COLUMBIA UNIVERSITY
IN THE CITY OF NEW YORK

FINAL REPORT

ENVIRONMENTAL IMPACT MEASUREMENT TOOL FOR AGRICULTURAL STARTUP

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Re-Nuble

SPS

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Foreword and Acknowledgements

The following report is an account of a capstone project from a group of students in Columbia University's Sustainability Management graduate program (SUMA), part of the Columbia Climate School. We come from different backgrounds, walks of life and career paths, but we were each drawn to this program because we wish to build a career in which we can help the world stave off and adapt to the climate crisis.

The capstone project is designed as a culmination of the SUMA program - a consultancy for a real world client which calls upon the five curricular areas of SUMA study: management, quantitative analysis, physical dimensions of sustainability, public policy and areas of elective study.

We wish to thank our client, Re-Nuble, for their constant and friendly cooperation and our faculty advisor, Jessica Prata, for her friendship and guidance throughout this experience. Lastly, we wish to thank the sustainability management program itself - Columbia has put us in classrooms with some of the most important sustainability professionals in the world and we are eager to go out and use what we have learned to make the world a better place.

Executive Summary

Re-Nuble is an agricultural technology startup which makes several products for indoor farming. Most notably, they produce a fertilizer product called *Away We Grow* which is made from unrecoverable pre-consumer food waste. While Re-Nuble has always had sustainability at their company's core, they came to us wanting to find new ways to demonstrate this and thus set themselves apart from their competitors. We worked with the client through several different ideas and scopes of work until we arrived at our final proposal: building Re-Nuble an Environmental Impact Measurement Tool with a baseline inventory, accompanying analysis and strategic recommendations.

During this process, we encountered several challenges including large gaps in the data provided and conflicting information on things like how their electricity is sourced. However, the group pushed through these obstacles and produced all four deliverables. The tool and inventory were shared only with the client and not included for this publication as they contain sensitive client data. However, we did include as much information about the tool and inventory as possible inside this report and we are also linking the manual and demo video with this report.

Our hope is that these deliverables catapult Re-Nuble into a new period of tracking and measuring their impact, pursuing new steps to increase the visibility of their sustainability culture and finding meaningful ways to share all of the above with their stakeholders.

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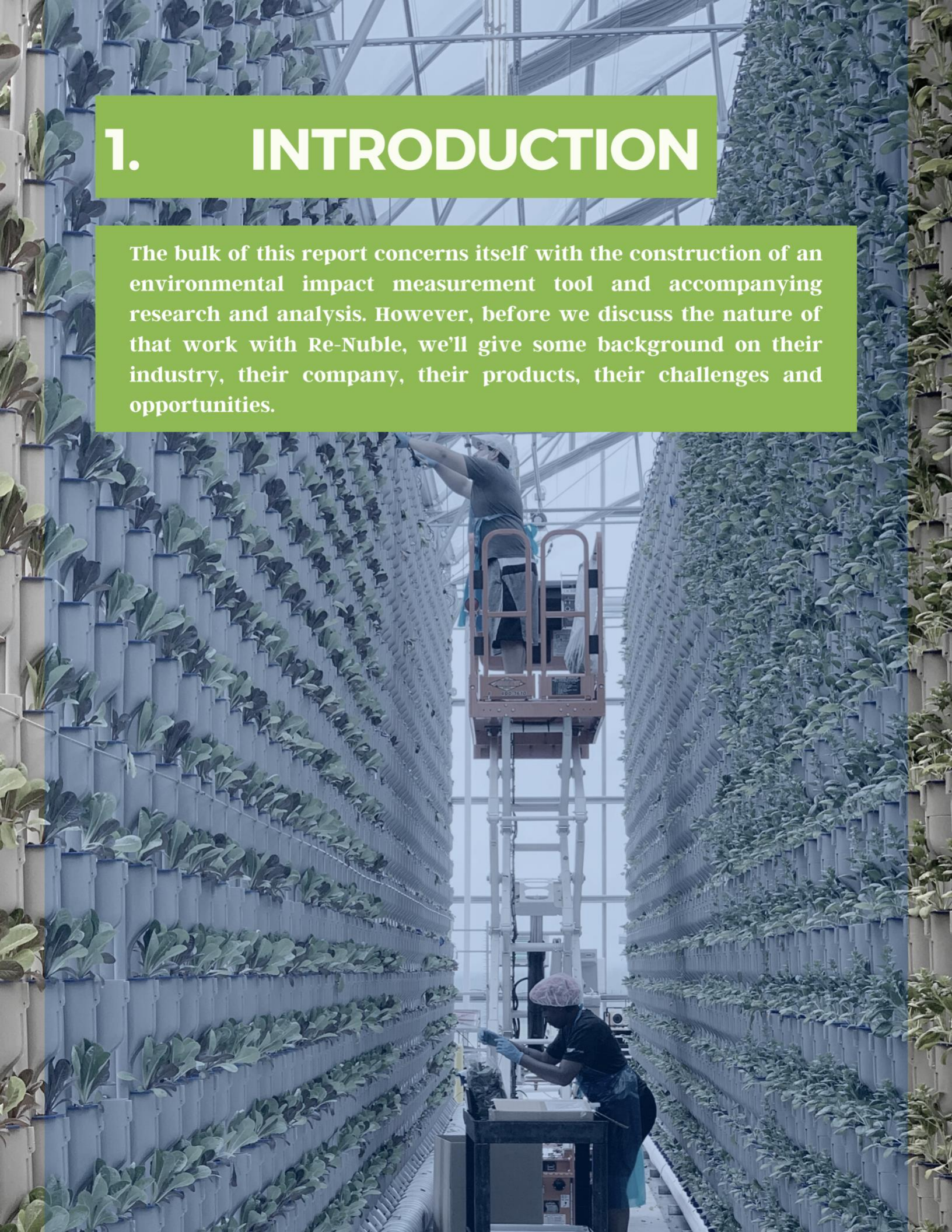
LIST OF ABBREVIATIONS

- **BTU:** British Thermal Unit. This is a unit of heat, the amount of heat required to raise the temperature of 1lb of water 1 degree fahrenheit.
- **CDFA:** California Department of Food and Agriculture.
- **CDP:** Formerly known as the Climate Disclosure Project. An organization which helps standardize and publish corporate environmental disclosure.
- **CDSB:** The Climate Disclosure Standards Board. The CDSB developed frameworks including a foundation for the Task Force for Climate-Related Financial Disclosures (TCFD).
- **CEA**: Controlled Environment Agriculture. This generally refers to indoor and/or hydroponic growing and farming operations.
- **CO2e:** Carbon Dioxide Equivalent. There are several different gasses which possess the ability to warm the atmosphere, however they each have a different "GWP" or global warming potential. At the end of emissions calculations, all of the different greenhouse gasses are totalled and put in terms of their carbon dioxide equivalent, or CO2e.
- **CRM:** Customer Relations Management. Usually refers to a software portal in which customer or client data and communications are stored.
- **ERP:** Enterprise Resource Planning. The integrated management of business processes using software.
- **GBCI:** Green Building Certification Incorporated. GBCI is a green standards board which created such famous platforms as the LEED certification for architecture and the TRUE zero waste certification.
- **GHG:** Greenhouse Gasses. These are the gasses with the potential to trap heat inside the earth's atmosphere.
- **GWP:** Global Warming Potential - the potency of a GHG to warm the atmosphere compared to CO2. If a gas has a GWP of 5, that means it warms the atmosphere 5x as much as CO2 would.
- **LCA:** Life Cycle Assessment. In LCA, one can determine the detailed impact of a product or service. While this is commonly focused on GHG emissions, LCAs can also examine a product or service's effect on biodiversity, water quality, etc.
- **MOS:** Mayor's Office of Sustainability (NYC).
- **MRP:** Materials Requirements Planning. A category of supply chain management.
- **MWh**: megawatt hour. A common unit of measurement for energy consumption that translates to 1,000 kilowatts of electricity used continuously for one hour.
- **OCS:** Organic Cycling Science. This is the process by which organic nutrients are transformed into viable, soluble nutrients.
- **OMRI:** Organic Materials Review Institute. A body which certifies agricultural products as organic.
- **SASB:** Sustainability Accounting Standards Board. SASB is an organization which offers guidance on how companies can report to stakeholders on sustainability in a standardized manner.
- **WRI:** World Resource Institute. The WRI monitors and creates impact programming around major areas of climate change (cities, climate, energy, food, forests, ocean and water).

1. INTRODUCTION

The bulk of this report concerns itself with the construction of an environmental impact measurement tool and accompanying research and analysis. However, before we discuss the nature of that work with Re-Nuble, we'll give some background on their industry, their company, their products, their challenges and opportunities.



a. Industry Description

The indoor farming market size was valued at USD 39.5 billion in 2021 and is expected to grow at a compound annual rate of 13.5% from 2022 to 2030.[i] This market is increasing due to the water efficiency, little land use, and advantages of controlled farming to climatic change. Indoor cultivation methods are used to improve the quality of the local food supply and give consumers access to fresh and healthy food while decreasing the impact of traditional agriculture methods. This type of farming maximizes nutrients that fertilize plants, making the food it produces exceptionally healthy. Even though vertical farming uses fewer resources like agrochemicals or pesticides, ensuring plant nutrition is still an essential objective for the indoor farmer.

Currently, the options available in the market for indoor growers vary between chemical fertilizers and biological or organic compounds made in traditional ways like composting. At the same time, according to the United States Environmental Protection Agency (EPA), almost 90 percent of garbage thrown away by households, cafeterias, and supermarkets is composed of recyclable food scrap.[ii] Moreover, a typical household generates nearly 474 pounds of food waste each year.[iii] When this organic waste is sent to landfills or the oceans, they not only consume space but also release methane, adding to the greenhouse emissions. In the United States, food waste is estimated at between 30-40% of the food supply. The United States Department of Agriculture's (USDA) Economic Research Service estimates that 31% food loss at the retail and consumer levels, this estimate corresponded to approximately 133 billion pounds and $161 billion worth of food in 2010.[iv]

Re-nuble helps combat the environmental ramifications associated with food waste by diverting unrecoverable produce from food processors and using it as their primary feedstock for their organic-based nutrient fertilizers.

b. Client Description

Re-Nuble was founded in 2015 with the mission to help global agricultural communities safely recover food waste and used to accelerate environmentally-friendly indoor growing practices.

The company produces sterile liquid, water-soluble, organic hydroponic nutrients sourced from food byproducts and at competitive costs, compared to carbon-

intensive synthetic mineral salts. Additionally, they created a growing media product made from fully recyclable materials (compared to rockwool and peat - the more common grow media for indoor farming). They are pushing the Controlled Environment Agriculture (CEA) industry to become more sustainable.[v]

Re-Nuble has designed a methodology called "Organic Cycling Science (OCS)," in which they transform organic nutrients into viable, soluble nutrients. This process can be performed at scale and is considered carbon-negative. Not only does this process create a closed loop, it provides a clear example of how Re-Nuble is superior to its competition in terms of sustainability.

Currently, Re-Nuble provides the market with two water-soluble nutrients products, one growing media made from sustainable and compostable materials, and a service to incorporate their technology into indoor growers' in-house operations.

The following briefly describes Re-Nuble's products and services:[vi]

- **Away We Grow® 4-1-1 Concentrate:** This is a water-soluble, liquid organic hydroponic nutrient-rich fertilizer sourced predominantly from sterilized vegetative waste. By using this product, a one-acre farm eliminates 1.62 metric tons of CO2e from the atmosphere annually. It removes 18.75 pounds of CO2e for every gallon that would otherwise have been released from food waste sent to landfills.

Figure 1.1. Away We Grow 4-1-1 Concentrate. (Re-Nuble)

- **Booster Shot® Biostimulant:** This is a water-soluble, liquid biostimulant-rich product sourced exclusively from sterilized vegetative waste and plant extracts. It promotes vigorous root growth as a germination accelerant and immunity enhancer.

Figure 1.2. Booster Shot Biostimulant. (Re-Nuble)

- **Ren Terra™:** This is a fully compostable and inert grow media that guarantees uniformity, water retention, and drainage. Its chitin and carbon from upcycled crustacean waste deliver additional value.

Figure 1.3. Ren Terra Media. (Re-Nuble)

- **On-site food waste recovery system:** This is a service to turn farms into a circular, resource-efficient operation. By helping to close the loop, Re-Nuble returns the value of farms' production byproducts (e.g., wastewater, roots, and produce trimmings) into value and decreases the dependence on external potable water and chemical inputs.

With their products and services, Re-Nuble provides indoor growers the following abilities:

- Viably grow organic food in soilless systems using true-to-source organic hydroponic nutrients. As a result, growers can "close the loop" and obtain a higher margin with an organic certifiable input.
- Reduce carbon emissions usually associated with inputs for their food value chain.
- Remove the requirement for additional time, supplemental products, and systems, often causing an operational burden for the product to work.

c. Food Waste Upcycle Process

To build their circular model, seen in Figure 1.4, first, Re-Nuble partners with food processors and producers to source organic waste that would otherwise be sent to landfills. In this process, the company carefully handles the products to ensure the safety and the quality of the nutrients in their final product. Following that, Re-Nuble takes it to its manufacturing facility, where they apply their proprietary technology, consisting of several steps. First, macerating the food waste, second mixing and passive solubilizing, third liquid extracting nutrients and finally, mixing the liquid extraction with other ingredients to obtain the product.

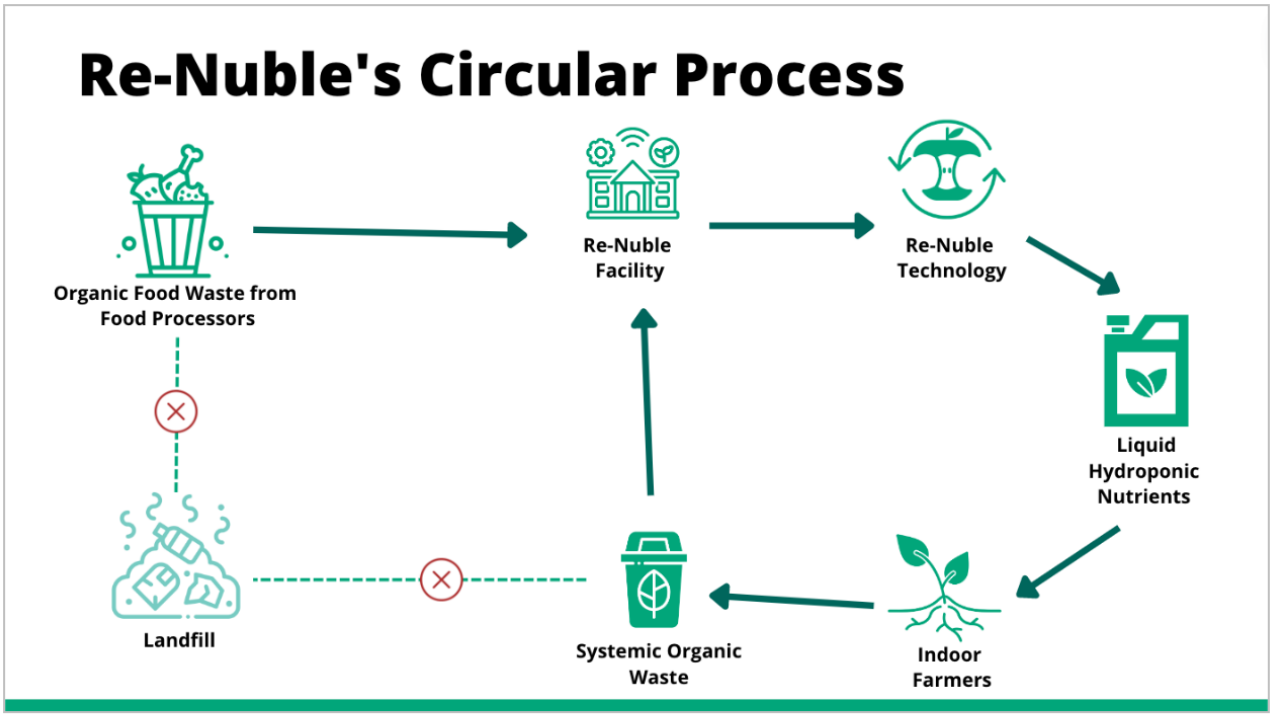


Figure 1.4. Re-Nuble's Circular Process Map. (The Capstone Team)

d. Overview of CEA Space

Controlled Environment Agriculture (CEA) combines engineering, plant science, and computer-managed greenhouse control technologies to optimize plant growing systems, quality, and production efficiency. CEA can range from simple shade structures

and hoop houses through greenhouses to entire indoor or vertical farms. There are many social and environmental benefits to Controlled Environment Agriculture, as well as a few drawbacks.[vii]

Benefits of CEA:

- CEA allows for secure, healthy, and cost-effective year-round production
- CEA offers the potential to increase local food production.
- CEA technologies are increasingly energy efficient.
- It can use up to 90% less land and 90% less water than conventional outdoor farming methods.
- Free of pesticides and herbicides and chemical runoff prevention.
- Climate change has the potential to disrupt traditional agricultural production.

Drawbacks of CEA:

- Vertical agriculture produces high yields; however, increases capital expenditures and operating expenses compared to traditional greenhouses.
- It is highly dependent on carbon-intensive mineral salts.

The benefits demonstrate the ability of CEA to tackle the effects of climate change and urbanization on urban food supply. However, the CEA industry has much progress to make toward closed-loop operations. Like traditional agriculture, CEA creates food waste through its operations, sending it to landfills, leading to greenhouse gas emissions, including harmful methane. [viii]

e. Composting & Water Inventory/Operations

The water requirements of CEA systems differ from conventional agricultural methods. In contained structures (roofed, glasshouse, plasticulture, etc.), evapotranspiration is reduced significantly, lessening water requirements. Evapotranspiration is the sum of evaporation from the land surface plus transpiration from plants. Precise water application and drip irrigation also minimizes water requirements. Hydroponic and vertical farming methods can save up to 99% of the water required to grow certain crops. Additional water reduction strategies include recycling municipal wastewater for vertical farm irrigation or substituting it with brackish water using desalination processes. As well as reducing water consumption and energy

costs, CEA systems can operate in arid desert land at large scales where conventional agricultural practices are not feasible and land suitable for crop production is already saturated or under threat.

