NET ZERO METHODOLOGY FOR HOTELS

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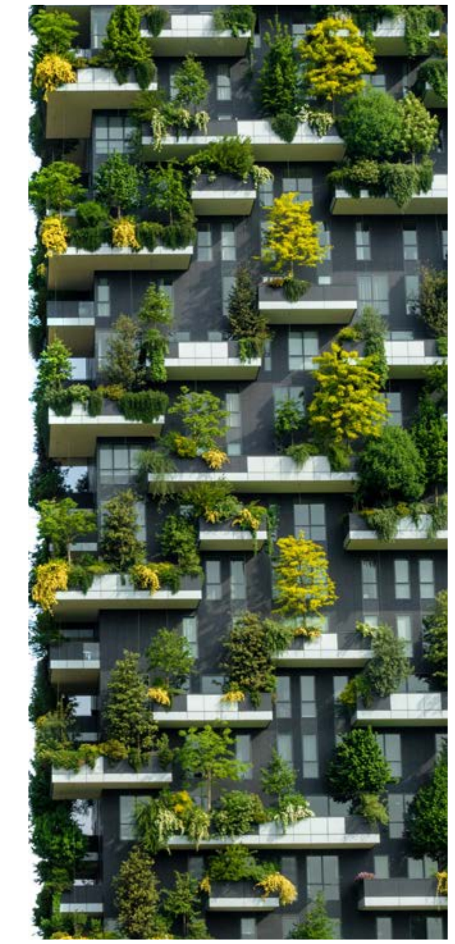
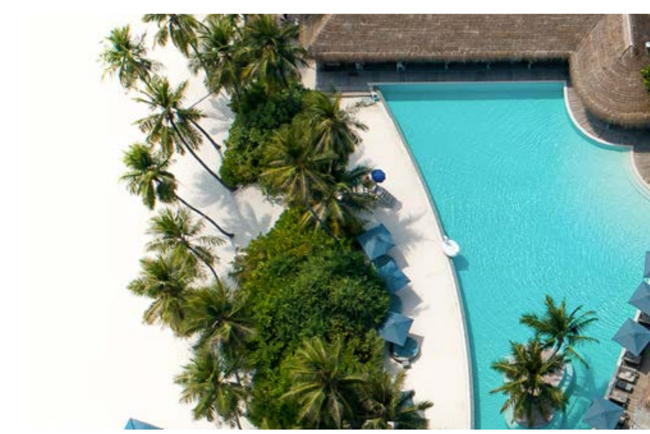
APPENDIX M

UPSTREAM EMISSIONS – EMBODIED CARBON IN HOTEL BUILDINGS, FF&E, AND FOOD & BEVERAGE





APPENDIX M: UPSTREAM EMISSIONS – EMBODIED CARBON IN HOTEL BUILDINGS, FF&E, AND FOOD & BEVERAGE

M.1 OVERVIEW OF EMBODIED CARBON IN BUILDINGS AND RELATED NET- ZERO INITIATIVES

INTRODUCTION TO EMBODIED CARBON

Decarbonizing buildings is a key part of achieving net zero to mitigate the adverse effects of climate change. Buildings are currently responsible for 38%[1] of global carbon emissions. Given that the global building stock is expected to increase with world population, the climate impact of buildings will only grow if its impact remains unaddressed. Carbon emissions are released from buildings not only when they are operational, but also before and after they are in use. Such emissions are commonly referred to as embodied emissions. As energy grids decarbonize and energy efficiency measures become commonplace, carbon emissions associated with operational energy use are expected to decrease and embodied carbon may become proportionately more significant. Embodied carbon must be tackled alongside efforts to reduce operational carbon.

Embodied carbon refers to carbon emissions associated with materials and construction processes throughout the whole lifecycle of a building or infrastructure. This includes emissions released before it begins operation, caused by extraction, manufacture/processing, transportation and assembly of every element and material used in the building. It also includes the emissions from maintenance and replacement activities during its use stage, and emissions from deconstruction/demolition and disposal during its end-of-life stage. Embodied carbon contributes 30-70%[2] of the total building lifecycle emissions. Embodied carbon is classified as Scope 3 emissions under the GHG Protocol emissions accounting guidelines and though cited by the Scope 3 Protocol that upstream emissions of capital goods – including buildings – should be accounted for at the time of acquisition and not amortized over time, in practice this is rarely, if ever, done for commercial building disclosures, much less hotels.

