MISSION INNOVATION

NET-ZERO COMPATIBLE INNOVATIONS INITIATIVE

Towards >60 Gigatonnes of Climate Innovations

Module 2

The Avoided Emissions Framework (AEF)

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September 2020

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The Avoided Emissions Framework (AEF) is at the core of the initiative and provides guidance for how avoided emissions can be assessed. The objective is to develop a draft framework that is capable of classifying and then ranking companies/solutions, based on their positive climate impact, through their supply of low carbon products and services. The AEF will be applicable to: 1) Products/solutions; 2) System solutions; and 3) Companies/cities.

The additional modules in the 1.5 °C Compatible Solution Framework are:

Module 1

A Three-Step Solution Framework for Net-Zero Compatible Innovations (TSF)

Module 3

1.5 °C Compatibility Pathfinder Framework (CPF)

The Net-Zero Compatible Innovations Initiative is one of the activities in the global Mission Innovation Action Plan for 2018 – 2020, which aims to accelerate the development and deployment of innovative solutions that can help tackle climate change.

The purpose of the initiative is to identify and support solutions (including technologies, products, services and business models) that are part of a net-zero development path. Examples include both more incremental and more disruptive solutions such as the use of virtual meetings to displace business travel, replacing a fossil motor vehicle with non-motorised/virtual mobility, or offering an advisory service to help companies move from business models based on selling products to offering access (dematerialised when possible).

So far, the climate challenge has primarily been approached as a problem where the focus is on reductions of emissions by companies, countries and cities. Most tools for measuring and reporting, as well as incentive structures, have therefore been developed under a reduction perspective. Negotiations and media ask for reduction targets, investors want to know how much companies emit, reporting frameworks help companies and cities to keep track of their emissions. There are many reasons for this, as discussed in Module One. Critically, initiatives and organisations were created before the impacts of the fourth industrial revolution and the scope and scale of the reductions needed in society were understood; and because the mandate of many initially involved in the climate discussion was to deal with the laggards in the corporate sector. **This resulted in a situation where companies, cities and countries were viewed as problems and the best they could do was to reduce their emissions to zero. When zero was not possible, this approach resulted in offsetting.**

To view companies, cities and countries as sources of emissions is however, only half of the equation. An innovation approach provides the opportunity to focus on the solutions the world needs and how companies, cities and countries can provide these. With the fourth industrial revolution and new business models, it is also becoming increasingly counterproductive to only ask companies, countries and cities for reductions as this will undermine many disruptive innovations and ignore solution providers.

Instead of starting by asking stakeholders how they shall reduce their emissions, it is time to identify low-carbon leaders by starting to ask what solutions they can provide. Such an approach can accelerate the uptake of both individual solutions as well as transformative system solutions that require new clusters for implementation.

The existing reduction tools are important as they allow tracking of emissions from companies and cities. They can also help in formulating targets for certain emission reductions, and help in risk management, identifying cost reduction opportunities and supporting policymaking that focuses on the emissions from the operation of organisations. Such work must continue and be strengthened.

However, tools for measuring and reporting, as well as incentive structures, are also needed for solutions and solution providers. In this area there has been far less consistency. There is also a need to understand which solutions are compatible with a net-zero development path and how to avoid high-carbon lock-in.

The approach and methodology outlined in this initiative has therefore been developed to provide a robust and coherent way to measure, assess, and compare the current and potential impact of innovations that help reduce greenhouse gas emissions in society and contribute to a net-zero development path. Such a framework has the potential to support greater levels of innovation, as well as unlocking growth and new revenue opportunities for the innovations, necessary to address the challenge of climate change and achieve the ambitions of the Paris Agreement.

Contents

Document History

This document, published in September 2020, is updated from the previous draft that was published in November 2019. This follows inputs and comments from various stakeholders, and also reflects experience gained in the calculation of numerous examples of innovations that will be presented at the 5th Mission Innovation ministerial meeting of 2020. 100 innovations have already been presented at the 2019 Mission Innovation ministerial meeting and are presented on the Avoided Emissions Framework Website. The November 2019 and October 2018 versions incorporated structured feedback from various stakeholders that was collected through workshops, webinars, meetings and interviews.

The following tables summarise the document's version history, the key feedback activities, and the more significant changes to the document.

Table 1: Version history

Document version	Publishing date	Status
V1	October 2018	Superseded
V2	November 2019	Superseded
V3	September 2020	Active

Comments and input were received from the following organisations:

BT; Carbon Trust; CDP; Church of England; Ericsson; FTSE Russell; Hermes Investment; Quantis International; Rapid Transition Alliance; RISE; Smith School, Oxford University; Stockholm County Council; Swedish Energy Agency; Wirtschaft macht Klimaschutz; World Resources Institute; WWF.

The following government departments and agencies were consulted:

Department of Environment and Energy, Australia;
Energy Research Company (EPE), Brazil;
Natural Resources Canada;
Ministry of Energy, Utilities and Climate, Denmark;
DG Climate Action (CLIMA), European Commission;
DG Energy (ENER), European Commission;
Joint Research Centre (JRC-ISPRA), European Commission;
DG Research and Innovation (RTD), European Commission;
VTT Technical Research Centre, Ministry of Employment and the Economy, Finland;
Ministry of Research and Innovation, France;
Ministry for Europe and Foreign Affairs, France;
National Informatics Centre, India;
Ricerca sul Sistema Energetico (RSE), Italy
The Institute of Applied Energy (IAE), Japan;
Secretariat of Energy, Mexico;
Swedish Energy Agency, Sweden;
Ministry of the Environment and Energy, Sweden;
Department of Business, Energy and Industrial Strategy, UK;

Table 2: Main Changes added to Version 2 of the document

Topic	Description of Update	Section within Methodology	Reason for Update
SDGs	A new sub-section was added discussing the synergies of the framework with the Sustainable Development Goals.	**1.3** - GHG accounting, reporting and ranking frameworks	Highlight how other sustainability aspects outlined under the SDGs should be taken into consideration when applying the AEF methodology.
Use of the AEF	New section added describing different uses of the Framework	**1.6** - Who might use the Avoided Emissions Framework	Provide additional guidance.
Future solutions	New section added for future solutions, including discussion and guidance for assessing clusters of solutions, market share, low TRL and strategic solutions.	**3.12** - Assessing future solutions	Provide additional guidance.
1.5°C compatibility	New section added on compatibility of solutions with a global 1.5°C scenario. Including discussion of approaches to test for 1.5°C compatibility.	**3.13** - Compatibility with a global 1.5°C scenario	Identify importance of compatibility with 1.5°C scenario. Describe current approach being developed.
Baseline	Added summary table to section discussing setting of the baseline	**3.6** - Baseline	Provide additional guidance in response to comments on the previous draft.
Application of Methodology	Added new sections 4. "Application of Methodology", including 4.1 "Learning from Existing Standards and Guidelines" based on interviews with key stakeholders, and 4.2 "Application of the AEF Methodology to other frameworks".	**4** - Application of Methodology	Outline learnings from developers and users of existing standards to highlight key issues around the adoption of the AEF. Discussion of the AEF in the context of three other frameworks: CDP, TCFD, and the EU Taxonomy.
Worked Examples	Added the three worked examples to illustrate use of the methodology	**5** – Worked Examples of Framework Application at a Solution Level	Worked examples added.
Checklist	Checklist added	**6.1** – Checklist	Provide quick reminder of some key items in performing the assessment of avoided emissions.
Data Sources	Table of indicative common data requirements for avoided emissions assessments, and discussion of data sources.	**6.2** – Data Sources	Examples of data requirements, with the intention to develop a project to create a data base of useful data points.
Appendix 1	Added more examples of related initiatives to the list in Appendix 1	**Appendix 1** - Examples and References	Additional examples have been identified.

In addition, minor clarifications and other changes have been made to the text.

Table 3: Main Changes added to Version 3 of the document

Topic	Description of Update	Section within Methodology	Reason for Update
Version history	Added table listing all document versions and indicating the latest "active" framework document. Added table to track changes between V2 and V3.	Document history	Facilitate identification of latest version of the framework and changes to past and current documents.
Key GHG reporting standards and frameworks	Added reference to ISO GHG related standards and highlighted difference between guidelines provided by relevant ISO and GHG Protocol standards and the AEF framework.	**1.3** – GHG accounting, reporting and ranking frameworks	Provide additional information and guidance.
TRLs	New section added on how to take into account TRL levels when assessing avoided emissions and highlighting key differences between low and high TRL technologies that can impact avoided emission calculations.	**3.13** - Assessing solutions at different Technology Readiness Levels (TRLs)	Provide additional guidance.
Allocation	Added more information on allocation approaches that should be considered, outlining when each one should be used, as well as the related benefits and challenges to implementation.	**3.10** – Attribution (Allocation)	Provide additional guidance.
Appendix 1	Added more examples of related initiatives to the list in Appendix 1	**Appendix 1** - Examples and References	Additional examples have been identified.

Structure of the Document

This document has the following structure:

1. **Introduction**

   introduction and background to the framework

2. **Guidance**

   this section provides an overview of the framework and approach; the general steps for applying the framework

3. **Methodology**

   provides details of the methodology and discussion of some of the aspects of the methodology

4. **Application of Methodology**

   discusses the methodology in the context of other guidance and frameworks.

5. **Worked examples**

   three examples are presented for applying the framework

6. **Checklist and Data Sources**

   a short checklist when using the methodology and a list of common data categories used for assessments

Appendix 1

Examples and references

Appendix 2

Glossary

1 Introduction

The Paris Agreement set an ambitious aim to hold the increase in global temperature to well below 2°C and pursue efforts to limit the temperature increase to 1.5°C. Achieving this aim is vital to avoid major disruption to human life on the planet. However, projections based on current NDCs predict a temperature rise of over 3°C.[1] To deliver the dramatic emissions reductions that are needed, will require more than a business-as-usual approach to companies reducing their existing emissions. It will require new approaches driven by companies delivering innovative and disruptive solutions that will bring about significant changes in societal behaviour and overall reductions in emissions. Many of the most significant emissions reductions today have been delivered by companies delivering solutions, not simply reducing their own emissions. Examples such as renewable energy, electric cars, dematerialisation, virtual meetings, etc. have been driven by companies providing solutions rather than by reducing their own emissions. The Fourth Industrial Revolution[2] (connectivity, new materials, and new business models) also provides ample examples of opportunities. This is not to say that companies own emissions are unimportant, we will only reach a zero-carbon society if all emissions are brought down to zero. However, rapid reductions in emissions require innovative solutions, and this requires an approach which can assess the impact of the avoided emissions from these solutions. This framework aims to provide a structure within which avoided emissions can be assessed and included into the strategies for overall emissions reductions and decarbonisation. It builds on existing practice and initiatives.

To accelerate emission reductions companies cannot only be driven by cost and risk reductions, but must also use their capacity for innovation to deliver the solutions that we need. Hence, solutions providers need the tools and credibility to be *able to demonstrate* their positive impacts in society. It is not sufficient to just allow polluting companies to show how they reduce their emissions, governments need to be able to direct support to providers of solutions in a cost-efficient way (most GHG emissions reduction for the buck). Investors need to be able to identify winners in a low/zero-carbon economy (not just avoid the losers). This will require a shift in emphasis from 'doing less bad' to 'doing more good', but will also need tools and methods to quantify and compare the impact of different solutions and potential solutions.

1.1 Introduction to framework

The Research Institutes of Sweden (RISE) is leading an initiative together with the Swedish Energy Authority, the Carbon Trust, and other partners, to provide an assessment framework that is able to identify companies, system solutions and technologies that have significant ability, or potential, to contribute to reduce greenhouse gas (GHG) emissions in society, so called avoided emissions. The initiative has been adopted as one of the activities in the Mission Innovation Action Plan for 2018-2020.[3]

The objective of the initiative is to develop a draft framework that is capable of classifying and then ranking companies/solutions, based on their positive climate impact, through their supply of low carbon products and services. The methodology framework will be applicable to: 1) Products/solutions; 2) System solutions; and 3) Companies.

This document is an initial step in the development of the methodology framework. It has been developed by starting with existing published methodologies that relate to avoided emissions.

1.2 Concept of avoided emissions

The overall concept of avoided emissions is that a solution (product or service) enables the same function to be performed with significantly less GHG emissions. The method of measuring avoided emissions is to compare a baseline scenario without the enabling solution with a scenario using the enabling solution, where the baseline represents the 'business as usual' (BAU) scenario.

1.3 GHG accounting, reporting and ranking frameworks

A short history of GHG accounting and reporting
Arguably, the formation of the United Nations Framework Conventions on Climate Change (UNFCCC) in 1992 and the Kyoto Protocol of 1997 focussed attention on the measurement of GHG emissions at a national scale. And this then looked at industrial sectors that contribute significant emissions. Hence the first generation of companies that measured their emissions were those companies directly responsible for significant emissions such as power plants, steel, chemical and cement plants (those with significant scope 1 emissions).

Over time, other companies also began to measure and report their emissions, including the emissions of their value chain which could also be significant – for example, automotive companies (due to the emissions from the cars) and food companies (due to the emissions from farming). However, the focus remained on the companies responsible for large emissions. This was due to a combination of factors, from NGOs and environmental authorities focus on companies as a problem, to the financial investment approach of only considering climate change as a risk where companies with high carbon exposure should be avoided.

Reporting of GHG emissions by companies is now well established, with most large corporations reporting their annual emissions as a matter of routine. However, commonly agreed approaches and standards for GHG accounting have only been established in the last 20 years, which is a mere flicker in time compared to the history of financial accounting.[4]

Frameworks for reporting of GHG emissions, and frameworks for ranking of companies on sustainability criteria, are also relatively recent, with the GRI formed in 1997 and the CDP being founded in 2000.

While over the last 10 years there have been a number of initiatives related to avoided emissions and net-positive approaches, there are currently no agreed standards for the assessment and reporting of avoided emissions, although the GHG Protocol Product Standard refers to avoided emissions.[5]

For a more detailed perspective on the history and evolution of the net-positive approach see the Cybercom report:[6] 'Digital Sustainability – Global sustainability as a driver of innovation and growth'.

Summary of key GHG reporting standards and frameworks
The GHG Protocol supplies the world's most widely used greenhouse gas accounting standards.[7] Three key GHG Protocol standards (and initial publication dates) are: the Corporate Standard (2001, revised 2004), the Product Standard (2011), and the Scope 3 Standard (2011).

The International Organisation for Standardization (ISO) has also published a series of standards related to GHG emissions. The ISO 14060 family of standards, part of the ISO 14000 series of International Standards for environmental management, provide guidance and requirements on quantifying, monitoring, reporting and verification of GHG emissions and removals at an organisational, project and product level. There are 3 key standards falling within this family that provide guidance to intended users (as opposed to verifiers):

- **ISO 14064-1:2018** - Organisational level principles and requirements for the quantification and reporting of GHG emissions and removals. ISO 14064-1 is consistent with and based on the GHG Corporate Standard.[8] Both this ISO standard and the GHG Protocol Corporate Standard do not provide specific guidance on avoided emissions, but focus on defining a GHG accounting approach for companies covering their direct emissions (emissions from sources owned and controlled by the reporting entity) and indirect emissions (emissions caused by activities of the reporting entity but from occurring at sources owned or controlled by other entities).

- **ISO 14064-2:2019** - Project level principles and requirements for the quantification, monitoring and reporting of activities intended to cause GHG emissions reductions or removal enhancements.[9] This ISO standard is aligned to the GHG Protocol for Project Accounting guidance. While there are similarities between the ISO and GHG Protocol methods for calculation emission reductions and the AEF approach, the former two focus on quantifying emission reductions achieved by specific projects that have been/are being implemented or that are planned for the near future. The AEF, on the other hand, has a broader scope aiming at guiding users in assessing the avoided emissions potential of existing or new technologies.

- **ISO 14067:2018** - Product-level carbon foot-printing quantification principles, requirements and guidelines.[10]This standard, similarly to the GHG Protocol Product Standard, aims at determining one or multiple product's total GHG emissions and removals on a lifecycle basis, but does not include avoided emissions in the calculation boundary.

The GRI Sustainability Reporting Standards are used by businesses and governments worldwide to understand and communicate their impact on critical sustainability issues such as climate change, human rights, governance and social well-being. In 2000 the GRI launched the first version of its reporting guidelines, representing the first global framework for comprehensive sustainability reporting. The guidelines have been continually updated with new releases, G4 was launched in 2013.

CDP was formed in 2000 to support companies to disclose their environmental impact primarily in terms of GHG emissions. It has become the global repository for corporates to report their GHG emissions, with over 7,000 companies reporting in 2019. CDP uses the responses from companies to create a ranking by scoring company responses from A to D.

However, all existing major measurement and ranking systems related to climate change impact still focus on companies' and cities' GHG emissions and emission reductions. The purpose of this document is to shift the focus to the potential positive impact that a company can have in reducing its customers' emissions through the use of its products and services, so called avoided emissions.

Other sustainability ranking systems, reporting frameworks and the SDGs

In addition to reporting standards and frameworks that primarily focus on GHG emissions, a number of other sustainability ranking systems exist, which cover a wider set of sustainability issues. Two of the most notable examples include the Dow Jones Sustainability Index (DJSI), and the FTSE4Good Index, (which is based on the FTSE Russell ESG rating system). The FTSE Russell Green Revenues model takes this further by measuring the proportion of a company's revenue that is linked to a green product or service, and providing a 'Green Revenue Factor' for different green revenue sectors.

The EU Taxonomy Technical Report, published in June 2019, defines a classification system for sustainable economic activities, developed as part of the EU Sustainable Finance initiative. It provides technical criteria to determine whether investments will be included in the EU Taxonomy. The relevance of the AEF Methodology to the EU Taxonomy and other frameworks is discussed further in section 4.2.

Another example are the Sustainable Development Goals (SDGs), which includes a set of 17 goals defined by the UN development agency (UNDP) with the aim to 'end poverty, protect the planet and ensure that all people enjoy peace and prosperity.' While these goals are for the most part used to assess progress at a country level, increasingly more companies have aligned their own targets and goals to the SDG framework. This is supported by initiatives such as the SDG Compass, which has translated the SDGs into a database of suitable indicators for businesses.

As the 'Avoided Emissions Framework' currently focuses solely on GHG emissions, it will be important take into account the wider sustainability impacts of the solutions, companies and portfolios that are being assessed. While it may be difficult to carry out a quantitative assessment against all SDGs, as a minimum, it is recommended to identify and report potential negative effects on any of the SDGs. This would ensure that solutions are evaluated and compared from a more holistic perspective and any trade-offs between GHG savings and other sustainability issues are clearly understood.

To further assist this evaluation, positive impacts on SDGs may also be identified and reported. This could, if possible, include a quantitative evaluation, or a qualitative description of the impacts. While theoretically all SDGs could be negatively or positively impacted by a solution, the following list of SDGs are the most likely to be effected by the solutions assessed under the 'Avoided Emissions Framework':

Goal 7: Affordable and Clean Energy
Goal 9: Industry, Innovation and Infrastructure
Goal 11: Sustainable cities and communities
Goal 12: Responsible Consumption and Production

Goal 13: Climate Action
All of these goals are interlinked with the reduction in GHG emissions required to limit global warming and therefore any solutions assessed under the 'Avoided Emissions Framework' will have some impact on these goals.

An example of how the 'Avoided Emissions Framework' relates to SDG 11 (Sustainable Cities), is through the PED[11] framework. The PED is a framework for "Positive Energy Districts and Neighbourhoods for Sustainable Urban Development" supported by the EU. PEDs are urban areas that produce net zero greenhouse gas emissions and have a surplus production of renewable energy. This is achieved through a combination of energy efficiency, energy production and energy flexibility. The 'Avoided Emissions Framework' can identify products and solutions that have a direct impact on these aspects of energy use in urban areas.

1.4 Avoided emissions – Maturity of approach and future ambition

There are today a number of examples of net-positive initiatives, approaches for assessing avoided emissions, and companies that are looking to change focus from 'doing less harm' to 'doing more good'. Appendix 1 lists some of these examples. One of the earliest documents to present an approach for assessing avoided emissions was GeSI's 'Methodology for evaluating the carbon-reducing impacts of ICT',[12] published in 2010. A number of ICT companies and other initiatives have since published work in the same direction, also using some of the earlier company led net-positive strategies from 2007 – 2010.

Thus the current examples and practice of net-positive approaches are developing and reasonably mature, although there remain a number of methodological challenges.

Current examples broadly fall into the following categories:

1. **Companies that are reporting avoided emissions and having net-positive targets**
   These include a number of international ICT companies, and other multi-national companies such as IKEA and Kingfisher.

   New initiatives are also emerging. The Net Positive Project is a cross sector collaborative initiative to develop principles, methodologies and promote the net positive concept (which extends beyond just GHG emissions to include other sustainability aspects).

2. **Financial investment and disclosure initiatives.**
   The finance and investor sector have historically had some ethical and socially responsible investment approaches that do not invest in certain sectors, and for a climate perspective do not invest in fossil fuel companies. More recent approaches are now looking at climate-positive investment decisions by actively selecting more sustainable companies, based on ranking criteria.

Examples include: the FTSE Russell Green Revenues ranking model; the Transition Pathway Initiative; Carbon Delta's 'green patent' assessment methodology; and WHEB's sustainability fund.

Mark Carney, the former Governor of the Bank of England, and Laurence Fink, CEO of Blackrock are two prominent leaders in the finance sector encouraging companies to fully disclose their climate change risks. The TCFD published its recommendations for financial disclosures in 2016.

3. **Identification and acceleration of new solutions**
   WWF have for over 15 years been active in researching, promoting and publishing reports in relation to avoided emissions, and have developed the Climate Solver Tool – an on-line calculator for assessing the carbon reduction potential from technologies. The Swedish energy agency have used a version of the WWF framework to assess its portfolio of low-carbon entrepreneurs. The possibilities to assess Mission Innovation initiatives is most closely related to these initiatives. An increasing number of cities are also increasingly focusing on supporting solution providers, not only supporting emissions reductions from big polluters.

As mentioned above, existing reporting frameworks and methodology initiatives have focused on companies as sources of emissions, not sources of solutions. Their offer to the financial sector and other stakeholders has been mainly about avoiding risks associated with significant dependence on fossil fuels, or to identify the worst in existing sectors. In later years there has been a growing understanding about the need to also identify those companies with solutions.

Sector specific methodologies have been published for the chemicals and cement industries. The WRI published a working paper relating to avoided emissions in March 2019 ('Estimating and Reporting the Comparative Emissions Impacts of Products.' – Working Paper).

(See Appendix 1, for more details of these examples).

Challenges
One of the key challenges of current approaches is providing a consistent method for reliably quantifying avoided emissions. The process often has a higher uncertainty compared to measurement of emissions within a company's direct control such as Scope 1 & 2 emissions. This is because it often relies on estimates and assumptions, and is inherently considering hypothetical cases when comparing to the base case (i.e. what would have happened if this did not happen). This means that the assessment may be resource intensive, and therefore costly. As data and routines are established the costs will fall. It is therefore important to apply the appropriate level of detail to data gathering and calculation relevant to the purpose for which the results will be used, so that efforts and resources are directed to those areas which have the most significant impact on the overall result.

What is important is to initially establish an understanding of the order of magnitude of the potential avoided emissions opportunities, so that companies with significant opportunities to reduce emissions though their products and services are encouraged to increase those contributions.

In the future, as even more reliable data and studies become available and easier to process due to factors like digitalisation, increased transparency, inexpensive sensors, process power, etc., the process to estimate positive contributions should become easier and more accurate.

Future Ambition
A future scenario would be where relevant companies routinely publish their avoided emissions (for all relevant products, and for the company as a whole). This would sit alongside their financial reporting, and the reporting of their GHG emissions. This information would then be used by investors and analysts to help understand a company's exposure to climate change related risks as well as their potential to make money and be successful under different reduction scenarios.

This future scenario could also include a situation where avoided emissions would be verified and traded.

1.5 Different motivations for assessing avoided emissions

Different stakeholders will have many different needs and motivations for assessing avoided emissions. These could vary from very initial, high-level estimates to detailed and verified assessments. The required assessment process will change as tools and data develop for doing the analysis, and as organisations travel through the different stages on their 'avoided emissions journey'.

