A Carbon Footprint Study of the Center of Science and Culture in San Jose, Costa Rica

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Centro Costarricense de Ciencia y Cultura

A CARBON FOOTPRINT STUDY

OF THE CENTER OF SCIENCE AND CULTURE IN SAN JOSE, COSTA RICA

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Abstract

As Costa Rica attempts to become the first carbon neutral country, our project consisted of assisting the CCCC to take the initial steps to become a carbon neutral organization and receive certification for it. We achieved this by calculating their carbon footprint and polling employees and the public on the topic of carbon neutrality. Ultimately, we provided the center with in-depth recommendations on how to reduce emissions, achieve certification, and sponsor vegetation growth to remove carbon from the environment.

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Executive Summary

One of the greatest challenges facing humans is also something they created. Global warming, the addition of greenhouse gases to the atmosphere, has an effect that, overtime, will warm the earth and have many other adverse effects upon it as well. Greenhouse gases are comprised of many different gases, divided into different categories. One of the largest and most well known categories are the Carbon Dioxide (CO2) emissions, or what will be referred to as: carbon emissions. As the problem has grown worse, global leaders have taken the initiative to make efforts towards reducing their impact, or, their carbon footprint. Amongst these leaders is the country of Costa Rica. During the 1950's and 60's, Costa Rica had one of the greatest deforestation rates in the world. It was only when Oscar Arias came to power in 1986, and instated new policies protecting the forests, that they would begin making strides in becoming one of the most eco-efficient and eco-friendly countries among the world today. Since the beginning of their movement to go green, Costa Rica has made some great accomplishments, including running on completely renewable energy for 300 straight days. The country has also launched a campaign to go completely carbon neutral by 2021, but this was later pushed back to 2085 in 2015.

Costa Rica's campaign to go carbon neutral has sparked initiative in many business and organizations within the country, one in particular being the Costa Rican Center of Science and Culture (CCCC), located in San Jose, Costa Rica. The center currently has nearly 230 employees and welcomed almost 250,000 patrons in 2018. The CCCC hopes to become a leader amongst businesses and the community in carbon neutrality, and in order to do this, they have asked that the team evaluate their carbon footprint and propose solutions for them to one day implement.

Their goals for the team were to: calculate their carbon footprint, create a list of recommendations with creative and innovative solutions, to present this information in a clear and concise fashion, and provide guidelines for the center to obtain certification.

In order to accomplish these goals, the team completed these objectives:

1. Gauge the community's perception of the CCCC and how their role in the community translates to their goal of becoming role models for carbon neutral businesses
2. Identify key stakeholders' vision for the CCCC carbon neutrality campaign
3. Determine the CCCC's carbon footprint and identify any specific areas or institutions that contribute large amounts of emissions
4. Develop recommendations and strategies to implement in the future in order to quantify, manage, and reduce the CCCC's carbon footprint.
5. Attain certification rewarding their efforts for carbon neutrality through El Instituto de Normas Técnicas de Costa Rica (INTECO)

The first two objectives were established as the team wanted to gather internal and external feedback on the importance and viability of the CCCC's carbon neutrality campaign. Interviews were conducted with the two main sponsor contacts, Saúl Martinez and Carolina Mora, in order to determine their vision for the neutrality campaign and how they foresaw its future. Standardized surveys were conducted with the museum patrons in order to determine their awareness of environmentally friendly practices and their perception of the museum's carbon neutrality campaign. Surveys were also conducted with employees in order to evaluate the organizational attitude towards being environmentally friendly and the improvements in the museum they believe can contribute towards the campaign. The assessment of these surveys' answers influenced the recommendations developed later, so that the museum is able to implement the team's recommendations smoothly while also expanding the neutrality campaign to eventually incorporate the community.

Before any quantifications could be carried out, the team began researching into methods used to calculate the carbon footprint. Although there are many available calculators online, the team decided to utilize methods establish by the Greenhouse Gas (GHG) Protocol, an international organization which sets out to standardize the methods used to quantify and report carbon footprint measurements in general. Through this, the team identified the potential GHG sources within the museum, which had to be accounted for, they included: energy usage, fuel usage, and the downstream waste generated from the center's operations and transportation. Data relevant to these areas was provided to the team by Carolina, and was used in the carbon footprint calculation in order to determine the biggest contributors to the museum's GHG emissions.