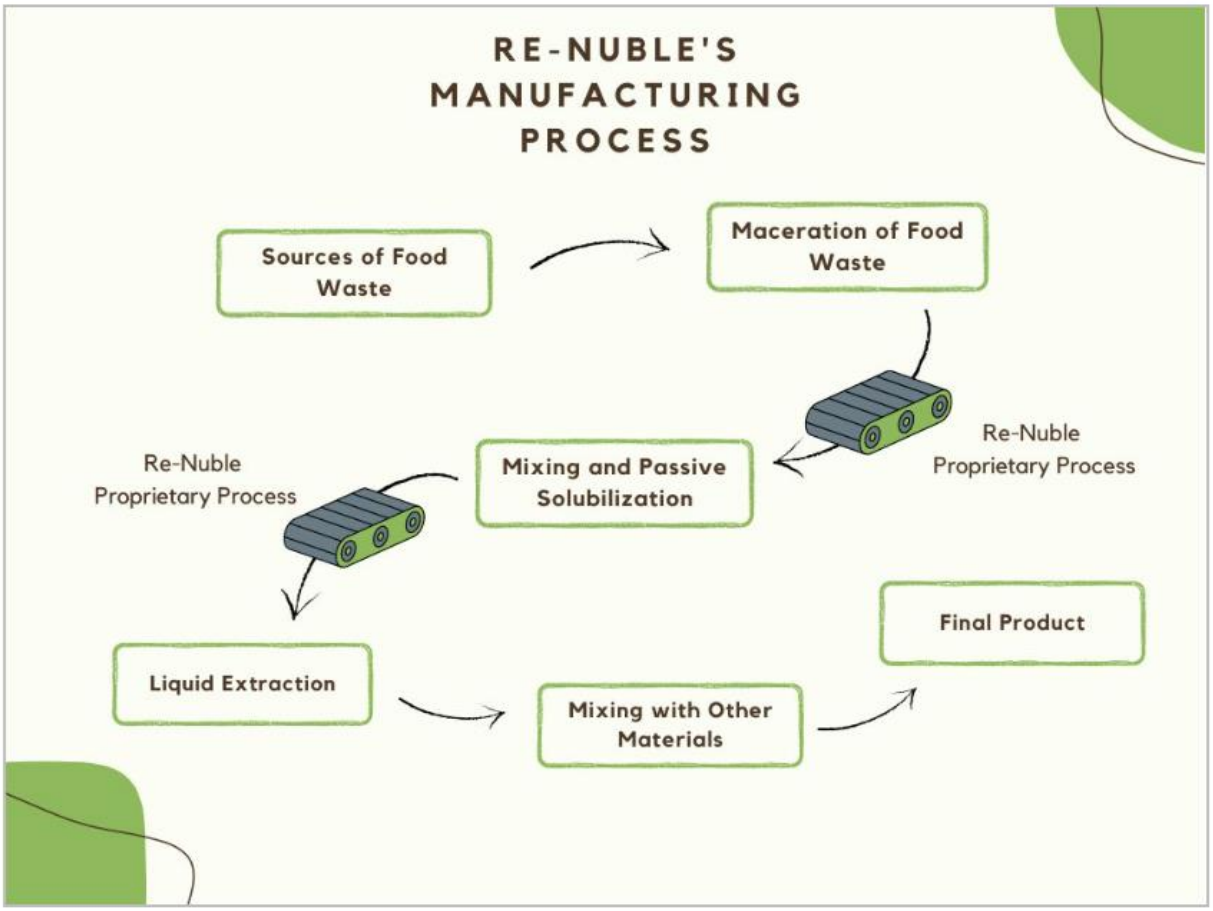


Figure 1.5. Re-Nuble's Manufacturing Process Flow Map. (The Capstone Team)

f. Statement of Problem and Evolution of Project Goals

Sustainability has always been at the core of Re-Nuble's business. They are committed to tracking, measuring, and addressing all emissions sources. They even conducted a LCA years ago of their previous production process which showed their product to have a carbon negative footprint. As Re-Nuble chases after a larger share of the market and more investors, they want to be able to say more conclusively, "we are the most sustainable choice." That is how this capstone group connected with Re-Nuble, but we didn't immediately arrive at the scope

of work. A number of additional possible deliverables were explored, such as certifications, API integration, social cost of carbon, etc.

Ultimately, we refined the scope of the project to include four deliverables for the client: (1) an Excel-based Environmental Impact Measurement Tool, (2) a baseline impact inventory, (3) accompanying analysis and research and (4) strategic recommendations for the future. Above all, the tool is our primary objective. It quantifies Re-Nuble's emissions, waste generation, and water consumption.

2. INVENTORY AND TOOL

In conducting this GHG inventory, our team followed the standards and guidelines established by the GHG Protocol, a globally recognized framework to measure and manage greenhouse gas (GHG) emissions in private sector organizations. As it applies to this project, the GHG Protocol greenhouse gas accounting standards were used to establish a baseline for our Scopes 1, 2, and 3 calculations and emissions tracking.

In this inventory, we have established 2021 as the reporting year because this boundary contains the most complete dataset for tracking Re-Nuble's operations. Additionally, we chose to follow the "Operational Control Approach" as the inventory's organizational boundary. Under this approach, we have calculated emissions under Re-Nuble's operational control where the company has the full authority to introduce and implement its operating policies at the operation.

a. Scope 1

i. S1 - Methodology

Scope 1 refers to direct GHG emissions from sources owned or controlled by the company, and includes the following four categories:

- **Stationary Combustion**

Description: Emissions from stationary combustion are associated with the consumption of fuel for generation of electricity, heat, steam, or power. This refers to company-owned/controlled boilers, furnaces, turbines, generators, and other equipment.

Re-Nuble: To date, the company does not combust any fuels in stationary equipment in any of its facilities—therefore, there are no emissions associated with stationary combustion for Scope 1.

- **Physical/Chemical Processing**

Description: These emissions are the result of the manufacturing process of certain chemicals and materials, such as cement, aluminum, and ammonia.

Re-Nuble: To date, the company's manufacturing process does not involve a chemical reaction that releases greenhouse gasses. Therefore, there are no emissions associated with physical/chemical processing for Scope 1.

- **Mobile Combustion**

Description: Emissions from mobile combustion are associated with fuel consumption in company-owned/controlled vehicles. This includes on-road vehicles such as cars, trucks, and buses; and off-road vehicles such as trains, ships, forklifts, etc.

Re-Nuble: To date, the company does not own or lease any vehicles throughout its value chain and therefore does not have any emissions in this Scope 1 category.

- **Fugitive Emissions**

Description: Fugitive Emissions result from leaks in refrigeration and air conditioning equipment through which refrigerant gas escapes.

Re-Nuble: Re-Nuble has operational control over both refrigeration and air conditioning equipment and therefore has associated fugitive emissions.

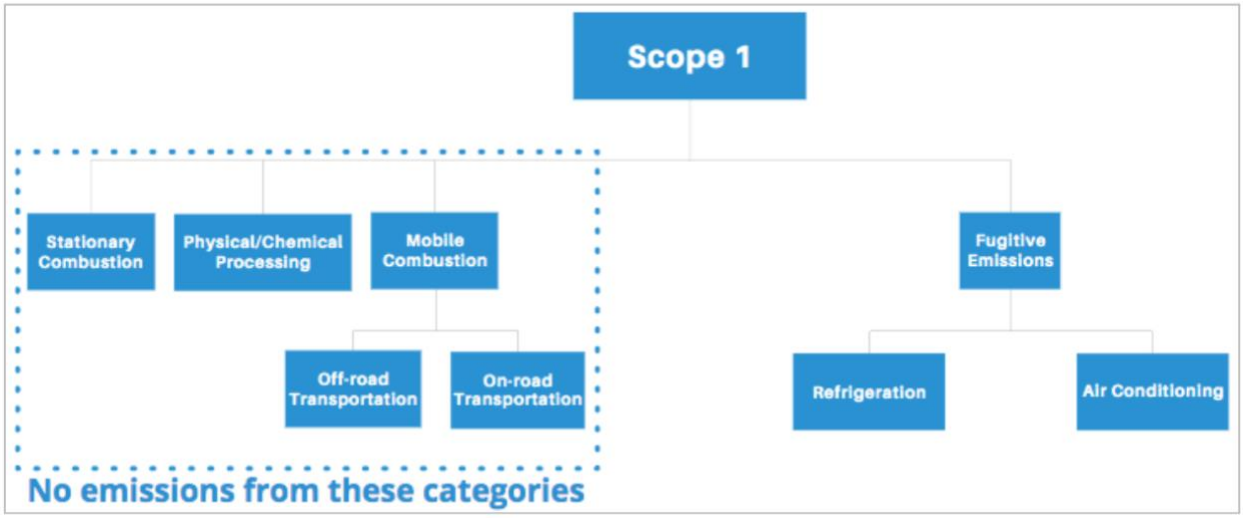


Figure 2.1. Visual representation of the different categories within a Scope 1 GHG emissions inventory, and where Re-Nuble does not have associated emissions. (GHG Protocol)

The figure above represents the categories included in a Scope 1 emissions inventory according to the GHG Protocol. Of these four categories, Re-Nuble only has emissions associated with "Fugitive Emissions"—as a result, this category constitutes the entire Scope 1 emissions inventory for this company.

The U.S EPA Center for Corporate Climate Leadership provides guidance for conducting greenhouse gas inventories based on the GHG Protocol. This guidance was used to calculate the Scope 1 emissions for Re-Nuble.

While multiple methods can be used to calculate fugitive emissions, the most relevant one is the "Lifecycle Stage Approach," as this method is best for companies who have contractors service their refrigeration and air conditioning equipment (i.e., the company does not service its own equipment). This method, however, requires more data that must be retrieved from the contractor who serviced the equipment. Due to limited access to this data, the EPA/GHG Protocol "Screening Method" was used to estimate the fugitive emissions from refrigeration and air conditioning equipment. (Note: A template for the more comprehensive "Lifecycle Stage Approach" is included in the GHG Emissions Tracking tool, which can be used by the company in the future to more accurately estimate its emissions).

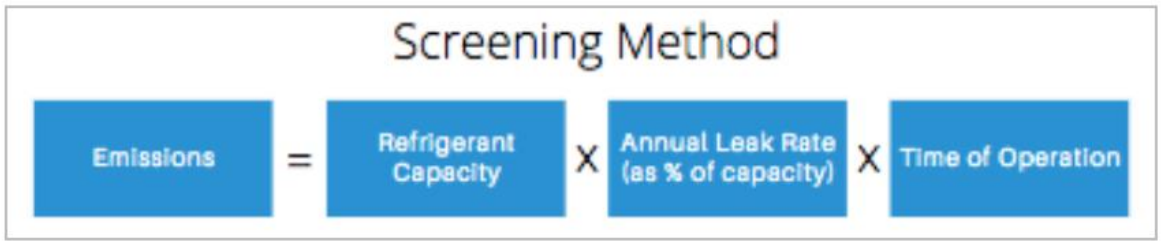


Figure 2.2. Emissions calculation using the EPA/GHG Protocol Screening Method for refrigeration and air conditioning equipment. (GHG Protocol)

The Screening Method used in this estimation includes emissions associated with the installation, operation, and disposal of refrigeration and air conditioning equipment during the reporting period. It was assumed that during the reporting period, no new equipment was installed and charged with refrigerant on-site at any facility that Re-Nuble has operational control over (i.e., headquarters and the manufacturing facility). Similarly, it was assumed that no pieces of equipment were disposed of during the reporting period. As a result, only emissions during the operation of the equipment were included in this estimation.

To calculate emissions during operation, the following equation was used for each piece of equipment, which gave emissions

Type of Equipment	Capacity (kg)	Installation Emission Factor k (% of capacity)	Operating Emissions x (% of capacity/yr.)	Refrigerant Remaining at Disposal y (% of capacity)	Recovery Efficiency z (% of remaining)
Domestic Refrigeration	0.05–0.5	1	0.5	80	70
Stand-alone Commercial Applications	0.2–6	3	15	80	70
Medium & Large Commercial Refrigeration	50–2,000	3	35	100	70
Transport Refrigeration	3–8	1	50	50	70
Industrial Refrigeration including Food Processing and Cold Storage	10–10,000	3	25	100	90
Chillers	10–2,000	1	15	100	95
Residential and Commercial A/C including Heat Pumps	0.5–100	1	10	80	80
Mobile Air Conditioning	0.5–1.5	0.5	20	50	50

Figure 2.3. Default emissions factors for air conditioning/refrigeration equipment—used to calculate fugitive emissions via the Screening Method. (EPA)

estimates in units of [kg] can be seen in Figure 2.3.

This number was then multiplied by the specific Global Warming Potential (GWP) of the refrigerant used in each piece of equipment, which gave emissions in CO2e. The results were then added together to get the total fugitive emissions from refrigeration and air conditioning.

Given that the type of refrigerant used was unknown for each piece of equipment, R-134a was used as the default, as this is the most common refrigerant used.[ix] GWP values were taken from the 2014 IPCC Fifth Assessment Report.

Due to limited data, the refrigerant capacity for each piece of equipment was estimated. The client provided model number information for one refrigerator at the manufacturing facility, but the refrigerant capacity could not be found via online research. Therefore, a conservative estimate was made by taking the high value in the range provided by the following table found on EPA's GHG Inventory Guidance for Fugitive Emissions.[x]

Throughout the calculation process, details of the air conditioning systems and equipment used at Re-Nuble's facilities were unknown. Because the company's facilities are within leased spaces in shared buildings, it was difficult to track down accurate information regarding air conditioning equipment specifications, size of the area served by the equipment, and the area under the control of Re-Nuble—all of which would be needed to more accurately allocate Re-Nuble's share of air conditioning usage. As a proxy, it was assumed that the company has a dedicated chiller for each of its spaces. The Refrigerant Capacity of a chiller is largely based on its size. Estimates for the size of the chillers were calculated from a factor of 20 [BTU/square foot] provided by the U.S Department of Energy.[xi] The square footage of each of Re-Nuble's facilities was also estimated but can be modified in the Excel tool. The size of the air conditioning unit was then converted to tons and multiplied by a factor of 3 [lbs of refrigerant/ton of cooling].[xii] Finally, converting this value to [kg] yielded an estimate for the refrigerant capacity for the air conditioning units at each of the company's facilities.

Annual Leak Rate values were also taken from the above table. Time of Operation

values are in years, and for an annual reporting period, would equal one.

ii. S1 - Summary of Findings

The calculations described above-yielded Scope 1 emissions of 2.48 metric tons of CO2e. Given the size of the company and the few items that could be included under Scope 1, we believe this is a reasonable estimation. Based on the company's operations, it's expected for Scope 2 to account for a greater share of emissions, with Scope 3 accounting for even more.

iii. S1 - Data Gap

In completing the Scope 1 GHG emissions calculation, several estimates were made as a result of a lack of data (as explained in the Methodology section). This also influenced the "Screening Method" usage for calculation rather than the more robust "Lifecycle Stage Approach" for fugitive emissions.

In the future, the company should dedicate more time and resources to tracking down the necessary data for accurate emissions accounting. This information will need to be obtained from the facilities manager and technicians that services the company's refrigeration and air conditioning equipment.

It should be reiterated that the categories other than "Fugitive Emissions" within Scope 1, namely "Stationary Combustion," "Physical/Chemical Processing," and "Mobile Combustion," were not excluded due to a lack of data, but because Re-Nuble did not have any emissions under these categories as defined by the GHG Protocol. Re-Nuble does not utilize any emissions-producing chemical processing and has no assets that release emissions from mobile combustion. Regarding stationary combustion, Re-Nuble's production space is heated via a shared ducted HVAC unit powered by a natural gas boiler which is owned and operated by the Kodak Eastman Business park. This means that the Kodak Eastman is responsible for the emissions from said heating infrastructure.

b. Scope 2

Emissions from purchased electricity, steam, heating, and cooling are termed "Scope 2" emissions. Building on The GHG Protocol Corporate Accounting and Reporting Standard,[xiii] our environmental

impact measurement tool calculates Scope 2 emissions for Re-Nuble's operations, capturing indirect emissions produced at the manufacturing facility at Eastman Business Park in Rochester, New York.

i. S2 - Methodology

	METHOD FOLLOWED	METHOD IN THE CONTEXT OF RE-NUBLE
1	Identify reporting boundaries	Indirect emissions associated with energy consumption generated from the purchase of electricity, steam, heat, or cooling to support Re-Nuble's business operations and service at Eastman Business Park Building in New York for the year of 2021.
2	Identify GHG emission sources for scope 2 emissions	Based on utility bills for the year of 2021 (Service usage for consumed electricity MWh & heat/steam in mmBtu)
3	Determine accounting method used for calculation	Location and Market Based Approach Our primary and complete calculation approach is a location based method, because it is based on average energy generation emission factors for defined geographic locations (in our case Rochester facility) that includes local, subnational, or national boundaries. The approach is location agnostic because the physics of energy production and distribution functions the same way in almost all grids, with electricity demand causing the need for energy generation and distribution. Since we have complete information for usage data provided in utility bills we calculate emissions for all greenhouse gasses (CO2, CH4, N2O, CO2e, kgCO2e/kWh) — Market Based Approach is a secondary calculation approach that we use for our calculation to capture emission factors provided by RED Rochester. Since we are limited to information that only helps us calculate carbon emissions (CO2) and does not provide detailed information on sourcing and purchase of contractual instruments (including direct contracts, certificates, or supplier-specific information) we restrict our market based emissions to emissions in CO2 (tonnes) only.
4	Collect activity data	Utility bills for service at company operations in Eastman Business Park Building 218.
5	Choose emission factor	For Location Based Calculation: Grid average-location in line with location-based data provided by the EPA[xiv] for NYLI as grid-region i.e. Facility ID on our tool. For Market Based Calculation: Custom emissions factors for purchased electricity and

		heat/steam, in terms of CO2 conversion were used. This information was provided by RED Rochester.
6	Match emission factor to each unit of electricity consumption	Reference taken to data in "Energy service usage" information on utility bills for Electricity in MWh, LP Steam in mmBtu factored as Heat/Steam Information not considered - Compressed Air & Nitrogen in KScf : Due to lack of usage data
7	Emission Calculation	Emissions GHG, fuel = Fuel Consumption fuel x Emission Factor GHG, fuel • *Multiply activity data* from each operation by the *emission factor* for that activity for each applicable GHG. • *Multiply global warming potential* (GWP) values by the *GHG emissions totals* to calculate total emissions in CO2 equivalent (CO2e). • *Report* final scope 2 in metric tons of CO2e.