These different stages will therefore require different levels of rigour, which should be borne in mind as this framework is applied.

For example, the following three stages could be envisaged on the 'avoided emissions journey' for a company:

A A company is starting to think about its potential role as a solution provider: It needs to get a general and approximate overview of the current situation, using current sales data and multiplying this by average sector estimations of carbon abatement factors. This assessment will be very rough, but will help the company to understand its potential role as a solution provider and what parts of the company are delivering reductions in society and what parts are resulting in increased emissions.

B Providing guidance for the development of a strategic plan for avoided emissions: This could drill into more details in quantifying the actual amount of avoided emissions and allow for calculations of how the market and income could change over different scenarios. This, in turn, would help the company to prioritise the development of certain products, where to invest, and identify potential new markets and revenue streams.

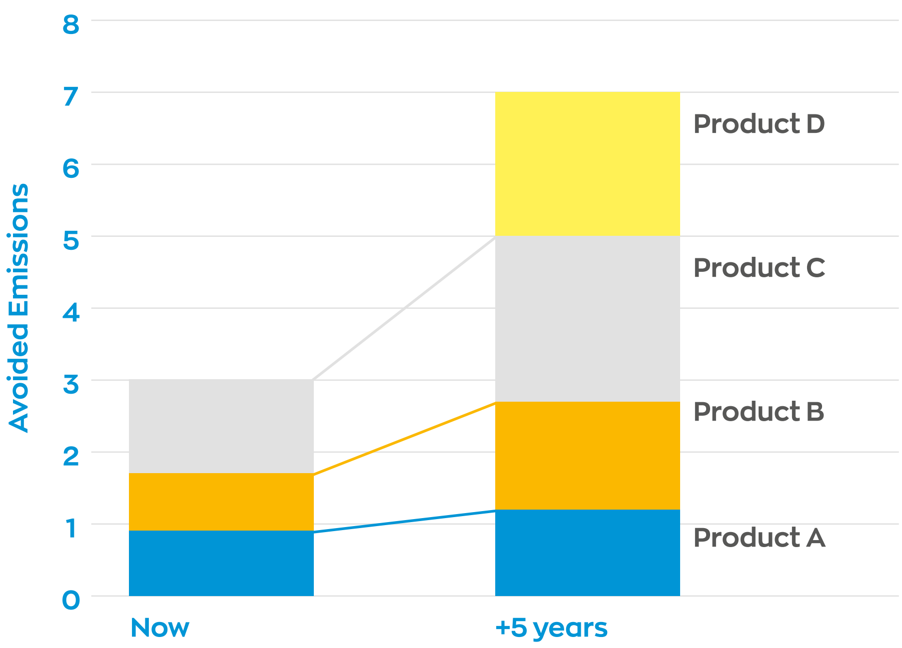
C Get actual reduction measures that can be traded/sold on a market. At this stage, it is envisaged that there would exist established markets for trading of avoided emissions credits. In this case, the numbers need to be verified and allocated in ways that are not important in stages A and B. This stage therefore requires a much more rigorous approach to the calculations, traceability of the data and justification of the assumptions, and an independent audit of the process. (Note: C might never happen).

1.6 Who might use the Avoided Emissions Framework

The approach of the Avoided Emissions Framework could be used by companies, government organisations and investors for different purposes and over different timescales. The following highlights some examples to illustrate usage:

Companies
Some companies already regularly report their current actual avoided emissions that are enabled by a portfolio of products. (See Appendix 1 for some examples). Similarly companies might project this analysis forward to set targets, and assess what the impact will be in 5 years' time. Additionally, a company might use the approach to assess the impact of new products, and use this to influence the development of the products.

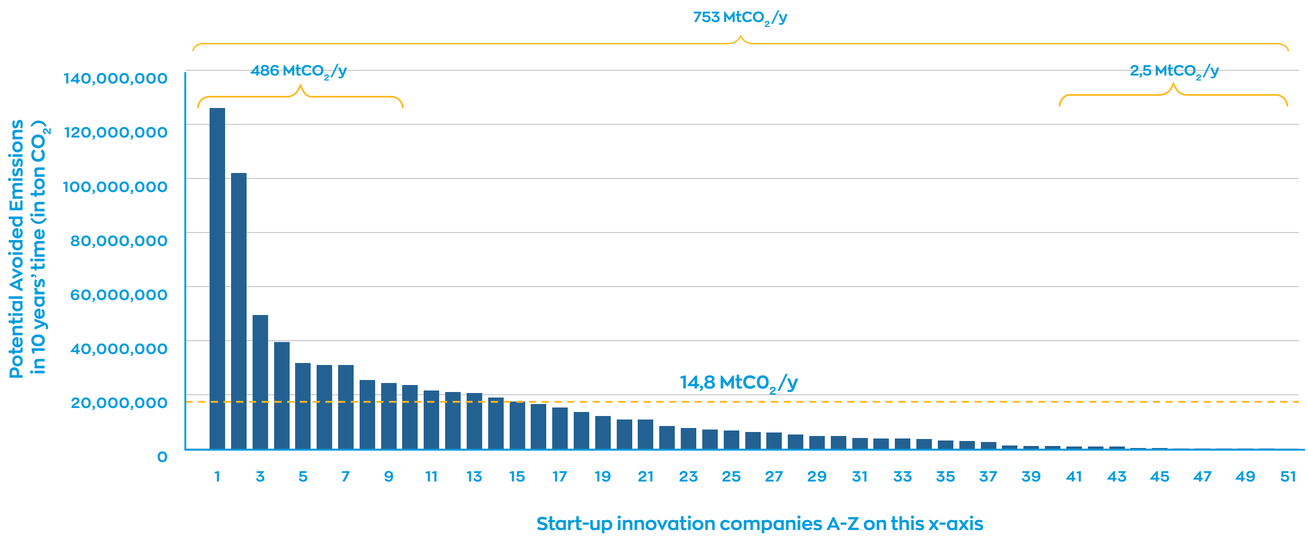
Figure 1: Company assessment and reporting of avoided emissions



Government Organisations

Government organisations wishing to invest in low carbon technologies can use the Avoided Emissions Framework to assess different technologies or solutions to prioritise and guide investment decisions. For example, the Swedish Energy Agency has been using this approach (using WWF's Climate Solver tool) to assess the potential avoided emissions from the portfolio of innovation companies that they are supporting. The chart below showing the results of this analysis.

Figure 2: Analysis of portfolio of innovation companies



Investors

Investors have started to focus on looking at the positive social and environmental impacts of their investments (moving from simply not investing in companies that have negative impacts). Some of these initiatives are listed in Appendix 1. Some investors are assessing the avoided emissions from a portfolio of investments. Multi-lateral development banks are assessing the environmental impacts of investments, and this is being extended in some cases to assess the avoided emissions. Green Bonds are becoming popular for ring-fencing finance for low energy and low carbon solutions, and require both specific criteria for the use of funds and specific regular reporting of the impact in terms of reduction of carbon emissions.

2 Guidance

2.1 Overview of Approach/Framework

2.1.1 A short note on terminology

'Avoided emissions' – definition

Avoided emissions can be defined as 'reductions in emissions caused indirectly by a product. This is where a product provides the same or similar function as existing products in the marketplace, but with significantly less GHG emissions'. This definition being derived from the GHG Protocol Product Standard – see chapter 11, sections 11.2 and 11.3.2. (Note that the Product Standard uses the term 'products' to mean either 'goods or services').

'Avoided emissions' is the terminology used by the GHG Protocol. This is elsewhere also referred to as 'carbon abatement' and is often referred to as being caused by 'the enabling effect' of a technology or solution.

Solutions

In this document the term 'solutions' is used to refer to either products or services that have an enabling effect to avoid emissions.

See the glossary in Appendix 2 for terminology used in this document.

2.1.2 Summary of Methodology

In summary, the methodology provides a comparison of the greenhouse gas (GHG) emissions from a business-as-usual (BAU) baseline scenario with those from a solution-enabled scenario to demonstrate the benefit of the solution to reduce overall system-level GHG emissions. This involves calculating the emissions in the following categories:

2.1.2.1 BAU system

The emissions from the BAU baseline, without the introduction of the enabling solution.

2.1.2.2 Enabling Effects

The avoided emissions due to the activities avoided as a result of using the solution. These are further subdivided into *primary (or immediate)* enabling effects and *secondary (or longer-term)* enabling effects.

2.1.2.3 Direct Solution Emissions

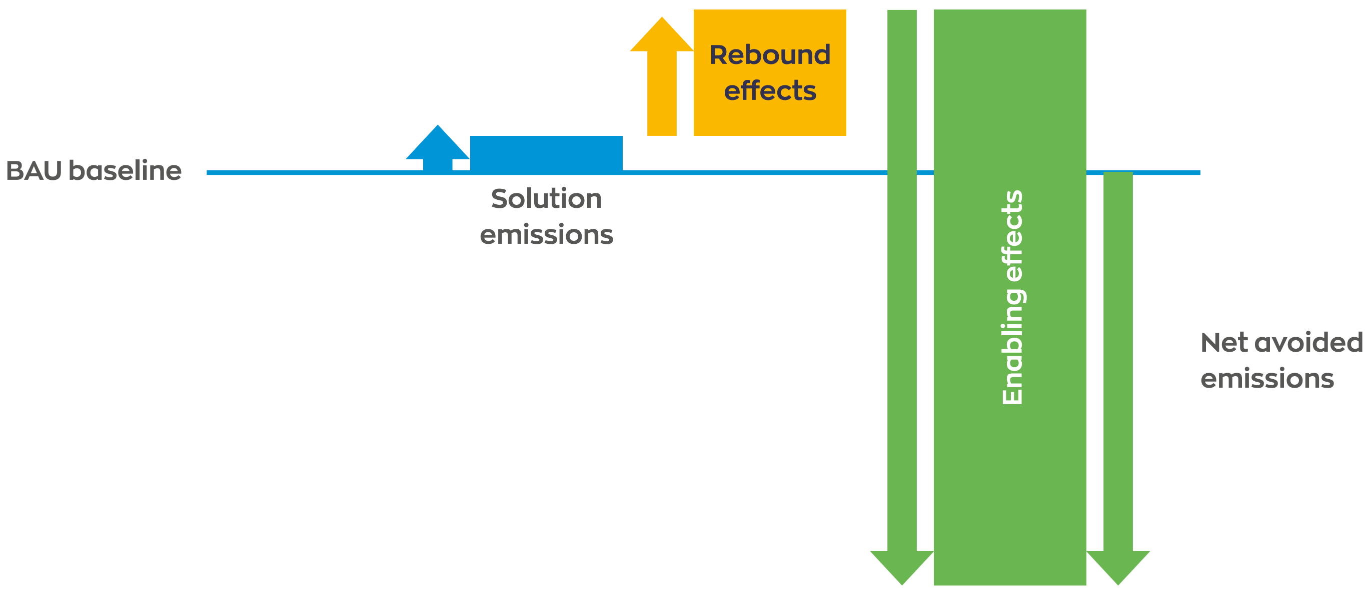
The life cycle emissions of the solution that is causing the enabling effect.

2.1.2.4 Rebound Effects

The increase in BAU emissions occurring as result of the enabling solution implementation. Rebound effects may be caused by related consequential effects or by unrelated (and sometimes unintended) effects and are often related to human behavioural changes in demand for carbon-intensive goods or activities. These effects are further subdivided into *immediate* rebound effects and *longer-term* rebound effects. Because of the nature of rebound effects, they are extremely hard to quantify and predict, and assessing them is inherently uncertain as it is difficult to accurately estimate the effects.

The net avoided emissions are then calculated as follows:

Net avoided emissions
= Enabling avoided emissions - Direct solution emissions - Rebound emissions



The net avoided emissions can alternatively be defined in relation to the BAU emissions as follows:

Net avoided emissions = BAU baseline emissions - emissions of the solution enabled scenario

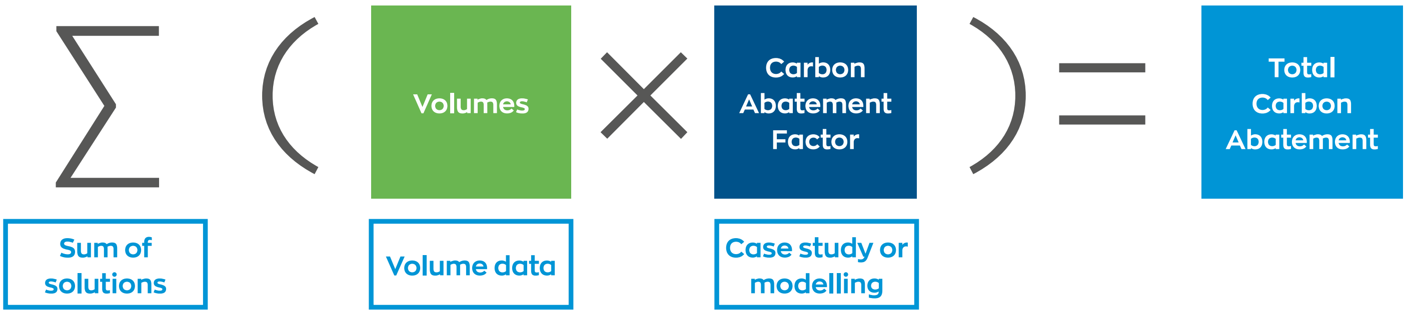
The avoided emissions solutions should deliver an overall reduction in global greenhouse gas emissions.

2.1.3 Calculation Method

Each individual enabling solution is assessed by determining a carbon abatement factor that reflects the net avoided emissions per unit of the solution implemented. (Thus for video conferencing this would be the avoided emissions per video conference, and would be measured in $kgCO_2e$ per video conference).

The advantage of using a carbon abatement factor is that it provides a normalised factor that can be compared between different assessments and studies, thus helping significantly with consistency and comparability. It can be thought of as analogous to the use of the 'emission factor' in product footprinting, which is multiplied by the activity data to calculate the product emissions.

The carbon abatement factor is based on existing academic or industry studies where available, or otherwise based on data or supported assumptions that demonstrate the carbon abatement. In order to calculate the total carbon abatement for a solution over a specific time period, the carbon abatement factor is multiplied by the volume of the solution deployed. And for multiple solutions, the total carbon abatement is the sum for the individual solutions:



In practice, the calculation is more complex than the simplified formula above suggests. Firstly, the 'carbon abatement factor' may require significant research and then additional analysis to appropriately apply it to the scenario being considered. Also, the carbon abatement factor may itself be multiple factors – for example where a solution that reduces electricity consumption is applied globally, the carbon abatement factor will vary regionally to reflect the local electricity grid emission factor. Further, a single solution may have multiple applications, and when used in different contexts can deliver very different outcomes. In this case, either multiple use-cases should be considered, or the analysis should be constrained only to those use-cases that are appropriate and relevant. In summary, it is important that the studies used to provide the carbon abatement factor are appropriate to the assessment, are scalable (i.e. do not only apply to an idealised test case), and the data and quality underlying the studies are relevant and transparent.

Note that there may also be an interconnectivity of volumes and carbon abatement factor – i.e. the carbon abatement factor may change dependent on the volume of deployment. Any analysis should consider this, and it is likely to be relevant for assessing future scenarios (see below). Warnings should be provided when factors and assumptions are not transferable.

Note that the terms carbon abatement and carbon abatement factor are intended to include all greenhouse gases (not only CO_2).

Also the calculation needs to acknowledge the uncertainty in the data and measurements. Ultimately the approach is an estimation, including some assumptions. An uncertainty analysis can be applied to each of the factors to derive an uncertainty figure for the total result. Or, alternatively, a qualitative discussion on uncertainty sources and their implications, combined with sensitivity analysis may be more useful.

Applying the calculation to assess future potential scenarios

Additionally, when applying this approach to future scenarios (which will often be the case for new technologies and solutions) then the probability of the solution delivering the expected benefits should be included (probability of successful development of the solution), as well as the probability of the solution being adopted at scale (probability of adoption).

Thus a more complex version of the calculation can be expressed as follows:

$$\sum\left(\text{Probability of success} \times \text{Probability of adoption} \times \text{Volumes} \times \text{Carbon Abatement Factor}\right) = \text{Total Carbon Abatement} \pm I$$

Thus if we want to assess the possible impact of a new technology, let us assume that the technology can reduce a person's annual emissions by 400 $kgCO_2e$. As this is a new technology we are not certain that it will be successfully developed due to technical challenges, and we assess the probability of success at 70%. The technology is applicable for all of the population, however not everyone will adopt the solution, and there may be alternative solutions that also take a share of the market, thus we assess the probability of adoption at 40%. Then for a country with a population of 50 million the avoided emissions would be:

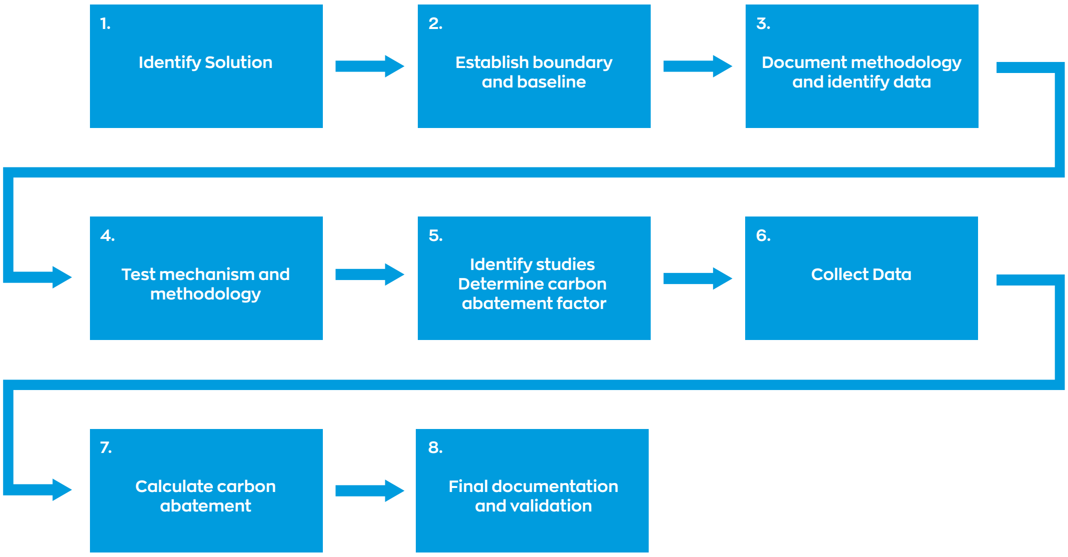
Avoided emissions of solution = 70% × 40% × 50,000,000 × 400 [$kgCO_2e$]

'Flags' for potential lock-in threats
The solution should be analysed for potential long term 'lock-in' threats. This is particularly relevant for long-life high capital investments, where there might be short term benefits, but in the future either the technology may become obsolete, or may lock-in carbon emissions that could have been avoided by different investment. For example replacing a coal-fired power station with a gas-fired power station reduces emissions, but also locks in fossil fuel emissions for a further 30 years.

The solution should be reviewed with regards to its potential impact on society's ability to move in a decarbonisation direction. Any identified risks should be transparently considered and described.

2.2 General steps for quantifying avoided emissions

Steps for quantifying avoided emissions



1 Identify solutions to be assessed

Identify the solutions that are to be assessed. This step may involve a rough calculation of the avoided emissions enabled by the solution in order to determine its significance, and therefore whether it would be useful to do a full detailed assessment, and if so to focus the data collection on the areas that will have the most significant contribution to the total avoided emissions.

2 Establish system boundary, carbon saving mechanism, and BAU baseline

For the chosen solutions, establish what the mechanism is that is causing the enabling effect – e.g. is it travel/fuel saving, or energy saving; and is the enabling effect directly attributable to the solution? Establish the system boundary, BAU baseline and functional unit

3 Document methodology and identify data requirements

Document the carbon saving mechanism and the calculation methodology. This will help to formalise the process, allow the methodology to be reviewed, and identify what data is required for the calculation. The documentation will be further refined when the calculation process has been completed.

4 Test mechanism & methodology

It may be useful to review the methodology at this stage. This may involve independent (internal or external) reviewers, and product specialists to test that the assumptions and proposed methodology are valid and reasonable.

5 **Identify studies and determine the carbon abatement factor**
Conduct research to collect data and studies that provide a quantitative basis for the calculation of the carbon abatement factor. These may be academic studies, other published reports, or internal project studies. The calculation of the carbon abatement factor should include the reference to the BAU baseline, the direct solution emissions, and rebound effects (where these can be quantified).

6 **Collect data (for volumes and carbon abatement factor)**
Complete the data collection related to the carbon abatement factor, and collect the data required to determine the volumes of the solution. (See discussion of data sources in section 3.7.4).

7 **Calculate carbon abatement**
The total carbon abatement can now be calculated by multiplying the carbon abatement factor by the volume for each solution, and then summing the results for all the products being assessed.

At this stage, where considering a portfolio of solutions, it is important to check for overlap between solutions, so that there is not double counting of the same avoided emissions being delivered by different solutions.

8 **Final documentation and validation of the process**
Fully document the methodology and calculation process, including the assumptions and data sources. Ideally, the documentation would be sufficient for someone to independently calculate the avoided emissions, and produce the same results. It is best practice to have the process independently validated. This provides for scrutiny of the assumptions, methodology and data sources; adds credibility to the process; and may identify any errors in the assumptions or calculations. This validation can be performed by either an external expert, an internal expert, or by a panel of reviewers.

2.3 Application of framework at solution, company and portfolio level

This methodology has been developed as a ‘bottom-up’ approach for individual products and services, and can then be applied to companies by totalling up the avoided emissions from the separate products for all of the company’s relevant products.

For investors with a portfolio of companies then the approach is to sum up the avoided emissions from each company.

At each stage of aggregation it is necessary to check for overlap, as the same avoided emissions may be being delivered by different products and by different companies.

In the future, it could be imagined that all companies will report their avoided emissions as routine all to a consistent agreed standard (similar to current reporting of Scope 1&2 GHG emissions to CDP). Then it could be a relatively simple exercise to aggregate avoided emissions from all the companies in an investment portfolio. The reality is that only a handful of companies currently report avoided emissions, and there are no officially recognised agreed standards for measurement and reporting.

2.4 Reporting of avoided emissions

When reporting avoided emissions at a company level, companies should take care to include this in context with other actions that the company is doing on climate change, and particularly to report its efforts in reducing its own emissions. Thus there should be a 'dual approach' of reporting the Scope 1, 2 and 3 emissions and actions to reduce these (including setting science-based reduction targets), as well as reporting on the avoided emissions enabled by the company. If this is not done then companies will be criticised for not taking responsibility for their own emissions, while claiming credit for reducing emissions elsewhere. Note that different companies will validly have different priorities and emphasis between own emissions and avoided emissions – for example a heavily emitting company (such as a steel or cement manufacturer) should focus on reducing their own emissions, while a service company with significant potential to enable avoided emissions can validly focus on their avoided emissions (such as an architecture company that can reduce the emissions of buildings that it designs). In any case, reporting of avoided emissions should not be used to focus attention only on positive examples while ignoring significant emissions elsewhere.

Avoided emissions should be clearly reported as separate from a company's own Scope 1, 2 and 3 emissions, and should not be subtracted from its own emissions.