The center's carbon footprint can be broken down into 5 separate areas, including all direct and indirect emissions from the center. The carbon footprint calculation incorporates the 2018 time frame, setting a reference period for the museum to use in its future calculations. The total carbon footprint calculated for the CCCC was 135.32 tonnes of CO_2.

SUMMARY		
SECTOR	CARBON EMISSIONS (kg CO2)	CARBON EMISSIONS (tonne CO2)
EMPLOYEE COMMUTES	49199.22	49.20
ELECTRICTY	37220.38	37.22
WASTE	21794.53	21.79
WATER	13752.80	13.75
FUEL	13348.37	13.35
TOTAL	135315.29	135.32

Summary of Total Emissions by Source through 2018

The table displayed shows the five focal points of the CCCC's carbon emissions, highlighting their biggest factors leading to the overall carbon footprint. This table was mainly utilized as a summary of what was found through the calculations, allowing the sponsor to easily identify their top contributors.

The responses to our surveys were centered on approval of the carbon neutrality campaign. Slightly more than half of the employees were already aware of the center's carbon neutrality campaign, while the rest approved of the goal despite a lack of prior knowledge. The public responses were just as positive, with every response indicating that this project is important for the center to complete. When asked on how the center could take steps to achieve its certification, both the employees and the public proclaimed that improved waste management and recycling were important areas, with a minority suggesting more technological improvements and reforesting projects. Due to the center already having a waste management system, we looked into alternatives to reduce the center's emissions.

Based on the research and calculations performed by the team, a list of recommendations was formed. The list consisted of ways to approach each of the target problem areas and mitigate their emissions, with varying degrees of feasibility. Below is an outline of each recommendation, with the accompanying feasibility ratings determined by the team's research and calculations.

Option	Impact on Program Goal	Technical Feasibility	Economic Feasibility	Sustainability	Organizational Culture Feasibility
Upgrade Lighting - LED	High	Medium	Medium	High	High
Sponsor a Forest Initiative	High	High	Medium	Medium	High
Water Efficient Toilets	High	Medium	Low to Medium	High	High
Going Paperless	High	Medium	Medium to High	High	Medium
Plastic Alternatives	High	High	Low	High	Medium
Solar Panels	High	Medium	Low	High	High
Carpooling Incentives	Low	Medium	Medium	Medium	Medium
Biodiesel	Low	Medium	Low	Medium	High

Recommendations Chart

Each of the recommendations is broken down into four categories: the technical feasibility (how easy it is to implement into the center), economic feasibility (ratio of investment cost versus payout period), sustainability (how long the project can last), and organizational culture feasibility (the impact each recommendation will have on the center's operations). These recommendations were presented along with several strategies to raise public environmental awareness and potential steps to obtain INTECO's carbon neutrality certification, establishing a foundation for the center to eventually become a leading institution in Costa Rica's carbon neutrality campaign.

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Deliverable 2: INTECO Help Sheet	Anthony Heng	All
Deliverable 3: Calculators	Zachary Huamán	All

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Chapter 1: Introduction

Throughout the world today, one of the most pressing issues plaguing our society is global warming. Global warming can be described as the warming of the Earth due to human related actions including burning coal, oil, and gas (Kennedy & Lindsey, 2015). This warming is best attributed to the greenhouse gases that excel at trapping heat within the Earth's atmosphere. There are a few naturally occurring gases classified as a greenhouse gas, which includes: water vapor, carbon dioxide, methane, nitrous oxide, and ozone. Looking specifically at the carbon based gases, carbon dioxide and methane, emissions of these two gases have increased by 30% and 50%, respectively, since the Industrial Revolution and it has been predicted that the carbon dioxide concentrations will increase by another 30-150% by the year 2100 (Belić, 2006).