Figure 2.4. Scope 2 Methodology. (GHG Protocol)

ii. S2 - Summary of Findings

Scope 2 - Activity Type	2021
Purchased electricity - location based	20.56
Purchased electricity - market based	11.61
Purchased heat and steam - location based	12.55
Purchased heat and steam - market based	16.92
Total Scope 2 - location based	**33.11**
Total Scope 2 - market based	**28.53**

Figure 2.5. Scope 2 Summary of Findings. (The Capstone Team)

iii. S2 - Data Gaps

There are some gaps in the utility bills data that was received. Specifically, the utility bills for the months of September 2020, October 2020, January 2021 and May 2021 were missing and therefore were excluded from the calculations in the current inventory. Moving forward, we recommend that Re-Nuble sets up a clear data management system for collecting and storing its monthly utility bill data in order to develop a more robust GHG inventory.

Additionally, we must speak to the nature of Re-Nuble's electricity procurement. Late in our work, we discovered that Re-Nuble does not procure their electricity as one would

expect (from the local grid), but rather from an on-site utility generation service called "Red Rochester." After a great effort, we were able to connect with a facilities manager at the Eastman Kodak business park as well as a manager at Red Rochester who, together, provided a more detailed picture of Re-Nuble's energy supply. While we are relatively confident in how we have captured and processed the data acquired around scope 2 emissions, it will be vitally important in Re-Nuble's second inventory to do a "deeper dive" in understanding how Red Rochester creates and provides utility services to Re-Nuble to ensure data is as accurate as possible.

c. Scope 3

i. Business Travel - Our Known Scope 3 Category

Since the client provided travel data, Scope 3 Business Travel (category 6) is the only Scope 3 category calculated. The minimum boundary for the Scope 3 Business Travel category is the emissions from transportation carriers that occur during the use of these modes of transportation. Examples include gas usage in a vehicle (gallons) or miles traveled in vehicles, aviation jet fuel consumed (in gallons) during flight (adjusted for the amount of seats or passengers on the plane), or miles traveled by plane.

In the 2021 reporting year, Re-Nuble gave an estimate that 1-2 employees took 4-6 flights from NYC's JFK / La Guardia to the Rochester airport. To account for the emissions of air travel, we used the distance-based approach to estimate emissions in CO2e by multiplying the air miles/ distance between JFK and Rochester airports with the frequency of travel, the number of employees, and the US EPA's emissions factor for short haul (<300 miles) commercial flights. The total emissions associated with business travel is 1.2 metric tons of carbon dioxide equivalent.

This section provides an overview of the 15 Scope 3 categories, including descriptions, high-level summaries of data collection methods, boundary guidace, and activity data and emissions factors needed to calculate emissions for each category. This information and more can also be found using the GHG Protocol for Scope 3 emissions.

We recommendation that Re-Nuble use this section to prioritize the Scope 3 categories from either of the two perspectives presented:

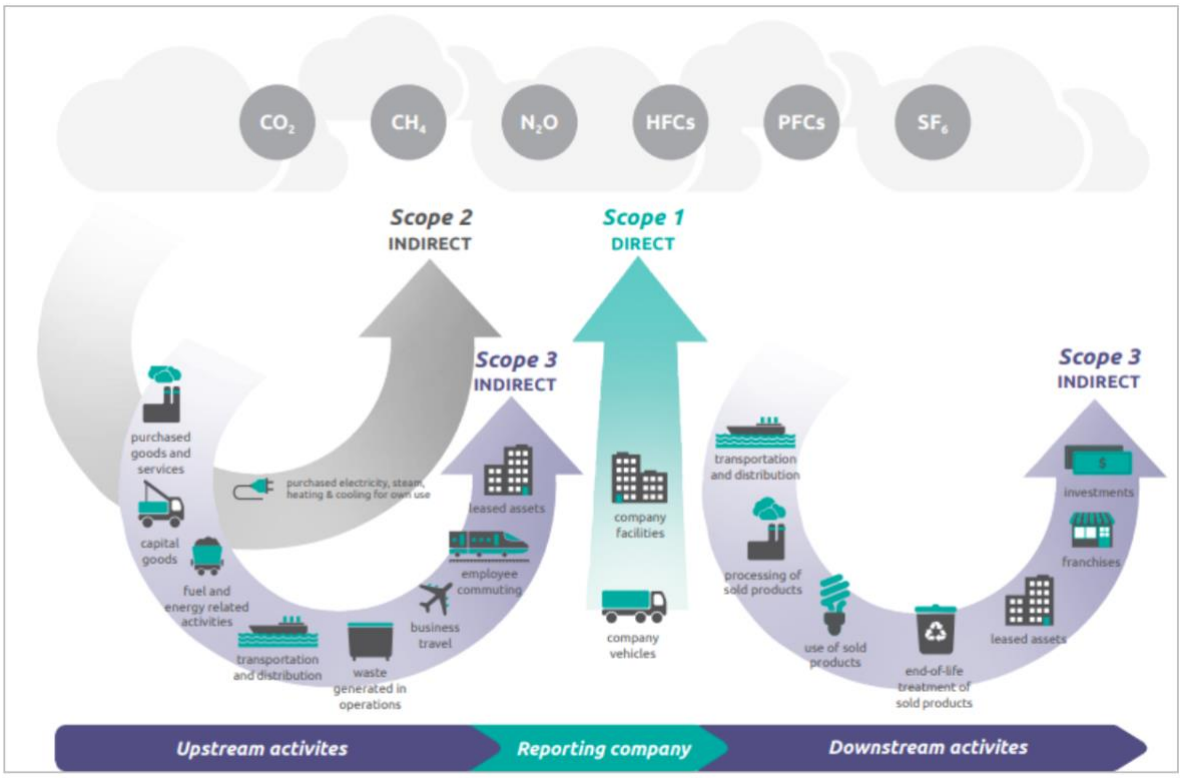


Figure 2.6. Overview of GHG Protocol Scopes and emissions across the value chain. (GHG Protocol)

- Emissions Materiality: Which Scope 3 categories contribute the most emissions relative to the total Re-Nuble emissions.

- Data availability: Which Scope 3 categories does Re-Nuble currently have data for and which categories could Re-Nuble easily begin to collect data for.

A note on the 5 principles: For most companies, Scope 3 represents the vast majority of their emissions, but is often the most complex and time intensive to calculate accurately due to data challenges. While it is important to disclose as many emissions sources as possible, it is also important to keep in mind the five principles of the Greenhouse Gas Protocol: Relevance, Completeness, Consistency, Transparency, Accuracy.[xv]

Oftentimes, Completeness and Accuracy or Consistency may be competing factors, especially when it comes to reporting scope 3 emissions. This dichotomy can be addressed by the Transparency principle. Acknowledging data gaps and challenges in a scope 3 inventory helps put findings and

data into perspective. To increase the credibility of an inventory, it is a best practice to have transparent calculation methodologies. Transparency is also useful if a company changes their methodology over time (for example, if they get better, more specific data) and thus, having an audit trail to see what has changed over time is important to maintain credibility. Notably, it is also a best practice to include any available Scope 3 categories. It is better to include the data that is available, even if it is incomplete, rather than wait for the full 15 categories because it takes a while to generate the full Scope 3. Figure 2.7 is an overview of the 15 Scope 3 categories defined in the GHG Protocol.[xvi]

d. Applicability to Re-Nuble

KEY
Likely Applicable for Re-Nuble
Likely Not Applicable for Re-Nuble

Scope 3 Category	Description	Data Needed, Notes
1. Purchased Goods and Services	Extraction, production and transportation of goods and services purchased or acquired by Re-Nuble in the reporting year	Re-Nuble should collect data on the upstream emissions of its purchased inputs and services used to make its products (e.g., feedstocks of the product itself and packaging and labeling materials). This category is typically time and resource intensive (especially if there are many inputs or unique inputs). We recommend Re-Nuble start with this their top three purchased goods and services by dollars or by volume the for the first time they report on this category and expand the coverage of this category over time.
2. Capital Goods	Extraction, production, and transportation of capital goods purchased or acquired in the reporting year	This would include any machinery purchased by Re-Nuble to be used in their manufacturing process (i.e., vegetable processors, manufacturing equipment).
3. Fuel-and energy-related activities not	Extraction, production, and transportation of fuels and energy purchased or acquired by the reporting company in the reporting year, not already accounted for in Scope 1 or Scope 2	To report this category, Re-Nuble should collect data on upstream emissions of its fuel and energy use. Category 3 does not include emissions from combustion of

included in Scope 1 or Scope 2		fuels (this is already accounted for in Scope 1 and 2), but includes emissions from extracting fuels (e.g., mining coal, refining gasoline, transmission and distribution of natural gas). We recommend prioritizing other Scope 3 categories first.
4. Upstream transportation and distribution	Transportation and distribution of products purchased by the reporting company in the reporting year between a company's tier 1 suppliers and its own operations (in vehicles and facilities not owned or controlled by the reporting company)	Re-Nuble should collect data on distance, mode(s) of transportation and fuel types used in transporting any incoming supplies or feedstocks to the manufacturing facility (e.g., feedstock traveling from the vegetable processing plant to the Re-Nuble manufacturing facility).
5. Waste generated in operations	Disposal and treatment of waste generated in the reporting company's operations in the reporting year (in facilities not owned or controlled by the reporting company)	Given's Re-Nuble's main feedstock is waste, emissions from Category 5 may be limited, but would include data on items sent to landfill and items recycled, etc.
6. Business travel	Transportation of employees for business-related activities during the reporting year (in vehicles not owned or operated by the reporting company)	Re-Nuble should collect data on employee travel excluding normal commute. Data ideally would include miles traveled and by what mode of transportation (bus, plane, train, passenger car).
7. Employee commuting	Transportation of employees between their homes and their worksites during the reporting year (in vehicles not owned or operated by the reporting company)	Re-Nuble should collect data on employee everyday commuting, including, frequency, distance, mode(s) of transportation and fuel types used.
8. Upstream leased assets	Operation of assets leased by the reporting company (lessee) in the reporting year and not included in Scope 1 and Scope 2 – reported by lessee	If applicable (i.e., outsourcing manufacturing), Re-Nuble should collect data on energy use of the leased assets used to produce Re-Nuble products or feedstocks.
9. Downstream transportation and distribution	Transportation and distribution of products sold by the reporting company in the reporting year between the reporting company's operations and the end consumer (if not paid for by the reporting company), including retail and storage (in vehicles and facilities not owned or controlled by the reporting company	Re-Nuble should collect data on distance, mode(s) of transportation and fuel types used to transport and distribute its process, inclusive of all transportation after a product leaves Re-Nuble's manufacturing sites until arriving at the final customer.
10. Processing of sold products	Processing of intermediate products sold in the reporting year by downstream companies (e.g., manufacturers)	If applicable, Re-Nuble should collect data on emissions from entities processing products up until they become finished goods.

11. Use of sold products	Emissions associated with the end use of goods and services sold by the reporting company in the reporting year	**Note**: This is one of the most complex scope 3 categories to calculate because companies do not usually readily collect data on how customers use their products. In the case of Re-Nuble, other aspects of a customer's hydroponic farm will also influence the emissions from the use of Re-Nuble products (e.g., emissions intensity of the grid from which the consumer pulls electricity for their vertical farm, energy efficiency of the building housing the vertical farm, water management practices and irrigation systems used by each specific farm, how each farm disposes of Re-Nuble products at the end of their useful life, etc.). Re-Nuble should collect data from its customers (i.e., through surveys or site visits) on customers' use of their products.
12. End-of-life treatment of sold products	Waste disposal and treatment of products sold by the reporting company (in the reporting year) at the end of their life	Re-Nuble should collect data from its customers (end-users of Re-Nuble products) on how (and in what timeframe) they dispose of all parts of Re-Nuble's products (including packaging). Again, this data is specific to customer use (i.e., if the customer recycles, landfills, composts, etc.) which makes this category difficult to calculate.
13. Downstream leased assets	Operation of assets owned by the reporting company (lessor) and leased to other entities in the reporting year, not included in Scope 1 and Scope 2 – reported by lessor	Although our team is not aware of any downstream leased assets, if Re-Nuble acquires any in the future, Re-Nuble should collect activity data on emissions attributable to producing Re-Nuble products.
14. Franchises	Operation of franchises in the reporting year, not included in Scope 1 and Scope 2 – reported by franchisor	Although our team is not aware of any Re-Nuble franchises, should Re-Nuble have franchises in the future, it should collect activity data on franchise operations (e.g., energy use).
15. Investments	Operation of investments (including equity and debt investments and project finance) in the reporting year, not included in Scope 1 or Scope 2	Sometimes referred to as financed emissions, this category is usually most applicable for the financial sector. Our team is not aware of any significant investments made by Re-Nuble and recommends prioritizing other Scope 3 categories first as this is not likely to be material to Re-Nuble.
Table Summary - Of the 15 Scope 3 categories, our analysis shows 10 to categories to be relevant to Re-Nuble. These are denoted in the table above in green. As calculating and reporting on Scope 3 emissions is typically a time and resource intensive effort, we recommend prioritizing and focusing on 3 to 5 categories to start and gradually building out data collection and enhancing disclosure in future reporting years.		

Figure 2.7. Scope 3 Categories' Applicability to Re-Nuble. (GHG Protocol)

e. Recommended Priority Areas

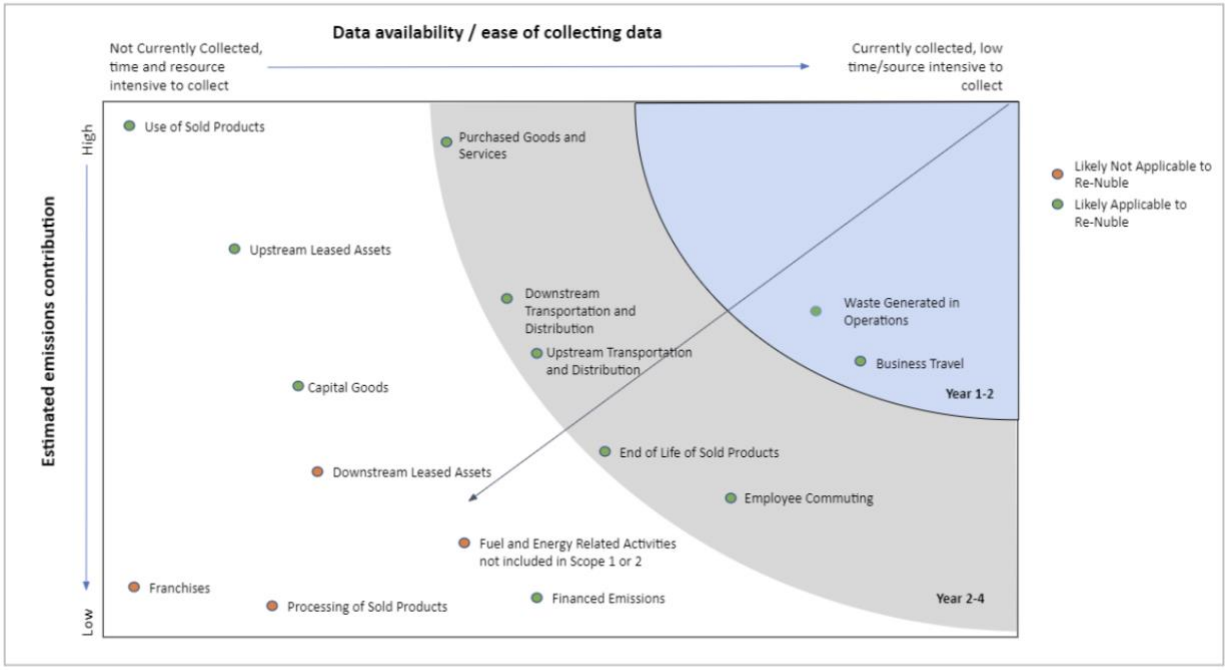


Figure 2.8. Priority Matrix of Scope 3 Categories. (The Capstone Team)

We conducted an initial priority assessment based on data collected and provided during the summer capstone project. However, we recommend Re-Nuble undertake its own assessment by bringing together and interviewing relevant stakeholders (i.e., customers, employees, suppliers, vendors, distributors, shareholders, investors, executive leadership, industry associations, etc.) to fully assess and determine priority topics to the company. This matrix should be refreshed on an annual basis to ensure it is still representative of the business activities and data availability.

While the matrix above may look like a materiality matrix at first glance, this is a visual aid designed to depict our initial assessment of Scope 3 categories, their relevance to Re-Nuble, their perceived contribution to future emissions inventories as well as the perceived ease of data collection.

The X axis (left to right) represents data availability or ease of collecting data, from most time and resource intensive to collect on the left, to least time and resource intensive to collect (right). The vertical axis (top to bottom on left side) represents the estimated[xvii] emissions contribution of each

Scope 3 category to Re-Nuble's total GHG footprint from High (top) to Low (bottom). The blue quarter circle represents recommended priority areas for years 1 and 2 in Re-Nuble's GHG reporting journey. As Re-Nuble establishes enhanced data collection practices, we recommend reporting on the additional categories in the gray quarter circle in years 2-4. Green dots accompanying a Scope 3 category denote that based on data collected during the summer capstone project, the category is 'likely applicable' to Re-Nuble. The orange dots accompanying Scope 3 categories denote that based on our initial assessment, the category is likely irrelevant to Re-Nuble. Note that the 'likely applicable and 'likely not applicable' are based on the capstone team's initial data collection and are subject to change as Re-Nuble enhances data gathering processes and further builds out its value chain.

f. SASB Mapping

Another useful tool for Re-Nuble to assess materiality is the Sustainability Accounting Standards Board (SASB). This is a reporting framework that helps organizations identify sustainability issues that have a financial impact. Under the SASB standards there are two categories that Re-Nuble could possibly fall under: Agricultural Products or Chemicals. Agricultural Products are considered to be items involved in the processing or producing of agricultural commodities. The Chemicals category includes agricultural chemicals such as fertilizers and agricultural biotechnology.

Figure 2.9 demonstrates all the material topics according to SASB. In yellow are the topics relevant to Agricultural Products, in blue are the topics relevant to the Chemical category, and in green are the overlapping topics relevant to both. Since Re-Nuble could possibly be either of these categories, we recommend our client pay particular attention to the green, overlapping sections. These topics are greenhouse gas emissions, energy management, water and wastewater management, and employee health and safety. Notably, this project helps our client in the three environmental topics relevant to both categories.