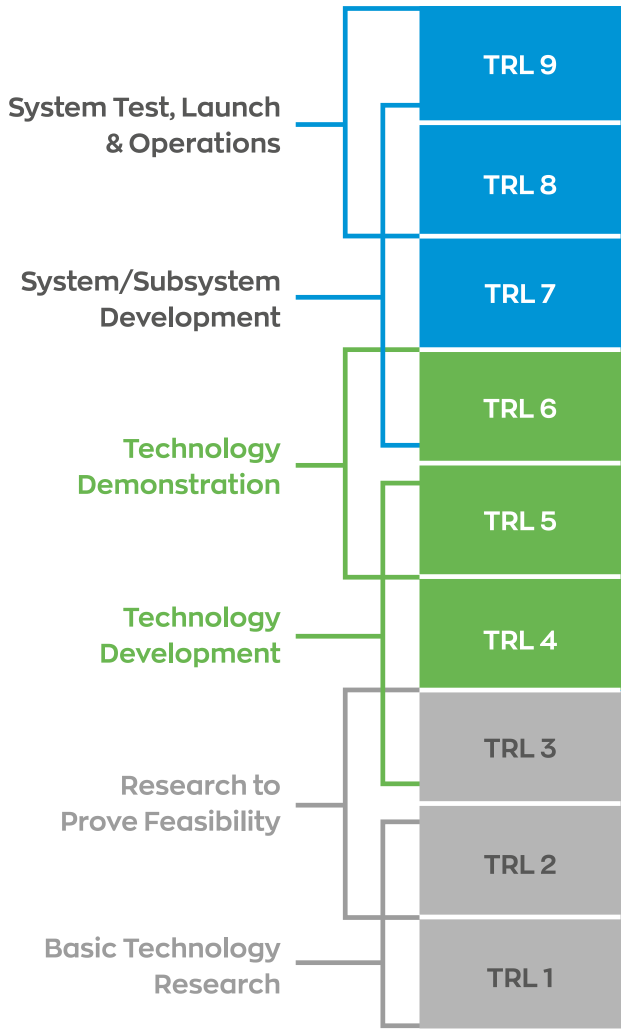
The reporting of avoided emissions should be transparent, clearly stating assumptions, and referencing sources of data. Ideally, the reporting would be sufficiently transparent that someone could independently calculate the avoided emissions, and produce the same results.

2.5 Assessing solutions at different TRL levels

In the calculation method (section 2.1.3) the concept of a 'probability of success' was introduced. This reflects the probability that the solution will be successfully developed, which relates closely to the concept of the 'Technology Readiness Level' (TRL). The greater the TRL, the greater probability that the solution will be successful. Thus if comparing two solutions that are at different TRLs, then all other things being equal, the solution with the higher TRL is likely to deliver greater avoided emissions.

This framework can be used to understand the impact of different development options for new technologies and what to focus on in the development process to deliver more significant avoided emissions. Depending at what stage of the TRL a technology is at, this analysis could fundamentally change the direction of the development (if at the lower end of the TRL scale), or might provide minor but significant changes in configuration and deployment of the technology (if at the higher end of the TRL scale).

The framework can also help with assessing different scenarios, in terms of the uncertainty of the solution, and how this might impact the magnitude and timing of the potential emissions reductions.



3 Methodology

This section expands and discusses further some specific aspects and considerations of the methodology, and explores challenges and opportunities presented by the methodology. It is expected that as this and other related methodologies and approaches are used more widely, then the methodology will further develop and mature.

3.1 General principles

It is expected that the assessment of avoided emissions follows the GHG Protocol accounting and reporting principles of relevance, accuracy, completeness, consistency, and transparency. These are reproduced here from the GHG Protocol Corporate Standard:

Relevance Ensure the GHG inventory appropriately reflects the GHG emissions of the company and serves the decision-making needs of users – both internal and external to the company.
Completeness Account for and report on all GHG emission sources and activities within the chosen inventory boundary. Disclose and justify any specific exclusions.
Consistency Use consistent methodologies to allow for meaningful comparisons of emissions over time. Transparently document any changes to the data, inventory boundary, methods, or any other relevant factors in the time series.
Transparency Address all relevant issues in a factual and coherent manner, based on a clear audit trail. Disclose any relevant assumptions and make appropriate references to the accounting and calculation methodologies and data sources used.
Accuracy Ensure that the quantification of GHG emissions is systematically neither over nor under actual emissions, as far as can be judged, and that uncertainties are reduced as far as practicable. Achieve sufficient accuracy to enable users to make decisions with reasonable assurance as to the integrity of the reported information.

Additionally, as the avoided emissions typically relate to a product or solution, it is recommended that where practical a life-cycle approach is taken to the assessment of the avoided emissions.

The nature of this document is necessarily quite generic. In practise, there will be specific considerations that are different for different sectors, and different approaches for assessment of products vs services. As with product carbon footprinting, there could be developed a hierarchical approach with a set of common generic rules or principles, and then further more specific rules for different sectors.

3.2 Materiality and refining of estimates

Another important principle is that of materiality – that is, the calculations and estimations should reflect the order of magnitude of carbon reductions and carbon emissions. Generally, more detail and better quality data is relevant for the most significant reduction potentials, while less detail is necessary for less significant areas. To understand the materiality, it is often useful to perform an initial high-level scoping assessment, which will identify the largest contributors to the carbon reductions.

This same principle should also be applied in relation to the scope and context of the assessment. For example, the same methodology can be used at a number of different levels:

- Assessing an individual product
- Assessing a company's net-positive product portfolio
- Assessing an investment portfolio including a number of companies
- Assessing future potential avoided emissions from an existing solution in a specific country
- Assessing future potential avoided emissions from a solution under development in a variety of countries

For each of these different scenarios, different levels of data quality and estimation techniques would be appropriate. This can be imagined as a funnel of assessments, and as the scope and context is refined and becomes more precise, then so do the data and estimation methods needed also become more precise.

A further future scenario, is where avoided emissions can be verified and traded. This would have an additional level of rigour and independent validation required, and more detailed protocol to specify the calculation methodology, which could be sector or product specific.

3.3 Identification of solutions

When selecting solutions to be assessed, it is natural to focus on those that are going to have the most significant reduction potential. However, it is important to not only look at those solutions and ignore other related solutions that may have a negative impact. To use an extreme example, a company has an advisory service for energy efficiency that is 5% of the total company operations. It would be disingenuous to discuss the positive impacts, by only looking at the impact from the energy efficiency portfolio and ignoring the negative impact if the other 95% of the company is advising on exploration of tar sand and coal.

It is important to consider all of a company's product portfolio to avoid the accusation of cherry-picking. Although there may be situations where a company assesses only one product or a few products, this should only be the case if the ambition is to eventually use it across the complete portfolio of the company's products.

A related issue is where multiple products have similar impacts, and there is the risk of double counting the avoided emissions where different products enable carbon reductions that overlap.

3.4 Disruptive solutions

Disruptive solutions are ones that render existing technologies obsolete and create new markets. Truly disruptive solutions are rare and difficult to predict, and often have multiple and unexpected consequences that may be both positive and negative from a climate change perspective. The nature of disruptive solutions means that they have the potential to enable significant avoided emissions, but there is also inherent uncertainty in their impact.

Assessing the future avoided emissions of disruptive technologies, requires some major assumptions about future market, adoption of the technology, behaviour changes, and success of the technology. Due to the potential scale of the impact, changes in assumptions will lead to significant range of results. Therefore, it is important to clearly state the assumptions used, and to perform some sensitivity analysis on the results. It can be useful to present different scenarios, to demonstrate the possible range of outcomes, as it is unlikely that there is only one valid scenario. It is always a brave and ambitious task to predict the future.

An example of a disruptive solution was the introduction and uptake of the mobile smartphone. This enabled new ways of working and interactions such as collaborative and mobile working, and has led to significant behaviour change. It has led to the ubiquitous rise of social media, and has been adopted at a massive scale world-wide.

3.5 Boundary

3.5.1 System boundary (Functional unit, direct emissions, LCA approach)

3.5.1.1 System boundary

The system boundary that is being considered should be clearly documented. The key principle of completeness should be followed – i.e. nothing should be deliberately left out, and also checks should be made for overlaps between different solutions which may deliver the same benefits and thus could result in double counting of the avoided emissions (see also section 3.11 on double counting).

The system boundary should clearly define what is included and what is excluded from the assessment. The following are examples of where there should be clarity over the inclusion or exclusion of specific items: embodied emissions of products; transportation of equipment and people; environmental control (e.g. cooling) of equipment; capital goods; and buildings. In particular, a consistent approach and boundary definition should be adopted for both the BAU scenario and the enabling solution scenario.

It is also important to state clearly what secondary enabling effects are included (if any), and similarly what rebound effects are included in the system boundary. For example, longer term secondary enabling effects are often excluded due to the greater uncertainty relating to these, and that these typically relate to infrastructure changes such as reductions in building infrastructure or transport infrastructure. (This is also further discussed in sections 3.5.3 and 3.5.4).

3.5.1.2 Functional Unit

The functional unit defines the system boundaries in which the BAU scenario is compared to the enabling solution. This means that the functional unit should be applicable to both the BAU scenario and the scenario where the enabling solution is used. The functional unit should be clearly defined and measurable.

The functional unit will typically define the following three parameters:

- The quantity of the solution
- The time period for the solution
- The quality of the solution

For comparison purposes, it is useful to express the avoided emissions for an annual period, even if the study period is different. The avoided emissions may be expressed in terms of more than one functional unit, where that is useful – for example the avoided emissions for a year and also for a five year period. (Although if doing this, then it is important to check that the results do simply scale over a longer timeframe, or if other considerations need to be made.

It is also recommended to estimate the life-time avoided emissions for a product, as the impacts for infrastructure that may be around for decades is very different from product with a life time of just a few years. (See also section 3.5.2 for further discussion of timeframe).

Example – Functional Unit:
Video-conferencing: Different functional unit could be used to calculate the avoided emissions.

- Per video-conference for one year.
- Per video-conference room for one year.
- Per video-conference room for life-time of equipment.

3.5.1.3 LCA approach - Direct emissions from the solution

The direct emissions from the enabling solution relate to any emissions directly or indirectly due to the introduction of the solution. This can include embodied carbon emissions of the solution itself (e.g. carbon emitted during its manufacture) or energy consumption resulting from the use of the solution. Direct emissions, particularly the embodied emissions of the enabling solution, may be difficult to quantify and can, depending on the solution, be small in magnitude when compared to the primary enabling effects.[13 14 15]

The impact of the direct emissions should be acknowledged and documented, and where likely to be materially significant should be included in the calculation of the net avoided emissions.

Example – Direct emissions:
Video-conferencing: the direct emissions of the enabling solution are the embodied emissions of the video conferencing equipment, the energy use of the video conferencing equipment, and the emissions associated with the telecommunications networks used to transmit the video data.

Typically for video-conferencing, (as for most other solutions based on digitalisation), the direct emissions of the solution are relatively small compared to the enabling emissions. When this is the case, appropriate approximations can be used to estimate the direct solution emissions, ideally based on relevant previously published studies or using a screening assessment.

To assess the emissions of the solution a life-cycle approach should be followed covering all the life-cycle stages: raw materials, manufacturing, transport, use, and end-of-life. A pragmatic approach should be taken, so for example where the embodied emissions are likely to be small compared to the use stage emissions, then appropriate estimations can be used. If an existing LCA is available and appropriate, then it can be used, or alternatively a proxy may be used for a similar product. The approach taken will depend on the materiality and data availability.

3.5.2 Timeframe

Avoided emissions are often reported for a one year period. This allows for simple comparison between solutions, and takes account of any season variability. However, there are a number of cases where it is important to also look over different time periods.

For new solutions the adoption rate can change rapidly over months or years – thus both historic and predictive assessments should acknowledge this.

It may be useful to include a life-time emission reduction estimation. This makes it easier to highlight different important estimations and identify potential lock-ins. This would also be helpful to illustrate the benefit of solutions that have a short-lifetime compared to those with long term impacts. For example, there are other factors that should be included if you deliver a building or bridge that might be around for 100 years, compared to a mobile charger that might be around for 2-3 years.

3.5.3 Rebound Effects

Rebound effects occur when carbon emissions increase due to often unintended or ancillary use of the enabling solution. These may be excluded from the calculation of the avoided emissions, where it is difficult to quantify rebound effects due to data limitations. As is the case with secondary enabling effects, any identified rebound effects should be acknowledged and documented.

Rebound effects relate to an increase in emissions caused by consequential or unrelated effects of the solution avoiding the emissions. These effects are often unintended and often relate to difficult to predict behavioural changes that are either a direct or longer-term effect of the newly introduced solution.

Rebound effects are difficult to estimate as a number of different variables will impact the magnitude of the rebound effect. As a result, despite being widely acknowledged in theory, rebound effects are often not accounted for when calculating the avoided emissions of solutions.

Example – rebound effects:
Video-conferencing: Due to the availability and ease of video-conferencing, this is likely to lead to an increase in the number of meetings. This will be reflected in an increase in the use of video-conferencing facilities and equipment, which consequently leads to an increase in the electricity used for videoconferencing equipment, and other emissions associated with the facilities.

Most calculations simply acknowledge the possibility of rebound effects, without further quantification. This highlights a very important gap between the theoretical and practical approach of estimating avoided emissions. Many documents on the topic of avoided emissions highlight the importance of taking all effects, including rebound effects, into account when calculating the avoided emissions of a solution. Forum for the Future for example encourage the estimation of rebound effects by conducting 'new research or by making an allowance based on existing complementary research'.

Acknowledging and assessing rebound effects are particularly important when their impact has the potential to outweigh the positive impact of the avoided emissions. In these circumstances, the failure to quantify rebound effects could lead to wrong conclusions about the net carbon impact of a solution. In these situations the likelihood of the rebound effect outweighing the positive carbon impact should be assessed by conducting a sensitivity analysis, which tests the impact of changes in different variables. Furthermore, it is recommended to investigate, over time, the uncertainty around individual variables allowing for a more accurate calculation of the rebound effect.

If the rebound effect is assumed to be relatively small compared to the impact of the avoided emissions, the most practical solution is to simply acknowledge the likely impact of the rebound effect on the total avoided emissions estimated.

Where it is not practical to quantify the rebound effects, a useful step is to identify the potential rebound sources and to identify ways to counteract them.

One particular kind of rebound effect is where the financial savings related to the enabling solution are used for other activities that cause additional carbon emissions. For example, a new domestic heating system saves energy and also saves money. This money is used for additional weekend holidays resulting in increased flight emissions. However, the counter-point to this is that as society decarbonises the alternatives for spending additional disposable income will also become lower carbon.

3.5.4 Primary and secondary enabling effects

Enabling effects, directly or indirectly attributable to the use of the enabling solution, should be identified and assessed in order to calculate the avoided emissions. The enabling effects are subdivided into two types:

1. **Primary Enabling Effects:**
   Immediate reduction of BAU emissions occurring as result of the solution implementation.
   All primary enabling effects should be included in the calculation of the avoided emissions.

2. **Secondary Enabling Effects:**
   Secondary enabling effects are those expected to reduce emissions relative to the BAU system, but which occur over a longer timeframe or as a result of increased scale of adoption.

Secondary enabling effects (sometimes called indirect effects) tend to have an impact over a longer time period. As a result it becomes difficult to establish a direct correlation between the enabling solution and the enabling effect. There is uncertainty both regarding the likelihood of these effects occurring, as well as the scale of adoption. This makes it even more difficult to quantify secondary enabling effects. In addition, secondary enabling effects may lead to unintentional rebound effects.

Secondary enabling effects, therefore, are often excluded from the calculation of the avoided emissions. However, any identified secondary effects should be acknowledged and documented.

Example – enabling effects (video conferencing):

Primary Enabling Effects: the reduction in business travel enabled by video-conferencing reduces distance travelled and associated emissions.

Secondary Enabling Effects: As the number of business trips is reduced, the use and need for company cars diminishes, and as a result the total number of vehicles owned by a company may also decrease resulting in a long-term reduction in emissions from the manufacture of new vehicles. Similarly this could lead to a reduced number of new aircraft manufactured.

3.6 Baseline

A reasonable and reliable baseline or BAU scenario needs to be defined in order to measure the avoided emissions of the solution. The baseline represents the 'before' scenario of a specific process, i.e. what is the most likely alternative solution to be used to achieve a certain outcome in the absence of the enabling solution. The BAU baseline reflects the situation in the absence of the enabling solution. Defining the baseline is a crucial step of the methodology, as the baseline is used to compare the enabling solution against, and will impact the scale of the avoided emissions.

One of the most important decisions to make when calculating the avoided emissions of a solution is to decide what to compare it to, i.e. what should the baseline or the Business-As-Usual scenario be. The baseline represents the situation as it would be without the enabling solution in place. The chosen baseline should represent the most widely used alternative to achieving the same outcome. The question that needs to be asked is: 'What would have happened without the solution?' As the baseline emissions will directly determine the magnitude of avoided emissions, it is important to choose an accurate and reliable baseline.

One challenge in choosing the baseline from which to measure the avoided emissions is determining the most widely used alternative. For example, the alternative to speaking to friends on the phone is visiting them in person. But what is the most widely used transport method to do so? It is obvious that today cars are preferred to horse carriages, which would have been the main form of transport more than a hundred years ago (before the telephone was widely available).

The emissions of the

Replace the emissions of the

However, in other cases, where technology has only recently been replaced, the decision may not be so obvious. The issue is that if a baseline is chosen, which no longer represents the most widely used alternative, avoided emissions might be over or understated. Furthermore, even at a single point in time, there may be more than one possible alternative. For example, the most widely used alternative to using a phone to call your friends today may be visiting them by car, airplane or even bicycle. This case highlights that location is another important factor that will influence what is considered to be the most appropriate baseline.

Furthermore, one could also argue that the most widely used alternative to using a phone to call friends is now using Skype to call your family over the internet. This highlights that the baseline might be rapidly changing due to changing technologies or because of a change in human behaviour. As a result, the baseline needs to be continuously reviewed and updated if necessary.

Recognising the challenges of choosing the most appropriate baseline, it may be sensible to develop a scenario based on a combination of different alternatives.

The following table summarises some of the issues related to selecting an appropriate baseline.

Table 4: Choosing the baseline – 'What would have happened without the new solution?'

Question / issue	Guidance
What should the baseline reflect?	'The most appropriate widely used alternative'. This may differ depending on what the situation is, and what the assessment is trying to show. For example, if the new solution is replacing an existing established product or solution then the baseline might be 'What is the average of what already exists'. However, if the solution is substituting for other new products on the market, then the baseline should be 'what is most likely to be sold'.
Are there multiple baselines?	The baseline might be different in different geographies, or there might be different technologies that make up the baseline. In this case, develop different baseline scenarios, or develop a combination scenario weighted from the different alternatives.
Will the baseline change over time?	Depending on how rapidly the baseline will change may determine how often to do a re-assessment. For example, it could be recommended to re-baseline every 5 years.
Future projections for long life products	It is necessary to include expected changes in the baseline into the future scenarios – for example, reflecting changes in the market, changes in regulation, and changes in grid electricity emission factors.

The WRI working paper[16] also has a useful section discussing issues related to setting the baseline.

3.7 Data quality

3.7.1 Uncertainty

Uncertainty describes how accurate results are or how close to the 'true' value a result is. Typically the uncertainty will relate to a statistical or probability assessment of the results. The calculation of avoided emissions typically uses various data sources including volume data and other factors to calculate the carbon savings. Often, the result is highly dependent on saving factors and assumptions, which have few data points and therefore cannot be analysed statistically. In this case it is not practical to perform a statistical uncertainty analysis. In other cases, where it is possible to perform an uncertainty analysis, the resource and time required may be excessive. An alternative, and a complementary approach, is to carry out a sensitivity analysis by varying some of the key parameters and assumptions to understand the impact on the result. As a minimum it is recommended to have a qualitative description of the uncertainty relating to the assessment, and what are the key parameters affecting the uncertainty.

3.7.2 Assumptions

Where possible, avoided emissions calculations should be based on available primary or secondary data. In the absence of required data, appropriate assumptions may be made. Assumptions should be clearly documented along with a justification and evidence supporting the assumption. Ideally, assumptions should be based on surveys, reports or other credible published data. If conflicting information is available for one assumption, the most conservative assumption should be used in order to not overstate the avoided emissions.

3.7.3 Types of Data

Different types of data can be used to calculate the avoided emissions. The different types of data include: primary, secondary and modelled data. Primary data relates specifically to the solution being assessed, secondary data is derived from other sources, and modelled data is derived from modelling based on sampling, proxies and assumptions. Primary data will always be the preferred option, although primary data may be substituted with secondary data in the absence of available primary data. Modelled data derived from a number of assumptions may also be used, but only if no other primary or secondary data is available. The level of data quality, including any uncertainties, should be documented.

3.7.4 Sources

In order to prevent the use of assumptions and data from biased sources, multiple sources should be considered for a single parameter and compared against each other wherever feasible. The source that offers the most relevant information for the calculation should be identified during the comparison of multiple sources. For example, a study providing a specific piece of data might be geographic-specific and therefore not appropriate to use. In order to avoid using dubious sources, all sources should be checked for unreliable data or inappropriate assumptions. All sources should be documented and clearly referenced.

Company sources may often be considered as biased - but in many cases companies are the only ones that have access to actual measured data and are preferred for that reason. This perhaps demands more validation, but not to use company sources may lead to lower data quality in many cases.

It is important to consider both the quality and original source of the data used in the calculation of the avoided emissions from any solution. First, it is important to ensure the highest quality data is used with primary data being applied where possible. If primary data is not available, secondary data from published sources can be applied. Finally, in the absence of secondary and primary data, estimations can be made based on validated assumptions. Any assumptions should be clearly stated and substituted with more accurate data if this becomes available.

The source of data is also important and considerations should be taken with regards to location and date of the data source. Where there are multiple sources for data points, the most recent data should be used and it is also important to consider the context and background of the study from which the data came. This will indicate whether the data point is appropriate for the calculation.

To avoid using biased data or data based on inappropriate assumptions, all data points used in the calculation of avoided emissions should be, if possible, cross-checked against multiple other data sources to validate that the data point is feasible. Furthermore, it is best practice to document and reference all data sources used for the calculation of avoided emissions of specific solutions based on digitalisation opportunities.

3.8 Transparency

Transparency is crucial to the process of calculating the avoided solutions from a solution. It helps to provide confidence to stakeholders that the avoided emissions calculations are as robust and accurate as possible. Being transparent includes clearly documenting all assumptions, data sources, gaps and issues, provided that this will not compromise any commercially sensitive information.

3.9 Emission factors

Emission factors should reflect full life cycle emissions – for example emission factors for electricity should include generation, transmission and distribution, and upstream 'well-to-tank' (i.e. emissions associated with extraction and transportation of fuel used for electricity generation).

Future projections should use emission factors that reflect projected decarbonisation of the electricity grid, and decarbonisation of transport. Thus future reductions in electricity use and reduction in transport will result in less avoided emissions than the same reductions today.

Emission factors should be appropriate to the assessment and the purpose. However, there may be a conflict, for example, between using a locally relevant emission factor compared to using one which is appropriate to the technology being considered. There may be a trade-off necessary to address such conflicts.

It should be transparently stated what emission factors have been used.

3.10 Attribution (Allocation)

Overview

Often avoided emissions are the result of multiple products or services working together. Therefore, one solution alone is not responsible for all the avoided emissions. For example, video-conferencing requires not just the telecommunication technology, but also the video equipment, and cloud-based servers. In cases such as this, it is difficult to determine how avoided emissions should be allocated between the different technologies involved. There is currently no consistent way to allocate avoided emissions, thus it is common practice to attribute all of the avoided emissions to a solution where that solution has a fundamental role in enabling the avoided emissions. The test of a fundamental role may be determined by whether the avoided emissions would only be realised with the existence of the solution (i.e. if the solution did not exist would the avoided emissions still take place?).

Example – attribution:

Video-conferencing: videoconferencing has an enabling effect through avoiding the requirement to travel for a business meeting. For the video-conference to take place we can assume that the following is necessary: the video-conference equipment, software running on the equipment, and the telecommunication network. Without any one of these technologies the video-conference would not be able to happen, thus they all have a fundamental role in enabling the avoided emissions.

Thus, in this example, all 3 companies (the equipment provider, the software provider and the telecommunications provider) could claim the total avoided emissions.

There are some challenges with this approach, including:

1. There is 'double counting' (with multiple companies claiming the same avoided emissions)
2. The avoided emissions claimed by each participant do not necessarily fairly represent their role in the overall solution (e.g. one participant may only have a minor role, but is still claiming credit for the total avoided emissions)

Companies have so-far not attempted to allocate avoided emissions because:

1. It adds an extra layer of complexity to an already expensive, complex and uncertain process.

2. Scope 3 carbon accounting allows for double counting. As an extension of an organisation's impact outside of their organisation, avoided emissions can be seen as analogous to an organisation's scope 3 impact (i.e. the positive side of their scope 3 impact) and therefore there is not a problem with double-counting of avoided emissions, so long as this is clear and transparent.