One of the most noticeable impacts of global warming is climate change. Climate change generally refers to the change in the climate of the earth due to any factor, human or natural. Over the course of Earth's history, the average temperature has fluctuated, however this vastly differs from the climate change we are experiencing today. The current increase in the global average temperature is happening much faster now than at any point since modern civilization and agriculture developed around 11,000 years ago (Kennedy & Lindsey, 2015). This acceleration of change explains the relationship between climate change and greenhouse gases, since this rise can be mainly attributed to the gases that are trapping heat within the atmosphere from humans burning fossil fuels so often and without restraint. However, this change has not gone unnoticed and many global leaders are pushing for a change in our standards in an attempt to slow down global warming and mitigate its effects.

In 2007, the officials of Costa Rica declared that their country would become the first completely carbon neutral country in the world. Carbon neutral is a term defined by a carbon footprint, which can be thought of as the amount of CO_2 and other greenhouse gas emissions that are produced by a mass in all senses (Murray & Dey, 2006). Understanding your carbon footprint can allow one to understand carbon neutrality, which can be described as "the concept of cancelling out the harm done to the earth's atmosphere" (Murray & Dey, 2006, p. 9) by human interactions, or their carbon footprint. From this, it can be understood that Costa Rica plans on attacking the problem head-on, isolating the main causes of their carbon footprint and then formulating and implementing solutions to reduce their footprint to a point of neutrality. The country has already taken some steps in this direction by gathering funding for projects partially sponsored by the United Nations Development Program.

The Costa Rican Center for Science and Culture (CCCC), which houses several organizations including, but not limited to: the Children's Museum, National Auditorium, and the Penitentiary Museum, hope to become leaders in Costa Rica's campaign for carbon neutrality. The center currently has nearly 230 employees and welcomed almost 250,000 patrons in 2018. The institution hopes that their sources of harmful emissions can be calculated and a plan to be devised that will ultimately neutralize their footprint.

The first step towards helping the CCCC is determining the total carbon footprint of the institution. This process involves collecting data over energy and fossil fuel usage throughout the campus and calculating its respective footprint. After determining the carbon footprint, implementation strategies will be devised for the museum to tackle specific areas within the institution. These plans involve the integration of interior and exterior aspects that will ultimately lower their emission output. The institution hopes to inevitably branch out with these solutions into the surrounding community in order to increase awareness about environmental impact and how everyone can contribute to the country's campaign. Finally, all the research and solutions suggested must be extremely organized and thorough, so that if implemented, the organization has the opportunity to continue growing their image as good role models and sustainability spokespeople for their country.

Another step the center is hoping to take is to become certified by INTECO. This certification will serve as proof to other institutions across Costa Rica that becoming carbon neutral can be a successful business model. The INTECO certification process would help identify some of the main factors of the center's carbon footprint and will give recommendations in order to remain certified (ISO Quality Services LTD., n.d.). In order to compensate for their areas of non-compliance, the center hopes that the team's developed plan will reduce the external impacts of running the business from within, which can be accomplished in a variety of ways, while helping the business save money. In the end, the return on investment for the company will be both monetary and environmental.

Chapter 2: Background

2.1 Costa Rica's Green History

Costa Rica has been an upstanding example of a country continually trying to reduce its carbon footprint. However, it was not always this way; from the post-1950's and into the early 1980's, Costa Rica had the highest deforestation rate in the world, at around 4% of land deforested per year (Flagg, 2018). It was not until a new forestry law was introduced in 1969 that the deforestation rates slowly began to fall and the destruction of the forests was averted. This was a great turning point for Costa Rica, as after this law was passed, they began to make great strides in sustainability and improving the understanding of their impact on the environment around them.

More recently, the efforts of Costa Rica have demonstrated a great yield. Costa Rica was the only tropical country to invert its rate of deforestation, increasing its forest cover from 21% in 1987 to 52% in 2013 (Castro, 2015). Costa Rica has made great progress towards carbon neutrality; with 81% of their progress being attributed to natural forest regeneration (Castro, 2015), the country has made great strides in sustainability, even passing the significant milestone along the way: logging more than 75 consecutive days of 100% renewable energy production (Fendt, 2015). Looking at the amazing things Costa Rica has done thus far in terms of reducing its carbon footprint, it will be important to also analyze where the country still has improvement to be made.