Key
Only Agricultural Products
Only Chemicals
Relevant to Both Categories
Less Relevant to Both Categories

Environment	Social Capital	Human Capital	Business Model & Innovation	Leadership & Governance
GHG Emissions	Human Rights & Community Relations	Labor Practices	Product Design & Lifecycle Management	Business Ethics
Air Quality	Customer Privacy	Employee Health & Safety	Business Model Resilience	Competitive Behavior
Energy Management	Data Security	Employee Engagement, Diversity & Inclusion	Supply Chain Management	Management of the Legal & Regulatory Environment
Water & Wastewater Management	Access & Affordability		Materials Sourcing & Efficiency	Critical Incident Risk Management
Waste & Hazardous Materials Management	Product Quality & Safety		Physical Impacts of Climate Change	Systemic Risk Management
Ecological Impacts	Customer Welfare			
	Selling Practices & Product Labeling			

Figure 2.9. Materiality comparison between the categories of Agricultural Products and Chemical. (SASB)

g. Other Options

Given the complexities of calculating Scope 3, the WRI, GHG Protocol, and Quantis have teamed up to provide a free, simplified and online Scope 3 calculator. Although the tool is based off of the GHG Protocol, it is a simplified and high-level version, and the outputs should not be taken to have been assured to be in accordance with the Scope 3 standard without a deeper assessment.

It is, however, a great starting point for companies who have not conducted a Scope 3 inventory before. Using industry averages and high-level estimates, the tool is able to

estimate emissions of certain activities based on procurement spend/data, rather than granular-level/cradle-to-grate emissions for a particular item or activity (which many companies do not have readily available). For companies who lack supplier-specific or other Scope 3 activity data, the tool serves as an excellent starting point building block to further evolve and enhance Scope 3 data collection and reporting in future reporting years.

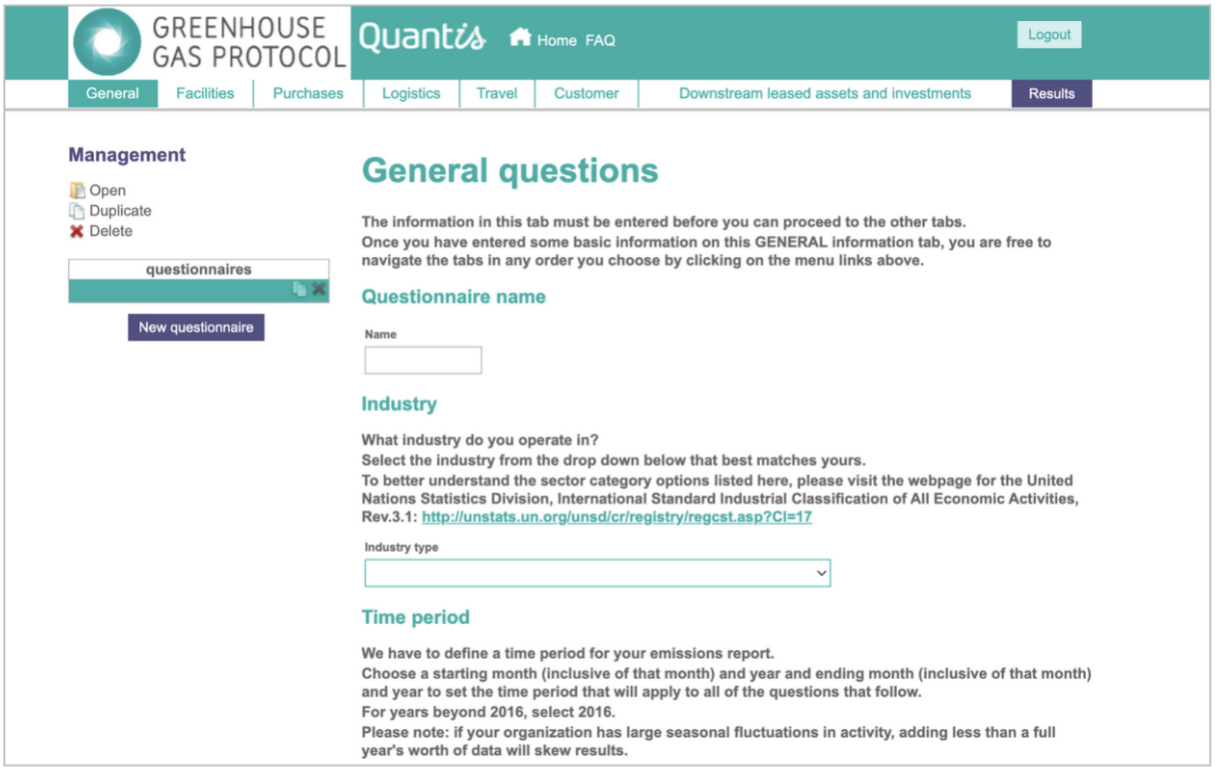


Figure 2.10. Scope 3 Evaluator (GHG Protocol and Quantis)

Link to Tool: https://quantis-suite.com/Scope-3-Evaluator/

h. Emissions Intensity of Products

Most companies who report emissions intensity metrics do so to avoid misinterpretation of emissions for durable and long-lasting products which typically have higher lifetime/use phase emissions. Re-Nuble's products are not designed to have a long lifespan (as they are bio-based). However, in an effort to differentiate their product from industry peers who claim their products are 'green' or are 'low-emissions,' Re-Nuble may be interested in calculating emissions intensity of its products to allow for comparison between its own products (for internal development and emissions reduction improvement over time) as well as to encourage further disclosure by industry

peers and differentiate themselves in the marketplace.

The first step in calculating emissions intensity metrics is to decide a relevant unit of measure. Examples of emissions intensity metrics include kg CO2e per 330 ml can (for a can of soda), kg CO2e per wash cycle (for washing machine), kg Co2e for one hour of watching TV (television) or kg Co2e per mile driven (car).

In Re-Nuble's case, we recommend a unit of measurement related to food production on either a per weight basis or a per crop basis. For example, the kg CO2e from the amount of product needed to produce one head of lettuce, or the kg CO2e per mass or volume of one unit of the product. Per crop estimates may be difficult as the efficacy of indoor growing often depends on other factors besides nutrient type/amount (i.e., lighting, irrigation, air filtration quality, temperature controls, etc. can all influence grow efficiency and crop yield). However, if Re-Nuble's products were more mass-efficient (i.e., less mass of Re-Nuble's product needed to grow one head of lettuce compared the mass needed of its competitors' products), Re-Nuble's product would have a lower emissions intensity.

If the amount of nutrients and grow media needed were consistent with competitors on a mass or volume basis (i.e., a head of lettuce would need roughly the same amount of Re-Nuble's product or a competitor's product to grow sufficiently), then using an emissions intensity metric of kg CO2e per gram of product would be a more useful basis for comparison. Ultimately, a mass or volume based unit of comparison would be less time and resource intensive than having to account for the complexities of variations in product needed per equivalent amount of crop growth in calculations.

We recommend a mass or volume based emissions intensity metric for GHG emission intensity calculations. One of Re-Nuble's clear differentiating factors is that its products produce less harmful chemicals compared to typical fertilizers or mineral salts. However, from a GHG emissions inventory standpoint, this sort of analysis will not be captured. For this level of granularity, we would recommend a complete cradle-to-grave LCA be conducted including impacts from product use and disposal, and assessing eco/marine-toxicity and chemical release impact categories. GHG emissions inventories are typically not granular enough

to capture toxicity impacts of nitrogen and phosphorus pollution (i.e., damage to waterways, environment, runoff, algal blooms, etc.) as they are only capturing GHG emissions, rather than total environmental impact.

3. FUTURE TOOL INTEGRATION AND RELEVANT RESEARCH

Information presented in this chapter is part of Re-Nuble's original requested deliverables; in addition to and Environmental Impact Measurement Tool, the client requested that the capstone team explore possibilities for integration of the Tool with their manufacturing software, MRPeasy, as well as research various environmental business certifications and current New York climate targets.

a. Integration of Re-Nuble's Manufacturing Software and Environmental Impact Measurement Tool

were two additional advantages which drove the client's request to explore integration options.

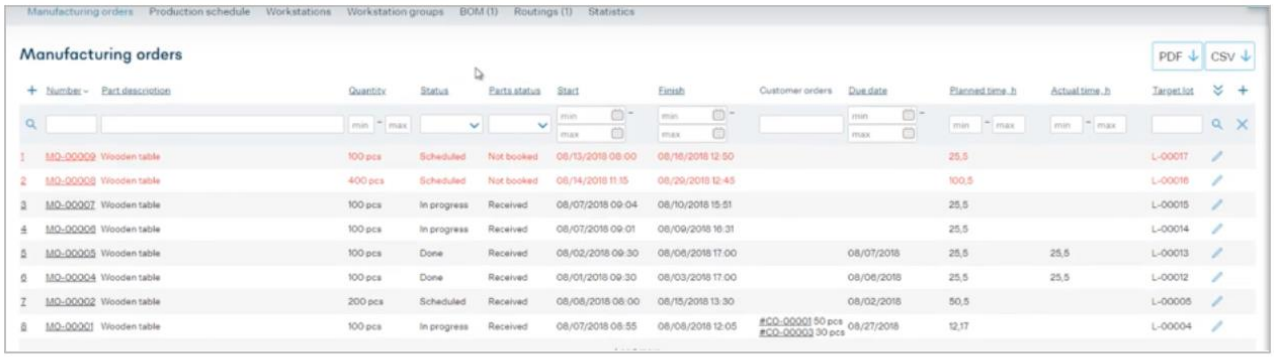


Figure 3.1. Production Planning and Manufacturing Management in MRPeasy. (MRPeasy.com)

In the original deliverables request, Re-Nuble expressed interest in integrating the Environmental Impact Measurement Tool with their manufacturing software, MRPeasy. The need for such an integration stemmed not only from Re-Nuble's desire to seamlessly quantify the environmental footprint of every stage in the manufacturing process, but also to clearly communicate to stakeholders, partners, and investors the advantages of each phase in their unique sourcing and production methodology.

The option of leasing to other MRPeasy users and clients the IP associated with the integrated tool as well as owning the aggregated data from the actual integration

i. MRPeasy Background

MRPeasy is a cloud-based self-service enterprise resource planning (ERP) and material requirements planning (MRP) software that enables small manufacturers and distributors (10-200 employees) businesses to plan and execute production. On-site manufacturing managers and company leadership are able to utilize MRPeasy for accurate production planning and reporting, real-time inventory overview, delivery management, and to ensure seamless communication across the organization, from sales, production, and warehousing, to procurement, administration, and finance.[xviii]

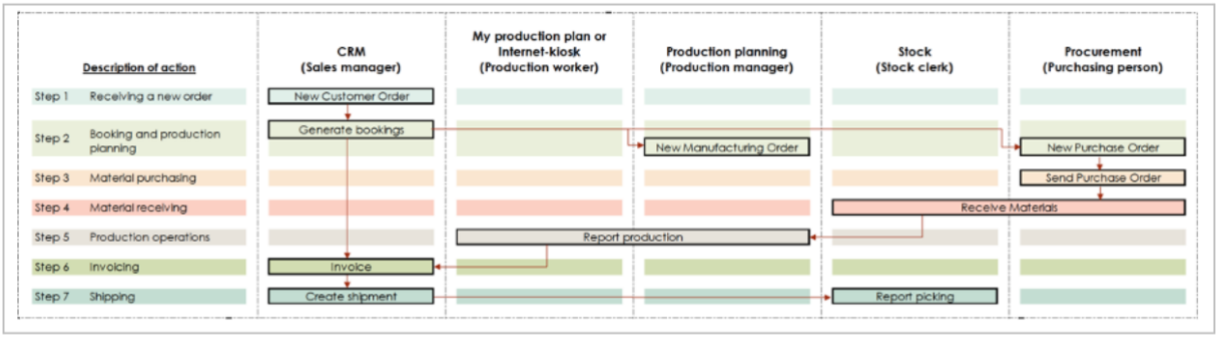


Figure 3.2. Typical MRPeasy workflow for managing sales orders. (MRPeasy Testing Manual)

MRPeasy is not only meant for the management or leadership but based on specific permissions granted to employees all departments in the company can leverage the software in order to make educated decisions in real-time based on sales, movement of stock, and production capabilities:

With a 'drag and drop' system, the software's Gantt Chart and manufacturing calendar can easily be customized and adapted to the specific needs of employees across the organization. The software tracks inventory and can inform the organization, from warehouse to production-floor and sales, on stock movements and optimized stock levels (in order to avoid shortages).

For customer relations management (CRM), sales teams can use MRPeasy in order to calculate and send out quotes or invoices and prepare, dispatch, and track shipments. The software can also be used to manage purchases or vendors and for accounting.

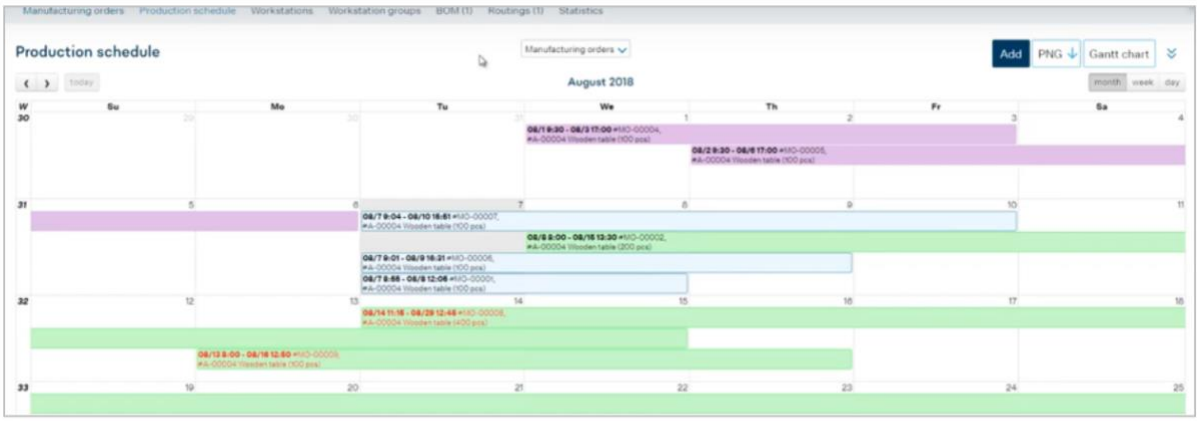


Figure 3.3. Gantt Chart for Overall Production Planning and Manufacturing Management in MRPeasy. (MRPeasy.com)

MRPeasy is used on a PC or mobile app. Most data can be manipulated and changed similarly to an Excel sheet and be exported as .xls and .csv files or accessed via API (programmatic integrations), though these capabilities are limited.

After researching the software, communicating with a number of representatives from MRPeasy, and meeting with the client about workflow possibilities, the capstone team established that while entering GHG emissions into MRPeasy manually for each workstation is possible, it currently cannot track or calculate GHG emissions.

ii. MRPeasy's Current API Capabilities and Explored Solutions

Throughout the process, the capstone team consulted four expert software engineers, programmers, and application developers that are also familiar with the climate space in order to accurately assess the viability of integrating the environmental impact tool and MRPeasy.

iii. Current API Capabilities

Though MRPeasy has some built-in capabilities for integrations with other software, apps, or services like Amazon, Dropbox, Google Drive, Salesforce, and QuickBooks integration is often limited and not customizable. I.e., though MRPeasy can communicate with Microsoft's OneDrive, data extraction at a level needed for the environmental tool to be accurate is not possible: *"MRPeasy allows attaching files to various documents and objects from external cloud storage. The files could be used for displaying the company logo on documents, attaching drawings and images to items […] attaching certificates to stock lots, attaching work instructions to routings, etc."*[xix]

The capstone team together with the consulted experts concluded that utilization of existing communication services software to connect to the environmental impact tool is not possible. Therefore, other interfaces are needed to be explored.

b. Solutions and Creating a Customized Lightweight Script

i. Dodo

Our group first searched for established methodologies or web user interfaces in order to locate existing *plug-and-play* solutions that can be adapted to extract information to and from the

environmental impact tool and MRPeasy. Dodo, an early-stage London-based startup that can utilize data from accounting software like QuickBooks in order to assess the carbon footprint of an organization was identified.

The option for a collaboration between the capstone and Dodo seemed extremely promising as the firm knows the climate space and understands the value of creating a GHG inventory while also having the programming knowledge and capacity to create the integration. Further driving this option is the fact that Re-Nubble uses QuickBooks as its accounting software and plans to connect it with MRPeasy in the future.

After a number of communications and meetings, the Dodo team's early assessments speculated that adapting their application to fit the needs of the project is possible. However, despite an encouraging start, the Dodo team decided to pass on the opportunity, not only due to a lack of internal resources, but mainly because of their application's inability to extract information from MRPeasy and integrate with a tool that precisely quantifies GHG emissions:

- Dodo can only pull data out of QuickBooks and cannot feed data into it. Therefore, Dodo cannot communicate with the Tool or MRPeasy.

- Along with the UK's Department for Environment, Food and Rural Affairs (DEFRA) and Department for Business, Energy and Industrial Strategy (BEIS) conversion factors Dodo implements the GHG Protocol's spend-based method to estimate an organization's Scope 2 and 3 emissions by pulling line items for purchased services and goods that appear in the accounting software.[xx] Therefore, the application cannot be used to calculate direct emissions or for a manufacturing company like Re-Nuble

ii. Final Solution and Next Steps for Tool MRPeasy Integration

Though a number of "workarounds" and solutions were hypothesized and explored by the other consulting engineers, most of them were deemed too "fragile," complicated, or costly, for Re-Nuble to use on a regular basis. Some of these ideas included writing a code that could work with MRPeasy's csv capabilities or creating a cloud-based landing page with an integrated dashboard. While the former would be extremely tedious as the user would have to manually copy and paste cells in precise locations every time when using the Tool, the latter would be extremely costly and complicated to create and costly to execute.

A software engineer who analyzed MRPeasy's API and who sat in a number of meetings with the capstone team and Re-Nuble, devised an optimal solution that would be economical and technically feasible. By creating a script (lightweight computer program), the environmental impact tool would be able to extract specific information from MRPeasy. The script would then be able to quantify a specific environmental footprint per stage and per category.