KEY SOURCES OF EMBODIED CARBON

Emissions from the materials used to construct buildings and during renovation, represent a significantly greater source of embodied carbon than all other stages in the building lifecycle. Common materials such as cement and steel are two of the most significant sources of embodied carbon emissions. Manufacturing of cement and steel contribute 7% and 7-9%[3] of global carbon emissions respectively. Both cement and steel require very high temperatures during production, making them energy and carbon intensive processes. Both manufacturing processes entail chemical reactions that also release carbon dioxide. Other materials such as aluminum and glass are also common sources of embodied carbon as they require high temperatures during manufacturing. Table M.1.1 below shows the list of common sources of embodied carbon in buildings, commonly cited as a relatively significant or insignificant source.

▼ **Table M.1.1** Sources of Embodied Carbon

SIGNIFICANT SOURCE	INSIGNIFICANT SOURCE
■ Steel/reinforcement steel ■ Cement ■ Aluminum ■ Glass ■ Insulation (especially petroleum-based products)	■ Biomaterials (e.g., wood, timber, bamboo, etc.) ■ Concrete containing cement substitute (e.g., fly-ash) and low-cement concrete ■ Ceramic tiles ■ Wool insulation

Some materials present opportunities for carbon capture and recycling. Biomaterials such as timber and bamboo capture atmospheric carbon during growth and carbon is stored within even after they are harvested for construction. Harvesting mature timber then frees up space for more biomaterials to be grown and more atmospheric carbon to be captured in effect. Using biomaterials from reputable and certified sources that practice proper forest management is important to ensure that construction of the building does not perpetuate deforestation. Reuse and recycling of biomaterials when buildings are decommissioned is also important to ensure that the captured carbon remains stored for as long as possible and prevents unnecessary logging. Otherwise, disposing biomaterials in landfills would release all the captured carbon back into the atmosphere as they decompose.

Besides biomaterials, concrete can also capture carbon from the atmosphere when it is exposed to air. Concrete also has a high thermal mass, or high ability to absorb and store heat energy, thereby have the potential to reduce operational emissions associated with heating and cooling. Given that having a high thermal mass (increasing embodied carbon) has the potential to lower heating/cooling loads (decreasing operational carbon), the overall benefits associated with concrete has to be properly evaluated and balanced.

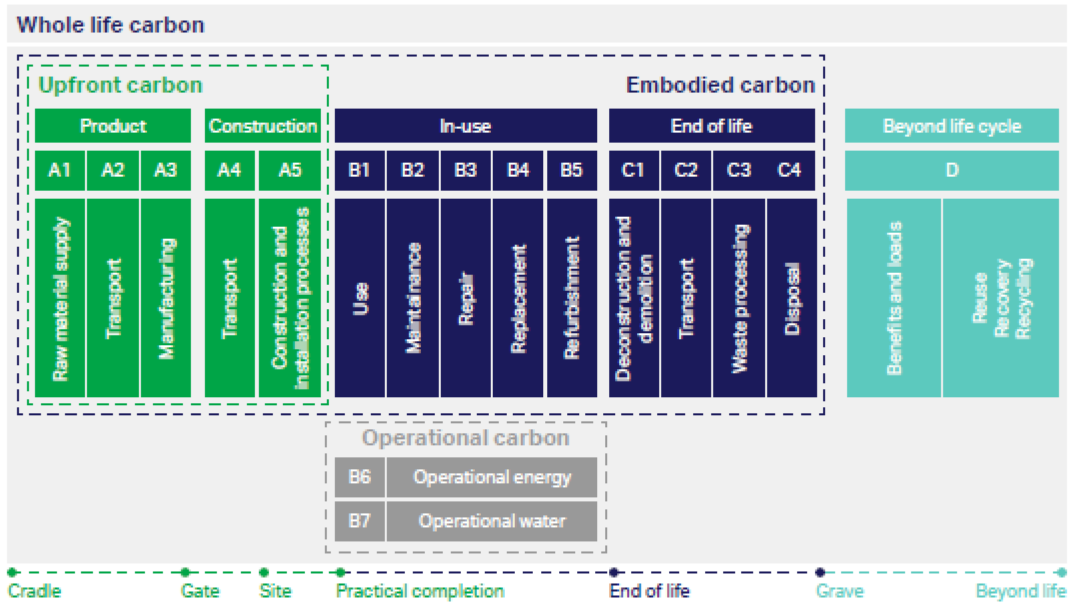
Metals such as steel and aluminum can be recycled infinitely without loss of quality or properties. Using recycled steel and aluminum, and re-using them after buildings are decommissioned, help to reduce overall embodied carbon of buildings. To properly account for all sources of embodied carbon and identify opportunities for reduction, a full building lifecycle approach can be applied.