Costa Rica's goals for its carbon neutrality had been set to be accomplished by 2021, which coincided with the country's bicentennial independence from Spain. While this short deadline is still a goal Costa Rica aspires to move towards, a more realistic goal of becoming totally carbon neutral by 2085 was established in 2015 during the negotiations for the Paris climate agreement (Irfan, 2018). In the meantime, one of Costa Rica's direct goals is to bring the amount of emissions they produce back down to the emission levels produced by the country in 2005. In 2005, Costa Rica was producing about 5.99 $MtCO_2$, excluding the land-use change and forestry ("Emissions summary for costa rica," n.d.), while in 2014 Costa Rica emitted 7.92 $MtCO_2$, excluding the land-use change and forestry (World Resources Institute, n.d.). With an explicit goal in mind, Costa Rica has put forth much effort into conducting research in order to find ways it can reduce parts of their emissions, with the hopes of being a leader in green energy as the world continues to evolve and grow towards more sustainable solutions for problems we are currently facing.

2.2 Oscar Arias' Dream

In the context of Costa Rica's carbon neutrality campaign, no one has had a more significant impact than Oscar Arias, who has been the president of Costa Rica twice. His two terms in the office were from 1986 - 1990 and 2006 - 2010. Leading up to Arias' terms, Costa Rica had the highest rate of deforestation in the world, with about four percent of land deforested a year (Flagg, 2018). This much deforestation caused Costa Rica's forested land to shrink from around forty percent to only twenty five percent by 1990. When Arias returned to office in 2006, he began making a concerted effort to make his country more "green." He immediately started working on a plan called "Paz con la Naturaleza", or Peace with Nature ("Declara de interés público la iniciativa "paz con la naturaleza" impulsada por la presidencia de la república," 2006).

Oscar Arias's first term consisted of brokering peace between the countries of Central America. His second term was defined by a conversation with Alvaro Ugalde, the former head of the nation's national parks system, who said "'you know, you brokered peace in Central America' during your first presidency, 'why not broker peace with nature during your second?' (Author's interview field notes 16 July 2015)" (Flagg, 2018). Oscar's second administration had one goal and that was to place the country on route to becoming carbon neutral. This feat would be just as big as it was to abolish Costa Rica's army during Arias' first term ("Paz con la naturaleza," 2007). During the second term, the government planted over nineteen million trees ("Fundacion Arias," n.d.). The government's determination to keep funding green initiatives is one of the main reasons Costa Rica has been at the forefront of climate change and how to counteract its impact.

Under Arias, the government created the carbon neutral pledge as well as a "National Strategy on Climate Change". This strategy includes six focus points: mitigation, adaptation, metrics, development of capacities and technological transfers, public sensitivity, education and culture, and finances (Flagg, 2018). Part of this endeavor includes FONAFIFO as well, the National Forestry Financing Fund, whose mission is to manage all services with regard to the forestry sector of Costa Rica since its creation in 1995 ("FONAFIFO | mision y vision," n.d.). The entirety of Arias' second term was focused on the betterment of Costa Rica's carbon footprint, starting with the Peace with Nature plan and continuing with the carbon neutral pledge.

2.3 Impact of Carbon Emissions

This section discusses the general definition of carbon neutrality, and the past global efforts and conferences held to debate this topic in regards to climate change. We will also discuss tools of measuring these emissions, as well as the drawbacks and discrepancies in utilizing such methods.

