# A CARBON FOOTPRINT ANALYSIS OF TRAVEL

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## Executive Summary

Tourism contributes approximately 8% of global greenhouse gas (GHG) emissions, making it a significant sector in the fight against climate change. As international travel continues to grow, decarbonizing the travel industry becomes increasingly urgent. This Master's Project addresses this challenge by conducting a carbon footprint analysis of a 2023 Duke Travels alumni trip to Italy's Lake District, organized by AHI Travel. The project aimed to quantify the emissions associated with this itinerary, evaluate realistic decarbonization strategies, and provide actionable tools for AHI Travel to improve the sustainability of its offerings. Using the GHG Protocol as the methodological foundation, the Master's Project team created a comprehensive emissions inventory, developed a custom carbon footprint calculator, and presented recommendations for integrating sustainability more deeply into AHI Travel's operations.

AHI Travel, a leading educational tour operator, joined this project to better understand the carbon footprint of a typical itinerary, building on its existing sustainability efforts in waste reduction and supplier evaluation. The selected trip followed AHI Travel's land-based itinerary "hub-and-spoke" format, with travelers based in a single hotel and taking day trips to surrounding areas. The Master's Project team conducted extensive data collection across four categories—food and beverages, lodging, ground transportation, and flights—to build an emissions profile aligned with the GHG Protocol. Flights accounted for 94% of overall emissions. Without flights, food and beverage was the largest contributor (48%), followed by lodging (27%) and ground transport (24%).

To explore potential emissions reductions, the Master's Project team ran sensitivity analyses testing factors such as hotel star ratings, room occupancy, meal types, vehicle fuel types, and airline seat class. Notably, switching all flights to economy class reduced total trip emissions by nearly 50%, and opting for 4-star hotels instead of 5-star accommodations decreased lodging emissions by over 57%. Removing beef cut food emissions significantly, while switching to biodiesel or electric vehicles reduced ground transport emissions by up to 80%. These findings were compiled into three scenario analyses—low, medium, and high emissions—demonstrating the carbon impact of various aspects of a trip. While the lowest-emissions scenario offered the

most significant reductions, the Master's Project team acknowledged that such changes may not always align AHI Travel's current business model or their customers' expectations.

The final deliverables—a data collection checklist and a custom Excel carbon calculator—will streamline future emissions tracking for AHI Travel's land-based itineraries. Together with AHI Travel's vendor sustainability scorecard, these tools enable an integrated approach to assessing trip emissions and promoting vendor sustainability. Also, the Master's Project team conducted a competitor analysis, benchmarking AHI Travel against other educational tour operators. They found that only two competitors—Lindblad Expeditions and Natural Habitat Adventures—have made public commitments to carbon neutrality and emissions reductions, highlighting an opportunity for AHI Travel to lead in sustainability within the educational travel space.

Based on the findings, the Master's Project team recommended that AHI Travel pilot a low-carbon trip with all economy or premium economy flights, plant-forward meals (only fish and chicken meat options), all EV or biodiesel ground transport, and 4-star hotels with two persons per room—while maintaining the high-quality, enriching experiences their travelers expect. Additionally, the team recommended AHI Travel invest in high-integrity carbon offsets (e.g. via Patch.io) and support sustainable aviation fuel (SAF) by joining coalitions such as Airports of Tomorrow, considering SAF Book and Claim systems, educating travelers, and advocating for SAF adoption at the airports it uses most frequently.

In general, luxury travel—through first-class flights, upscale hotels, and high-impact meals—is inherently more carbon-intensive. While air travel offers the greatest potential for emissions, it remains the hardest to tackle due to customer preferences, limited operator control over fuel choices, and financial incentives tied to premium bookings. Given these challenges, travel operators like AHI Travel should also adopt a broader sustainability approach that goes beyond carbon and includes reducing water use, supporting local vendors, and reducing waste. Through strategic planning, transparent data collection, ongoing carbon tracking, and engagement with vendor partners and travelers, AHI Travel can help drive meaningful progress toward a more sustainable tourism industry.

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# Introduction

## Travel & Tourism Sector

The global travel and tourism sector employed 330 million people and contributed 9.1% of the global Gross Domestic Product (GDP) in 2023, worth about 9.9 trillion US dollars (World Travel & Tourism Council, 2023). The sector spans multiple industries, including aviation, accommodations, tour operators, cruises, and travel agencies. In the United States alone, it generated about 1.9 trillion dollars in economic output, making up nearly 3% of GDP while employing 9.5 million Americans (US International Trade Administration, 2023). Given the immense size of the travel industry, the World Travel and Tourism Council (WTTC) estimates its associated economic activities at about 8.1% of the world's total greenhouse gas (GHG) emissions (2021).

The sector is expected to continue growing in the coming decades, and if it continues to operate as it has in the past, its carbon footprint will increase as well. For 2024, the WTTC projects that the sector's economic contribution will be a record-breaking 11.1 trillion US dollars (WTTC, 2024). By 2034, the WTTC projects that this will grow to about 16 trillion US dollars, forming an even larger chunk of the global GDP at about 11.4% (ibid). Therefore, decarbonizing travel is imperative to achieving the goal of the Paris Climate Agreement, which is to keep warming to well below 2 degrees Celsius above pre-industrial levels (United Nations Framework Convention on Climate Change, n.d.).

## Carbon Accounting Background

Carbon accounting is the process of measuring and tracking the amount of GHG emissions produced directly and indirectly by an organization, product, or activity (GHG Protocol, 2023). It helps companies, governments, and other entities understand their environmental impact on climate change and develop strategies to reduce that impact. Emissions are typically categorized into three groups (see Figure 1 below). Scope 1 is commonly known as direct emissions,

covering sources of GHGs that an organization owns or controls, such as fuel combustion from natural gas heaters, fleet vehicles, or fugitive emissions from refrigerant leakage. Scope 2 includes indirect emissions from the generation of purchased electricity, steam, heating, or cooling used by the organization. Finally, Scope 3 includes all other indirect emissions that occur throughout the value chain, including emissions from purchased goods and services, business travel, employee commuting, downstream transportation, use of sold products, and more.

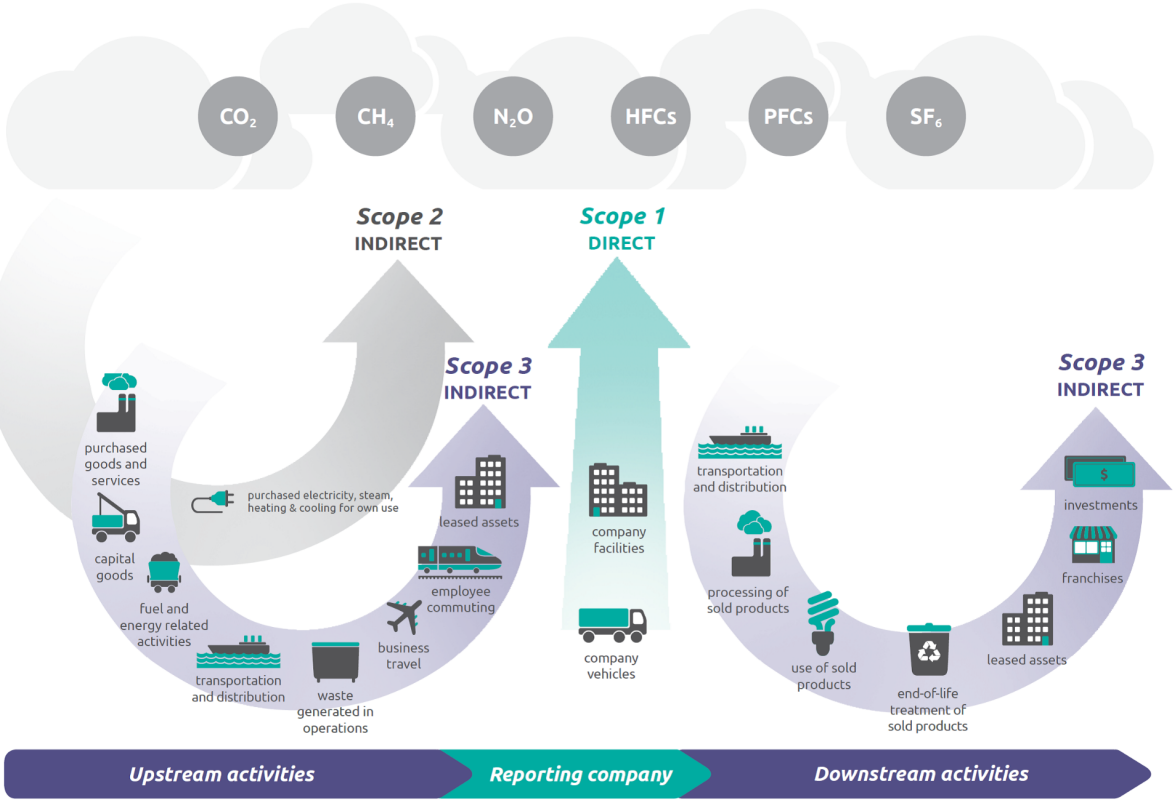


**Figure 1: Overview of GHG Protocol scopes and emissions across the value chain from the GHG Protocol's Corporate Value Chain's Reporting Standard (2011).**

In terms of standard methodologies for carbon accounting, the aforementioned GHG Protocol is the most widely used international accounting framework for measuring and managing greenhouse gas emissions. It provides standards, guidance, and tools for organizations to quantify, report, and reduce their emissions across all Scope categories. Developed through a long process with multiple stakeholders from different countries and organizations, the GHG

Protocol ensures consistency and transparency in emissions reporting. The Master's Project team uses the methodologies and frameworks laid out in both the *Corporate Standard* and the *Corporate Value Chain (Scope 3) Accounting and Reporting Standard* throughout this project.

In the context of carbon accounting and this Master's Project, several key terms will be used and should be defined. Carbon dioxide equivalent ($CO_2e$) is a standard metric in GHG accounting that expresses the impact of all greenhouse gases—such as methane and nitrous oxide—in terms of the amount of carbon dioxide that would have the same global warming potential. This allows for a single, comparable figure to represent the total climate impact of multiple gases. Business-as-usual (BAU) refers to a scenario where no additional efforts are made to reduce GHG emissions, meaning emitting activities continue without any change and worldwide temperature rise is not mitigated (DGAP, n.d.). Cradle-to-gate describes an emissions assessment boundary that includes all emissions from resource extraction (cradle) through to the point the product leaves the manufacturers gate, before it reaches the consumer (GHG Protocol, 2013). Transmission and distribution (T&D) refers to the infrastructure and processes involved in delivering electricity from power plans to end users. Emissions from T&D losses are always considered in carbon accounting, although their place in either Scope 2 or Scope 3 depends on the reporting organization's role in the energy supply chain.

## Low-Carbon Tourism

Low-carbon tourism aims to minimize greenhouse gas emissions from travel in alignment with broader climate and sustainable development goals. Multiple approaches are available, though the process begins with quantifying baseline emissions from operations (Scopes 1 and 2) and its value chain (Scope 3) through carbon accounting. The carbon inventory helps identify emissions hotspots and design targeted mitigation strategies, such as adopting energy-efficiency measures, electrifying building and fleets, reducing waste, purchasing renewable energy certificates, investing in on-site renewable generation, and decarbonizing an organization's value chain through targeted product redesigns and supplier engagement. Aside from informing decision-making, carbon accounting helps organizations comply with regulations that require carbon

disclosure, like California's SB219 and respond to climate-related inquiries from investors and customers (GHG Protocol, 2023).

Multiple studies indicate a growing demand within the tourism sector and among travelers for less carbon-intensive travel. A survey by Trip.com found that 59% had "opted for some form of sustainable travel in recent years," 69% "are actively (always or occasionally) seeking sustainable travel options," and 75% "desire to choose sustainable travel options in the future" (World Travel & Tourism Council, 2023). Most respondents had also paid for carbon offsets or were willing to purchase them "if the price was right" (World Travel & Tourism Council, 2023). In response to the market signals, more than 850 organizations in the industry have become signatories of the Glasgow Declaration on Climate Action in Tourism, including the WTTC (UN Tourism, n.d.). Key parts of this declaration include halving emissions by 2030 and reaching net zero before 2050, delivering on climate action plans, and reporting on progress.

## Client Background

Our client, AHI Travel, is a tour operator within the educational travel industry. AHI Travel was established as a family-run business in 1962 and was acquired by a private equity firm, Certares Management LLC, in November 2021. AHI Travel designs and sells enriching international travel experiences tailored for educated university alumni travelers. These tours are marketed through university partners, offering a seamless experience that includes accommodations, dining, transportation, excursions, and local expert guides. AHI Travel primarily serves universities across the US and Canada, with Duke University's Duke Travels being one of their key partners. Their ideal clients are universities that view the relationship as both a business partnership and a collaboration, sharing the goal of providing educational, transformative, and sustainable travel experiences.

AHI Travel plans its upcoming trips through a selective process involving various internal departments. Guided by executive leadership,the product team selects destinations and itineraries based on successful past programs to create a diverse lineup that appeals to educated travelers

typically ages 55 and above. Once the product team finalizes the itineraries and budgets, the AHI Travel sales team presents trips to their clients, encouraging them to choose which trips each university's travel department would like to offer their alumni. Aside from the unprecedented impacts of the 2020-2023 COVID-19 pandemic, the company's business model is relatively stable, allowing it to accurately project the number of trips and travelers it can support each year.

After choosing their preferred itineraries, Duke Travels and other alumni associations recruit alumni for trips, pairing with each itinerary a knowledgeable Duke faculty member who will travel alongside alumni and offer enriching educational content. As the rosters fill up with travelers, the operations team at AHI Travel steps in to manage group logistics, gathering individual traveler information and coordinating with suppliers such as hotels, ground operators, and guides, while the marketing team promotes trips through co-branded materials. Inside sales then handle traveler bookings, converting prospects into confirmed participants, who are subsequently managed by customer service and air coordinators. The human resources, finance, and accounting departments provide essential support, while sales administrators maintain day-to-day contact with alumni associations.

AHI Travel's process for selecting trip vendors is based on over 60 years of experience and their long-standing relationships within the global travel industry. The company maintains consistent partnerships with many vendors, but when quality declines or new vendors are needed, they issue detailed Request for Proposals (RFPs) for new service providers. These RFPs outline trip requirements and include specific details such as what excursions to source, what type of guide is requested, and food requirements. AHI Travel partners with destination management companies to manage transportation, excursions, and dining. Hotels and ships, however, are contracted directly, with a thorough evaluation process ensuring they meet specific criteria, such as providing 4-star or higher services. This detailed vendor selection process (discussed in Appendix J) ensures high-quality experiences for travelers and offers opportunities to incorporate sustainability criteria throughout the trips.

