Supporting Tower Hill Botanic Garden's Capabilities to Assess its Environmental Impact

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Abstract

Climate change is a global issue that poses large risks to all life, and energy consumption plays a significant role in this. The goal of this project was to find a way to help Tower Hill Botanic Gardens monitor and manage their environmental impact by assessing their carbon footprint. This was achieved by establishing indicators that are relevant to the institution, developing a tool based on the indicators to assess the facility, and engaging the staff and the public through the results of the tool. We were able to accomplish this goal and estimate Tower Hill's carbon footprint and which sources impact the footprint most. After we measured the footprint of Tower Hill, we provided recommendations for Tower Hill to manage their carbon emissions.

Acknowledgements

This project would not have been possible without the continued efforts and support from our sponsor, Tower Hill Botanic Gardens, specifically the sustainability committee and the members within that committee, and our advisors Professor Laureen Elgert and Professor Derren Rosbach.

We would first off like to thank our sponsor, Tower Hill Botanic Gardens for supporting our efforts within this project, specifically the members of the Sustainability Committee. This committee includes Jeff Haselton, Mark Richardson, Jane Ellis, Emma Kerr, Jessica Pederson, and Ruth Seward. Throughout our work at Tower Hill, the group was always very supportive of our efforts and of all work we did for them. Without their continued support, it would have been much more challenging to get the project completed. We were also able to get a lot of useful information and guidance from them, such as detailed records of energy use and needs and values of Tower Hill.

We would like to thank the facilities manager, Jeff Haselton, personally for the work he did for this project. He showed us around the area, pointing out different details and challenges surrounding Tower Hill's sustainability that we would not have been able to guess ourselves. He was the one to reach out to WPI, searching for students to help with this project. Without his work for Tower Hill, this IQP would not have materialized and nothing would have been accomplished. We appreciate his constant efforts and support to this team and to this project.

The last group of people we would like to thank would be our project advisors, Professor Laureen Elgert and Professor Derren Rosbach. These two professors were greatly helpful in this project and in leading us in where to go. They constantly made time in their schedules to meet with us and Tower Hill to discuss where we were and how to get to where we wanted to be. They put in a great deal of effort to edit and suggest things we should do to change the report and make it better. With all the work they put into this project, not only did the report come out better, but the whole direction of the project came out better. They helped us to stay grounded in what we wanted to do and made sure our ambitions were realistic and attainable, but also a challenge for us to take on.

Executive Summary

As climate change becomes a ubiquitous concern, and sustainability becomes a key requisite for responsible citizenship, institutions are increasingly working to manage how their operations impact the environment. Some institutions have developed methods to measure their environmental impact and overall sustainability efforts using indicators. Indicators show if an institution is improving in terms of aspects of sustainability. For example, carbon emissions per consumption type can serve as an environmental indicator. If there is a rise in carbon emissions, it shows the institution is negatively impacting the environment. If there is a decrease in carbon emissions, the institution is positively impacting the environment (Laurent et al., 2012).

Institutions such as universities and museums have already developed systems that measure their environmental impact and overall sustainability using indicators. By looking at these and other systems that institutions use to measure their environmental impact, methods can be developed for another institution to show how energy consumption directly impacts their carbon footprint. It is additionally important to recognize that efforts to limit environmental impacts are important lessons to engage the public and people of an institution.

One institution, Tower Hill Botanic Gardens, wanted to develop ways to see the impact their energy consumption has on their carbon footprint by identifying indicators related to their institution. Additionally, they wanted to make sure that the work was able to be presented in a way that would educate both visitors and employees. The goal of this project was to improve Tower Hill's capability to monitor and manage their environmental impact by developing a tool that could show the carbon emissions from their energy consumption over time.

The Process: Understanding Environmental Impact at Tower Hill

The goal for this project was to improve Tower Hill's capability to monitor and manage their environmental impact. We aimed to do this through three major objectives.

1. Establish indicators that are appropriate, useful, and relevant to the institution.
2. Develop a tool based on these indicators to assess current, past, and future sustainability efforts.
3. Implement the tool at Tower Hill and convey the significance of the tool to Tower Hill's staff and visitors.

Objective 1

Establishing indicators for a specific institution is the foundation for assessing an institution's environmental impact. For this objective, we defined what factors of sustainability we were looking at for Tower Hill's facility. In doing so, we identified what indicators drive the

facility's impact on the environment. Moreover, we described the participatory process used to identify indicators relevant to the institution and our reasoning for this process.

Objective 2

Developing a tool based on these indicators was the next step. The purpose of the tool was to give us a detailed carbon footprint of the facility by taking input from consumption data provided by Tower Hill. When trying to monitor their facility's environmental impact, it was important to see its carbon footprint and how it has changed over the years, and the primary sources that impact the carbon footprint. The tool focused on carbon footprint in relation with time of operation and the source of the emissions.

Objective 3

Tower Hill Botanic Gardens has sustainability as one of their core values, including learning and inclusivity. To fulfill these core values, we showed them how to use the tool to monitor their carbon footprint and how to add parameters of analysis to the tool to move forward in terms of sustainability. Conveying this information to Tower Hill was the first step as they need to fully understand what is going on in their facility so they can learn where they stand in terms of sustainability and environmental impact.

The Findings: Developing a Way to Monitor Carbon Footprint

Indicators

We were able to narrow down the indicators to those most important to Tower Hill. Specifically, these included fuel (oil, propane, gasoline, and diesel), water, and electricity (Appendix A). These were chosen over others as they were most applicable, and they related directly to the carbon footprint of the institution. These indicators were analyzed using 6 different criteria of identifying indicators: simplicity, scope, quantification, assessment, sensitivity, and timeliness. All the indicators were additionally identified to follow the carbon dioxide emissions of the facility. Each one of them measures carbon emissions per type on a monthly and yearly basis, and they can be seen over time and how they change in their ability to change.

Carbon Footprint Tool

From the indicators identified above, we created a tool that was able to take information from the indicators we identified and produce a breakdown of Tower Hill's carbon footprint by converting energy consumption data into a common unit of pounds of carbon dioxide. The tool was then tested on data we received from Tower Hill between 2016 and 2019, and were able to produce graphs to show trends in their overall carbon footprint over those years, showing the annual and seasonal overall change, as well as the change in the individual components (Appendix B). Additionally, it showed the primary sources of carbon emissions by fuel type, how they have increased over the years, and the total make up of carbon emissions per source at the facility. Once the tool was completed, we created detailed documentation of how to use and modify the tool at any point in the future.

Data Analysis

The largest contributor to Tower Hill's carbon footprint is oil used for heating. The second largest is the electricity usage. These two are overwhelmingly the majority of the carbon footprint of the facility, as both oil and electricity usage add up to slightly more than 85% of the overall carbon footprint. Using 2016 as the baseline, the facility's footprint has increased 12% as of 2019. The primary reason for this is the increase of oil consumption over the years. Oil consumption has increased 10.88% as of 2019. We determined that this is the main contributor to CO2 emissions due to the fact that oil has the highest amount of carbon production in relation to the amount of energy it produces. Though electricity is another larger carbon producer, its usage has remained constant throughout the years. The usage of gasoline, propane, and diesel has gone up significantly, however its percentage in the whole carbon footprint is still comparatively small (15% on average).

Results and Recommendations: Moving Towards Carbon Neutrality

Drawing recommendations and conclusions from Tower Hill's carbon footprint assessment of their facility, we suggest the following:

Indirect carbon emissions such as the carbon emissions produced from freighting goods, commuting employees, or traveling visitors can have a significant impact on an institution's carbon footprint. Quantifying these types of indicators, however, are difficult. For that reason, **we suggest that Tower Hill focuses on the direct impact that the facility has on its nearby environment.** Specifically, this means Tower Hill should focus on the carbon emissions that are produced from their fuel consumption along with electricity and water usage.

With the carbon footprint assessment tool, Tower Hill will be able to implement new parameters into the program. Parameters such as costs of energy consumption, zones of the facility that produce the most carbon emissions, and even average outside temperature can easily be added to the program. The addition of these parameters, along with others not mentioned can significantly improve Tower Hill's capability of making educated decisions on how to decrease their carbon footprint. In terms of implementing a cost benefit analysis factor to the program, however, we recognize that much of this can be done as back hand calculations rather than formalized into the program. Therefore, **we recommend that Tower Hill looks to add**

important parameters such as costs of energy consumption, monthly average temperature, and zones of the facility with the most carbon emissions.

Monitoring Tower Hill's carbon footprint is the first step towards a more sustainable and environmentally friendly future. This will allow Tower Hill to observe how their carbon footprint is changing and to pinpoint the main sources of their carbon emissions. For these reasons, **we recommend that Tower Hill continue to monitor their carbon footprint and to set a goal to decrease a percentage of their carbon footprint starting from whichever year they desire.** Having a goal in place will set in motion for preparation and planning for the future. This will also help keep Tower Hill accountable to themselves to make sure that measures are being taken to steadily limit their environmental impact.

Using this carbon footprint assessment tool, **we recommend that Tower Hill research methods to conserve their energy consumption from their two main sources of carbon emissions: oil and electricity.** Being that the two sources of energy make up approximately 85% of the institution's carbon footprint, we suggest implementing measures to conserve and find more efficient ways of heating, cooling, and lighting the facility. Within this process of finding the most beneficial methods, cost benefit analyses need to be done to see which method can limit the most carbon emission for the lowest costs.

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Glossary

Sustainability: Sustainability generally refers to depleting resources at a rate that they can be replenished.
Indicators: Elements that are looked at to gauge sustainability of an institution. In our case, these are greenhouse gas emissions per fuel or material usage.
Institution: An institution is an organization founded for an educational, social, economic, or similar purpose, including its members and facilities.
Carbon footprint: A measure of the net carbon emissions by an institution.
Ecological footprint: A measure of how much land an institution requires to sustain its operations.

Chapter 1: Introduction

Over the past few decades, climate change has escalated to a global crisis as the Earth's average temperature increases annually (Archer & Rahmstori, 2010). Its impacts include more extreme weather patterns and disruptions to habitats and communities where people, animals, and plants alike are dying because of these environmental changes. These changes in the climate pose large risks as a higher frequency of natural disasters are likely to happen due to these weather fluctuations and will result in millions of homes being ruined (Van Aalst, 2006). One of the main causes of climate change is greenhouse gas emissions (Weber & Stern, 2011). Carbon dioxide makes up about 70% of these greenhouse gas emissions (Ehhalt & Prather, 2001). One of the major sources of carbon dioxide emissions come from energy consumption, which consists of the burning of fuels to generate forms of energy such as electricity (Olivier et al., 2005).

As carbon dioxide emissions continue to rise, institutions recognize their responsibility to make changes to their energy consumption by implementing methods to limit their respective carbon footprints. Some institutions have developed systems to quantify their efforts in decreasing carbon dioxide emissions and to quantify their overall efforts in sustainability. The consumption of fuels and electricity required to power a facility are often the major drivers for a facility's operation and additionally are the major contributors to a facility's carbon dioxide emissions (Culp et al., 2016). For these reasons, the amount of energy consumed by an institution and the amount of carbon dioxide emitted per energy source are often indicators used to quantify an institution's progress in limiting their carbon footprint and overall environmental impact.

Different institutions have different factors to consider when trying to limit their carbon footprint and overall environmental impact. As a result, the system a specific institution might implement to quantify their progress in environmental impact can differ due to the different dynamics and factors of the institution. By comparing different methods that institutions use to quantify their environmental impact and ability to sustain themselves, a new method can be synthesized to measure the environmental impact another type of institution has. Equally as important, institutions see their efforts to measure their environmental impact as opportunities to engage the public and to spread their environmental consciousness to the nearby community.

Tower Hill Botanic Garden has begun to investigate how they can improve their environmental impact by making changes to their energy consumption. Day to day operations and preservation of the facility, and the flora that resides in it, require ample amounts of energy. As a result, carbon dioxide emissions are produced and contribute to global climate change. Tower Hill's sustainability committee, therefore, began planning to develop ways of assessing their current, past, and future environmental impacts.

We supported Tower Hill by developing a tool that helps them monitor and manage their carbon emissions. We accomplished this by identifying quantifiable indicators that are relevant to the botanic garden. Then, we developed a carbon footprint assessment tool based on these indicators to assess the facility's current, past, and future environmental impact. Additionally, they wanted to make sure that the work was able to be presented in a way that would educate both visitors and employees. The goal of this project was to improve Tower Hill's capability to monitor and manage their environmental impact by developing a tool that could show the carbon emissions from their energy consumption over time.

Chapter 2: Background and Literature Review

As institutions look to be more conscious of the environment, they begin to develop methods that assess their current efforts in limiting their overall environmental impact. Some institutions already developed systems that quantify their respective environmental impacts and have also incorporated their progress in sustainability. In this section, we define what environmental impact means in terms of sustainability, how institutions derive indicators to measure their environmental impact and sustainability, the existing systems that institutions currently use to assess their environmental impact and sustainability, and ways that institutions can engage their employees and the public in the work they have done to become more environmentally friendly.

Foundations of Measuring Environmental Impact

The Role of Environmental Impact in Sustainability

For different institutions, environmental impact can mean different things and associate many different factors. These factors can incorporate different environmental characteristics that institutions have an impact on. For example, a farm might have more of an environmental impact on the nearby quality of soil, whereas a university might be more concerned with the environmental impact of its carbon footprint (Klemes, 2015). As a result, it is important to recognize that different institutions incorporate different sources of environmental impact when assessing the overall sustainability of their institution. By looking at systems that different institutions use to measure their environmental impact and sustainability, methods can be drawn and applied to an institution with a different source of environmental impact.

Quantifying Sustainability with Indicators

Institutions implement systems that utilize indicators to measure their progress in sustainability. Indicators are attributes of an institution that are the simplification of complex measurements that can explain the institution's current success and operation (Bell et al., 2008). These indicate whether or not an institution is becoming more sustainable. Sustainability indicators can be classified using the three main pillars of sustainability: economic, social, and environmental to see if the broader goals of an institution are being achieved (Tallis et al., 2009). Within these main pillars, indicators can dive deeper into the specific area. For example, carbon emissions can serve as an environmental indicator. If the carbon emissions rise, it indicates the institution is moving in the wrong direction of making the institution more environmentally friendly. If the carbon emissions decrease, it indicates that the institution is moving in the right direction (Laurent et al., 2012).

Identifying indicators is an essential first step towards developing a system that measures sustainability and environmental impact. It allows for the stakeholders of an institution to make educated estimations and new policies to specific areas of sustainability they want to improve upon. These indicators are most effective when they follow these key criteria (Tallis et al., 2009):

- **Simplicity-** straight to the point
- **Scope-** related to all issues of the problem being tackled and each indicator should not overlap
- **Quantification**- measurable in one way or another
- **Assessment**- able to show trends of change over time
- **Sensitivity**- able to change
- **Timeliness**- identify trends with specific timing

Systems & Case Studies

There is an array of systems that institutions use to quantify sustainability with indicators. In this section, various types of these methods are analyzed by looking at applications used by institutions like Tower Hill to see what parts of these approaches are applicable to their case.

Sustainability in Universities

The Association for the Advancement of Sustainability in Higher Education (AASHE) is an organization that helps universities to rate themselves in terms of sustainability using a common set of indicators. To assess a university's current state of sustainability, the organization has a set of guidelines for the university to follow in self-assessment, with representatives from the organization being available to assist them or answer questions. The set of guidelines is called the Sustainability Tracking, Assessment and Rating System (STARS). STARS takes into account a selected university's academics, engagement, operations, planning, administration, and innovation and leadership (The Sustainability Track, Assessment & Rating System, 2020). After the guidelines are applied to a specific institution, results are given as a score out of a maximum for each indicator, which are summed to give the total score. Additionally, the results are placed in a specific percentile above or below the national average. STARS uses this rating metric system to show where a university currently is relative to the average as well as areas of improvement. Using this valuable data, colleges can make improvements where they are lacking sustainability that will improve their overall STARS score.

Sustainability in Museums

Like universities using the STARS rating metric systems, a set of museums in Romania sought to create a set of indicators with which to measure the sustainability of museums in the National Network of Romanian Museums (NNRM). With these measurements of sustainability, the museums were ranked against each other. The researchers undertaking this task began by deciding on the set of the most important and encompassing areas of sustainability, and they decided on four main pillars: economic sustainability, social sustainability, cultural sustainability, and natural sustainability (Pop & Borza, 2016). Each of the pieces of each pillar influence not only the pillar it belongs to, but also the other pillars. For example, if an institution were to spend all of their money on getting the newest, greenest technology to increase their natural sustainability, it would negatively impact their economic sustainability.

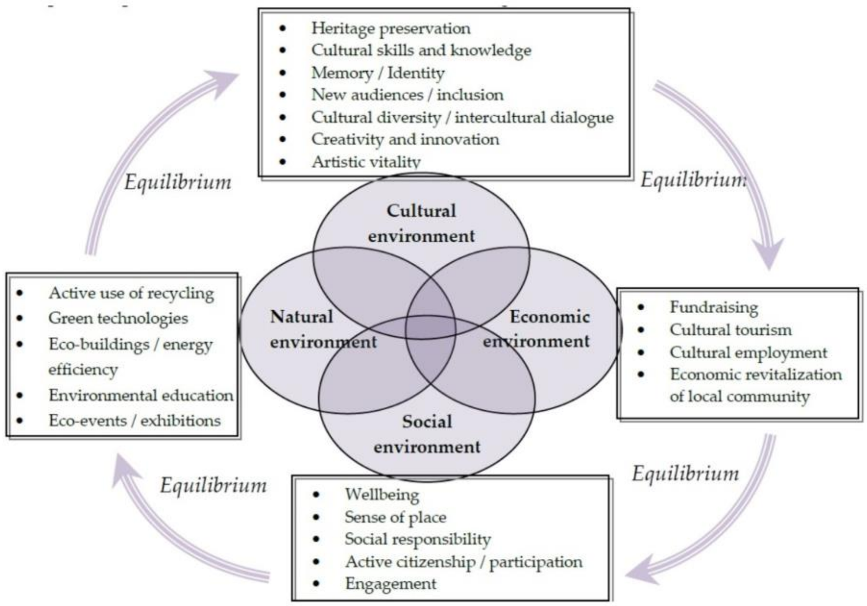

***Figure 1:** Four pillars of sustainability*
Image Source: Pop & Borza, 2016

First, the researchers interviewed a set of museum officials and experts from the NNRM, asking them questions about whether they think certain aspects have a great impact on museum sustainability. By the end, they had developed a total of 33 indicators. These indicators were measured for each of the museums, turned into numbers that depended on the measure of "most sustainable" museum in each indicator, and then the museums were ranked (Pop & Borza, 2016).

The piece of this study that is relevant to our project is the way that the set of indicators was decided on. The set of indicators were identified through interviewing museum officials and experts. This is useful in assessing the most important parts of an institution to consider when attempting to measure how sustainable a place is, as the museum officials and experts know which factors influence certain aspects of a museum.

Footprint-based Metrics

Another way that sustainability is measured is by means of an environmental footprint. The two most common types of these footprints are ecological footprint and carbon footprint.

Ecological footprint is measured in units of hectares (a unit of land area) and is a way to show how much land a certain institution requires in order to operate (Flint, 2001). Carbon footprint is measured in units of carbon dioxide equivalent (CO_2e) and is a way to show how much carbon dioxide the institution emits or sequesters in its operations (Letete et al., 2011).

Both footprint types are similar in that they are measured by multiplying gathered energy consumption data from institutions by conversion factors to determine their respective units and sum them up. Any institution's ecological footprint is always going to be a positive number, as any institution is going to require at least the land it is built on in order to operate. An institutions' carbon footprint can be positive, negative, or zero, if it has net emissions, net sequestering, or is carbon neutral. In terms of climate change, carbon footprint is also a more useful method, as carbon emissions contribute directly to climate change.

The 2008 Climate Change Act requires the UK to reduce its net greenhouse gas emissions by 80% by 2050 from its 1990 baseline level, with an interim target of 34% by 2020 (U.K. Department for Environment, Food, and Rural Affairs, 2009). To help the UK organizations meet this goal, the Department for Environment, Food and Rural Affairs (Defra) published a document that gives a comprehensive framework for how to measure their greenhouse gas emissions in terms of tons of CO_2e (carbon dioxide equivalent) (U.K. Department for Environment, Food, and Rural Affairs, 2009). The first step was to identify and categorize emissions-related activities into scopes: direct emissions, energy indirect, and other indirect. Once all the data related to these categories was collected, each number was multiplied by its respective conversion factor (U.K. Department for Business, Energy & Industrial Strategy, 2019) to get it in terms of CO_2e. Once an organization has these numbers, they can analyze them across a set of years, or over what activities produce the most emissions, and attempt to reduce emissions going forward (U.K. Department for Business, Energy & Industrial Strategy, 2019).

De Montfort University established their carbon footprint with three main categories: building energy, travel emissions, and procurement (Ozawa-Mieda et al., 2013). Building energy consists of direct emissions from University buildings and equipment. Travel emissions consist of direct and indirect emissions from commuting staff and students, as well as student trips home, and visitor travel. Procurement consists of indirect emissions from the supply chain emissions of the goods and services consumed by the university. Their approach consists of three steps: (1) determine activity/consumption data in each sector, (2) derive associated GHG factors, and (3) multiply the data by the associated GHG factor to estimate emissions in kilograms of CO_2e for each sector and add them together to determine the overall carbon footprint (Ozawa-Mieda et al., 2013).

The authors had an easy time getting necessary numbers for building energy, as everything was being recorded internally by the university. For travel, they considered both vehicles owned by the university for waste management and security, as well as travel by staff and students estimated by sending out a survey. For procurement, the authors derived the data from datasets of the university's financial information system providing spending data and e-card data from purchases conducted by authorized credit card users, sorting each item in the datasets into other categories and multiplying by their respecting emission factor (U.K. Department for Business, Energy & Industrial Strategy, 2019).

The carbon footprint metric is very well-documented, easily modifiable, and applicable to different types of institutions. Although it does not necessarily cover all aspects of sustainability, it can be used to comprehensively estimate an institution's impact on the environment to the extent that works best for the institution.

Summary of Case Studies

Overall, sustainability can be measured through the use of indicators. Whether it be applied to universities, museums, or other institutions, sustainability is measured by different factors that apply to that institution. The most important factors of each of these approaches are the ideas of how to quantify a facility's sustainability efforts. People with knowledge about an institution's facilities need to be consulted to identify key factors of sustainability and develop a common metric to compare different types of energy and consumption data.

Engaging the Public

Engaging the public is a very important task that also must be considered at Tower Hill. Efforts to increase the sustainability of Tower Hill represent an opportunity to engage visitors and raise their awareness about sustainability issues. The way this is accomplished is also very important as it will determine whether a lasting impression is made on visitors.

Teaching Sustainability

There are 8 things to consider when teaching sustainability (Mcdaniel, 2019):

1. **Beware of student overload:** the huge overall problems could overwhelm the student and cause feelings of disempowerment and disengagement, which "disrupt the learning process."
2. **Avoid doom and gloom:** introducing the challenges that come with sustainability may invoke a sense of overload.
3. **Focus on quality of life issues:** discuss their view on life and how sustainability correlates to that, instead of the demoralizing view on sustainability.
4. **Peer engagement and support:** engagement relieves some feelings of overload which can develop some critical thinking and leadership skills.
5. **Student analysis of data:** students learn more when they can wrestle with the problem or idea themselves, and it helps to engage them.
6. **Deconstruct eco-rhetoric:** working on breaking down the language that is being used can help the students understand the workings of sustainability better.

7. **Precautionary principle:** it is important to note this principle as it states that the burden of an action being not harmful, without proof that it is harmful, is solely rested on those taking the action.
8. **Embrace interdisciplinarity:** a thorough understanding of sustainability comes from many different areas and teaching many different areas broadens the students' view.

A few of these considerations are of particular importance when educating about sustainability at Tower Hill, those being, avoiding "doom and gloom," peer engagement and support, and allowing those who are being taught to analyze the data themselves. Avoiding doom and gloom is important because negative framing can impair a visitor's ability to see the good that can come out of sustainability efforts. When focusing on the positive and the more optimistic side of things, students, or visitors in this case, are more apt to see that they can make a difference. This flows into peer engagement and support. They must be engaged and supported as well as given a positive attitude to stop feelings of overload. Otherwise, the information given to them overwhelms them and turns them off to the idea of moving forward and actually getting involved. It's important to recognize that the audience also will need to be involved in the data analysis as they need to understand what different aspects of the situation mean and what the different levels allow for and what they signify.

Relaying to the Public

Some other considerations include deconstructing eco-rhetoric and avoiding overload within the message (Mcdaniel, 2019). Deconstructing the eco-rhetoric means to define and simplify the wording we choose like sustainability and what that means in our context. More specifically, this means to explain complicated terms involving sustainability in ways that the average person will be able to understand. Overload is very important to take into consideration as it could overwhelm the people learning and turn them off to the idea and towards thinking more about it.

Relaying to Tower Hill

Tower Hill is attempting to make changes that will improve their operations and change in a positive way towards being more sustainable. In order to assist them with their goal, we must learn more about what has been done in the past by other institutions. From interviews with many institutions, one can learn a lot about what can be done in terms of sustainability from similar institutions. Some institutions will have a lot of successes that can be used to follow, and others will have failures that can be noted and used as "what not to do." Nevertheless, reaching out to similar institutions can give Tower Hill recommendations on how to move forward with their sustainability efforts and can help build healthy relationships with other local institutions.

Chapter 3: Overview of Tower Hill

Tower Hill Botanic Garden is a botanic garden with a passion for growing plants for their ornamental, economic, and ecologic value, while engaging the public in that passion (Tower Hill Botanic Garden, 2019). Tower Hill wants to present themselves as a pinnacle for sustainability, and along with that, serve as a role model to its community. The garden has served as a non-profit, beautiful sanctuary in Boylston, Massachusetts under the leadership of the Worcester Horticultural Society since 1986. With the help of the society and its many members, the botanic garden has been able to function successfully by housing more than 17 unique gardens with flowers and trees from all over the world (Haselton, 2019). Despite its prosperity, the facility still does not have a sustainability policy that takes into account its impact on the environment.

Figure 2: *Map of Tower Hill's facility and gardens*
Image Source: Tower Hill Botanic Gardens Website: "Tower Hill Botanic Garden" *towerhillbg.org*, 8, Jan. 2020, https://www.towerhillbg.org/garden-map/

Tower Hill has decided to change this by developing a sustainability committee consisting of their facilities manager, Jeff Haselton, director of horticulture, Mark Richardson, adult education manager, Emma Kerr, director of Education, Jessica Pederson, chief financial officer, Jane Ellis, and the director of outreach and community engagement, Ruth Seward. Their goals focus on making Tower Hill a model of sustainability so the community can learn from them and apply their sustainability strategies to their lives at home. Tower Hill's sustainability committee and the rest of the organization wants to not only guide the community towards more sustainable means but also wants to see beneficial changes in their sustainability policies and their facility.

Currently, 31,000 gallons of oil needs to be burned throughout the facility due to inefficient HVAC systems, air handlers, and oil burners/furnaces (Haselton, 2019). This along with dozens of inefficient halogen light bulbs, poor roofing, and heat inefficient spaces leaves the institution causing more pollution than desired. So far, the only sustainability efforts made by the organization was to form a committee to focus on sustainability. The committee meets twice a month, but due to new gardens, attractions, and other construction, progress has stopped (Haselton, 2019). The committee has begun to make changes to their environmental impact by looking into ways to monitor and manage their carbon emissions, and therefore has asked WPI to help them with this effort.

Chapter 4: Methodology

Our goal for this project was to improve Tower Hill's capability to monitor and manage their environmental impact. We aimed to do this through three major objectives:

1. Establish indicators that are appropriate, useful, and relevant to the institution.
2. Develop a tool based on these indicators to assess current, past, and future sustainability efforts.
3. Implement the tool at Tower Hill and convey the significance of the tool to Tower Hill's staff and visitors.

This chapter will detail our different approaches we used to accomplish this overarching goal along with the three objectives. We will also discuss the reasons for our approaches and proposed action plan.

Objective 1

Establishing indicators for a specific institution is the foundation for assessing an institution's environmental impact. Within this objective, we defined what factors of sustainability we were looking at for Tower Hill's facility. In doing so, we identified what indicators drive the facility's impact on the environment. Moreover, we described the participatory process used to identify indicators and eliminate indicators not relevant to the institution, and our reasoning for this process.

Defining Sustainability with Tower Hill

As Tower Hill is primarily focused on their carbon emissions, we identified indicators that measure the effects that the facility and their grounds have on their carbon footprint. Despite these indicators being specific to only the environmental side of things, we also communicated that economic and social factors must also be present in decision making and discussion. For example, we might have carbon dioxide emissions from oil consumption as an indicator. We thus might see a rise in carbon dioxide emissions from oil consumption. Hypothetically, the administration might see this and begin brainstorming how to solve the issue for the future. They might suggest the addition of solar panels to limit their use on oil, however, this solution could be difficult to achieve without compromising the financial stability of the institution. The measurements will be able to indicate positive or negative change, but it's important to keep in mind what the most viable means are to make this change so that the institution will not suffer economically or socially.

The Metric

Through the literature review, we've established that the most helpful and accessible type of tool for evaluating environmental impacts of a facility is a footprint-based tool. In particular, using carbon-footprint metrics, as that is the standard for the UK Government and the EPA (Environmental Protection Agency, 2020).

Establishing Indicators for Tower Hill

After scanning through the literature and conversations with Tower Hill staff, we first developed a preliminary list of indicators that would be most applicable to Tower Hill. They were separated into three different scopes: 1) Fuel and other equipment dependent on fuel, 2) Electricity, and 3) Waste and material usage. These major scopes and their associated indicators were selected due to relevance to Tower Hill's facility and each indicator's ability to be measured and quantified.

Co-creating Sustainability Indicators with the Tower Hill Staff

In order to clearly define which indicators are most applicable to the institution, staff perspectives on the importance and prioritization of these different indicators are required. We aimed to find the indicators that match with the goals that Tower Hill has in terms of sustainability and changed them where needed to more closely match the needs and goals of Tower Hill. We planned on doing this by aligning sustainability indicators with Tower Hill's mission and goals through interviews and focus groups with staff, and then addressed and worked with them to identify areas of improvement.

Interviews were conducted to collect data on Tower Hill's sustainability actions and plans. The sustainability committee was interviewed and others outside of Tower Hill were contacted for other information surrounding sustainability and our plans for Tower Hill.

Objective 2

Developing a tool based on these indicators was the next big step. The purpose of the tool was to use measurements taken from the facility to give us a detailed carbon footprint of the facility. As mentioned previously, carbon footprint is one of the primary sources of impact that a facility can have on its nearby environment. Therefore, it's important to see its carbon footprint and how it has changed over time, and the primary sources of carbon emissions. The tool focused on carbon footprint in relation with time of operation and the source of the emissions.

Creation of the Tool

The list of carbon-based indicators that we created is based on the government emissions conversion factors released by the UK government to measure carbon footprint. These factors are numbers that are multiplied by some measurement to convert that measurement into tons of carbon dioxide equivalent. A new dataset of conversion factors is put out yearly to account for new data availability, methodology improvements, or corrections to errors in methodology (U.K. Department for Business, Energy & Industrial Strategy, 2019). Accordingly, we used the most recent dataset (2019) in our tool. After gathering all applicable conversion factor types through interviews and literature review, we looked further into the conversion factors to find which ones we can obtain data for, and how frequently it is recorded.

Addressing Current Inefficiencies of the Facility

Data from previous years was necessary to make a timeline of how their sustainability has looked like in the past, and to give them an idea of whether or not they have been on the road to sustainability so far. Once measured, it's capable of examining what aspects of the facility were providing the largest amount to their carbon footprint. Some areas, like heating, by nature will always have one of the largest impacts on the carbon footprint of the facility. However, we were able to see other areas that also significantly contributed to the facility's carbon footprint that could more easily be improved.