Additional advantages of the script include that it would be easy to use, wouldn't require high computing power, and could be installed on a simple laptop. Furthermore, since the problem is not a novel one and since the Environmental Impact Measurement Tool implemented standard GHG emission calculation methodologies, the engineer estimates that by tweaking existing *off-the-shelf* software a seamless integration can be created in less than two work days.

Since Re-Nuble has not yet created a full workflow on MRPeasy, an integration that would satisfy the Environmental Impact Measurement Tool could not be programmed. Once Re-Nuble finalizes its manufacturing process and can

provide access and data, it should contract the recommended engineer in order to write the script and finalize the integration.

Though we had to leave this portion of our work to rest here, we are pleased to offer Re-Nuble yet another capability when they are ready for it.

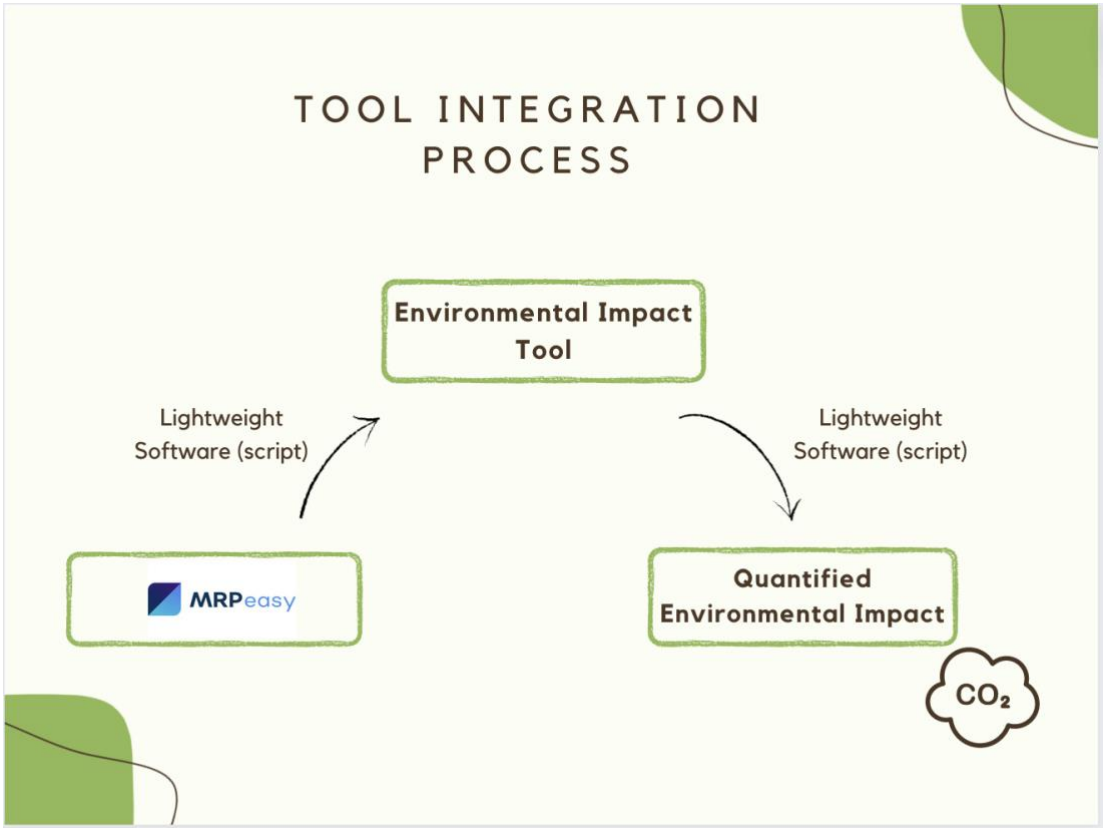


Figure 3.4. Tool Integration Process Map. (The Capstone Team)

c. B Corp and Other Certifications

B Corp certification is a comprehensive impact assessment organized as governance, workers, community, environment, and customers. It aims to provide evaluation, benchmarking, and material management issues to stakeholders. B Corp certification is available to any for-profit business worldwide if it has been operating for at least 12 months. Certification is initially self-assessed, intending to maintain the profit-driven focus of the company. To be included in the B Corp Directory, a company must complete an impact report comprising five categories and score a minimum of 80 out of 100 points. The certification can attract staff and consumers seeking socially responsible businesses, boost an established public company's stock price, and help investors find companies that balance profit and purpose.

i. Re-Nuble's Interest in B Corp, Why It Doesn't Connect to Our Work

Our work aimed to assess Re-Nuble's interest in B Corp certification and the connection to GHG emissions requirements. Our team used the B Corp impact assessment to understand the GHG reporting requirements. The impact assessment has a section for Air and Climate questions. They are all multiple choice, and more points are given depending on how advanced (or "better") the answers are for each given section. The questions pertain to energy use, GHG emissions management, supply chain and distribution, and carbon offset practices. Our work aims to create an Environmental Impact Measurement Tool, a baseline inventory, and provide specific recommendations to reduce Re-Nuble's impacts. Since environmental impact is not significantly measured in the B Corp certification process, our deliverables do not fully align with the B Corp certification attainment.[xxi]

Re-Nuble has previously expressed interest in becoming a certified B corp. This certification is often seen as the 'gold standard' in overall environmental, social, and governance performance brand recognition. It should be noted that the environmental section of the B Corp impact assessment has multiple questions surrounding emissions tracking and environmental impact measurements. However, this tool alone will not guarantee that Re-Nuble will meet the requirements to be certified as a B Corp. Our tool will provide Re-Nuble with a baseline understanding of

their environmental impact and how to move towards being as sustainable as possible. Despite our tool being a helpful step in the process of a B Corp certification, there are many other steps outside of sustainability that B Corp requires for certification.

Assurance and verification are common last steps when completing or publishing a GHG inventory or sustainability report. Regarding the B Corp certification, assurance, or verification of the GHG inventory is not required.

ii. True Zero Waste

The TRUE Certification is a zero-waste certification through GBCI (Green Business Certification Inc.).[xxii] TRUE helps businesses establish an in-depth waste inventory to understand the types of waste and disposal methods used. This certification would be very beneficial to Re-Nuble if they were to pursue it in the future.

By establishing an official waste inventory, Re-Nuble would be able to monitor and reduce waste outputs from its manufacturing facilities on a company-wide scale. This would also help increase Re-Nuble's overall waste diversion rate. However, their wastewater diversion rate (through impressive water reclamation techniques) is relatively high, the TRUE certification would establish the necessary means to increase the solid waste diversion rate. Eventually, with the TRUE Certification, Re-Nuble would divert all solid waste from landfill and incineration disposal methods.

iii. Certification and Reporting Standards Table

The four reporting standards and initiatives that appear in Figure 3.5 are arguably the most well-known in the sustainability industry at the moment. It is critical to understand the main standards when assessing how Re-Nuble can move forward with sustainability certifications and disclosures in the future.

GRI	The Global Reporting Initiative (GRI) was the first international standards framework, which focuses on global best practices for sustainability. There are three "universal standards" through GRI that organizations can complete in addition to specific "topic standards," as applicable.[xxiii] GRI tends to cover the environmental, social, and economic impact of the organization.

CDP	The CDP is a very granular questionnaire that currently has three sections: Climate Risk, Forests, and Water Security.[xxiv] The questionnaire tends to focus on the topics of greenhouse gas emissions, forest management and protection, water use, and energy consumption. Once completed, the CDP provides a grade to companies to assess their environmental and climate impact.
SASB	The Sustainability Accounting Standards Board (SASB) has published a set of 77 sustainability standards, which are globally applicable, yet industry-specific.[xxv] These standards tend to focus on dimensions of sustainability, including human and social capital, business innovation, leadership and governance, and the environment.
CDSB	The Climate Disclosure Standards Board developed frameworks including a foundation for the Task Force for Climate-Related Financial Disclosures (TCFD). In 2021, they announced that it would also be forming a new International Sustainability Standards Board (ISSB). TCFD and ISSB both tend to focus on climate risks and how these considerations are included in business strategies.[xxvi]

Figure 3.5. Comparison of Reporting Frameworks. (The Capstone Team)

iv. What Is Their Competition Doing? How Can Re-Nuble Be Different?

As part of our efforts, our work aimed to assess competitors or similar companies in the space to understand what Re-Nuble's peers are doing. As part of the industry research, as seen in Figure 3.6, we were looking for companies with published information on their sustainability performance, GHG inventories, and certifications. We looked at other companies producing hydroponic nutrients, companies using food waste as feedstock, and mineral salt providers.

Name	Description	Sustainability and Certifications	Disclosures
AgroThrive Organic Bio-Fertilizers	Fast-acting liquid organic fertilizers that have undergone the digestion process prior to application (Progressive Digestion Process).	• The Progressive Digestion Process (PDP) makes the products fast-acting, cutting 2 to 6 weeks out of the organic growing process. • OMRI • CDFA • WSDA	N/A
Netafim (Orbia)	Netafim (an Orbia company) produces irrigation systems, filters, digital farming technology, and other agricultural services. However, Netafim does not manufacture	• Follows the Global Reporting Initiative Principles • Is aligned with the UN's Sustainable Development	Orbia submitted to the CDP on behalf of all subsidiaries. They received a B-score on Climate in 2021.

	growing media or nutrients.	Goals	
BioBiz	Produces and exports organic fertilizers and agricultural materials such as microorganisms mix, boosters, activators, and soil substrates.	• Certified EU organic input • Clean Green Certification • Point Vert (Sustainable Packaging Certification) • OMRI Listed for Organic Use	N/A
Gaia Green Organics	Provides soil management solutions such as organic fertilizers and natural soil amendments. Products include worm castings, soluble seaweed, mined minerals, and more.	• Some products are certified Organic Inputs in Canada • No added pesticides or synthetic fertilizers	N/A
Aerofarms	Aerofarms is a vertical farming company that grows over 550 different fruit and vegetable products. Through their farming practices, they have established over 250 invention disclosures from their innovative growing systems.	• B Corp certified • Aligned with the UN's Sustainable Development Goals • Ethical Corporations award-winner • First agricultural company honored in the Circular Economy 100 by Ellen MacArthur Foundation	N/A
ENVIROKURE	Biostimulant/fertilizer from chicken excrement. Patented and aqueous composting technology extracts nutrients and microbes from chicken manure. Can be used in traditional soil based farms and hydroponics.	N/A	N/A
Pre-Empt	Developed for recirculating nutrient film technique (NFT) crops including lettuce, leafy greens, basil and other herbs. Testing has proven Pre-Empt to be a suitable hydroponic fertilizer for nearly all crops without any additives.	N/A	N/A
Sensational Solutions	Uses blends of natural ingredients in a micronization process to produce fertilizers that are concentrated, more efficient, fast acting, and easy to use. All products can be applied	• EnvirOganic	N/A

	through sprayers and emitters, watered in, mixed into the growing medium, or added to aerated teas.		
Growers Secret - Organic Earth Emulsion	Products include organic fertilizers like liquid nitrogen, seaweed powder soluble, granules, and more. Earth Emulsion is double screened through 200 micron filters, so it will not clog systems (drip irrigation emitters, pivot, tractor sprayers, aerial sprayers or back pack sprayers).	• OMRI Listed for Organic Use • B Corp • CG Responsible Agriculture • CDFA Registered Organic Input Material	N/A
Sierra Natural Science - 604A Root & Stalk Fertilizer	604A & B are fertilizers with concentrated blends of primary nutrients, blended with distilled radish and marine extracts. 604A & B enhance metabolic growth, promote root and flower development, encourage fruit swelling, and facilitate essential oil production. They also encourage beneficial microbial activity in the root zone.	• National Organic Program Certified • OMRI Listed for Organic Use	N/A

Figure 3.6. Comparison of Re-Nuble's Competition. (The Capstone Team)

When analyzing Re-Nuble's competition, we found that very few, if any, companies in the CEA or hydroponic space had public GHG or climate-related disclosures. However, as seen in the Competition Table (Figure 3.6), Orbia (on behalf of the subsidiary Netafim) reported to the CDP in 2021. In the Climate Questionnaire from that year, Orbia received a B score. It should be noted that Netafim does not produce products that are made from food waste as Re-Nuble does; they do, however, make up a large space in the agricultural systems sector, producing primarily digital farming technology, precision irrigation products, and water meter systems.

Though other organizations hold certifications or are aligned with the UN Sustainable Development Goals, there were no other organizations that had publicly available GHG disclosures. Several other organizations hold "green" or organic certifications, such as OMRI and CDFA Registered Organic. Aerofarms and Growers Secret are also B Corp certified. No other

organizations were listed as TRUE Zero Waste Certified.

d. Relation to Local Region and Existing Policies

To ensure Re-Nuble understands their role in regional climate efforts, our client should stay up to date with the most recent local climate targets and legislation. In recent years, New York City has addressed climate change through impressive legislation and climate goals. In September 2014, Mayor Bill de Blasio announced a goal of reducing NYC's greenhouse gas emissions by 80% by 2050. However, in June 2017, President Trump announced his intention to abandon US leadership on climate change, and withdrew the United States from the Paris Agreement. In September of 2017, the City increased its ambition by targeting carbon neutrality by 2050 and committing New York City to the principles of the Paris Agreement. The result was the creation of a plan to set the path to achieve the goal of the Paris Agreement to limit temperature rise to 1.5 degrees Celsius.[xxvii]

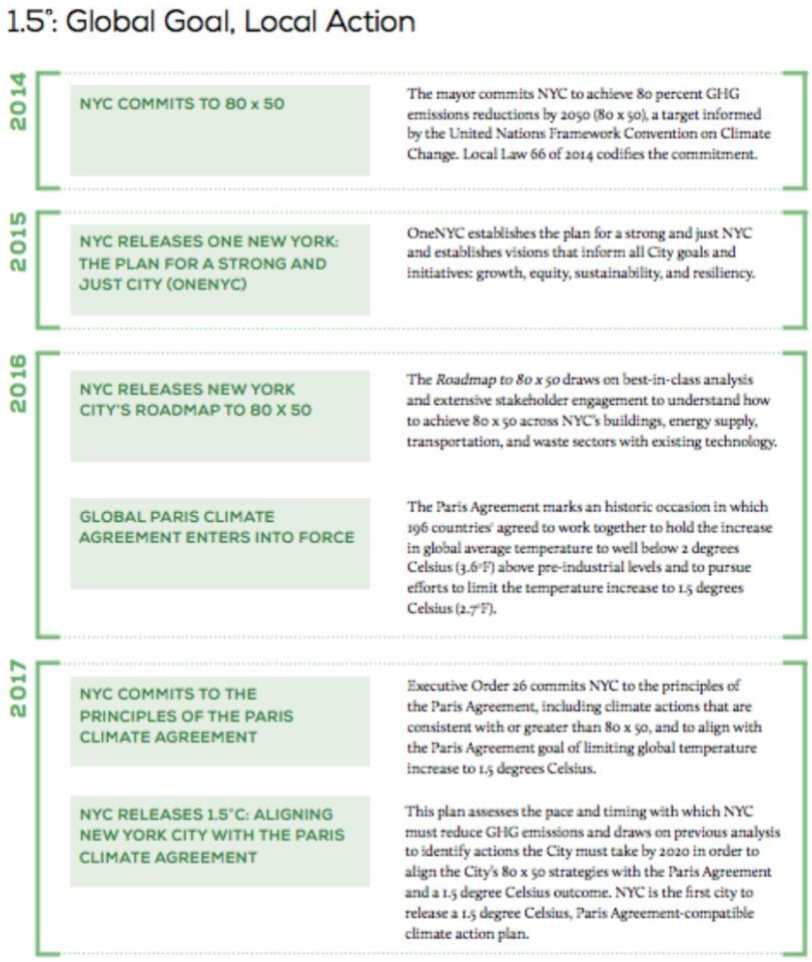


Figure 3.7. New York City's evolution of climate commitments. (NYC Mayor's Office of Sustainability)

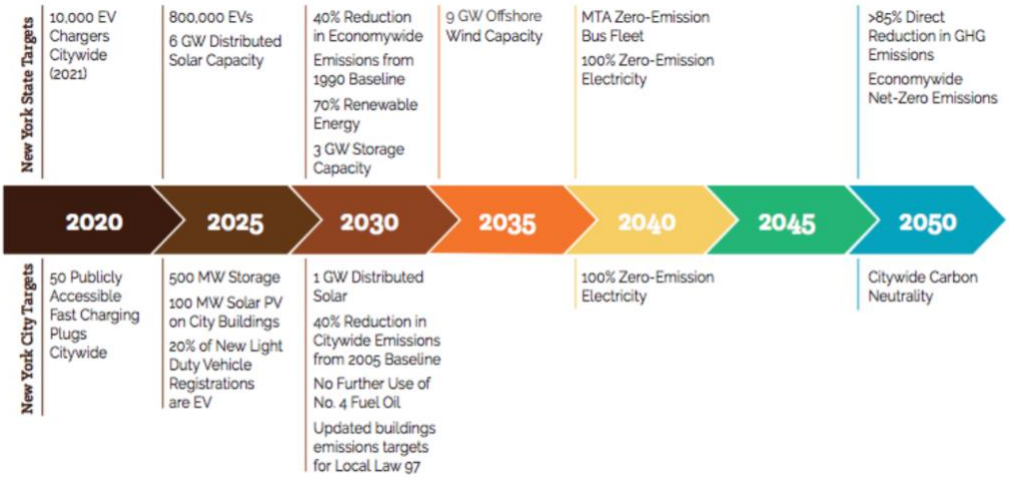


Figure 3.8. Climate Policy Timeline in NYC and NY State. (The City of New York)

A study conducted in April 2021 by NYC's Mayor's Office of Sustainability (MOS), Con Edison, and National Grid found that the City's and New York State's current policies offer a solid framework for climate progress; the current policies indicated in this study's Policy Reference Case are projected to lower emissions by more than 40% by the middle of the century. By taking additional measures (referred to in this study as emissions reduction pathways) to modernize New Yorkers' energy use, rethink the function of existing energy infrastructure, and work toward carbon neutrality, NYC can continue to support this clean energy transition and achieve direct emissions reductions of 80% or more (as shown in Figure 3.8). It will take constant innovation, cutting-edge technology, and premium offsets to achieve carbon neutrality by 2050. The study emphasized the need for the involvement of decision-makers, entrepreneurs, utilities, financiers, building owners, and others to realize the city's full potential for dramatic change.[xxviii] We found this work relevant to our client as they are not only headquartered in New York City but they operate their production facility from the State of New York as well.