## AHI Travel and Sustainability

AHI Travel is aware of the increasing focus on sustainability within the travel industry. However, the COVID-19 pandemic delayed some of their internal plans to incorporate sustainability into their operations due to funding challenges and the pressing need to address pandemic-related concerns. While they currently do not have a formal organizational carbon inventory or detailed climate change initiatives, AHI Travel is working to integrate more sustainable practices into its operations. Although sustainability does not directly influence their choice of destinations, per McCorstin et al. in their 2020 Nicholas School Master's Project with the travel firm, AHI Travel "recognizes the impact of overcrowding on destinations, and focuses on catering towards small group sizes and traveling during the serene season…to alleviate pressure on natural areas." Additionally, through client interviews, the 24-25 Master's Project team learned that although AHI Travel recognizes that carbon emissions are an unavoidable aspect of travel, they remain committed to balancing sustainability with providing educational travel experiences to their customers.

Much of AHI Travel's environmental sustainability initiatives so far have focused on waste reduction. AHI Travel has begun minimizing the use of single-use plastics on their trips, encouraging guests to bring reusable water bottles to refill along the trip itineraries and requesting destination vendors add more refill stations across their destinations. The marketing team is also exploring ways to reduce printed promotional materials, like brochures and catalogs, to further minimize their environmental footprint in communicating with potential travelers.

Notably, AHI Travel utilizes a comprehensive Impact Evaluation Program Assessment scorecard (see Appendix J) to assess the sustainability of vendors. AHI Travel applies the scorecard to existing programs, identifying areas that need improvement and in turn, make changes accordingly. The scorecard explores three categories: the vendor's environmental impact, social and economic impact, and experimental travel enhancements. Subsections within each category are rated with 1 if the vendor does meet the criteria and 0 if they do not meet the criteria. Note that the social and economic impact category and experimental travel enhancements category has

a minimum score. They are then given a score out of 30 possible points, ultimately allowing AHI Travel to more efficiently assess whether their vendors are meeting their sustainability standards. In particular, it helps AHI Travel identify which vendors they need to encourage to make improvements that will help them meet AHI Travel's sustainability standards. This is an effective method to grade not only the environmental impact of vendors, but also other dimensions of overall sustainability, like interactions with local communities.

Additionally, AHI Travel seeks to incorporate broader sustainability principles into its travel itineraries through an ongoing review. The product team is conducting social and environmental impact assessments of all their programs to identify and augment initiatives that destination managers, hotels, and other vendors are already implementing. For instance, AHI Travel partners with a hotel in Wales with an expansive garden that supplies local produce, poultry, and honey for its menu. This offers travelers a unique and sustainable local experience. AHI Travel would like to increase its offerings of such hyper-local, hyper-sustainable products.

In terms of carbon emissions, the typical GHG emissions profile for asset lite tour operators like AHI Travel is as follows:

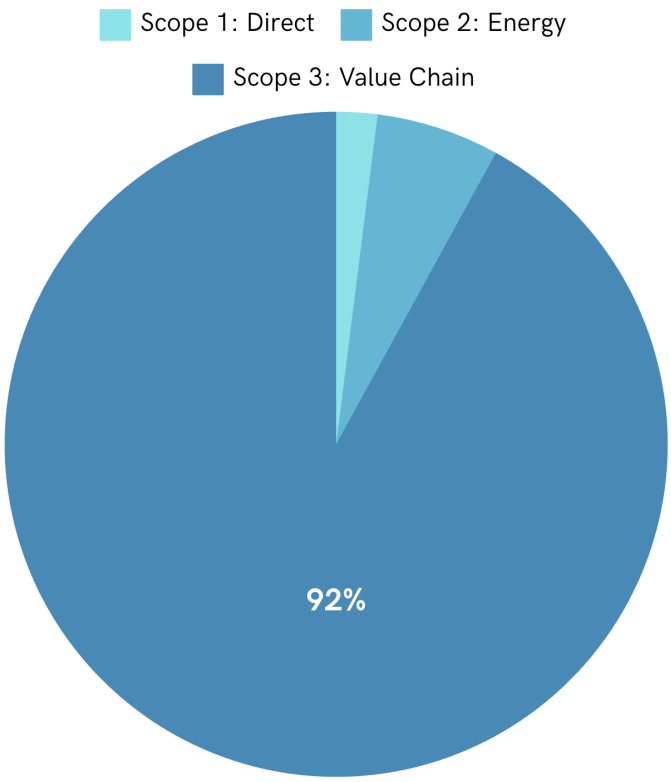


**Figure 2: A Typical Emissions Profile for Tour Operators *(*World Travel & Tourism Council, 2021*).***

As described by the WTTC's *Net Zero Roadmap for Tourism*, Scope 1 for tour operators typically includes direct emissions caused by office heating and cooling, as well as fleet vehicle emissions. Scope 2 includes energy purchased from utilities for offices, and Scope 3 includes business travel, commuting, brochures, upstream and downstream transport, and waste.

For the purposes of this accounting, the Master's Project team made the assumption that 100% of the value chain emissions calculated are from activities related to this trip. The overall aim of this project is to help AHI Travel quantify and reduce these emissions. By setting a performance marker through this analysis, the company aims to establish a baseline for the carbon footprint of its trips and explore ways to incorporate sustainability into trip planning. This includes considering the environmental impact when selecting specific destinations, program home bases, and suppliers. AHI Travel's overall goal is to drive sustainability efforts while continuing to deliver the high-quality experiences that their travelers expect.

## Objectives

1. Build a robust GHG inventory of emissions for one typical AHI Travel trip aligned with the GHG Protocol.
2. Recommend general strategies to reduce travel-associated GHG emissions that are operationally feasible, financially viable, and desirable.
3. Propose recommendations and create tools for future data collection to enable AHI Travel to estimate emissions for other trips.

## Methods

First, the Master's Project team met with both Duke Travels and AHI Travel to discuss the project's scope and learn more about the production of alumni trips and AHI Travel's operations. The Master's Project team provided AHI Travel with a list of data points necessary to perform the requested carbon accounting. This data included the full trip itinerary, the number of travelers on the trip, hotel data (amount of rooms booked and room type, length of stay, address, how many stars/type of hotel, how many people per room, availability of laundry services, any energy data and waste stream data, and whether the hotels are associated with a major hotel brand) and ground transport data (miles traveled, fuel type, coach model, number of passengers, and number of vehicles). Ground transport data included the local travel of the Italy-based AHI Travel Director. Additionally, the Master's Project team requested meal data (meat or plant-based, beverage choice, amount of alcohol provided, and waste associated with meals), excursion data (amount of contractors used and type of excursion), and flight data (ticket class and airport of origin) of travelers, including the AHI Travel Director.

It is important to note that flights for the Duke professor and their optional companion joining the trip are always booked by AHI Travel, whereas travelers may choose AHI Travel to book airfare for them. Typically, around half the passengers select this option. However, as flights are

the most emission-intensive aspect of a trip, the Master's Project team decided that estimated traveler flight-associated emissions be included within the scope of this project's analysis. Responsibility for emissions associated with flights booked on behalf of travelers is currently a debated topic in the industry, with most consensus being that they are emissions facilitated by the travel agency. Currently, there is no clear guidance on where to account for these facilitated emissions in a broker's emission inventory; as noted by this Master's Project's advisor who sits on the Scope 3 working group, this is currently under review by the GHG Protocol, with updated guidance forthcoming.

After assessing the data needs and finding a trip with the most available relevant data, AHI Travel asked the Master's Project team to conduct carbon accounting for their "Italy's Magnificent Lake District" itinerary. This itinerary was used for a Duke Travels alumni trip in 2023. This 2023 trip supplied the flight destinations, flight classes, passenger counts, room counts, menu contents, and ground transportation data used for calculations. AHI Travel provided the necessary data about this trip. Any additional data not already held by AHI Travel was acquired by contacting their vendors. AHI Travel categorizes this trip as a "hub-and-spoke" trip, meaning that travelers stay at the same hotel for the duration of the trip and travel to nearby destinations each day by coach. They were curious to see if this trip style released fewer GHG emissions.

The main part of the project was the carbon accounting of AHI Travel's value chain emissions for the selected trip in accordance with the GHG Protocol. GHG Protocol approved emissions factors came from a variety of sources, as shown in Appendix I. Region/country-based emissions factors associated with certain elements like accommodations, food, beverages, and electricity were used. As needed and in accordance with the GHG Protocol, Cradle-to-gate and T&D emissions factors were used for emissions calculations. After the final emissions total was generated for the trip, the average emissions per traveler was calculated. After calculating emissions based on the baseline assumptions from the provided itinerary and data, the Master's Project team conducted sensitivity analyses using various adjustable factors. These included but

weren't limited to eliminating red meat consumption, switching to biodiesel for passenger transport vehicles, and changing the flight class of all passengers to either economy or business, with the overall goal to assess how each change would affect the emissions of the trip.

Based on the sensitivity analyses and additional research, the Master's Project team then recommended strategies for AHI Travel to reduce emissions. Recommendations were informed by research into low-carbon travel initiatives and verified carbon offsets promoted by travel coalitions and consultancies like the World Travel & Tourism Council, Tourism Cares, the Travel Corporation, the World Sustainable Hospitality Alliance, the Cornell School of Hotel Administration, Sustainable Travel, GreenTripper, Synergy, and Duke University's Sustainability Office (see the bibliography for more information). Additionally, benchmarking with the decarbonization practices of other tour operators, who are AHI Travel's top competitors, was instrumental, including those who work with Duke Travels and beyond.

Finally, drawing on their experience obtaining data from AHI Travel and calculating trip-related emissions, the Master's Project team developed two tools designed to streamline and support future carbon accounting efforts. First, the team created a comprehensive data checklist to capture essential trip details, including transportation distances, vehicle models, hotel classifications and room counts, passenger numbers, primary meal proteins, and types of excursions. Second, the team developed a custom Excel-based carbon footprint calculator for AHI Travel to estimate the GHG emissions associated with their land-based itineraries. Both tools were designed to be user-friendly and easily integrated into AHI Travel's existing trip planning and sustainability practices.

The team established protocols to collaborate and keep organized throughout the project. Data and documents were shared within a Google Drive folder. The associated conversions and assumptions were housed in a Google Sheet, with tabs associated with each category of emission calculations: flights, ground transportation, accommodations, and meals. This allowed ease of navigation throughout the data and simplified the calculation of emissions. Google Sheets also

made it easy to create figures for data visualization and glean insights across different scenarios. Additionally, research related to the sustainable and regenerative tourism industry, specific aspects of the trip itinerary and sustainable alternatives, and databases for emissions factors and carbon accounting were housed in a shared annotated bibliography. Canva was used to generate a visually appealing final presentation. The Master's Project team worked closely throughout the process with their advisor, Holly Emerson, as well as the team at AHI Travel and Duke Travels to ensure efficient progress on project goals and communication regarding data needs.

## Competitor Analysis

AHI Travel's top competitors are Orbridge, Odysseys Unlimited, Gohagan and Co., Go Next, Criterion Travel, Arrangements Abroad, Lindblad Expeditions, Natural Habitat Adventures (Nat Hab), and Sports and Entertainment Travel. By benchmarking the companies' websites, the Master's Project team found that about half of the competitors have a sustainability webpage on their website, including Orbridge, Lindblad, Nat Hab, and Sports and Entertainment Travel (Orbridge, n.d.; Lindblad Expeditions, n.d.; Natural Habitat Adventures, n.d.; Sports & Entertainment Travel, 2023). Aside from Lindblad and Natural Habitat, which claim to be carbon neutral through offsetting 100% of their emissions (Lindblad Expeditions, n.d.), all competitors do not have publicly announced climate goals and Science Based Target Initiative (SBTi) approved targets. Nat Hab is an outlier, as it started exploring setting an SBT in 2023 (Natural Habitat Adventures, n.d.). Across the board, the most common forms of climate action are carbon offsets, funding conservation projects, addressing waste, and engaging in more sustainable partnerships. The climate leaders are clearly Lindblad and Nat Hab.

Lindblad Expeditions integrates sustainability into its business by addressing carbon emissions, reducing waste, sourcing responsibly, and funding conservation projects (Lindblad Expeditions, n.d.). To reduce its environmental impact, the company offsets 100% of its carbon emissions and has eliminated single-use plastic bottles, cups, straws, and stirrers across its fleet. Guests are instead provided with reusable stainless steel water bottles. Additionally, the company

collaborates with vendors to minimize plastic use throughout its supply chain and partners with Bionic Yarn, an innovative company that converts ocean plastic into sustainable clothing. Lindblad's commitment to sustainable food sourcing is reflected in its seafood policy, which supports local responsible fishing efforts while ensuring that only the most sustainable species are served. Beyond these operational initiatives, the company funds conservation projects such as the Pristine Seas expedition and the LEX-NG Fund to protect marine ecosystems. Through these efforts, Lindblad sets a high bar for environmentally responsible travel.

Natural Habitat Adventures reduces its environmental impact through carbon reduction, waste management, sustainable innovation, and conservation support (Natural Habitat Adventures, n.d.). The company is investing in SAF, which is a lower-carbon fuel than Jet A fuel, and developing a robust climate action plan aligned with SBTi to significantly lower its carbon footprint. In addition to offsetting 100% of its carbon emissions, Nat Hab funds carbon reduction projects and partners with Tomorrow's Air, a social enterprise that vets cutting-edge carbon removal technologies. Its sustainability efforts extend to transportation, with the introduction of an electric, solar-powered safari vehicle to minimize emissions. Waste reduction is another key focus, as Nat Hab has eliminated plastic bottles and straws from its trips, provides all travelers with reusable stainless steel water bottles, and implements office waste management strategies such as recycling and composting. The company has even tested zero-waste travel on one of its expeditions - to learn about this and other initiatives, the Master's Project team conducted an interview with a Nat Hab representative (see Appendix G for the resulting case study). In addition to its commitment to operational sustainability, Nat Hab actively advances conservation efforts through its partnership with the World Wildlife Fund (WWF) and its support of various philanthropic initiatives focused on wildlife conservation, education, transportation, and sustainable agriculture. Through these efforts, Nat Hab illustrates how adventure travel can be thoughtfully aligned with sustainability.