3. No obvious solution exists and no standards exist for assessment of avoided emissions.

Successful attribution criteria

An organisation may wish to allocate avoided emissions to different elements of the solution in order to communicate a 'fairer' picture of the positive impact they are delivering. This may help drive organisations to innovate further and deliver solutions with a positive carbon impact.

The AEF methodology does not aim at being prescriptive in regards to how avoided emissions should be allocated, but focuses on providing guidance on how to approach this issue. For instance, a successful attribution methodology should meet the following criteria:

- Practicable (i.e. data exists that could be used for calculations, or could be easily measured)
- Objective (i.e. reduces how arbitrary an attribution is)
- Accessible (i.e. easy to understand)
- Fair (i.e. claims are representative of the company's role in the solution)
- Affordable (i.e. can be performed in a cost-effective manner)
- Transferrable (i.e. can be consistently applied across different products / companies / sectors)

In absence of an official standardised allocation method, it is key that companies are fully transparent about their selected approach to ensure the correct interpretation of the presented calculations and outcomes.

Potential allocation approaches
Possible allocation approaches to consider include:

1. Accept double counting
2. Allocate all avoided emissions to fundamental solution
3. Allocate equally between all different elements
4. Financial cost or financial value attribution
6. Stakeholder consensus

The pros and cons of each of the listed approaches, as well as examples of scenarios where they could be applied, are further explored below.

Accept double counting
If a company is assessing the avoided emissions of a specific technology/service that contributes to an overarching enabling solution, together with other technologies/services from other companies, then double counting can be acceptable, as long as this is clearly disclosed. For example, if a company provides an electric car sharing app and another company provides the electric cars used for car sharing, then both companies could claim the avoided emissions of the e-car sharing solution.

The benefits of taking this approach is that it avoids adding complexity to the avoided emissions calculation process. On the flip side, allowing for double counting may incentivise companies to claim avoided emissions even for technologies/ services that play a marginal role in an overarching enabling solution.

Whenever a company is taking a portfolio approach to calculating avoided emissions, double counting should be strictly avoided. In such cases, a conservative approach should be taken to ensure that the portfolio's avoided emissions are not inflated by overlapping emission savings created by different technologies.

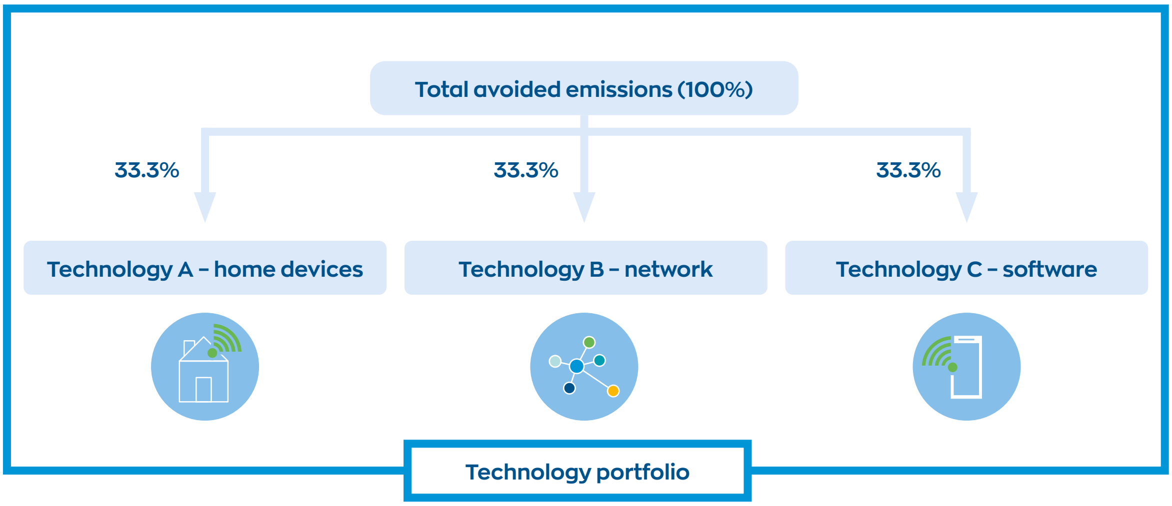
Allocate all avoided emissions to fundamental solution
As outlined in the overview section, the main approach used by companies to deal with the allocation issue is to allocate all avoided emissions to the technology that plays a fundamental role in delivering the outcome – with fundamental being defined as a technology without which the overall solution would not function. For instance, a company providing off-grid solar PV systems to enable energy access could allocated the avoided emissions of replacing fossil-fuel based off-grid generation to their off-grid technology.

This approach is simple and practical to apply. However, for enablement solutions reliant on multiple fundamental technologies (see videoconferencing example), the full value of avoided emissions could be attributed to all of these technologies, leading to the risk of double counting. While double counting can be acceptable if each technology is assessed individually within a company or if the technologies are provided by different companies, this approach should be avoided by companies looking to sum avoided emissions from all fundamental technologies. The latter scenario could take place, for instance, if a company is looking to perform a portfolio level analysis of its technologies' avoided emissions.

Allocate equally between all different elements
Another potential method to deal with allocation is to split avoided emissions equally across the relevant contributing technologies. This method could be relevant for companies providing multiple fundamental elements of a solution and looking to calculate avoided emissions across their technology portfolio.

For example, let us consider a smart home technology made up of the following fundamental components: home devices (sensors and other appliances), a network to connect devices and the user, and the software through which the user can monitor and remotely control the connected home systems. A company providing all of the three key elements of a smart home system could allocate a third of avoided emissions to each element.

Figure 3: Smart home example of equal allocation of avoided emissions among fundamental technologies within a portfolio



This method provides a relatively simple way to recognise the role of different technologies in delivering a solution's avoided emissions, while avoiding the risk of double counting when aggregating avoided emissions from specific technologies. However, allocating avoided emissions equally across technologies does not necessarily capture the true contribution of each element. It may also not always be obvious what constitutes a separate technology – thus for an example where the technologies could be subdivided into either three or four separate technologies, then one technology could be allocated either a third or a quarter of the avoided emissions.

Financial cost or value attribution

Allocating avoided emissions across different technologies provided by a company could also be achieved by attributing each technology a share of the solution's total emission savings that is proportional to their financial cost (total costs of production) or financial value (the product's/service's worth assessed by the market).

Taking financial cost as an example of apportioning method, consider a company providing 2 technologies (A and B) as part of a solution. The cost of producing technology A accounts for 60% of the total solution cost, while costs associated with technology B account for the remaining 40%. In this case, 60% of total avoided emissions should be attributed to technology A and 40% to technology B. A similar approach can be used to allocate avoided emissions based on the technologies' financial values.
The key benefits of the financial cost and value approaches is that they recognise the relative resources invested in the development of a technology (for financial costs) or the relative utility derived by consumers (for financial value) through the attribution criteria. Similarly, compared to the equal allocation approach, this method would avoid double counting when aggregating avoided emissions across a portfolio of technologies.

However, a technology's financial cost or value may not provide an accurate representation of its contribution to delivering emission savings. Hence, the resulting allocation may not fairly represent the contribution of the different technologies (for example where a technology with a high value plays only a minor role in enabling the avoided emissions). Additionally, as costs of production or valuation methods may differ significantly between companies, this method should only be applied to allocate avoided emissions within a single company's technology portfolio.

Stakeholder consensus

A possible approach to allocating avoided emissions across different technologies provided by several stakeholders would be for stakeholders to engage in discussions and achieve a consensus on the technologies' emission savings attribution.

This method would ensure that all companies involved in delivering a solution take the same approach to allocating avoided emissions and should also avoid double counting across these stakeholders. Moreover, this stakeholder engagement process should incentivise companies to claim a share of avoided emissions that well represents the relative contribution of their technology to overall emission savings. On the flip side, this approach is more complex compared to all the other allocation methods previously outlined. Until a standardised engagement procedure and incentives for companies to engage are established, it is likely that this method will be considered too cumbersome to be effectively applied.

Table 5: Allocation approach summary

Approach	Applicability	Pros	Cons
Accept double counting	• Technology-level assessment	• Simple and practical approach • Established practice in Scope 3 accounting	• Risk of technologies playing a marginal role in an overarching enabling solution still claiming significant avoided emissions
Allocate all avoided emissions to fundamental solution	• Technology-level assessment	• Simple and practical approach	• Double counting risk
Allocate equally between all different elements	• Company technology portfolio assessment	• Simple and practical approach • Avoids double counting	• Risk of incorrectly reflecting the relative contributions of each technology/service involved in delivering the overall solution
Financial cost or value attribution	• Company technology portfolio assessment	• Simple and practical approach • Avoids double counting	• Risk of incorrectly reflecting the relative contributions of each technology/service involved in delivering the overall solution
Stakeholder consensus	• Technology portfolio assessment (including across different companies)	• Collaborative process • Outcome should be reflective of each technology's relative contribution • Avoids double counting	• Complex approach • More time consuming /costly • Harder to replicate across a portfolio of different solutions

3.11 Double-counting

Double counting of avoided emissions should be avoided where possible, although there are some cases where it may be valid to have double-counting. If this is the case, then this should be clearly stated and explained. Some possible situations involving double-counting of avoided emissions have been mentioned previously and are discussed further below:

- Accounted for in multiple contributors to the same solution
- Accounted for in other GHG scope of the company
- Accounted for by overlapping product of the same company

Accounted for in multiple contributors to the same solution
This situation has been discussed earlier in the section on 'Attribution' (see 3.10), and reflects the case where multiple products or services contribute to the overall enabling solution, and all claim credit for the avoided emissions. This may be valid, where this relates to products from different companies, as it is analogous to Scope 3 accounting, which by definition involves double-counting of emissions.

Accounted for in other GHG scope of the company

This situation is where a company is reporting its avoided emissions in comparison to its own Scope 1, 2 or 3 emissions and some of the avoided emissions are the same as a reduction in the company's Scope 1, 2 or 3 emissions. For example, if a company reports its avoided emissions in comparison to its own operational emissions, and it provides a solution that reduces the number of truck rolls required, and the trucks are owned by the company, then the emission reductions associated with the trucks would already be accounted for in company's scope 1 and 2 carbon footprint, and should not be included in the carbon abatement.

Accounted for by overlapping product of the same company

In the case where the avoided emissions of two products from the same company overlap, then the overlapping avoided emissions should only be counted once. For example, a company might provide vehicle telematics solutions, and also provide a mobile app to improve driver behaviour to its customers. Both these solutions enable carbon savings by improving driving behaviour. Where a customer has both the mobile app and the telematics solution, then the overlapping avoided emissions should only be accounted for once.

3.12 Assessing future solutions

As described in the overview (section 2.1), the methodology can be applied both to existing products / solutions, and to future solutions (where it is necessary to include factors for probability of success and probability of adoption). When assessing future solutions, there are also a number of additional challenges, which are summarised here:

Uncertainty and assumptions

Inherently, future scenarios will have greater uncertainty, thus it is important to clearly explain assumptions and data sources, and carry out sensitivity analysis on key parameters. (See also section 3.7).

Emission factors

Future projections should use emission factors that reflect projected decarbonisation of the electricity grid, and decarbonisation of transport. (See also section 3.9).

Clusters of solutions

There may be an interdependency of solutions, where one solution relies on the development of another, or on the development of a specific market. For example, wide adoption of electric vehicles will require an infrastructure of charging points, and will also benefit from developments in battery technology. Thus for related solutions it may be appropriate to assess groups or clusters of solutions, in terms of their overall impact.

Future Market Share and Market makers vs. Market takers
This issue is related to the previous item about clusters of solutions. A key question for future solutions is how to assess what the future market size will be, and what market share the solution will have. A solution may be an enabler (e.g. charging infrastructure) that is helping to create a market (market maker), or may be relying on a market to develop (market taker). And the projected market share may be based on an extrapolation of existing market developments, or it may be based on the market that the new solution is expected to develop. This will also in turn depend on whether the market already exists or if it is being developed. If a solution is not yet developed commercially, then when is it expected that it will enter the market (e.g. is 5 years or 10 years in the future a reasonable assumption?), and what is the penetration speed expected?

Note, the WWF Climate Solver tool includes a template for calculating future market share.

Low TRL vs. High TRL solutions
Assessing future solutions should include assessing the current Technology Readiness Level (TRL). (See also section 3.13).

Strategic solutions
Strategic solutions should be considered as those that may have a significant strategic impact. These might be addressing specific hard-to-decarbonise areas, or areas subject to 'emissions gaps'. As such, these solutions might be given greater support from a policy perspective, as if they are successful then they will have a more significant strategic impact.

3.13 Assessing solutions at different Technology Readiness Levels (TRLs)

Overview
As introduced in section 2.5, assessing avoided emissions potential of future solutions should include an evaluation of the solutions' current Technology Readiness Level (TRL). A technology's estimated degree of maturity provides important insights on several factors that can impact avoided emissions calculations, including:

- **Probability of success:** probability of the solution being successfully developed and delivering the expected benefits.
- **Magnitude and timing of emission reductions:** the quantitative measures of expected avoided emissions and the timeframe in which they are expected to materialise.
- **Development options:** degree to which the avoided emissions assessment of a technology can be used to influence its development process.
- **Data quality & transparency:** the availability of high-quality data and the related degree of uncertainty linked to the figures and assumptions used in calculations.

When assessing the impact of technology maturity for each above listed factor, it is helpful to distinguish between low TRL solutions (early stage of development) and high TRL solutions (mature development – ready for market).

Factors to consider and differences between low and high TRLs
A high-level description of how the maturity of technologies can impact the previously listed factors, along with practical examples are presented below.

Probability of success
The probability of success can be interpreted as the likelihood of a technology progressing in the TRL scale up to achieving its planned technical features and becoming market ready. The greater the TRL, the closer a solution is to market deployment and the greater the probability of it being successful.

Recalling the calculation of avoided emissions applied to future potential scenarios (section 2.1.3), maintaining all other factors equal, an increase in the probability of success would lead to higher avoided emissions. Thus, if comparing two solutions that are at different TRLs, then all other things being equal, the solution with the higher TRL is likely to deliver greater avoided emissions.

There are, however, other factors besides a technology's TRL that can influence its probability of success, including:

- Costs and funding availability
- Development timescales
- Technical challenges

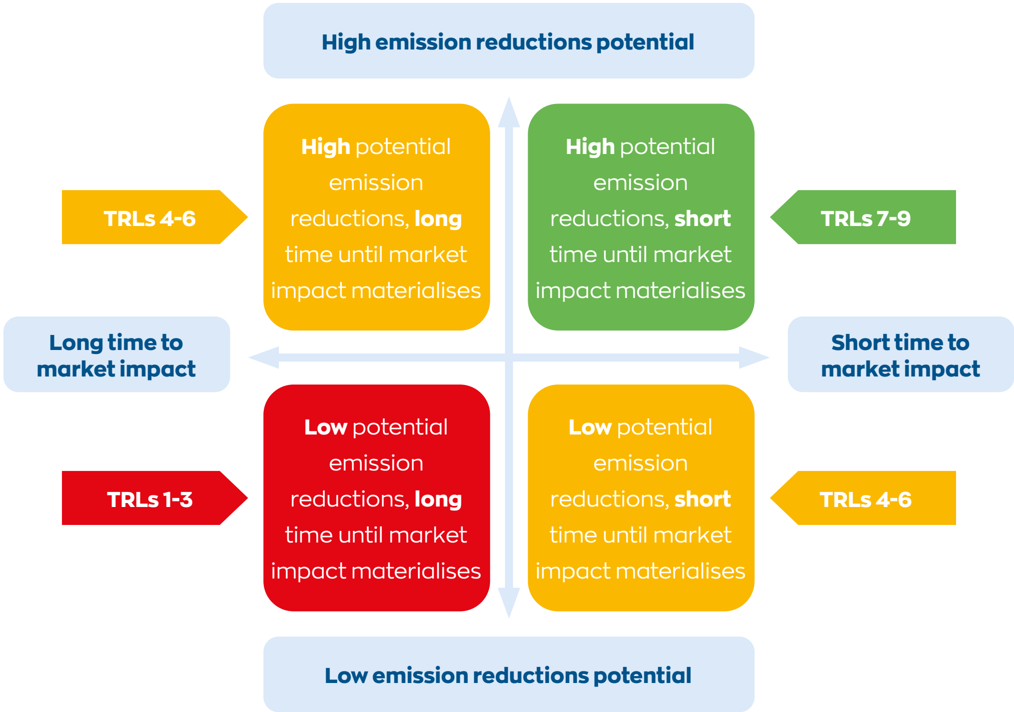
All of these factors are expected to vary greatly between different types of technologies, which will lead to different methodologies for quantifying probabilities of success. It is, hence, extremely important for companies to clearly outline their calculations approach.

Magnitude and timing of emission reductions
The TRL framework can be used to conduct a scenario analysis to capture uncertainties around the total magnitude of potential emission reductions, determined by the combination of an innovation's technical features and its market adoption, and the timing in which the impact is expected to materialise (see **Figure 4**).

For instance, low TRL solutions may have a significant potential future impact, but will likely be many years until the market impact is significant. High TRL solutions, on the other hand, are expected to be closer to commercial implementation and, hence, there is a higher probability of their impact materialising sooner.

Applying a scenario analysis to different innovations considering their TRLs will ensure that uncertainties related to a technology's stage of maturity are factored in the calculations.

Figure 4: Scenario analysis matrix of potential emission reduction's magnitude and timing, including key TRL ranges expected to be most relevant to each quadrant



Development options

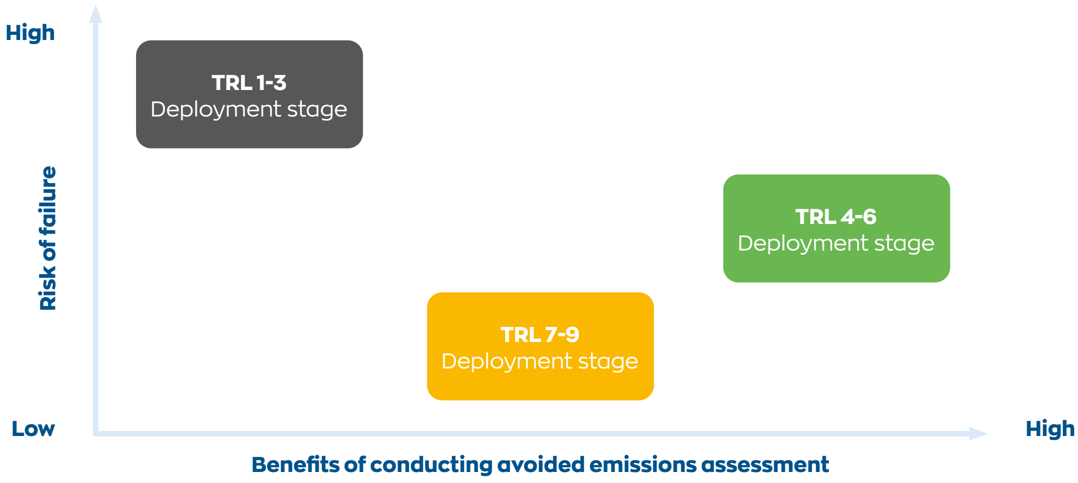
As briefly touched upon in section 2.5, performing an assessment of a solution's expected avoided emissions during the solution's development may influence the impact of the development process itself to various degrees, also depending on the technology's TRL.

Technologies that are still within a research stage (TRLs 1-3) have a relatively higher probability of failure, or a lower probability of success, due to a higher risk of encountering technical, cost or timeline challenges compared to more developed technologies. Conducting an avoided emissions assessment during these early stages of the development cycle may bring limited benefits in terms of improving a technology's potential emission savings, due to the risk of failure.

Assessing the potential for avoided emissions while a technology is in its development stage (TRLs 4-6) provides significant opportunities to implement fundamental changes in the technology's development to ensure that higher avoided emissions are achieved.

For technologies that have already achieved deployment stages (TRLs 7-9), and for which the development process is close to completion, an assessment of avoided emissions could produce smaller changes in configuration and deployment of the technology. Nevertheless, these changes may still add up to significant increases in avoided emissions.

Figure 5: Summary of benefits of conducting an avoided emissions assessment at different technology development stages



Data quality & transparency

As underlined in section 3.7, avoided emissions calculations are highly dependent on the data inputs and assumptions used for the analysis. Assessing the uncertainty level of the analysis, either qualitatively or through a sensitivity analysis is always recommended to better understand how variations in the parameters and assumptions used can impact the results.

For low TRL solutions, by definition it is difficult to get reliable representative data (especially where there is no commercial solution yet available, so no field data is available). It is therefore likely that there will be large uncertainty in the result, and it will be necessary to rely on expert opinion. In these cases, it is recommended to follow an approach such as:

1. Test if the solution is 1.5 °C compatible
2. Research to see if there are studies or data available that would help in the assessment or validate any data or assumptions.
3. Use a moderated expert opinion approach. For example, a multiple peer review process can challenge particularly significant data or assumptions. This can be an informal process, but avoids relying on only one expert opinion. Another approach is to collect different opinions independently (i.e. blind), and then compare to select an appropriate data point (or a range of data points).

Particularly for high uncertainty cases, it is important to state what the key assumptions are, and if appropriate include an uncertainty range (by applying some sensitivity analysis).

For high TRL solutions, the availability of representative primary data from pilot/ demonstration projects would be a valuable input to reduce uncertainty in the calculations. However, it is still expected that this will need to be integrated with secondary data, modelled data and assumptions where primary inputs are not available.

Summary of comparison between low and high TRLs
The table below summarises the implications for solutions with low and high TRLs related to each of the factors analysed in the previous sub-sections.

Table 6: Summary of key factors impacted by a technology's TRL

Factor	Low TRL	High TRL
Probability of success	Relatively lower probability of success due to potential technical challenges that may arise in the journey to commercialisation.	Relatively higher probability of success as the solution is closer to market deployment.
Magnitude and timing of emission reductions	Potentially significant magnitude of impact, but long timeframe to market roll-out.	Solutions closer to commercial implementation and, hence, with a higher probability of their impact materialising sooner.
Development options	Significant opportunities to influence the technology's development to ensure that higher avoided emissions are achieved.	Opportunities to implement smaller changes in configuration and deployment of the technology which may lead to higher avoided emissions.
Data quality & transparency	Lack of reliable and representative data leads to high uncertainty in results and may lead to the need to rely on an expert opinion to validate figures.	Potential availability of representative primary data from pilot/ demonstration projects can decrease uncertainty in calculations.

3.14 Compatibility with a global 1.5 °C scenario

A fundamental objective of avoided emissions solutions is that they should deliver an overall reduction in global greenhouse gas emissions. Initially attractive solutions that appear to deliver reductions in emissions may on a longer term inadvertently contribute to increases in emissions – for example either through rebound effects (see section 3.5.3) or through lock-in (see section 2.1.3). Rebound effects may cause new emissions greater than the avoided emissions, for example by increasing the demand for new products and services, or through the phenomenon of Jevons' paradox. Lock-in can prevent future lower carbon solutions replacing established solutions.

An approach to test a solution at a more macro level, is to assess whether a particular solution is compatible with a global 1.5°C scenario (i.e. a scenario that keeps global temperature rise to below 1.5°C compared to pre-industrial levels). This can be done either using a quantitative approach or a causality approach. The quantitative approach would compare the future emissions of a solution to the sector emissions for a 1.5°C emissions pathway to assess whether these are above or below the pathway trajectory. This is similar to the approach used for the Sectoral Decarbonisation Approach for calculation of Science-Based Targets. The causality approach uses a map of causal pathways to identify if a solution fits with pathways that support a 1.5°C scenario. This approach has been developed for the Net Zero Compatible Innovations Initiative (NCI) by Charlie Wilson of the Tyndall Centre for Climate Change Research. It is published alongside this document by the NCI as the1.5 °C Compatibility Pathfinder Framework (CPF), and develops on concepts[17] used to create the 1.5°C low energy demand scenario used in the IPCC Special Report on Global Warming of 1.5°C (SR15)[18].