Objective 3

Tower Hill Botanic Gardens has sustainability as one of their core values, including learning and inclusivity. In order to fulfill these core values, we helped them learn how to use the tool to monitor their carbon footprint and how to use this tool to move forward in terms of sustainability. Conveying this information to Tower Hill was the first step as they need to fully understand what is going on in Tower Hill so they can learn the position they were in terms of sustainability and environmental impact.

Engaging Tower Hill

The first thing to do was to show the staff how to use the tool we created to the benefit of them and the organization. We did this by working with Jeff and the organization, through simple tutorials they can come back to. We talked to the people who will specifically be using the tool and taught them how each aspect of the tool works. From there, they spread the word throughout the facility. Once we showed them how the tool works then we taught them how to analyze the data and interpret what it means and what it signifies, how to create graphs and interpret the results, and how to portray that data throughout the facility.

During this process, we followed the 8 points to consider when teaching sustainability. The first thing we did was break down the words we were using and made it connected to them directly so they could better understand what we were focusing on. A better understanding broadened their viewpoint on sustainability and gave them a better understanding of the situation. We made sure that nothing we gave them was too overwhelming and it was simple enough to understand so they wouldn't be overloaded. The tool itself had the tutorials that taught them how to use it, but the tool also was kept straightforward and easily learnable even without the written or video user manual. Additionally, everything was brought up with a sense of positivity, allowing the institution seeing the silver lining in the situation. Furthermore, we kept them all engaged together and up to date on what was going on. We also had them look at the data we collected and analyze it themselves instead of telling them what it meant to make sure they knew that they were also a part of our team. Lastly, we reinforced the importance that they should be focusing on where they are instead of what good they could have done in the past.

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Chapter 5: Findings

From working with Tower Hill's sustainability committee, we identified indicators that illustrate their facility's carbon footprint, and created a tool that was able to take that information and produce a breakdown of their carbon footprint. The tool was then tested on data we received from Tower Hill of their consumption in these indicators we decided upon between 2016 and 2019 and was able to produce graphs to show various trends in their carbon footprint. Once the tool was completed, we created detailed documentation for whomever the tool is given to in order to use and modify the tool at any point in the future.

Establishing the Indicators

Choosing Indicators

First, indicators were established that would be used to analyze the carbon footprint of Tower Hill. Interviews were conducted with the members of the sustainability committee at Tower Hill (Sustainability Committee, February 27, 2020). After the interviews were completed and the answers were collected, we were able to narrow down to indicators that were deemed most significant to the institution, being those relating to the carbon footprint of Tower Hill. Specifically, those incorporated fuel (oil, propane, and diesel), water, and electricity. These were chosen over others as they were most applicable, and they related directly to the carbon footprint of the institution. A list of the indicators can be seen below.

- ➔ Carbon Dioxide Emission per Gallon of Oil Consumed per month
- ➔ Carbon Dioxide Emission per Gallon of Propane Consumed per month
- ➔ Carbon Dioxide Emission per Gallon of Gasoline Consumed per month
- ➔ Carbon Dioxide Emission per Gallon of Diesel Consumed per month
- ➔ Carbon Dioxide Emission per kWh of Electricity Consumed per month
- ➔ Carbon Dioxide Emission per Gallons Water Consumed per three months

These indicators were analyzed for their consistency with the 6 different criteria of identifying indicators; simplicity, scope, quantification, assessment, sensitivity and timeliness. All the indicators were simple and straight to the point of the project, making them directly on topic for the goal of them which was to look at carbon dioxide emissions for the carbon footprint. Each one of them is measurable for their carbon emissions, and they can be seen over time and how they change in their ability to change. Some of the other indicators considered included the second-hand emissions created through freighted goods or the waste disposal and what happens to it. These were put aside for the time being but can be implemented in the future.

Boundaries of Analysis

Determining the environmental impact of 171 acres of land can be troublesome and tricky. The Tower Hill sustainability committee discussed the possibilities of analyzing the carbon footprint in specific sections of the facility, the carbon footprint from ground maintenance, and also the carbon footprint of vehicles traveling to and from the facility. When regarding the overall footprint of a facility, especially with an institution where its sole source of income is from visitation, it's important to lay down boundaries and limit the scope of analysis to the area where the most environmental impact is.

The sustainability committee, therefore, determined that it would be most beneficial if most of the analysis was focused on the facility. This is primarily due to the fact that the facility causes most of the environmental impact, as it is forced to consume fuel, electricity, and even water to care for the patrons and flora of the gardens. The fuel used for garden maintenance was also accounted for so it would encompass the overall carbon print of the institution.

Now, a significant portion of the carbon footprint is the carbon dioxide produced from the amount of fuel used for transportation of visitors, employees, plant material, and regular supplies. The problem with analyzing these types of carbon production, however, is the difficulty in quantifying them. There are conversion factors that are easily applicable to both types, but the collection of the data is the difficult part. More simply put, it’s easy to find how far a person or vehicle has traveled, however, the different modes of transportation require new conversion factors to accurately figure out the carbon production and that information is not easily accessible or even given. For these reasons, the sustainability committee decided to focus on the carbon footprint that directly comes from the facility.

Corresponding Conversion Factors with Indicators

In choosing our conversion factors, we used ones from the EPA to be more specific to the US and the region where possible, and the rest were taken from the most recent IPCC annual report due to their use in multiple case studies we reviewed (Ozawa-Meida et al., 2013) (Letete et al., 2011). The factors used from the EPA were electricity in the New England region and propane. The other conversion factors were taken from the most recent annual IPCC report, those being oil (burning oil), gasoline (petrol), diesel (gas oil), and water (water supply).

Indicators	Conversion Factors (Pounds of CO2 per desired unit)
Oil	21.201
Gasoline	18.7
Propane	12.61
Diesel	23.018
Water	0.002871
Electricity	0.5582

Table 1: The indicators we chose and their respective conversion factors.

Carbon Footprint Assessment Tool

Finding the Appropriate Data Gathering Platform

In order to create the tool to analyze Tower Hill's carbon footprint, we looked through different electronic tools to visualize the data. The two that stood out were Microsoft Excel and Tableau, which we presented to Tower Hill. Both programs are able to look at the exact same types of datasets and produce similar types of graphs, but Tableau is more freely capable of changing between different graphs without as much effort. The choice came down to primarily a financial decision, as Tableau costs $70/month to use (Tableau, 2020), as well as familiarity, as the members that would be directly using the tool are more familiar with Microsoft Excel than they are with Tableau. For these reasons, we ended up going with Microsoft Excel. The tool will need an input of consumption from each of the areas we decided on broken down by month. The tool then produces a breakdown of contributions by area for the entire year, and by season, as well as the trend over years of the carbon footprint over the whole year and by season.

Baseline Data

The baseline data we gathered from Tower Hill included all of their consumption data for the indicators (oil, gasoline, propane, diesel, water, and electricity) from January 2016 to February 2020. From this data, we used the part of the data that came from 2016 as the baseline for them to compare their future data to and tested the tool out for the entire set of data we were given. The data for oil, gasoline, propane, diesel, and electricity was on a monthly basis, while the data for water was on a quarterly basis. For this reason, the amount of water they used per quarter was split up evenly over the months in each quarter to get an estimate of their total consumption by month. The data was analyzed on a monthly, yearly, and seasonally basis, with the seasons being split up thusly: Winter was January, February, and March. Spring was April, May, and June. Summer was July, August, and September. Fall was October, November, and December.

Construction of the Assessment Tool

When constructing the tool, the very first thing we did was compile the amount of fuel consumed on a monthly basis. As seen below, we tallied the amount of gallons Tower Hill used monthly and used the corresponding conversion factor to find the amount of carbon dioxide emitted per that specific fuel type.

Month	Oil	Gasoline	Propane	Diesel	Water	Electricity
January	5463.70	44.99	1066.30	5.04	43033.33	34224.00
February	3595.70	30.76	853.10	0.00	43033.33	32083.00
March	2814.70	0.00	324.00	0.00	97200.00	28741.00
April	1457.30	45.36	486.40	10.97	97200.00	25397.00
May	0.00	46.53	0.00	0.00	97200.00	27447.00
June	0.00	53.24	0.00	10.67	710633.33	41796.00
July	0.00	47.82	0.00	0.00	710633.33	37938.00
August	1691.50	60.57	0.00	21.17	710633.33	51230.00
September	0.00	42.06	0.00	9.59	242933.33	35268.00
October	0.00	30.91	151.70	32.05	242933.33	27445.00
November	3355.60	0.00	313.30	10.85	242933.33	32129.00
December	2462.40	41.78	1451.60	0.00	39533.33	38378.00
TOTALS	20840.90	444.02	4646.40	100.34	3277899.97	412076.00
CARBON	441847.92	8303.17	58591.10	2309.63	9410.85	230020.82
TOTAL CF	**750483.50**					

Season	Oil	Gasoline	Propane	Diesel	Water	Electricity	**TOTALS**
Winter	251742.79	1416.53	28289.27	116.01	526.16	53055.79	335146.56
Spring	30896.22	2713.93	6133.50	498.11	2598.35	52828.05	95668.16
Summer	35861.49	2813.42	0.00	708.03	4777.92	69460.18	113621.03
Fall	123347.42	1359.30	24168.33	987.47	1508.42	54676.81	206047.75

Figures 3 & 4: *Fuel consumption on a monthly basis within the carbon footprint assessment tool.*

The numbers within the beige highlighted cells are the cells consisting of the amount of fuel used per that corresponding month, which is in the leftmost column of the first chart. The top row of that chart consists of the fuel types we are measuring. The third to last row, where it says “TOTALS”, adds up the total amount of that specific fuel throughout the months to show the amount used the entire year. The second to last row, where it says “CARBON” is the carbon emission calculated in pounds via that specific fuel type. Last but not least, the final row, where it says “TOTAL CF” is the total amount of carbon produced via all the fuel types. Below the first chart is another chart that displays the same carbon emissions but on a seasonal view. It simply sums the amount of carbon emissions in the specific fuel type in those corresponding seasonal months.

Within the program, the beige highlighted cells are the only cells that are intended for users to type in data. The intention is that these are the cells where the users type in the amount of the specific fuel that has been used within that month once they get that particular monthly bill. Moreover, these carbon dioxide emissions were then plotted into a bar graph in relation with their fuel type as seen below in Figure 9. These charts were repeated for each desired year and each set of charts and graphs were separated into its own specific tab (from 2016-2020).

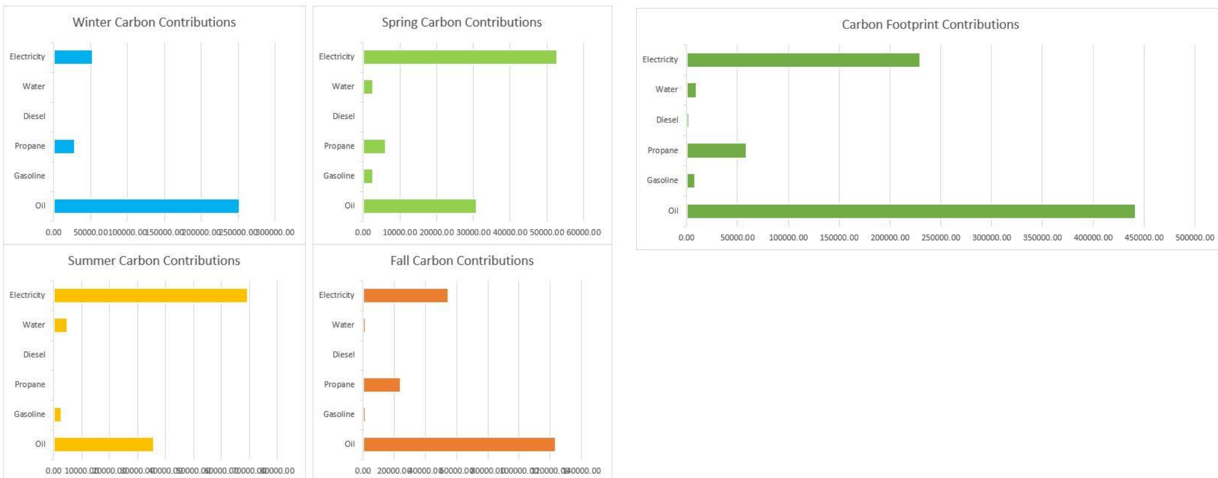

Figure 5: *Carbon footprint by fuel type by year and season.*

All of this data within the yearly tabs feed into the very first tab of the program, which shows the total yearly usage of energy and carbon emissions. Along with that is percentage increases of the annual carbon footprint and the amount of carbon footprint caused by source and its percentage in the total makeup of the facility's carbon footprint. A more comprehensive look can be seen in Figures 10 and 11.

Primary Energy Consumption (Gallons)	2016 Baseline	2017	% Increase from Previous Year	% Increase from Baseline	2018	% Increase from Previous Year	% Increase from Baseline	2019	% Increase from Previous Year	% Increase from Baseline	2020	% Increase from Previous Year	% Increase from Baseline
Oil	20840.90	22451.83	7.73%	7.73%	22591.00	0.62%	8.40%	23108.30	2.29%	10.88%	5385.90	-76.69%	-74.16%
Gasoline	444.02	482.96	8.77%	8.77%	506.58	4.89%	14.09%	1061.23	109.49%	139.00%	59.08	-94.43%	-86.70%
Propane	4646.40	6879.40	48.06%	48.06%	7817.20	13.63%	68.24%	7103.70	-9.13%	52.89%	1701.80	-76.04%	-63.37%
Diesel	100.34	63.22	-36.99%	-36.99%	116.50	84.28%	16.11%	472.57	305.64%	370.97%	31.92	-93.24%	-68.19%
Water	3277899.97	2430966.67	-25.84%	-25.84%	2507766.63	3.16%	-23.49%	2420900.01	-3.46%	-26.14%	0.00	-100.00%	-100.00%
Electricity	412076.00	390507.00	-5.23%	-5.23%	410202.00	5.04%	-0.45%	394010.00	-3.95%	-4.38%	29119.00	-92.61%	-92.93%

Carbon Impact Conversion	Pounds of CO2 per desired unit
Oil	21.20
Gasoline	18.70
Propane	12.61
Diesel	23.02
Water	2.87E-03
Electricity	0.56

Carbon Footprint in lbs of CO2	2016 Baseline	2017	% Increase from Previous Year	% Increase from Baseline	2018	% Increase from Previous Year	% Increase from Baseline	2019	% Increase from Previous Year	% Increase from Baseline	2020	% Increase from Previous Year	% Increase from Baseline
Oil	441847.92	476001.25	7.73%	7.73%	478951.79	0.62%	8.40%	489919.07	2.24%	10.88%	114186.47	-329.05%	-74.16%
Gasoline	8303.17	9031.35	8.77%	8.77%	9473.03	4.66%	14.09%	19844.96	52.26%	139.00%	1104.72	-1696.38%	-86.70%
Propane	58591.10	86749.23	48.06%	48.06%	98574.89	12.00%	68.24%	89577.66	-10.04%	52.89%	21459.70	-317.42%	-63.37%
Diesel	2309.63	1455.20	-36.99%	-36.99%	2681.60	45.73%	16.11%	10877.57	75.35%	370.97%	734.80	-1380.34%	-68.19%
Water	9410.85	6979.31	-25.84%	-25.84%	7199.80	3.06%	-23.49%	6950.40	-3.59%	-26.14%	0.00	#DIV/0!	-100.00%
Electricity	230020.82	217981.01	-5.23%	-5.23%	228974.76	4.80%	-0.45%	219936.38	-4.11%	-4.38%	16254.23	-1253.10%	-92.93%
Total (Pounds)	750483.50	798197.34	6.36%	6.36%	825855.86	3.35%	10.04%	837106.05	1.34%	11.54%	153739.91	-444.49%	-79.51%
Metric Tons	340.41	362.06	6.36%	6.36%	374.60	3.35%	10.04%	379.70	1.34%	11.54%	69.74	-444.49%	-79.51%
Percent of Baseline	100%	106%	6.36%	6.36%	110%	3.35%	10.04%	112%	1.34%	11.54%	20%	-444.49%	-79.51%

Consumption by % of carbon footprint	2016 Baseline	2017	% Increase from Previous Year	% Increase from Baseline	2018	% Increase from Previous Year	% Increase from Baseline	2019	% Increase from Previous Year	% Increase from Baseline	2020	% Increase from Previous Year	% Increase from Baseline
Oil	59%	63%	4.55%	4.55%	64%	0.39%	4.94%	65%	1.46%	6.41%	15%	-50.07%	-43.66%
Gasoline	1%	1%	0.10%	0.10%	1%	0.06%	0.16%	3%	1.38%	1.54%	0%	-2.50%	-0.96%
Propane	8%	12%	3.75%	3.75%	13%	1.58%	5.33%	12%	-1.20%	4.13%	3%	-9.08%	-4.95%
Diesel	0%	0%	-0.11%	-0.11%	0%	0.16%	0.05%	1%	1.09%	1.14%	0%	-1.35%	-0.21%
Water	1%	1%	-0.32%	-0.32%	1%	0.03%	-0.29%	1%	-0.03%	-0.33%	0%	-0.93%	-1.25%
Electricity	31%	29%	-1.60%	-1.60%	31%	1.46%	-0.14%	29%	-1.20%	-1.34%	2%	-27.14%	-28.48%

Carbon Footprint in lbs of CO2 by season	2016 Baseline	2017	% Increase	2018	% Increase	2019	% Increase	2020	% Increase
Winter	335146.56	342302.14	2.14%	340268.74	-0.59%	315600.48	-7.25%	163888.44	-48.07%
Spring	95668.16	136290.46	42.46%	112860.48	-17.19%	152822.60	35.41%	0.00	-100.00%
Summer	113621.03	68132.92	-40.03%	85723.22	25.82%	80927.42	-5.59%	0.00	-100.00%
Fall	206047.75	251471.82	22.05%	287003.41	14.13%	287755.55	0.26%	0.00	-100.00%

Figure 6: *Overall energy usage and carbon footprint tab*

All of these cells are auto populated by looking into the yearly tabs and taking information from them. This thus makes the program very easy to manage and change. All that it takes to add new years to track new data is the copy and pasting of columns where the formulas should do the rest. Taking information from these tabs, we inserted graphs that will auto populate as well and will provide helpful visuals of how their carbon footprint has changed over the years and what the primary sources of the carbon emissions have been. These graphs can be seen in Figures 8-11.

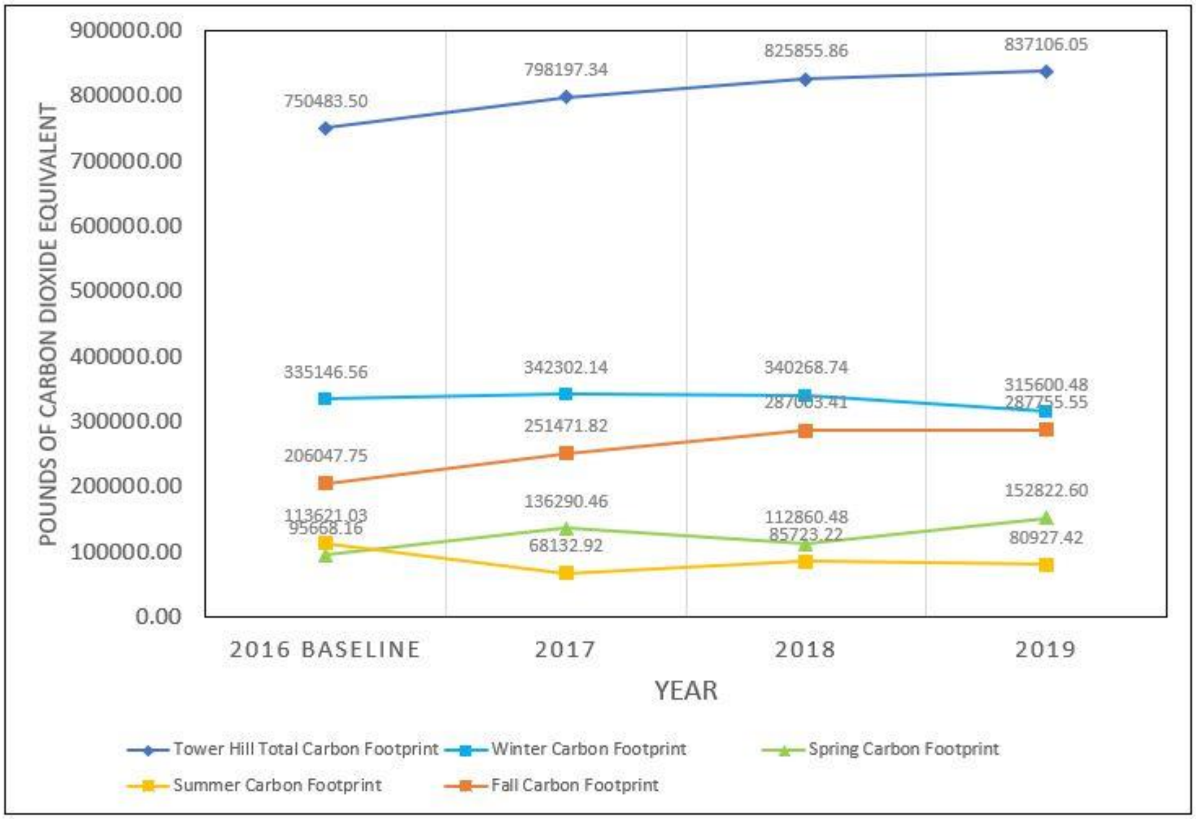

Figure 7: *Annual carbon footprint*

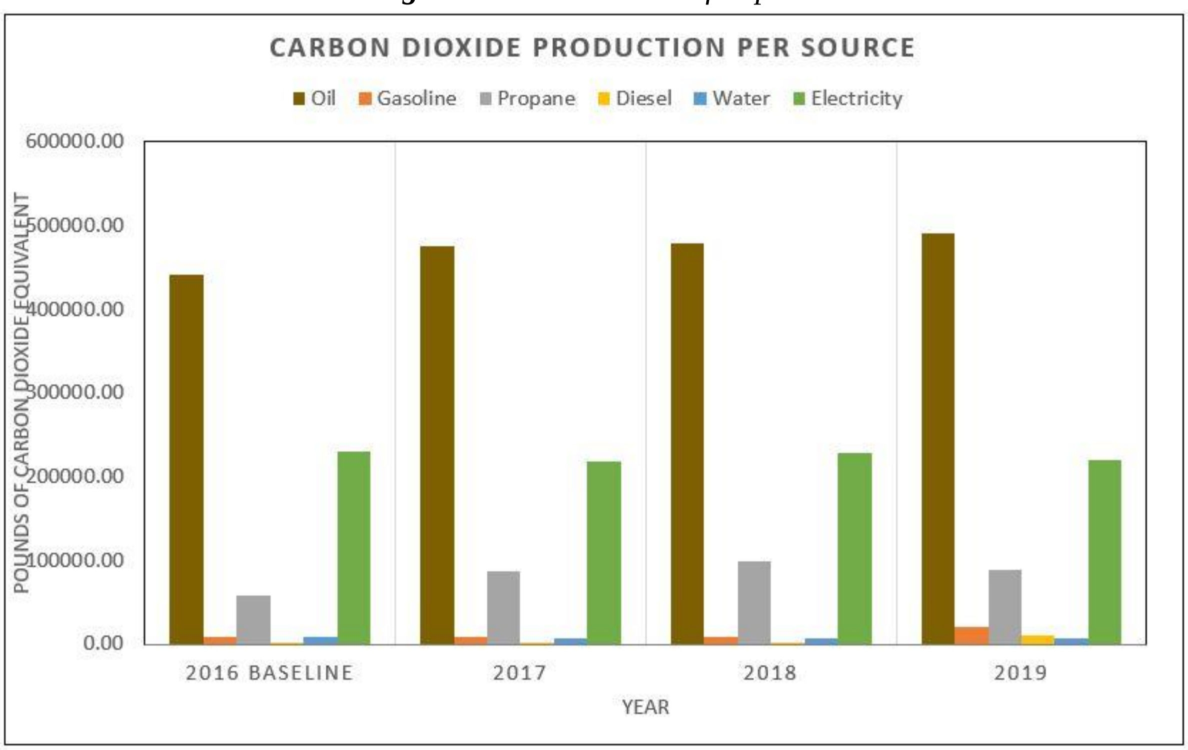

Figure 8: *Annual carbon footprint by source*

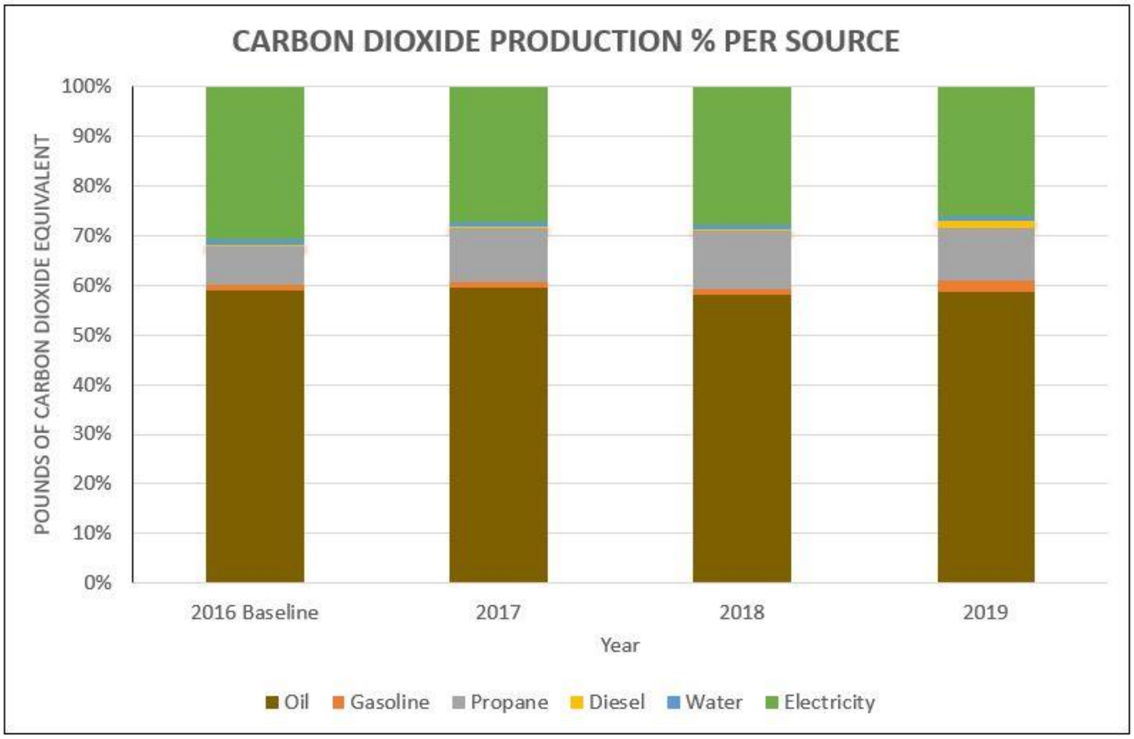

Figure 9: *Carbon footprint by source % I*

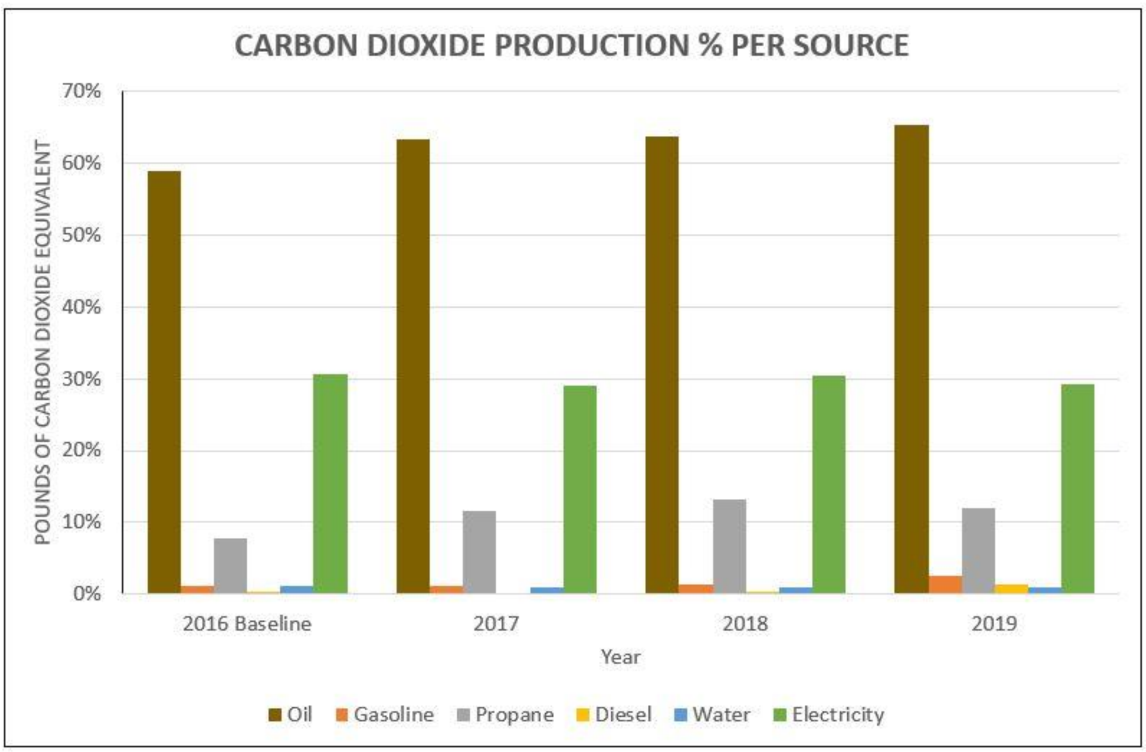

Figure 10: *Carbon footprint by source % II*

Data Analysis

The largest contributor to Tower Hill's carbon footprint is the oil used for heating. The second largest is the electricity usage. These two are overwhelmingly the majority of the carbon footprint of the facility, as both oil and electricity usage add up to slightly more than 85% of the overall carbon footprint. Using 2016 as the baseline, the facility's footprint has increased 12% as of 2019. The primary reason for this is the increase of oil consumption over the years. Oil consumption has increased 10.88% as of 2019. We have ruled that this is the main culprit since oil has the increase in carbon production in relation to the overall amount of carbon dioxide Tower Hill produces. Though electricity is another larger carbon producer, its usage has actually remained steadily constant throughout the years. The usage of gasoline, propane, and diesel has gone up significantly, however, its percentage in the whole carbon footprint is so small (15% on average) that it's negligible.

Advice from other Institutions

In order to align Tower Hill with common sustainability practices with other similar institutions, we needed to look to see what others have done under similar circumstances and apply that towards the people at Tower Hill. In order to do this, we interviewed the Vice President of Operations for Mass Audubon, Bancroft (Banks) Poor. We reached out to multiple different institutions (including the Horticulture Center, the Worcester Ecotarium, the Boston Science museum, and others) but because of the COVID-19 virus outbreak that and other things have been made difficult. Communication became a challenge for a lot of institutions, and many did not get back to us on a meeting time for us to get any information from them. Though we faced this challenge, we were still able to get a lot of information about how Mass Audubon handles the issue of sustainability and use that to help determine our recommendations for Tower Hill.

Around 15-20 years ago, staff at Mass Audubon started thinking about their carbon footprint and wanted to lead the public towards being sustainable and wanted to do this through example. They wanted to show visitors how to live so they can take it home and work on it themselves. They started this work through measuring their carbon footprint. From the results of their carbon footprint, they started auditing and looking at recommendations that came from that audit, then started making smaller changes such as insulation, air sealing, window, door and furnace replacement, and so on, to change their carbon footprint. Before looking into renewable sources of energy, they wanted to get consumption down as low as possible (by conserving energy and other methods). Renewables can be expensive so Poor suggested buying RECs (Renewable Energy Credits) until renewables are affordable. Composting and soils management were some of the other recommendations made to Tower Hill. Poor also suggested electric tractors and to take advantage of some of the programs at Massachusetts Department of Agricultural Resources (MDAR).