1 UNEP 2020 Global Status Report for Buildings and Construction: https://wedocs.unep.org/xmlui/bitstream/handle/20.500.11822/34572/GSR_ES.pdf?sequence=3
2 IHG-Arup Net Zero Hotels: https://www.ihgplc.com/-/media/ihg/files/news/2021/2021_05_04/whitepaper---net-zero-carbon-hotels-vf.pdf
3 WorldGBC Bringing Embodied Carbon Upfront (2019): https://www.worldgbc.org/sites/default/files/WorldGBC_Bringing_Embodied_Carbon_Upfront.pdf

BUILDING LIFECYCLE

The building lifecycle is often described to have four stages as shown in Figure M.1 below; blue dashed line represents the boundary of embodied carbon in buildings.

▼ Figure M.1 Building Lifecycle and its Different Carbon Boundaries[4]



Product Stage

Emissions from the Product Stage are associated with activities such as raw material extraction (A1), transport to manufacturer (A2) and manufacturing (A3). Emissions from these activities represent a significantly greater source of embodied carbon than all other stages in the building lifecycle. Building elements such as foundations, structures and frames often represent a major source of embodied carbon. Not only are large volumes of materials needed, but they also contain materials such as cement and steel that have carbon-intensive manufacturing processes. Table M.1.2 below from the Carbon Leadership Forum (CLF) Embodied Carbon in Construction Calculator (EC3) Tool Methodology shows the relative contribution of embodied carbon of common structural materials from the three activities under Product Stage. Building facades and enclosures that use large amounts of carbon-intensive materials like aluminium and glass also represent another significant source. Building finishes such as carpets and tiles are also contributors to total embodied carbon.

▼ Table M.1.2 Relative Contribution of Embodied Carbon[5]

SUB-STAGES / MATERIAL	ATTRIBUTE	A1: RAW MATERIAL EXTRACTION	A2: TRANSPORT TO MANUFACTURER	A3: MANUFACTURING
Steel	**Portion of embodied carbon**	>90%	<5%	<10%
	Source	Ore mining	Transportation to fabricator	Shaping steel
Concrete	**Portion of embodied carbon**	>80%	<20%	<10%
	Source	Production of cement	Transportation to concrete plant	Concrete mixing
Cement	**Portion of embodied carbon**	<10%	<5%	>90%
	Source	Mining	Transportation to cement kiln	Production of cement
Clay masonry	**Portion of embodied carbon**	<5%	Small	>95%
	Source	Mining	Transportation and storage	Firing
Glue laminated beam	**Portion of embodied carbon**	<10%	<5%	>90%
	Source	Planting, harvesting, drying	Transportation to fabricator	Cutting, gluing, pressing