## Data Gathering

## AHI Travel Data

In early discussions with AHI Travel, the Master's Project team explored the types of trips they offer and identified those most suitable for gathering detailed information. This helped to narrow the scope of the project and identify which itinerary was best suited for this initial carbon accounting effort. AHI Travel is best known for hub-and-spoke trips and river cruises. The Master's Project team collectively decided to analyze a hub-and-spoke trip which entails all travelers meeting at the destination and staying at a single hotel for the duration of the trip. The Master's Project team provided AHI Travel with a document detailing all data needed to complete the carbon accounting for the chosen trip.

This Data Needed sheet outlined the project goals and asked for the following:

- Itinerary information
    - Full itinerary
    - Typical number of people on the trip
    - Dollar amounts spent and breakdown into what areas
- Transportation
    - Different transportation modes used during the trip
    - Mileage used
    - Fuel type
    - Vehicle make and models
    - Number of vehicles
- Accommodation
    - Number of rooms
    - Length of stay
    - Hotel address
    - Type of hotel/number of Stars
    - International/national brand
    - Room type
    - Number of people per room
    - Laundry services provided

    - Other energy data or waste stream data are available
- Meals
    - List of all meals
    - Meals organized by AHI Travel
    - Average # of chicken vs. beef vs. seafood vs. vegetarian vs. vegan meals
    - Average food waste per meal in kg
    - Typical breakdown of dietary preferences of travelers (% vegetarian, vegan, pescetarian, omnivore, and more)
    - Sourcing (local vs. not)
    - Organic vs. not
- Waste
    - Waste gathered/produced throughout the trip
    - Waste most often produced during the trip
    - Availability of composting and recycling (at the hotel, sites visited, and more)
    - Approximate % of the waste produced that is composted and recycled
- Flights
    - Number of flights
    - Flight destinations
    - Ticket types: First-class vs. business class vs. economy
- Number of contractors and types of excursions

AHI Travel provided the full Italian Lakes itinerary and an Excel sheet that included the breakdown of the travelers' flight originations. They gathered this information from their internal itinerary repository. The Master's Project team was able to attain the location of the hotel, the number of meals, and ground transportation events based on the provided itinerary. Also, the Master's Project team was provided vehicle types (Volvo 9900 and Mercedes Sprinter Euro 6), the total number of people on the trip (28 passengers plus 1 AHI Travel Director), and the flight information from AHI Travel.

## Food & Beverages

AHI Travel partners with destination management companies to select food and find options for travelers, depending on cost and menu. For the Italy trip, meals were either at the hotel, at AHI Travel-selected restaurants, or nearby restaurants selected by travelers during free time at their discretion. AHI Travel contacted the hotel and restaurants directly to attain accurate meal data. Hotel La Palma was not able to provide any consumption estimates for their breakfast buffets, but they gave a full list of items available, including bread, cheeses, fruit, fish, eggs, sausages, cold cuts, beverages (juices and milk), yogurt, cereals, jams, and Nutella. Dinners at the hotel included a starter, a main course, and dessert. Additionally, the restaurants Aperitif, Il Vicoletto, and Suisse Restaurant provided a three-course menu. The Master's Project team used the main protein in each menu to estimate the carbon emissions associated with the meal. For meals with multiple main course options, the Master's Project team assumed that an equal number of travelers chose each option.

As for beverages, coffee, tea, wine, and bottled water were served to travelers. The Master's Project team assumed that all travelers consumed the American average of 14.1oz of coffee per day (Loftfield, E. et al, 2021). Furthermore, the Master's Project team assumed that travelers consumed 3,200 ml of bottled water per person per day, the average of the water intake recommended for men and women (*How much water do you need to stay healthy?* n.d.). White wine was assumed to be served since it pairs better with light dishes (like ravioli with ricotta cheese). The itinerary from AHI Travel noted that each person consumed 1/2 bottle of wine per day which is equivalent to 375 ml.

Emission factors used were mainly from the ADEME's Base Empreinte, a French database. This database was chosen because it provides average emission factors for meals by protein type and the source is within the EU. For meals that had eggs, bacon, cheese, veal, and fish as their main protein, the Master's Project team used emission factors from the Poore & Nemecek study (2018), a meta-analysis of the environmental impacts of 40 agricultural goods worldwide with data from about 38,000 farms as these protein types were not available in the ADEME database.

For those calculations (kg CO2e / kg of protein), the Master's Project team assumed 25% of the meal's weight was protein (see Appendix B for more information).

## Lodging

All lodging during the trip was at a single hotel, Hotel La Palma, in Stresa, Italy. This data was provided by AHI Travel via their itinerary. AHI Travel also provided passenger booking information, including booking numbers and names. The number of hotel rooms required was estimated based on the number of unique booking numbers. In cases where multiple individuals shared the same booking number, the Master's Project team assumed they were traveling together and would share a room. Based on this assumption, there were 28 people on the trip and 16 unique booking numbers. The Master's Project team then added one additional room to account for the AHI Travel Director that accompanied the group. This brought the total to 17 rooms.

To determine the appropriate emissions factor for these accommodations, the Master's Project team identified the Cornell Hotel Sustainability Benchmarking Index as a reputable source (Greenview, n.d.). This Excel sheet is a tool jointly developed by Greenview and students at the Cornell Peter and Stephanie Nolan School of Hotel Administration and Center for Hospitality Research. Within the tool, the Master's Project team was able to narrow down to get the emissions factor for the desired area. The Master's Project team utilized the drop-down menu in the tool to identify the trip's geography type by country, then selected Italy as the country and Milan as the metro area. Stars were then selected as the segment type and a 4-star non-resort was used for Hotel La Palma. The tool provided various different factors based on what measurement one is trying to find. The Master's Project team applied Measure 3: Hotel Carbon Footprint per Occupied Room (kg CO2e) as the emissions factor to focus on AHI Travel's specific contribution to the hotel's emissions, accounting only for the rooms occupied by their travelers. This metric was able to be compared across different stars. Once the measurement was chosen, the Master's Project team decided to use the mean number given, which was 15.72 kg CO2e/

occupied room, and this number was multiplied by the total number of rooms to get the total CO2e for lodging.

## Ground Transportation

The data necessary for ground transport calculations was provided by contacts at AHI Travel. Information regarding coach model, sprinter van model, vehicle trip destinations, boat trip destinations, boat trip lengths, travel distances for the Italy-based AHI Travel Director, and number of passengers on each transportation event were gathered by AHI Travel from their stored trip data and by contacting their tour operators in Italy. Additional needed information, such as kilometers per litre for the vehicles and boat trip distances were taken from internet sources like vehicle manufacturer pages and Google Earth, respectively. For calculations based on potential levers, the internet provided information regarding proxy EV models from the same manufacturers of the actual vehicles used on the trip (Volvo and Mercedes). It was assumed that the AHI Travel Director's vehicle and the taxi they took was an average, petroleum-fueled vehicle. Also, it was assumed that two passengers took a train to a nearby town on their free day. Distances for the assumed train trip on the free day were taken from Google Earth. Appropriate emissions factors were used from a variety of tabs in the UK Government's GHG Conversion Factors 2024, including those for cradle-to-gate emissions. Additionally, for EV emissions calculations, appropriate electricity emissions calculations were performed, requiring transmission and distribution emissions factors too.

## Flights

The data necessary for evaluating flight emissions was provided by AHI Travel. Based upon the actual data they had regarding the 2023 Duke University alumni trip, they were able to provide the airports that travelers departed from on their way to Italy and the airports travelers arrived at on their way back from Italy. They had data for most passengers regarding their seat class (economy or business). For the travelers for whom AHI Travel did not know the flight class, the Master's Project team assumed 50% were business class and 50% were economy class. It was

assumed that none of the flights had layover destinations on their way to Italy as the Master's Project team were not provided with that information. An online flight distance calculator was used to acquire the distances flown by each traveler. The Master's Project team used the UK Government's GHG Conversion Factors 2024, under the tab 'Business Travel- Air.'

## Results for Italian Lakes Trip Carbon Inventory

Shown in Figure 3 below, the results have clear implications as to which parts of travel most impact GHG emissions. Perhaps not surprisingly, the bulk of kg CO2e emitted during the itinerary is from flights–94.38% to be precise. As noted by previous sections, this trip had a combination of business class and economy class seats, making it a fairly good approximation of the mix of ticket types commonly on AHI Travel's flights.

| Emissions Type | Total CO2e / Trip (kg CO2e) | Total Paying Guests | Total CO2e / Trip / Guest (kg CO2e) | Percentage of Total Trip Emissions | Percentage of Total Trip Emissions (No Flights Included) |
|---|---|---|---|---|---|
| **Food / Bev** | 3,345.30 | 28 | 119.48 | 2.73% | 48.52% |
| **Lodging** | 1,870.68 | 28 | 66.81 | 1.53% | 27.13% |
| **Ground Transport** | 1,678.45 | 28 | 59.94 | 1.37% | 24.35% |
| Car | 15.04 | 28 | 0.54 | 0.01% | |
| Bus | 896.85 | 28 | 32.03 | 0.73% | |
| Boat | 756.22 | 28 | 27.01 | 0.62% | |
| Rail | 10.36 | 28 | 0.37 | 0.01% | |
| **Plane** | 115,683.72 | 28 | 4,131.56 | 94.38% | |
| **Attractions** | 0.00 | 28 | 0.00 | 0.00% | |
| **Totals** | **122,578.15** | | **4,377.79** | **100.00%** | |
| **Totals (No Flights Included)** | **6,894.44** | **28** | **246.23** | **5.62%** | |

**Figure 3: Calculated kg CO2e for AHI Travel's Italian Lakes itinerary.**

The rest of the emissions categories (Food & Beverage, Lodging, and Ground Transportation) made up only 5.62% of the overall CO2e emissions. Attractions account for 0 kg CO2e as the sedate nature of these activities, such as walking tours of towns and cathedrals, as well as lectures at the hotel, shopping, and visiting museums, meant that outside of the transportation required to get there (captured in the ground transport tab), any emissions for such attractions

were found to be de minimis, or too negligible to calculate. Those attractions for which the transport *was* the attraction (ex. a boat trip on Lake Como) had their emissions calculated in the ground transportation tab.

## Sensitivity Analyses

### Food & Beverages

When considering the food and beverage portion of the itinerary, the Master's Project team compared the GHG emissions associated with the planned itinerary provided by AHI Travel to other, different types of meal planning. The baseline assumption included meals as planned and served by AHI Travel, with a mix of vegetarian and non-vegetarian options and featuring dishes such as fish, duck, eggs with bacon, cheese, pork, chicken, veal, lamb, tuna, and various cheeses. These meals were provided at Hotel La Palma, Il Vicoletto in Stresa, other restaurants in the area, and finally, by guests themselves. If a meal was provided by the guests themselves, to be the most conservative, the team chose an emissions factor for the entire meal that assumed meat was consumed with an average of the potential protein choices.

To conduct the sensitivity analyses, the Master's Project team examined seven distinct scenarios to evaluate how different protein types and beverage choices influenced carbon emissions. This analysis also offered valuable insights into how the meal options in the travel itinerary measured up against the baseline AHI Travel menu in terms of sustainability and emissions reduction. Figure 4 below shows the results of this analysis. To summarize, the largest impact on food-based emissions was switching all proteins to beef; this more than doubled the amount of emissions from the food portion of the trip. This is primarily due to the significant enteric methane emissions produced by cattle, along with the extensive land required for grazing and feed production—land that is sometimes made available through deforestation (Waite & Zionts, 2022). As for beverages, removing coffee had the largest impact on emissions, while the effect of removing wine or bottled water was limited. Coffee has a significant carbon footprint due to

various factors related to its cultivation, processing, and consumption, such as land-use changes (like deforestation for plantations), the use of synthetic fertilizers and pesticides, and energy consumption during processing and transportation (UCL, 2021). While removing protein is the largest way that food choices may reduce greenhouse gas emissions, the limited impact of switching to vegetarian meals is due to the fact that at least half of the trip's meals are guest-provided and assumed to include meat. To remain conservative, the carbon accounting includes all food and beverages but does not adjust guest-provided meals based on AHI Travel's protein offerings. Whether guests are open to AHI Travel influencing their protein choices in their free time remains uncertain, though unlikely.

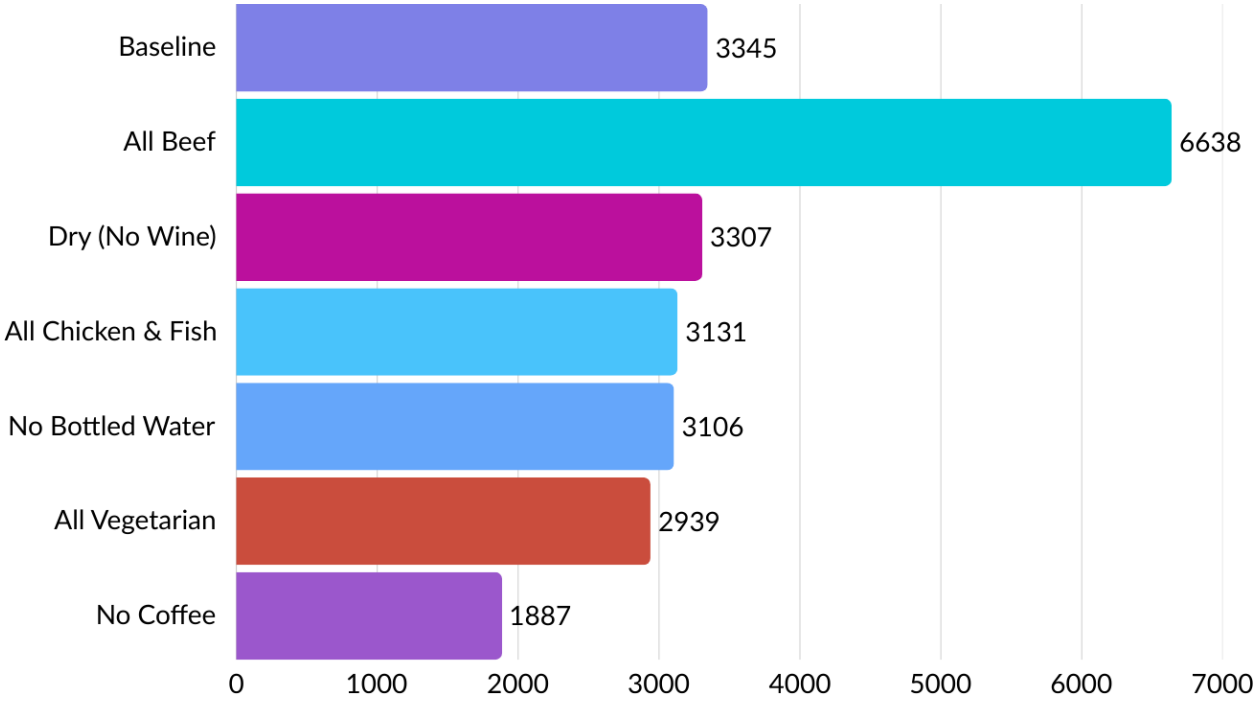


**Figure 4: Food and beverage emissions sensitivity analyses.**

## Lodging

For the lodging sensitivity analyses, the Master's Project team examined how variations in room occupancy and hotel star rating affected carbon emissions. Room occupancy was shown to be a key factor, as higher occupancy rooms meant fewer rooms booked by AHI Travel. Since carbon

emissions were calculated per occupied room, increasing the number of people per room directly reduced overall trip emissions. The same emissions factor used in the original analysis was also used to compare rooms with different occupancy rates, while room quantity was altered to reflect the number of rooms used by the group. The baseline assumptions for lodging were 17 rooms at the 4-star La Palma Hotel, as determined by the data provided by AHI Travel. In the scenario analyses, the Master's Project team started with 4 people per room which decreased the number of rooms from 17 to 8, reducing the emissions for lodging by 52.94%. Next, 3 people per room resulted in the use of 10 rooms and decreased the emissions by 41.18%. Furthermore, 2 people per room utilized 15 rooms, which was slightly lower than the 17 baseline room assumption and decreased emissions by 11.76%. Finally, 1 person per room increased the room count to 29 rooms and increased the carbon footprint by 70.59%.