Figure 3.9 indicates the additional strategies needed to achieve net zero by 2050.

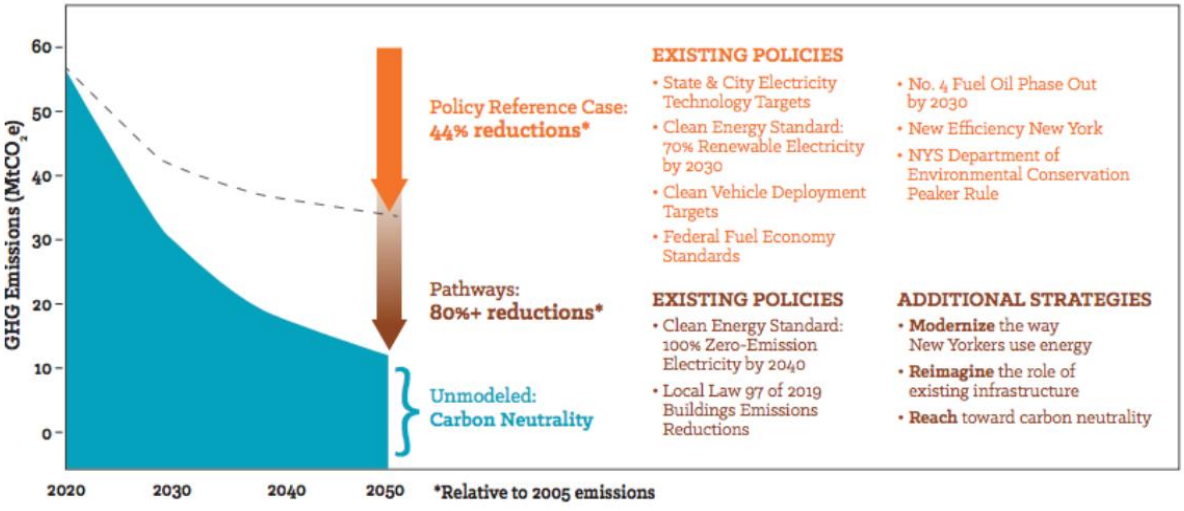


Figure 3.9. Existing Policies and Additional Strategies Required for Deep Decarbonization. (The City of New York)

There are some essential areas that companies like Re-Nuble should be focusing on to advance with the City's targets: energy efficiency upgrades in buildings and transportation, adoption of light-duty zero emissions vehicles "ZEVs" and electric buses, reduction in the use of personal cars, and a goal of 100% zero-emission power by 2040.

We highlighted some relevant areas and specific solutions which are more related to the company's operations and thus should be prioritized in setting their climate and net-zero targets.

i. Energy

- Energy efficiency upgrades and electrification of heating systems.
- Better-performing equipment.
- Explore distributed energy resources such as solar photovoltaics (PV) combined with battery storage, standalone building scale, or thermal storage.
- Using gas-fired systems in a fraction of the facilities.
- Dual fuel heating systems, maintaining gas-fired heating systems in facilities that retrofit with electric systems. These buildings would operate with electric heating systems but use the gas-fired systems during electric peak load hours.
- Managed vehicle charging by encouraging charging when electricity demand is low.

ii. Transportation

- Personal vehicles, predominantly located in outer boroughs, need to be rapidly replaced by ZEVs.
- Reducing private vehicle usage and replacing gasoline vehicles with more than 1.5 million battery electric vehicles and some plug-in hybrid electric vehicles.
- Medium-duty vehicles (MDV) and heavy-duty vehicles (HDV) can depend on electrifying or increasing low carbon fuel availability.
- Routes planning and other technologies that decrease vehicle usage and improve efficiency.

iii. Waste

- Measure and set targets for landfilled waste, wastewater treatment, biological treatment, and any waste-related sources.

e. Greenwashing in the Industry

According to Oceanic Global, greenwashing is the misrepresentation of information to falsely represent environmentally responsible practices or behavior.[xxix] Companies like Nestle, Coca-Cola, and IKEA have been called out for such practices.[xxx] Greenwashing exists in all spheres of sustainability and environmental action. Not only is it rampant in the fashion and waste industries, but it also occurs in government and throughout the private sectors. Once a company is publicly labeled for greenwashing, it tends to be type-casted in that role until it formally commits to sustainability and provides actionable results.

Although there are no clear examples of greenwashing in the biowaste or growing industry, there are adequate examples in the plastic and composting industry. In fact, there is a subject called "Unsustainable Composting," coined by Plastics Today. As they clarified, there is a stark difference between Biodegradable and Compostable. Biodegradable refers to an item that can fully degrade but has no predetermined end-of-life. Biodegradable products will eventually disappear but could take decades to even begin the process.[xxxi] At the same time, compostable refers to an item that can fully degrade, without a trace, in just a few months in a composting environment.

Greenwashing has been a consistent issue among companies that claim to be eco-friendly. However, there are companies that have successfully maintained their "green" values. Among these big businesses are Walmart, Apple, and the tech giant Northrop Grumman. However, for startup businesses, it is more difficult to create, organize, maintain, and present data supporting sustainable goals due to a lack of manpower. One way for startups to avoid greenwashing is by engaging in green building practices. Green Building is the overarching brand of marketing that asserts a company is "green." For example, after a business claims to align with sustainability, it adds green building and marketing tactics. The Advantages of green building are that a company can enter new markets when it brings attention to positive environmental impact. They can be used to gain more profit from green marketing,

utilize green marketing to bring a competitive advantage, and raise awareness on important environmental or social issues. The disadvantages of green building is that this change can lead to costs, such as green certifications, and of course, greenwashing.

Therefore, Re-Nuble has to be mindful of potential greenwashing in their green building and development practices as a burgeoning startup. When weighing the advantages and disadvantages of green building in its attempt to grow and market itself, Re-Nuble must provide consistent, accurate, and transparent data. This simple action will mitigate the risks of greenwashing. Re-Nuble already identifies as a business which produces negative emissions. All that is left is verifying these claims through trustworthy data.

So much of the work contained in this report relates directly to avoiding greenwashing - we want to empower Re-Nuble to demonstrate its sustainability accurately. When they are able to prove and quantify themselves as the sustainable choice, they will be able to confidently speak about this part of their business without concern of greenwashing.

f. Impact Reduction Recommendations

In order to make recommendations for Re-Nuble, we should revisit the problem they originally brought to us. How can they show themselves as a more sustainable choice for indoor farmers? Much of our work has centered around building them an Environmental Impact Measurement Tool to quantify how sustainable their business is, but we also want to offer several suggestions on how they can improve these figures in the future.

There are two recommendations which could help Re-Nuble begin their impact reduction journey immediately:

First, Re-Nuble should conduct an energy audit. This would be a chance for an outside party to review various practices and pieces of equipment in the Re-Nuble production process to identify any areas where greater energy efficiency could be achieved. The most common example is “de-lamping” as the changing of light bulbs and light fixtures is a cheap way to reduce energy cost and use without great amounts of money or effort.

Second, Re-Nuble should purchase Renewable Energy Credits (RECs). While Re-Nuble likely cannot install and operate their own renewable energy infrastructure at their production location, the purchase of RECs could artificially lower their Scope 2 emissions from purchased electricity.

g. Further Steps on Sustainability Measurement and Management

Beyond the energy-focused impact reduction recommendations, we are making four longer-term recommendations that we feel will continue the work we started in quantifying Re-Nuble's sustainability.

First, we recommend that Re-Nuble take a complete inventory of all categories of Scope 3 emissions. As described in this report, Scope 3 most likely represents the largest source of Re-Nuble's GHG emissions and thus it should be quantified as soon as possible. Not only would this help Re-Nuble build an accurate emissions accounting to further drive their reduction strategy, but having Scope 3 emissions measured would tie directly to Re-Nuble's ability to write a sustainability report and submit it to authorities like GRI, SASB, etc.

Second, we recommend that Re-Nuble create and publish a could be submitted to authorities like GRI and SASB. Publishing reports with these agencies would be another way to set Re-Nuble apart from their competition in terms of sustainability superiority.

Third, we recommend that Re-Nuble pursue a True Zero waste certification. As described earlier in this report, Re-Nuble already has admirably minimal waste habits, and we believe they are well positioned for this certification. A True Zero logo included in Re-Nuble's sustainability branding would be another great opportunity to set them apart from their competitors.

Finally, we recommend that Re-Nuble conduct another LCA on its flagship product, Away We Grow. While an LCA of this product was performed in the past, it is out of date and does not reflect their current production process. This is the most important step Re-Nuble can take because there appears to be nothing stronger in their sustainability case than the fact that they use diverted food waste to make this product. Like the inventory our team created, an LCA would be a chance for Re-Nuble to quantify

their sustainability; to prove that they are the more sustainable choice.

4. CONCLUSION

a. Restate the Purpose of Project

The purpose of this project was to create four deliverables which would help our client Re-Nuble show its stakeholders with greater certainty that they are the "sustainable choice" for indoor farming products. Those deliverables are (1) the Environmental Impact Measurement Tool (2) the baseline impact inventory, (3) research and analysis to provide context, and (4) recommendations for impact reduction and further measurement and management of sustainability.

b. Obstacles and Successes

Our greatest challenge was the often evolving connection with our client. At first, this came in the form of a shifting set of goals. Then, this evolved to communication delays in data requests. By the end of our work, this challenge took the form of some last-minute game-changing discoveries about things like their production operations or how they procure their utilities. We think of this as simply the nature of working with a startup business. Their talented and kind staff is small, their employees are often pulled in several different directions at once and they might not track and organize data the way a more mature company might.

For us, being able to navigate that challenge of working with a startup with grace and flexibility was our greatest success. When some piece of information wasn't available, we found another way to get it. When we learned something which drastically changed our original understanding, we wasted no time in pivoting to a new procedure. When the client needed guidance through their field of goals to landing on a single objective, we found the way to do it with tact.

Another success was simply the way in which our team "stepped up to the plate." The project manager and two deputy project managers did a wonderful job creating a work plan and team structure, but none of this would have been a success without the full and enthusiastic adoption from the team members. For most of the semester, the class was divided into three teams and within each team, each individual class member seemed to truly find their own corner of the work; a piece of expertise to call their own.

Finally, we should point to the quality of the Environmental Impact Measurement Tool which we were able to deliver. The level of detail our group was able to create while still creating an easy to understand user

experience is a great point of pride for our group and something which we hope will serve Re-Nuble well for years to come.

C. Conclusion of findings

There are several conclusions which we can draw from our work. First, in terms of the baseline environmental impact inventory, Re-Nuble has a long way to go before their collection approaches "completeness." We believe further attention should be given to Scope 1 stationary emissions, regardless of which part (owner or lessee) has true responsibility for these emissions. Additionally, there are at least nine other categories of Scope 3 which should be included in further inventories, as explained in detail in our Scope 3 section. The next inventory needs to pay special attention to the onsite utility generation via Red Rochester which was discovered very late in our work. Lastly, the quality of data for non-GHG environmental impact could easily be improved in the future. All the above being said, Re-Nuble appears to have an admirably low impact for a company of its size, in both emissions and waste. We do not believe they are yet in a place where they can report on or make claims about their environmental impact given the incomplete nature of their current inventory.

In terms of future integration between environmental impact tracking and their production management software MRPeasy, we learned that while this is possible, they need more time spent with this software and with the developer we worked with to find a workflow which serves their further use of this program and inventory tracking appropriately.

In terms of their competition and certifications, we learned that the sustainability measures taken by Re-Nuble's peers vary greatly. Some hold minor certifications, some have taken simple reporting measures but very few have reported a GHG inventory. We believe this is an important conclusion which can be used in the future to set Re-Nuble apart once it has a more complete inventory to share. We also believe that a TRUE zero waste certification would be an easy certification to obtain which could also help set Re-Nuble apart.

Some of the most important conclusions from our work came in the form of the recommendations we have put forth earlier in the report. In terms of impact reduction, we believe Re-Nuble should conduct an energy audit and purchase renewable energy credits.

In terms of future measurement and management, we believe Re-Nuble should (1) get TRUE zero waste certified, (2) perform a more complete environmental impact inventory, (3) Create a GRI and or SASB report or (4) conduct an up to date LCA of their product "Away we Grow."

D. How the Inventory Sets Re-Nuble Apart

In closing, we hope that our work meets the objective that we set out to accomplish. Namely, to help Re-Nuble set themselves apart from their competition; to show themselves as the more sustainable choice. Part of this comes in the form of the recommendations we've made but most importantly, it's about being a company which is collecting and preparing to share with the world an environmental impact inventory. Taking on this work for Re-Nuble felt like an honor because it was about helping a company who has always had sustainability at its core find a fresh way to highlight that for a next generation of stakeholders.


Re-Nuble

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[xvii] Note that these 'emissions contribution' for each category is only an estimate based on Re-Nuble's business model and is not based on actual data. When evaluating priority Scope 3 areas, Re-Nuble should refresh the matrix to determine if the 'most material' emissions categories are still accurate.

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6. APPENDIX

a. Environmental Impact Measurement Tool GHG Tutorial

Link or https://youtu.be/OA2CY3lrYlE

b. Environmental Impact Measurement Tool Manual Waste, Water, and Manual Tutorial

Link or https://youtu.be/C6hnhcO73l4

COLUMBIA UNIVERSITY
IN THE CITY OF NEW YORK

Re-Nuble

RE-NUBLE

ENVIRONMENTAL IMPACT MEASUREMENT TOOL

Prepared by :

MS Sustainability Management Student Consultants

Columbia University

Purpose and Summary

To understand where Re-Nuble stands in terms of **sustainability** and environmental consciousness, it is critical to assess the company's associated **greenhouse gases and environmental factors**.

Greenhouse gas and environmental inventories provide not only the company, but also its **stakeholders**, with the necessary information about how "**green**" the operations truly are. This tool quantifies Re-Nuble's operational processes, including **Scopes 1, 2, and 3** greenhouse gas emissions, **waste** outputs, and **water** consumption.

In the future, this tool can be updated as the company continues to expand and grow its operational capacity. From there, Re-Nuble can accurately **assess their environmental impact** and take the necessary actions to reduce emissions and become a **sustainable leader** within the Controlled Environment Agricultural space.

Re-Nuble®

Key elements

Tabs

There are several tabs within the Environmental Inventory Tool.

Under the **Cover Page, Instructions, and Model Architecture** tabs, you will find detailed instructions and critical definitions needed to understand the tool. This manual is meant to supplement the information found throughout the tool.

Other tabs:

- Revision Log
  - You can internally log previous revisions to the tool, open issues, and recommendations in this tab.
- Parameters
  - Basic parameters, custom emissions factors, base year data, and more can be found here.
- Emission Factors
  - Emission Factors provided by the GHG protocol can be found here.
- Scope 1 tabs
  - S1-Stationary Combustion
  - S1-Mobile Combustion
  - S1-Fugitive Emissions
- Scope 2 tab
  - S2-Purchased Electricity
- Scope 3 tab
  - S3-Transportation
- Results Summary
  - Summary data of all greenhouse gas calculations is in this tab.
- Additional Analysis
  - Quantifications of waste and water data is summarized in this tab.
- Waste
  - Quantifications of waste and a waste diversion rate can be found here.
- Water
  - Quantifications of water use/consumption and a wastewater diversion rate can be found in this tab.

***Note: There are also three "hidden" tabs, which are used as background structure for the tool:

- Dropdowns
- Conversions
- Data

You do *not* need to edit these tabs.

Scopes of Emissions

Scope 1

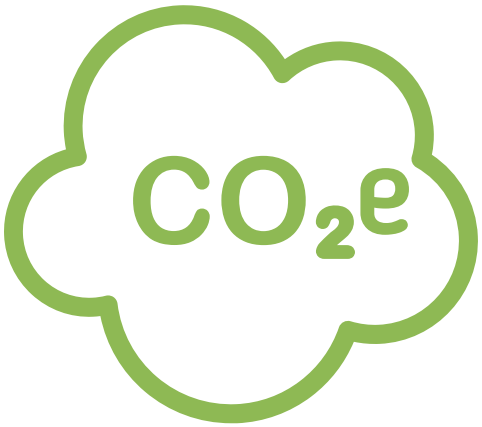
Scope 1 refers to direct GHG emissions from sources owned or controlled by the company and includes stationary combustion, physical/chemical processing, mobile combustion, and fugitive emissions. See the definition section for a definition of each of the four categories.

Scope 2

Scope 2 refers to emissions from purchased electricity, steam, heating, and cooling. Scope two emissions are primarily based on utility bills.

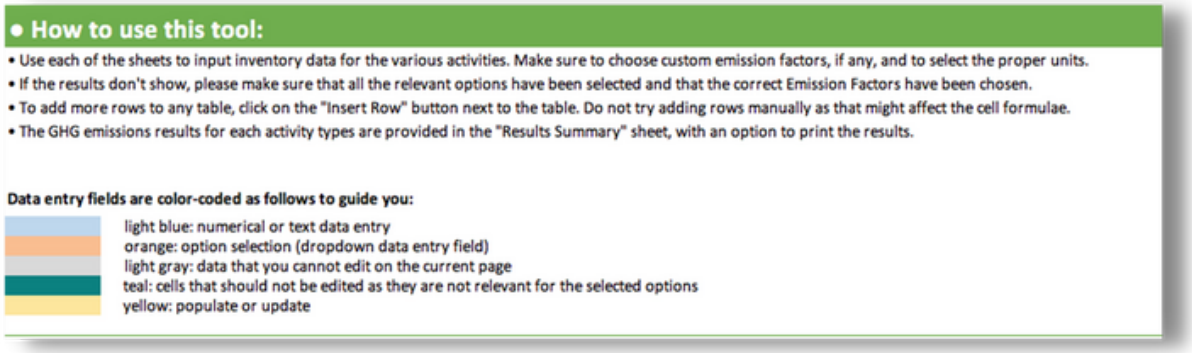
Scope 3

Scope 3 emissions are the result of activities from assets not owned or controlled by the reporting organization but that the organization indirectly impacts in its value chain. Scope 3 emissions include all sources not within an organization's scope 1 and 2 boundaries.