Construction Stage

This stage refers to the actual construction of the building, including activities such as transport of finished materials and products from manufacturer to project site (A4), and on-site construction and installation (A5). Some specific emissions can occur using diesel-powered heavy construction equipment, on-site fabrication, energy use for power tools, construction waste from unused or damaged building materials, and construction site runoff containing sediments of building materials, concrete washout, paint, etc. into the stormwater management system. In addition, though not part of the building structure emissions, other impacts from land use and land cover change can be significant and should be incorporated, particularly in the case of hotels built in more remote or pristine areas. Land use change from natural environment to other man-made purposes such as buildings result in negative environmental impact such as vegetation loss and soil sealing, which represents the loss of carbon storages. A promising practice to reduce emissions in the construction stage is off-site modular construction, whereby building modules are prefabricated in factories before delivery for on-site assembly. Modular construction fares better in emissions performance as there is less transport emissions, less energy waste during installation and less on-site material waste.

4 WBCSD-ARUP Net-zero buildings: Where do we stand?: https://www.wbcsd.org/contentwbc/download/12446/185553/1
5 CLF EC3 Tool Methodology: https://carbonleadershipforum.org/ec3-methodology/

In-use Stage

This stage refers to the use (B1), maintenance (B2), repair (B3), replacement (B4) and refurbishment (B5) of building systems. Note that operational emissions related to the energy and water use during building operations (B6 and B7) fall under this stage but are not within the boundary of "embodied carbon". Emissions from materials, its transport and equipment use during maintenance and renovation represent significant source of embodied carbon in the building lifecycle.

End-of-Life Stage

Emissions from this stage refers to those associated with energy use and waste produced during deconstruction/demolition (C1), transport of waste to end-of-life facilities (C2), waste processing for reuse, recycling, or disposal (C3) and landfill disposal (C4). Modular construction offers higher potential for reuse and recycling of building components and materials, thus reducing emissions associated with the end-of-life stage of buildings.

CURRENT DEVELOPMENT

While it is widely acknowledged that embodied carbon is highly complex to tackle, there are existing approaches to quantify embodied carbon in buildings and initiatives for net-zero buildings.

Calculating Embodied Carbon

One popular approach is to conduct a life cycle assessment (LCA) to understand the environmental impacts associated with all four stages of the building lifecycle. Most available calculation guides focus on quantifying the embodied carbon from the Product and Construction Stages. Emission factors for construction materials are also increasingly publicly available, with some manufacturers including the factors on product datasheets and Environmental Product Declarations (EPDs). The Inventory of Carbon and Energy (ICE) database is a well-known compilation of cradle-to-gate emission factors of key constructional materials. Some noteworthy resources include:

- **Embodied Carbon in Construction Calculator (EC3) Tool** by the Carbon Leadership Forum (CLF), https://buildingtransparency.org/ec3, https://carbonleadershipforum.org/ec3-methodology/
- **Inventory of Carbon and Energy (ICE) Database Version 3.0** by Circular Economy and University of Bath, https://circularecology.com/embodied-carbon-footprint-database.html
- **IFC EDGE India Construction Materials Database**, https://edgebuildings.com/india-construction-materials-database/
- **Integrated Carbon Metrics Database**, Embodied Carbon Life Cycle Inventory Database, UNSW Sydney, https://unsworks.unsw.edu.au/entities/dataset/
- **How to Calculate Embodied Carbon**, the Institute of Structural Engineers https://www.istructe.org/resources/guidance/how-to-calculate-embodied-carbon/
- **Building Life Cycle Assessment in Practice Guide** (2010) by the American Institute of Architects (AIA), https://www.aia.org/resources/7961-building-life-cycle-assessment-in-practice
- **Methodology to Calculate Embodied Carbon of Materials** (2012) by Royal Institution of Chartered Surveyors (RICS), https://www.igbc.ie/wp-content/uploads/2015/02/RICS-Methodology_embodied_carbon_materials_final-1st-edition.pdf
- **Embodied Carbon Guidance** (2019) by International Living Future Institute (ILFI), https://buildingtransparency-embodiedcarbonguidancedocpdf.pdf
- **Embodied Carbon Resources** by Getting to Zero, https://gettingtozeroforum.org/embodied-carbon/
- **Embodied Carbon Pilot** by University of British Columbia (UBC), https://strategicplan.ubc.ca/embodied-carbon-pilot-helps-building-industry-address-climate-change/
- **EPD Certified Building Concept**, https://epd-australasia.com/epd/nxt-concept-building-wyndham-lux-perth-hotel/

Net Zero Building Initiatives

The International Finance Corporation (IFC) Excellence in Design for Greater Efficiencies (EDGE) [6]green building program aims to help buildings reduce operational energy and water use, and embodied energy of construction materials. Buildings covered under the program include hotels and resorts. The program provides a practical resource for calculating embodied carbon in buildings in the form of a global dataset of embodied energy from emerging economies[7].