As for star ratings, the Master's Project team utilized the same Cornell Hotel Sustainability Index 2024 to calculate emissions factors for a 3-star and 5-star non-resort hotel in the Milan region, choosing the same "Measure 3: Hotel Carbon Footprint per Occupied Room" for an apples-to-apples comparison to the baseline assumption. While analyzing the effect of hotel star ratings on emissions, the Master's Project team kept the baseline assumption of 17 rooms. Shown in Figure 5, the results showed decreasing the star rating from 4 to 3 correspondingly decreased CO2e emissions by 57.39%, while increasing to 5 stars increased emissions by 181.90%. In a conversation at GreenBiz in February, 2025, Andrew Loranger, Manager of Energy & Sustainability at Host Hotels & Resorts, confirmed that emissions tend to increase with higher star ratings, as well as resorts over non-resorts. This is due to the additional amenities offered—such as pools, saunas, and generally larger room sizes—which contribute to greater energy consumption.

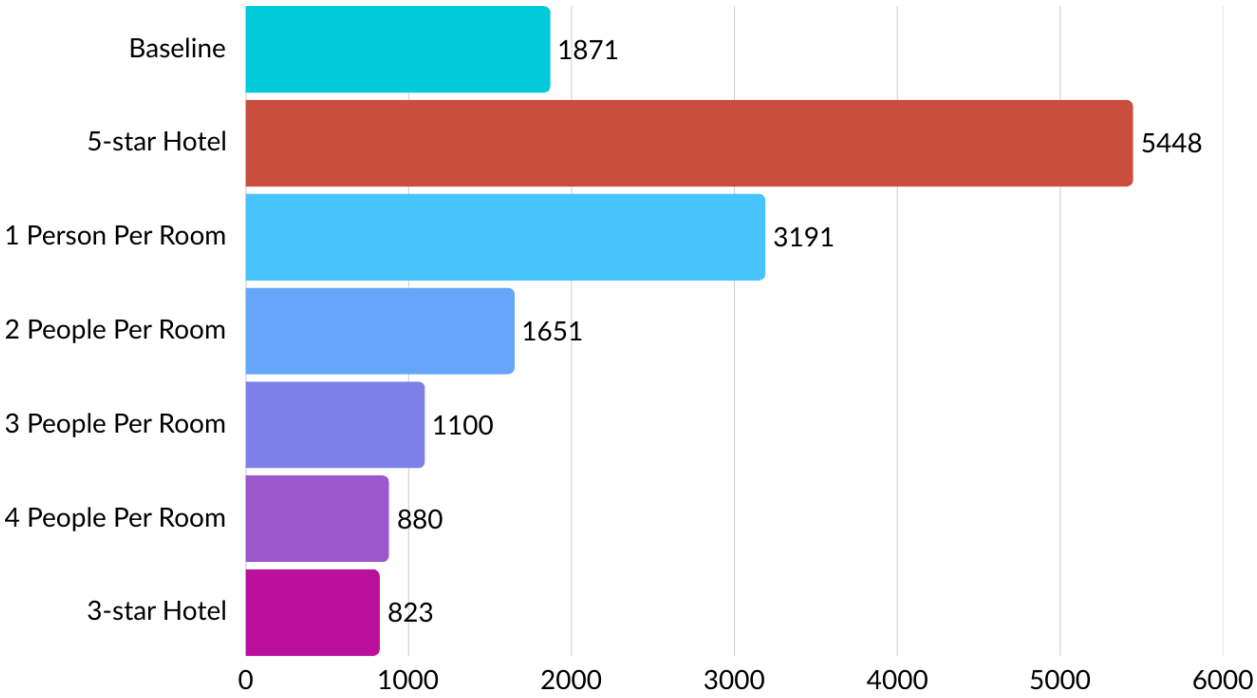


**Figure 5: Lodging emissions sensitivity analyses.**

## Ground Transportation

For ground transportation, sensitivity analyses investigated the impacts of using EVs for coach and sprinter van transportation, using EVs and biodiesel HVO (hydrotreated vegetable oil) for private boats, using EVs and biodiesel HVO for private boats as well as eliminating the two sprinter van trips on the final day to the airport, using biodiesel HVO (hydrotreated vegetable oil) for all coaches and private boats, using biodiesel ME (methyl ester) for all coaches and private boats, using biodiesel ME for private boats with all else being the baseline assumptions, and using biodiesel HVO for private boats with all else being the baseline assumptions. The baseline assumptions are the actual data gathered from the trip (see the Data Gathering: Ground Transport section for more information). These levers were not applied to the transportation of the Italy-based AHI Travel Director or public transportation, as these factors were deemed out of the influence of AHI Travel. Note that the baseline assumptions for ground transportation were the actual vehicles, destinations, and passenger counts used on the 2023 Duke Travels trip as reported to the Master's Project team by AHI Travel.

Biodiesel ME is a first-generation biofuel (meaning it is made from biomass that is often used for food such as corn and soy) and is produced through the transesterification of lipids with methanol (Nagler & Gerace, 2024). Biodiesel HVO is a second-generation biofuel (meaning it is made from non-food biomass as well as biomass byproducts and waste) and is synthesized through a hydrogenation process. Biodiesel HVO has less associated emissions than biodiesel ME mostly due to biodiesel HVO being generated from waste materials and the nature of its synthesis process (*HVO fuel vs biodiesel - which fuel is right for your business?,* n.d). Biodiesel HVO typically costs more than biodiesel ME, however the majority of diesel vehicles can run completely on biodiesel HVO without needing to perform engine modifications (Yadav, 2024). Conversely, most diesel vehicles cannot run completely on biodiesel ME (usually, it is a mix of biodiesel ME and standard diesel) due to its abilities to degrade materials in the engine and gel in cold temperatures; running on completely biodiesel ME would likely require engine modifications that may be more expensive than purchasing biodiesel HVO and not needing to modify the vehicle's engine (IEA Technology Collaboration Program, n.d.)

The biggest takeaway from the ground transportation sensitivity analysis was that using both forms of biodiesel actually resulted in less emissions than using EVs. One note is that biodiesel was used for coaches, sprinter vans, and private boats, while EV was only applied to coaches and sprinter vans. Due to the low fuel efficiency of private boats, changing their fuel type to biodiesel ME and biodiesel HVO proved to be the most significant levers in this analysis. Despite not having tailpipe emissions, it is difficult to ensure that the electricity being used for EVs is generated by a renewable energy source. In Italy, the majority of their grid is fossil-fuel based, resulting in a higher emissions factor for their electricity than that of a country like Paraguay which uses completely renewable energy for its grid (IEA, n.d.). Therefore in Paraguay, it is likely that using EV would prove less emissions-intensive than biodiesel.

As previously discussed, biodiesel HVO has less emissions than biodiesel ME, so the ground transport scenario that resulted in the smallest amount of emissions was changing all coach, sprinter van, and private boat trips to biodiesel HVO. Specifically, in comparison to the all-biodiesel ME scenario, the all-biodiesel HVO trip resulted in an additional decrease of 24.31 kg

of CO2e. In comparison to the baseline assumptions, this is a decrease of 1,092.47 kg of CO23, or 80%.

Also, the Master's Project team analyzed one scenario where all EVs were used as well as biodiesel HVO for private boats, additionally eliminating the two sprinter van trips to the airport on the last day and instead taking all travelers to the airport together on one coach trip. This only resulted in a 59% emissions decrease, however after discussing with AHI Travel, it was deemed not feasible to remove the sprinter van trips from the analyses as it would too greatly compromise guest experience. Offering travelers only one chance to depart for the airport per day may lead to a longer stay at the airport than warranted, resulting in guest dissatisfaction and an unfavorable conclusion to their trip.

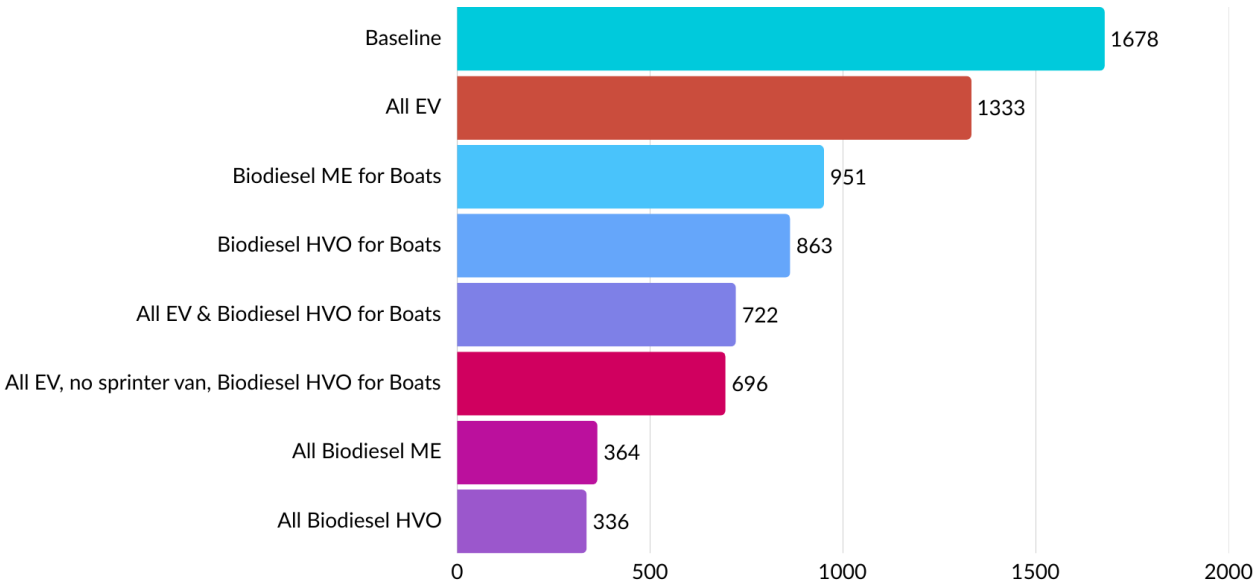


**Figure 6. Ground transport emissions sensitivity analyses.**

After discussions with AHI Travel, the sensitivity analysis identified the most realistic scenario as one using baseline assumptions for ground vehicles and biodiesel HVO for private boats. The MP team notes that transitioning coach fleets to EVs would likely require considerable time and investment, whereas biodiesel HVO for private boats does not require engine modifications. As

shown in in Figure 6, this approach results in a 49% reduction in emissions compared to the baseline trip

## Flights

The Master's Project team assessed seven levers for flight decarbonization: all economy, all premium economy, all business class, all first-class, all flights using a 10% SAF blend, all flights using a 70% SAF blend, and all flights offsetting their emissions. Since flights make up about 94% of the trip's total emissions, it is not surprising that changes in flights are the most impactful levers to pull for decarbonization.

Under the baseline assumptions, which use AHI Travel data and assume a 50-50 split between business and economy class, the average CO2e emissions per person is 4,131.56 kg. If all flights were economy class, the emissions go down to 2008.82 kg per person, which is a 51.38% reduction for the flight-associated emissions and 48.05% reduction for overall trip emissions. Meanwhile, if all flights were premium economy class, the emissions per person would amount to 3,499.80 kg, a 15.29% decrease in flights-associated emissions and a 14.43% decrease in overall emissions compared to the baseline. This considerable drop is mainly because economy flights have an emission factor of about one-third as much as business flights, owing to their smaller floor space and tendency to have a higher occupancy than business or first-class seats (Climate Action Accelerator, n.d.).

If all flights were business class, the emissions would grow to 5,824.94 kg per person, a 40.99% increase in flight emissions and a 38.68% increase in overall emissions. The carbon intensity would be the highest if all flights were first class with 7,792.45 kg of CO2e per person. This nearly doubles the baseline emissions, representing an 88.61% increase in flight emissions and a 83.62% increase in total emissions. The significant increase is attributable to the larger floor space for upper-class travelers (e.g. extra legroom) and the heavier weight of premium seats. The heavier the plane is, the more fuel needs to be burned, and the more GHGs emitted.