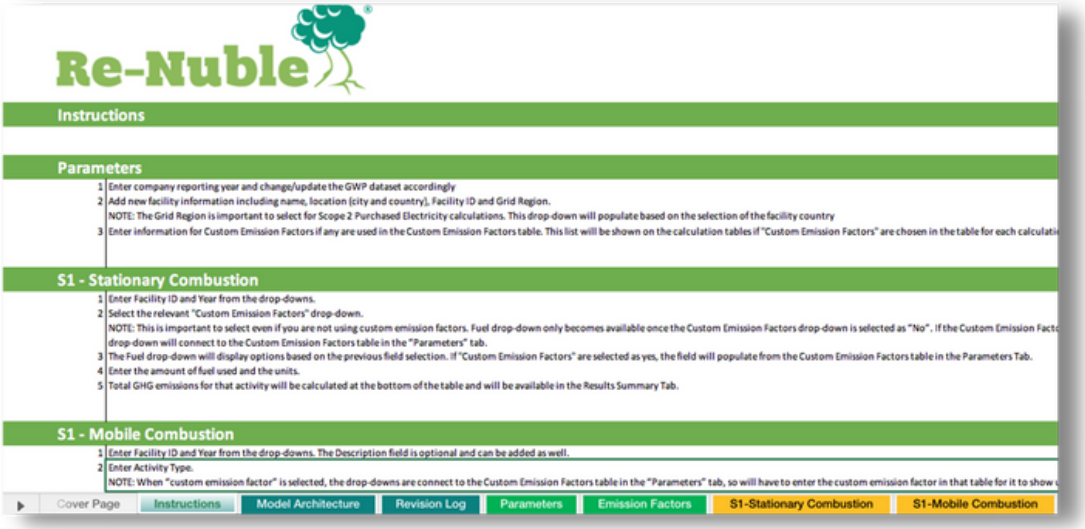
Input Navigation

As mentioned, this tool has been built so anyone can easily follow steps and input data. The **"cover page"** tab provides a general overview of how data should be input into the tool.



- **Light blue:** The ***only*** space in which data would need to be introduced manually following the category or units described in the colored cell.
- **Orange:** A dropdown menu will be displayed for the user to choose the adequate option.
- **Light gray:** Indicates that data should not be edited in the tab and usually contain coded formulas with results from the introduced data.
- **Teal:** Cells that should not be edited as they are not relevant for the selected options.
- **Yellow:** Populate or update.

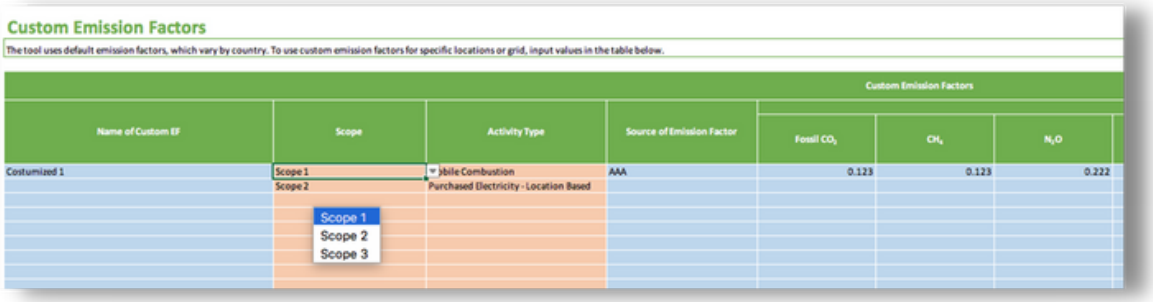
There are also general instructions on the "**Instructions**" tab.



Input Navigation

Suggested steps to input data:

1. Read the "**Cover Page**" carefully and understand color codes and the tool's scope.
2. Read the "**Instructions**" tab to learn what data needs to be selected or provided in each Scope tab.
3. Read the "**Model Architecture**" for the summary of all tabs and the whole tool.
4. "**Parameters**" is the first table that must be completed.
    - First, choose the **GWP database** to work with.
    - List the company facilities, their location, and grid region.
    - The default information is already provided in all the blue cells, but it could be modified according to any necessary changes.
    - Finally, if the company wishes to work with customized emission factors, the data can be entered under "**Custom Emission Factors**."



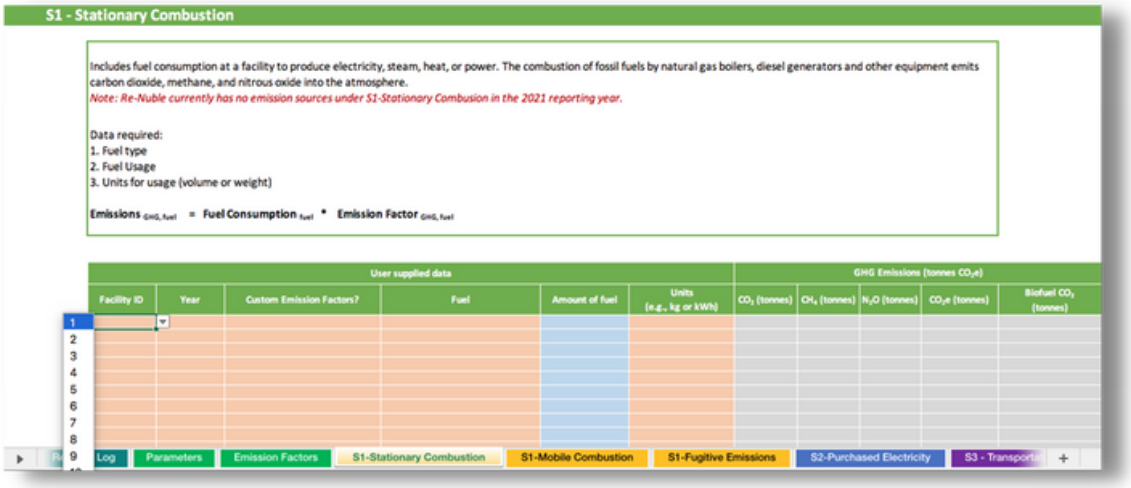
5. After introducing the parameters, proceed to fill in each emission table. Then, complete the Environmental Inventory (waste and water consumption).

6. All results for the GHG Tool will appear in the "**Results Summary**" tab. All results for the Waste and Water (Environmental) Tool will appear in the **"Additional Analysis"** tab.

Sample Scenarios

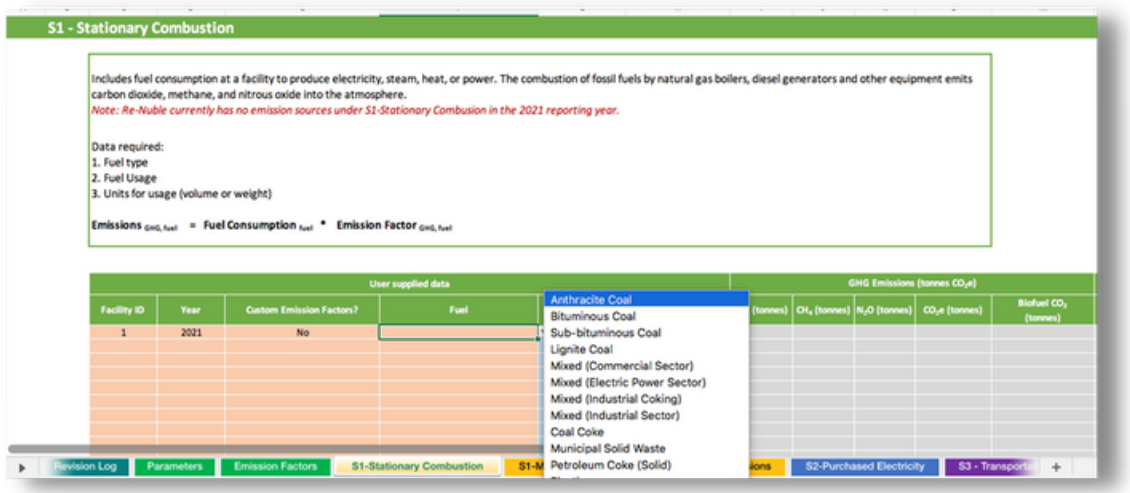
Example: “Scope 1 Stationary Combustion Emissions." Your site facility happens to produce electricity through an on-site diesel generator.

1. Select the company’s facility responsible for emissions.
2. Select the year you wish to work with.



3. Select if you wish to work with customized emission factors or the ones provided by the tool.

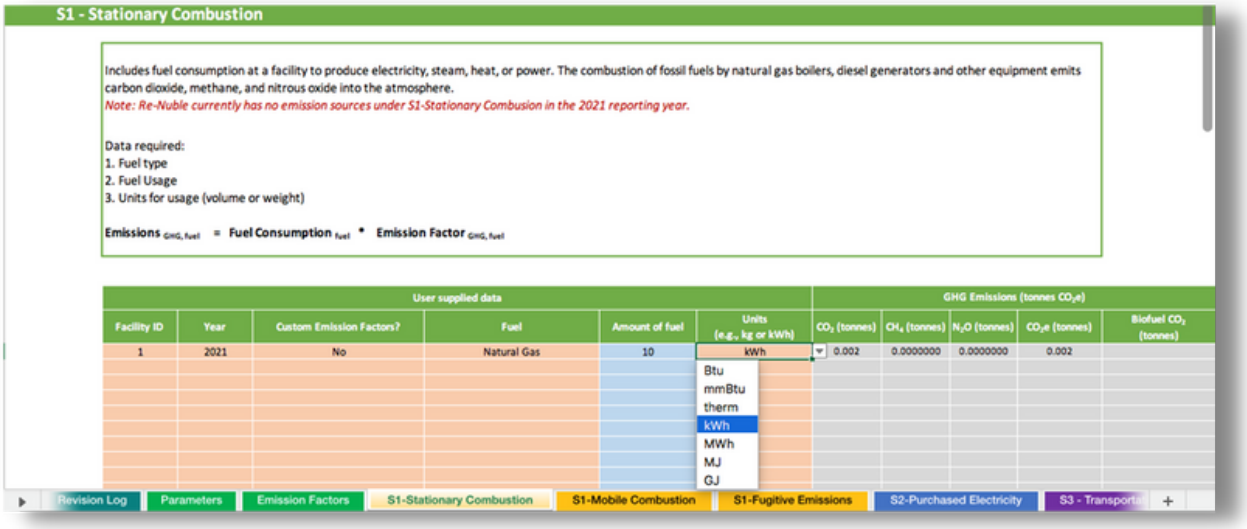
4. Select the type of fuel used to generate electricity, power, heat, or steam. (Diesel)



Sample Scenarios

6. Type the amount of fuel used.

7. Select the units for the used fuel.



8. The previous data will automatically generate the emission factor for that activity and produce the result in the "**Result Summary**" tab.

9. Continue introducing the next source of emissions for this category or move to the next one.

10. After going through the same process in each of the Scope 1,2,3 tabs, the results will be summarized in the "**Results Summary**" tab.

Waste and Water

Types of Water

Process Water: Water used in industry and manufacturing processes. It is used directly in producing a product.

WWT and Sewer: Water that is discharged and sent to a wastewater treatment facility.

Potable Water: Water utilized that is suitable for human consumption.

Reclaimed Water: Water recycled through reverse osmosis within the manufacturing boundary.

Diversion Rates

For both **Waste and Water**, Diversion rates were calculated by dividing the total recycled, reclaimed, or reused materials by the total waste produced.

Types of Waste

Waste Landfilled: Materials sent to the landfill for disposal, without any type of reuse or recycling involved.

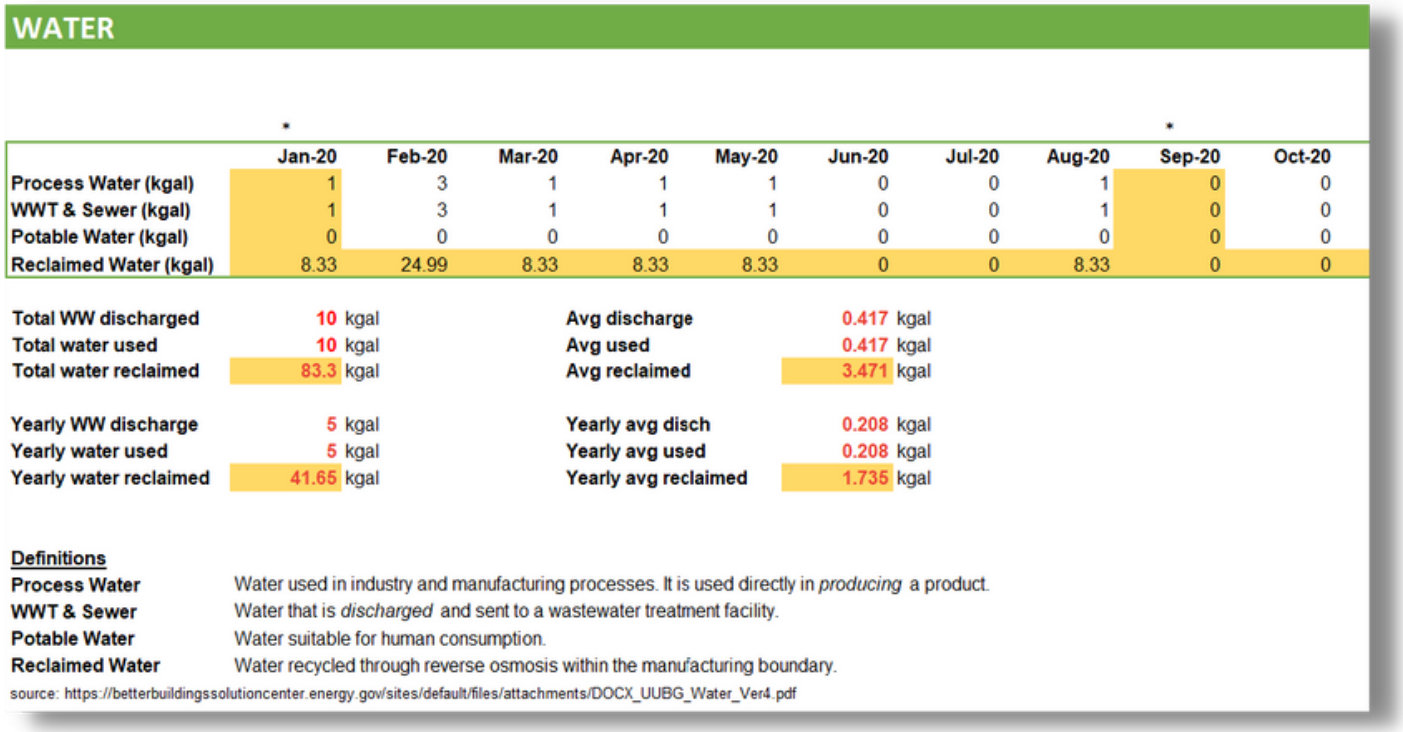
Waste Reused or Recycled: Materials that were either reused on-site or sent to a recycling plant to be recycled.

For this tool, landfill waste was *not* categorized by material. Recycled materials included **Cardboard** and **Plastic** only.

Sample Scenarios

Example: Your utility bills show that you utilize 1 kilogallons a month of "new" **process water**, with some variation throughout the year. The water discharged into the **sewer** from manufacturing processes is also around 1 kilogallons, with some variation. After some calculations, you find that through the **reverse osmosis** process, you reclaim around 8 kilogallons a month. This water is cycled through your manufacturing process every month, leading to a low process water use.

1. Enter data for all water types, ideally taken from utility bills or equivalent.
2. Yearly data and totals are automatically calculated from monthly inputs.
3. Wastewater Diversion rates are also automatically calculated in the "**Additional Analysis**" tab.



WATER

	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20
Process Water (kgal)	1	3	1	1	1	0	0	1	0	0
WWT & Sewer (kgal)	1	3	1	1	1	0	0	1	0	0
Potable Water (kgal)	0	0	0	0	0	0	0	0	0	0
Reclaimed Water (kgal)	8.33	24.99	8.33	8.33	8.33	0	0	8.33	0	0

Total WW discharged	10	kgal	Avg discharge	0.417	kgal
Total water used	10	kgal	Avg used	0.417	kgal
Total water reclaimed	83.3	kgal	Avg reclaimed	3.471	kgal
Yearly WW discharge	5	kgal	Yearly avg disch	0.208	kgal
Yearly water used	5	kgal	Yearly avg used	0.208	kgal
Yearly water reclaimed	41.65	kgal	Yearly avg reclaimed	1.735	kgal

Definitions

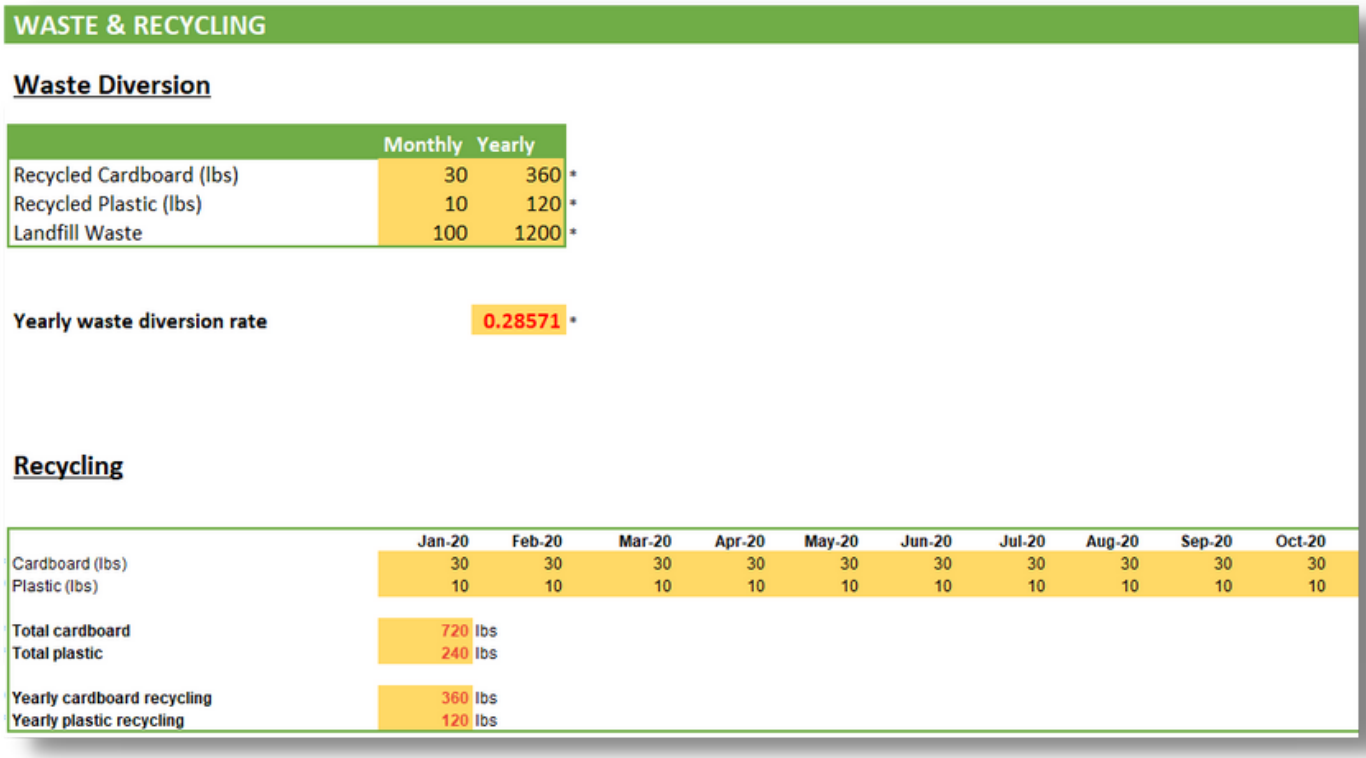
Process Water	Water used in industry and manufacturing processes. It is used directly in *producing* a product.
WWT & Sewer	Water that is *discharged* and sent to a wastewater treatment facility.
Potable Water	Water suitable for human consumption.
Reclaimed Water	Water recycled through reverse osmosis within the manufacturing boundary.

source: https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/DOCX_UUBG_Water_Ver4.pdf

Sample Scenarios

Example: Your waste hauler tickets for the month show that 100 pounds of waste was sent to the **landfill** through a dumpster pickup service. You pay a **recycling** service to pick up the remaining waste, which was 30 pounds of cardboard and 10 pounds of plastic.