Engaging Tower Hill

Teaching How to Assess Carbon Emission

It's important to have methods of transferring information on how to operate the carbon footprint assessment tool from person to person. For that reason, we have implemented both writing and video methods to make sure that anyone, regardless of background experience, can operate the carbon footprint. Appendix C showcases the written and video user manual for the carbon footprint assessment tool.

Displaying the Sustainability Efforts

Additionally, we wanted to display our analysis for the public. For this, we made an infographic that can be displayed as a poster throughout the facility to showcase the impact of carbon footprint at Tower Hill. In order to make the infographic (Figure 11), we looked at the 8 considerations for teaching sustainability and incorporated them into our work. We were aware that the people looking at this infographic would be people throughout the Tower Hill community, and as such, we want to incorporate knowledge that they may not within the visual. Moreover, we wanted to implement key facts that would help the view visualize the carbon footprint production we mention. We also went on to explain carbon footprint so that the poster comes across as educational and not something that is condescending. The data we included within the heel of the footprint incorporates what we found with the tool. This allows for the viewers to analyze the data themselves and create their own conclusions from it, gaining more insight from it than if the conclusions were just written out. Everything that was incorporated into the infographic provided information to the viewer while considering the different aspects of teaching sustainability.

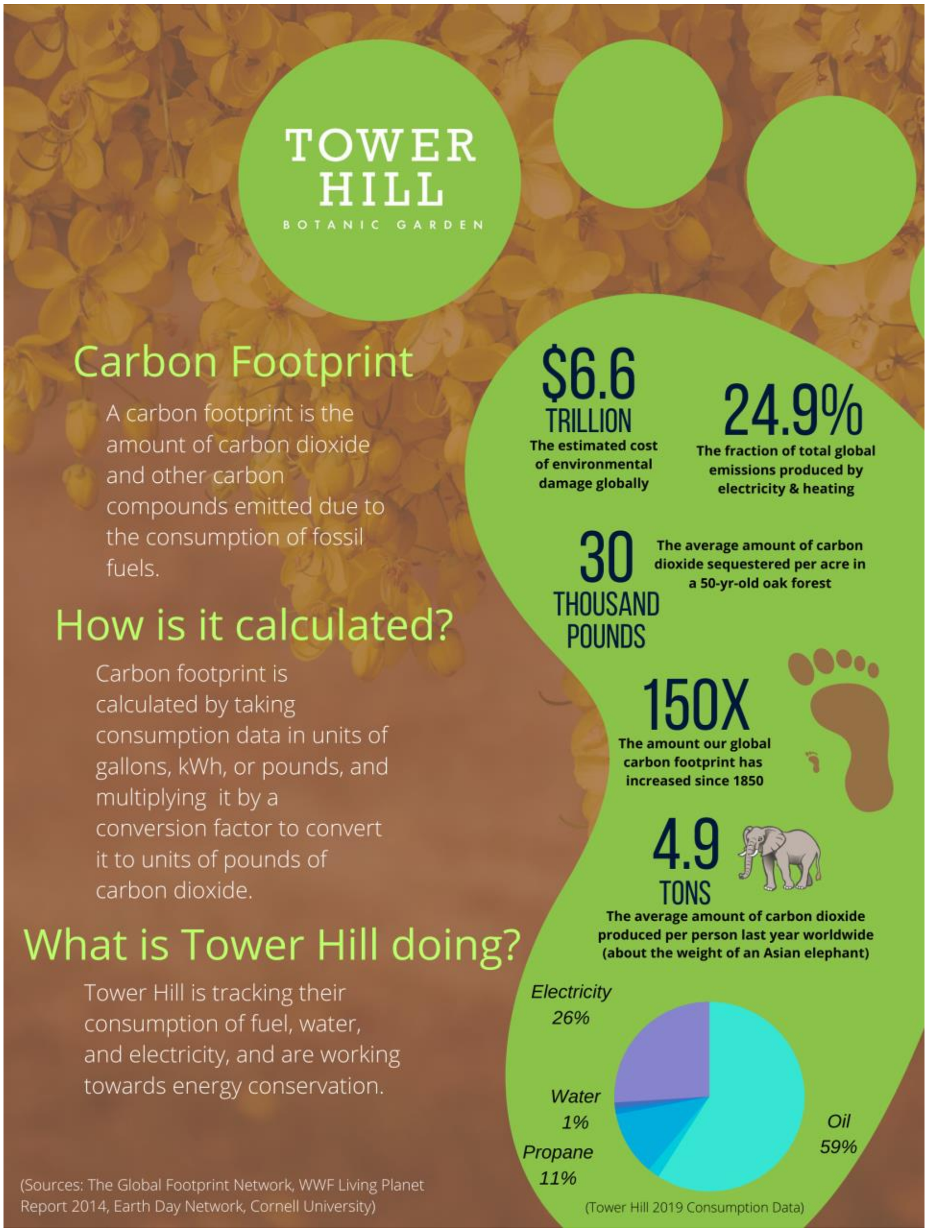

Figure 11: *Carbon footprint infographic*

Chapter 6: Recommendations

Assessing the carbon footprint of a facility lays the groundworks for continued management of an institution's environmental impact. Besides direct carbon emissions, indirect carbon emissions can also contribute a significant portion to an institution's carbon footprint. Other important factors such as the cost of implementing sustainable changes need to be considered when deciding how to limit an institution's carbon footprint. Within this chapter, we will discuss the conclusions drawn from the analysis of Tower Hill's carbon footprint assessment of their facility and on how Tower Hill can move forward with managing their environmental impact.

Scope of the Carbon Footprint Assessment

As mentioned in the previous chapter, indirect carbon emissions such as the carbon emissions produced from freighting goods, commuting employees, or traveling visitors can have a significant impact on an institution's carbon footprint. Quantifying these types of indicators, however, are difficult. For that reason, **we suggest that Tower Hill focuses on the direct impact that the facility has on its nearby environment.** Specifically, this means for Tower Hill to focus on the carbon emissions that is produced from their fuel consumption along with electricity and water usage.

Implementing New Parameters

With the carbon footprint assessment tool, Tower Hill will be able to implement new parameters into the program. Parameters such as costs of energy consumption, zones of the facility that produce the most carbon emissions, and even average outside temperature can easily be added to the program. The addition of these parameters, along with others not mentioned can significantly improve Tower Hill's capability of making educated decisions on how to decrease their carbon footprint. In terms of implementing a cost benefit analysis factor to the program, however, we recognize that much of this can be done as back hand calculations rather than formalized into the program. Therefore, **we recommend that Tower Hill looks to add important parameters such as costs of energy consumption, monthly average temperature, and zones of the facility with the most carbon emissions.**

We concluded that a cost benefit analysis would be better left out of the program due to the fact that one of the key aspects of this type of analysis is figuring out the payback time of investing in a change to the facility. When evaluating payback, one needs to account for inflation and any type of discount rate that will be offered from the vendor or seller to find the present and future value of money provided for the investment. It would be difficult to incorporate this into the existing program without compromising its existing integrity. For these reasons, it will be much easier to either perform a cost benefit analysis in a separate program or conduct it by hand.

Continue to Monitor

Monitoring Tower Hill's carbon footprint is the first step towards a more sustainable and environmentally friendly future. This will furthermore allow Tower Hill to observe increases, decreases, or fluctuations of their carbon footprint and to pinpoint the main sources of their carbon emissions. For these reasons, **we recommend that Tower Hill continue to monitor their carbon footprint and to set a goal to decrease a percentage of their carbon footprint starting from whichever year they desire.** Having a goal in place will set in motion for preparation and planning for the future. This will also help keep Tower Hill accountable to themselves to make sure that measures are being taken to steadily limit their environmental impact.

Moving Forward

We have supported Tower Hill in creating the foundations for a sustainable future. Using this carbon footprint assessment tool, **we recommend that Tower Hill research methods to conserve their energy consumption from their two main sources of carbon emissions: oil and electricity.** Being that the two sources of energy make up approximately 85% of the institution's carbon footprint, we suggest implementing measures to conserve and find more efficient ways of heating, cooling, and lighting the facility. Finding these methods can be tricky and research intensive as well as focused on costs. Within this process of finding the most beneficial methods, cost benefit analyses need to be done to see which method can limit the most carbon emission at the most sustainable costs. **We further hope that Tower Hill continues to work with WPI on this path towards a more sustainable future. Possible projects that can be done in the near future could consist of researching methods of conserving fuel consumption at Tower Hill, developing ways to teach Tower Hill's visitors how they can limit their environmental impact, or expanding the capabilities of the tool. All of these can support Tower Hill's journey in sustainability.**

Conclusion

As climate change continues to devastate homes, animals, and people alike, institutions are beginning to combat their carbon emissions by limiting their energy consumption. In order to support Tower Hill in limiting their energy consumption, we researched how other institutions have limited theirs in a sustainable manner, and how they were able to measure their progress in this over time. We then began to develop ways to manage and monitor Tower Hill's environmental impact in these 3 steps:

1. Establish indicators that are appropriate, useful, and relevant to the institution.
2. Develop a tool based on these indicators to assess current, past, and future sustainability efforts.
3. Implement the tool at Tower Hill and convey the significance of the tool to Tower Hill's staff and visitors.

As a result of these steps, we were able to support them in developing a carbon footprint assessment tool that calculates Tower Hill's carbon emissions from their energy consumption over time. The analysis of their carbon footprint allowed us to identify an increase in their carbon emissions over past years, where the largest source of carbon emissions was coming from, and which fuel has been directly contributing to their annual increase. Overall, we helped Tower Hill be able to manage and monitor their carbon emissions over time and be able to gauge decisions from the data to sustainably decrease their environmental impact.

Tower Hill has become a trailblazer for many institutions as they begin to change their facilities and focus to become more sustainable and environmentally friendly. By doing this, their culture of preservation and conservation of natural beauty can be spread to their employees and visitors. This focus and awareness will hopefully spread to institutions across the United States and the rest of this globe. It's up to institutions and communities to raise environmental awareness and change the way our society views and fights climate change.

Expert Interviews

Bancroft Poor, interviewed by Giovanni Mannino, Eric Lopes, and Jenna Currie, April 3rd, 2020.

Jeff Haselton, interviewed by Giovanni Mannino, Eric Lopes, and Jenna Currie, October 7th, 2020.

Sustainability Committee, interviewed by Giovanni Mannino, Eric Lopes, and Jenna Currie, April 9th, 2020.

Sustainability Committee, interviewed by Giovanni Mannino, Eric Lopes, and Jenna Currie, April 27th, 2020.

Sustainability Committee, interviewed by Giovanni Mannino, Eric Lopes, and Jenna Currie, February 27th, 2020.

Sustainability Committee, interviewed by Giovanni Mannino, Eric Lopes, and Jenna Currie, March 26th, 2020.

Sustainability Committee, interviewed by Giovanni Mannino, Eric Lopes, and Jenna Currie, November 13th, 2019.

Sustainability Committee, interviewed by Giovanni Mannino, Eric Lopes, and Jenna Currie, May 5th, 2020.

Sustainability Committee, interviewed by Giovanni Mannino, Eric Lopes, and Jenna Currie, May 7th, 2020.

Sustainability Committee, interviewed by Giovanni Mannino, Eric Lopes, and Jenna Currie, September 12th, 2019.

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Appendix A: List of Conversion Factors

Carbon Impact Conversion Factors	Pounds of CO2 per desired unit
Oil	21.201
Gasoline	18.7
Propane	12.61
Diesel	23.018
Water	0.002871
Electricity	0.5582

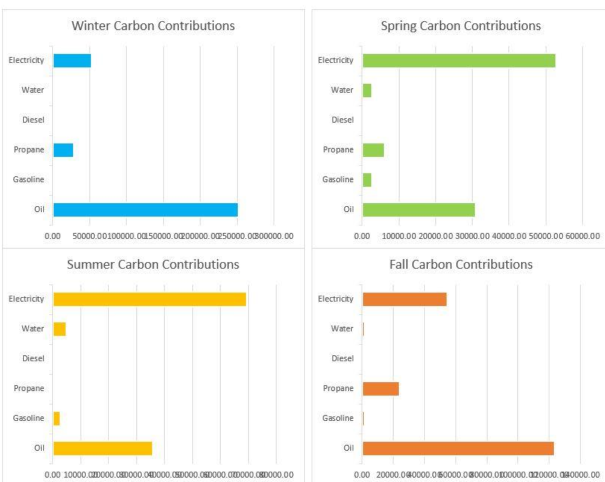
Table 1: Oil, gas, diesel, and water conversion factors are from the UK Government. Propane and electricity conversion factors are from the EPA. Both converted to desired units.

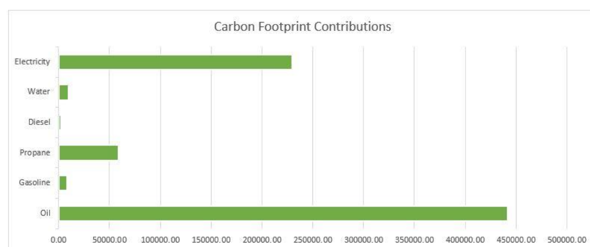
Appendix B: Images Regarding Tower Hill's Carbon Footprint

Month	Oil	Gasoline	Propane	Diesel	Water	Electricity
January	5463.70	44.99	1066.30	5.04	43033.33	34224.00
February	3595.70	30.76	853.10	0.00	43033.33	32083.00
March	2814.70	0.00	324.00	0.00	97200.00	28741.00
April	1457.30	45.36	486.40	10.97	97200.00	25397.00
May	0.00	46.53	0.00	0.00	97200.00	27447.00
June	0.00	53.24	0.00	10.67	710633.33	41796.00
July	0.00	47.82	0.00	0.00	710633.33	37938.00
August	1691.50	60.57	0.00	21.17	710633.33	51230.00
September	0.00	42.06	0.00	9.59	242933.33	35268.00
October	0.00	30.91	151.70	32.05	242933.33	27445.00
November	3355.60	0.00	313.30	10.85	242933.33	32129.00
December	2462.40	41.78	1451.60	0.00	39533.33	38378.00
TOTALS	20840.90	444.02	4646.40	100.34	3277899.97	412076.00
CARBON	441847.92	8303.17	58591.10	2309.63	9410.85	230020.82
TOTAL CF	**750483.50**					

Season	Oil	Gasoline	Propane	Diesel	Water	Electricity	TOTALS
Winter	251742.79	1416.53	28289.27	116.01	526.16	53055.79	335146.56
Spring	30896.22	2713.93	6133.50	498.11	2598.35	52828.05	95668.16
Summer	35861.49	2813.42	0.00	708.03	4777.92	69460.18	113621.03
Fall	123347.42	1359.30	24168.33	987.47	1508.42	54676.81	206047.75

Fuel consumption on a monthly basis within the carbon footprint assessment tool





Carbon Footprint graphs by fuel type on each yearly tab.

Primary Energy Consumption (Gallons)	2016 Baseline	2017	% Increase from Previous Year	% Increase from Baseline	2018	% Increase from Previous Year	% Increase from Baseline	2019	% Increase from Previous Year	% Increase from Baseline	2020	% Increase from Previous Year	% Increase from Baseline
Oil	20840.90	22451.83	7.73%	7.73%	22591.00	0.62%	8.40%	23108.30	2.29%	10.88%	5385.90	-76.69%	-74.16%
Gasoline	444.02	482.96	8.77%	8.77%	506.58	4.89%	14.09%	1061.23	109.49%	139.00%	59.08	-94.43%	-86.70%
Propane	4646.40	6879.40	48.06%	48.06%	7817.20	13.63%	68.24%	7103.70	-9.13%	52.89%	1701.80	-76.04%	-63.37%
Diesel	100.34	63.22	-36.99%	-36.99%	116.50	84.28%	16.11%	472.57	305.64%	370.97%	31.92	-93.24%	-68.19%
Water	3277899.97	2430966.67	-25.84%	-25.84%	2507766.63	3.16%	-23.49%	2420900.01	-3.46%	-26.14%	0.00	-100.00%	-100.00%
Electricity	412076.00	390507.00	-5.23%	-5.23%	410202.00	5.04%	-0.45%	394010.00	-3.95%	-4.38%	29119.00	-92.61%	-92.93%

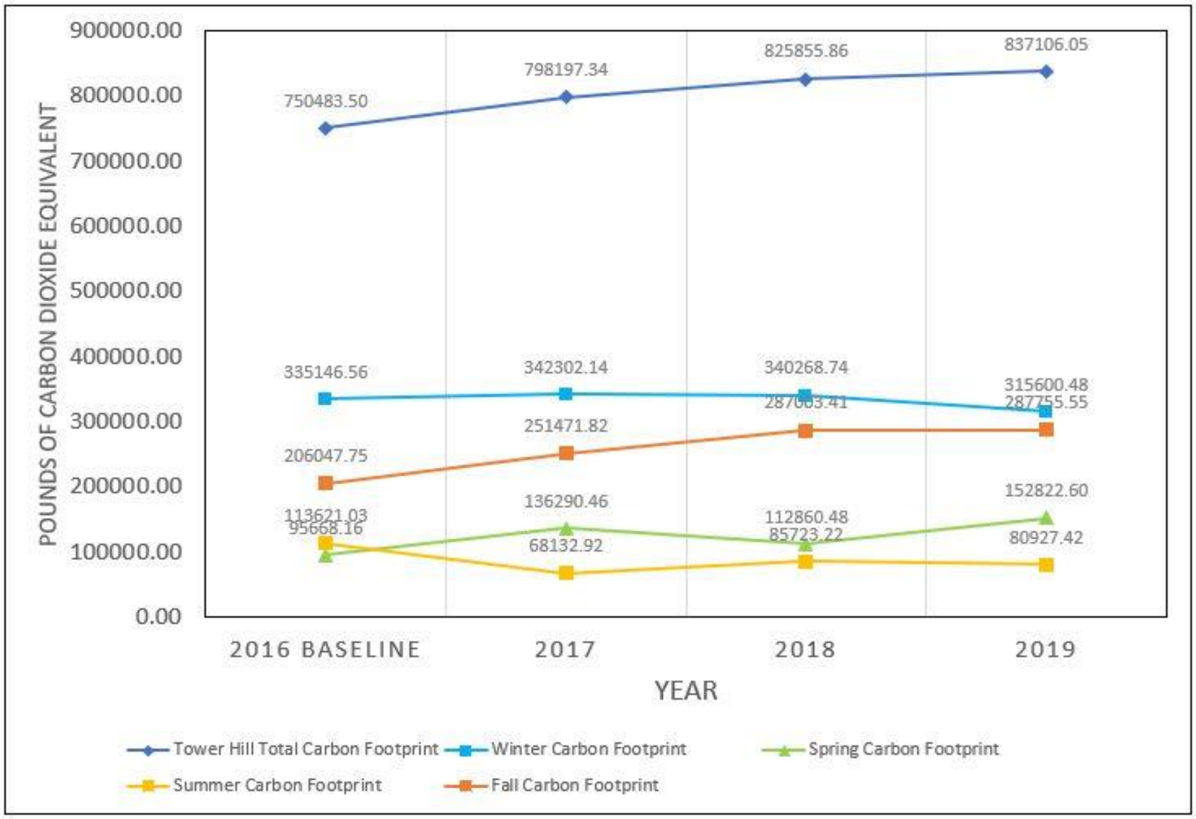
Carbon Impact Conversion	Pounds of CO2 per desired unit
Oil	21.20
Gasoline	18.70
Propane	12.61
Diesel	23.02
Water	2.87E-03
Electricity	0.56

Carbon Footprint in lbs of CO2	2016 Baseline	2017	% Increase from Previous Year	% Increase from Baseline	2018	% Increase from Previous Year	% Increase from Baseline	2019	% Increase from Previous Year	% Increase from Baseline	2020	% Increase from Previous Year	% Increase from Baseline
Oil	441847.92	476001.25	7.73%	7.73%	478951.79	0.62%	8.40%	489919.07	2.24%	10.88%	114186.47	-329.05%	-74.16%
Gasoline	8303.17	9031.35	8.77%	8.77%	9473.03	4.66%	14.09%	19844.96	52.26%	139.00%	1104.72	-1696.38%	-86.70%
Propane	58591.10	86749.23	48.06%	48.06%	98574.89	12.00%	68.24%	89577.66	-10.04%	52.89%	21459.70	-317.42%	-63.37%
Diesel	2309.63	1455.20	-36.99%	-36.99%	2681.60	45.73%	16.11%	10877.57	75.35%	370.97%	734.80	-1380.34%	-68.19%
Water	9410.85	6979.31	-25.84%	-25.84%	7199.80	3.06%	-23.49%	6950.40	-3.59%	-26.14%	0.00	#DIV/0!	-100.00%
Electricity	230020.82	217981.01	-5.23%	-5.23%	228974.76	4.80%	-0.45%	219936.38	-4.11%	-4.38%	16254.23	-1253.10%	-92.93%
Total (Pounds)	750483.50	798197.34	6.36%	6.36%	825855.86	3.35%	10.04%	837106.05	1.34%	11.54%	153739.91	-444.49%	-79.51%
Metric Tons	340.41	362.06	6.36%	6.36%	374.60	3.35%	10.04%	379.70	1.34%	11.54%	69.74	-444.49%	-79.51%
Percent of Baseline	100%	106%	6.36%	6.36%	110%	3.35%	10.04%	112%	1.34%	11.54%	20%	-444.49%	-79.51%

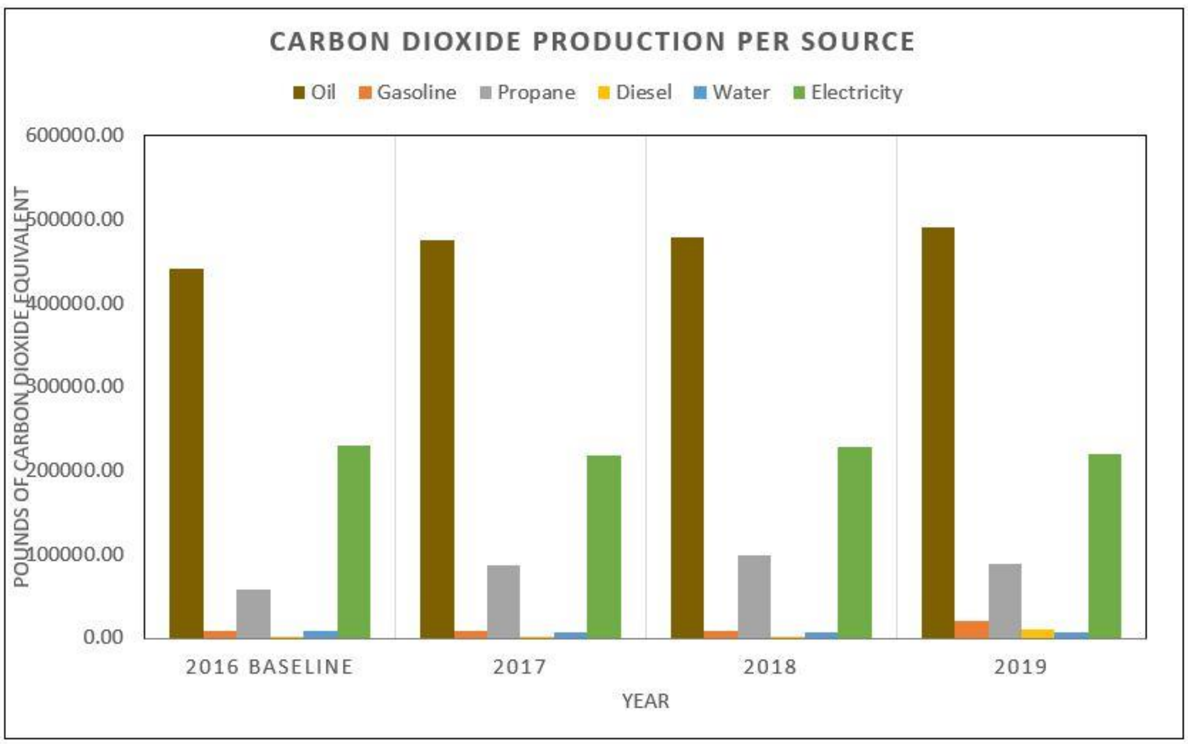
Consumption by % of carbon footprint	2016 Baseline	2017	% Increase from Previous Year	% Increase from Baseline	2018	% Increase from Previous Year	% Increase from Baseline	2019	% Increase from Previous Year	% Increase from Baseline	2020	% Increase from Previous Year	% Increase from Baseline
Oil	59%	63%	4.55%	4.55%	64%	0.39%	4.94%	65%	1.46%	6.41%	15%	-50.07%	-43.66%
Gasoline	1%	1%	0.10%	0.10%	1%	0.06%	0.16%	3%	1.38%	1.54%	0%	-2.50%	-0.96%
Propane	8%	12%	3.75%	3.75%	13%	1.58%	5.33%	12%	-1.20%	4.13%	3%	-9.08%	-4.95%
Diesel	0%	0%	-0.11%	-0.11%	0%	0.16%	0.05%	1%	1.09%	1.14%	0%	-1.35%	-0.21%
Water	1%	1%	-0.32%	-0.32%	1%	0.03%	-0.29%	1%	-0.03%	-0.33%	0%	-0.93%	-1.25%
Electricity	31%	29%	-1.60%	-1.60%	31%	1.46%	-0.14%	29%	-1.20%	-1.34%	2%	-27.14%	-28.48%

Carbon Footprint in lbs of CO2 by season	2016 Baseline	2017	% Increase	2018	% Increase	2019	% Increase	2020	% Increase
Winter	335146.56	342302.14	2.14%	340268.74	-0.59%	315600.48	-7.25%	163888.44	-48.07%
Spring	95668.16	136290.46	42.46%	112860.48	-17.19%	152822.60	35.41%	0.00	-100.00%
Summer	113621.03	68132.92	-40.03%	85723.22	25.82%	80927.42	-5.59%	0.00	-100.00%
Fall	206047.75	251471.82	22.05%	287003.41	14.13%	287755.55	0.26%	0.00	-100.00%

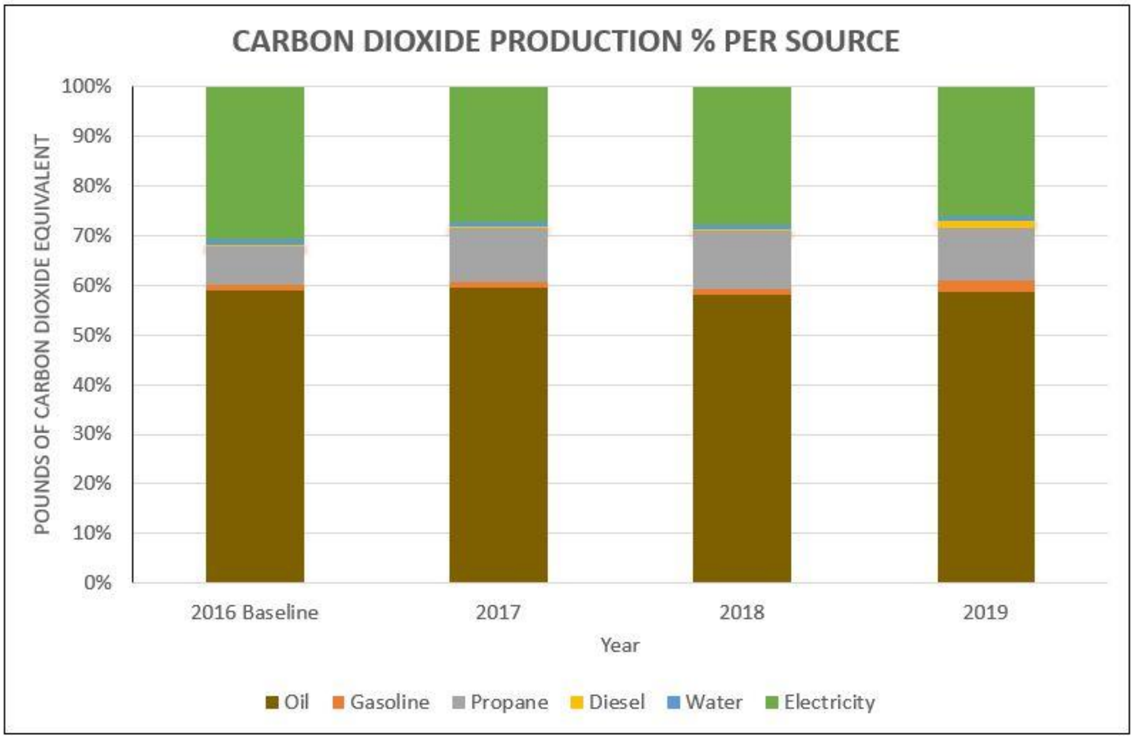
Overall Energy Usage and Carbon Footprint Tab



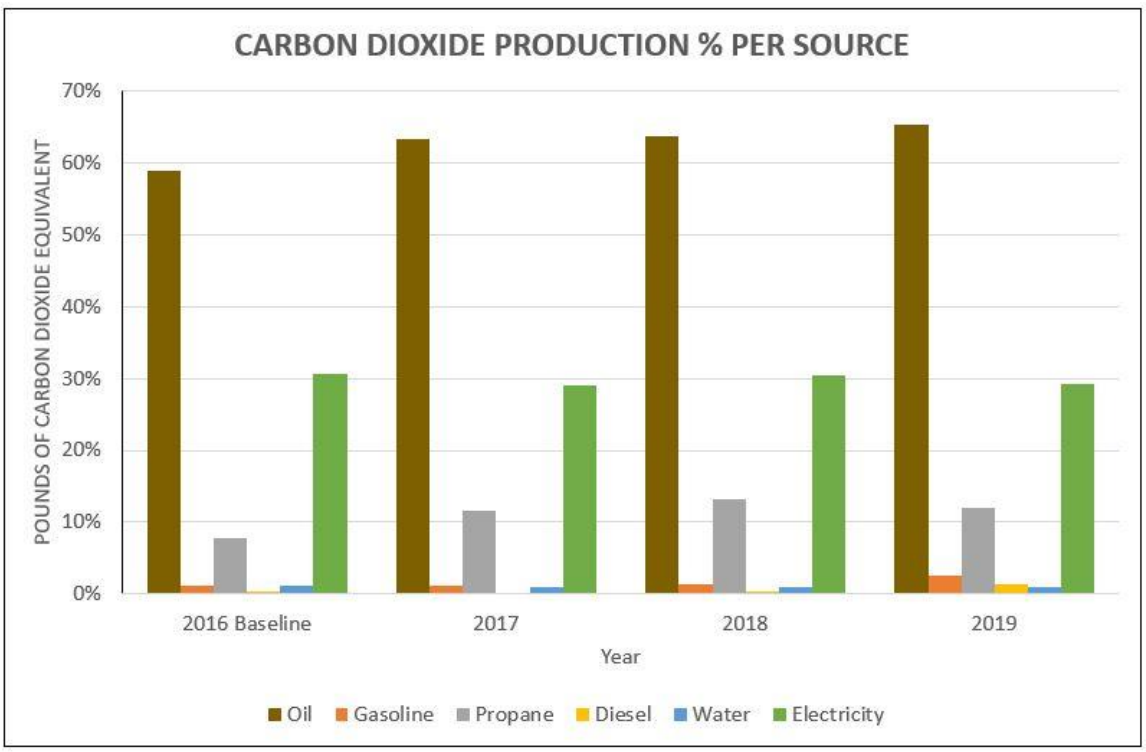
Annual Carbon Footprint



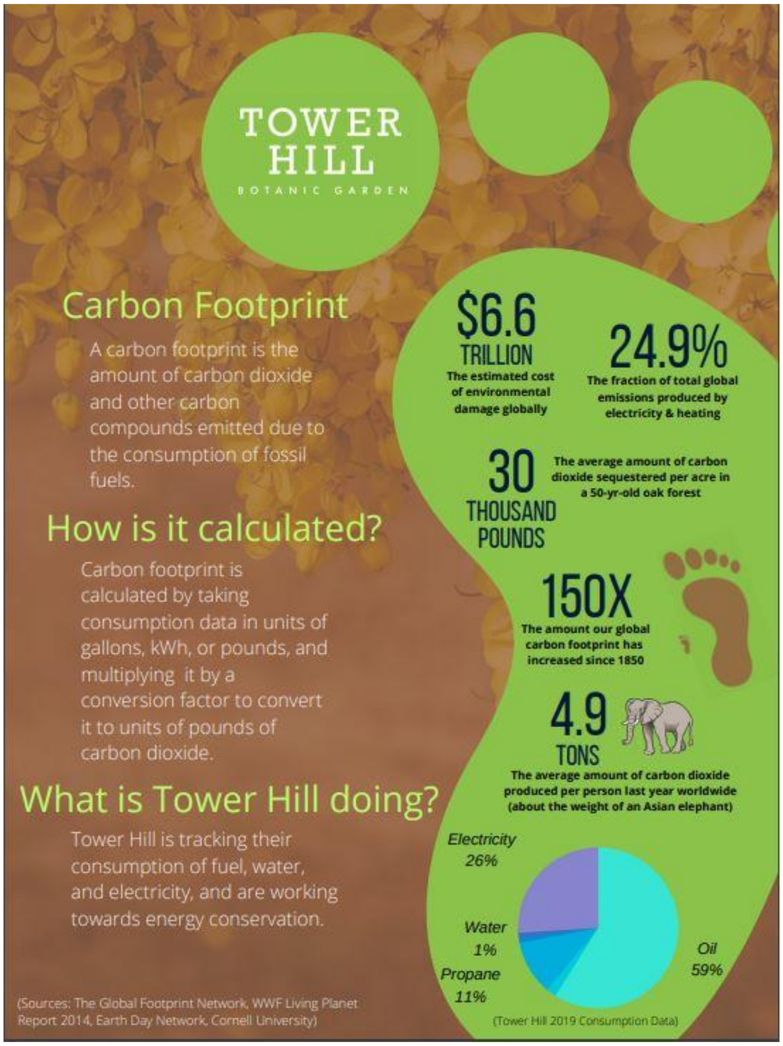
Annual Carbon Footprint by Source



Carbon Footprint by Source % I



Carbon Footprint by Source % II



Carbon Footprint Infographic

Appendix C: Manual of the Tool

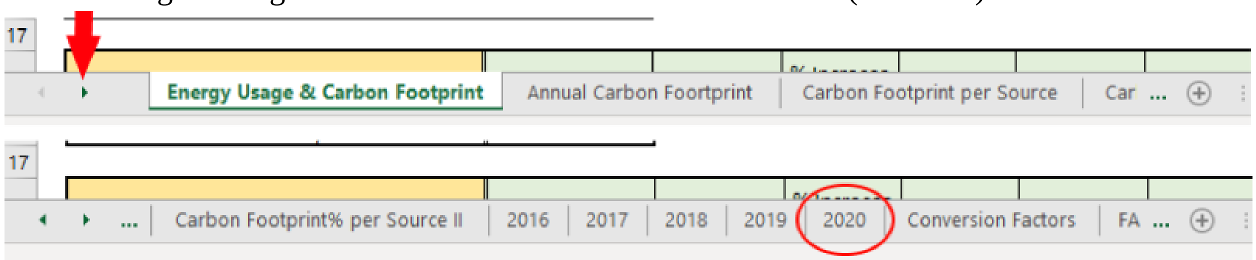
Written Manual:

Located below as well as in WPI digital commons along with this report.