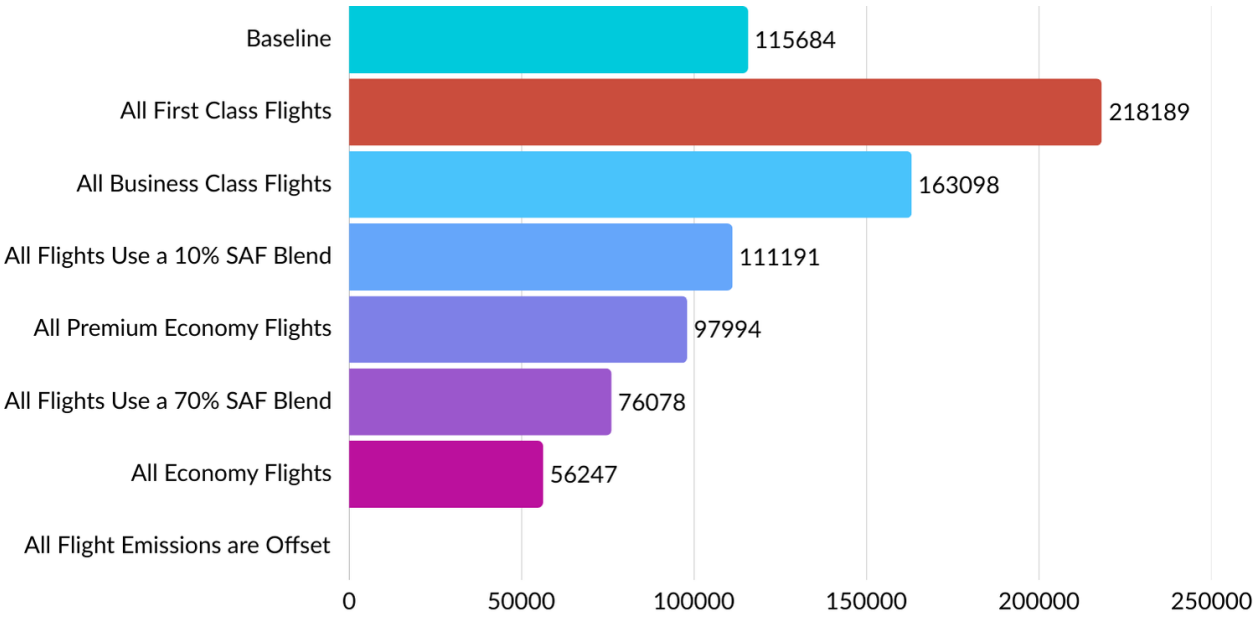


**Figure 7: Flight emissions sensitivity analyses.**

According to discussions with AHI Travel, incentivizing travelers to go all-economy is "in conflict with" their current process. The flight experience spills over to the overall tour experience, so AHI Travel encourages upgrades to provide a better experience. Travelers like to see the upgrade options even if they do not intend to choose business or first-class. Also, there are financial benefits to AHI Travel for using higher-level seats. For these reasons, as well as to "best serve their association partners and make sure they are represented positively," it is unlikely that AHI Travel would step back from offering upgraded tickets. Realistic possible levers to pull would be around purchasing carbon offsets and integrating emissions into talking points with travelers to increase their awareness.

SAF is a lower-carbon footprint, drop-in fuel that can be made through various manufacturing processes and non-petroleum feedstocks, such as waste oil and fats, municipal solid waste and agricultural residues. Although SAF is a lever beyond AHI Travel or its travelers' direct control, it would be pertinent to know how using Jet A fuel blended with SAF would impact AHI Travel's trip emissions, especially since the aviation industry is gradually shifting to higher SAF usage, with multiple airlines like American and United aiming to use 10% SAF by 2030 (Hillyer, 2021). This analysis assumes that SAF has a 50% lower carbon footprint than Jet A fuel, which

was chosen since SAF needs to have at least 50% lower lifecycle emissions to qualify for tax credits (US Internal Revenue Service, 2022) under the US Inflation Reduction Act. If all flights use a 10% SAF blend, the flight emissions come down by only 3.88%, which is a 3.67% reduction in overall trip emissions. If all flights use a 70% SAF blend, the requirement by 2050 for EU member states (European Commission, 2023), flight emissions decrease by 34.24% whereas overall trip emissions decrease by 32.31%. For SAF to reach economic viability is likely to take decades given the limited supply of SAF feedstocks and its price premium, costing about 3-5 times as much as Jet A fuel (Reuters & World Economic Forum, 2023). This suggests that decarbonizing flights should not rely solely on the aviation industry, but should go hand in hand with shifts to less carbon-intensive ways of travel such as premium economy or economy, avoiding long-haul trips, and using high-speed rail when applicable.

## Scenarios

Based upon the previously described levers within each category, scenario analyses were performed at three levels: high emissions, medium emissions, and low emissions (see Appendix C). Only realistic levers were pulled in the scenarios. Realisticness was determined based on conversations with AHI Travel. For example, although impactful, it was deemed not realistic to have a scenario where no coffee is consumed. Also, it is important to note that two comparable scenarios were run for each level with lodging being the differentiating factor: one based on how many hotel rooms are used per night and the other based on the hotel's star rating. This approach was taken as it was deemed more efficient to separate these factors than look at them combined as the Master's Project team considers them different levers that AHI Travel may pull per trip. It was important to show AHI Travel's potential impact in terms of star rating and the customer's impact in choosing how many people occupy a room. Note that baseline assumptions in the scenario analyses are the actual data from the Italian Lakes itinerary.

The first low scenario utilized the following criteria. Food as vegetarian only, lodging as a 3-star hotel with baseline assumption room occupancy (17 rooms), all ground transport using biodiesel

HVO, and all air transport as economy class. The alternative low scenario is equivalent except the lodging scenario is 4 people per room, totalling 8 rooms.

Next, the first medium scenario utilized the following criteria. Food as chicken and fish only, lodging as a baseline assumption 4-star hotel and room occupancy (17 rooms), all ground transport using EV, and all air transport as premium economy class. The alternative low scenario is equivalent except the lodging scenario is 2 people per room, totalling 15 rooms.

Additionally, the first high scenario utilized the following criteria. Food as beef only, lodging as a 5-star hotel with baseline assumption room occupancy (17 rooms), all ground transport using baseline assumptions (mostly standard diesel), and all air transport as business class. The alternative low scenario is equivalent except the lodging scenario is 1 person per room, totalling 29 rooms.

***Scenario Analysis - Hotel Stars Comparison***

| | Standard Assumptions (Meals and Transport as provided) | Low | Medium | High |
|---|---|---|---|---|
| **C02e - Food/ Bev (kg)** | 3,345.30 | 1,202.95 | 1,395.01 | 4,901.44 |
| **C02e - Lodging (kg)** | 1,870.68 | 823.48 | 1,870.68 | 5,447.82 |
| **CO2e - Ground Transportation** | 1,678.45 | 335.68 | 1,332.99 | 1,678.45 |
| **CO2e - Flights** | 115,683.72 | 56,247.10 | 97,994.41 | 218,188.59 |
| **Total kg C02e** | **122,578.15** | **58,609.20** | **102,593.09** | **230,216.30** |

***Scenario Analysis - Hotel Room Number Comparison***

| | Standard Assumptions (Meals and Transport as provided) | Low | Medium | High |
|---|---|---|---|---|
| **C02e - Food/ Bev (kg)** | 3,345.30 | 1,202.95 | 1,395.01 | 4,901.44 |
| **C02e - Lodging (kg)** | 1,870.68 | 880.32 | 1,650.60 | 3,191.16 |
| **CO2e - Ground Transportation** | 1,678.45 | 335.68 | 1,332.99 | 1,678.45 |
| **CO2e - Flights** | 115,683.72 | 56,247.10 | 97,994.41 | 218,188.59 |
| **Total kg C02e** | **122,578.15** | **58,666.04** | **102,373.01** | **227,959.64** |

**Figure 8. Scenario comparison tables.** The table on the top shows the three scenarios with the hotel lever as the hotel's star rating. The table on the bottom shows the three scenarios with the hotel lever as the number of rooms used per night. The hotel stars have a larger effect, with a lower low amount of kg CO2e (58,609.20) and a higher high amount of kg CO2e (230,219.30).

As shown in Figure 8, the most effective emissions reduction scenario used all vegetarian food, 3-star hotels, biodiesel HVO, and all economy class flights. It is important to note that this is the ideal result, but after discussions with AHI Travel, it would likely take substantial workshopping and incentivizing to create a version of this trip that was profitable and met customer satisfaction. However, as discussed later in the Recommendations section, these results prompted the idea of a sustainable itinerary for AHI Travel that they might use in an environmentally-friendly country like Switzerland. They hope to use these scenario analyses to brand the trip as sustainable as well as overall help customers recognize the positive and negative environmental impacts of their choices such as their flight class or whether they choose to eat fish versus beef. Additionally, AHI Travel plans to leverage these results to guide future discussions with current and prospective vendors on initiatives such as transitioning to biofuels or EVs and expanding vegetarian offerings.

## Software and Consulting Options

Unbeknownst to all those involved with originally scoping and setting up this project (Duke Travels, AHI Travel, the Master's Project Client Lead, and Advisor), numerous existing companies and consultancies already perform carbon accounting for trip operators. As a result, the Master's Project team expanded the project scope by interviewing companies open to collaboration, aiming to gain deeper insights into sustainable travel practices. Additionally, the Master's Project team provided potential recommendations for AHI Travel should they choose to further explore GHG accounting for other itineraries in the future.

Two companies were willing to engage with the Master's Project team directly through interviews: Synergy Enterprises and Greentripper. A third company, Sustainable Travel

International, was willing to dialogue with the Master's Project team over email, and also allowed them to use their online carbon footprinting tool to compare with carbon accounting results. The final company, Carmacal Beta, never responded to repeated requests for information.[1]

The questions the Master's Project team looked to answer with these industry experts are summarized as follows:

1. **Consulting Services**: Confirm the scope of travel consulting services, focusing on carbon accounting, emissions reduction strategies, offsetting options, sustainability certifications, client engagement, client training, and third-party verification of results.

2. **Data Collection and Reporting**: Clarify the data formats used for accurate trip accounting, recommended tools and systems for data collection, and handling of emissions variations (e.g. transportation modes, service class). Understand customization options for reports, including granularity and alignment with client goals such as net-zero strategies, or offset programs.

3. **Timelines and Costs**: Clarify typical service timelines and cost ranges based on previous engagements.

4. **Calculation Tools (GreenTripper.Org specific)**: Inquire about their existing API's ability to connect into client travel booking platforms, request details about their upcoming trip calculator release, including features, timeline, cost model (e.g. subscription), and use cases.

[1] It should be noted that while Synergy Enterprises calculates carbon itineraries in order to offer decarbonization strategies, both Greentripper and Sustainable Travel International calculate carbon itineraries with the intent to offer carbon offsets for purchase.

## Synergy Enterprises

Headquartered in Victoria, BC, Synergy Enterprises is a boutique consulting firm specializing in decarbonization strategy and GHG Emissions accounting, with expertise in the tourism industry (Synergy Enterprises, n.d.). The Master's Project team discovered Synergy Enterprises through a reference from The Travel Corporation, who worked directly with Synergy on the carbon accounting for all their trip itineraries and published their carbon accounting methodology in 2023 (The Travel Corporation, 2023).

In January 2025, the Master's Project team spoke with Arctica Cunningham, Director of Client Services at Synergy Enterprises. The interview focused on carbon accounting in travel itineraries, with an emphasis on decarbonization strategies. Key points included the importance of setting a goal to plan itineraries specifically reducing carbon emissions, such as encouraging guests to choose more sustainable travel options like rail over flights or incentivizing lower-carbon menu choices. The interviewee highlighted challenges in encouraging luxury travelers to reduce their carbon impact without compromising their experience, noting the difficulty in encouraging guests to switch from first-class flights or steak to more sustainable options and stressing the importance of education and transparent communication about the environmental impacts of customer choices.

Also, the conversation covered carbon offsets, with the interviewee cautioning against low-quality offset projects and advocating for high-quality, third-party verified options. They discussed the challenges surrounding land-based carbon offsets, particularly conservation projects; their company has currently paused those offset types and is evaluating future use.

In terms of data collection, the interviewee emphasized that theirs is a hands-on, bespoke approach, where clients are responsible for pulling and submitting data, usually in CSV format. The company does not rely on third-party tools or software but works closely with clients to gather raw source data, such as fuel supplier receipts and flight booking reports, which is then processed using Excel.

In terms of cost and timeline, the interviewee provided insight into two approaches to carbon accounting: one based on representative trips, which is a more cost-effective and quick 75-hour engagement, and another more detailed method involving custom Excel tools for full itinerary tracking, which requires about 200 hours to develop. These tools allow clients to input trip data and assess the carbon impact with sensitivity analysis options. As for cost, none was provided; through industry research, the Master's Project team estimates a cost of $150-$250 per hour, but recommends engaging with Synergy directly for industry pricing, as many factors will go into determining the final costs.

## Greentripper

Based in Brussels, Belgium, Greentripper helps travelers and tourism professionals reduce their carbon footprint (Greentripper, n.d.) Through its online platform, Greentripper currently allows individuals and businesses to calculate the CO2 emissions from their trips online through an easy to use interface, comparing transportation options, and then contributing to climate projects aimed at reducing emissions. While this calculator is easy to use, it is designed for relatively simple travel itineraries; trip operators will find the interface too basic for managing the complexities of full itineraries and Greentripper is working on an updated version for operators' business requirements.

In January 2025, the Master's Project team spoke with Natacha Laermans, Business Development Executive at GreenTripper. The interview covered various aspects of Greentripper's carbon calculator and services, with a focus on integration, pricing, and consulting. Greentripper currently offers a flexible API that integrates with different systems, allowing clients to automate the carbon calculation process through a simple copy-paste module for their websites or reservation systems. As noted by the interviewee, pricing for integration is based on the number of API calls or calculations per month, with a minimum cost of €589 per year for up to 1,000 calculations.

The company is currently working on a travel itinerary tool set to launch in March, which will allow businesses to import PDF itineraries and calculate carbon itineraries directly from those itineraries through AI assistance. This service will be offered via annual subscription in three tiers, though the exact price and service level is still to be determined. In the meantime, Greentripper's current consulting services provide carbon calculations per itinerary, with fixed pricing per trip and additional fees for updates. Also, they offer emissions reduction strategies for their clients, and can create reduction plans aligned with science-based targets.

Greentripper offers carbon offset certificates through Gold Standard and Verra verified projects in both developing countries and Europe, with costs starting at €17 per metric tonne of CO2

abated. The interviewee estimated that less than 5% of their travelers offset carbon emissions, but the demand for carbon accounting services is increasing due to upcoming Scope 3 regulation requirements in Europe, such as Corporate Sustainability Reporting Directive.