3.15 Best practices

These are some of the learnings from calculating avoided emissions by the companies. It is not intended as an exhaustive list, but aims to highlight some the key issues together with a discussion of how to address these, and how they impact the avoided emissions.

The following points highlight best practice when calculating avoided emissions:

- Where possible, **avoid using arbitrary assumptions** (e.g. 'we assumed 50% adoption'). Preferably, base all assumptions on data and studies, or undertake sample surveys to have a more factual basis.
- If there is high uncertainty about the assumptions then **be cautious with the assumptions** – i.e. understate the benefits and use conservative assumptions. And preferably present the

results for different scenarios, and perform a sensitivity analysis.

- **Documentation** of assumptions and methodology should be sufficiently detailed that someone else could independently calculate the avoided emissions, and produce the same results. This adds credibility and may identify errors in the assumptions or calculations.
- It is best practice to carry out an **Independent Review** of the assumptions and calculations. This may be undertaken internally or externally. Guidance on carrying out independent reviews is provided in the GHG Protocol Product Standard,[19] Chapter 12: Assurance.
- Carry out **sense checks** on the assumptions, data and results:
  - Do the assumptions, data and results seem **reasonable?** Do they match with experience, are they credible? Often, expressing the savings in percentage terms helps to provide the context to do a reasonableness check.
  - **Cross check** against other data – compare with national statistics, other sources of data, and other studies. And where there are discrepancies discuss how the results differ, and the motivation for using specific data.
  - Carrying out **both top-down and bottom-up assessments** is another method to check how reasonable the results are. How close are the results from a top-down approach compared to a bottom-up approach? Do the two methods 'meet in the middle'?
  - **Avoid using single source of data** – some data and studies may not be representative, either because of the scope of the study, or because it was a trial under idealised conditions. Where possible get two or three sources for data and take a judgement as to which is the most representative, or take an average, or take the most conservative. Often an expert opinion may be more reliable than simply taking data at its face value, particularly where there is conflicting data, or the underlying assumptions behind the data are not clear.
  - **Check the results against total sector emissions** – expressing the avoided emissions results as a percentage of the total carbon emissions of the related sector (or of the total deployment of the original solution) will provide a very useful sense check. Is it reasonable that the scale of the enablement being considered is able to achieve this impact? For example, if the avoided emissions are more than 100% of the relevant emissions, then there is something wildly incorrect.
  - **If reusing data from previous studies**, check that the assumptions in the original study are relevant to the assessment being carried out. Are the same conditions applicable? Are the geographical and technological scopes the same?
  - Do the results pass the **'blush test'**? That is, would you be comfortable to stand on a public platform and explain the results and the assumptions without fear of embarrassment and awkward questions that cannot be convincingly answered?

4 Application of Methodology

4.1 Learnings from Existing Standards and Guidelines

The concepts behind the 'Avoided Emissions' methodology outlined in this document, build on a number of existing Standards and Guidelines that have been published by different stakeholders on this topic over the last 10 years. Table 7, which is taken from the recent WRI working paper 'Estimating and Reporting the Comparative Emissions Impacts of Products', highlights a few of these documents and summarises their general methodology[20]. (These documents are also referenced in the Appendix 1).

Table 7. Existing Standards or Guidelines around Avoided Emissions[21]

Publication	Sector	General Methodology
Evaluating the Carbon-Reducing Impacts of ICT: An Assessment Methodology (GeSI and BCG 2010)	Information and communications technology (ICT)	Attributional: Compare product GHG inventories; the impact is calculated at the level of a functional unit.
Addressing the Avoided Emissions Challenge (ICCA and WBCSD 2013)	Chemical	Attributional: Compare product GHG inventories; the impact is calculated at the level of a functional unit.
Greenhouse Gas Protocol Policy and Action Standard (WRI 2014)	All sectors	Consequential: GHG effects of a policy or action are estimated relative to a baseline scenario.
Guidance on Quantifying Greenhouse Gas Emissions Reductions from the Baseline for Electrical and Electronic Products and Systems, IEC/TR 62726:2014 (IEC 2014)	Electrical and electronic products and systems (e.g., ICT systems and components of renewable energy systems)	Impact of a product is quantified relative to either another product or an actual project.
Methodology for Environmental Life-Cycle Assessment of Information and Communication Technology Goods, Networks and Services, ITU-T L.1410. (ITU 2014)	ICT goods, networks, and services; guidance also provided on software	Attributional: Compare product GHG inventories; the impact is calculated at the level of a functional unit.
Guidelines for Assessing the Contribution of Products to Avoided Greenhouse Gas Emissions (ILCA 2015)	All sectors	Attributional: Compare product GHG inventories; the impact is calculated by multiplying the avoided emissions per functional unit by the amount of final product(s) in use and then by an attribution factor

In order to incorporate learnings from these Standards and guidelines into the 'Avoided Emissions Framework', we interviewed a number of stakeholders, who were involved in the creation or adoption of these Standards and guidelines to understand why they developed them, how they have seen these Standards and Guidelines being used (e.g. good and bad examples) and what, in their view, are the most important steps in the adoption of an 'Avoided Emissions Framework' going forward.

Some of the early discussion around the concept of 'Avoided Emissions' started not with the concept of 'Avoided Emissions' in mind, but rather from an interest in product footprinting as a means to measure the lifecycle carbon impact of products, in particular during the use phase. There was also a particular interest in the concept of 'Avoided Emissions' from specific sectors, such as the ICT sector, which have, in the past, been particularly prone to questions around their global carbon impact. These sectors saw an opportunity in the concept of 'Avoided Emissions' to demonstrate how they are, despite their increase in absolute carbon emissions, supporting other sectors in helping them reduce their emissions. Furthermore, they also wanted to show that the emissions intensity of their sector (e.g. in terms of data growth for the ICT sector) has been going down rather than up.

The creation of industry Guidelines and Standards was soon followed by individual companies adopting or developing their own guidelines around 'Avoided Emissions'. By developing their own guidelines, companies were able to report on their progress. Additionally, by developing their own guidelines, companies were able to establish credibility amongst both internal and external stakeholders required to support this process.

As increasingly more companies saw an opportunity to calculate and report their 'Avoided Emissions', other reporting frameworks started to discuss the inclusion of 'Avoided Emissions' in their own processes. While some of these discussions were the result of an increasing interest in the use of 'Avoided Emissions' from individual companies, there was also an increasing concern across the carbon accounting community around both the technical implementation aspects of 'Avoided Emissions' as well as around the external communication practices.

While the stakeholders we interviewed as part of this process highlighted that they have seen some good examples of how individual companies use 'Avoided Emissions' in their external advertising and product promotion as a USP of their solutions, it was also acknowledged that this will often require an interest from customers to be successful, which unfortunately is not always there. However, if customers do show interest, 'Avoided Emissions' can be used by companies to talk to their customers from a more positive angle and push the sale of lower carbon products. Furthermore, there have been some good examples where calculating 'Avoided Emissions' at a corporate level has helped companies to communicate their net carbon impact. Some companies have even set a ratio target, which compares the 'Avoided Emissions' of the products and services they sell to their customers against their own emissions. While these targets have helped companies communicate their overall impact to customers and their wider stakeholders, critics of such targets have also been vocal by pointing out the risk of misusing such targets for greenwashing purposes. Furthermore, the lack of sufficient good quality data required for the 'Avoided Emissions' calculations, has been pointed out as an example of how an even well-intended implementation of the existing methodologies can lead to bad examples.

Both the lack of data and the uncertainties around some of the methodological concepts (i.e. cherry-picking, double-counting), which are discussed in section 3 of this document, emphasize the need for transparency in the calculations of avoided emissions and the importance of following a set of common principles. This should also be supported by an improvement in the quality and availability of data used in the calculations. Going forward, it will be important to assess 'Avoided Emissions' not only from a product or company level, but also from a systems perspective and to shift the focus away from a reporting framework to a way of identifying solutions that will support to pathway to keeping global warming below 1.5 degrees Celsius.

4. 2 Application of the AEF Methodology to other frameworks

This section discusses the AEF Methodology in the context of three other reporting and disclosure frameworks, namely:

- **CDP**
- **TCFD**
- **EU Taxonomy**

CDP, formed in 2000, has become the global repository for corporates to report their GHG emissions, with over 7,000 companies reporting in 2019. Included in the CDP questionnaire is Question C4.5, which asks if a company has low-carbon products or products that enable a third party to avoid GHG emissions. While the questionnaire does not ask for the quantity of avoided emissions, it does ask what percentage of revenue these products represent. The AEF methodology directly relates to the assessment of products that enable avoided emissions.

TCFD (the Task Force on Climate-related Financial Disclosures) is an initiative to develop a set of recommendations for consistent climate-related financial risk disclosures by companies. The recommendations (published in June 2017) cover four core elements: Governance, Strategy, Risk Management, and Metrics and Targets. Under the section on climate-related opportunities, it recommends that companies look specifically at their products and services to identify low-emission products including products with a low carbon footprint, and products that have the ability to reduce emissions. The AEF methodology helps directly with identifying and quantifying the avoided emissions from products that have the ability to reduce emissions.

The **EU Taxonomy** is a classification system for sustainable economic activities, developed as part of the EU Sustainable Finance initiative. It covers six environmental objectives, but initially focusses on climate change mitigation and climate change adaptation.
To be included in the proposed EU Taxonomy, an economic activity must contribute substantially to at least one environmental objective and do no significant harm to the other five, as well as meet minimum social safeguards.

The EU Taxonomy Technical Report, published in June 2019, covers 67 activities across 7 sectors. Each activity has activity metrics defined and potentially a threshold value (or values) for the metric. The activity metric and threshold value can be used to assess a proposed activity development, to determine whether that can be considered Taxonomy-eligible. This then can be used by institutional investors and asset managers to determine that their investments are environmentally sustainable. For example, the criteria for cement manufacture is that the emissions associated to the clinker and cement production processes are lower than 0.498 tCO_2e/t of cement. And, for electricity production the threshold activity metric is for facilities operating at life cycle emissions lower than 100gCO_2e/kWh, declining to 0gCO_2e/kWh by 2050.

The six Taxonomy environmental objectives are:
I. climate change mitigation;
II. climate change adaptation;
III. sustainable use and protection of water and marine resources;
IV. transition to a circular economy, waste prevention and recycling;
V. pollution prevention and control;
VI. protection of healthy ecosystems.

The 7 sectors covered are:
- Agriculture and forestry
- Manufacturing
- Electricity, gas, steam and air conditioning supply
- Water, sewerage, waste and remediation
- Transport
- Information and Communication Technologies (ICT)
- Buildings

The EU Taxonomy is a set of criteria to classify if a particular investment can be considered to contribute to sustainable economic activities, while it has specific technical criteria to determine whether an activity can be considered Taxonomy-eligible, it does not attempt to quantify the environment impacts of the activity. The AEF methodology is complimentary to the EU Taxonomy in this regard, as it provides an approach to assess the avoided GHG emissions of an activity.

5 Worked Examples of Framework Application at a Solution Level

These three worked examples help to illustrate how the methodology could be applied, and also include a discussion of the opportunities and challenges presented by these examples.

These examples, although developed based on real data, should only be considered as illustrative of the methodology, and not used or referenced for the results of the examples without further appropriate analysis.

The three examples cover:

- **Mobility** – Car club sharing
- **Buildings** – domestic heat pumps
- **Nutrition** – reducing emissions intensity of food

Also, in addition, there are a large number of example cases on the Avoided Emissions Framework website:
https://www.misolutionframework.net/

5.1 Mobility – Car club sharing

Car club membership is a low-carbon alternative to owning a private car, as it has been shown to reduce greenhouse gas (GHG) emissions whilst providing other benefits such as improved air quality and safety.

The car club model offers users private mobility without the commitment to car ownership, by allowing members to conveniently book vehicles on an hourly, daily or longer basis. Car club vehicles service a greater number of users and many members can either dispose of an owned vehicle or avoid purchasing one, resulting in avoided embodied emissions through reduced demand for vehicles.

At the same time, the per-use pricing of car clubs vs. the significant capital ownership of an owned car encourages the use of more sustainable modes of transport for shorter journeys or where good public transport links exist. Finally, car club vehicles are, on average, newer and have lower emissions than the private car fleet.

5.1.1 Solution Description and Scope

Car club membership is a low-carbon alternative to owning a private car, as it has been shown to reduce greenhouse gas (GHG) emissions whilst providing other benefits such as improved air quality and safety.

The car club model offers the user a private mobility option without the commitment to car ownership, by allowing members to conveniently book vehicles on an hourly, daily or longer basis. Car club vehicles service a greater number of users and many members can either dispose of an owned vehicle or avoid purchasing one, resulting in avoided embodied emissions through reduced demand for vehicles.
At the same time, the per-use pricing of car clubs vs. the significant capital ownership of an owned car encourages the use of more sustainable modes of transport for shorter journeys or where good public transport links exist. Finally, car club vehicles are, on average, newer and produce lower tail-pipe emissions than the private car fleet.

This case study covers car clubs in England and Wales and is based on Research published by Carplus in April 2017.

The functional unit for the carbon abatement assessment is one average annual car club membership. The 'carbon abatement factor' representing the avoided emissions is calculated per car club membership per year. This factor can be multiplied by the number of members to calculate the total annual avoided emissions.

5.1.2 Carbon Avoidance Mechanism

Car Club membership can deliver avoided carbon emissions through a number of mechanisms. The key mechanisms addressed in this study are:

4. Reduced annual car mileage of car club members compared to their previous travel patterns
5. Newer and more efficient car club vehicles compared to the average private car fleet, leading to reduced emissions from completed car club journeys
6. Avoided private car purchases leading to avoided embodied emissions of new vehicles.

There is some degree of rebound effect, where car club membership provides access to car mobility, where ownership was not a viable option, leading to an increase in car travel. Such cases must be taken into account in determining the average reduction in car mileage by car club members.

The methodology defines net avoided emissions as:

Net Avoided Emissions
= Enabling avoided emissions - Direct solution emissions - Rebound emissions

The table below defines the three carbon savings mechanisms and the constituent parts needed for the net avoided emissions calculation:

Table 8: Car Club (CC) Carbon Saving Mechanisms

Carbon Saving Mechanism	Description	Primary Avoided Emissions	Secondary Avoided Emissions	Direct Solution Emissions	Rebound Emissions
Reduced Annual Mileage	Reduced annual mileage for CC members	Emissions from reduced/ avoided mileage driven – based on average vehicle fleet emissions	Reduced wear and tear on highway infrastructure and reduced maintenance (excluded)	Some of the journeys not taken by car will have been taken by other modes of transport (train, bus, taxi, bike), whereas others will not have happened.	A number of car club members increase their annual car mileage after joining.
More Efficient Vehicles	CC annual mileage completed in more efficient CC vehicles	Emissions from CC annual mileage completed in national average vehicles	Reduced fossil fuel refining for petroleum (excluded)	Emissions from CC annual mileage completed in more efficient CC vehicles	No rebound effect
Avoided Private Car Purchases	CC members do not buy new private cars	Emissions from manufacturing new vehicles	Reduced car showroom & test-drive emissions (excluded)	CC purchases new vehicles	Car clubs have a higher turnover of vehicles, but they will be sold on the second-hand market and thus should not lead to increased number of new vehicles.

5.1.3 Methodology

The calculation methodology for the three carbon saving mechanisms are outlined below.

5.1.3.1 Reduced Annual Mileage

BAU Baseline Emissions

The BAU baseline for this carbon saving mechanism is the average annual car mileage travelled by members prior to joining a car club. The additional mileage is assumed to have been driven in an average car.

Primary Avoided Emissions

The Carplus data is based on annual survey of car club members reporting annual car mileage driven before and after joining a car club. Whilst some members report an increased mileage after joining a car club, more members report a greater reduction in miles, so the net effect is a reduction. By combining these figures, the rebound effect is automatically accounted for in the calculation of avoided emissions.

$$\textit{Total Primary Avoided Emissions } (kgCO_2e)_{(Reduced\ Mileage)}$$
$$= \textit{Weighted average avoided distance}(km)$$
$$\times \textit{ National average emissions factors } (kgCO_2e/km)$$

Direct Solution Emissions
The reduced car mileage must be assumed to have been replaced by a combination of other modes of transport as well as avoided trips. The Carplus study is not specific on this point, so statistics on mileage travelled by purpose and main mode from the Department for Transport was used. As a conservative assumption, it can be considered that no journeys were avoided and were instead taken by other modes of transport based on their share of travel.

$$\text{Total Direct Emissions}_{\text{Reduced Mileage}} = \sum_{\text{mode}} \left(\text{Total avoided car travel (km)} \times \text{Modal share}_{\text{mode}} \times \text{Emissions Factor}_{\text{mode}} \right)$$

Rebound Emissions
Rebound emissions are already accounted for in the primary avoided emissions calculation.

Emissions per Functional Unit
Assuming that the average avoided car distance is expressed per car club member, the carbon abatement factor for reduced annual car mileage is simply the difference of primary avoided emissions and direct solutions emissions:

$$\text{Carbon Abatement Factor (kgCO}_2\text{e per CC member)}_{\text{(Reduced Car Mileage)}} = \text{Primary Avoided Emissions (kgCO}_2\text{e)}_{\text{(Reduced Mileage)}} - \text{Direct Solution Emissions (kgCO}_2\text{e)}_{\text{(Reduced Mileage)}}$$

'Secondary Avoided Emissions' are excluded from this calculation (see Table 8).

5.1.3.2 More Efficient Vehicles
BAU Basline
The BAU baseline for this carbon saving mechanism is that the annual Car Club (CC) mileages are driven in national average vehicles.

Primary Avoided Emissions

$$\text{Total Primary Avoided Emissions (kgCO}_2\text{e)}_{\text{(More Efficient Vehicles)}} = \text{Total CC mileage (Miles)} \times \text{National average emissions factors (kgCO}_2\text{e per mile)}$$

Direct Solution Emissions
The Carplus data is reported by the following regions: London, England & Wales and Scotland. Emission factors are provided for each of these regions. The calculation below uses weighted averages by Car Club (CC) completed miles.

$$\text{Total Direct Solution Emissions (kgCO}_2\text{e)}_{\text{(More Efficient Vehicles)}} = \text{Total CC mileage (Miles)} \times \text{Weighted average CC emissions factors (kgCO}_2\text{e per mile)}$$

Emissions per Functional Unit
These emissions are normalised using the functional unit to calculate the 'carbon abatement factor' for 'more efficient vehicles'.

$$\textit{Carbon Abatement Factor } (kgCO_2e \text{ per CC member})_{(\text{More Efficient Vehicles})} = \frac{\left(\text{Primary Avoided Emissions } (kgCO_2e)_{(\text{More Efficient Vehicles})} - \text{Direct Solution Emissions } (kgCO_2e)_{(\text{More Efficient Vehicles})}\right)}{\text{Number of Car Club Members}}$$

'Secondary Avoided Emissions' and 'Rebound Emissions' are excluded from this calculation (see Table 8).

5.1.3.3 Avoided Private Car Purchases

BAU Baseline
The Carplus research indicates that a percentage of members would have purchased new cars had they not joined the Car Club (CC). The percentages are provided per CC region. A weighted average percentage of avoided new car purchases is calculated across all regions, based on the number of members in each region.

The BAU baseline for this carbon saving mechanism is the purchasing of new private cars by CC members, calculated by multiplying the weighted average percentage of avoided new car purchases with the number of new members joined in the last 12 month period.

Primary Avoided Emissions

$$\begin{aligned} &\text{Total Primary Avoided Emissions } (kgCO_2e)_{(\text{Avoided Private Car Purchases})} \\ &= \text{Weighted av.percentage of avoided new car purchases } (\%) \\ &\times \text{Number of new CC members a year (No.)} \\ &\times \text{Av. Embodied Emissions for a new car } (kgCO_2e \text{ per car}) \end{aligned}$$

Direct Solution Emissions
The direct solution emissions is the number of cars purchased by the Car Club (CC) in a year.

$$\begin{aligned} &\text{Total Direct Solution Emissions } (kgCO_2e)_{(\text{Avoided Private Car Purchases})} \\ &= \text{Number of new cars purchased by CC a year (No.)} \\ &\times \text{Av. Embodied Emissions for a new car } (kgCO_2e \text{ per car}) \end{aligned}$$

Emissions per Functional Unit

These emissions are normalised using the functional unit to calculate the 'carbon abatement factor' for 'more efficient vehicles'.

$$\textit{Carbon Abatement Factor } (kgCO_2e \textit{ per CC member})(\textit{Avoided Private Car Purchases}) = \frac{\left(\begin{array}{l}\textit{Primary Avoided Emissions } (kgCO_2e)_{(\textit{Avoided Private Car Purchases})} - \\ \textit{Direct Solution Emissions } (kgCO_2e)_{(\textit{Avoided Private Car Purchases})}\end{array}\right)}{\textit{Number of Car Club Members}}$$

'Secondary Avoided Emissions' and 'Rebound Emissions' are excluded from this calculation (see Table 8).

5.1.3.4 Total Carbon Abatement Factor

The Carbon Abatement Factors per Car Club (CC) Member for the three Carbon Savings Mechanisms above, can be added together to calculate the Total Carbon Abatement Factor for Car Club membership in the UK (excl. NI).

$$\begin{aligned}\textit{Carbon Abatement Factor } (kgCO_2e \textit{ per CC member}) \\ = \ & \textit{Carbon Abatement Factor } (kgCO_2e \textit{ per CC member})_{(\textit{Avoided Private Car Purchases})} \\ + \ & \textit{Carbon Abatement Factor } (kgCO_2e \textit{ per CC member})_{(\textit{More Efficient Vehicles})} \\ + \ & \textit{Carbon Abatement Factor } (kgCO_2e \textit{ per CC member})_{(\textit{Reduced Car Mileage})}\end{aligned}$$

5.1.4 Assumptions

- The average annual mileage reduction is expressed per household. For simplification, one car club membership has been assumed per household.
- It has been assumed that the reduction in mileage is not due to car club members avoiding journeys after joining Car Club, but rather that they are still making these journeys using more sustainable modes of transport (i.e. public transport). This is a conservative assumption as it is possible that some of the reduction in mileage may have been a result of avoided journeys.
- It has been assumed that the number of car club members has grown at a constant rate for the last ten years to derive the number of new car club members in 2016/17.
- To estimate the total number of new car club vehicles in 2016/17, it has been assumed that the total number of vehicles in UK was 4,000 in both 2015/16 and 2016/17 and that the decrease in the London fleet was made up by increase in the England & Wales fleet as well as an increase in the Scotland fleet.

Data Sources

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- Carplus, 2017. Carplus annual survey of car clubs 2016/17.London.
- Available at: https://como.org.uk/wp-content/uploads/2018/06/Carplus-Annual-Survey-of-Car-Clubs-2016-17-London.pdf
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- https://como.org.uk/wp-content/uploads/2018/06/Carplus-Infographics-2017-London-AW.pdf
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- Department for Environment, Food and Rural Affairs (DEFRA), 2016. Greenhouse Gas Conversion Factor Repository. Available at: http://www.ukconversionfactorscarbonsmart.co.uk/
- Department for Transport Statistics (DfT), 2017, National Travel Survey, Average distance travelled by purpose and main mode: England, 2017. Available at: https://www.gov.uk/government/statistical-data-sets/nts03-modal-comparisons

5.1.6 Calculated Carbon Avoidance

The table below highlights the carbon savings from the three carbon savings mechanisms and the constituent parts of the net avoided emissions calculation:

Table 9: Car Club (CC) Carbon Savings per annum

Overall, each car club member avoids around 261 $kgCO_2e$ per year. This amounts to around 64,000 tCO_2e of carbon savings in the UK per year.