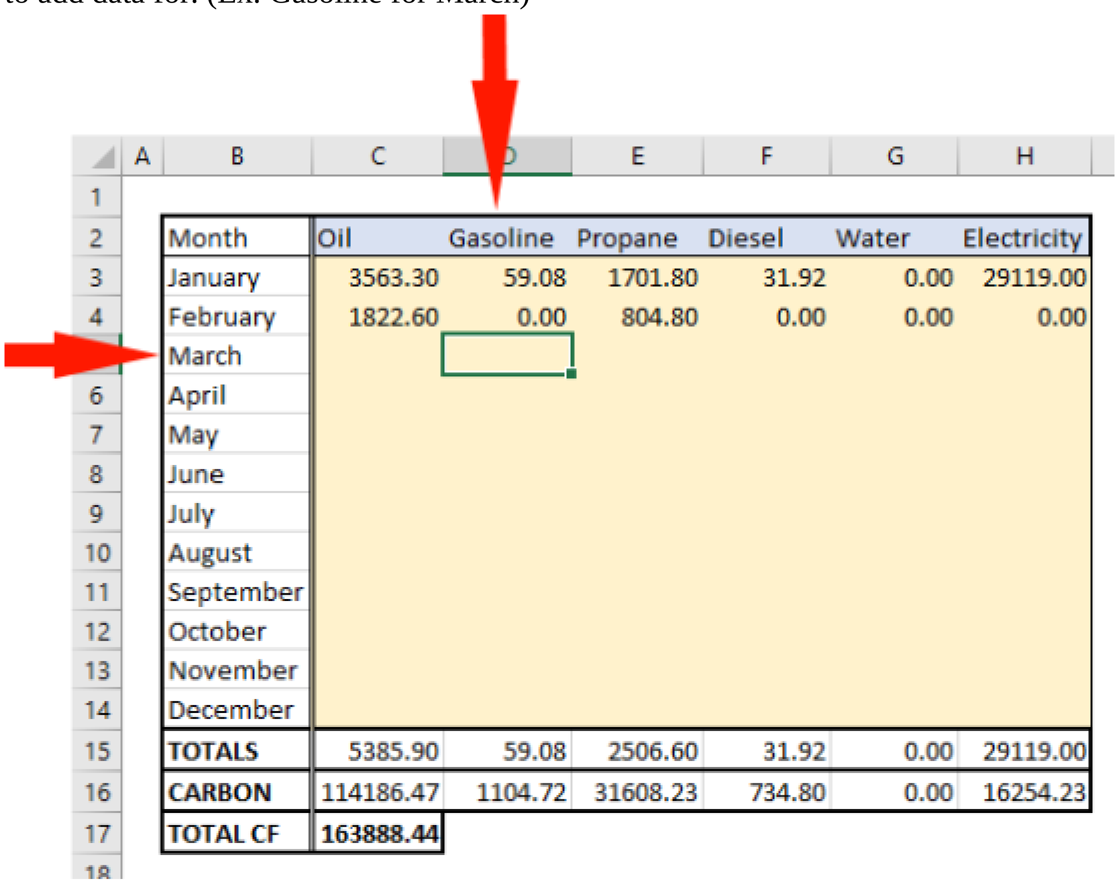
Entering data for a year

This section is for help on entering data for a year tab that already exists.

1. Find and click on the year for which you want to add data. If the year is not visible, press the left or right facing arrows on the bottom left until it is visible. (Ex. 2020)



2. Find the cell in that that corresponds to the month and consumption data you would like to add data for. (Ex. Gasoline for March)



Month	Oil	Gasoline	Propane	Diesel	Water	Electricity
January	3563.30	59.08	1701.80	31.92	0.00	29119.00
February	1822.60	0.00	804.80	0.00	0.00	0.00
March						
April						
May						
June						
July						
August						
September						
October						
November						
December						
TOTALS	5385.90	59.08	2506.60	31.92	0.00	29119.00
CARBON	114186.47	1104.72	31608.23	734.80	0.00	16254.23
TOTAL CF	163888.44					

3. Enter in the data in the correct units (gallons for oil, gasoline, propane, diesel, and water; kilowatt hours for electricity) and press enter.. (Ex. 16.47 gallons)

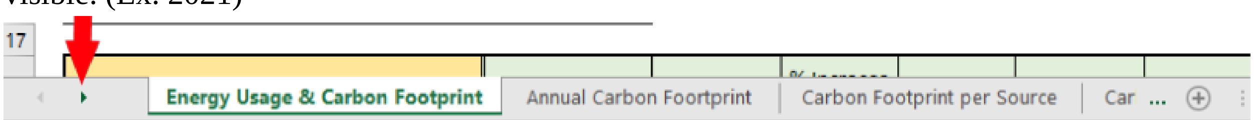
Month	Oil	Gasoline	Propane	Diesel	Water	Electricity
January	3563.30	59.08	1701.80	31.92	0.00	29119.00
February	1822.60	0.00	804.80	0.00	0.00	0.00
March		16.47				
April						
May						
June						
July						
August						
September						
October						
November						
December						
TOTALS	5385.90	59.08	2506.60	31.92	0.00	29119.00
CARBON	114186.47	1104.72	31608.23	734.80	0.00	16254.23
TOTAL CF	**163888.44**					

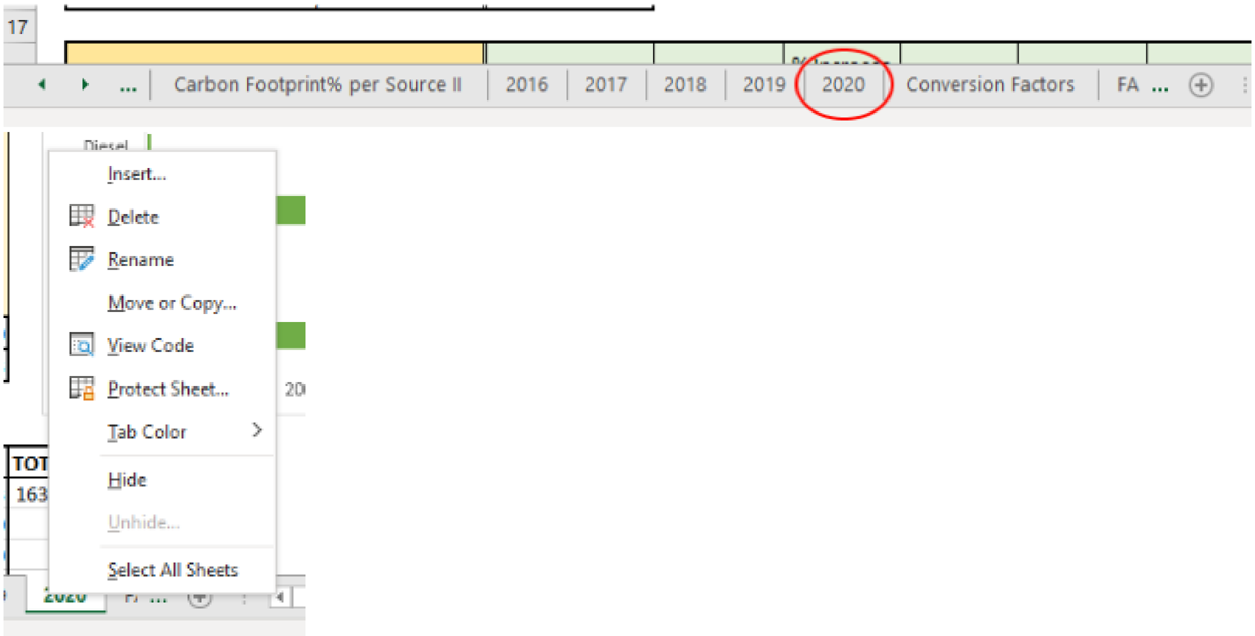
4. You have successfully input data.

Creating a new year

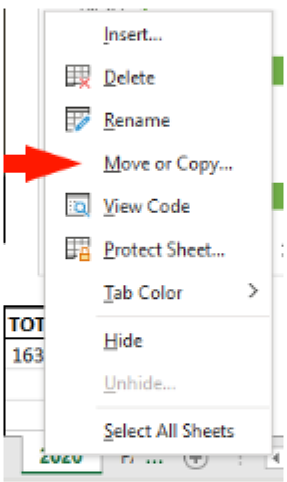
This section is for help on creating a new tab for a new year that is after the ones appearing on the table.

1. Find the tab for the year closest to the one you want to add and right click on the tab.. If the year is not visible, press the left or right facing arrows on the bottom left until it is visible. (Ex. 2021)

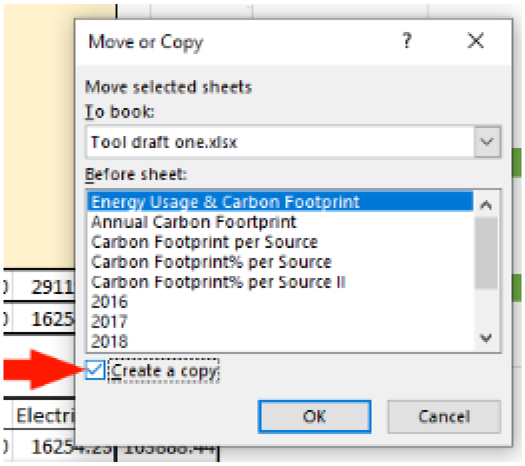


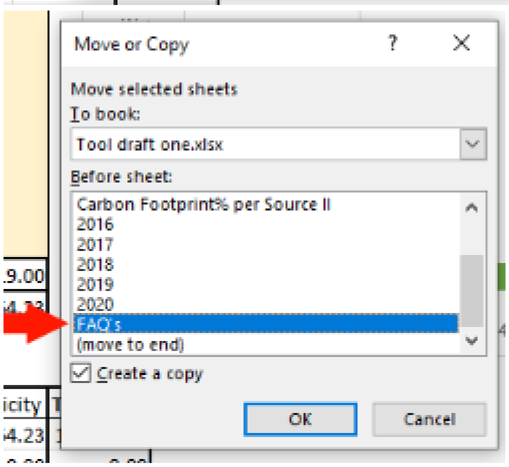


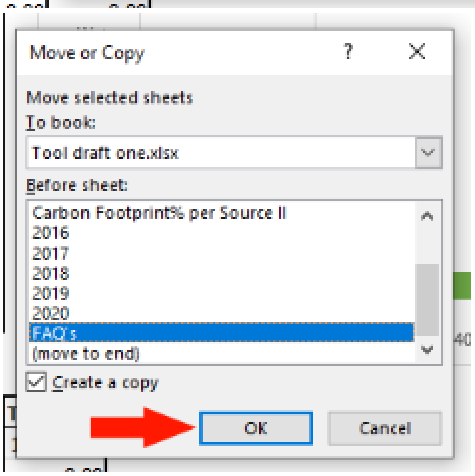
2. Click on “Move or Copy…”



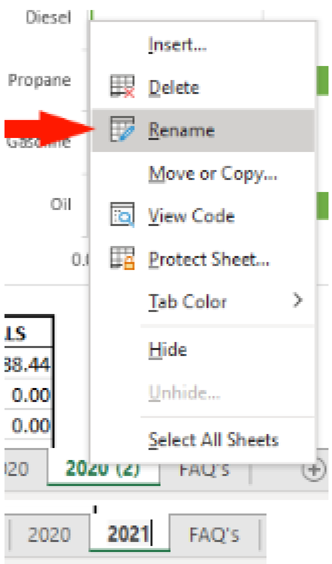
3. Click on “Create of Copy” and select the item on the list right below the item that corresponds to the tab you are copying, then click on “OK”. (Ex. I am copying the tab named “2020” so I find the item that is right after “2020” on the list, which is “FAQ’s”)







4. You should immediately be brought to the new tab, which should be the name of the tab you duplicated with “(2)” after it. (Ex. 2020 (2)) Right click on the tab you are on, click on “Rename”, and rename the tab to the year you want to add. (Ex. 2021)

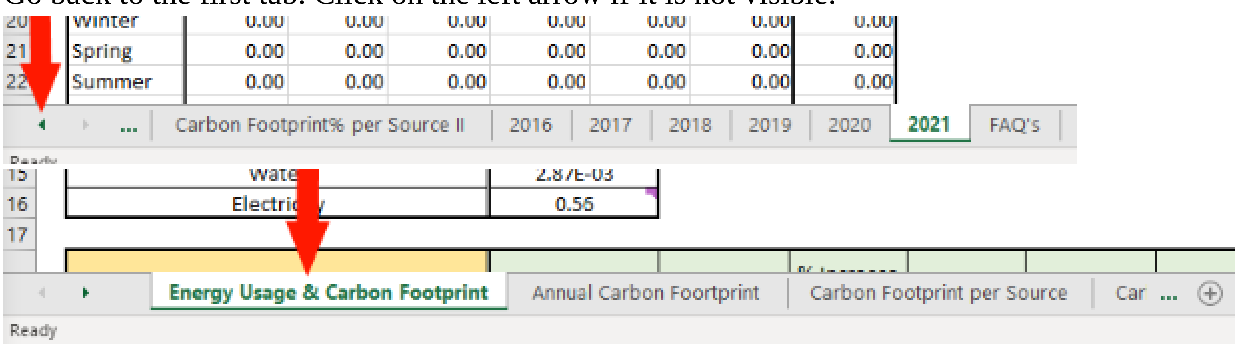


5. Select all the tan cells towards the top left of the sheet, then press the “delete” key on your keyboard. (Ex. The cells in the square between C3 and H14)

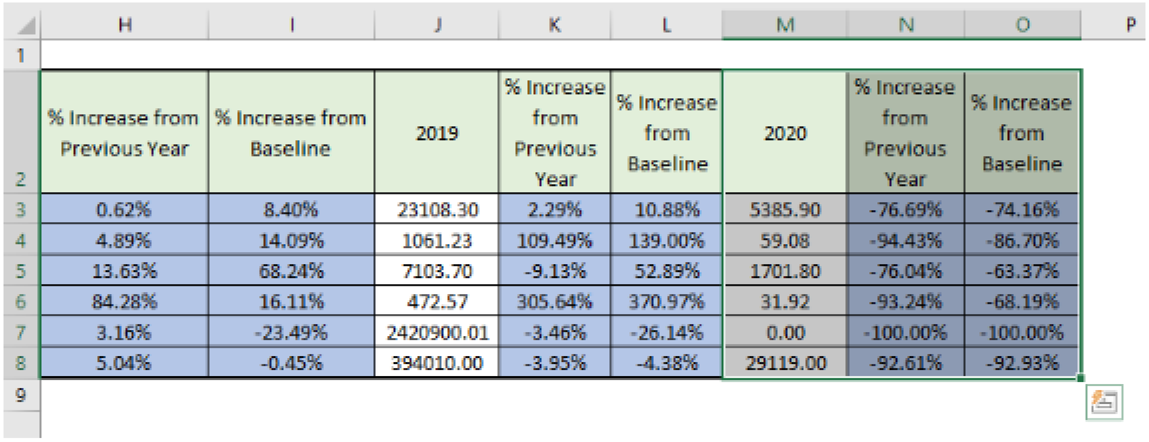
Month	Oil	Gasoline	Propane	Diesel	Water	Electricity
January	3563.30	59.08	1701.80	31.92	0.00	29119.00
February	1822.60	0.00	804.80	0.00	0.00	0.00
March						
April						
May						
June						
July						
August						
September						
October						
November						
December						
TOTALS	5385.90	59.08	2506.60	31.92	0.00	29119.00
CARBON	114186.47	1104.72	31608.23	734.80	0.00	16254.23

Month	Oil	Gasoline	Propane	Diesel	Water	Electricity
January						
February						
March						
April						
May						
June						
July						
August						
September						
October						
November						
December						
TOTALS	0.00	0.00	0.00	0.00	0.00	0.00
CARBON	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL CF	0.00					

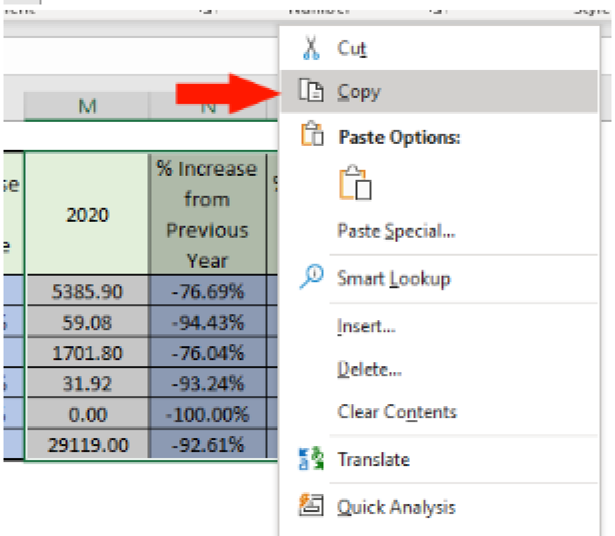
6. Go back to the first tab. Click on the left arrow if it is not visible.



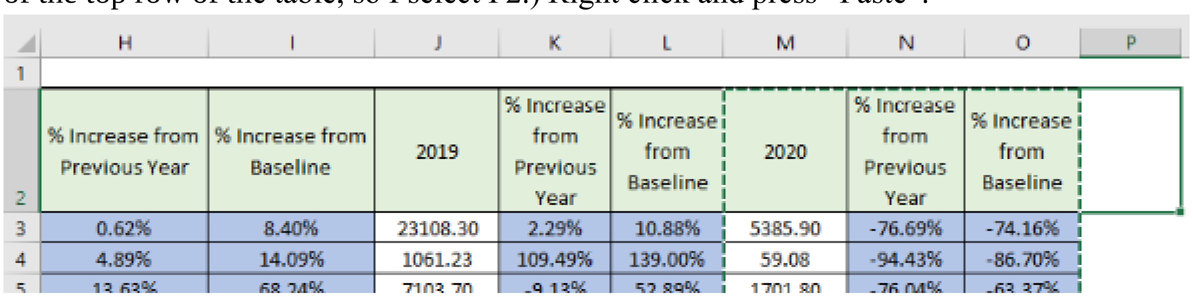
7. Go to the end of the first table on the first tab, and select the last 3 columns. Right click and press “Copy”.



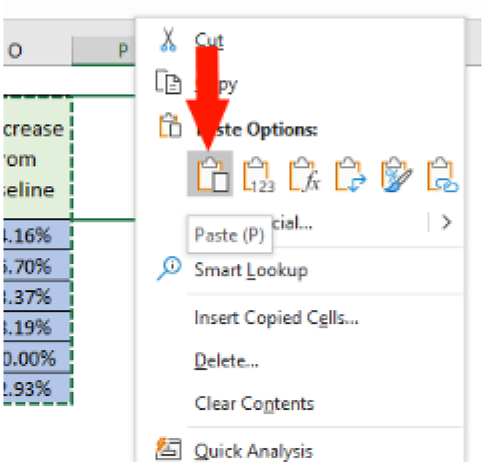
H	I	J	K	L	M	N	O
% Increase from Previous Year	% Increase from Baseline	2019	% Increase from Previous Year	% Increase from Baseline	2020	% Increase from Previous Year	% Increase from Baseline
0.62%	8.40%	23108.30	2.29%	10.88%	5385.90	-76.69%	-74.16%
4.89%	14.09%	1061.23	109.49%	139.00%	59.08	-94.43%	-86.70%
13.63%	68.24%	7103.70	-9.13%	52.89%	1701.80	-76.04%	-63.37%
84.28%	16.11%	472.57	305.64%	370.97%	31.92	-93.24%	-68.19%
3.16%	-23.49%	2420900.01	-3.46%	-26.14%	0.00	-100.00%	-100.00%
5.04%	-0.45%	394010.00	-3.95%	-4.38%	29119.00	-92.61%	-92.93%



8. Select the cell right after the end of the top row of the table. (Ex. O2 is the cell at the end of the top row of the table, so I select P2.) Right click and press "Paste".



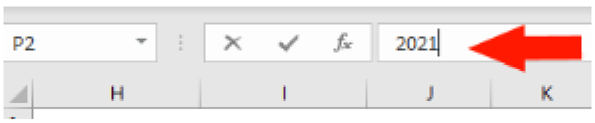
H	I	J	K	L	M	N	O	P
% Increase from Previous Year	% Increase from Baseline	2019	% Increase from Previous Year	% Increase from Baseline	2020	% Increase from Previous Year	% Increase from Baseline	
0.62%	8.40%	23108.30	2.29%	10.88%	5385.90	-76.69%	-74.16%	
4.89%	14.09%	1061.23	109.49%	139.00%	59.08	-94.43%	-86.70%	



	M	N	O	P	Q	R
ase n ne	2020	% Increase from Previous Year	% Increase from Baseline	2020	% Increase from Previous Year	% Increase from Baseline
%	5385.90	-76.69%	-74.16%	31.92	-99.41%	-99.85%
)%	59.08	-94.43%	-86.70%	0.00	-100.00%	-100.00%
%	1701.80	-76.04%	-63.37%	29119.00	1611.07%	526.70%
7%	31.92	-93.24%	-68.19%	0.00	-100.00%	-100.00%
1%	0.00	-100.00%	-100.00%	0.00	#DIV/0!	-100.00%
%	29119.00	-92.61%	-92.93%	0.00	-100.00%	-100.00%

9. Select the top cell of the first column of the three you just pasted and type in the year you are adding on the top bar. (Ex. The top cell of the first column I pasted is cell P2, and I am renaming it to be 2021)

M	N	O	P	Q	R
2020	% Increase from Previous Year	% Increase from Baseline	2020	% Increase from Previous Year	% Increase from Baseline
5385.90	-76.69%	-74.16%	31.92	-99.41%	-99.85%
59.08	-94.43%	-86.70%	0.00	-100.00%	-100.00%
1701.80	-76.04%	-63.37%	29119.00	1611.07%	526.70%
31.92	-93.24%	-68.19%	0.00	-100.00%	-100.00%
0.00	-100.00%	-100.00%	0.00	#DIV/0!	-100.00%
29119.00	-92.61%	-92.93%	0.00	-100.00%	-100.00%



10. In the next cells in that same column underneath the top row, replace all instances in the top bar of the old year with the new year. (Ex. I am replacing "2020" with "2021" in these cells.)

='2020'!F15

I	J	K	L	M	N	O	P
ncrease from Baseline	2019	% Increase from Previous Year	% Increase from Baseline	2020	% Increase from Previous Year	% Increase from Baseline	2021
8.40%	23108.30	2.29%	10.88%	5385.90	-76.69%	-74[illegible]	31.92
14.09%	1061.23	109.49%	139.00%	59.08	-94.43%	-8[illegible]	0.00
68.24%	7103.70	-9.13%	52.89%	1701.80	-76.04%	-6[illegible]	29119.00
16.11%	472.57	305.64%	370.97%	31.92	-93.24%	-6[illegible]	0.00
-23.49%	2420900.01	-3.46%	-26.14%	0.00	-100.00%	-10[illegible]	0.00
-0.45%	394010.00	-3.95%	-4.38%	29119.00	-92.61%	-9[illegible]	0.00

='2021'!K15

I	J	K	L	M	N	O	P
ncrease from Baseline	2019	% Increase from Previous Year	% Increase from Baseline	2020	% Increase from Previous Year	% Increase from Baseline	2021
8.40%	23108.30	2.29%	10.88%	5385.90	-76.69%	-74.1[illegible]	0.00
14.09%	1061.23	109.49%	139.00%	59.08	-94.43%	-86.[illegible]	0.00
68.24%	7103.70	-9.13%	52.89%	1701.80	-76.04%	-63.[illegible]	0.00
16.11%	472.57	305.64%	370.97%	31.92	-93.24%	-68.[illegible]	0.00
-23.49%	2420900.01	-3.46%	-26.14%	0.00	-100.00%	-100.[illegible]	0.00
-0.45%	394010.00	-3.95%	-4.38%	29119.00	-92.61%	-92.[illegible]	0.00

11. Repeat steps 7, 8, and 9 for the third and fourth tables with the last 3 columns.

	M	N	O	P	Q	R
18	2020	% Increase from Previous Year	% Increase from Baseline	2021	% Increase from Previous Year	% Increase from Baseline
19	114186.47	-329.05%	-74.16%	0.00	#DIV/0!	-100.00%
20	1104.72	-1696.38%	-86.70%	0.00	#DIV/0!	-100.00%
21	21459.70	-317.42%	-63.37%	0.00	#DIV/0!	-100.00%
22	734.80	-1380.34%	-68.19%	0.00	#DIV/0!	-100.00%
23	0.00	#DIV/0!	-100.00%	0.00	#DIV/0!	-100.00%
24	16254.23	-1253.10%	-92.93%	0.00	#DIV/0!	-100.00%
25	153739.91	-444.49%	-79.51%	0.00	#DIV/0!	-100.00%
26	69.74	-444.49%	-79.51%	0.00	#DIV/0!	-100.00%
27	20%	-444.49%	-79.51%	0%	#DIV/0!	-100.00%

	M	N	O	P	Q	R
30	2020	% Increase from Previous Year	% Increase from Baseline	2021	% Increase from Previous Year	% Increase from Baseline
31	15%	-50.07%	-43.66%	0%	-15.22%	-58.88%
32	0%	-2.50%	-0.96%	0%	-0.15%	-1.11%
33	3%	-9.08%	-4.95%	0%	-2.86%	-7.81%
34	0%	-1.35%	-0.21%	0%	-0.10%	-0.31%
35	0%	-0.93%	-1.25%	0%	0.00%	-1.25%
36	2%	-27.14%	-28.48%	0%	-2.17%	-30.65%
37						

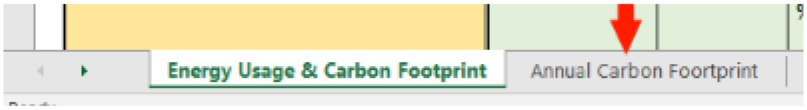
12. Repeat steps 7, 8, 9, and 10 for the fifth (and last) table with the last 2 columns.

	J	K	L	M
38	2020	% Increase	2021	% Increase
39	163888.44	-48.07%	0.00	-100.00%
40	0.00	-100.00%	0.00	#DIV/0!
41	0.00	-100.00%	0.00	#DIV/0!
42	0.00	-100.00%	0.00	#DIV/0!

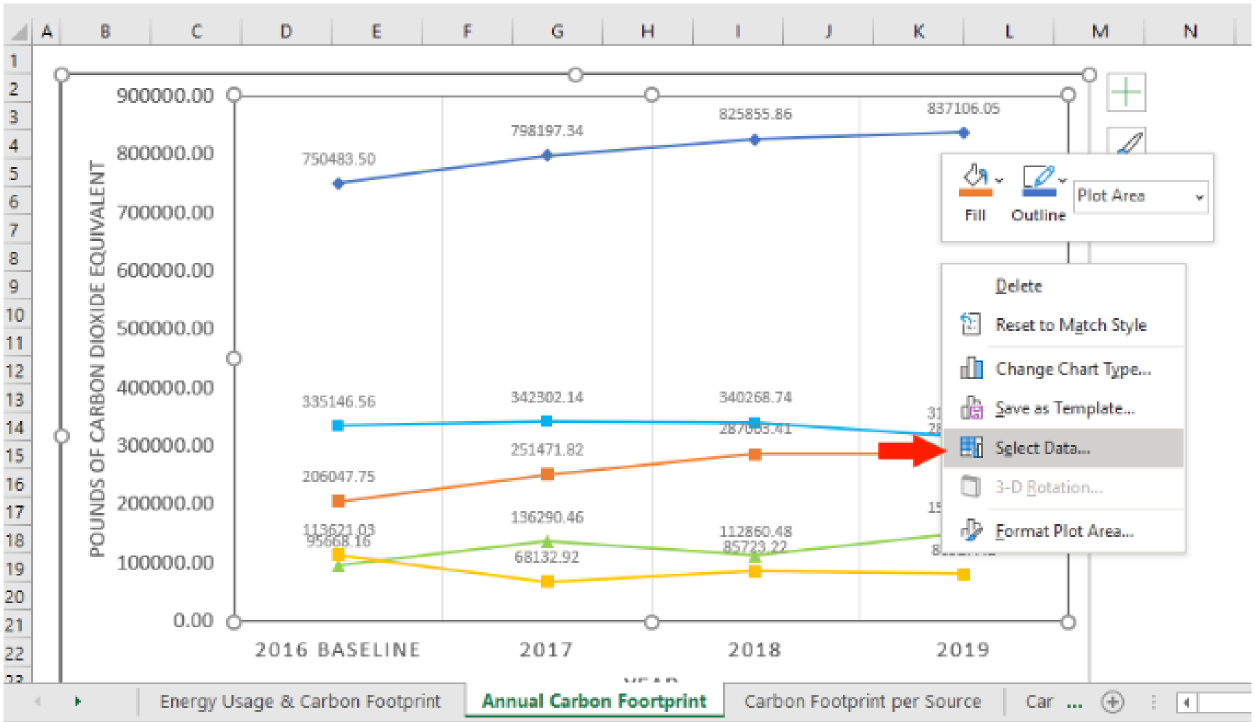
Incorporating a new year into graphs

This section is for help on adding more years into the graphs on the first few tabs of the tool.