The Royal Institute of British Architects (RIBA)[8] launched the voluntary 2030 Climate Challenge for Chartered Practices to meet the performance targets on all their new and major refurbishment projects. There are four targets covering operational energy, potable water use, health and wellbeing metrics, and embodied carbon. The aim is to reduce embodied carbon by at least 40% from current business as usual baseline figures before offsetting, or less than 750 kgCO2e/SqM for new build offices.

The London Energy Transformation Initiative (LETI)[9] supports the net-zero transition of the United Kingdom's built environment by 2050 in alignment with the national 2050 net-zero target. The initiative directly addresses embodied carbon, illustrating key milestones in the net-zero trajectory, providing guidance materials on embodied carbon reduction strategies, introducing an embodied carbon rating system for performance tracking, and providing embodied carbon reporting templates to kickstart reporting consistency in the industry. To meet the national target, all new buildings need to achieve a 65% reduction in embodied carbon emissions by 2030. Some best practices identified include reducing embodied carbon to less than 350 kgCO2e per sqm, having 50% building materials from re-used sources and 80% building materials to be re-usable at end-of-life for non-domestic buildings.

6 IFC EDGE: https://edgebuildings.com/
7 IFC EDGE India Construction Materials Database: https://edgebuildings.com/india-construction-materials-database/
8 RIBA: https://www.architecture.com/-/media/files/Climate-action/RIBA-2030-Climate-Challenge.pdf
9 LETI: https://www.leti.london/

The World Green Building Council (WorldGBC) Net Zero Carbon Buildings Commitment, which aims for organisations to achieve net zero by 2030, currently focuses on operational energy-related emissions and does not include embodied carbon within the scope. Some challenges identified include limited calculation methodologies for global portfolios and the over-reliance on carbon offsets given that embodied carbon is often considered difficult to abate. However, the WorldGBC intends to include embodied carbon in the future.

As countries and cities are in the process of adopting building electrification and decarbonization policies, the New Buildings Institute (NBI) Building Decarbonization Code provides guidance on updating building codes for newly constructed buildings to adopt electrification technologies and use 100% carbon-free energy sources. The Code provides a decarbonization overlay of the building code and identifies key future-proofing measures such as renewable energy production, battery storage, and electric vehicle changing stations. While the Code currently focuses on new construction and does not address embodied carbon, the NBI intends to release future iterations which include decarbonization code language for existing buildings for example.

Embodied Carbon in Hotels

Within the hotel industry, IHG released a white paper titled 'Transforming Existing Hotels to Net Zero Carbon' in collaboration with ARUP, Gleeds and Schneider Electric. Embodied carbon was found to make up 30%-70% of a typical building's total lifecycle emissions. Besides upfront embodied carbon from the Product and Construction Stages, another typical source of embodied carbon is regular major and minor refurbishments that hotels undergo every 6 to 7 years. The paper serves as a good reference for hotels to become net zero operationally, demonstrating ways to reduce (but not eliminate) embodied carbon by choosing refurbishment upgrades over building replacement for a case study hotel. Indeed, a research study has found that the mean embodied carbon for refurbished buildings is 33–39% lower than newly built projects, and the cost for refurbished buildings is 22–50% lower than newly built projects (per square meter of floor area)[10].

Hotels present some unique characteristics in comparison to other buildings which will need to be further explored. Several of the frameworks and calculation methods mentioned above can be built upon to identify and account for structural differences such as placing more bathrooms per square meter and related piping and plumbing than other building types, as well as whether to include the upstream emissions from purchased FF&E in the embodied carbon boundary from time of opening, or separately.