Carbon Saving Mechanism	Primary Avoided Emissions	Secondary Avoided Emissions	Direct Solution Emissions	Rebound Emissions	Total Carbon Abatement
Reduced Annual Mileage	~171 $kgCO_2e$/car club member	Excluded	~51 $kgCO_2e$/ car club membership	Accounted for in the primary avoided emissions	~120 $kgCO_2e$/ car club member
More Efficient Vehicles	~18.6 $kgCO_2e$/ car club member	Excluded	~12.8 $kgCO_2e$/ car club member	No rebound effect	~6 $kgCO_2e$/car club member
Avoided Private Car Purchases	~166 $kgCO_2e$/ car club member	Excluded	~31 $kgCO_2e$/car club members	Excluded	~135 $kgCO_2e$/ car club member

5.1.7 Technology Readiness Level and Future Opportunities

Car clubs, such as the services provided by companies such as Zipcar and Carplus are already available for consumers and can be found in operation in metropolitan areas across the UK. Therefore this solution would be considered to be at TRL level 9.

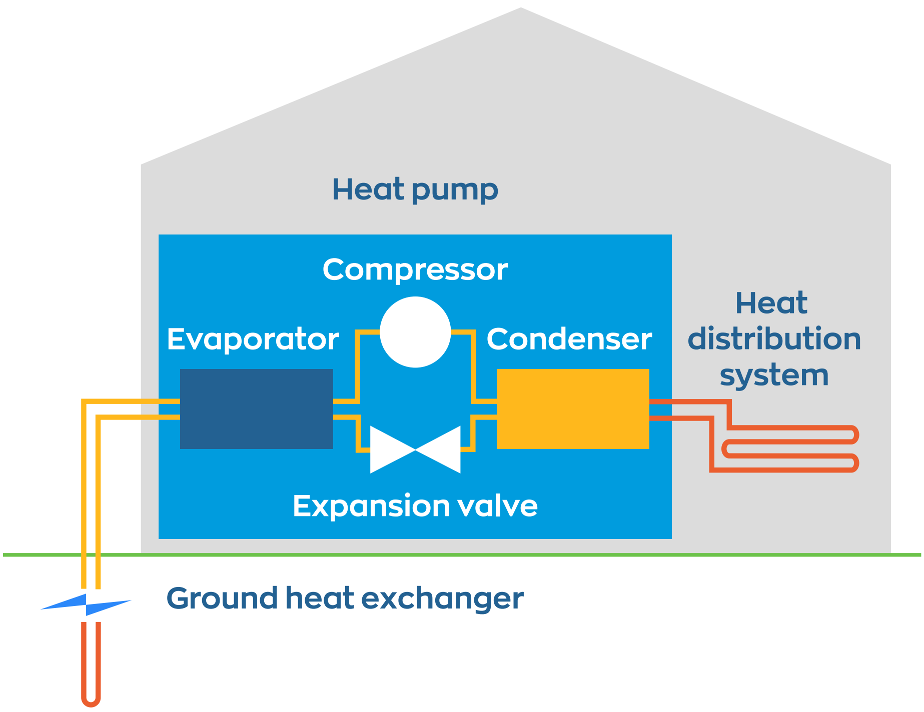
The number of car club operators and car club memberships in the UK has been steadily growing over the past years, reaching around 245k members in 2017. This amounts to ca. 64,000 tonnes CO_2e saved per year. The majority of these members (ca. 193k) are based in London, and Transport for London (TFL) has committed to increasing the number of car club members to 1 million by 2025 in London. If successful, this could avoid up to 261,000 tonnes CO_2e per year. These savings could be even higher if the UK car club fleet is replaced entirely by electric vehicles.

5.2 Buildings – Domestic heat pumps

This worked example considers replacing existing domestic heating by heat-pumps. The base case is the existing domestic heating systems, which may be gas, oil or conventional electricity-powered heating systems. The worked example is used to illustrate the calculation of the avoided emissions, and also considers the impact of different factors such as comparing different countries, and different electricity grid rates.

5.2.1 Solution Description and Scope

Figure 6: A typical GSHP system.[22]



Ground source heat pumps (GSHPs) are a technology that extract heat from the ground via buried pipes filled with fluid, which is then passed through a compressor to raise the temperature of the fluid. This fluid can then be used to heat radiators, underfloor or warm air heating systems, and hot water in homes.

By using the natural energy stored in the ground, GSHPs are able to generate the same amount of heat, with less energy than is required by heating systems using gas, oil or electricity. They have some impact on the environment as they need electricity to run, but the heat they extract from the ground is being constantly renewed naturally.

This case study covers GSHPs replacing alternative residential heating systems (e.g. oil and electric heating) in the United Kingdom and China.

The functional unit for the abatement assessment is one household. The 'carbon abatement factor' representing the avoided emissions is calculated per household per year. This factor can be multiplied by the potential number of households that could feasibly install a GSHP to calculate the total annual carbon abatement.

5.2.2 Carbon Avoidance Mechanism

GSHPs can deliver avoided carbon emissions via the following mechanism:

1. Reduced energy usage for heating compared to previous heating system

Both cost and carbon savings will depend on the system that is installed compared to the previous system. Factors that will affect savings include whether underfloor heating is being used, the type of fuel that was used for the previous system, the efficiency of the previous system, whether water is to be heated and/or whether controls have been used.

The methodology defines net avoided emissions as:

Net avoided emissions
= Enabling avoided emissions - Direct solution emissions - Rebound emissions

The table below defines the carbon saving mechanism and the constituent parts needed for the net avoided emissions calculation:

Table 10: Ground Source Heat Pump (GSHP) Saving Mechanism

Carbon Saving Mechanism	Description	Primary Avoided Emissions	Secondary Avoided Emissions	Direct Solution Emissions	Rebound Emissions
Reduced energy consumption	Reduced energy usage for heating compared to previous heating system	Emissions from reduced fossil fuel consumption compared to the previous heating system.	Reduced fossil fuel refining (excluded)	The GSHP still requires some electricity to run. Furthermore, certain installations require an auxiliary electric immersion heater to raise the water temperature periodically to over 60°C to reduce the risk of Legionella. GSHP also require the use of refrigerants that normally leak from the system. These refrigerants have, in some cases, a quite high GWP.	The reduction in heating costs resulting from the GSHP may mean that a home is heated more than it otherwise might have with fossil fuel heating.

5.2.3 Methodology

The calculation methodology for the carbon saving mechanism is outlined below.

5.2.3.1 Reduced Energy consumption

BAU Baseline Emissions

The BAU baseline for this carbon saving mechanism is the average emissions caused by electric storage and oil heaters. According to the BSRIO World Market Intelligence Division, these are the heating systems that are most feasible to be replaced by GSHPs.

Primary Avoided Emissions

Primary avoided emissions for oil heaters are calculated using the following equation:

$$\textit{Average Primary Avoided Emissions}_{(Oil\ heaters)}\ (kgCO_2e)$$
$$= \textit{Average avoided energy consumption}\ (kWh)$$
$$\times\ \textit{National average emissions factors}\ (kgCO_2e/kWh)$$

Primary avoided emissions for electric storage heaters are calculated using the following equation:

$$\textit{Average Primary Avoided Emissions}_{(Electric\ heaters)}\ (kgCO_2e)$$
$$= \textit{Average avoided energy consumption}\ (kWh)$$
$$\times\ \textit{National average emissions factors}\ (kgCO_2e/kWh)$$

The avoided emissions for replacing oil heaters with GSHPs will be multiplied by the number of households with oil heaters to calculate the potential avoided emissions.

Similarly, the avoided emissions for electric storage heaters will be multiplied by the number of households with electric storage heaters. These two figures will then be added together to give the total avoided emissions.

Direct Solution Emissions

Direct solution emissions refer to the electricity consumption of the GSHP. Total direct solution emissions are calculated using the following equation:

$$\textit{Total Direct Emissions}_{GSHP} = \textit{Average electrical consumption GSHP (kWh)} \times \textit{Emission factor } (kgCO_2e/kWh) + \textit{Average refrigerant leakage (kgs)} \times \textit{Refrigerant GWP } (kgCO_2e/kg)$$

Rebound Emissions

There are a number of examples of rebound effects from the use of heat pumps. Halvorsen et al. (2016) found that for their study of households in Norway, households with and without a heat pump used approximately the same amount of electricity. This was due to rebound effects including higher indoor heating temperatures, less firewood and fuel oil use, and less use of night-set-backs or reduced temperatures when homeowners were away. Tweed et al. (2015) found a similar result for their study of households in the UK, that a 'spatial rebound' effect exists where occupants inhabit rooms they previously could not afford to heat.

Both studies are qualitative in nature, and there is not a good degree of data available. Therefore these rebound effects have not been quantified as part of this analysis.

Emission per Functional Unit

Assuming that the average avoided emissions saving from a GSHP is expressed per household, the carbon abatement factor for installing a GSHP is the difference of primary avoided emissions and direct solutions emissions:

$$\textit{Carbon Abatement Factor } (kgCO_2e \textit{ per household}) = \textit{Primary Avoided Emissions } (kgCO_2e) - \textit{Direct Solution Emissions } (kgCO_2e)$$

5.2.3.2 Total Carbon Abatement Factor

The Carbon Abatement Factor per household is represented by the 'Emission per Functional Unit' equation:

$$\textit{Carbon Abatement Factor } (kgCO_2e \textit{ per household}) = \textit{Primary Avoided Emissions } (kgCO_2e) - \textit{Direct Solution Emissions } (kgCO_2e)$$

5.2.4 Assumptions and exclusions

- It is assumed that a GSHP has an average Co-efficient of Performance (COP) of 3.
- It is assumed that installing a GSHP is only economically feasible for homes off the mains gas grid and that do not use biomass as the main source of heating energy – it is considered for replacing oil and electric heaters (in the UK) and coal, electric and other heaters (in China).
- It is assumed that there is no auxiliary heat pump required alongside the GSHP.
- It is assumed that the average energy demand for heating is 12,000 kWh in the UK 11,456 kWh in China.
- Refrigerant leakage was excluded due to the large uncertainty behind it. GWP factors vary greatly across different types of refrigerant and normal residential-sized systems, as the one portrayed above, have very low leakage rates.

Data Sources

- Department for Environment, Food and Rural Affairs (DEFRA), 2018, UK Government GHG Conversion Factors for Company Reporting. Available at: https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2018.
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- Duan, X. et al., 2014, Household fuel use for cooking and heating in China: Results from the first Chinese Environmental Exposure-Related Human Activity Patterns Survey (CEERHAPS). Applied Energy. 136. pp 692-703.

5.2.6 Calculated Avoided Emissions

The tables below highlight the carbon savings from the carbon savings mechanism and the constituent parts of the net avoided emissions calculation:

Table 11: GSHP Carbon Savings Per Annum for the UK case-study

Carbon Saving Mechanism	Primary Avoided Emissions	Secondary Avoided Emissions	Direct Solution Emissions	Rebound Emissions	Total Carbon Abatement
GSHP (from oil heating)	~3,530 $kgCO_2e$/ household	Excluded	~1,132 $kgCO_2e$/ household	Excluded	~2,398 $kgCO_2e$/ household
GSHP (from electric storage heating)	~3,397 $kgCO_2e$/ household	Excluded	~1,132 $kgCO_2e$/ household	Excluded	~2,265 $kgCO_2e$/ household

Table 12: GSHP Carbon Savings Per Annum for the China case-study

Carbon Saving Mechanism	Primary Avoided Emissions	Secondary Avoided Emissions	Direct Solution Emissions	Rebound Emissions	Total Carbon Abatement
GSHP (from coal heating)	~4,157 $kgCO_2e$/ household	Excluded	~2,596 $kgCO_2e$/ household	Excluded	~1,561 $kgCO_2e$/ household
GSHP (from electric storage heating)	~7,788 $kgCO_2e$/ household	Excluded	~2,596 $kgCO_2e$/ household	Excluded	~5,192 $kgCO_2e$/ household

Overall, in the UK each household could avoid around 2,398 $kgCO_2e$ per year from converting oil heating to a GSHP, and around 2,265 $kgCO_2e$ per year from converting electric storage heating to a GSHP. In China, as the emission factor of electricity is much higher, the potential carbon savings of switching from an electric storage heating system to a GSHP are more than double than the ones found in the UK (5,192 $kgCO_2e$ per year). For the same reason, the direct solutions are higher which lowers the potential avoided emissions for the other heating technologies: coal (1,561 $kgCO_2e$ per year); and other – considered as oil (774 $kgCO_2e$ per year).

If all oil and electric heating systems across households in the UK were converted to GSHPs, this could amount to carbon savings of around 6.9 million tCO_2e per year.

In China, if all coal and electric residential heating systems were converted to GSHPs the total carbon savings would amount to more than 447 million tCO_2e per year.

5.2.7 Sensitivity Analysis

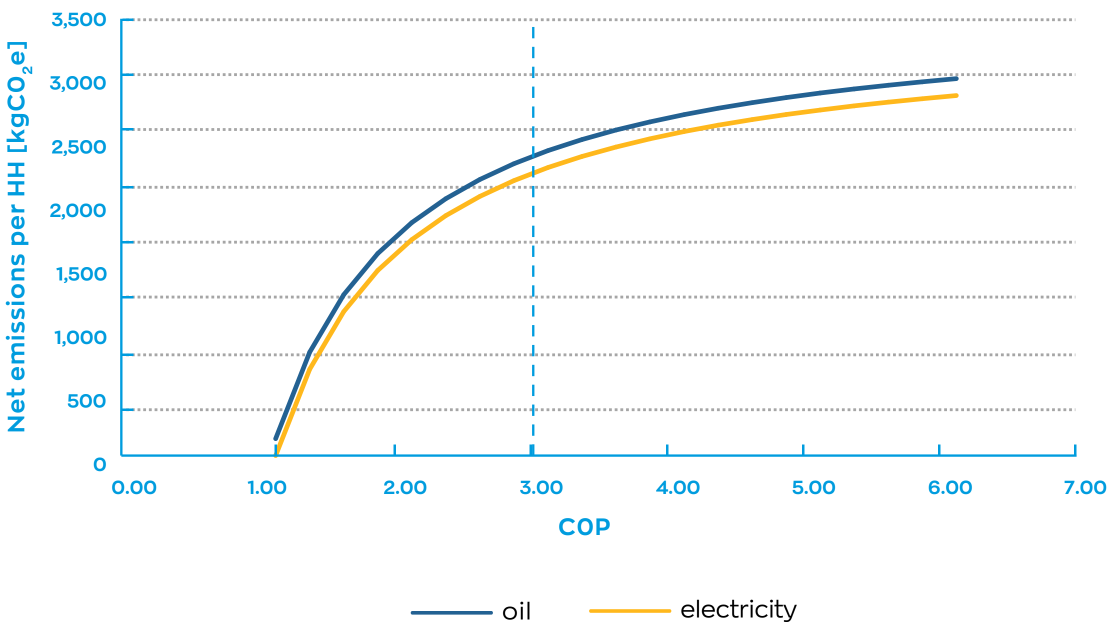
Due to the nature of this study, assumptions had to be made to represent an average household and its oil and electricity storage heating system and the GSHP that could replace it. To understand the potential impact of these assumptions on the results obtained, a sensitivity analysis is presented below regarding two of the assumptions for which there is a larger degree of uncertainty: the COP ratio and the average energy demand for heating in the UK and Chinese households.

5.2.7.1 COP (Coefficient of Performance)

COP values largely depend on the temperatures of the heat source and the cold 'side'. For extreme cold conditions, when the difference between these numbers is larger, the COP can reach very low numbers (close to 1). However, recent test runs of high efficiency GSHP have shown COP values over 5.5. Considering these factors, the range used for the COP sensitivity analysis was of 1 to 6.

For the UK, oil and electricity heating systems present similar levels of carbon savings and the behaviour against the variation of the COP ratio is also identical for both heating systems. For COP values close to 1, the carbon savings are almost negligible. For more common COP values (2.5 to 4 range), the carbon savings per household are over 2,000 kgCO_2e per year. Even though there is a large impact if the COP value is much lower than the one assumed, this only occurs in very extreme conditions which are unlikely to happen for prolonged periods.

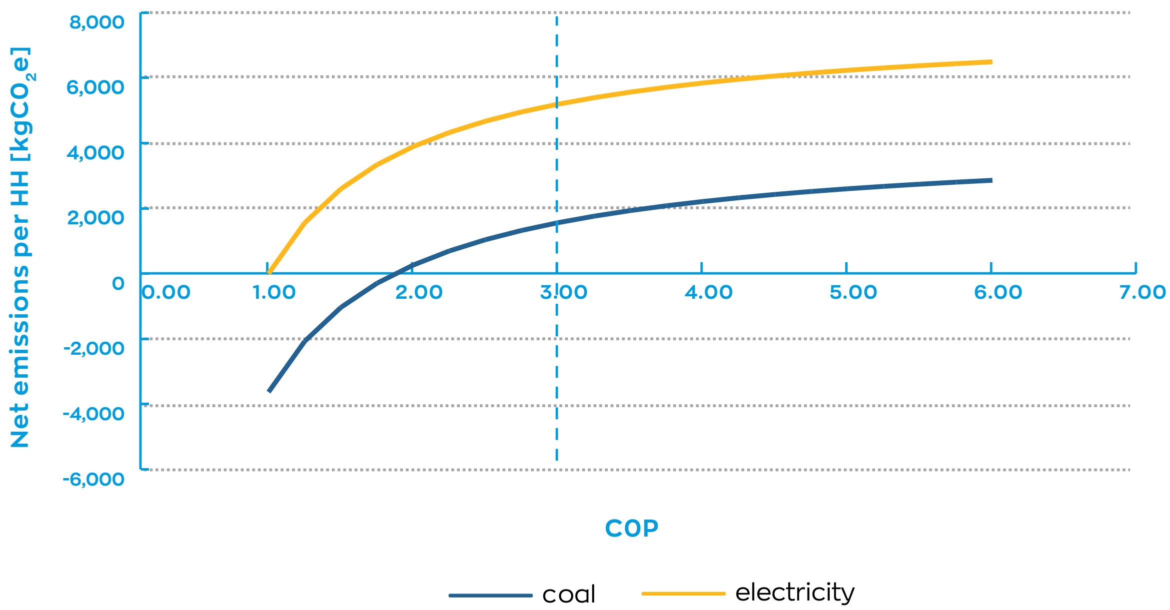
Figure 7: COP sensitivity analysis for net avoided carbon emissions per household in the UK



In China, the analysis is different as there are only carbon savings in replacing coal heating systems when the COP value is close to or above 2. This is, again, due to the high emission factor associated with grid electricity; because of this, the carbon savings associated with coal heating are always lower than the carbon savings associated with the replacing of electric heating systems. Nonetheless, GSHP delivers a positive carbon benefit compared to coal or electric storage heating, assuming a COP value in the common range of 2.5 to 4.

Additionally, China has put incentives in place for the installation of GSHPs and these have a requirement of a minimum COP value (which depend on the dimension of the system). The minimum COP value in these policies is 3.4, which would deliver even greater carbon savings than those considered in this study with the COP value of 3.

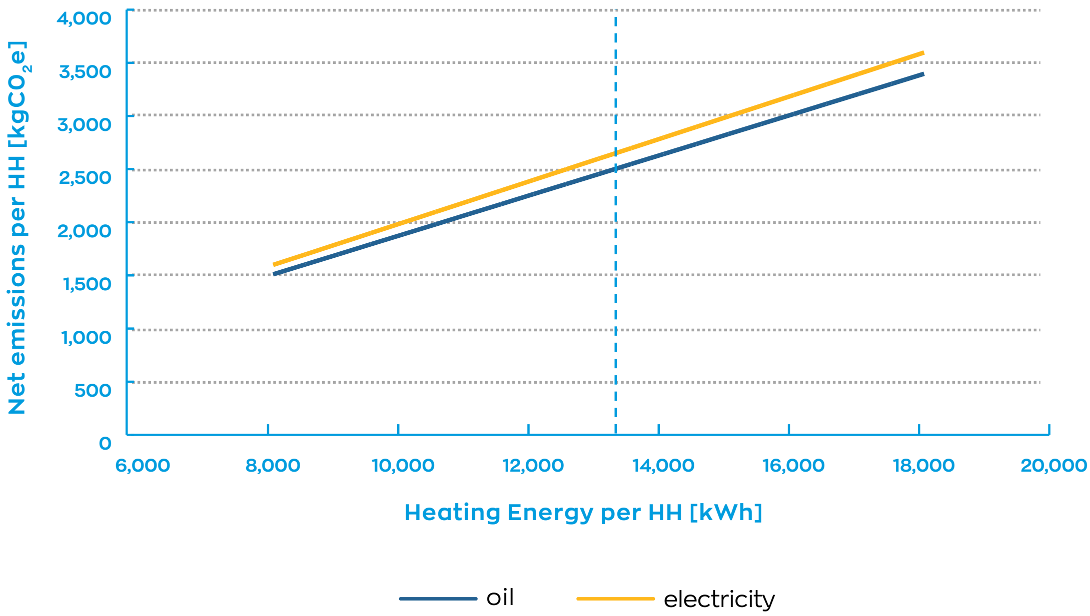
Figure 8: COP sensitivity analysis for net avoided carbon emissions per household in China



5.2.7.2 Heating Energy

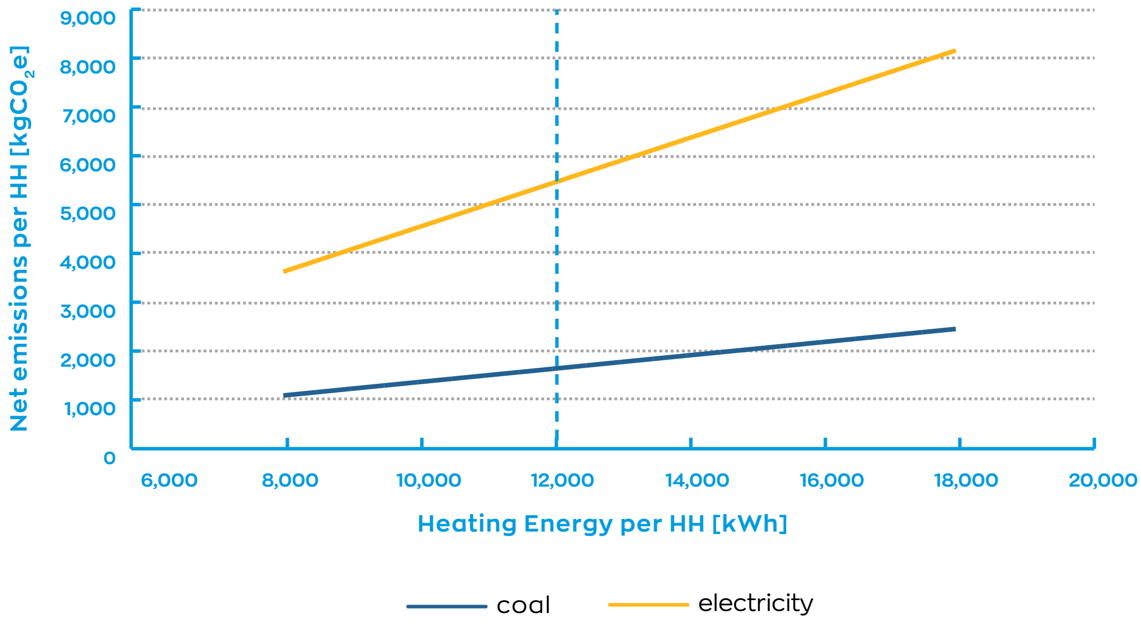
The total annual heating energy demand per household used for the two countries were very close (12,000 kWh for the UK and 11,456 kWh for China). These values were obtained from different sources relating to statistics of energy consumption in households for each country. Despite the similarity of these values, it is acknowledged that there are multiple factors that impact on residential heating demands such as climate, thermal insulation of buildings and definition of temperature of comfort. For the current analysis a range of 8,000 kWh to 18,000 kWh was used which is believed to cover most of the energy demands in countries where heating is necessary.

Figure 9. Heating energy per household (HH) – sensitivity analysis for net avoided carbon emissions per HH in the UK



In both figures (Figure 9 and Figure 10), the carbon savings show a linear relation with heating demand, as expected. Again, the avoided emissions per household in the UK for both the replaced heating oil and electricity heating systems show a similar trend with avoided emissions ranging from ~1,500 kgCO_2e to slightly over 3,500 kgCO_2e per year. In China, the increase in carbon savings is much greater for replacing electric heating systems where savings are estimated to rise up to ~8,000 kgCO_2e for households at the top of the range of heat demand.