### Sustainable Travel International

Sustainable Travel International is an organization focused on promoting environmental responsibility within the travel industry, providing tools for businesses and travelers to measure, reduce, and offset the carbon emissions associated with travel (Sustainable Travel International, n.d.). Their services include an online carbon footprint calculator for one itinerary, decarbonization strategies, and access to certified carbon offset projects. Also, the organization offers resources for climate adaptation and resilience planning, helping destinations and travel-related companies adopt more sustainable practices. Additionally, they provide an API for real-time emissions tracking.

Through their connection with Ken Frohling, Director of Climate Solutions Partnerships, the Master's Project team was given permission to use Sustainable Travel International's online carbon footprint for trip itineraries in order to compare their calculation methodologies to the team's. The small differences between the results found from the Sustainable Travel International's online calculator and the Master's Project team's calculations are attributable to differing assumptions made by both tool and team (see Appendix F). As noted before in the Key Learnings and Insights section, assumptions can make a huge difference in overall calculations; any operator looking to do this work must make certain they have a documented way they plan to handle these assumptions throughout their trip portfolio and keep these assumptions consistent throughout their calculations.

## Recommendations

Once the Master's Project team finalized their analysis and spoke with their clients, it was determined that the best next step to decarbonize was to start with a low carbon pilot trip that was focused on one location. The Master's Project team also created a checklist that can be used during the trip to gather data that would be necessary to easily complete a carbon inventory to be calculated through the custom Excel tool. The Master's Project team also recognizes that there are many other players in the travel industry, which is why they also recommend that AHI Travel invest in SAF adoption within the industry and credible carbon offsets to help move the industry forward with decarbonization.

### Low-Carbon Pilot Trip

Participation in this Master's Project has highlighted a potential opportunity for AHI Travel: the development of a dedicated low-carbon itinerary. Introducing a low-carbon itinerary would serve multiple strategic purposes. First, it would position AHI Travel as a leader in sustainable academic travel, appealing to a growing segment of environmentally conscious travelers who are seeking ways to align their values with their travel choices. Second, it would provide an opportunity to demonstrate that meaningful emissions reductions can be achieved without compromising the comfort, cultural depth, and personalized service that define AHI Travel's programs. By carefully curating accommodations, transportation, and dining options with sustainability in mind—such as prioritizing economy class flights, 3- or 4-star hotels, plant-forward menus, and low-impact activities—AHI Travel can showcase how responsible travel can also be rewarding and memorable. Finally, piloting a low-carbon itinerary would offer AHI Travel valuable insights into customer preferences and expectations around sustainability. It would create a space for feedback and learning that can inform future product development and potentially shape the evolution of the broader AHI Travel portfolio. In an industry where traveler

expectations are shifting and sustainability is becoming a differentiator, this proactive approach could enhance brand reputation, foster customer loyalty, and open new market opportunities.

## AHI Travel Data Collection

To ease the data collection process for future GHG accounting, the Master's Project team created an in-trip data collection checklist to identify key information about the trip, including on-ground transport, lodging, and food. This will facilitate organized collection of all data necessary to use in the custom Excel-based tool for carbon accounting (see Appendix D for more information).

## Excel-based Tool for Carbon Accounting for All Land-Based Itineraries

As a supplement to their single itinerary carbon calculation, the Master's Project group created an Excel-based tool to streamline AHI Travel's future itinerary carbon accounting efforts (see Appendix E). This tool will help AHI Travel easily assess the GHG emissions associated with itineraries in different regions, including Africa, Asia, South America, the Caribbean, and Europe, showcasing the different emissions profiles for each region as much as possible and allowing the sustainability team to understand better the regional differences in the levers they can pull. This tool covers all AHI Travel's land-based itineraries, which make up about 70% of all AHI Travel's trips. AHI Travel can also use the tool to compare the emissions for trips that are hub and spoke and versus those that are not. Calculating carbon footprints for their itineraries will allow AHI Travel to showcase their commitment to sustainability, and by understanding the emissions of different itineraries, AHI Travel can identify opportunities to make trips more environmentally sustainable.

## Sustainable Aviation

Given the large role flights play in the CO2e emissions of travel operators' itineraries, some of the most meaningful impact AHI Travel and other travel operators can have on their carbon footprint lies in addressing aviation-related emissions. While travel operators have limited direct

control over how airlines operate or which aircraft are used, there are actions AHI Travel can take to move the needle in the right direction.

One of the most promising opportunities is supporting the adoption of SAF. SAF can significantly reduce life-cycle emissions compared to traditional jet fuel, but its production and uptake remain limited (Reuters & World Economic Forum, 2023). AHI Travel can use its influence as a respected operator to encourage industry groups to lobby for increased availability and use of SAF, particularly at the airports its programs most frequently use, helping to create demand signals that encourage broader industry adoption.

Another practical step is pushing for the approval and implementation of Book and Claim systems under the SBTi, which is often considered the gold standard for companies setting climate targets and emission reduction plans. Book and Claim allows companies to purchase SAF certificates, even if the SAF is not physically used on their specific flights (Mills, 2023). This system makes it easier for travel providers like AHI Travel to invest in SAF and claim the corresponding emissions reductions, acting a carbon credit, while driving more funding towards more sustainable aviation without being tied to specific routes or carriers. The SBTi is now accepting public feedback on version 2 of its Draft Corporate Net-Zero Standard (Science Based Targets Initiative, 2025), which includes language that allows the use of a book-and-claim model for SAF. AHI Travel or its affiliated industry group could respond to the consultation survey before June 1, 2025 in support of this.

Also, AHI Travel can amplify its impact by joining collaborative efforts like the Airports of Tomorrow coalition, which brings together stakeholders across the travel and aviation sectors to accelerate the transition to lower-carbon air travel (World Economic Forum, n.d.). Being part of these industry-wide initiatives not only strengthens AHI Travel's sustainability credentials, but also gives the company a seat at the table in shaping the future of more responsible aviation.

## Sustainable Travel Vendors

The Master's Project team acknowledges that AHI Travel is already incorporating sustainability in their vendor assessments using a comprehensive sustainability scorecard (Appendix J). AHI Travel can use their scorecard in correlation with using the emissions calculation tool created by the Master's Project team. The emissions calculation can help them gauge specific areas of needed emissions reductions, such as finding a coach operator that uses EV, and then their existing sustainability scorecard may be used to further evaluate vendors and their alignment with AHI Travels' overall sustainability goals. Ultimately, the combination of these two tools will help them pick the most sustainable vendors that meet their service requirements and help them provide sustainability guidance to vendors with whom they already have a relationship.

## Carbon Offsets

Given the large carbon footprint of flights and the limited ability and incentive for travel operators to encourage consumers to buy lower-class tickets, carbon offsets and removals become a necessary consideration for a travel company aiming to decarbonize. Many consumers remain skeptical about the effectiveness of carbon offsets — and with good reason. The Voluntary Carbon Market has faced significant challenges, particularly in its early stages of development (Gabbatiss, 2023). Therefore, if AHI Travel were to purchase offsets in the future, it is crucial that they meet the criteria for higher-integrity offsets. This includes additionality (whether the offset project reduces GHG emissions beyond what would have happened anyway), permanence (whether those carbons savings will last over time), overestimation (whether the amount of carbon being reduced is exaggerated), and not being associated with significant negative social and environmental impacts, such as harming local communities or ecosystems in the process (GHG Management Institute & The Stockholm Environment Institute, n.d.). The Oxford taxonomy of carbon credits and the Oxford Carbon Offsetting principles are worth referring to for guidance on using carbon offsets and the categories of offsets and removals in the market.

Assessing offsets can be a heavy lift, so the Master's Project team recommends turning to existing trusted marketplaces for high-integrity carbon offsets. Based on the Master's Project

team's discussion with Matthew Arsenault, Assistant Director of Carbon and Sustainability Operations at Duke's Office of Climate & Sustainability, the Patch.io platform appears to be a promising option worth exploring by AHI Travel. The platform includes projects vetted by registries like Verra, American Carbon Registry, and Gold Standard, which, according to various online sources, are highly reputable in the voluntary carbon markets space (Jennifer L, 2022). Their prices vary widely depending on the type of carbon project, though a good ballpark figure is about 50 USD to offset 1 ton of carbon emissions. Indeed, as discussed earlier, Greentripper.org offered carbon offsets of €17 per metric tonne of CO2; however more work would need to be done to clarify the verification process for these offsets. Regarding the costs, AHI Travel could absorb them in the interim. According to an interview the Master's Project team conducted, Natural Habitat Adventures includes the cost of offsets as part of their marketing budget, as this attracts the kind of traveler who is willing to pay the premium for sustainability (see Appendix G for this case study). Additionally, if AHI Travel purchases the offsets from Patch.io, this removes the administrative and technical hassle from the traveler's end of purchasing their own offsets.

## Conclusion

The results of the emissions analysis highlight a clear takeaway: reducing flight emissions is the most impactful way to lower the overall carbon footprint of travel. Equally clear through the research is that this is also the hardest lever for travel operators to pull. Encouraging travelers to choose economy class, which results in significantly lower CO2e emissions compared to premium economy or business class, presents a challenge. Many travelers prefer the additional comfort and amenities associated with higher-end seats. At the same time, travel operators such as AHI Travel have a financial incentive to offer and promote premium seating options, as these typically generate higher revenue. As a result, both customer preferences and business considerations tend to favor luxury options, which complicates efforts to reduce flight-related emissions.

The same pattern holds true for other aspects of luxury travel: more luxury typically means more emissions.[2] A stay at a 5-star hotel can produce twice the emissions of a 4-star stay. Choosing beef over chicken at dinner often doubles the emissions associated with a meal. And flying first class can easily double the carbon footprint of a flight compared to economy. Unfortunately, many of the things travelers associate with a premium experience—comfort, exclusivity, and indulgence—are also the things that tend to emit the most carbon.

One key question for further research that would impact the emissions calculations for ground transportation is understanding the average fuel efficiency for various types of vehicles across different countries and regions. Due to limited data availability, the Master's Project team used uniform figures in their carbon accounting tool (see Appendix D for more information). However, there are likely significant regional differences, especially when comparing developing countries such as Botswana or Cuba to developed countries such as the UK or Norway. Access to more granular, country-specific data would help improve the accuracy of future, itinerary-wide analyses and help AHI Travel make more targeted transportation choices across their portfolio.

Reducing carbon emissions in the travel industry remains a complex challenge—particularly given traveler expectations for premium experiences. AHI Travel's work prioritizing sustainability can play an important role in the industry by demonstrating that responsible practices and high-quality travel are not mutually exclusive. Through initiatives such as gathering more carbon data for future carbon emissions projects, supporting the adoption of SAF industry-wide, including sustainability qualifications in vendor decisions, considering carbon offsets, and exploring lower-carbon itinerary options, AHI Travel can help set new standards for environmentally conscious travel. By taking a leadership position, AHI Travel not only reduces its own environmental impact, but also encourages broader change across the sector.

[2] Typically, but not always. See Appendix G for the case study on Natural Habitat, a carbon neutral travel company, based on the Master's Project team's conversation with Nat Hab's CSO Court Whelan.

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# Appendix

## Appendix A: Complete Emissions Calculations

The "Italian Lakes" spreadsheet contains the complete emissions calculations for the selected trip. This is how the Master's Project team obtained the baseline assumption emissions information for each category (food and drinks, lodging, ground transport, and flights). Each tab is complete with necessary data gathered from primary research and materials from AHI Travel. Also, each calculation is marked with the source of appropriate emissions factors.

Additionally, this crucial spreadsheet is where the Master's Project team performed sensitivity analyses where they analyzed the effects on emissions of changing certain aspects of each category, such as choosing all vegetarian meals.

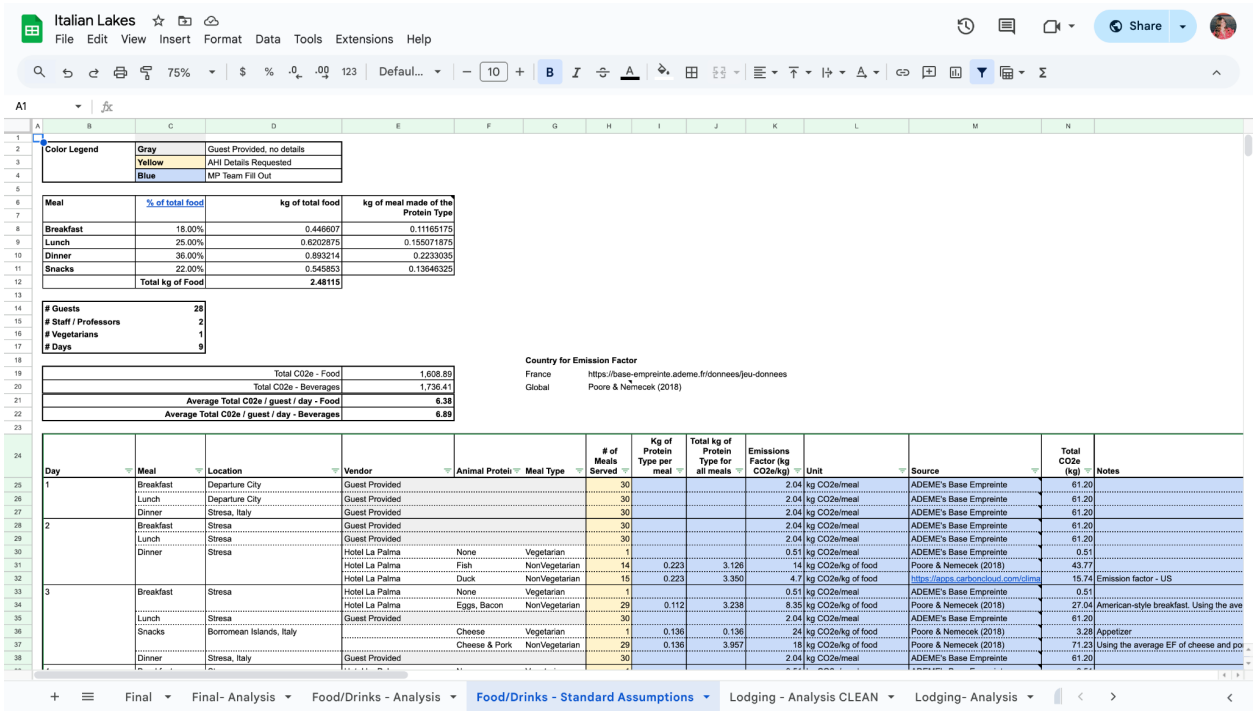



**Figure 9. Screenshot of "Italian Lakes" Google Sheets calculation table.** This table includes all the emissions calculation work and sensitivity analyses that form the basis of this Master's Project.