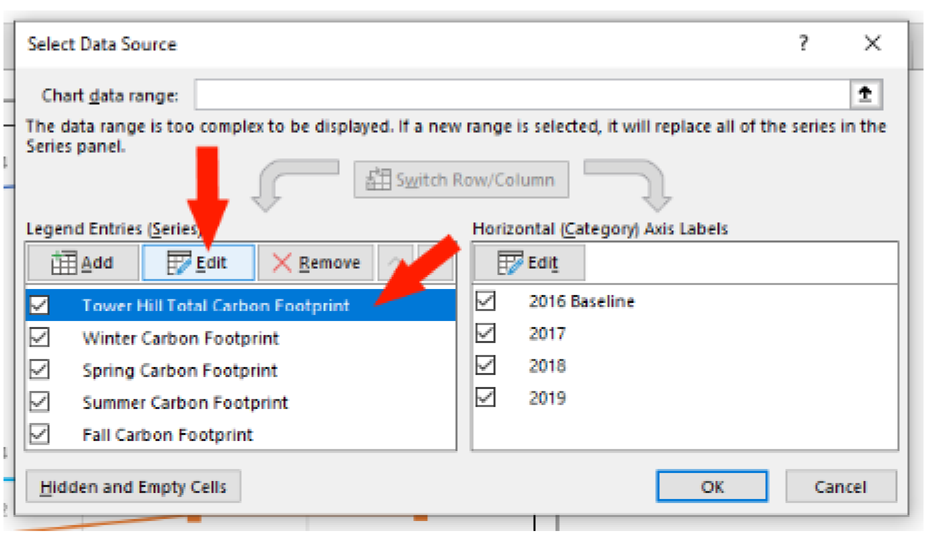
1. Find the tab labelled “Annual Carbon Footprint”, which should be the second tab.



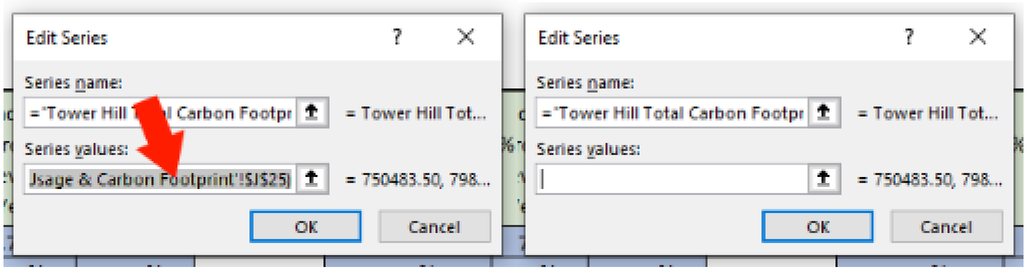
2. Right click on the graph and select “Select Data…”.



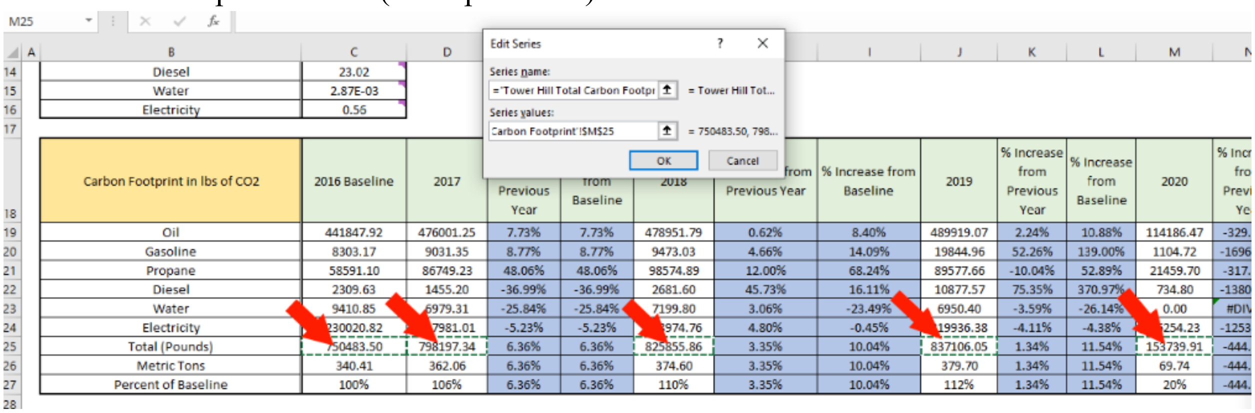
3. Select the first item on the left-hand list (labelled “Tower Hill Total Carbon Footprint”) and click “Edit”.



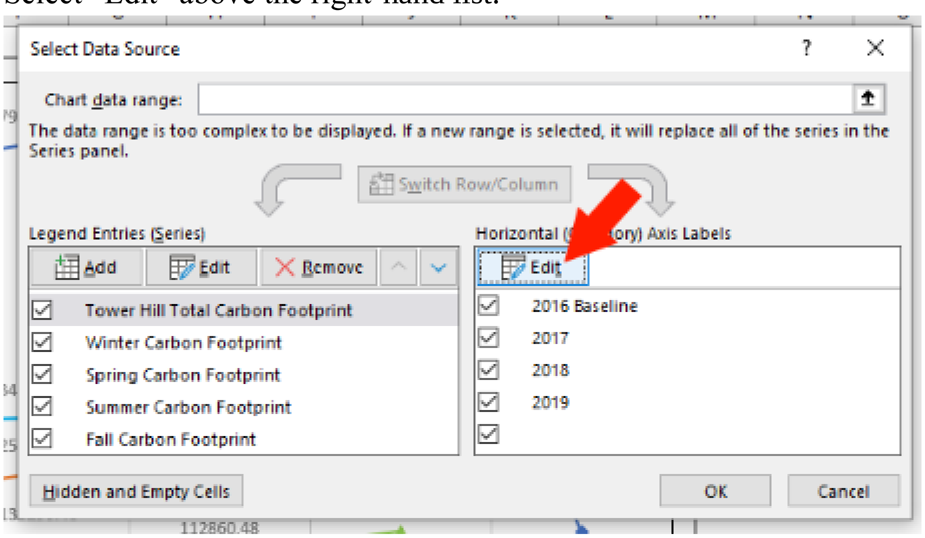
4. Select everything in the text box underneath “Series values:” and press “backspace” or “delete” on your keyboard.



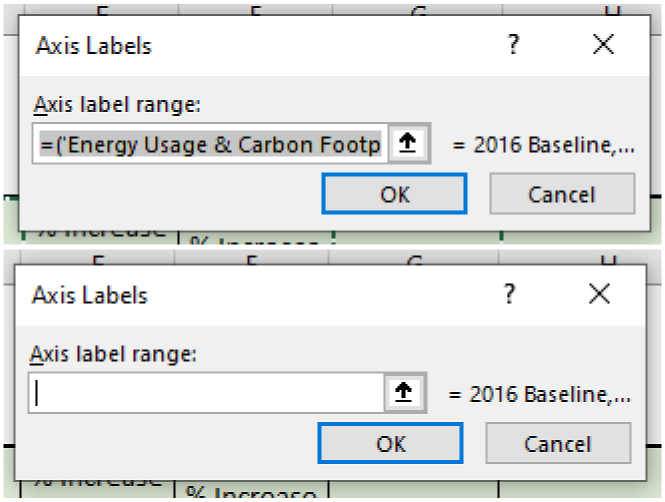
5. If you were not taken to the first sheet, go to it, and find the third table. While holding the “ctrl” key on your keyboard, select each cell in the row labelled “Total (Pounds)” only for columns that correspond to years (white columns) up to and including the year you want to add and press “OK”. (Ex. Up to 2020)



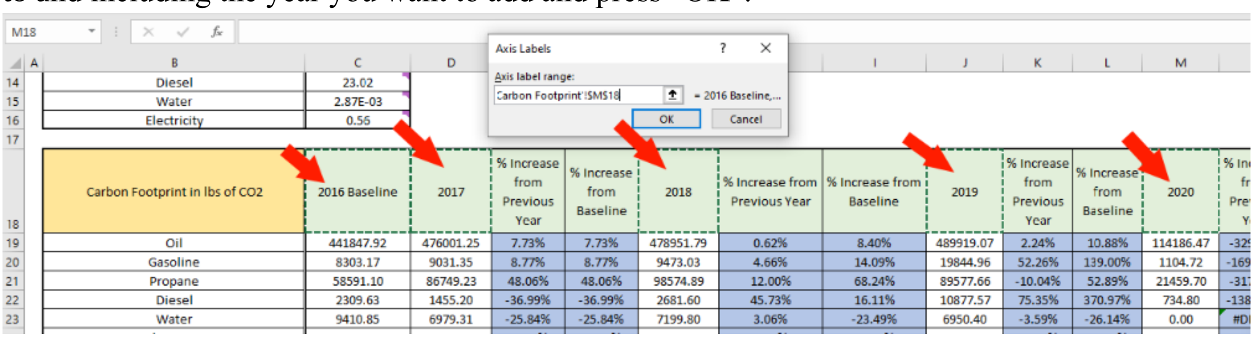
6. Select “Edit” above the right-hand list.



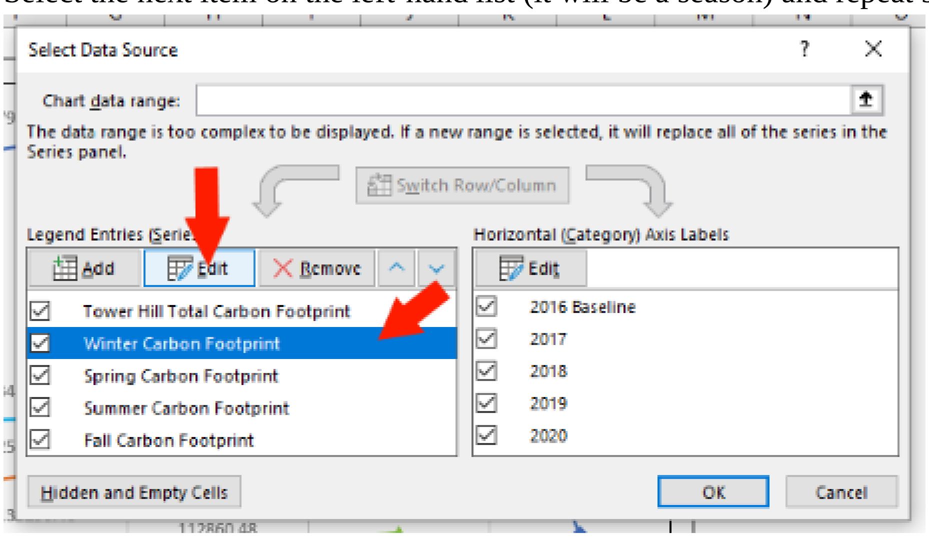
7. Select everything in the text box and press “backspace” or “delete” on your keyboard.



8. If you were not taken to the first sheet, go to it, and find the third table. While holding the “ctrl” key on your keyboard, select each cell in the top row corresponding to each year up to and including the year you want to add and press “OK”.

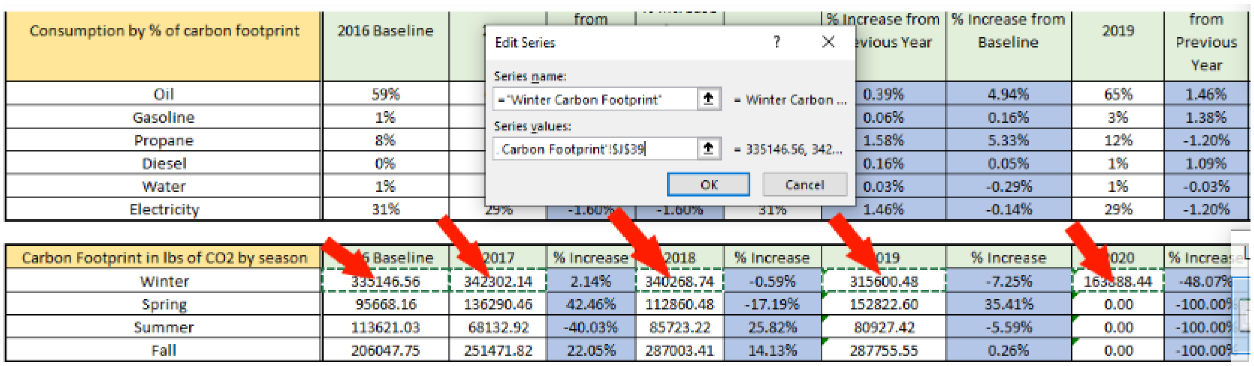


9. Select the next item on the left-hand list (it will be a season) and repeat step 4.

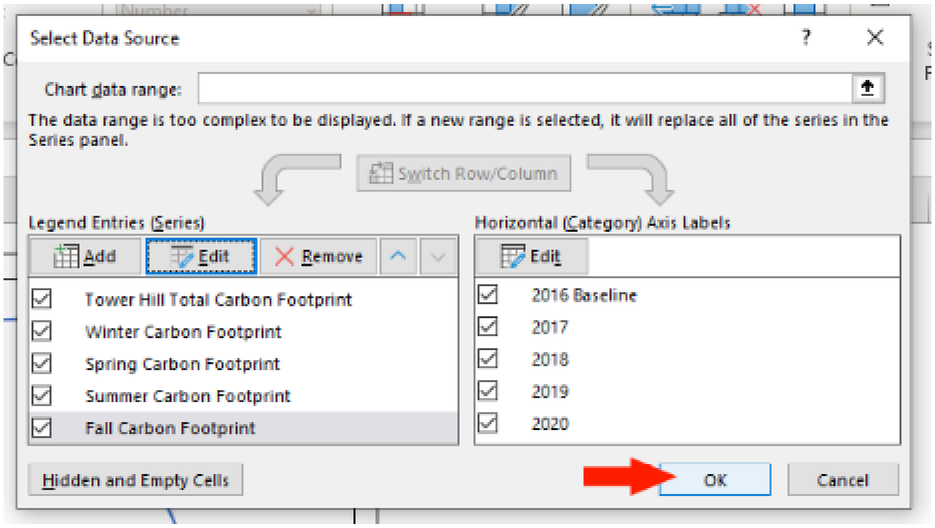


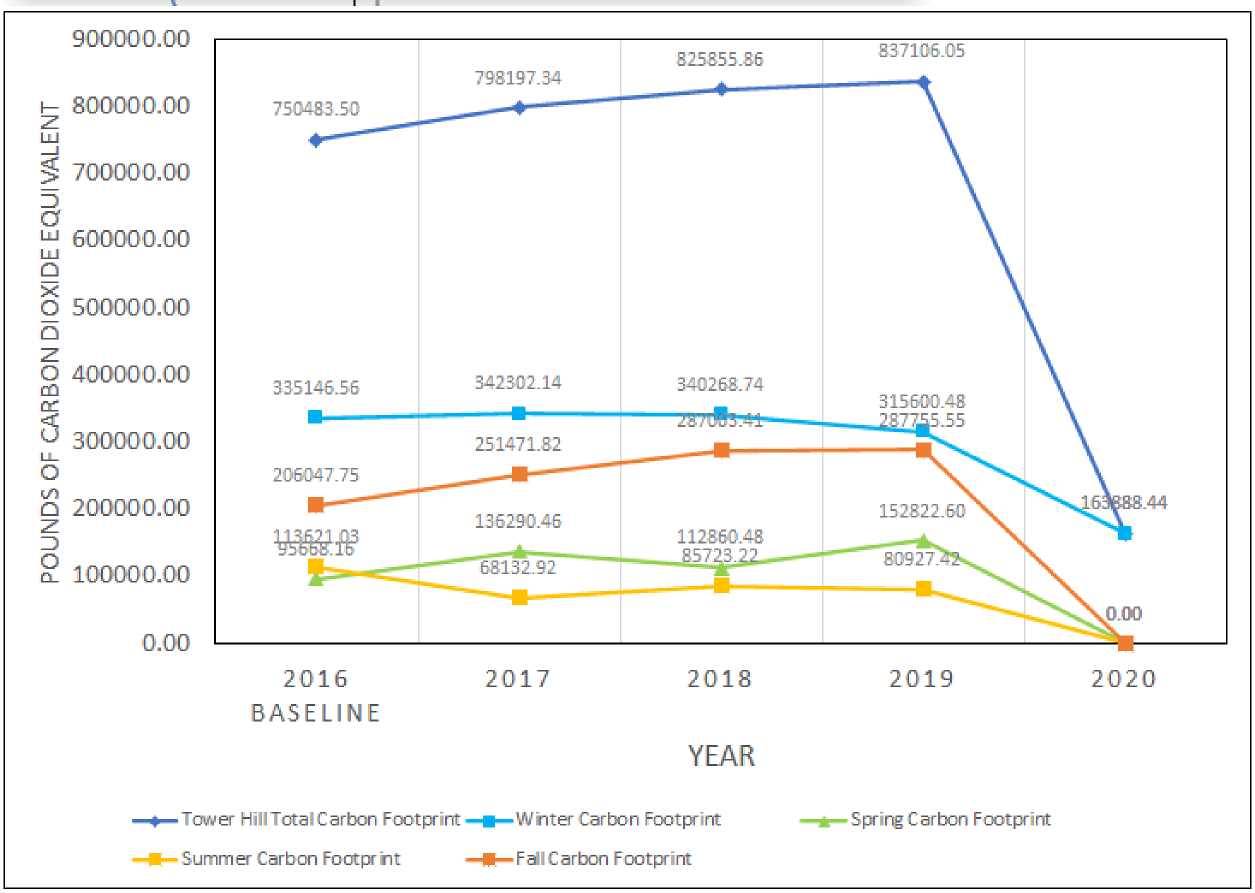
10. If you were not taken to the first sheet, go to it, and find the fifth table. While holding the “ctrl” key on your keyboard, select each cell in the row corresponding to the season in the column corresponding to years up to and including the year you want to add and press

“OK”.

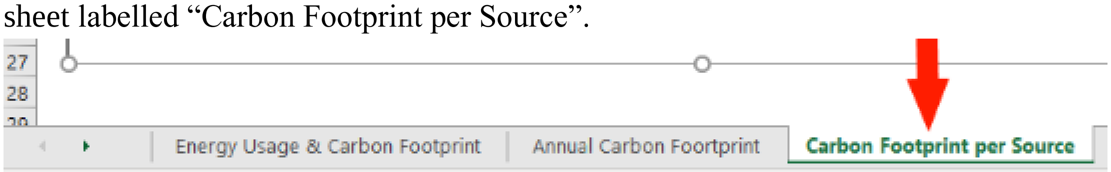

Edit Series
Series name:
="Winter Carbon Footprint"
= Winter Carbon ...
Series values:
Carbon Footprint'!J39
= 335146.56, 342...
OK
Cancel
Consumption by % of carbon footprint
2016 Baseline
Oil
Gasoline
Propane
Diesel
Water
Electricity
Carbon Footprint in lbs of CO2 by season
Winter
Spring
Summer
Fall

11. Repeat steps 9 and 10 for the remaining 3 seasons. Press "OK" once you are done.

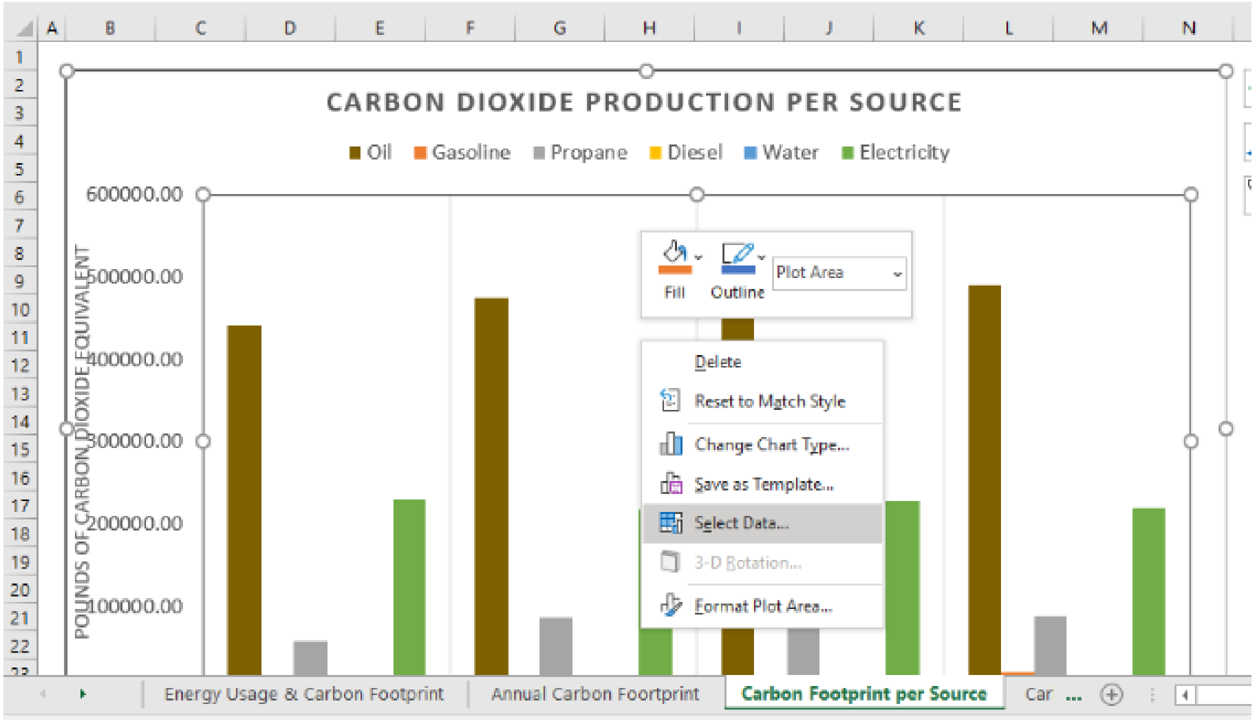




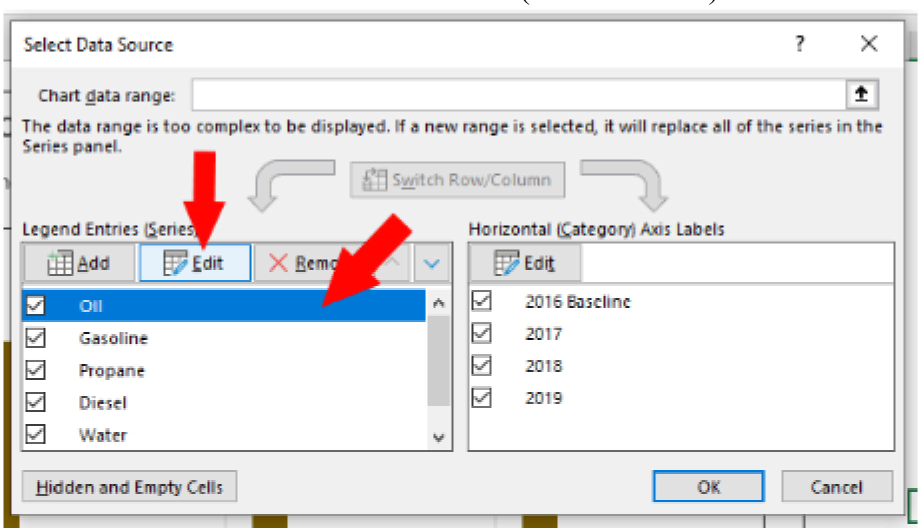
12. You have added a new year to one graph, but there are 3 more graphs. Find the third sheet labelled "Carbon Footprint per Source".



13. Right click on the graph and select "Select Data…".

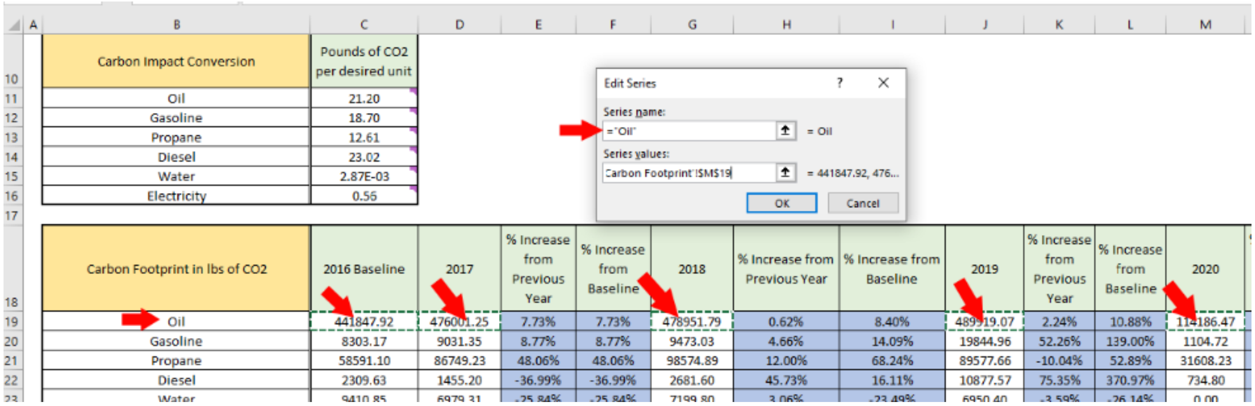


14. Select the first item on the left-hand list (labelled "Oil") and click "Edit".

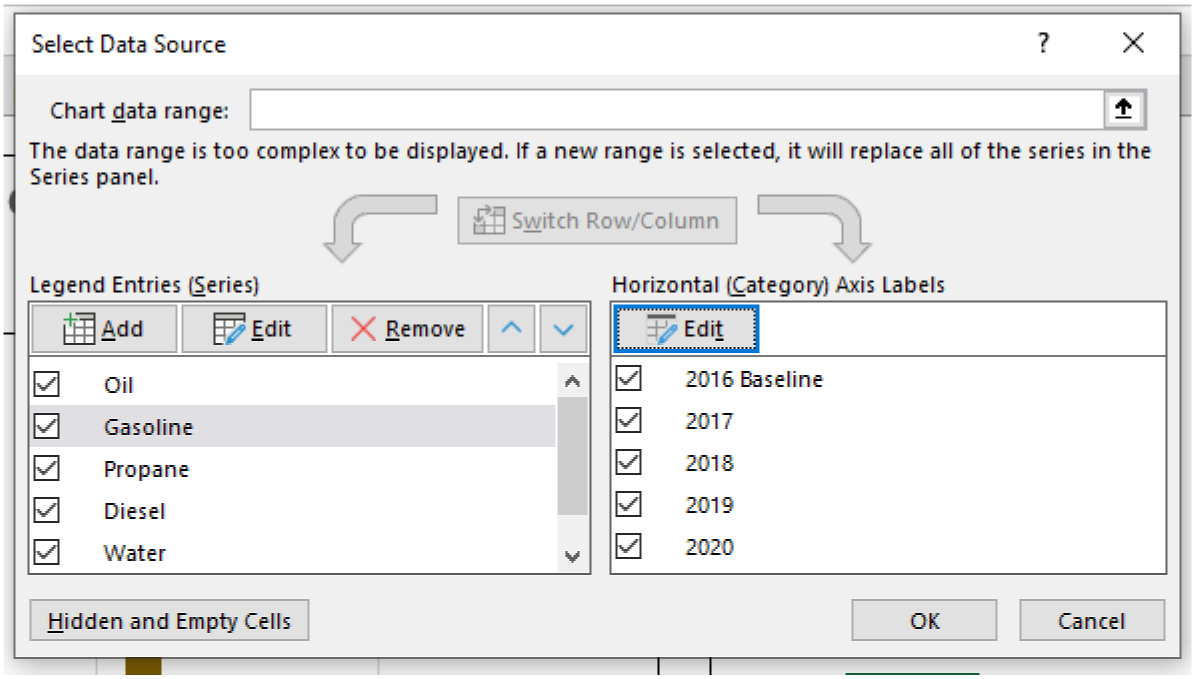


15. Repeat step 4.
16. If you were not taken to the first sheet, go to it, and find the third table. While holding the "ctrl" key on your keyboard, select each cell in the row corresponding to the series you are editing ("Oil" should be the first one) only for columns that correspond to years (white columns) up to and including the year you want to add and press "OK". (Ex. Up to

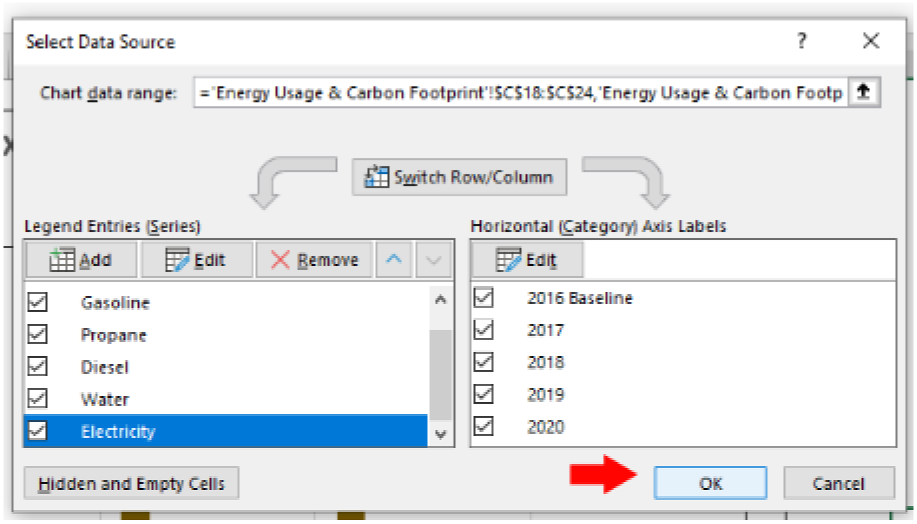
2020)