1. Enter data for waste disposal. If you have separate quantities for each month, utilize the "**Recycling**" table at the bottom.
2. Average monthly data should be input into the main **Waste Diversion Table** at the top.
3. Yearly data is automatically calculated from monthly inputs.
4. Waste Diversion rates are also automatically calculated and can also be found in the "**Additional Analysis**" tab.



WASTE & RECYCLING

Waste Diversion

	Monthly	Yearly	
Recycled Cardboard (lbs)	30	360	*
Recycled Plastic (lbs)	10	120	*
Landfill Waste	100	1200	*

Yearly waste diversion rate	0.28571	*

Recycling

	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20
Cardboard (lbs)	30	30	30	30	30	30	30	30	30	30
Plastic (lbs)	10	10	10	10	10	10	10	10	10	10

Total cardboard	720	lbs
Total plastic	240	lbs
Yearly cardboard recycling	360	lbs
Yearly plastic recycling	120	lbs

Appendix

- Definitions
- Resources
- Other Links

Definitions

Greenhouse Gas (GHG) - Any gas in the atmosphere, which absorbs and re-emits heat and thereby keeps the planet's atmosphere warmer than it otherwise would be. The main GHGs in the Earth's atmosphere are water vapor, carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), and ozone (ecometrica).

Carbon Dioxide (CO2) - Carbon dioxide (CO2) is the most common GHG emitted by human activities in terms of the quantity released and the total impact on global warming. As a result, the term CO2 can be used as a shorthand expression for all greenhouse gasses. However, a more accurate way of referring to many GHGs collectively is to use the term "carbon dioxide equivalent" or "CO2e".

Carbon Dioxide Equivalent (CO2e) - A term for describing different greenhouse gasses using a standard unit. For any greenhouse gas, CO2e signifies the amount of CO2 which would have the equivalent global warming impact. This term allows the various GHGs to be compared to each other or bundled together.

Carbon Negative - Carbon negative is when an organization removes more carbon than it emits. It requires both the setting of a target to reduce emissions to get to net zero and offsetting or removing even more of its unavoidable emissions. (EY)

Stationary Combustion - Includes fuel consumption at a facility to produce electricity, steam, heat, or power. The combustion of fossil fuels by natural gas boilers, diesel generators, and other equipment emits carbon dioxide, methane, and nitrous oxide into the atmosphere.

Mobile Combustion - Includes fuel consumption by vehicles owned or leased/rented by the company. The combustion of fossil fuels in vehicles (including cars, trucks, planes, and boats) emits carbon dioxide, methane, and nitrous oxide into the atmosphere.

Purchased Electricity - Emissions associated with the generation of purchased electricity consumed by the reporting company are reported in scope 2. Activities that use purchased electricity indirectly cause emissions of greenhouse gases (GHG). The resulting emissions depend on the amount of energy used and the mix of fuel that produces this electricity.

Green Power Product/Green Tariff - A consumer option offered by an energy supplier distinct from the "standard" offering. These are often renewables or other low-carbon energy sources, supported by energy attribute certificates or other contracts.

Emission Factor (EF) - A Value that characterizes the potential of a given waste/wastewater to generate a certain gas. Emission factors are translated into emissions by multiplication with an activity rate. High EF values are associated with high emissions. (Waste, 2011)

Custom Emission Factors - When standard EPA emission factors don't cover your calculation needs, custom emission factors are required. Custom factors are often used in industrial processes and renewable energy.

Definitions

Renewable Energy Certificate (REC) – A market-based instrument that certifies the bearer owns one megawatt-hour (MWh) of electricity generated from a renewable energy resource. RECs play an important role in accounting, tracking, and assigning ownership to renewable electricity generation and use. (EPA)

Market-Based Emissions Factors – calculates emissions based on the electricity organizations have chosen to purchase, often spelled out in contracts or instruments like Renewable Energy Certificates (RECs). The following are the types of market-based emission factors available, listed in order of preference based on the precision of the factors:

- **Energy Attribute Certificates –** If an energy attribute certificate carries an emission factor, that factor can be used to quantify emissions in the market-based method. Examples are renewable energy certificates (RECs) or Guarantees of Origin (GOs).
- **Contracts –** An organization may have a contract, such as a power purchase agreement (PPA), to purchase electricity from a specified generating facility. The certificate or contract carries the emission factor associated with the generation facility. Contractual instruments are not carbon offsets.
- **Supplier-Specific Emission Factor –** An electricity supplier, such as a regulated utility or a deregulated supplier, may inform its customers about the emission factor associated with its electricity product.
- **Residual Mix Emission Factor –** The default emission factors representing untracked or unclaimed energy and emissions. Companies without specified green power purchases must use a residual mix—an emission factor representing the average emissions from all unclaimed energy.

Location-Based Emissions Factors – calculates emissions based on the emissions intensity of the local grid area where the electricity usage occurs. The location-based method assigns the local grid average emission factor to off-site renewable use. Depending on availability, this emissions factor may be a regional or national grid average emission factor.

eGrid – The Emissions & Generation Resource Integrated Database (eGRID) is a comprehensive inventory of environmental attributes of electric power systems. The preeminent source of air emission data for the electric power sector, eGRID, is based on available plant-specific data for all U.S. electricity generating plants that provide power to the electric grid and report data to the U.S. government.

Application Programming Interface (API) – API is the acronym for Application Programming Interface, which is a software intermediary that allows two applications to talk to each other.

Grid Region – The U.S. grid is divided into three major regions, the Eastern Interconnection, the Western Interconnection, which covers the Pacific Ocean to the Rocky Mountain states, and the Texas Interconnected System. Within each of these regions are interconnected local electricity grids. For U.S. grid regions' emission data, EPA provides recent and historic air emissions, including CO2 for U.S. portions of grid regions, States, and Puerto Rico.

Definitions

Fugitive Emissions – the unintentional and undesirable direct release to the atmosphere of GHG compounds from various types of equipment and processes. Fugitive emissions are particularly relevant to industrial manufacturers such as chemical companies. Fugitive emissions sources that are common for organizations in many sectors: refrigeration and air conditioning systems, fire suppression systems, and the purchase and release of industrial gasses.

Refrigerants – Found in everything from air conditioning systems to industrial warehouses. The majority of the gases used in refrigerants are hydrofluorocarbons, or HFCs, which are significantly more potent than carbon dioxide.

Global Warming Potential (GWP) – A measure of how much energy the emissions of 1 ton of a gas will absorb over a given period of time, relative to the emissions of 1 ton of carbon dioxide (CO2). The larger the GWP, the more that a given gas warms the Earth compared to CO2 over that time period.

	Greenhouse Gas	Global Warming Potential (GWP)
1.	Carbon dioxide (CO_2)	1
2.	Methane (CH_4)	25
3.	Nitrous oxide(N_2O)	298
4.	Hydrofluorocarbons (HFCs)	124 – 14,800
5.	Perfluorocarbons (PFCs)	7,390 – 12,200
6.	Sulfur hexafluoride (SF_6)	22,800
7.	Nitrogen trifluoride (NF_3)[3]	17,200

British Thermal Unit (BTU) – a unit of heat used to measure the input/output of domestic and commercial heating and cooling systems such as water heaters, boilers, furnaces, air conditioners, and heat pumps in the United States.

IPCC Fourth Assessment Report (AR4) – the Fourth Assessment Report of the United Nations Intergovernmental Panel on Climate Change (IPCC) was published in 2007 and is the fourth in a series of reports intended to assess scientific, technical and socio-economic information concerning climate change, its potential effects, and options for adaptation and mitigation.

IPCC Fifth Assessment Report (AR5) – **The Fifth Assessment Report of the United Nations Intergovernmental Panel on Climate C**hange (IPCC) is the fifth in a series of such reports and was completed in 2014.

Radiative Forcing (RF) – a measure of the additional environmental impact of aviation. These include emissions of nitrous oxides and water vapor when emitted at high altitude. Waste Water and Sewer Discharge - Water that is discharged and sent to a wastewater treatment facility.

Potable Water – Water suitable for human consumption.

Process Water – Water used in industry and manufacturing processes. It is used directly in producing a product.

Reclaimed Water – Water recycled through reverse osmosis within the manufacturing boundary.

Waste Diversion Rate – Your waste diversion rate represents how much of waste you divert from your facility without burn (incineration) or buy (landfill). When you are looking to improve the success of your recycling program it is critical to know your current waste diversion rate as a benchmark.

Resources

GHG Protocol: The GHG Protocol is a platform which establishes comprehensive global standardized frameworks to measure and manage greenhouse gas (GHG) emissions from private and public sector operations, value chains and mitigation actions. The Protocol identifies an action agenda to address climate change and the need for standardized measurement of GHG emissions. It also supplies the world's most widely used greenhouse gas accounting standards. As it applies to this project, the GHG Protocol was used to establish a baseline for our Scopes 1-3 comparisons, standards, and tool.
-https://ghgprotocol.org/about-us

Climate Registry: Established in 2007, The Climate Registry was formed to continue the work of the California Climate Action Registry (CCAR). CCAR promoted and protected businesses' early actions to manage and reduce their greenhouse gas (GHG) emissions. Through the state mandate, CCAR established protocols to guide emissions inventories and manage an online reporting tool, the Climate Action Registry Reporting Tool (CARROT), to serve as a central database for emissions reports. The Climate Registry (TCR) is a non-profit organization that empowers North American organizations to do more in the fight against climate change by providing services and tools that help them reduce their emissions. TCR also drives climate action and ambition on the road to net zero by recognizing and showcasing sub-national leadership, and by building strategic partnerships with and between national and international entities. TCR is advised by a Council of Jurisdictions that includes representatives from diverse U.S. states and Canadian provinces and territories. Their mission is to empower our generation to reduce its carbon footprint.
- https://www.theclimateregistry.org/

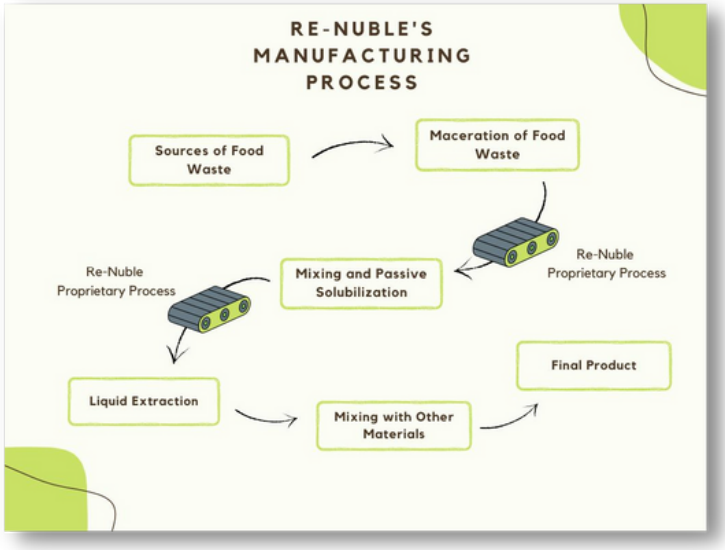
WRI Scope 3 Evaluator: The Scope 3 Evaluator is a free, web-based tool from Greenhouse Gas Protocol and Quantis that makes it easier for companies to measure, report, and reduce emissions throughout their value chain. GHG Protocol's Corporate Value Chain (Scope 3) Standard is the global standard in value chain GHG accounting and the tool allows users to estimate emissions for all 15 Scope 3 categories defined in the standard regardless of the size or type of company. The Scope 3 Evaluator offers a clear starting point for companies aiming to take a full inventory of scope 3 emissions. This tool requires minimal data collection and is appropriate for both experts and those new to carbon accounting. The Evaluator reduces the time needed to estimate scope 3 emissions, helping companies take a first, essential step on the path to joining industry leaders in scope 3 measurement and reporting. Companies typically use this information to start identifying areas in which to pursue a more accurate inventory and focus their reduction efforts. The Scope 3 Calculator was used as a mechanism of reference in creating our tool for GHG Calculations.
- https://quantis-suite.com/Scope-3-Evaluator/
- https://ghgprotocol.org/scope-3-evaluator

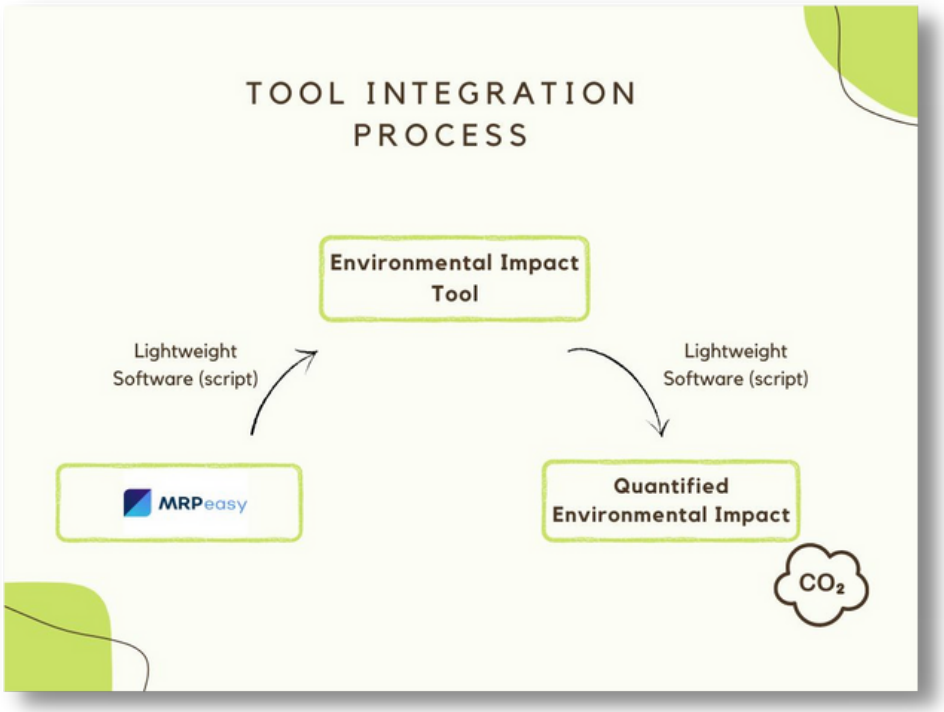
Reporting Principles: The Conference of the Parties (COP) of the United Nations (UN) has developed standardized requirements for reporting national inventories to maintain the quality of greenhouse gas (GHG) inventories relies on the integrity of the methodologies used, the completeness of reporting, and the procedures for compilation of data. Under the UNFCCC reporting guidelines on annual inventories for Annex I Parties, inventory submissions are in two parts:

Resources

Common reporting format (CRF) tables – a series of standardized data tables containing mainly quantitative information; and the National Inventory Report (NIR) – a report containing transparent and detailed information on the inventory. It should include descriptions of the methodologies used in the estimations (including references and sources of information), the data sources, the institutional arrangements for the preparation of the inventory (including quality assurance and control procedures), and recalculations and changes compared with the previous inventory. The Reporting Principles of the UNFCCC were used in creating our tool for GHG Calculations.

- https://unfccc.int/process-and-meetings/transparency-and-reporting/reporting-and-review-under-the-convention/greenhouse-gas-inventories-annex-i-parties/reporting-requirements





Other Links

- https://www.epa.gov/sites/default/files/2016-03/documents/electricityemissions_3_2016.pdf
- https://ghgprotocol.org/sites/default/files/Scope2_ExecSum_Final.pdf
- https://support.measurabl.com/hc/en-us/articles/4406903207565-What-are-Market-Based-and-Location-Based-Scope-2-emissions-
- https://www.epa.gov/egrid/egrid-questions-and-answers#egrid1
- https://www.epa.gov/green-power-markets/us-grid-regions
- https://docs.microsoft.com/en-us/industry/sustainability/calculate-emission-factors
- https://cleanriver.com/blogwhat-waste-diversion-important/
- https://www.epa.gov/sites/default/files/2015-07/documents/fugitiveemissions.pdf
- https://ecometrica.com/assets/GHGs-CO2-CO2e-and-Carbon-What-Do-These-Mean-v2.1.pdf
- https://www.ey.com/en_gl/sustainability/carbon-negative-achievement
- https://www.sciencedirect.com/topics/earth-and-planetary-sciences/emission-factor
- https://www.epa.gov/green-power-markets/renewable-energy-certificates-recs
- https://www.sciencedirect.com/topics/engineering/british-thermal-unit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