Key Actions

While strategies and calculations to reduce and ultimately eliminate embodied carbon are still evolving, some clear actions have emerged given the increasing attention to the issue.

- Use fewer materials, such as preserving and reusing existing substructures and building frames.
- Use low carbon materials
- Ensure building can be adapted for future changes in building uses and for climate resilience, such as opting for modular design.
- Avoid composite materials that are hard to deconstruct and produce high amount of demolition waste; opt for materials that are easy to disassemble, reuse and recycle.

M.2 UPSTREAM EMISSIONS FROM PURCHASED FURNISHINGS

INTRODUCTION

Similar to embodied carbon, upstream emissions from purchased furnishings refers to carbon emissions associated with extraction, manufacture/processing, transportation, and assembly of every material used in the furnishing until the point that it is installed at the site building. In addition, downstream emissions from disposal may occur at end-of-life stage.

The upstream emissions associated with purchased furnishings are often neglected as it is widely thought to comprise a small percentage of buildings' total carbon emissions; it is commonly cited to be less than 10% of total building lifecycle emissions[11]. However, given that hotels are significant consumers of furnishings for guestrooms and public areas, attention to the carbon emissions associated with its materials and manufacturing processes is due. This is especially important since hotels periodically undergo interior renovations and purchase new furnishings which would add to the buildings' total embodied carbon. A study found that the cumulative embodied carbon of a commercial building's interior renovations exceeded the embodied carbon of its building structure and envelope[12].

KEY SOURCES OF EMISSIONS

Some common examples of hotel furnishing include upholstery, bedding, carpets, and lighting. Furniture is one of the most significant sources of upstream carbon emissions in hotels. Products such as mattresses, sofas and task chairs were found to have the largest carbon impacts among key furniture items[13]. The largest contributor to the carbon impact of mattresses and sofas is its raw material content, comprising materials such as foams and fillings, textiles, and metals. For task chairs, metal and plastic are major contributors as the two materials make up around 70% of such chairs.

Carpets are another significant source of upstream carbon emissions in hotels[14]. For carpets made from nylon fibers, oil and gas extraction and processing to produce such plastic materials is the largest contributor to the carbon impact of most carpets. Carpets made from natural fibers such as wool can also have large carbon impacts as the manufacturing and dyeing process of carpets is energy intensive. For example, large amounts of natural gas are often used to evaporate water and melt plastics into carpet backings.

Lighting is another significant source of upstream carbon emissions in hotels. While the use of LED lighting has led to significant savings in operational energy and carbon, the process to manufacture LEDs is more energy and carbon intensive than the process for conventional lamps[15].

10 Hybrid Input-Output Analysis of Embodied Carbon and Construction Cost Differences between New-Build and Refurbished Projects: https://www.mdpi.com/2071-1050/10/9/3229
11 Why Interior Designers Must Fight Climate Change: https://metropolismag.com/viewpoints/interior-designers-climate-carbon/
12 Why Interior Designers Must Fight Climate Change.
13 FIRA – A Study into the Feasibility of Benchmarking Carbon Footprints of Furniture Products (2011): http://www.healthyworkstations.com/resources/Environment/FIRA.CarbonFootprint.pdf
14 Carbon Impact of Carpet: https://materialspalette.org/carpet/
15 Life cycle assessment of light courses – Case studies and review of the analyses: http://lib.tkk.fi/Diss/2013/isbn9789526052502/isbn9789526052502.pdf

CURRENT DEVELOPMENT
Calculations and Initiatives

There is currently a lack of sector-wide net-zero initiatives or approaches towards quantifying (other than preliminary quantification based on EEIO method) and eliminating upstream emissions associated with purchased furnishings. UK-based research found that all furniture manufacturer respondents feel that the sector is lacking a clear net-zero strategy[16]. One notable initiative by the Furniture Industry Research Association (FIRA) in 2011 quantified the carbon footprint of key furniture products[17].