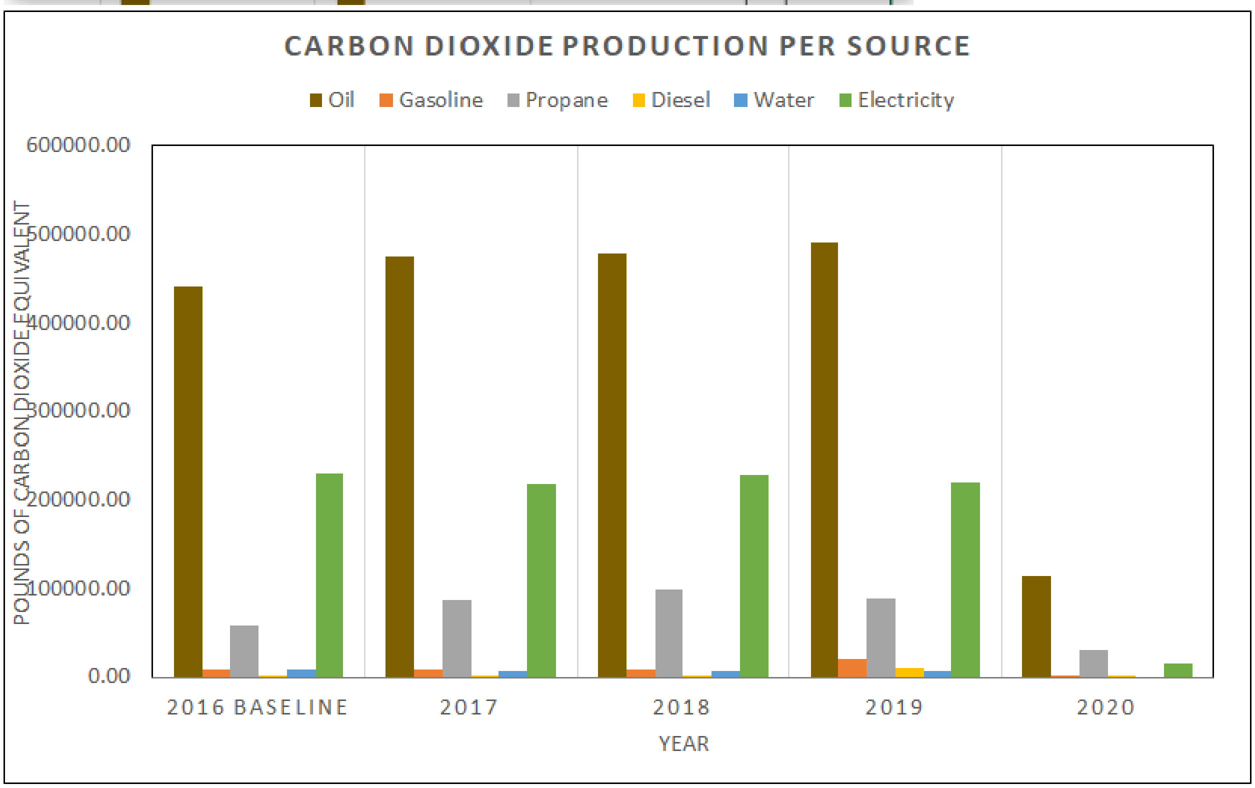


17. Repeat steps 6, 7, & 8.

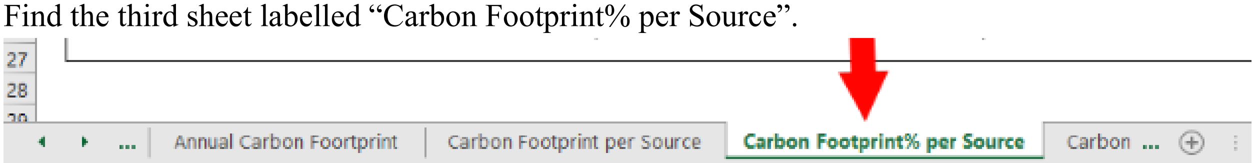


18. Repeat steps 14, 15, & 16 for the remaining items on the left-hand side list. Press "OK" once you are done.

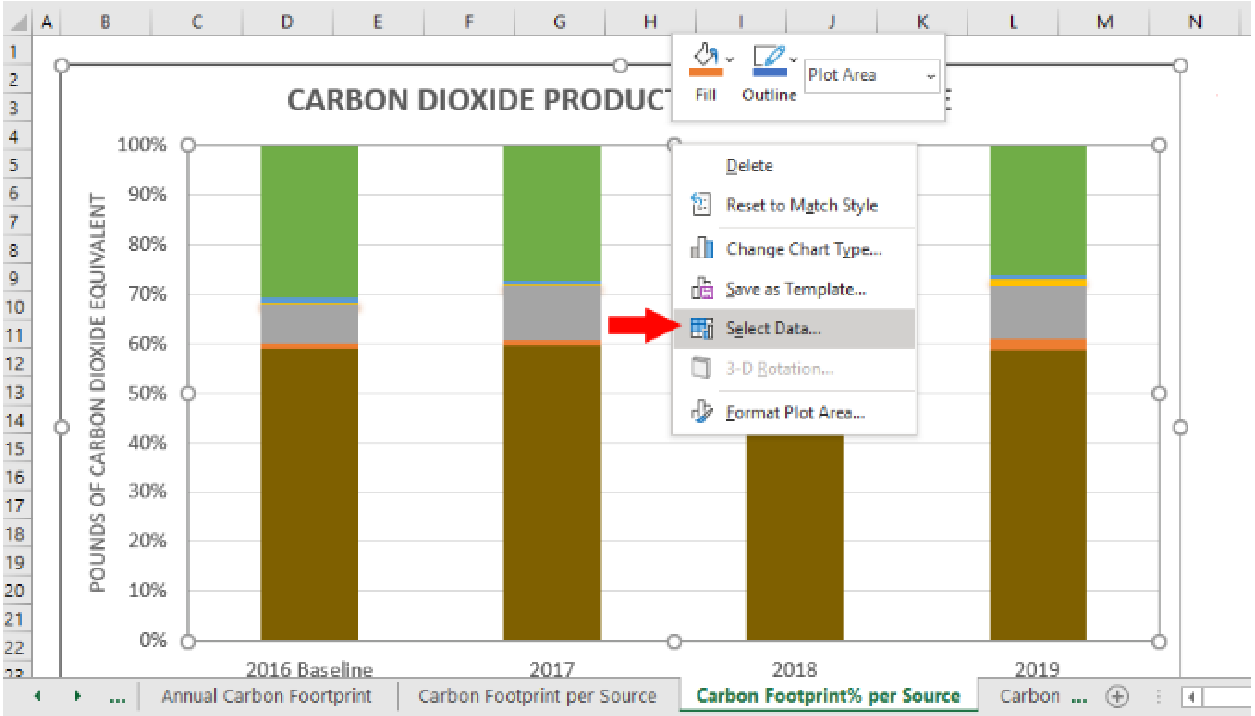




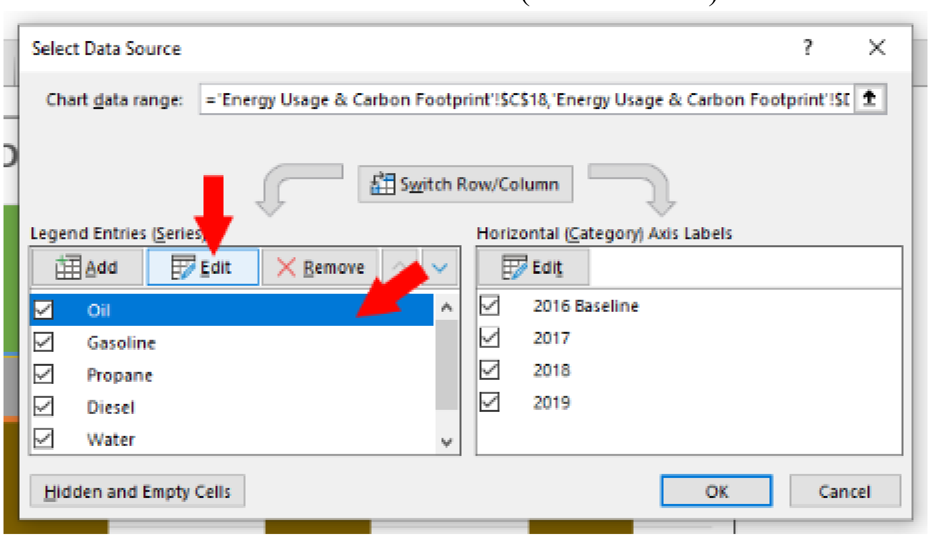
19. Find the third sheet labelled "Carbon Footprint% per Source".



20. Right click on the graph and select "Select Data…".

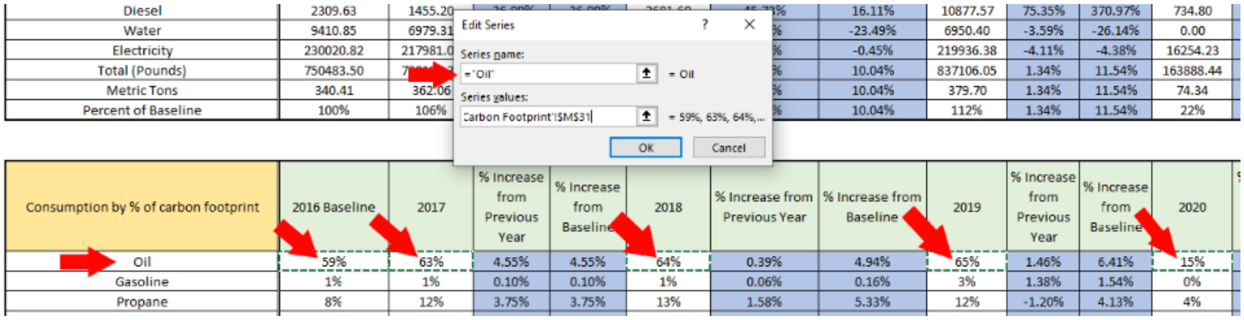


21. Select the first item on the left-hand list (labelled "Oil") and click "Edit".

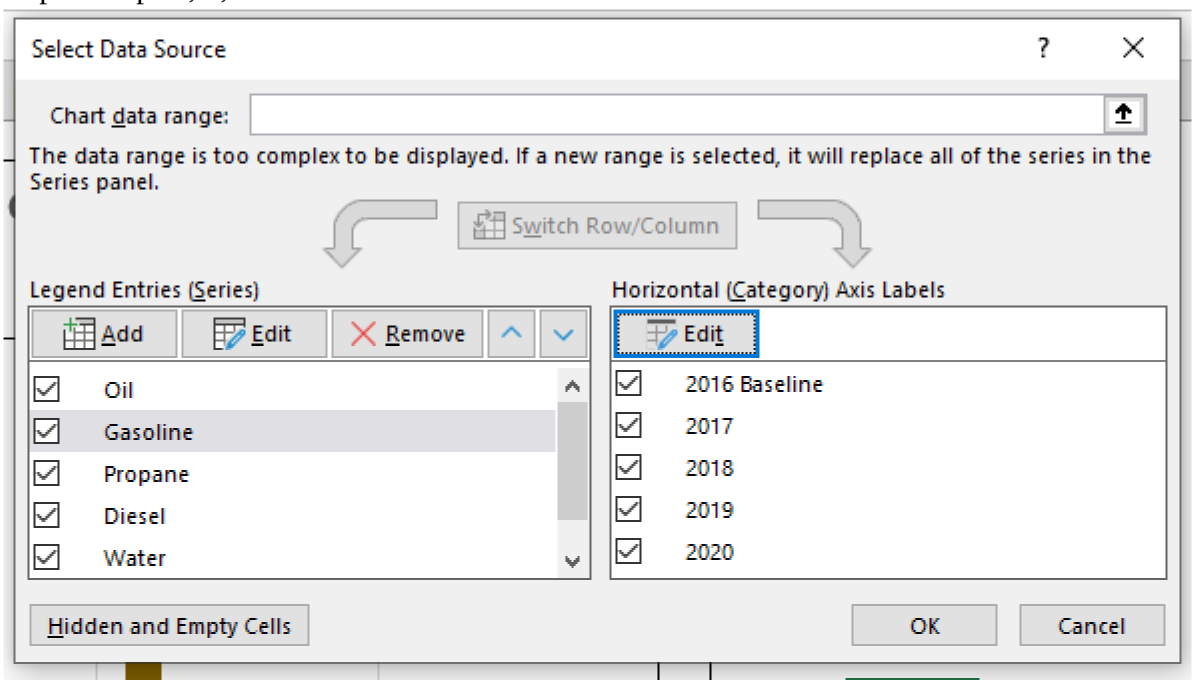


22. Repeat step 4.
23. If you were not taken to the first sheet, go to it, and find the fourth table. While holding the "ctrl" key on your keyboard, select each cell in the row corresponding to the series you are editing ("Oil" should be the first one) only for columns that correspond to years (white columns) up to and including the year you want to add and press "OK". (Ex. Up to

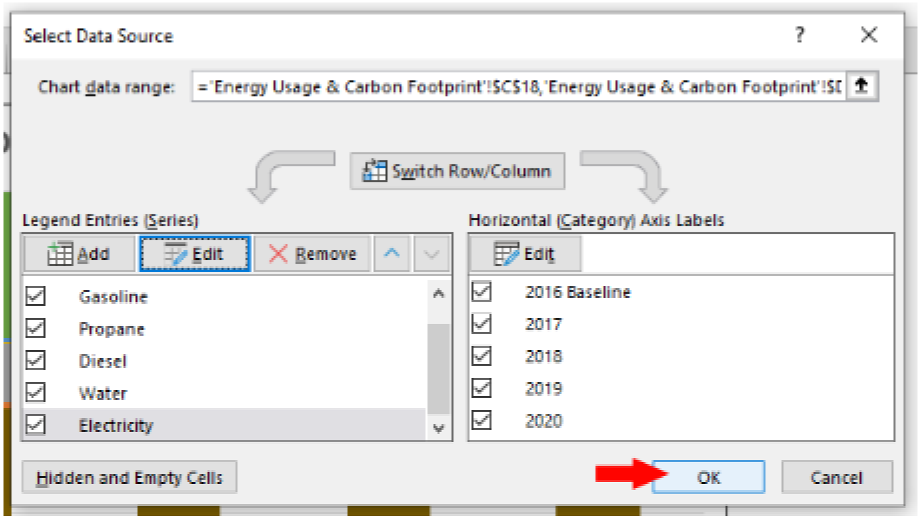
2020)

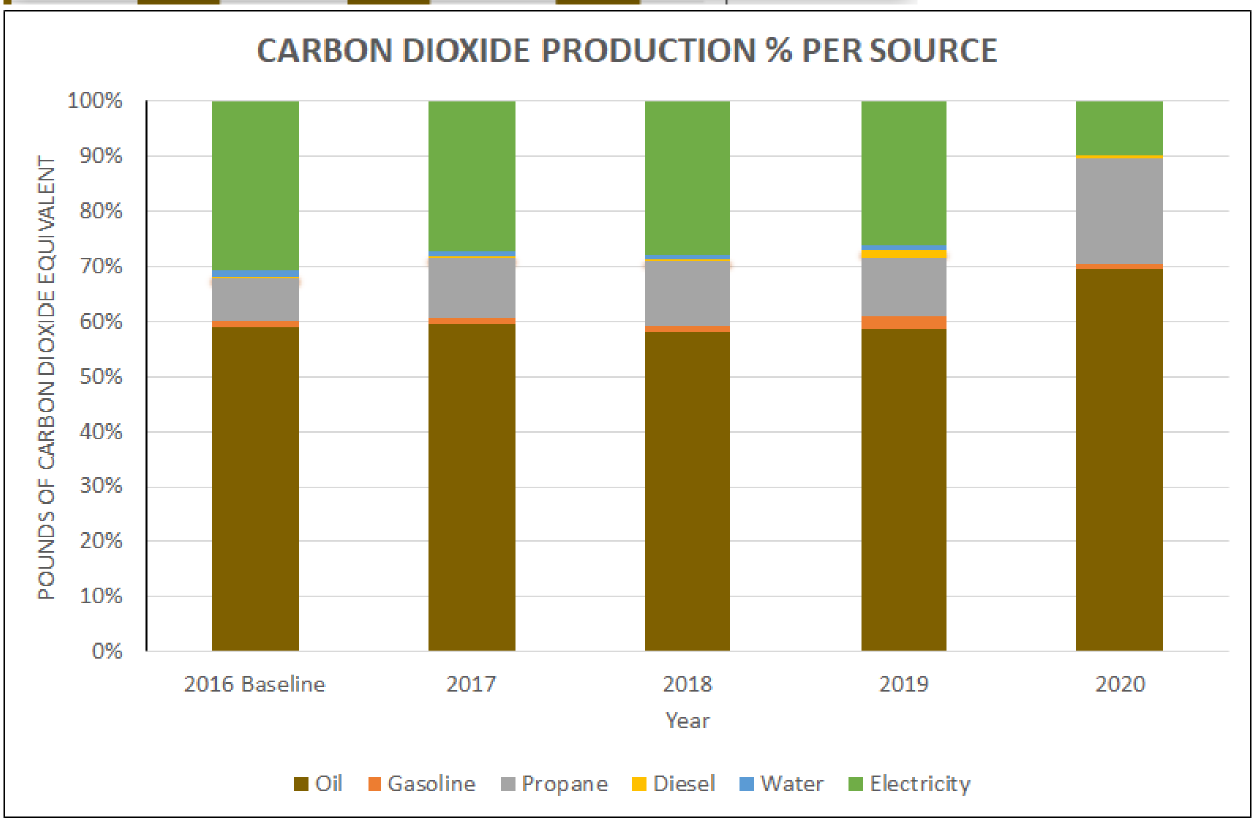


24. Repeat steps 6, 7, & 8.

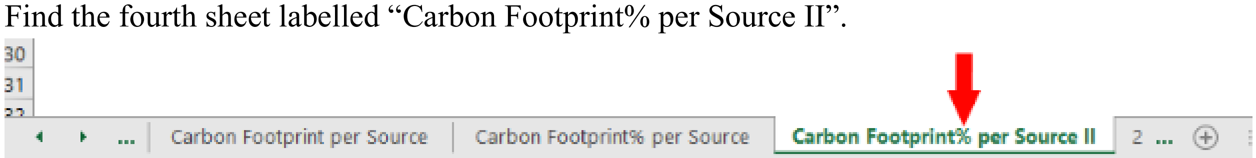


25. Repeat steps 22, 23, & 24 for the remaining items on the left-hand side list. Press “OK” once you are done.

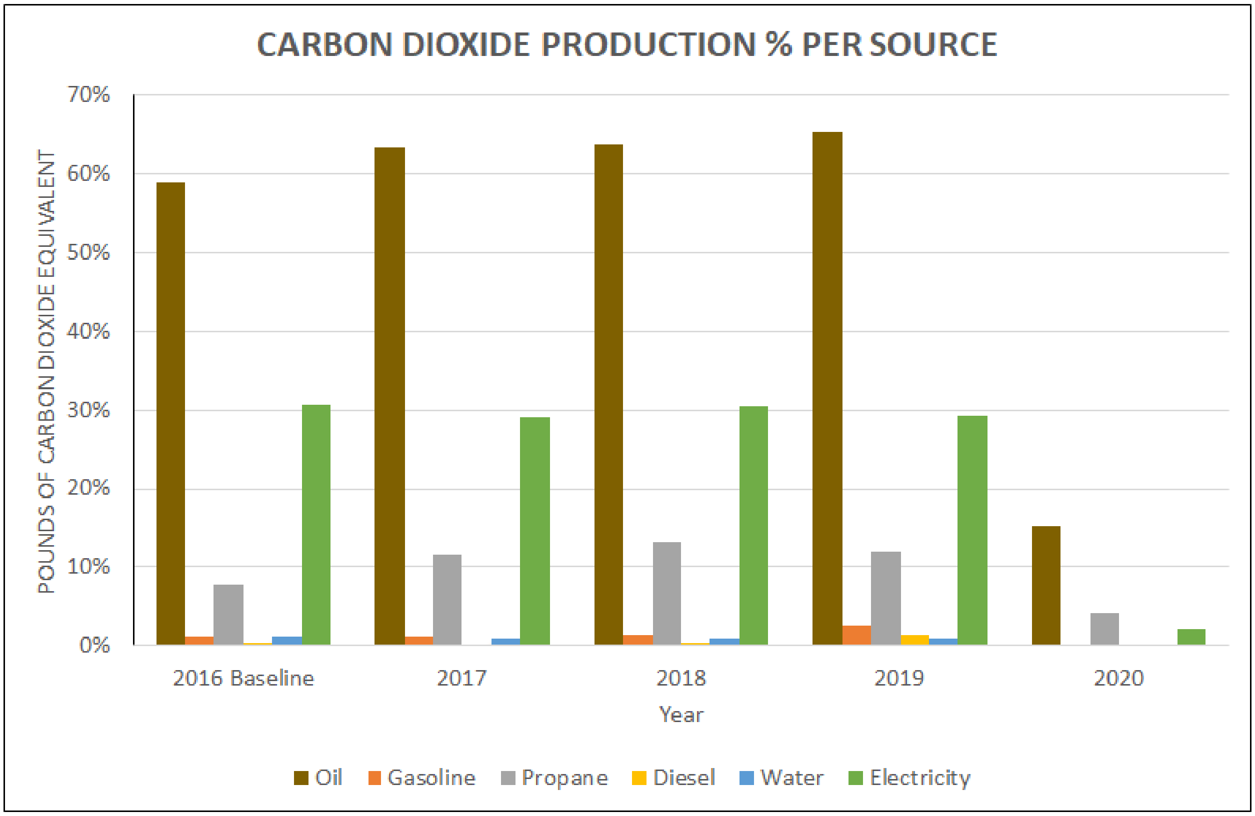




26. Find the fourth sheet labelled “Carbon Footprint% per Source II”.



27. Repeat steps 21, 22, 23, 24, & 25.



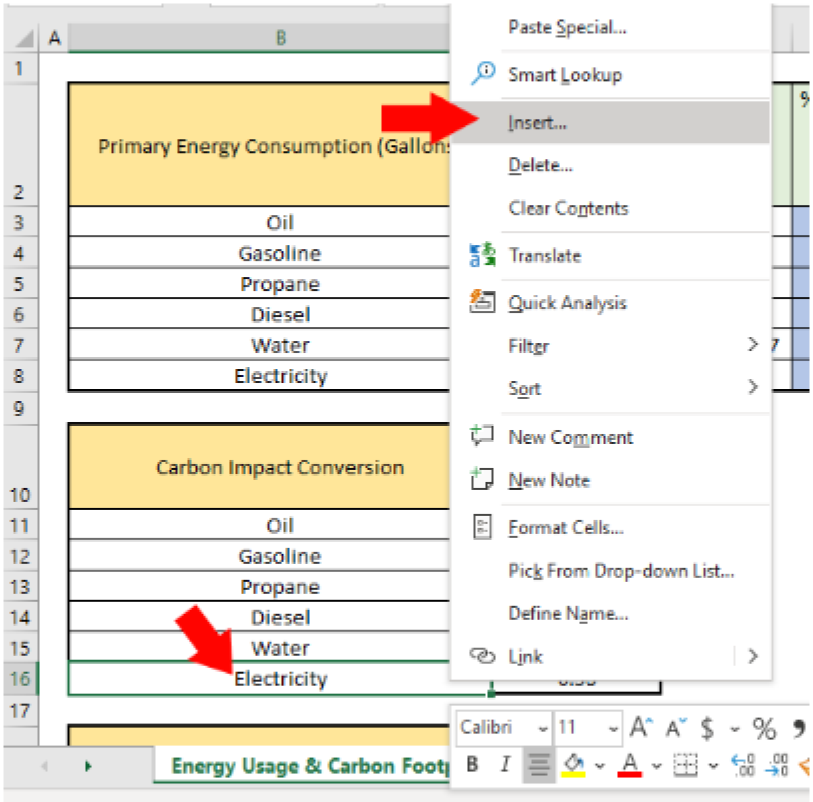
28. You have successfully added a new year into all of the graphs.

<u>Adding new types of consumption data</u>

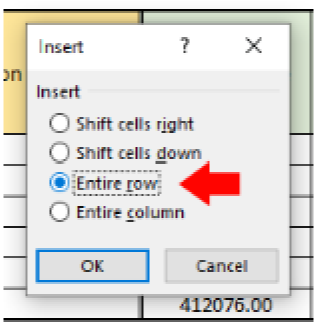
This section is for help on adding new types of consumption data to be used in carbon footprint calculation.

1. Obtain the carbon dioxide conversion factor in units of pounds per unit of the data.

2. On the first sheet, locate the second table. Right click on the bottom cell in the first column and select “Insert…”.

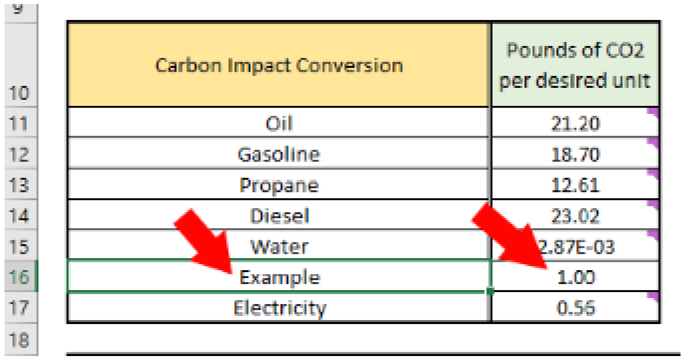


3. Select “Entire row” and press “OK”.

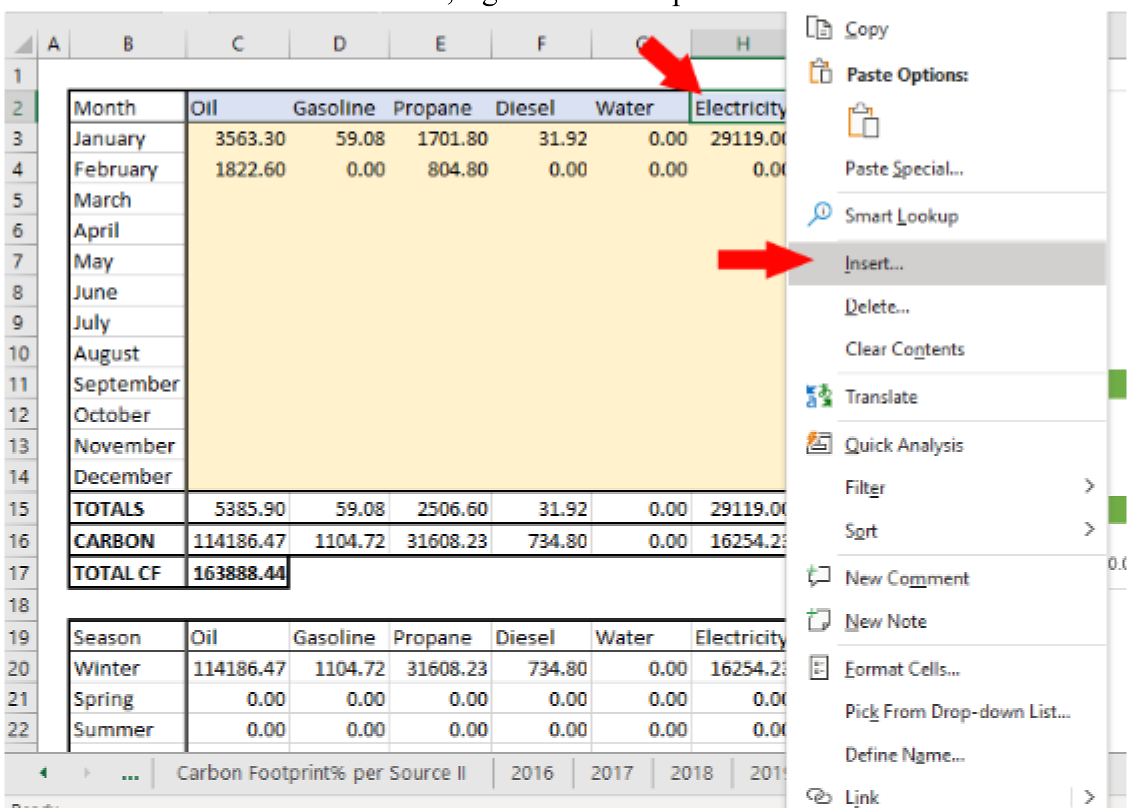


4. In the newly created blank cell in the first column, type in the name of the type of consumption data (Ex. Example), and in the second column type in the conversion factor.

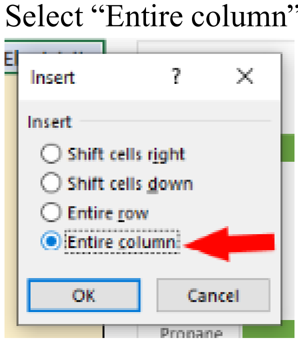
(ex. 1 pound of CO2 per 1 unit of Example)



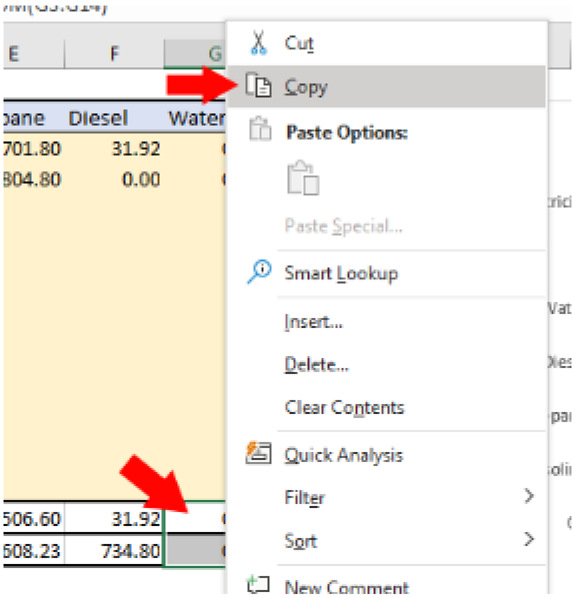
5. Go to the sheet corresponding to the year(s) you would like to add the consumption data for. (Ex. 2020)
6. In the last column of the first table, right click the top cell and select "Insert…".



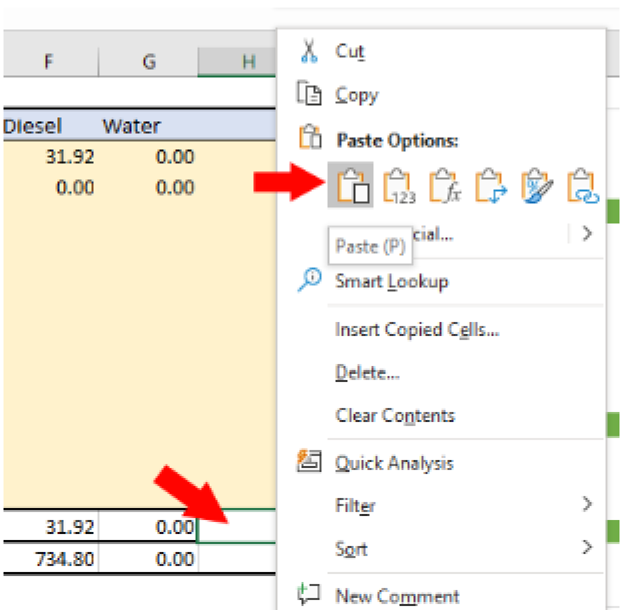
7. Select "Entire column" and press "OK".



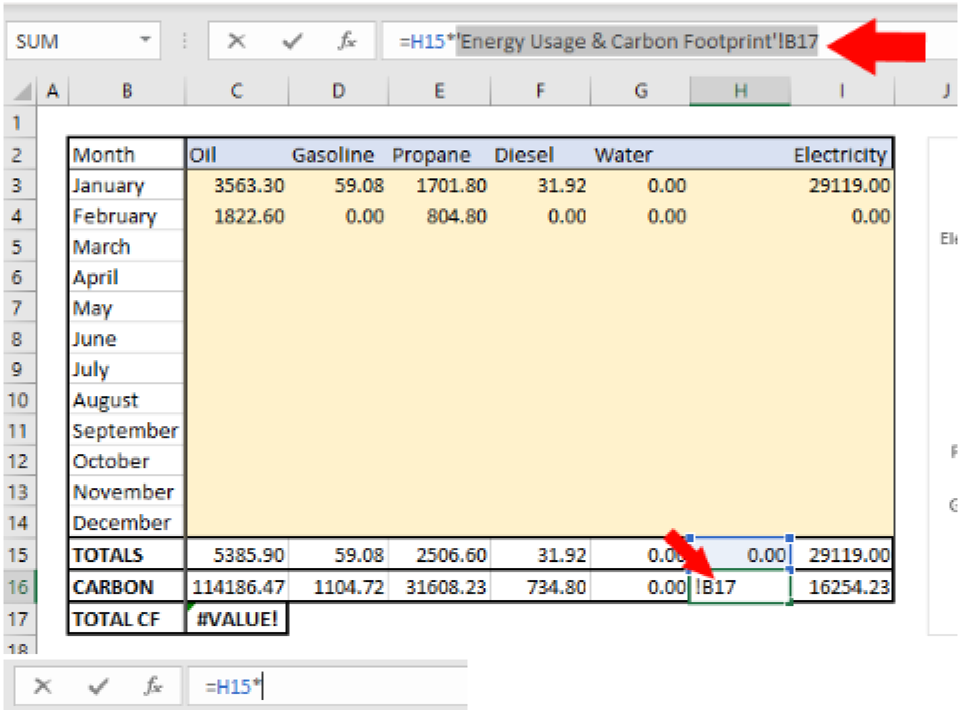
8. In the third to last column of the first table, select the last two cells in the table, right click on one, and select "Copy".