## Appendix B: Carbon Accounting Calculation Assumptions for Each Emission Category

**Food and Beverage**

- 1 person is vegetarian, which is 3.57% of the 28 passengers
- The average American eats 1996 lbs per year / 5.47lbs per day / 2.48115 kg per day (Aubrey, 2011)
- American adults eat 18% of their food at breakfast, 25% at lunch, 36% at dinner, and 22% at snacks (Bailey et al., 2022)
- Protein is assumed to make up around 25% of an average meal (*Protein - The Nutrition Source*, 2012)
- A gluten-free diet has negligible impact on the CO2e emissions vs. a carnivorous diet
- If multiple options for protein are available for a meal, an equal number of guests pick each protein.
- All guest-provided meals are assumed to have meat.

**Lodging**

- 28 guests on the trip are staying at the hotel
- Hotel is 4-stars
- Hotel is non-Resort
- Hotel is located close enough to Milan to be considered "Milan region"
- Room quantity is based on quantity of booking IDs, + 1 for AHI staff

**Ground Transportation**

- Per AHI Travel: assume 50% travel economy and 50% travel business
- Assume AHI Travel Director's car and taxi are average medium cars that use petrol
- Per boat operator: defining consumption for a single tour is not very reliable because of many external factors to be considered. For the vessel used in the Borromean Islands, assume ~80/90 liters per hour of navigation.
    - Assume: 85 litres/hour = 1.42 litres/min (85 litres between the given ~80/.90 litres per hour)
- Estimated lengths of time on the public ferry between islands:
    - Stresa to Isola Madre: ~10 min

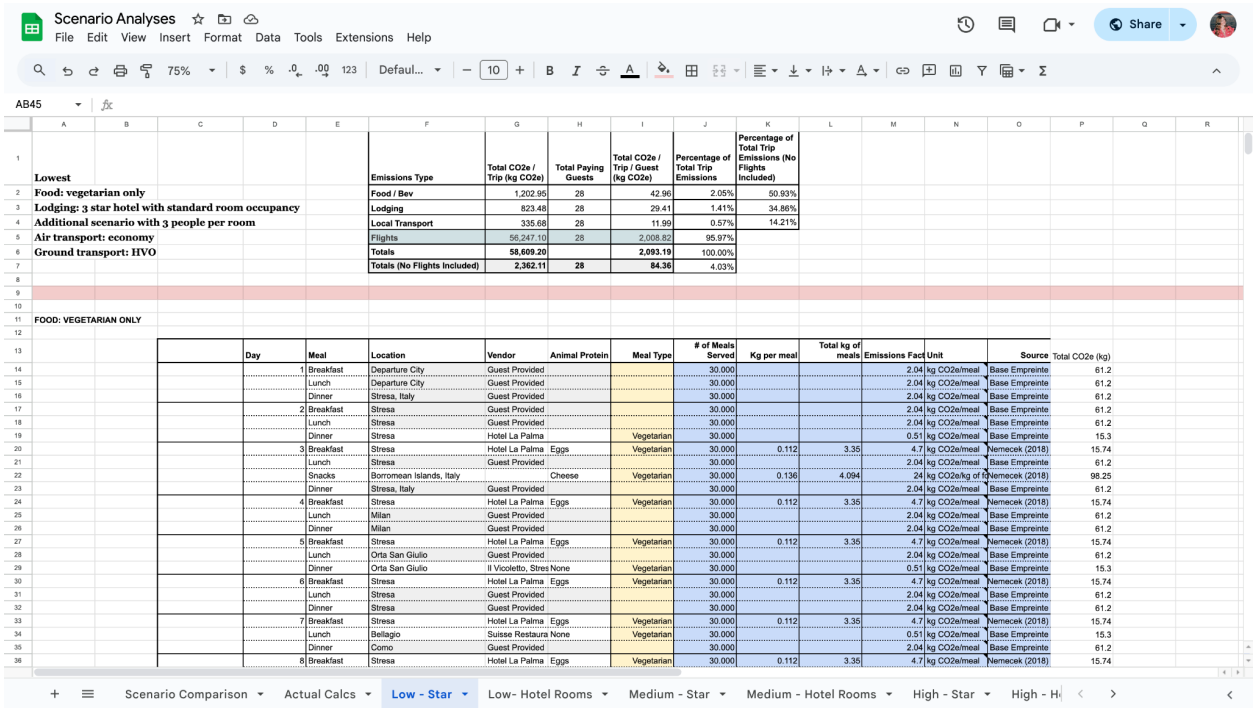
    - Isola Madre to Isola Pescatori: ~15 min
    - Isola Pescatori to Isola Bella: ~15 min
    - Isola Bella to Stresa: <10 min
- Assume 2 passengers take public train to a nearby town and back (Baveno is next town over) on free day
- Assume +2 on full group ground transport for AHI Travel Director and driver/boat captain
- Assume no EV for boats or guide's car/taxi rides
- Assume equivalent EV proxy vehicle for motorcoach is Volvo 7900 (gets about 1.1 kWh/km) and for sprinter van is Mercedes 2025 eSprinter (gets about 0.282 kWh/km)

**Flights**

- For the travelers for whom AHI Travel did not know the flight class, assume 50% were business class and 50% were economy class
- Assume none of the flights had layover destinations on their way to Italy

## Appendix C: Scenario Analyses Calculations

The Scenario Analyses calculations table includes all calculations completed to analyze a variety of different realistic scenarios that might occur to alter the emissions associated with the Italian Lakes itinerary. High, medium, and low emissions scenarios were investigated to analyze the impacts of pulling different levers on itinerary-associated emissions.



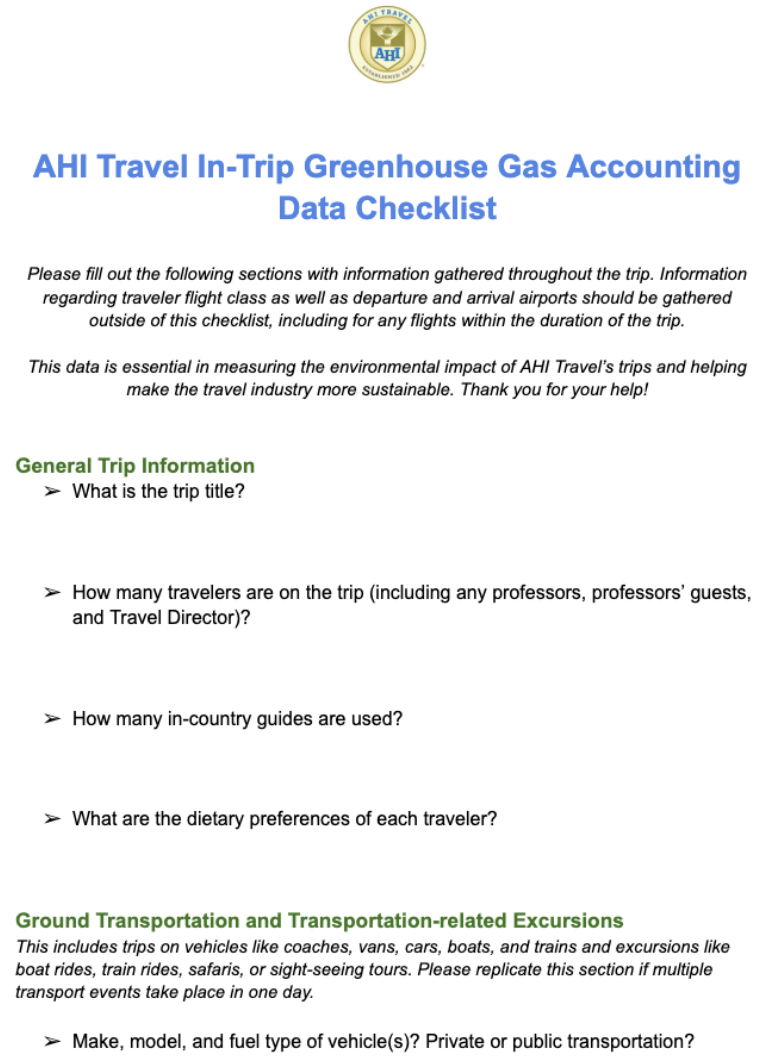

| Emissions Type | Total CO2e / Trip (kg CO2e) | Total Paying Guests | Total CO2e / Trip / Guest (kg CO2e) | Percentage of Total Trip Emissions | Percentage of Total Trip Emissions (No Flights Included) |
|---|---|---|---|---|---|
| Food / Bev | 1,202.95 | 28 | 42.96 | 2.05% | 50.93% |
| Lodging | 823.48 | 28 | 29.41 | 1.41% | 34.86% |
| Local Transport | 335.68 | 28 | 11.99 | 0.57% | 14.21% |
| Flights | 56,247.10 | 28 | 2,008.82 | 95.97% | |
| Totals | 58,609.20 | | 2,093.19 | 100.00% | |
| Totals (No Flights Included) | 2,362.11 | 28 | 84.36 | 4.03% | |

| Day | Meal | Location | Vendor | Animal Protein | Meal Type | # of Meals Served | Kg per meal | Total kg of meals | Emissions Fact | Unit | Source | Total CO2e (kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Breakfast | Departure City | Guest Provided | | | 30.000 | | | 2.04 | kg CO2e/meal | Base Empreinte | 61.2 |
| | Lunch | Departure City | Guest Provided | | | 30.000 | | | 2.04 | kg CO2e/meal | Base Empreinte | 61.2 |
| | Dinner | Stresa, Italy | Guest Provided | | | 30.000 | | | 2.04 | kg CO2e/meal | Base Empreinte | 61.2 |
| 2 | Breakfast | Stresa | Guest Provided | | | 30.000 | | | 2.04 | kg CO2e/meal | Base Empreinte | 61.2 |
| | Lunch | Stresa | Guest Provided | | | 30.000 | | | 2.04 | kg CO2e/meal | Base Empreinte | 61.2 |
| | Dinner | Stresa | Hotel La Palma | | Vegetarian | 30.000 | | | 0.51 | kg CO2e/meal | Base Empreinte | 15.3 |
| 3 | Breakfast | Stresa | Hotel La Palma | Eggs | Vegetarian | 30.000 | 0.112 | 3.35 | 4.7 | kg CO2e/meal | Nemecek (2018) | 15.74 |
| | Lunch | Stresa | Guest Provided | | | 30.000 | | | 2.04 | kg CO2e/meal | Base Empreinte | 61.2 |
| | Snacks | Borromean Islands, Italy | | Cheese | Vegetarian | 30.000 | 0.136 | 4.094 | 24 | kg CO2e/kg of fo | Nemecek (2018) | 98.25 |
| | Dinner | Stresa, Italy | Guest Provided | | | 30.000 | | | 2.04 | kg CO2e/meal | Base Empreinte | 61.2 |
| 4 | Breakfast | Stresa | Hotel La Palma | Eggs | Vegetarian | 30.000 | 0.112 | 3.35 | 4.7 | kg CO2e/meal | Nemecek (2018) | 15.74 |
| | Lunch | Milan | Guest Provided | | | 30.000 | | | 2.04 | kg CO2e/meal | Base Empreinte | 61.2 |
| | Dinner | Milan | Guest Provided | | | 30.000 | | | 2.04 | kg CO2e/meal | Base Empreinte | 61.2 |
| 5 | Breakfast | Stresa | Hotel La Palma | Eggs | Vegetarian | 30.000 | 0.112 | 3.35 | 4.7 | kg CO2e/meal | Nemecek (2018) | 15.74 |
| | Lunch | Orta San Giulio | Guest Provided | | | 30.000 | | | 2.04 | kg CO2e/meal | Base Empreinte | 61.2 |
| | Dinner | Orta San Giulio | Il Vicoletto, Stres | None | Vegetarian | 30.000 | | | 0.51 | kg CO2e/meal | Base Empreinte | 15.3 |
| 6 | Breakfast | Stresa | Hotel La Palma | Eggs | Vegetarian | 30.000 | 0.112 | 3.35 | 4.7 | kg CO2e/meal | Nemecek (2018) | 15.74 |
| | Lunch | Stresa | Guest Provided | | | 30.000 | | | 2.04 | kg CO2e/meal | Base Empreinte | 61.2 |
| | Dinner | Stresa | Guest Provided | | | 30.000 | | | 2.04 | kg CO2e/meal | Base Empreinte | 61.2 |
| 7 | Breakfast | Stresa | Hotel La Palma | Eggs | Vegetarian | 30.000 | 0.112 | 3.35 | 4.7 | kg CO2e/meal | Nemecek (2018) | 15.74 |
| | Lunch | Bellagio | Suisse Restaura | None | Vegetarian | 30.000 | | | 0.51 | kg CO2e/meal | Base Empreinte | 15.3 |
| | Dinner | Como | Guest Provided | | | 30.000 | | | 2.04 | kg CO2e/meal | Base Empreinte | 61.2 |
| 8 | Breakfast | Stresa | Hotel La Palma | Eggs | Vegetarian | 30.000 | 0.112 | 3.35 | 4.7 | kg CO2e/meal | Nemecek (2018) | 15.74 |

**Figure 10. Screenshot of "Scenario Analyses" Google Sheets table.**

## Appendix D: Data Collection Checklist

The data collection checklist for in-trip data collection during land-based itineraries is meant to organize all data needed to calculate itinerary-associated emissions using the Excel-based tool created by the Master's Project team for AHI Travel. The data collection checklist is meant to be supplemented digitally throughout the trip by the AHI Travel Director accompanying the travelers. This is meant to streamline data collection and reduce the time needed post-trip in collecting necessary carbon accounting metrics.



**AHI Travel In-Trip Greenhouse Gas Accounting Data Checklist**

*Please fill out the following sections with information gathered throughout the trip. Information regarding traveler flight class as well as departure and arrival airports should be gathered outside of this checklist, including for any flights within the duration of the trip.*

*This data is essential in measuring the environmental impact of AHI Travel's trips and helping make the travel industry more sustainable. Thank you for your help!*

**General Trip Information**

- What is the trip title?
- How many travelers are on the trip (including any professors, professors' guests, and Travel Director)?
- How many in-country guides are used?
- What are the dietary preferences of each traveler?