Figure 10: Heating energy per household (HH) – sensitivity analysis for net avoided carbon emissions per HH in China



5.2.8 Technology Readiness Level and Future Opportunities

GSHPs are already available for consumers, with around 22,000 heat pumps installed in 2017 (note this will also include air-source and water-source heat pumps) in the UK. In China, 2010, there were already 227 billion ft2 of buildings floor area conditioned with GSHP systems and the heat pump market is one that has shown a massive growth (CAGR between 2013 and 2018 estimated to be of 28%). Therefore, this solution is readily available to the consumer and would be considered to be at TRL level 9.

For the UK, using the BEIS Energy and Emission Projections (2017), the UK grid is projected to decarbonise to ~54 gCO_2e/kWh by 2035. Using the current assumption that it is only practical to replace off-grid electric and oil heaters with GSHPs in the UK, the potential household carbon savings for replacing oil heating in 2035 would be 3,004 $kgCO_2e$ and 432 $kgCO_2e$ for replacing electric heaters with GSHPs. This could result in potential total carbon savings of 3,867,720 tCO_2e by 2035. This is lower than the current potential carbon savings in the UK, as the carbon abatement of replacing an electric heater with a GSHP will be lower in 2035 due to the lower electricity emission factor.

However, as the price of fossil fuels, particularly gas, becomes more expensive, the financial incentives to install a GSHP may become higher. Assuming that 90% of the 27 million UK households have a garden and currently use gas heating (and can therefore install a GSHP), the potential savings from GSHPs will rise to 46.8 million tCO_2e.

5.3 Nutrition – reducing emissions intensity of food

This worked example looks at replacing animal based protein food with plant based protein.

The worked example illustrates the calculation of the avoided emissions, and also considers the impact of different factors such as comparing different countries.

5.3.1 Solution Description and Scope

Over the past decade, more and more individuals are deciding to replace their daily meat consumption with alternatives. The livestock industry currently contributes around 15% to global emissions, resulting from both the processing of meat, as well as agricultural emissions related to keeping livestock. Although reasons for switching to a low-meat diet may vary across individuals, there are a number of environmental benefits associated with a low meat diet, which can result in lower GHG emissions. Plant based meat substitute products have a lower carbon intensity than the meat alternatives and therefore, replacing meat consumption with these low-carbon alternatives can reduce greenhouse gas (GHG) emissions whilst potentially providing other benefits such as improved health. This case study will determine the carbon savings from replacing carbon intensive meat consumption with plant based protein products.

5.3.2 Carbon Avoidance Mechanism

Replacing meat with plant based protein products can deliver avoided carbon emissions through the following key mechanism:

Reduced meat production
The reduction in meat production results in a reduction in agricultural emissions, related to fermentation from ruminants, manure storage and processing, transportation and processing of animal products, as well as from feed production and processing. Further emissions are caused by land use change, resulting from the production of feed.

There is no direct rebound effects, as it has been assumed that the nutritional value from meat products is more or less identical to the nutritional value of plant based protein products, and consumers would therefore consume the same amount of each product to gain the same amount of nutrients. However, indirect rebound effects could result from price differences between meat products and plant based protein products, which may result in consumers spending money on other carbon-intensive goods with the money saved from switching to plant based protein products. However, this will vary depending the price per products and little evidence exists that quantifies how any additional money is spent.

The methodology defines net avoided emissions as:

Net avoided emissions
= *Enabling avoided emissions - Direct solution emissions - Rebound emissions*

The table below defines the carbon savings mechanism and the constituent parts needed for the net avoided emissions calculation:

Table 13: Plant based protein Meat Substitute Carbon Saving Mechanism

Carbon Saving Mechanism	Description	Primary Avoided Emissions	Secondary Avoided Emissions	Direct Solution Emissions	Rebound Emissions
Reduced meat production	Reduced meat consumption replaced with low-carbon alternatives	Emissions from reduced meat production, including agricultural emissions and emissions from land use change	Emissions from land use change resulting from deforestation	Emissions from the production of plant based protein products.	No direct rebound effect.

5.3.3 Methodology

The calculation methodology for the carbon saving mechanism is outlined below for the two case studies considered: UK and Brazil.

5.3.3.1 Reduced Meat Intake

BAU Baseline Emissions

The BAU baseline for this carbon saving mechanism is the average annual meat consumption by individuals both in the UK and Brazil. The total consumption of meat is derived from national statistical average food purchase data (obtained from Defra, UK and Conab, Brazil) minus the amount of meat purchases going to waste, estimated using an average percentage of household food waste figure, obtained from WRAP.

Primary Avoided Emissions

The emissions from meat consumption per year per person have been calculated by multiplying the annual meat consumption by the average emission factor for meat, which is calculated using a weighted average of emission factors for the most popular types of meat in each country.

Total Primary Avoided Emissions $(kgCO_2e)_{(Meat\ Consumption)}$
= *Meat consumption per year (kg)*
× *Weighted average emissions factor* $(kgCO_2e/km)_{(Meat)}$

Direct Solution Emissions
The reduced meat consumption is assumed to be replaced entirely with plant based protein products. The emission factor for the production of plant based protein products will vary depending on the basis of the product (e.g. legumes, nuts, cultured protein). The emission factor used for this study was based on a commonly available cultured protein product.
It has been assumed that all plant based protein products have the same carbon intensity.

Total Direct Emissions

$$= \sum \left(\text{Total avoided meat consumption per year (kg)} \times \text{Emissions Factor}_{(Plant)} \right)$$

Rebound Emissions
No direct rebound effects have been identified and any indirect rebound effects are excluded from the calculation due to lack of sufficient data.

Emissions per Functional Unit
The carbon abatement factor for reduced meat consumption is simply the difference of primary avoided emissions and direct solutions emissions:

$$\text{Carbon Abatement Factor (kgCO}_2\text{e per person)}_{(Reduced\ Meat\ Consumption)}$$
$$= \text{Primary Avoided Emissions (kgCO}_2\text{e)}_{(Reduced\ Meat\ Consumption)}$$
$$- \text{Direct Solution Emissions (kgCO}_2\text{e)}_{(Reduced\ Meat\ Consumption)}$$

‘Secondary Avoided Emissions’ are excluded from this calculation (see Table 13).

5.3.3.2 Total Carbon Abatement Factor

The Carbon Abatement Factors per capita for the reduction in meat consumption can be summarized in the following equation:

$$\text{Carbon Abatement Factor (kgCO}_2\text{e per person)}$$
$$= \text{Carbon Abatement Factor (kgCO}_2\text{e per person)}_{(Reduced\ Meat\ Consumption)}$$

5.3.3.3 Assumptions

- It has been assumed that the nutritional value of 1 kg of meat is identical to the nutritional value gained from consuming 1 kg of plant based protein product.
- It has been assumed, due to lack of data, that the emission factor for lamb is the same as the emission factor for beef.
- It has been assumed that the emission factors for each type of meat are the same in the UK and Brazil.
- It has been assumed that percentage of meat going to waste in the UK per person is the same as the percentage of total food going to waste in UK households.

5.3.3.4 Data Sources

- Defra, Family Food 2016/17: Purchases. 2018. Available at: https://www.gov.uk/government/publications/family-food-201617/purchases
- WRAP, Household Food and Drink Waste in the United Kingdom 2012. 2013. Available at: http://www.wrap.org.uk/sites/files/wrap/hhfdw-2012-summary.pdf
- Audsley, E. and M. Wilkinson (2012). Using a model-based LCA to explore options for reducing national greenhouse gas emissions from crop and livestock production system. 8th International Conference on Life Cycle Assessment in the Agri-Food Sector (LCA Food 2012). Saint Malo, France. Rennes, France.
- Farmers Weekly, UK meat consumption – in numbers and pictures. Available at: https://www.fwi.co.uk/business/uk-meat-consumption-numbers-pictures
- Guardian article citing Morrisons report (2018), Third of Britons have stopped or reduced eating meat – report. Available at: https://www.theguardian.com/business/2018/nov/01/third-of-britons-have-stopped-or-reduced-meat-eating-vegan-vegetarian-report
- ONS, Statistical bulletin:Families and Households: 2017. Available at: https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/families/bulletins/familiesandhouseholds/2017
- Globo article citing Conab statistics (2017), Consumo per capita de carnes no Brasil é o menor em oito anos. Available at: https://revistagloborural.globo.com/Noticias/Criacao/noticia/2017/07/consumo-capita-de-carnes-no-brasil-e-o-menor-em-oito-anos.html
- ABPA Report (2018), Relatório Anual 2018. Available at: http://abpa-br.com.br/storage/files/relatorio-anual-2018.pdf
- Globo article citing Ibope report (2018), Brasil tem 14% de vegetarianos e 81% de adeptos à dieta com carne, diz pesquisa Ibope. Available at: https://g1.globo.com/bemestar/noticia/brasil-tem-14-de-vegetarianos-e-81-de-adeptos-a-dieta-com-carne-diz-pesquisa-ibope.ghtml

5.3.4 Calculated Carbon Avoidance

The tables below highlight the total net carbon abatement of the carbon saving mechanism and the correspondent calculations.

Table 14: Plant based protein Meat Substitute Carbon Saving per annum in the UK

Carbon Saving Mechanism	Primary Avoided Emissions	Secondary Avoided Emissions	Direct Solution Emissions	Rebound Emissions	Total Carbon Abatement
Reduced Annual Meat Intake	~299 $kgCO_2e$/capita	Excluded	~30 $kgCO_2e$/capita	Excluded	~269 $kgCO_2e$/capita

Table 15: Plant based protein Meat Substitute Carbon Saving per annum in Brazil

Carbon Saving Mechanism	Primary Avoided Emissions	Secondary Avoided Emissions	Direct Solution Emissions	Rebound Emissions	Total Carbon Abatement
Reduced Annual Meat Intake	~ 520 $kgCO_2e$/ capita	Excluded	~65 $kgCO_2e$/ capita	Excluded	~454 $kgCO_2e$/ capita

Overall, each person avoids around 269 $kgCO_2e$ in the UK and 454 $kgCO_2e$ in Brazil per year. The savings in Brazil are much higher due to one factor, a much larger intake of meat per person (90kg in Brazil versus 52kg in the UK). The percentage of carbon intensive meat is very close in both countries with beef consumption being 37% of the total in Brazil, and in the UK the sum of beef and lamb consumption being 36% (26% and 10% respectively).

Assuming that the replacement of meat by vegetarians is done entirely by switching to plant based protein products, the total carbon savings of avoiding meat all together is of 2,220 $ktCO_2e$ in the UK (based on 12.5% of the population is vegan or vegetarian) and of 13,310 $ktCO_2e$ in Brazil per year (based on 14% of the population is vegetarian).

5.3.5 Technology Readiness Level and Future Opportunities

Plant based protein products are already available across supermarket in the UK. Therefore, this product would be considered to be at TRL level 9.

The number of consumers reducing their meat consumption is growing, as more and more consumers are either switching to a vegetarian or vegan diet, or are also consciously reducing their meat intake. Assuming that the percentage of non-meat eaters will grow to 25% by 2025, and all the avoided meat consumption is replaced with plant based protein products, this would save around 4,440 $ktCO_2e$ per year in the UK.

However, it is quite unlikely that all avoided meat would be replaced by plant based protein products. This case study has not looked at the full carbon impact of switching to a vegetarian or vegan diet, which involves consumers replacing their meat consumption with a variety of non-meat foods, as well as meat substitutes, different adoption rates, and different options for the carbon intensity of the foods or diets.

6 Checklist and Data Sources

This section includes a checklist to help with assessments of avoided emissions, and also a discussion of some common data requirements, and suggestions of data sources.

6.1 Checklist – key things to consider in the assessment

Item	Check	Reference to paragraph in document
Scope and impact	Does the solution reduce overall global emissions?	3.14 and 2.2
Scope – all GHGs	Include all GHGs not just CO_2.	3.1 and 2.1.3
1.5°C compatibility	Is the solution 1.5°C compatible? And does it avoid lock-in threats?	3.14 and 2.1.3
Baseline	Is the baseline reasonable and appropriate to the solution being assessed?	3.6
Direct Solution emissions	Have the direct emissions of the solution been considered?	3.5.1.3
Rebound effects	Have rebound effects been considered? And assessed either quantitatively or qualitatively?	3.5.3
Data sources	Are data sources reliable and referenced?	3.7.4
Cross-check	Cross check critical data points with other data sources to validate robustness of the data.	3.15
Assumptions	Avoid using arbitrary assumptions. If in doubt be conservative with assumptions and selection of data sources - i.e. attempt to not overstate the benefits.	3.15
Emission factors	Emission factors should reflect full life-cycle emissions. Future projections should use emission factors that reflect projected decarbonisation. Clearly state what emission factors have been used.	3.9
Sense Checks	Do the assumptions, data and results seem reasonable and credible? Are the calculated avoided emissions reasonable? (E.g. compare the total avoided emissions as a percentage of the total sector emissions).	3.15
Uncertainty	Perform an uncertainty assessment - either qualitative or quantitative or a sensitivity analysis.	3.7.1
Review	Perform an Independent Review or validation.	3.15
Reporting of results	Reporting - clear explanation of methodology, data sources and assumptions. - Based on this, could someone else independently calculate the avoided emissions, and produce the same results?	2.4
Reporting of factors	Are results and factors transferable - or do they related to specific boundary conditions (e.g. geography, time, scale)?	2.1.3
Units / metrics	Are units and metrics clearly stated? (e.g. $kgCO_2e$ or tCO_2e, and time period - per year, or per life of product?)	2.4 and 3.5.1.2

6.2 Data Sources

Assessments of avoided emissions relies on having robust and reliable data sources. Consistency in assessments will also be improved by using common and agreed data sources.

It is hoped that the Avoided Emissions Framework can work with government and other international agencies to develop a consistent, open-source set of data for use in avoided emissions assessments. Some of the data will be common to other carbon assessments (e.g. life cycle assessments (LCA) and carbon footprinting).

The table below is indicative of some common data requirements that have been identified during initial assessments for the AEF initiative. Most of these data items will be needed both as current factors / data, and for future (e.g. 2030).

Data Item	Description / possible data sources
General Emission Factors (EFs) for a range of materials and products – both current and future	There are a number of existing LCA and EEIO data bases (some are openly available and some proprietary). There are also a number of tools of varying reliability that will 'calculate' emissions for consumer products. It would be useful to collate the best of these into an accessible data base – however this would be time consuming. Having a list of default EFs for a basic set of products and materials would be a useful start.
Fuel EFs	These are fairly well defined and available from sources such as BEIS , IPCC
Electricity EFs	Current electricity EFs are available from IEA, and from National data sources. Future electricity EFs can be derived from the energy scenarios data in the IEA 'Energy Technology Perspectives' report.
Global economy projections	Various global statistics and projections available from national government data, UN data, World Bank data, IEA data.
Transport	Number of vehicles by category (road: cars, vans, buses, LGVs, HGVs; rail; sea; air) and country. Annual distance by vehicle category. EFs by vehicle category. Number of electric vehicles. Data sources include national statistics, IEA projections, international agencies (e.g. IMO for shipping, and ATAG for air travel).
Buildings	Categories of buildings. Emissions by type of building. Projection for growth in number of buildings.
Land use	Forests - density and annual growth rates. Carbon sequestration rates. Data sources: FAO
Energy and emission scenarios	E.g. IEA (by sector). E.g. IPCC scenarios (simplified)
Carbon abatement factors	Collated factors from other published assessments or studies. However, note that these would require context and assumptions to be useful, as carbon abatement factors may vary based on time, geography, scale etc.

Data Item	Description / possible data sources
Reference list of useful robust studies	Reliable studies relating to avoided emissions. E.g. impact of transport/ mobility changes, BAU scenarios, population and affluence changes, behavioural changes, research on rebound effects.
Market sizes and Market studies	Research into market development and market sizes for products and services. Market research into behavioural changes.
Life-time data	Expected life-time for various technologies.
Renewables	Installation rates, annual electricity generation (typical annual energy output per kW capacity). Data available from IRENA and national renewable energy associations.

Appendix 1 – Examples and References

Introduction

This includes a selection of related initiatives that are relevant for the concept of avoided emissions. These include related methodologies, standards, calculation tools, and examples of use by investors, companies and other organisations.

The list is purely meant to provide examples and references, and does not claim to be exhaustive or complete. Any omissions or errors are the responsibility of the authors of this document and do not reflect the organisations themselves.

It is intended that this list may be extended and added to in future.

Examples of related initiatives

The following table summarises examples of related initiatives.

Initiative	Category	Brief Description	Reference
FTSE Russell Green Revenues data model and Green Revenues Classification System	Classification Framework	The Green Revenues Classification System defines the 60 industry subsectors which are supporting the transition to a green economy within eight broad sectors: energy generation, energy equipment, energy management, energy efficiency, environmental infrastructure, environmental resources, modal shift and operational shift. The data model then measures how much of a company's revenue is linked to a green good, product or service.	https://www.ftserussell.com/financial-data/sustainability-and-esg-data/green-revenues-data-model
WWF Climate Solver Tool and methodology	Tool and Methodology	The Climate Solver Tool is an online platform that estimates the avoided greenhouse gas emissions and energy use from an innovative product. The calculations are based on the potential market for an innovation, the climate impact of the innovation, the climate impact of a baseline scenario and the estimated market share for the innovation. The tool was launched in 2012.	http://www.climatesolver.org/

Appendix 1 – Examples and References

Initiative	Category	Brief Description	Reference
Climate Impact Forecast (CIF) assessment tool	Assessment tool	The Climate Impact Forecast tool was developed by Climate-KIC, which is a public-private partnership that works on innovative ways to adapt to climate change. The tool allows a business to assess whether a product or idea has a negative or positive carbon footprint compared to the product or idea it is replacing. The user can input data about their product and analyse if it reduces, prevents or replaces fossil fuels within different areas of production. The tool allows to calculate the direct impacts of a solution, indirect impacts from enabling solutions, as well as adaptation impacts.	https://impactforecast.org/
Carbon Delta 'green patent' approach	Methodology	Carbon Delta's 'Climate Value-at-Risk (VaR)' methodology analyses the amount of patents a company has and categorises these into which are green as a predictor for low carbon profits. Patents are evaluated on their market potential, cost and monetisation strategy and are combined with other patents to determine how much a company's portfolio is green.	https://www.carbon-delta.com/
'Business Sustainability 3.0' - Lausanne	Methodology	The Business School Lausanne (BSL) in Switzerland has developed a methodology called True Business Sustainability/Business Sustainability 3.0. This approach evaluates the level that sustainability is integrated into a business and helps them take advantage of the benefits of aligning actions to the Sustainable Development Goals.	https://www.bsl-lausanne.ch/business-sustainability-typology/
WHEB Sustainability Fund and Impact Report	Investment assessment	WHEB's strategy is to invest in companies that benefit from, and enable, the shift to a more sustainable economy. The WHEB Sustainability Fund groups different environmental investment themes that are then used to calculate the green credentials of the fund. WHEB assesses the companies in the fund and measures the total ability to save energy, generate clean energy and avoid emissions to calculate an avoided emissions figure.	http://www.whebgroup.com/media/2017/05/WHEB-Impact-Report-2016-1.pdf
Blackrock - Laurence Fink open letter Jan 2018	Open letter	Blackrock is the world's largest investment management company with over $6.3 trillion in assets. Blackrock have published reports on adapting investment portfolios to climate change, detailing the risks and opportunities going forward. On 26 January 2018, Blackrock's CEO Laurence Fink sent an open letter about companies needing to think more about their long-term future and put purpose at the heart of their business, which has sent a clear environmental message to investors around the world.	http://www.ethicalcorp.com/comment-how-laurence-finks-letter-ceos-has-raised-bar-business
Transition Pathway Initiative (TPI) Methodology	Methodology and investment analysis	The TPI was set up between the investment bodies of the Church of England and the Environment Agency Pension Fund. It is supported by asset managers and owners with over £5 trillion under their control. The TPI assesses high-impact sectors, such as oil, gas and mining, to understand what the transition to a low carbon looks like and how businesses can adapt their business models. The analysis is also used to direct investment decisions and engagements with companies in an investment portfolio.	http://www.lse.ac.uk/GranthamInstitute/tpi/methodology/

Appendix 1 – Examples and References

Initiative	Category	Brief Description	Reference
Buildings EDGE tool for World Bank -	Standard and certification	The Excellence in Design for Greater Efficiencies (EDGE) is a sustainable building standard and a free online software that gives specific building stakeholders an insight into the most cost-effective options for resource-efficient design. The EDGE software and standard directs investments towards sustainable solutions that reduce water, resource and energy use, thus avoiding CO_2.	https://www.edgebuildings.com
IRENA avoided emissions calculator	Assessment tool	The International Renewable Energy Association, IRENA, has developed a tool to estimate the greenhouse gas emissions avoided each year as a result of renewable energy deployment in a country.	http://www.irena.org/climatechange/Avoided-Emissions-Calculator
Climate KIC Mitigation assessment	Methodology guidance	Climate-KIC invest in projects and solutions that help address climate change. All projects develop and implement products, processes, technologies, services and tools that can significantly reduce greenhouse gas emissions. Climate-KIC has developed a technical guidance that helps estimate the projects in terms of mitigating greenhouse gas emissions.	http://www.climate-kic.org/wp-content/uploads/2016/07/Guidance-Mitigation-Climate-Impact-Assessment.docx
Caring for Climate Initiative	Methodology	Caring for Climate is organised by the UN Global Compact, UN Environment and UNFCCC, and brings together businesses to tackle climate change. They published a paper in 2009 to provide an overview of the possibilities for calculating and reporting a company's positive contributions to societal emissions reductions.	http://caringforclimate.org/forum/wp-content/uploads/LCLP_Calculations.pdf
IFC GHG reduction accounting guidance	GHG reduction accounting guidance	The World Bank's International Finance Corporation (IFC) have published the 'IFC greenhouse gas reduction accounting guidance for climate-related projects' (May 2017). This is a technical guidance for IFC investment and advisory staff assessing the GHG emissions reductions for climate related projects.	https://www.ifc.org/wps/wcm/connect/21d21b80423bdbf19f39bf0dc33b630b/IFC+GHG+Reduction+Accounting+Guidance.pdf?MOD=AJPERES
ICCA and WBCSD avoided emissions guidelines for chemicals	Methodology guidelines	The International Council of Chemical Associations (ICCA) and the World Business Council for Sustainable Development (WBCSD) have developed guidelines for reporting avoided greenhouse gas emissions along the value chain of different chemical products.	https://www.wbcsd.org/contentwbc/download/1888/24018
LafargeHolcim avoided emissions protocol for cement-based products	Methodology	Protocol for quantifying avoided GHG emissions along the value chains of cement and concrete products.	https://www.lafargeholcim.com/sites/lafargeholcim.com/files/atoms/files/lafargeholcim-avoided-emissions-protocol.pdf
GEF Guidelines on GHG Accounting and Reporting for GEF Projects	Methodology	The Global Environment Facility (GEF) has developed guidelines for greenhouse gas emissions accounting and reporting for assessing GEF projects. It identifies the impact of a policy, action or project and then estimates a baseline scenario and compares it against a policy scenario and alternative solution in order to estimate the GHG reduction effect.	http://www.thegef.org/sites/default/files/council-meeting-documents/EN_GEF.C.48.Inf_.09_Guideline_on_GHG_Accounting_and_Reporting_for_GEF_Projects_4.pdf
GHG reductions enabled by solar PV systems	Academic paper	Academic paper describing a simple methodology for estimating the climate change mitigation of solar photovoltaic (PV) systems by calculating the avoided GHG emissions for specific PV applications in respective regions. Christian Breyer, Otto Koskinen, Philipp Blechinger.	http://www.sciencedirect.com/science/article/pii/S1364032115003317