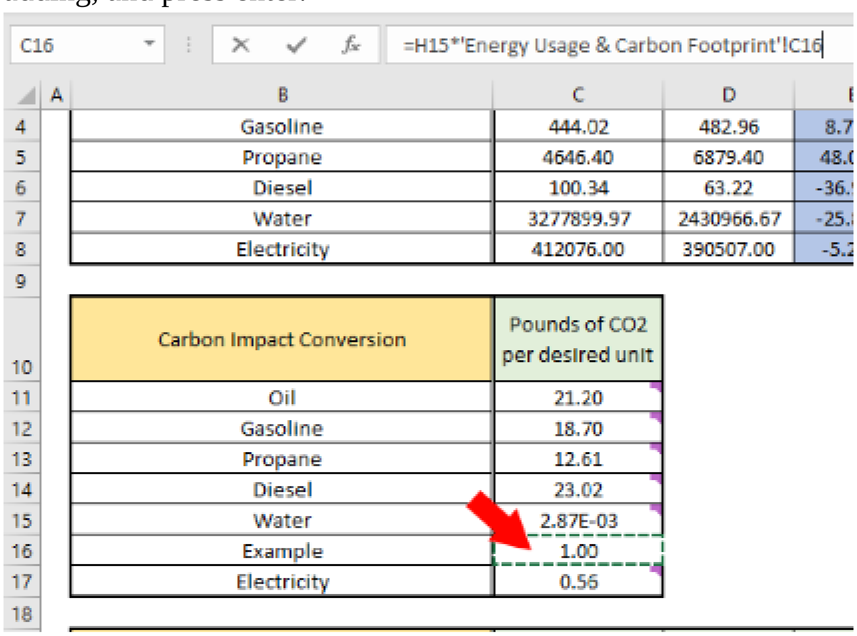
9. Select the second to last cell in the new column (second to last), right click, and select "Paste".



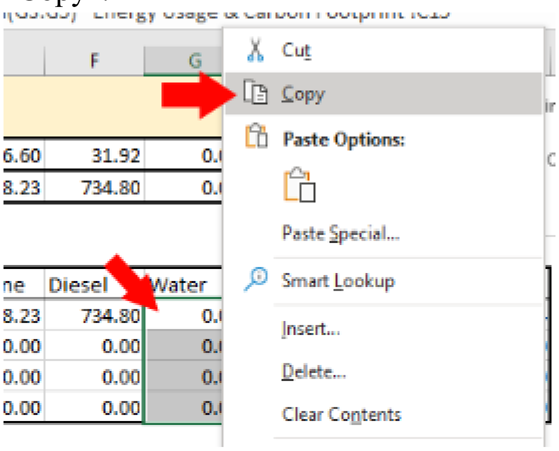
10. Select the last cell in the new column, and remove the text after the asterisk in the text box at the top.



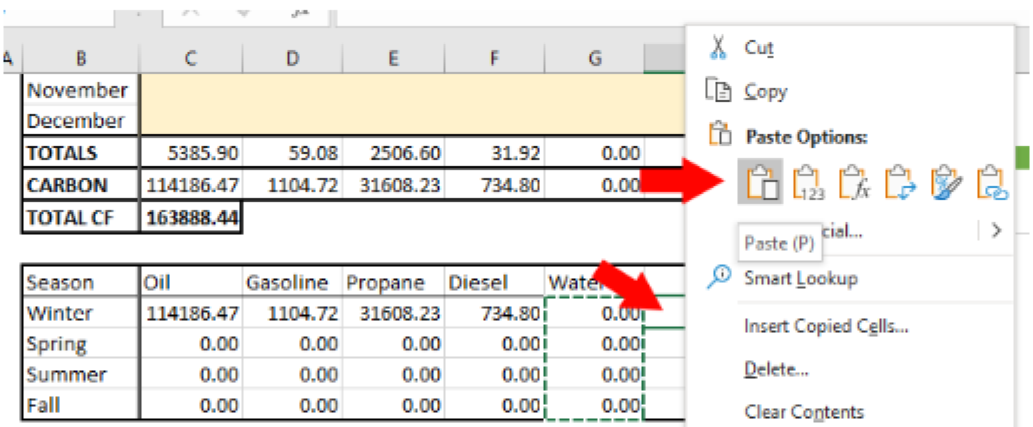
11. Without clicking on any other cell, go to the first sheet, and locate the second column. Click on the cell corresponding to the conversion factor for the type of data you are adding, and press enter.



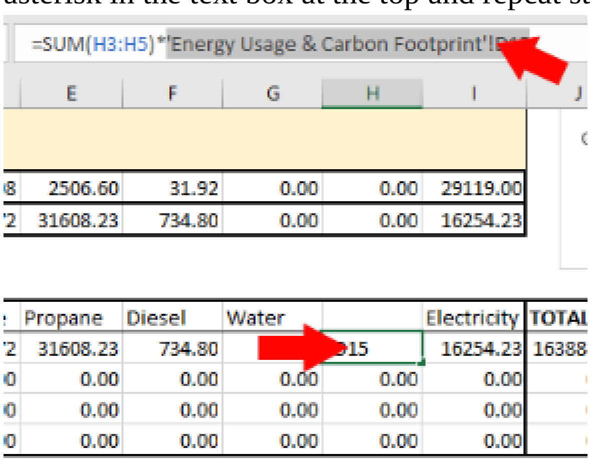
12. In the second table, select the last 4 cells in the third to last row, right click, and select "Copy".



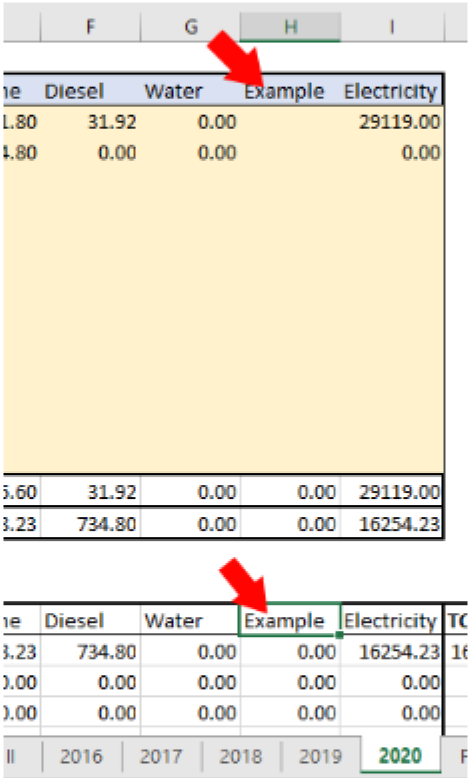
13. Select the second cell in the second to last column of the second table, right click, and select "Paste".



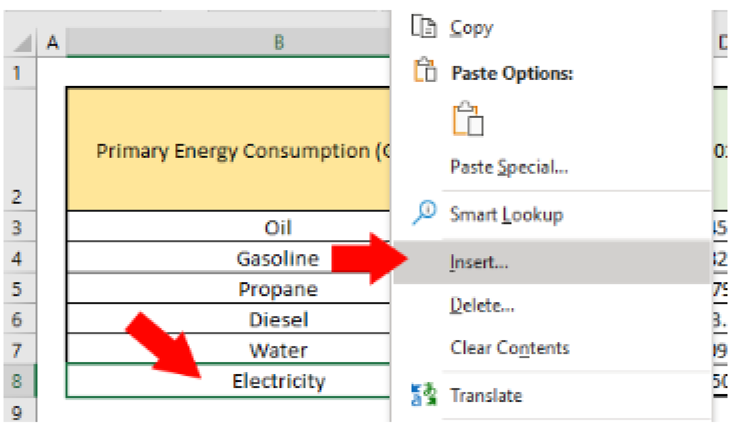
14. For each of the 4 last cells in that row, select it and remove all of the text after the asterisk in the text box at the top and repeat step 11.



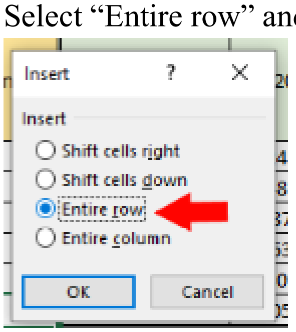
15. For the top cells in the new rows in both the first and the second tables, type in the name of the new type of data you are adding. (Ex. Example)



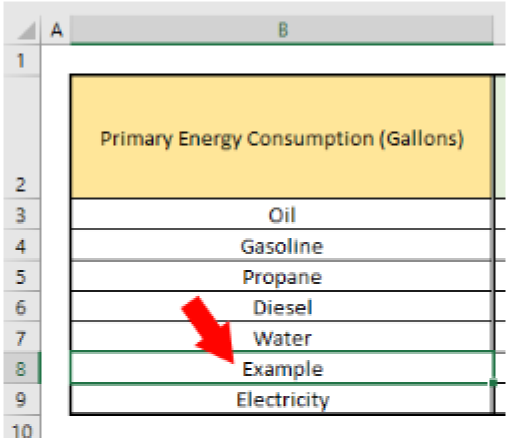
16. Go back to the first sheet. In the last row of the first table, right click the first cell and select "Insert…".



17. Select "Entire row" and press "OK".

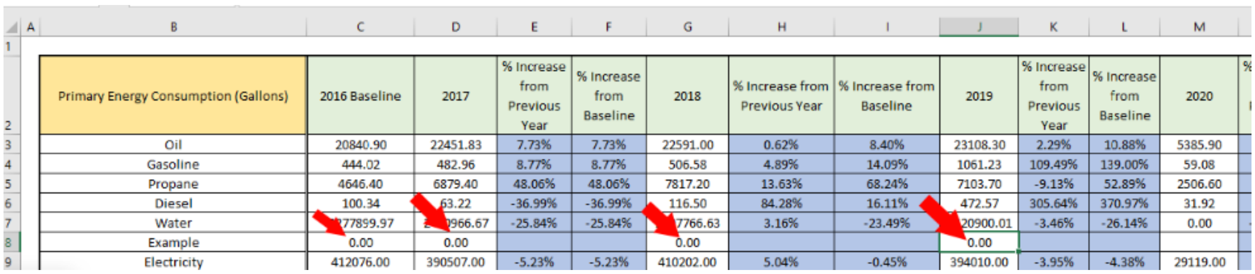


18. In the first cell of the row you created, type in the name of the type of data you are adding.



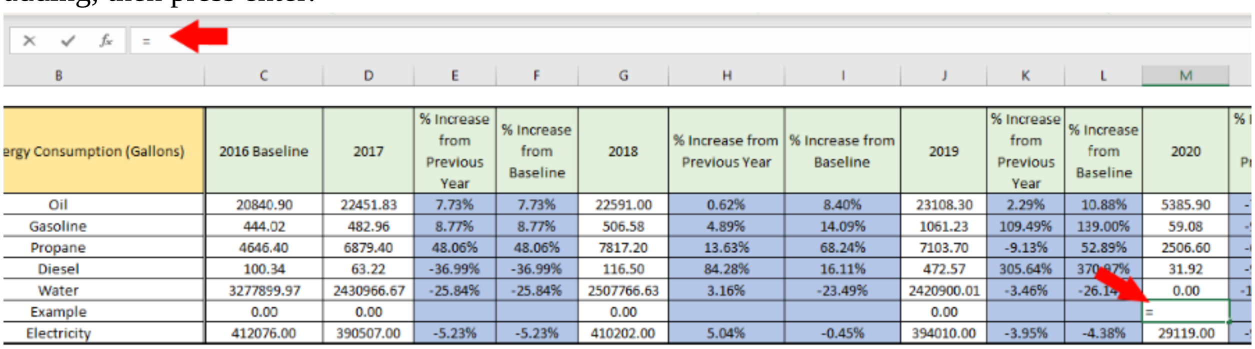
	A	B
1		
2		Primary Energy Consumption (Gallons)
3		Oil
4		Gasoline
5		Propane
6		Diesel
7		Water
8		Example
9		Electricity
10		

19. For the columns corresponding to the years that you are **NOT** adding data, enter a 0 in the row for the data type you are adding.



Primary Energy Consumption (Gallons)	2016 Baseline	2017	% Increase from Previous Year	% Increase from Baseline	2018	% Increase from Previous Year	% Increase from Baseline	2019	% Increase from Previous Year	% Increase from Baseline	2020
Oil	20840.90	22451.83	7.73%	7.73%	22591.00	0.62%	8.40%	23108.30	2.29%	10.88%	5385.90
Gasoline	444.02	482.96	8.77%	8.77%	506.58	4.89%	14.09%	1061.23	109.49%	139.00%	59.08
Propane	4646.40	6879.40	48.06%	48.06%	7817.20	13.63%	68.24%	7103.70	-9.13%	52.89%	2506.60
Diesel	100.34	[illegible]63.22	-36.99%	-36.99%	116.50	84.28%	16.11%	472.57	305.64%	370.97%	31.92
Water	[illegible]77899.97	[illegible]966.67	-25.84%	-25.84%	[illegible]7766.63	3.16%	-23.49%	[illegible]20900.01	-3.46%	-26.14%	0.00
Example	0.00	0.00			0.00			0.00			
Electricity	412076.00	390507.00	-5.23%	-5.23%	410202.00	5.04%	-0.45%	394010.00	-3.95%	-4.38%	29119.00

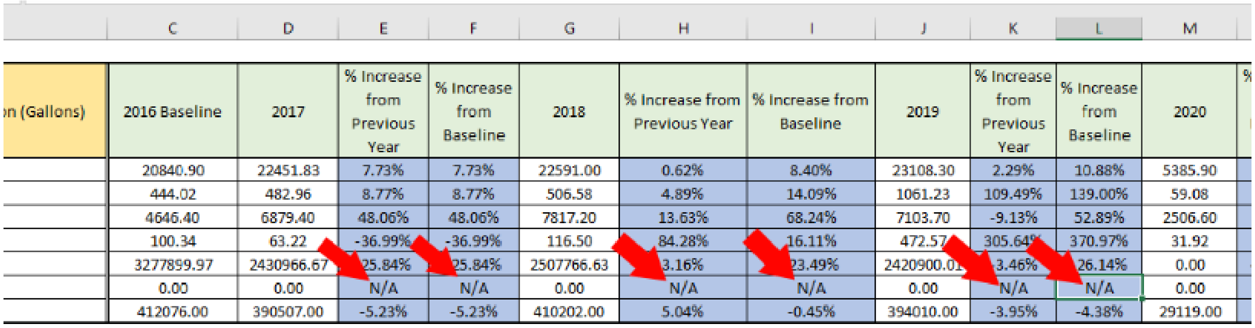
20. For the columns corresponding to the year(s) for which you are adding the data type, click in the text box at the top and type in "=" and, without clicking on any other cells or pressing any keys, go to the sheet corresponding to the year you are doing this for, and selecting the second to last cell of the column corresponding to the data type you are adding, then press enter.



ergy Consumption (Gallons)	2016 Baseline	2017	% Increase from Previous Year	% Increase from Baseline	2018	% Increase from Previous Year	% Increase from Baseline	2019	% Increase from Previous Year	% Increase from Baseline	2020
Oil	20840.90	22451.83	7.73%	7.73%	22591.00	0.62%	8.40%	23108.30	2.29%	10.88%	5385.90
Gasoline	444.02	482.96	8.77%	8.77%	506.58	4.89%	14.09%	1061.23	109.49%	139.00%	59.08
Propane	4646.40	6879.40	48.06%	48.06%	7817.20	13.63%	68.24%	7103.70	-9.13%	52.89%	2506.60
Diesel	100.34	63.22	-36.99%	-36.99%	116.50	84.28%	16.11%	472.57	305.64%	370.97%	31.92
Water	3277899.97	2430966.67	-25.84%	-25.84%	2507766.63	3.16%	-23.49%	2420900.01	-3.46%	-26.14%	0.00
Example	0.00	0.00			0.00			0.00			=
Electricity	412076.00	390507.00	-5.23%	-5.23%	410202.00	5.04%	-0.45%	394010.00	-3.95%	-4.38%	29119.00

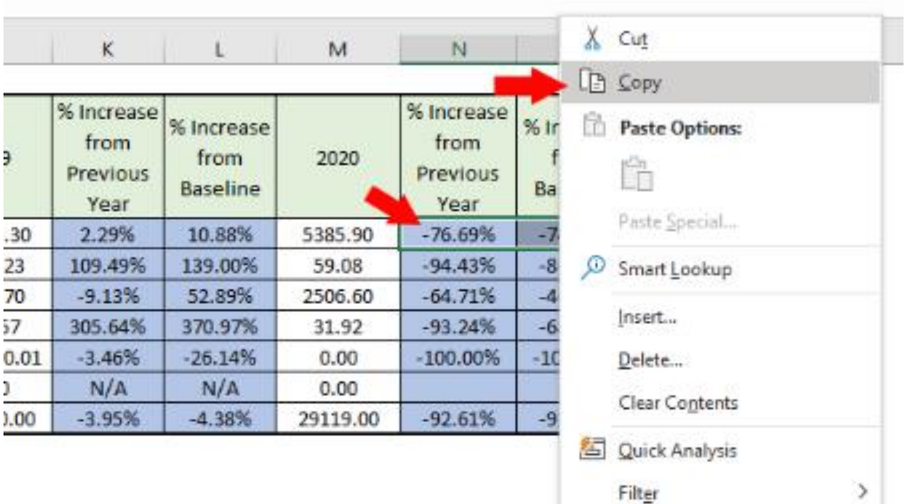
21. For the columns corresponding to "% Increase from Baseline" and "% Increase from Previous Year" for the years that you are **NOT** adding a new data type for, type in "N/A"

in the cells in the row for the new data type.

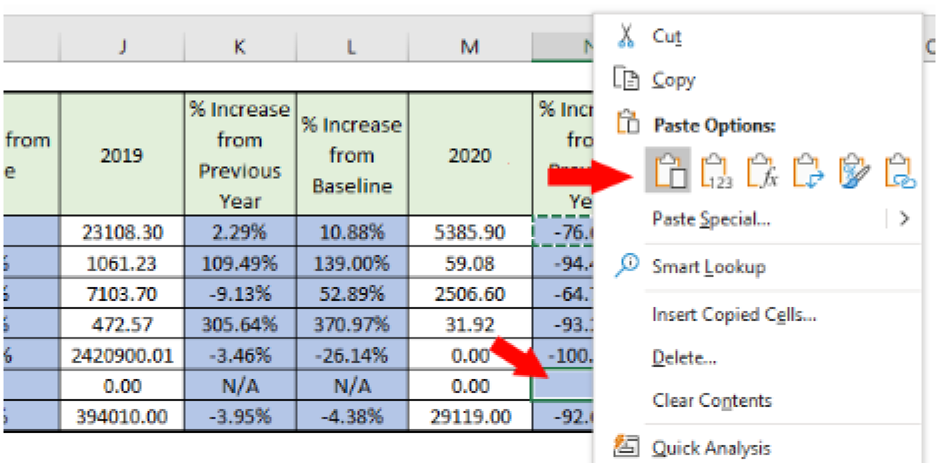


n (Gallons)	2016 Baseline	2017	% Increase from Previous Year	% Increase from Baseline	2018	% Increase from Previous Year	% Increase from Baseline	2019	% Increase from Previous Year	% Increase from Baseline	2020
	20840.90	22451.83	7.73%	7.73%	22591.00	0.62%	8.40%	23108.30	2.29%	10.88%	5385.90
	444.02	482.96	8.77%	8.77%	506.58	4.89%	14.09%	1061.23	109.49%	139.00%	59.08
	4646.40	6879.40	48.06%	48.06%	7817.20	13.63%	68.24%	7103.70	-9.13%	52.89%	2506.60
	100.34	63.22	-36.99%	-36.99%	116.50	84.28%	16.11%	472.57	305.64%	370.97%	31.92
	3277899.97	2430966.67	25.84%	25.84%	2507766.63	3.16%	23.49%	2420900.01	3.46%	26.14%	0.00
	0.00	0.00	N/A	N/A	0.00	N/A	N/A	0.00	N/A	N/A	0.00
	412076.00	390507.00	-5.23%	-5.23%	410202.00	5.04%	-0.45%	394010.00	-3.95%	-4.38%	29119.00

22. Select the second cells in the last two columns of the first table, right click, and select “Copy”.

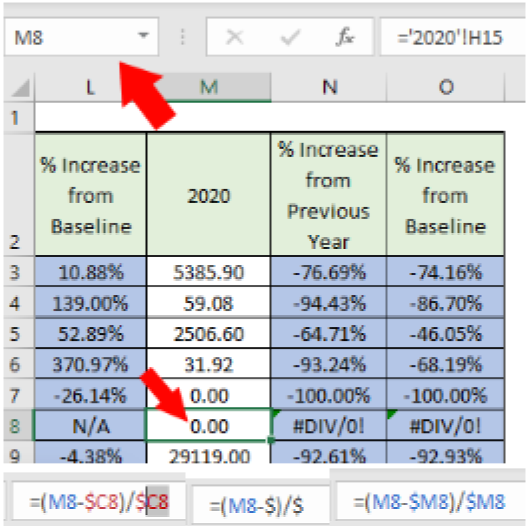


23. For the columns corresponding to the “% Increase from Previous Year” for the year(s) for which you are adding the data type in, select the cell corresponding to the data type, right click, and select “Paste”.

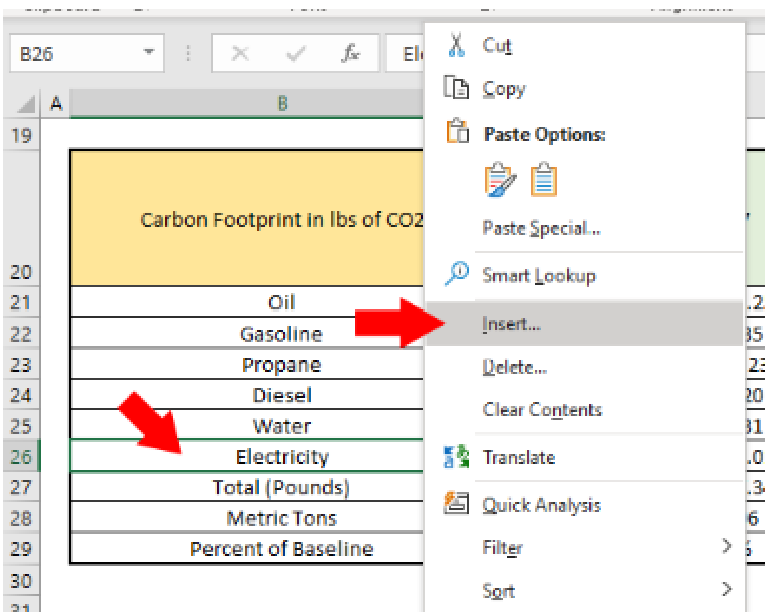


24. For the columns corresponding to the “% Increase from Baseline” for the year(s) for which you are adding the data type in select the cell corresponding the the data type and replace the cell after the “$” sign with the cell that corresponds to the first year that you

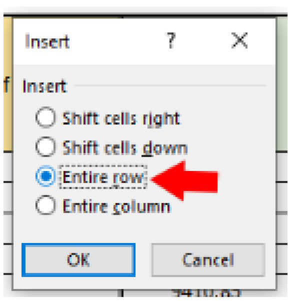
have data for, in the row corresponding to that data type, then press enter. (Ex. I am only adding in the new data type for 2020, so that will be the new baseline year for that data type.)



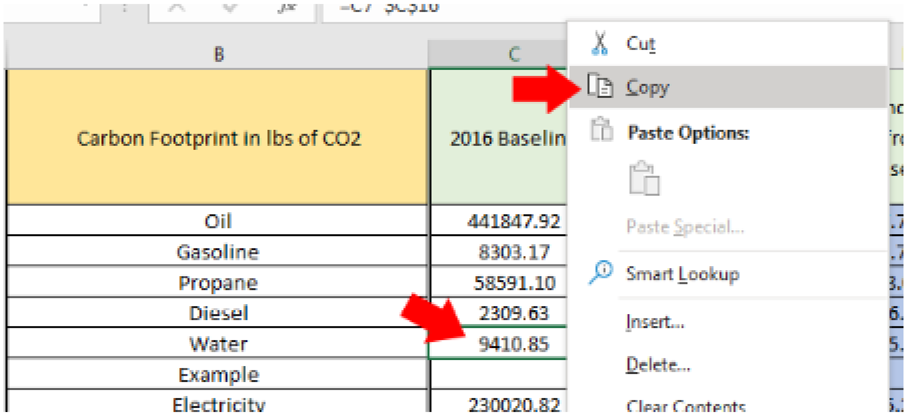
25. Select the first cell in the fourth to last row of the second table. Right click and select "Insert…".

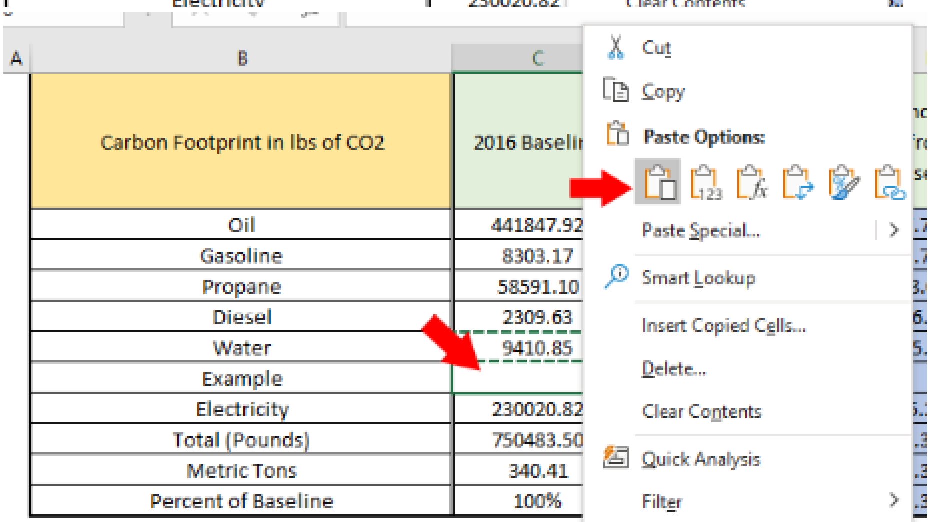


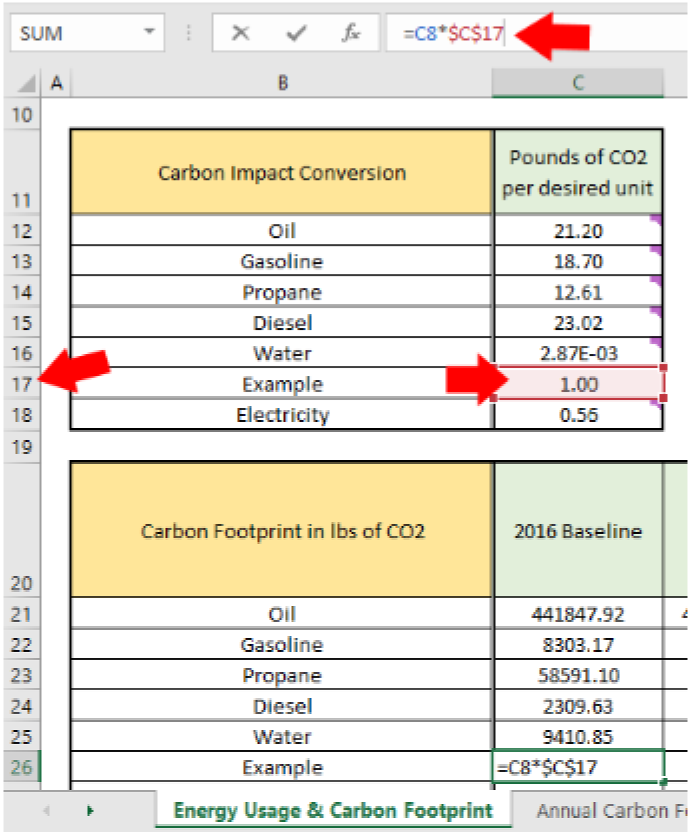
26. Select "Entire row" and press "OK".