2.3.1 Carbon Neutrality Definition

Carbon neutrality refers to the process of achieving net zero carbon emissions, so that the total amount of carbon released into the atmosphere by the actions of a specific entity are balanced or offset by methods aimed at removing carbon from the atmosphere. In general, this term applies to many different processes involved in releasing carbon dioxide, such as industrial manufacturing, waste, energy generation, and transportation, among many other activities. As such, any type of transformation towards carbon neutrality would aim at mitigating the effects of the carbon emissions from these sources. The definition of carbon neutrality, however, can be rather vague and confusing, because carbon neutrality can extend to other types of greenhouse gases (GHGs) as well. In the context of climate change, the totality of greenhouse gases is considered, rather than just carbon dioxide emissions. Therefore, carbon neutrality can be extended to include the other gases regulated by international resolutions, such as methane (CH4), sulfur hexafluoride (SF6), nitrous oxide (N20), hydrofluorocarbons (HFC), and perfluorocarbons (PFC). All of these different gases and their impacts can be measured in reference to carbon dioxide, meaning these gases can be expressed in terms of an equivalent amount of carbon dioxide ("The meaning of carbon neutrality," n.d.). Due to this, the term "carbon neutrality" is often confusing because its scope can vary in interpretation, as there is no set international definition for the term despite climate change being discussed in a global setting with the involvement of many different countries. Regulations and standards will vary from country to country, as well as from institution to institution. Thus, it is important to gain a better understanding and context of the term by exploring the past international resolutions and campaigns against climate change.

2.3.2 Global Efforts against Climate Change

Although the effects of greenhouse gases on the climate had been studied as early as 1820, the international community had only begun working towards mitigating the devastating effects of global warming in the more recent years. Events such as droughts, rising seawater levels, wildfires, and loss of the planet's biodiversity has united many countries in developing conferences through which nearly every country can implement various policies and participate in the campaign to reduce these effects ("Global warming and climate change," 2018). In 1995, the United Nations introduced an annual conference in order to deliberate the reduction of climate change in the context of the United Nations Framework Convention on Climate Change, a treaty signed in 1992 that committed industrialized nations to stabilizing their greenhouse emissions to 1990 levels by 2000. However, the major flaw of this resolution was that there was no set limits on the GHG emissions and there was no enforcement body, effectively rendering the treaty non-binding (Lerner & Lerner, 2003).

In 1997, the representatives in the UN gathered in Kyoto, Japan in order to draft and implement an improved resolution known as the Kyoto Protocol, which bound industrialized countries that ratified the treaty to reduce their GHG emissions by 5.2% below their 1990 levels by 2012 .These emissions included carbon dioxide, nitrous oxide, sulfur dioxides, methane, hydrofluorocarbons and perfluorocarbons. The target goals varied from country to country, and there were no set stipulations for countries that were still developing. However, the Kyoto Protocol provoked controversy within the international community, especially with developed countries who believed that the binding limits could be potentially harmful economically and argued that developing countries should not be granted limits that are more lenient. Due to this, the United States never ratified the Kyoto Protocol, with President Bush rejecting the resolution and instead proposing his own plan to reduce the U.S's emissions. In 2011, Canada had backed out of the agreement as well. These sentiments were also echoed by industrial delegates who claimed that the protocol was virtually impossible to implement, and that attempting to enforce limits would result in economic disaster. On the other hand, environmentalists criticized the Kyoto Protocol, alleging that the agreement was not enough to battle the effects of climate change and should be expanded even further (Blanchfield, 2011).

In order to improve upon the efforts of the Kyoto Protocol, in 2015 a conference was held in Paris heavily encouraged by many governments and nongovernmental organizations (NGOs) in order to reach a new consensus in regards to mitigating the effects of greenhouse gas emissions. The most important aspect of the new international agreement was its overall consensus, as countries such as the United States and China agreed to the set specifications. The legally binding Paris Climate Agreement was based around the approach of Intended Nationally Determined Contributions (INDCs), in which each country factored their own individual national circumstances and needs in creating country-specific strategies to reduce their national emissions. The countries agreed to gather every five years in order to communicate their progress and potentially negotiate other deals, with the global aim of preventing the global average temperature increase from reaching 2℃. (Paris Climate Agreement, 2018). This agreement essentially provided a natural flow between national regulations and an international framework that provided flexibility in conjunction with urgency. In this context, Costa Rica developed its own objectives in order to contribute to the overall goal negotiated.