Appendix 1 – Examples and References

Initiative	Category	Brief Description	Reference
ING	Investment fund example	In January 2018, Dutch Bank ING launched a €100m Sustainable Investments fund that will provide capital support targeted at companies with proven concepts that can deliver positive environmental impacts.	https://www.edie.net/news/6/ING-announces-EUR100m-Sustainable-Investments-fund/
Net Positive Project	Coalition and metodology guidance	The Net Positive Project is a coalition of organisations committed to developing a net positive approach for businesses. It has published frameworks and guidance principles for measuring and communicating an organisation's net positive approach. The Net Positive Project was launched in 2016 by Forum for the Future, BSR and SHINE, and had developed from the previous Net Positive Group (convened in 2013 by FFF, TCG and WWF).	https://www.forumforthefuture.org/project/net-positive-project/overview
MIROVA Carbon Impact Methodology	Methodology	Mirova is a French responsible investment manager, which has developed a carbon impact methodology. This uses the indicators: 'Induced Emissions' (i.e. Scope 1, 2 & 3), and 'Avoided emissions'. These are combined to give a 'Carbon Impact Ratio' (the avoided emissions / the induced emissions). The trend in induced and avoided emissions is evaluated using an analysis of investments that will affect a company's GHG emissions. A new categorisation of companies is defined depending on how they will be impacted by the energy transition.	http://www.mirova.com/Content/Documents/Mirova/publications/va/studies/MIROVA_Study_Measure_Carbon_Impact_Methodology_EN.pdf
EU Sustainable Finance initiative: EU Taxonomy	Classification system and Proposal for regulation	Related to its Sustainable Finance Initiative, the EU Commission announced (24 May 2018) a set of proposals aimed at boosting private investment in low-carbon technologies. This includes a new taxonomy to assess sectors on environmental sustainability criteria. The EU Taxonomy Technical Report was published in June 2019, and covers 67 activities across 7 sectors.	https://www.euractiv.com/section/energy-environment/news/eu-tables-ground-braking-low-carbon-benchmark-for-green-finance/ https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance_en https://ec.europa.eu/info/publications/sustainable-finance-teg-taxonomy_en
GeSI ICT Enablement Methodology	Methodology	'Evaluating the carbon reducing impacts of ICT: An assessment methodology' is a report developed by BCG for the Global e-Sustainability Initiative (GeSI) to provide a common framework for assessing low-carbon enabling effects of ICT solution. It was one of the earlier frameworks of its kind and a number of ICT companies, other initiatives, and standards organisations have subsequently published work, for the ICT sector, following this approach.	https://gesi.org/report/detail/evaluating-the-carbon-reducing-impacts-of-ict-an-assessment-methodology
GeSI Mobile Carbon Impact report	Report	This study developed by the Carbon Trust and commissioned by the Global e-Sustainability Initiative identifies how mobile communication technology is enabling sustainable development. The report assessed the carbon abatement that is enabled by mobile communication technology by analysing 60 carbon saving mechanisms across ten industry categories.	https://www.carbontrust.com/resources/reports/advice/mobile-carbon-impact
Assessing the Greenhouse Gas Abatement Potential of ICT.	Academic research paper	Research paper by Jan Bieser and Lorenz Hilty looking at methodological challenges in assessing the GHG abatement potential of ICT. The paper reviewed a previous study by Accenture on GHG abatement in Switzerland. They confirmed that ICT has the potential to reduce GHGs, but that the potential is smaller than anticipated, due to several methodological differences. These include selection of use-cases, definition of the baseline, and the allocation of impacts to IT.	https://www.zora.uzh.ch/id/eprint/151654/

Appendix 1 – Examples and References

Initiative	Category	Brief Description	Reference
Nordic Public Sector Issuers (NPSI): Position Paper on Green Bonds Impact Reporting	Practical guide	Guide on impact reporting for Nordic public sector green bond issuers. The guidance is targeted at those engaged in impact reporting in issuer organisations. The guidance contains key financial, environmental and procedural aspects for reporting.	https://www.munifin.fi/recents/news/2017/10/24/nordic-issuers-release-guide-on-green-bonds-impact-reporting
ASN Bank Carbon profit and loss methodology	Methodology document	Methodology document to describe the 'Carbon Profit and Loss Methodology and Tool' developed by Ecofys to footprint ASN Bank's total portfolio.	https://www.ecofys.com/files/files/4501704_asn_carbon-profit-and-loss-methodology-v5.pdf
Potential avoided emissions in Vontobel Fund – clean technology	Explanatory document	Work completed by ISS-Ethix Climate Solutions for Vontobel Asset Management, to measure the potential avoided emissions of the Vontobel Fund – Clean Technology. Each company within the fund was asked to provide data to calculate avoided emissions relative to a comparable baseline.	https://www.vontobel.com/Download/Fund/052d3e0c-fb73-4e75-b0a1-65591fe18240/Potential%20Avoided%20Emissions%20in%20Vontobel%20Fund%20Clean%20Technology_20180223_en_Vontobel%20Fund%20-%20Clean%20Technology.pdf
Article 173 – French SIF Law	Guidance document for French Energy Transition Law	French Energy Transition for Green Growth Law was adopted in August 2015. It strengthened the mandatory carbon reporting requirements for listed companies and introduced carbon reporting for institutional investors. This guidance document summarises the requirements more specifically.	https://www.legifrance.gouv.fr/eli/loi/2015/8/17/DEVX1413992L/jo#JORFARTI000031045547
Mercer report	Report	'Investing in a time of climate change' – 2017 report by Mercer to help asset owners and investment managers increase the sophistication with which they consider the impact of climate-policy changes and related factors on their portfolios.	https://www.mercer.com/our-thinking/investing-in-a-time-of-climate-change.html
CDM – Clean Development Mechanism	Methodology	Methodological tool that provides a step-wise approach to demonstrate and assess the additionality of a Clean Development Mechanism (CDM) project. The aim of the methodology is to ensure that the project reduces emissions more than would have occurred in the absence of the intervention created by the CDM.	https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-01-v7.0.0.pdf
CDM – Avoided emissions from organic waste	Methodology	A baseline and monitoring methodology for avoided emissions from organic waste through alternative waste treatment processes.	https://cdm.unfccc.int/filestorage/9/W/V/9WVIN7Z06A8UGLFPO4Y51BDMJ23QXT/EB55_repan04_AM0025_ver12.pdf?t=M3d8cGV3NnhvfDBOzQ4qQ6HKCHi5ft3Pc-7r
EIB project carbon footprint methodology.	Methodology	Methodologies designed to guide European Investment Bank staff in the calculation of the carbon footprint of the projects financed by the bank. The methodology provides guidance on measuring the absolute emissions arising from a project, and comparing these to the emissions of a theoretical baseline 'without project' scenario.	http://www.eib.org/attachments/strategies/eib_project_carbon_footprint_methodologies_en.pdf
ILCA Guidelines for assessing avoided emissions	Methodology guidelines	'Guidelines for Assessing the Contribution of Products to Avoided Greenhouse Gas Emissions', published by the Institute of Life Cycle Assessment, Japan (ILCAj). These guidelines are for assessing avoided GHG emissions of products compared to a baseline. The impact is calculated by multiplying the avoided emissions per functional unit by the amount of final product(s) in use and then by an attribution factor.	https://www.ilcaj.org/lcahp/doc/iLCAj_Guidelines_avoided_emissions_assessment_v1_1_english.pdf
JEITA Guidance on calculating emission reduction of electronic components	ICT metodology guidance	'Guidance on Calculating GHG Emission Reduction Contributions of Electronic Components', published by the Japan Electronics and Information Technology Industries Association. Guidance for calculating GHG emission reductions by comparison between the target product and the baseline.	https://home.jeita.or.jp/ecb/pdf/GHG_Guidance_e.pdf
Ecuador submission	Procedure document	A submission from Ecuador to UNFCC to explain the concept of Net Avoided Emissions (NAEs), and how an overall framework might work.	https://unfccc.int/files/bodies/awg-lca/application/pdf/2012-04-10_nae_-_modalities_and_procedures_(revised)-1.pdf

Appendix 1 – Examples and References

Initiative	Category	Brief Description	Reference
Green Bond Principles	Guidelines for Green Bonds	The Green Bond Principles (GBP) are voluntary process guidelines that recommend transparency and disclosure and promote integrity in the development of the Green Bond market. They provide issuers guidance on the key components involved in launching a credible Green Bond; they aid investors to evaluate the environmental impact of their Green Bond investments; and they assist underwriters by moving the market towards standard disclosures which will facilitate transactions.	https://www.icmagroup.org/green-social-and-sustainability-bonds/
Climate Bonds Initiative	Standard and Certification for Green Bonds	The Climate Bonds Standard and Certification Scheme allows investors and intermediaries to assess the environmental integrity of financial bonds. The Scheme is used globally by bond issuers, governments, investors and the financial markets to prioritise investments which genuinely contribute to addressing climate change. The Climate Bonds Initiative have developed a taxonomy and technical criteria relating to specific sectors.	https://www.climatebonds.net/ and https://www.climatebonds.net/standard/sector-criteria
Carbon4 Finance	Tool and Methodology	Carbon4 Finance use a proprietary methodology (Carbon Impact Analytics) for assessing the climate impact of investor portfolios through bottom-up measurement of greenhouse gas emissions directly and indirectly induced and saved. The method also assesses the alignment of portfolios with a climate-focused strategy.	http://www.carbon4finance.com/transition-risks-and-avoided-emissions/
UNEP Finance Initiative (FI)	Principles and tools for Positive Impact Finance	UNEP-FI defines a set of principles for Positive Impact Finance in response to the SDG financing challenge.	https://www.unepfi.org/positive-impact/principles-for-positive-impact-finance/
UNEP Finance Initiative (FI)	Principles for Responsible Banking	The UN Principles for Responsible Banking provide the banking industry with a single framework for sustainable banking. The Principles align banks with the Sustainable Development Goals and the Paris Climate Agreement	https://www.unepfi.org/banking/bankingprinciples/
Carbon Yield	Methodology	. Carbon Yield is a publically available methodology for allocating avoided emissions associated with a Green Bond framework to the capital investment. The method calculates an annual potential avoided emissions per unit of invested capital. Bond issuers can use the Carbon Yield method to communicate the climate change mitigation impact of their bonds. Investors can then, in turn, use this to calculate the overall carbon impact at a portfolio level.	http://carbonyield.org/
METI Guidelines for Quantifying GHG emission reductions	Methodology Guidelines	Guidelines for Quantifying GHG emission reductions of goods or services through Global Value Chain, March 2018, Ministry of Economy, Trade and Industry	https://www.meti.go.jp/english/press/2018/pdf/0330_002.pdf
Energy Transition Commission (ETC) – Mission Possible report	Report	Report focusing on harder to decarbonize sectors of heavy duty transport – trucking, shipping and aviation – and industry – steel, cement and plastics. Together these sectors represent 40% of carbon emissions from the energy systems in 2018, but this share will grow to 60% of remaining emissions by 2040 in a 2˚C scenario.	http://www.energy-transitions.org/mission-possible

Appendix 1 – Examples and References

Initiative	Category	Brief Description	Reference
Impact Management Project	Framework and Guidelines	The Impact Management Project (IMP) is a forum for building global consensus on how to measure, compare, and report ESG risks and positive impacts. Assessment of impact (for a company or investor) needs to understand the impact against the five dimensions of performance: What, Who, How Much, Contribution and Risk. And also to relate the impact back to the SDGs.	https://impactmanagementproject.com/
Partnership for Carbon Accounting Financials (PCAF)	Methodology Guidelines	The PCAF is an industry-led partnership aiming to develop a Global Carbon Accounting Standard for financial institutions. The PCAF is running a public consultation on the draft Standard between August 3rd and September 30th 2020 and aims at publishing the final Standard in November 2020. According to the draft Standard, avoided emissions should be measured and reported when relevant to loans and investments and if data is available. The Standard only considers avoided emissions from renewable energy and energy efficiency projects. Avoided emissions are calculated based on the GHG Protocol for Project Finance and cover only operational emissions as opposed to lifecycle emissions. According to PCAF, avoided emissions should be calculated separately from a financial institution's scope 1, 2 and 3 GHG inventories.	https://carbonaccountingfinancials.com/about https://carbonaccountingfinancials.com/consultation-signup
1 Gigaton coalition	Methodology	The 1 Gigaton Coalition aims to measure and report reductions of GHG emissions resulting from renewable energy and energy efficiency initiatives and programmes in developing countries. The coalition aims to do so by creating a methodology in their annual 1 Gigaton Coalition reports, which will highlight specific countries and programmes by applying this methodology.	https://www.1gigatoncoalition.org/
European Commission Innovation Fund	Investment fund example	The European Commission's Innovation Fund aims at financing the demonstration of low carbon technologies, with key focus areas including: energy intensive industries, carbon capture and utilisation (CCU)/ carbon capture and storage (CCUS), renewable energy and energy storage. The fund is financed by revenues from the EU Emission Trading Scheme's revenues from auctions of emission allowances between 2020-2030. The first call for project proposals was launched in July 2020 and will provide EUR 1 billion grant funding to large-scale clean technology projects.	https://ec.europa.eu/clima/policies/innovation-fund_en https://ec.europa.eu/commission/presscorner/detail/en/IP_20_1250

Appendix 1 – Examples and References

Initiative	Category	Brief Description	Reference
Canada Strategic Assessment of Climate Change (SACC)	Methodology for impact assessments	The Government of Canada, through the Environment and Climate Change Canada, released new guidance on how project proponents are required to assess climate change impacts as part of a federal impact assessment under the Impact Assessment Act (IAA). The SACC aims at enabling "consistent, predictable, efficient and transparent consideration of climate change throughout the impact assessment process." All projects are required to provide an estimate of the project's net GHG emissions, which needs to be calculated as follows: Net GHG Emissions = Direct GHG emissions + Acquired energy GHG emissions – CO_2 captured and stored – Avoided domestic GHG emissions – Offset credits The avoided domestic GHG emissions calculation only covers emissions included in the net GHG emissions formula, hence upstream emissions are not covered. Project proponents will need to provide the "total net baseline scenario emissions" and the "total net baseline scenario removals", which need to be realistic and conservative, taking into account market and policy conditions and feasibility. Avoided foreign emissions should not be included in these calculations.	https://www.strategicassessmentclimatechange.ca/ https://www.lexology.com/library/detail.aspx?g=31c704da-40a5-4a6e-8a4e-a828453881db

Appendix 1 – Examples and References

Relevant GHG standards and related guidance documents

Standard or guidance document	Category	Brief Description	Reference
GHG Protocol Project Standard	Standard	A comprehensive, policy neutral accounting tool for quantifying the greenhouse gas benefits of climate change mitigation projects.	https://ghgprotocol.org/standards/project-protocol
GHG Protocol Policy and Action Standard	Standard	The GHG Protocol Policy and Action Standard provides a standardized approach for estimating the greenhouse gas effect of policies and actions relative to a baseline scenario.	http://ghgprotocol.org/policy-and-action-standard
WRI working paper -'Estimating and Reporting the Comparative Emissions Impacts of Products'	Working Paper	Working paper by the World Resource Institute (WRI) discussing the challenges and recommended options for accounting for the emissions impact of a product relative to the situation where that product does not exist (frequently called 'avoided emissions'). Includes a synthesis of findings based on analysis of methodologies, and of research with companies engaged in work on assessing avoided emissions.	https://www.wri.org/publication/estimating-and-reporting-comparative-emissions-impacts-products
ITU-T L.1410 / ETSI ES 203 199	Standard for ICT sector	2014 standard developed by ETSI and ITU to assess the direct environmental impact of ICT goods, networks and services, as well as their indirect impact on the GHG emissions of the non-ICT sector.	https://www.itu.int/ITU-T/recommendations/rec.aspx?rec=12207&lang=en
IEC TR 62726:2014	Standard for ICT sector	'Guidance on quantifying greenhouse gas emission reductions from the baseline for electrical and electronic products and systems' published by the International Electrotechnical Commission (IEC). The guidance document focuses on the enabling effects and covers the methodology for measuring GHG emissions reductions through the use of electrical / electronic products and systems compared to a baseline.	https://webstore.iec.ch/publication/7401
ICT Sector Guidance	Methodology for ICT sector	This sector guidance provides guidance on calculating the lifecycle emissions from ICT products. It is built on, and in conformance with the *GHG Protocol Product Standard*. It aims to answer some of the challenging questions around the measurement of ICT emissions, including the measurement of the avoided emissions resulting from the enabling effect of ICT.	https://ghgprotocol.org/sites/default/files/GHGP-ICTSG%20-%20ALL%20Chapters.pdf

Appendix 1 – Examples and References

Standard or guidance document	Category	Brief Description	Reference
ISO 14064	Standard	First published in 2006, the ISO 14064 standards are part of the ISO 14000 series of International Standards for environmental management. ISO 14064 is comprised of three standards, each providing guidance on measuring, reporting and reducing GHG emissions at an organisational/ project level. • **ISO 14064-1 Part 1:** Organisational level principles and requirements for the quantification and reporting of GHG emissions and removals. • **ISO 14064-2 Part 2:** Project level principles and requirements for the quantification, monitoring and reporting of activities intended to cause GHG emissions reductions or removal enhancements. • **ISO 14064-3 Part 3:** Document specifying principles and requirements and providing guidance for verifying and validating GHG statements related to an organisation, project or product.	https://www.iso.org/standard/66453.html https://www.iso.org/standard/66454.html https://www.iso.org/standard/66455.html

Selected individual company examples of avoided emissions impacts

Company	Category	Brief Description	Reference
Ericsson	Company example	Ericsson report: 'Measuring Emissions Right'. This report presents a method for assessing the potential reduction of future CO_2e emissions by avoiding or substituting those emissions with environmentally smarter solutions.	https://www.slideshare.net/EricssonFrance/ericsson-report-measuring-emissions-right-methodology https://www.ericsson.com/en/about-us/sustainability-and-corporate-responsibility
Novozymes	Company example	In their 2017 environmental performance report, Novozymes report that their solutions saved customers a total of 76 million tonnes CO_2 in 2017.	https://report2017.novozymes.com/accounts-and-performance/environmental-performance
IKEA	Company example	IKEA has set an ambition to become climate positive by 2030. Examples of initiatives to achieve this include offering plant-based meat alternatives, producing longer-lasting products, and expanding solar panel sales.	https://www.ikea.com/gb/en/this-is-ikea/people-planet/
BT	Company example	BT have a public goal to help their customers avoid three times as much carbon emissions as their own end-to-end impact by 2020.	https://www.btplc.com/Digitalimpactandsustainability/Tacklingclimatechange/Ourmethodology/index.htm
KPN	Company example	KPN have set a target that in 2020, their customers will avoid as much energy consumption as KPN themselves consume.	https://overons.kpn/content/downloads/KPN-environmental-policy-March-2017.pdf
Swisscom	Company example	Swisscom have set a 2:1 target, whereby it aims to work together with its customers to save twice as much CO_2 as it emits throughout the entire company including the supply chain by 2020.	http://reports.swisscom.ch/en/2016/report/corporate-responsibility/energy-efficiency-and-climate-protection/energy-efficiency-energy-consumption-and-savings
Verizon	Company example	Verizon have been measuring and reporting the avoided emissions from Verizon connected solutions, including fleet telematics, smarts meters and remote patient monitoring. In 2018, they set a new goal that by 2022, Verizon's networks and connected solutions will save more than two times the amount of global emissions that their operations create.	https://www.verizon.com/about/responsibility/sustainability
AT&T	Company example	AT&T has a target to enable carbon savings 10x the footprint of its own operations, and has published a methodology for measuring this, and has teamed up with a number of companies to publish case studies that demonstrate the carbon savings of specific products.	https://about.att.com/csr/10x https://about.att.com/content/dam/csr/otherpdfs/ATT-10x-Methodology-2017.pdf
Vodafone	Company example	Vodafone has been measuring and reporting how their IoT applications enable its customers to save carbon. Vodafone had set a goal to help its customers reduce their GHG emissions by two tonnes for every one tonne of GHG generated from its own operations. This goal was achieved in 2018.	https://www.vodafone.com/content/dam/vodafone-images/sustainability/downloads/sustainablebusiness2018.pdf
Triodos Bank	Company example	In their 2019 annual report, Triodos Bank reported that their financed sustainable energy projects resulted in a total of 962 kilo tonnes of CO_2e avoided emissions compared to fossil-fuel power generation.	http://www.annual-report-triodos.com/2019/

Appendix 2 – Glossary

Avoided emissions

'Reductions in emissions caused indirectly by a product. This is where a product provides the same or similar function as existing products in the marketplace, but with significantly less GHG emissions'.

BAU baseline

The Business-as-Usual (BAU) baseline reflects the situation in the absence of the enabling solution.

The baseline represents the 'before' scenario of a specific process, i.e. what is the most likely alternative solution to be used to achieve a certain outcome in the absence of the enabling solution.

Carbon emissions

The term carbon emissions in this document refers to emissions from all greenhouse gases (i.e. not just CO_2).

Emissions are releases to air and discharges to water and land that result in greenhouse gases entering the atmosphere.

Enabling solution

The product, service, or technology that enables the avoided emissions.

Rebound effects

Rebound effects negate some portion of the enabling-effect avoided emissions due to additional changes in human behaviour within the system boundary caused by or related to the availability of the enabling solution.

Endnotes

1 https://climateactiontracker.org/

2 https://www.weforum.org/about/the-fourth-industrial-revolution-by-klaus-schwab

3 http://mission-innovation.net/wp-content/uploads/2018/05/MI3-Action-Plan.pdf (see under Goal 02).

4 It can be argued that financial accounting has existed for more than 7,000 years, with ancient accounting records having been found in Mesopotamia. The Roman Empire kept detailed financial records. Luca Pacioli, recognized as The Father of accounting and bookkeeping was the first person to publish a work on double-entry bookkeeping in 1494. The first international standard on GHG accounting was the ISO 14040 on life cycle assessment first published in 1997.

5 See the GHG Protocol Product Standard, chapter 11, sections 11.2 and 11.3.2. The Product Standard defines avoided emissions, but classifies them as outside the boundary of a product's life cycle, and as such must be reported separately from the product's life cycle emissions.

6 https://www.pamlin.net/s/Cybercom-Digital-Sustianability-full-report.pdf

7 http://www.ghgprotocol.org/standards

8 ISO 14064-1:2018(en). Greenhouse gases — Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals. Available at: https://www.iso.org/obp/ui/#iso:std:iso:14064:-1:ed-2:v1:en

9 ISO 14064-2:2019(en). Greenhouse gases — Part 2: Specification with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements. Available at: https://www.iso.org/obp/ui/#iso:std:iso:14064:-2:ed-2:v1:en

10 ISO 14067:2018(en). Greenhouse gases — Carbon footprint of products — Requirements and guidelines for quantification. Available at: https://www.iso.org/obp/ui/#iso:std:iso:14067:ed-1:v1:en

11 https://jpi-urbaneurope.eu/ped/

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15 Ericsson.2009. E-health Croatia: Life Cycle Assessment of ICT enablement potential https://www.ericsson.com/res/thecompany/docs/success_stories/2009/e-health_croatia.pdf

16 WRI (2018), Estimating and Reporting the Comparative Emissions Impacts of Products, World Resources Institute (see p.14)

17 See 'A low energy demand scenario for meeting the 1.5°C target and sustainable development goals without negative emission technologies'; Grubler, Wilson et al.; Nature Energy, Vol 3, June 2018.

18 Special Report: Global Warming of 1.5 °C (SR15); IPCC; https://www.ipcc.ch/sr15/

19 GHG Protocol (2011), Product Life Cycle Accounting and Reporting Standard, World Resources Institute and World Business Council for Sustainable Development.

20 WRI (2018), Estimating and Reporting the Comparative Emissions Impacts of Products, World Resources Institute

21 Ibid.

22 Domestic Ground Source Heat Pumps; Design and installation of closed-loop systems' (2007). Available at: https://www.gshp.org.uk/documents/CE82-DomesticGroundSourceHeatPumps.pdf

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http://mission-innovation.net/about-mi/business-and-investor-engagement/

bwa.design Version 3.2

RISE

Swedish Energy Agency

Climate-KIC

Climate-KIC is supported by the EIT, a body of the European Union

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