27. Type in the name of the data type you are adding in the first cell of the new row.
28. For the remaining cells in the row corresponding to a year (the white cells) select the cell directly above the empty cell, right click and select "Copy". Select the empty cell right below, right click, and select "Paste". In the text box at the top of the screen, change the number after the second "$" sign to the number of the row corresponding to the conversion factor in the second column of the second table for the data type you are adding. (Ex. 2016)



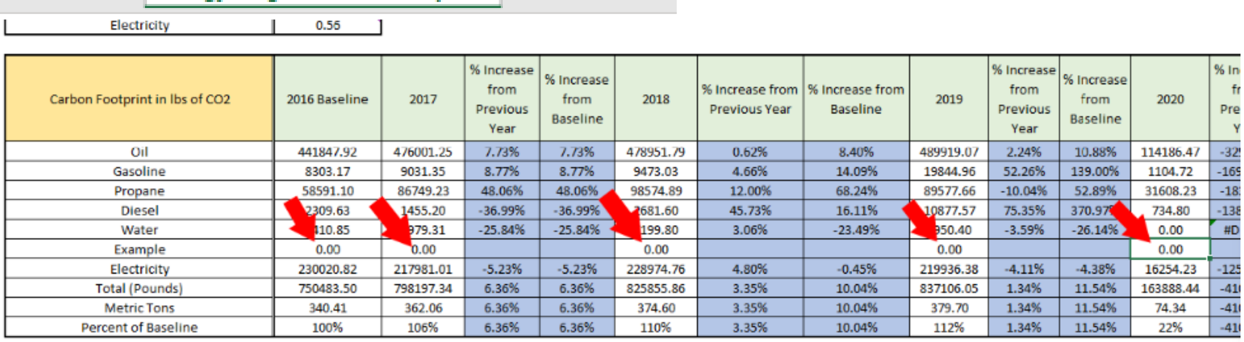




SUM | =C8*C17

	A	B	C
10			
11		Carbon Impact Conversion	Pounds of CO2 per desired unit
12		Oil	21.20
13		Gasoline	18.70
14		Propane	12.61
15		Diesel	23.02
16		Water	2.87E-03
17		Example	1.00
18		Electricity	0.56
19			
20		Carbon Footprint in lbs of CO2	2016 Baseline
21		Oil	441847.92
22		Gasoline	8303.17
23		Propane	58591.10
24		Diesel	2309.63
25		Water	9410.85
26		Example	=C8*C17

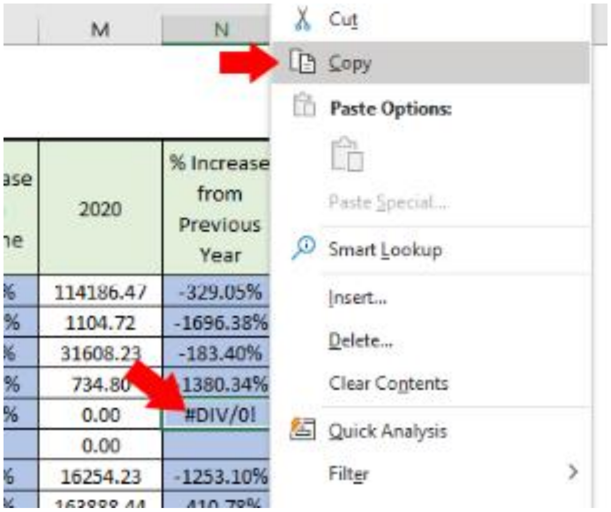
Energy Usage & Carbon Footprint | Annual Carbon F

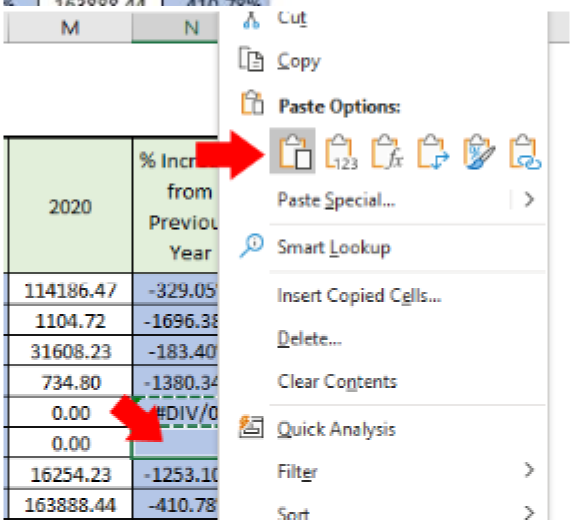


Electricity	0.56

Carbon Footprint in lbs of CO2	2016 Baseline	2017	% Increase from Previous Year	% Increase from Baseline	2018	% Increase from Previous Year	% Increase from Baseline	2019	% Increase from Previous Year	% Increase from Baseline	2020	% In fr Pre Y
Oil	441847.92	476001.25	7.73%	7.73%	478951.79	0.62%	8.40%	489919.07	2.24%	10.88%	114186.47	-32
Gasoline	8303.17	9031.35	8.77%	8.77%	9473.03	4.66%	14.09%	19844.96	52.26%	139.00%	1104.72	-169
Propane	58591.10	86749.23	48.06%	48.06%	98574.89	12.00%	68.24%	89577.66	-10.04%	52.89%	31608.23	-18
Diesel	2309.63	1455.20	-36.99%	-36.99%	681.60	45.73%	16.11%	10877.57	75.35%	370.97	734.80	-138
Water	410.85	979.31	-25.84%	-25.84%	199.80	3.06%	-23.49%	950.40	-3.59%	-26.14%	0.00	#D
Example	0.00	0.00			0.00			0.00			0.00	
Electricity	230020.82	217981.01	-5.23%	-5.23%	228974.76	4.80%	-0.45%	219936.38	-4.11%	-4.38%	16254.23	-125
Total (Pounds)	750483.50	798197.34	6.36%	6.36%	825855.86	3.35%	10.04%	837106.05	1.34%	11.54%	163888.44	-41
Metric Tons	340.41	362.06	6.36%	6.36%	374.60	3.35%	10.04%	379.70	1.34%	11.54%	74.34	-41
Percent of Baseline	100%	106%	6.36%	6.36%	110%	3.35%	10.04%	112%	1.34%	11.54%	22%	-41

29. For the cells in the new row corresponding to "% Increase from Previous Year" and "% Increase from Baseline" corresponding to years to which you are **NOT** adding the new data type, type in N/A.
30. For the cells in the new row corresponding to "% Increase from Previous Year" corresponding to years to which you are adding the new data type, select the cell directly above the empty cell, right click, select "Copy". Select the empty cell, right click, and select "Paste".
31. For the cells in the new row corresponding to "% Increase from Baseline" corresponding to years to which you are adding the new data type, select the cell directly above the empty cell, right click, select "Copy". Select the empty cell, right click, and select "Paste". In the text box at the top, replace the cell after the "$" symbol with the cell for the first year that you have data for the new data type. (Ex. 2020)


M
N
Cut
Copy
Paste Options:
Paste Special...
Smart Lookup
Insert...
Delete...
Clear Contents
Quick Analysis
Filter
2020
% Increase from Previous Year
114186.47
-329.05%
1104.72
-1696.38%
31608.23
-183.40%
734.80
1380.34%
0.00
#DIV/0!
0.00
16254.23
-1253.10%


M
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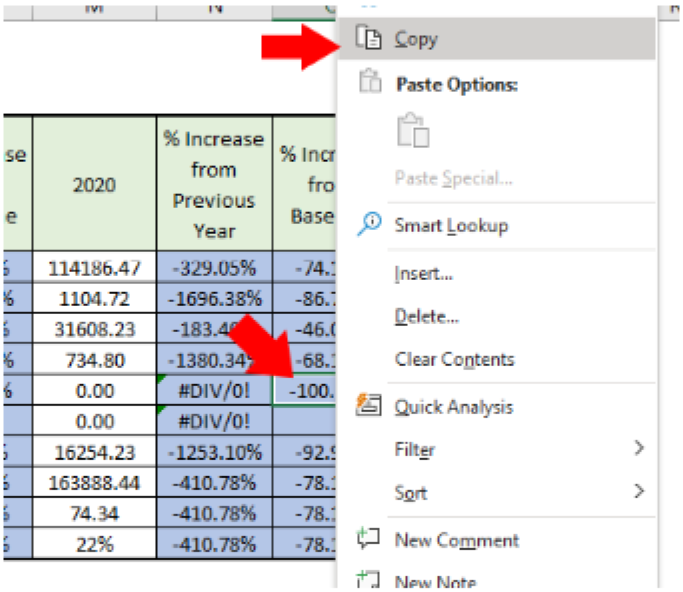
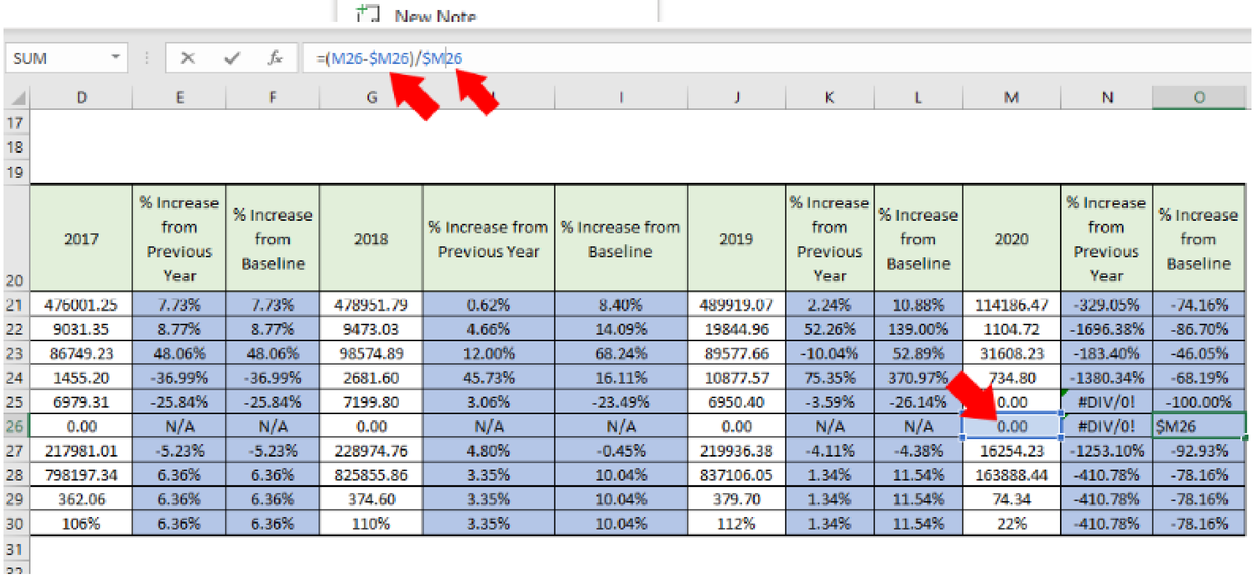
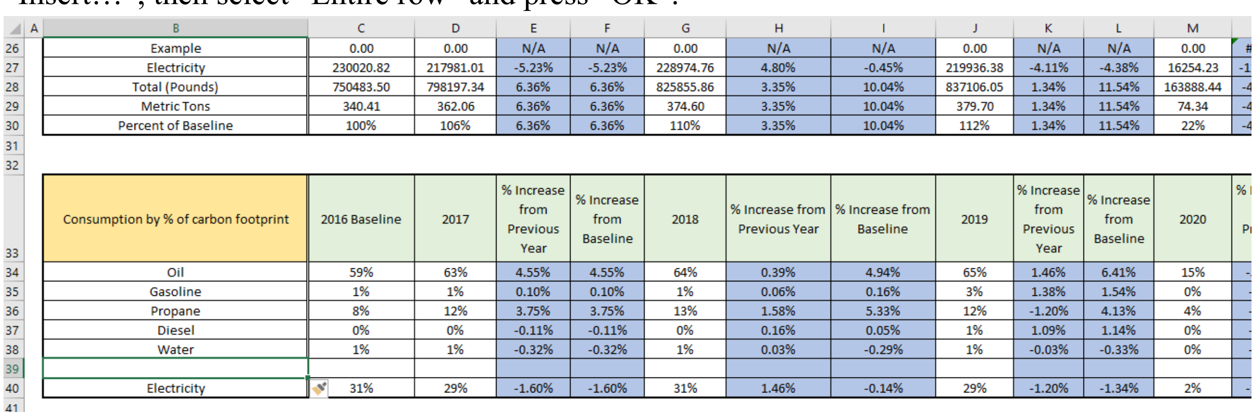
Cut
Copy
Paste Options:
Paste Special...
Smart Lookup
Insert Copied Cells...
Delete...
Clear Contents
Quick Analysis
Filter
Sort
2020
114186.47
1104.72
31608.23
734.80
0.00
0.00
16254.23
163888.44





	D	E	F	G	H	I	J	K	L	M	N	O
20	2017	% Increase from Previous Year	% Increase from Baseline	2018	% Increase from Previous Year	% Increase from Baseline	2019	% Increase from Previous Year	% Increase from Baseline	2020	% Increase from Previous Year	% Increase from Baseline
21	476001.25	7.73%	7.73%	478951.79	0.62%	8.40%	489919.07	2.24%	10.88%	114186.47	-329.05%	-74.16%
22	9031.35	8.77%	8.77%	9473.03	4.66%	14.09%	19844.96	52.26%	139.00%	1104.72	-1696.38%	-86.70%
23	86749.23	48.06%	48.06%	98574.89	12.00%	68.24%	89577.66	-10.04%	52.89%	31608.23	-183.40%	-46.05%
24	1455.20	-36.99%	-36.99%	2681.60	45.73%	16.11%	10877.57	75.35%	370.97%	734.80	-1380.34%	-68.19%
25	6979.31	-25.84%	-25.84%	7199.80	3.06%	-23.49%	6950.40	-3.59%	-26.14%	0.00	#DIV/0!	-100.00%
26	0.00	N/A	N/A	0.00	N/A	N/A	0.00	N/A	N/A	0.00	#DIV/0!	$M26
27	217981.01	-5.23%	-5.23%	228974.76	4.80%	-0.45%	219936.38	-4.11%	-4.38%	16254.23	-1253.10%	-92.93%
28	798197.34	6.36%	6.36%	825855.86	3.35%	10.04%	837106.05	1.34%	11.54%	163888.44	-410.78%	-78.16%
29	362.06	6.36%	6.36%	374.60	3.35%	10.04%	379.70	1.34%	11.54%	74.34	-410.78%	-78.16%
30	106%	6.36%	6.36%	110%	3.35%	10.04%	112%	1.34%	11.54%	22%	-410.78%	-78.16%

32. Select the last cell in the first column of the fourth table. Right click, and select “Insert…”, then select “Entire row” and press “OK”.



	B	C	D	E	F	G	H	I	J	K	L	M
26	Example	0.00	0.00	N/A	N/A	0.00	N/A	N/A	0.00	N/A	N/A	0.00
27	Electricity	230020.82	217981.01	-5.23%	-5.23%	228974.76	4.80%	-0.45%	219936.38	-4.11%	-4.38%	16254.23
28	Total (Pounds)	750483.50	798197.34	6.36%	6.36%	825855.86	3.35%	10.04%	837106.05	1.34%	11.54%	163888.44
29	Metric Tons	340.41	362.06	6.36%	6.36%	374.60	3.35%	10.04%	379.70	1.34%	11.54%	74.34
30	Percent of Baseline	100%	106%	6.36%	6.36%	110%	3.35%	10.04%	112%	1.34%	11.54%	22%

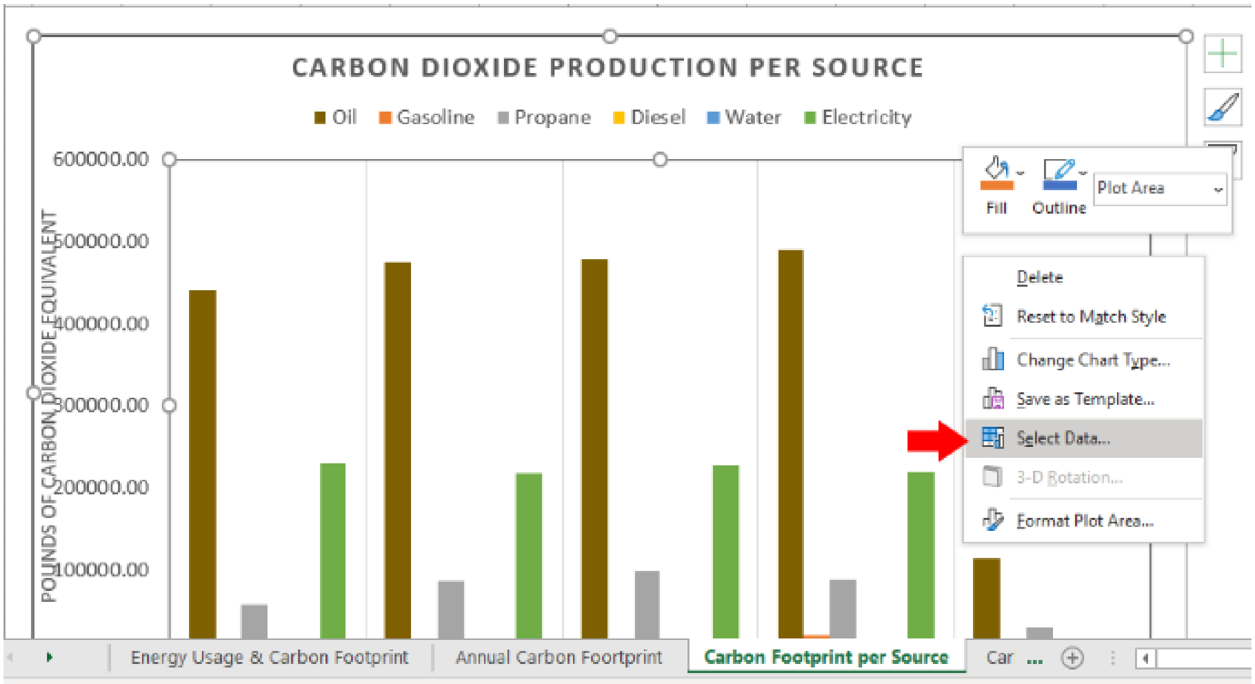
	B	C	D	E	F	G	H	I	J	K	L	M
33	Consumption by % of carbon footprint	2016 Baseline	2017	% Increase from Previous Year	% Increase from Baseline	2018	% Increase from Previous Year	% Increase from Baseline	2019	% Increase from Previous Year	% Increase from Baseline	2020
34	Oil	59%	63%	4.55%	4.55%	64%	0.39%	4.94%	65%	1.46%	6.41%	15%
35	Gasoline	1%	1%	0.10%	0.10%	1%	0.06%	0.16%	3%	1.38%	1.54%	0%
36	Propane	8%	12%	3.75%	3.75%	13%	1.58%	5.33%	12%	-1.20%	4.13%	4%
37	Diesel	0%	0%	-0.11%	-0.11%	0%	0.16%	0.05%	1%	1.09%	1.14%	0%
38	Water	1%	1%	-0.32%	-0.32%	1%	0.03%	-0.29%	1%	-0.03%	-0.33%	0%
39												
40	Electricity	31%	29%	-1.60%	-1.60%	31%	1.46%	-0.14%	29%	-1.20%	-1.34%	2%

33. In the first cell in the new row, type in the name of the new data type you are adding.

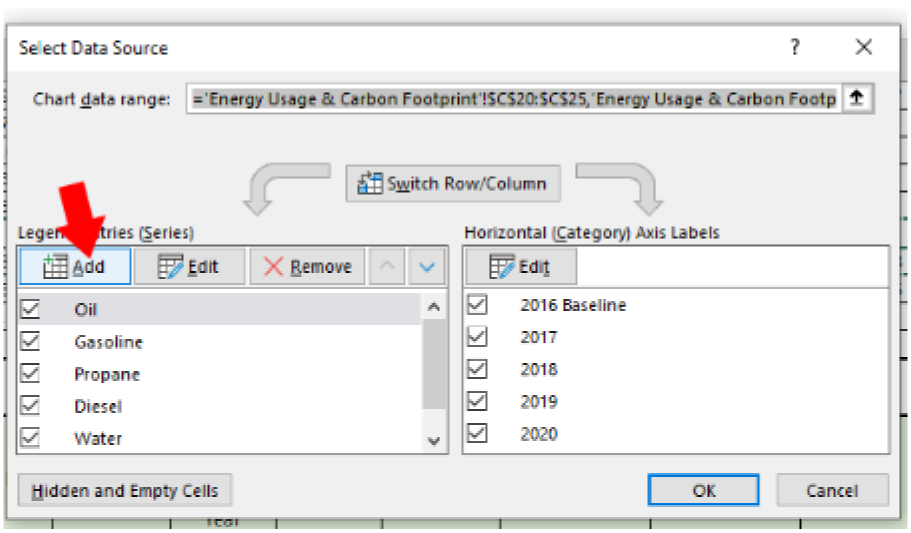
34. For every remaining cell in the new row, select the cell directly above it, right click and select “Copy”. Select the cell right below it, right click, and select “Paste”.

Consumption by % of carbon footprint	2016 Baseline	2017	% Increase from Previous Year	% Increase from Baseline	2018	% Increase from Previous Year	% Increase from Baseline	2019	% Increase from Previous Year	% Increase from Baseline	2020	% Increase from Previous Year	% Increase from Baseline
Oil	59%	63%	4.55%	4.55%	64%	0.39%	4.94%	65%	1.46%	6.41%	15%	-50.07%	-43.66%
Gasoline	1%	1%	0.10%	0.10%	1%	0.06%	0.16%	3%	1.38%	1.54%	0%	-2.50%	-0.96%
Propane	8%	12%	3.75%	3.75%	13%	1.58%	5.33%	12%	-1.20%	4.13%	4%	-7.72%	-3.60%
Diesel	0%	0%	-0.11%	-0.11%	0%	0.16%	0.05%	1%	1.09%	1.14%	0%	-1.35%	-0.21%
Water	1%	1%	[illegible]0.32%	[illegible]0.32%	1%	0.03%	-0.29%	1%	-0.03%	[illegible]0.33%	0%	[illegible]93%	[illegible]1.25%
Example	0%	0%	0.00%	0.00%	0%	0.00%	0.00%	0%	0.00%	0.00%	0%	0.00%	0.00%
Electricity	31%	29%	-1.60%	-1.60%	31%	1.46%	-0.14%	29%	-1.20%	-1.34%	2%	-27.14%	-28.48%

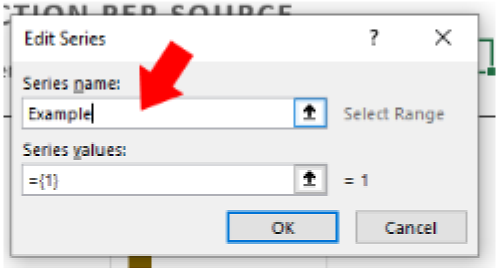
35. Go to the third sheet. Right click the graph and select “Select Data…”.



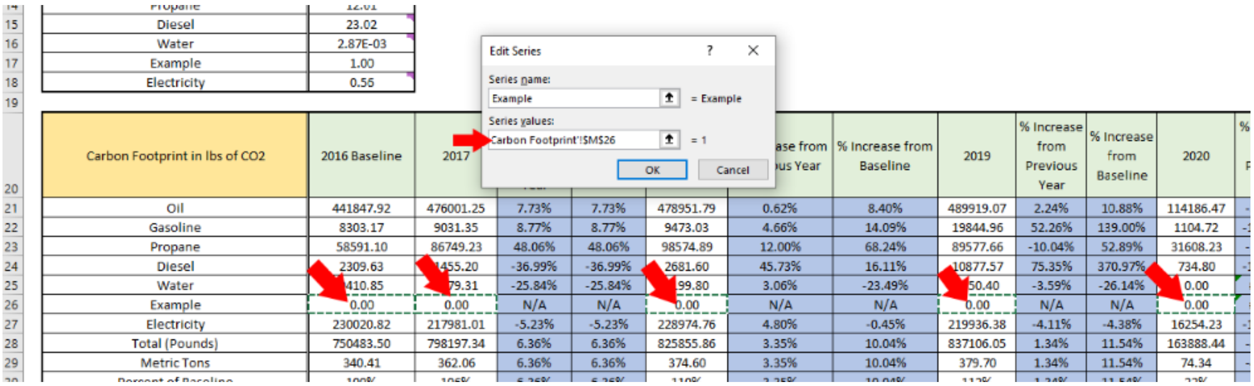
36. Select “Add” above the left-hand side list.



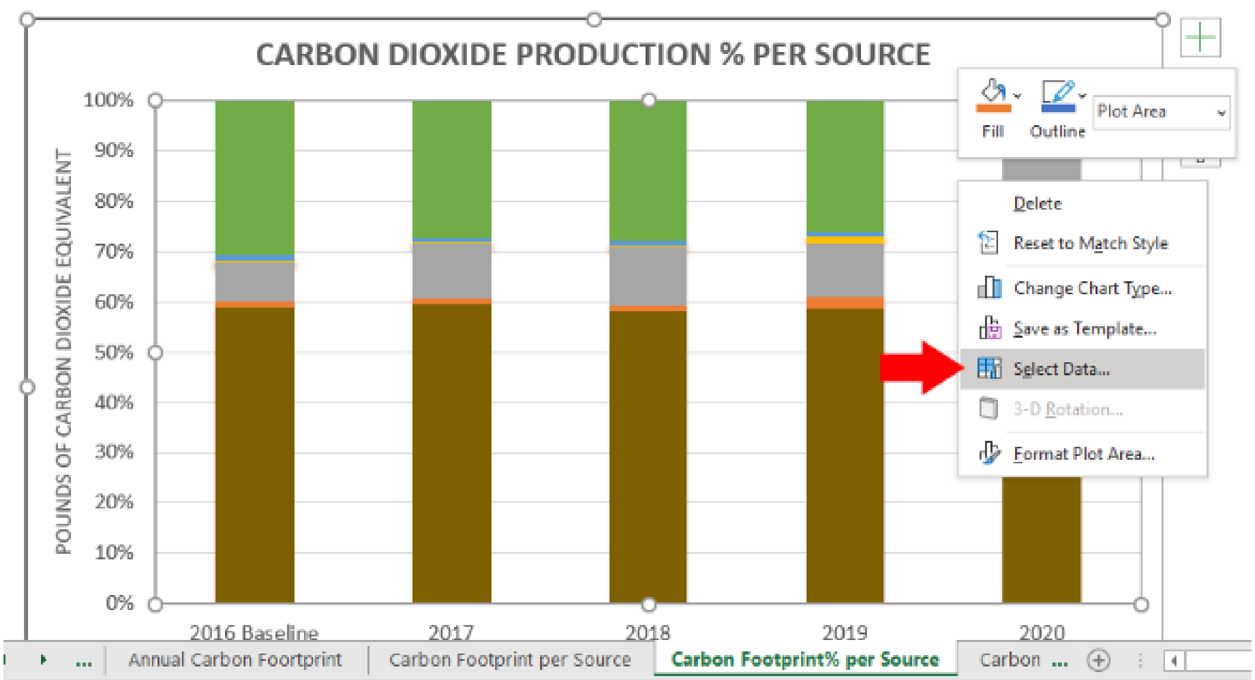
37. In the first box, type in the name of the data type you are adding.



38. In the second text box, delete all the text. Go to the first sheet. While holding control, select only the cells in the third table in the row corresponding to the data type you are adding, corresponding to years. Press “OK”, and then “OK” again.

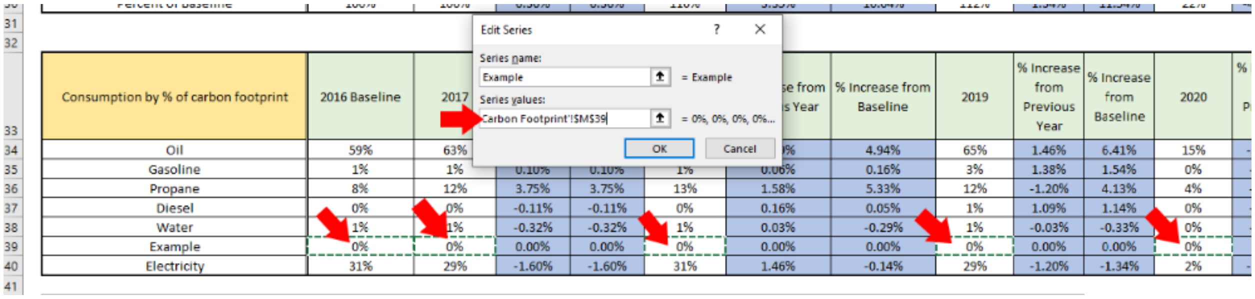


39. Go to the fourth sheet. Right click the graph and select “Select Data…”.

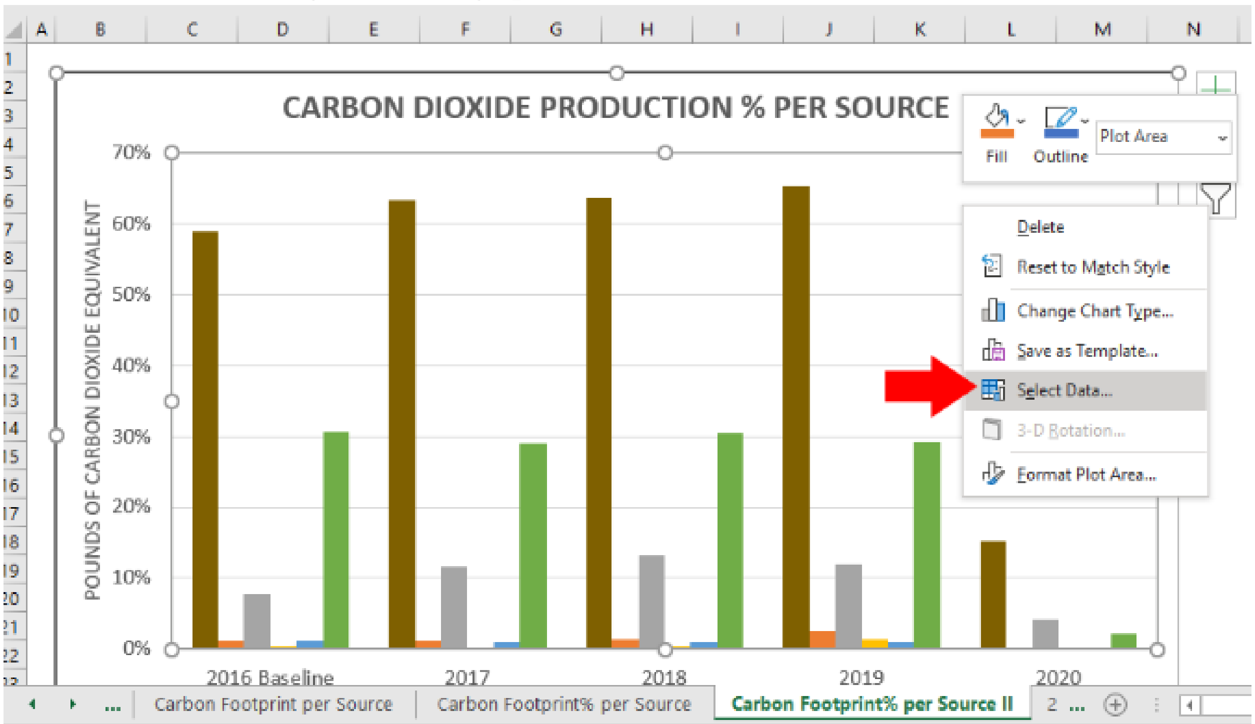


40. Select “Add” above the left-hand side list.
41. In the first box, type in the name of the data type you are adding.
42. In the second text box, delete all the text. Go to the first sheet. While holding control, select only the cells in the fourth table in the row corresponding to the data type you are

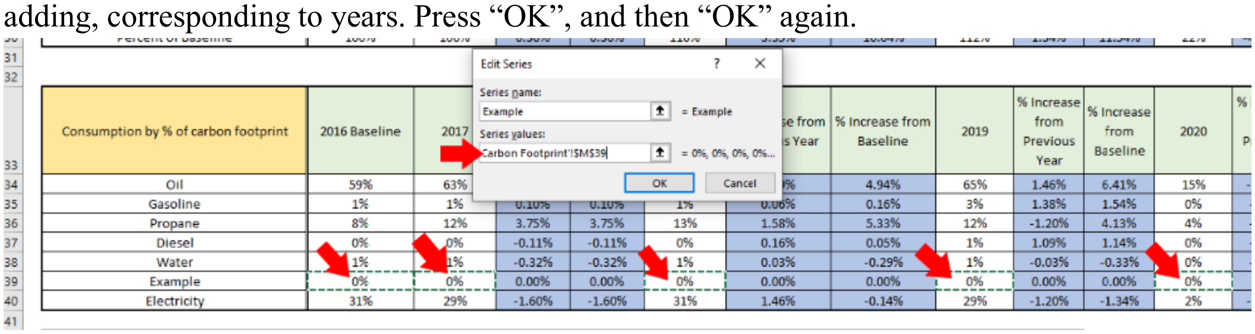
adding, corresponding to years. Press “OK”, and then “OK” again.



43. Go to the fifth sheet. Right click the graph and select “Select Data…”.



44. Select “Add” above the left-hand side list.
45. In the first box, type in the name of the data type you are adding.
46. In the second text box, delete all the text. Go to the first sheet. While holding control, select only the cells in the fourth table in the row corresponding to the data type you are adding, corresponding to years. Press “OK”, and then “OK” again.



Video Manual:

Located in WPI digital commons along with this report.

Appendix D: Interview Questions for Mass Audubon

1. What is your role at Mass Audubon?
2. We’ve seen the types of projects Mass Audubon has done with different buildings of theirs. Have you been involved in any of these?
3. Tower Hill is a non-profit like Mass Audubon. Was it difficult in receiving financial backing from companies and the local state government for these sustainability projects?
4. Moreover, conserving energy is a major aspect of limiting a facility’s carbon footprint. Mass Audubon has seemed to have done a great job at this as 63% of their energy comes from renewable wind energy while 37% in solar. What were the steps like for the organization to acquire these types of energy? Especially as a non-profit?
5. We noticed on your website, it mentions annual carbon emissions decreasing. Are you accounting for carbon sequestration in that? What program are you using to calculate that? Can you show us the raw numbers used?
6. We saw an article on your website on capturing carbon in Mass Audubon forests. Can you tell us how that’s calculated?
7. Does each location (conservation/sanctuary) calculate their carbon emissions and sequestration separately or is it done all together from the start?
8. Are you able to get us conversion factors that Mass Audubon uses in calculating their carbon footprint, so we can compare our conversion factors?
9. Any recommendations or considerations you have for Tower Hill? Maybe in terms of some projects you believe are applicable for Tower Hill?
10. Are there any other local institutions that are investing heavily into sustainability and renewable energy? Any non-profits that should be considered when trying to invest into renewable energy (ie. Green Energy Consumers Alliance)?