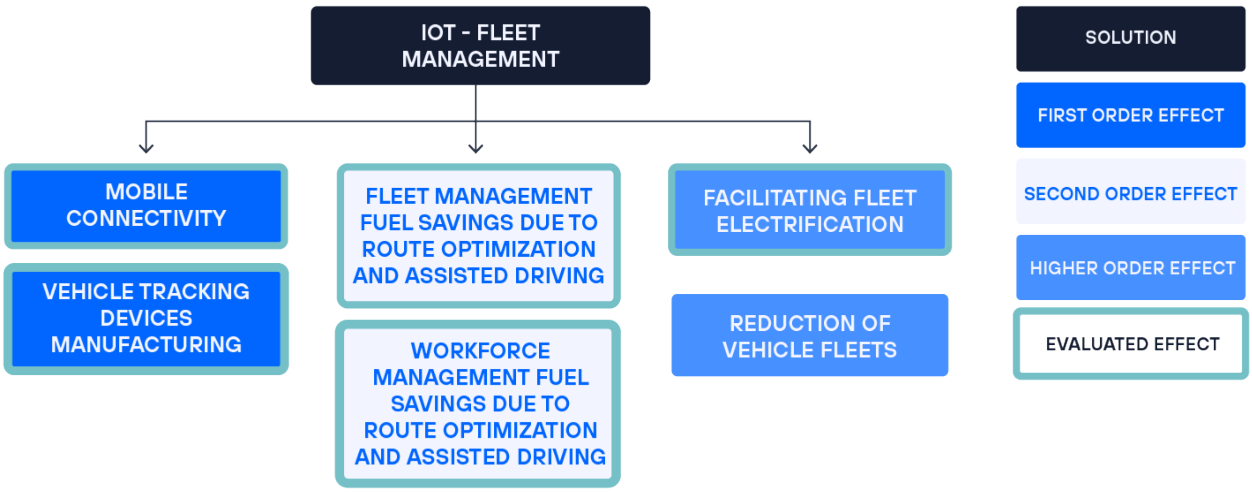


Figure 27 .- Fleet management solution consequence tree

Fleet management as an IoT solution has several environmental effects, which can be grouped into different levels that can go, according to the methodology, from first order effects to second and higher order effects. More details on this classification are explained in section 2.5 of this methodological report.

→ FIRST ORDER EFFECTS

- Mobile connectivity: The smart devices involved in this solution must have access to mobile connectivity, enabling that the data gathered on the performance of the vehicles being managed is properly transferred to the management platform. This first order effect corresponds to the impacts coming from the use of Telefónica's mobile telecommunication networks. In this case, the devices involved in the solution use 4G technologies whenever it can, although fallback to 2G is possible in the situations where there is no good 4G coverage.

- Vehicle tracking devices manufacturing: For this service to be deployed, some smart tracking devices are required. This kind of devices can send real-time information of the vehicle fleets performance. The requirement of raw materials and manufacturing efforts for these devices is considered as a first order effect in this solution.

→ SECOND ORDER EFFECTS

- Fleet management fuel saving due to route optimization and assisted driving: Better routing and co-ordination of transport vehicle fleets result in a reduction of the total distance travelled by the transport vehicles. This effect has an associated avoidance of fuel consumption and GHG emissions.

- Workforce management fuel saving due to route optimization and assisted driving: Better routing and co-ordination of workforce vehicle fleets result in a reduction of the total distance travelled by the transport vehicles. This effect has an associated avoidance of fuel consumption and GHG emissions.

→ HIGHER ORDER EFFECTS

- Facilitating fleet electrification: One of the features contained in the Geotab platform is the detailed evaluation of the electrification potential of the fleet being managed, based on the routes that the vehicles are taking. Most of the fleet owners do not switch to electric vehicles based on cost premises, but according to research from Geotab, almost 60% of the European fleet vehicles could switch to fully electric vehicles today, with a lower total cost of ownership (local cost of acquisition, maintenance, fuel and energy). In the analysis the higher order effect of this veiled potential is evaluated.