Key Actions
Some strategies to reduce upstream emissions from purchased furnishings include:

- Use fewer materials, such as by opting for items like carpets with high recycled content.
- Choose furniture with timeless design to avoid furnishings becoming unfashionable and ensure they can last a long time.
- Select furniture that can be easily disassembled, repaired, maintained. Examples selecting furniture that uses screws and bolts or other joinery methods instead of glue, and upholstery fabrics that can be detached and machine-washed instead of dry-cleaned.
- Consider product leasing services for items such as furniture and floor finishes.

M.3 UPSTREAM EMISSIONS FROM FOOD AND BEVERAGE

INTRODUCTION
Emissions from food and beverage (F&B) products refer to the greenhouse gas emissions associated with growing, rearing, farming, manufacturing, and processing, storing, transporting them until they are delivered to hotels, and lastly wastage after consumption. Food production is found to account for around 26% of global GHG emissions[18]. Upstream food-related emissions can be further broken down into livestock and fisheries (31%), crop production (27%), land use for human food and livestock (24%), and supply chain activities (18%) such as processing and transport. On the other hand, estimates show that one-third of all food produced lost or wasted, accounting for 8% of total GHG emissions[19].

KEY SOURCES OF EMISSIONS
Animal products such as meat, cheese and eggs have the highest upstream carbon emissions, while fruits, vegetables, beans, and nuts have much lower emissions[20]. Notably, beef has the highest carbon emissions at 99.48 kgCO_2e for every kilogram. A major source of emissions for animals such as cattle, sheep and goats are methane, which occurs during feed digestion and manure management[21]. On the other hand, feed provision is the largest source of emissions for animals such as pigs and poultry. This is due to soil emissions of nitrous oxide (N_2O) and carbon emissions from the production of fertilizers. Energy consumption to maintain suitable animal housing conditions for animals such as chickens can also be significant, especially if the national grid is powered by fossil fuels.

CURRENT DEVELOPMENT
Calculation, Initiatives and Key Actions

There is no straightforward way of calculating emissions from F&B products due to many factors, from production, locations, manufacturing processes, transportation modes and ingredient composition, to having direct and indirect carbon emissions. Not only are there upstream emissions associated with the F&B products until they arrive at the hotel, but there are also downstream emissions from food waste that may be included in the coefficients used for calculation, resulting in double counting for a hotel that already includes emissions from its waste.

Cool Food[22], a global project by WRI in collaboration with environmental and health organizations aims to help food providers and dining facilities reduce GHG emissions through the following key initiatives:

- Commits to a science-based target to reduce food related emissions by 25% by 2030 and by 38% per calorie relative to 2015 base year, through the **Cool Food Pledge**[23].
    - The pledge existing signatories come from various sectors, including companies, restaurants, city governments, universities, schools, and hospitals and as of August 2022, over 60 organizations are participating as signatories or members of the Cool Food movement.
    - WRI monitors both the absolute and relative performance of the signatories and report collective, aggregate performance against targets annually.
- Introduction of **Cool Food Meals**[24] to identify low-emitting meals to eventually meet the above emissions reduction target where –
    - A maximum threshold of per-meal emissions is established based on initial data from the Food & Agriculture Organization of the United Nations (FAO) Food Balance Sheets calculated using the Cool Food Calculator.
    - Cool Food Meals certification with primary data collected based on recipe data using a dish's ingredients submitted to, measured, and verified by WRI.
    - Cool Food Meals are subject to a nutrition safeguard to ensure they meet a minimum threshold of nutritional quality. Publicly recognizing climate-friendly food providers, and steering consumers toward low-emitting menu options, can help accelerate the transition toward a sustainable food future.
    - Aims to reducing agriculture's pressure on natural resources and aims to shift diets that are high in meat, especially beef and lamb toward more plant-based foods.
- **Cool Food calculator**, designed to measure a set of metrics and track progress toward the emissions reduction target, taking into considerations of the following sources:

16 British Furniture Manufacturing – Sentiment of the Sector & the Road to Net Zero Report (2021): https://www.furnitureproduction.net/news/articles/2021/06/2055426337-new-report-highlights-need-sector-wide-environmental-strategy
17 FIRA – A Study into the Feasibility of Benchmarking Carbon Footprints of Furniture Products (2011)
18 Reducing food's environmental impacts through producers and consumers (2018): https://globalsalmoninitiative.org/files/documents/Reducing-food%E2%80%99s-environmental-impacts-through-producers-and-consumers.pdf; Data visualization: https://ourworldindata.org/food-ghg-emissions
19 FAO Food Wastage Footprint & Climate Change (2015): http://www.fao.org/3/bb144e/bb144e.pdf
20 Data visualization: https://ourworldindata.org/environmental-impacts-of-food
21 FAO Food Wastage Footprint: Impacts on natural resources (2013): http://www.fao.org/3/i3347e/i3347e.pdf
22 WRI Cool Food, https://coolfood.org/
23 Waite, R., D. Vennard, and G. Pozzi, 2019 Tracking Progress Toward the Cool Food Pledge, Technical Note, WRI. www.wri.org/research/tracking-progress-toward-cool-food-pledge
24 Waite, R., and S. Blondin. 2022. "Identifying Cool Food Meals: 2022 Update." Technical Note, WRI. https://www.wri.org/research/identifying-cool-food-meals

- Agricultural supply chain emissions which include livestock-related emissions, soil fertilization, energy use, rice paddies, activities between the farm gate and the point of purchase such as transport and packaging. The calculator also estimates emissions associated with food losses that occur at each supply chain step.
- Carbon opportunity costs which estimate the amount of carbon that could be stored in plants and soils if the land used to produce food sourced by the food provider were instead allowed to return to its native vegetation e.g., forests.
- The calculator includes regional default emission and conversion factors from several recent sources[25].

Other Approaches

Net-zero initiatives in the food-related sector are largely evolving. These are additional noteworthy resources for reference:

- **Food and Drink Federation**, set out ambitions for the UK's food and drink sector to reach net zero by 2040. **https://www.fdf.org.uk/**
- **Courtauld Commitment 2030**, a voluntary agreement for players along the entire UK food chain to deliver reductions in both per capita food waste and GHG emissions by 50% by 2030. **https://wrap.org.uk/taking-action/food-drink/initiatives/courtauld-commitment**
- **Food Loss and Waste Protocol**, to quantify food loss and waste occurring across supply chain activities, in designing targeted strategies to reduce waste. **https://www.flwprotocol.org/**
- **FAO's #123 Food Loss and Waste Pledge**, aiming to halve food waste by 2030 and reduce food losses by at least 25%. **https://www.fao.org/index.php?id=102558**
- **Nutrition & Consumption** by WWF Germany covering topics including sustainable food system, food waste and so on. **https://www.wwf.de/themen-projekte/landwirtschaft/ernaehrung-konsum**
- **Statistic on Environmental Impacts of Food Production** based on 2018 research paper - Reducing food's environmental impacts through producers and consumers. **https://ourworldindata.org/environmental-impacts-of-food**, **https://globalsalmoninitiative.org/files/documents/Reducing-food%E2%80%99s-environmental-impacts-through-producers-and-consumers.pdf**
- **Environmental Impact of Key Food Items**, a study conducted in 2019 to understand the environmental landscape of the food items in Singapore. **https://www.ecosperity.sg/content/dam/ecosperity-aem/en/reports/Environmental-Impact-of-Key-Food-Items-in-Singapore_Oct2019.pdf**

In a nutshell, strategies to reduce emissions from food-related products may include:

- Improving the productivity and environmental performance of agriculture including crops, livestock, fisheries, and aquaculture.
- Shift away from carbon-intensive foods such as meat diets toward plant-based foods.
- Reducing food loss and waste across supply chains activities.
- Source food produced locally or in neighboring countries and choose food to be transported via low emissions mode of transportation.
- Source food from suppliers or locations that use renewable energy instead of fossil fuels for electricity generation.
- Increase consumer awareness in choosing sustainable food options.

25 FAO Food Balance Sheet (FAO 2022), Poore and Nemecek 2018; Searchinger et al. 2018.