**Ground Transportation and Transportation-related Excursions**

*This includes trips on vehicles like coaches, vans, cars, boats, and trains and excursions like boat rides, train rides, safaris, or sight-seeing tours. Please replicate this section if multiple transport events take place in one day.*

- Make, model, and fuel type of vehicle(s)? Private or public transportation?

**Figure 11. Screenshot of page 1 of the data collection checklist.**

## Appendix E: AHI Travel Carbon Accounting Tool

The Master's Project group created an Excel tool to supplement their single itinerary carbon calculation and streamline AHI Travel's future carbon accounting efforts. Delivered directly to the client, this tool is intended to help AHI Travel assess the GHG emissions impact of trips across different regions, compare regional emissions profiles, and identify opportunities to make itineraries more sustainable.

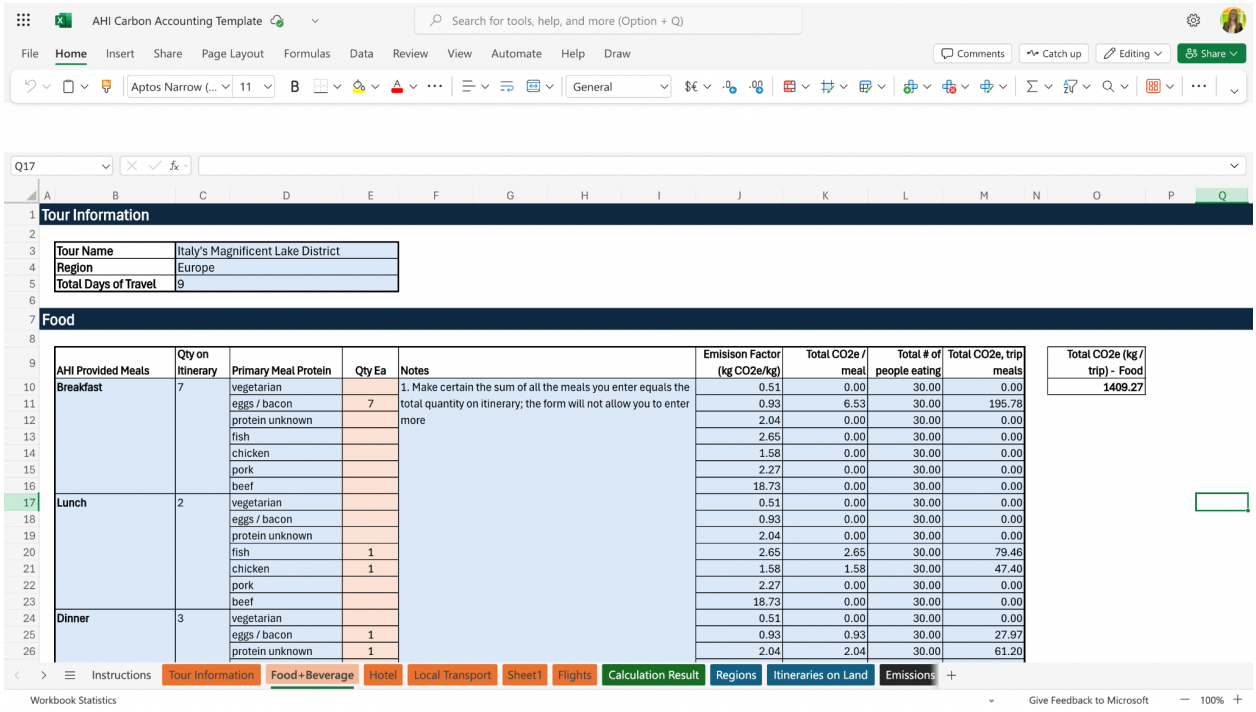



**Figure 12. Screenshot of "AHI Carbon Accounting Template" Excel sheet.** This table allows users to input trip-specific data on each tab, ultimately generating emissions associated with each part of the trip.

## Appendix F: Sustainable Travel International Italian Lakes Itinerary Carbon Footprint

The below benchmarking calculation was conducted to compare with the emissions estimates produced by the Master's Project team with an industry expert. It was generated by inputting the relevant data from the Italian Lakes itinerary into Sustainable Travel International's online calculator and the resulting analysis was shared with the Master's Project team via email from Sustainable Travel International. The differences between this analysis and the one completed by the Master's Project team can be explained by the assumptions the Sustainable Travel International tool used, including but not limited to the flights being all premium economy versus a mix of business and economy.

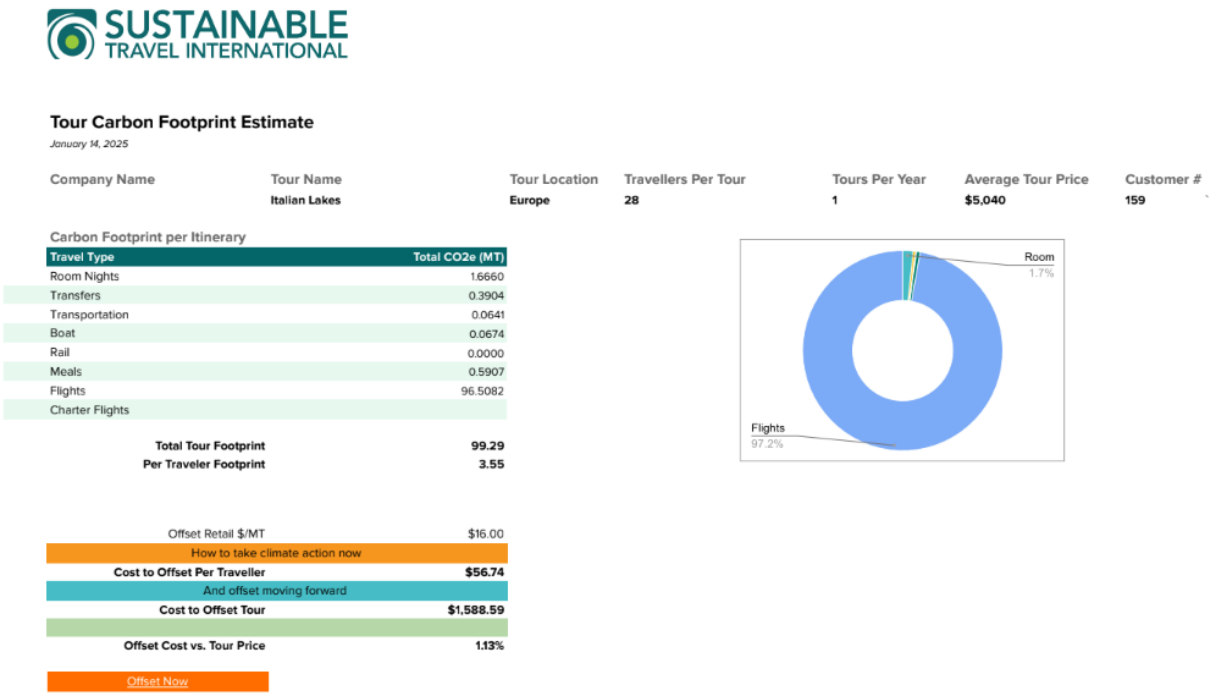



**Figure 13. Screenshot of Sustainable Travel International's carbon footprint calculation based on the baseline assumptions data for the Italian Lakes itinerary.**

## Appendix G: Master's Project Team's Case Study of a Carbon Neutral Tour Operator

Natural Habitat Adventures (Nat Hab) is a carbon neutral travel operator specializing in small-group wildlife expeditions that focus on conservation and immersive nature experiences. Partnered with WWF, they offer sustainable luxury journeys to some of the planet's most remote natural habitats, led by expert guides. As related in the Master Project team's interview with the company's CSO Court Whelan, Nat Hab defines luxury not by conventional hotel star ratings or amenities, but by what they see as the high quality of the experience itself. While the camp sitting in the African savannah cannot boast traditional luxuries, its true indulgence lies in the rare connection it offers with nature, with megafauna like giraffes and zebras mere yards away from the breakfast tent.With smaller footprints and less amenities, their accommodations may produce fewer emissions than typical luxury properties; however, operating travel sites in remote off-grid locations require both transport and power generation, both CO2e emitting activities. While conscious of their carbon emissions, Nat Hab understands that GHG reduction is not the only worthwhile sustainability initiative, and prioritizes supporting local communities, ecosystems, and biodiversity through initiatives like waste reduction, hiring local staff, and promoting conservation.

In terms of carbon management, Nat Hab partners with organizations like Tomorrow's Air and Neste to invest in SAF, though they acknowledge SAF is significantly more expensive than traditional offsets. For their offset portfolio, they utilize Gold Standard and other verified carbon credits, diversifying their portfolio every year across three projects, including reforestation, renewable energy, and projects like replacing cookstoves to support more local communities. Although the company is committed to setting a SBTi, they recognize that for small- and medium-sized enterprises, SBTis primarily addresses Scope 1 and 2 emissions. For flight emissions, which are Scope 3 and make up around 80% of Nat Hab's overall GHG inventory, Nat Hab will continue to purchase offsets to neutralize their impact.

To account for traveler-purchased flights, while Nat Hab initially encouraged individuals to opt-in for offsets, they found that 10% or less of their travellers would offset their emissions voluntarily. As a result, the company later assumed full responsibility for calculating and

offsetting these emissions themselves, finding it more effective overall. Although advocating for SAF among travelers is difficult due to cost and traveler skepticism, CSO Whelan still sees value in creating awareness and fostering a conservation mindset. His team communicates their sustainability initiatives through integrated storytelling in marketing materials, webinars, sustainability reports, and guide-led discussions, aiming to engage both guests and employees in a way that's accessible and relevant without overwhelming them. Their overarching goal is to position sustainability not just as a responsibility, but as an inherent part of the luxury travel experience.

## Appendix H: Acronym List

| Acronym | Meaning |
|---|---|
| API | Application programming interface |
| CO2 | Carbon dioxide |
| CO2e | Carbon dioxide equivalent |
| CSV | Comma separated values |
| EVs | Electric vehicles |
| GDP | Gross domestic product |
| GHG | Greenhouse gas |
| HVO | Hydrotreated vegetable oil |
| ME | Methyl ester |
| RFP | Request for proposals |
| SAF | Sustainable aviation fuel |
| SBTi | Science Based Targets Initiative |
| WTTC | World Travel & Tourism Council |
| WWF | World Wildlife Fund |

## Appendix I: Emissions Factor Sources

| Title | Link |
|---|---|
| ADEME's Base Empreinte | https://base-empreinte.ademe.fr/donnees/jeu-donnees |
| CarbonCloud - Dressed Duck | https://apps.carboncloud.com/climatehub/product-reports/id/2266128360787 |
| CarbonCloud - Roasted and Ground Coffee | https://apps.carboncloud.com/climatehub/product-reports/id/157191051652 |
| Carbon Footprint's Country Factors from Fuel Mix | https://www.carbonfootprint.com/docs/2024_international_electricity_factors.xlsx |
| Cornell eCommons: Hotel Sustainability Benchmarking Index 2024 | https://greenview.sg/wp-content/uploads/2024/06/Hotel_Sustainability_Benchmarking_Index_2024v2.xlsm |
| Poore & Nemecek (2018) | https://ourworldindata.org/grapher/food-emissions-supply-chain |
| UK Govt. GHG Conversion Factors for Company Reporting | https://assets.publishing.service.gov.uk/media/6722567487df31a87d8c497e/ghg-conversion-factors-2024-full_set__for_advanced_users__v1_1.xlsx |

## Appendix J: AHI Travel Impact Assessment Program Evaluation Scorecard

This is a screenshot of the scorecard AHI Travel uses to assess the sustainability of their vendors and where there is potential for improvement. This helps them pick vendors that align with their sustainability goals and identify places their current vendors can improve their operational sustainability.

**AHI Travel Impact Assessment**
**Program Evaluation**

**Program: FRALIFEs25 & STANAIX25 -Adagio Aix en Provence Centre**
**Date: 18 Sept 2024**
**Grid completed by: Sandra**

| | 1 = Yes<br>0 = No |
|---|---|
| **ENVIRONMENTAL IMPACT** | |
| Hotel uses green energy (per hotel) | 1 |
| Hotel has implemented measures for energy consumption reduction (e.g. HVAC, water, lighting efficiencies, etc.) (per hotel) | 1 |
| Hotel uses Eco-friendly cleaning products (per hotel) | 1 |
| Hotel has a waste management policy – recycling system, no single-use toiletry bottles (per hotel) | 1 |
| Hotel has an internationally recognized certification such as:<br>*Global Travelife / Biosphere / EarthCheck /Green Key Sustainable /Tourism Council / Green Globe / LEED Certification* | 1 |
| Hotel offers sustainable in-room gifts (local and eco-friendly products)(per hotel) | |
| Hotel offers water to refill reusable water bottles / Reducing plastic use (e.g. alternative to PVC room cards) (per hotel) | 1 |
| Program offers limited number of paper documents (maps, etc) | 1 |
| Program includes use of public transport (per day) | |
| Program includes use of electric vehicles | |
| Program includes efforts to reduce food waste ( no buffet meals ), or sustainable sourcing, etc. | 1 |
| Program includes activities supporting wildlife protection project/program | |
| Use of trains over flights for domestic trips where a rail trip is available | |
| | |
| **Minimum score: 5** | **8** |
| **SOCIAL & ECONOMIC IMPACT** | |
| Partnership with independently owned hotel (per hotel) | |
| Partnership with non-profit organization | 1 |
| Lecture by a local (per lecturer) | 1 |
| Hiring local guide/s | 1 |
| Partnership with local coach company (within 80km of group hotel) | |
| PYJ option(s) includes supporting community project or charitable cause | 0 |
| Program includes a visit during off-peak hours | 0 |
| Program includes attending cultural performance | 0 |
| Program includes Farm-to-table meal experience | 0 |
| | |
| **Minimum score: 5** | **3** |
| **EXPERIMENTAL TRAVEL ENHANCEMENTS** | |
| Program includes local experience with a 'foodie' twist / tastings, etc. | 1 |
| Hands-on experience / cooking lesson, hand crafts, etc. | 1 |
| At least 50% of the menus include local specialties | 1 |
| Interaction with locals | 1 |
| Exclusive access to a museum, etc. | 0 |
| Choice of activities for pax with different levels of mobility | 1 |
| Program includes main course choices for all meals | 1 |

**Figure 14. Screenshot of AHI Travel's Impact Assessment Program Evaluation scorecard.**