- Reduction of vehicle fleet: If the use of the transport fleet gets optimized, at some point companies may decide that they do not need the same quantity of vehicles to fulfil the same function. This potential reduction of vehicle fleets may lead to a reduction in the resource consumption due to avoiding the production of new transport vehicles. Note that this effect has not been quantified for this solution, due to lack of quantitative information about this future outcome.

3.2.4.4. Calculation logic

The avoided emissions logic for this solution is calculated according to the following diagram. The first group of effects have a positive contribution, avoiding emissions, while the second group contains effects generating additional GHG emissions compared to the baseline scenario.

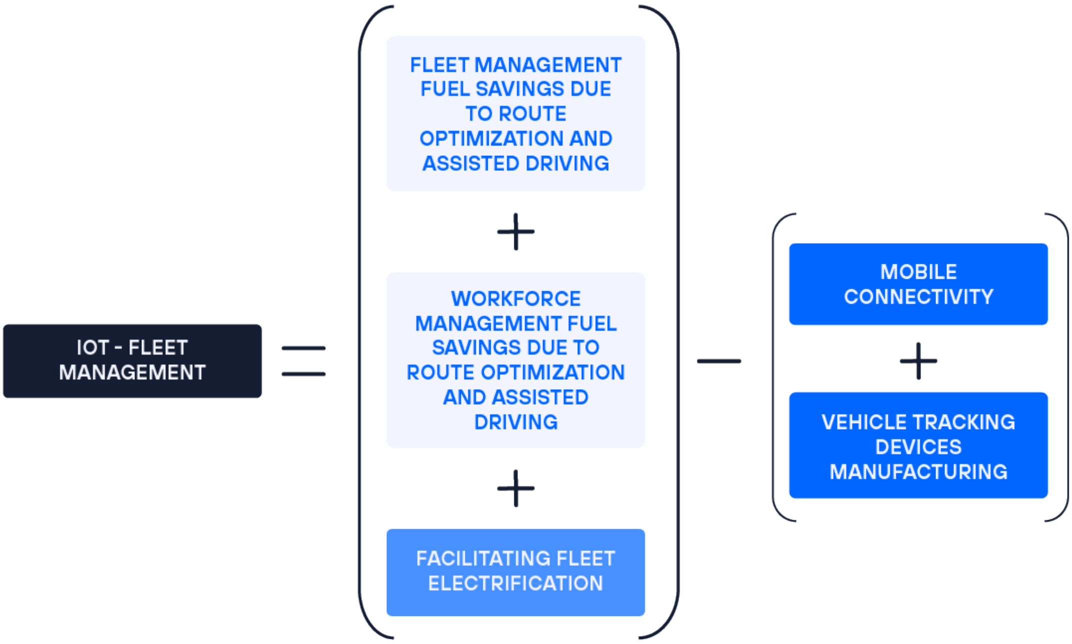


Figure 28 .- Calculation logic for fleet management solution

3.2.4.5. Data quality, specificity and uncertainty

The main sources of information for each data item used to create the evaluation model for this solution, are contained in the following table, where an evaluation of the source quality is performed.

DATA ITEM	DATA SOURCE	SOURCE QUALITY	REFERENCE YEAR	GEOGRAPHICAL SCOPE
Telefónica's fleet management connections	Telefónica – Yearly activity data	Primary	2024	Country specific
Mobile access emission factor	Telefónica - ITC networks LCA	Primary	2022	Country specific
Fleet management device manufacturing	Specific device LCA conducted using technical datasheets of the device	Primary + Secondary	2024	Europe

DATA ITEM	DATA SOURCE	SOURCE QUALITY	REFERENCE YEAR	GEOGRAPHICAL SCOPE
SIM Cards manufacturing	Fraunhofer IZM – Comparative LCA for SIM and e-SIM cards	Secondary	2022	Europe
Fuel saving due to smart fleet management	Geotab – Average of the fuel savings from 9 real use cases published by the Geotab platform	Secondary	2021-2024	Spain
Vehicle related emissions	DEFRA - UK Government GHG Conversion Factors for Company Reporting	Secondary	2024	UK
Fleet electrification potential	Geotab - Taking charge. On the road to the EV future	Secondary	2024	Country specific for Spain and Germany. Proxy for Brazil
Difference in the GHG emissions between ICE and EV	IDAE - Instituto para la diversificación y el ahorro de la energía // DEFRA - UK Government GHG Conversion Factors for Company Reporting // Ferramenta do Programa Brasileiro GHG Protocol // Umwelt Bundesamt - Vergleich der durchschnittlichen emissionen einzelner verkehrsmittel des linien und individualverkehrs im personenverkehr in Deutschland	Secondary	2024	Country specific
Fleet management vehicles use profile and average distance travelled	Telefónica – Own assumption based on previous experiences	Proxy	2024	Europe
Workforce management vehicles use profile and average distance travelled	Telefónica – Own assumption based on previous experiences	Proxy	2024	Europe

Table 17 .- Fleet management - Data quality evaluation

From the uncertainty perspective, associated to the data quality used for this solution, there are only two data sources with "proxy" quality, which have a slightly lower data quality than the rest, so an uncertainty analysis can be done. These sources are part of the calculation for both the two positive second order effect and the higher order effect, meaning that this estimated information is directly linked with the avoided emissions result.

It should be noted, according to the expert judgment of the professionals in this solution at Telefónica, that the avoided emissions declared for this digital solution are uncertain. It is important to highlight that the vehicle use profiles, and the average distances travelled, although being a proxy, have been directly defined by the team in charge of this digital solution. Therefore, only slight deviation is expected for these parameters.

The secondary sources used are mostly recent and coming from credible organizations such as the smart devices manufacturer, public institutions to define the emission factors or Geotab, which is the data analytics solution developer.

Main additional assumptions are:

- The monthly data traffic expected for the SIM cards used in this service is less than 100 MB/month. Accordingly, the Telefónica 4G network operation-related impacts have been adapted to better reflect the situation of this IoT technology.

- Only the fleet management solution required an associated Geotab device. For the workforce management solution, the service works through an APP, which does not even require a dedicated M2M SIM card.

- 12.18% is assumed as the average fuel efficiency achieved both by the fleet management and the workforce management solutions. The same efficiency is used due to difficulties in splitting the information coming from the use cases between the specific solution, as sometimes the use case involved both solutions. However, a conservative approach has been taken, as it is known that higher efficiencies are achieved in fleet management, given that a higher baseline fuel consumption generally entails more improvement potential.

- Vehicle related emissions have been calculated based on the most common vehicle profiles provided by Telefónica Tech on the fleet management service and on the workforce management service, differentiating between the emission intensities for different vehicles. The profiles for the fleet management service include light vehicles, medium vehicles and heavy vehicles while the profiles for the workforce management service include only light and medium vehicles.

- It is assumed that the electrification benefit for the share of vehicles that Geotab considers currently technically and economically feasible to be EV will happen in a maximum of 7 years, which is the expected service life for a fleet of this kind. Thus, the calculated potential is divided by 7 when calculating the avoided emissions, to reflect only the yearly benefit of this higher order effect.

- The source document for the fleet electrification potential does not have information regarding American scope. However, the last technical note published in 2024 by OLADE (Organización Latinoamericana de Energía) on electric mobility evidences the growing electric mobility capacities for this region. 20% electrification potential, which is the minimum value in the "Taking charge - On the road to the EV future" report, is assumed as proxy for Brazil.

The analysis of the model created for this solution has medium specificity level, according to the specificity evaluation matrix.

		DIGITAL SOLUTION		
REFERENCE SCENARIO	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 18 .- Fleet management - Specificity of the solution

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