2.3.3 Carbon Footprint

In context to the previous treaties instituted by the United Nations, the mitigation of the effects of global warming has regulated not just carbon emissions, but the rest of the greenhouse gases deemed significant in contributing to the global phenomenon as well. With the concept of the “carbon footprint,” GHG emissions can be measured and normalized to a standard in relation to carbon emissions. The carbon footprint is a measurement of the greenhouse gas emissions produced either directly or indirectly from an entity's everyday activities and processes. The carbon footprint essentially functions as an indicator of the overall environmental impact that an individual, business, or event has in the context of carbon emissions. This measurement grants additional flexibility as well, as the carbon footprint can be applied to other processes, such as consumer products, services, and even countries (Carbon Footprint, 2018). In terms of organizations and companies, carbon footprints are calculated through comprehensive audits that analyze the institution’s activities and formulate the carbon emissions caused by them. Typically, the framework of a carbon footprint analysis is laid down through a life-cycle assessment (LCA), which is a broad evaluation of a product or service’s environmental impact. Although the foundations for the LCA concept date back to the 1960s and 1970s, LCA analysis became internationally popular and standardized in the 1990s. The LCA factors in the entire life cycle of an entity, and through between every single step in its formation and existence, identifies the impact that its presence has on the environment (Apul & Franchetti, 2012).

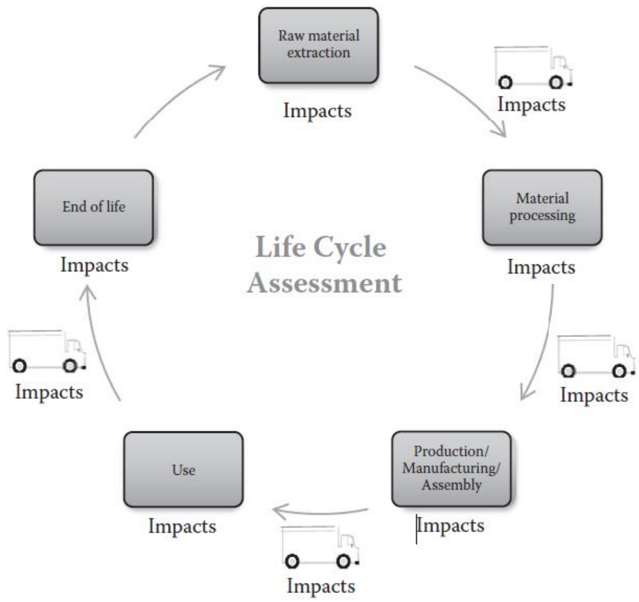

Figure 1: Life Cycle Assessment in a product's environmental impact (Apul & Franchetti, 2012)

It should be noted that the LCA is extremely broad, encompassing the analysis of many different types of environmental impact, such as resource depletion, land use, loss of biodiversity, and even socially vital concepts such as working conditions and human rights. A carbon footprint analysis is simply one of the many types of impacts that the LCA grants organizations the ability to investigate. Although the LCA is initially geared towards the analysis of products, LCA analysis can be expanded to include businesses and organizations as well. The utilization of the LCA approach provides a layered framework through which its application can be narrowed down specifically for carbon footprint analysis, forcing institutions to examine every single entity and service under their possession and how they contribute to their carbon footprint along every step in their existence.

However, just like there is no set international standard for the definition of carbon neutrality, there is no universal agreement on the factors that should be considered in calculating a carbon footprint, thereby giving this measurement ambiguity in scope and interpretation. The carbon footprint can incorporate the GHGs specified by the Kyoto Protocol, or it can involve solely carbon emissions. Depending on the entity being analyzed, the carbon footprint can also include other relevant sources as well, such as industrial manufacturing, products and services, agriculture, and land use. Due to this uncertainty, many discrepancies arise between various carbon footprint calculators available online, as these calculators account for different factors and industry-specific sources of GHGs.

Although there is no global standard to address this vagueness on an international level, the Greenhouse Gas Protocol Initiative was established by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD) as one of the world's most respected institutions in carbon footprint accounting. The GHG Protocol establishes a comprehensive, standardized framework for calculating, reporting, and managing GHG emissions, working with institutions ranging from governments to businesses and NGOs. The GHG Protocol defines carbon footprint as involving other greenhouse gases as well, and thereby utilizes GHG emissions as a synonymous term. The Protocol identifies varying scopes to be utilized in their calculation tools, as shown in Figure 2.

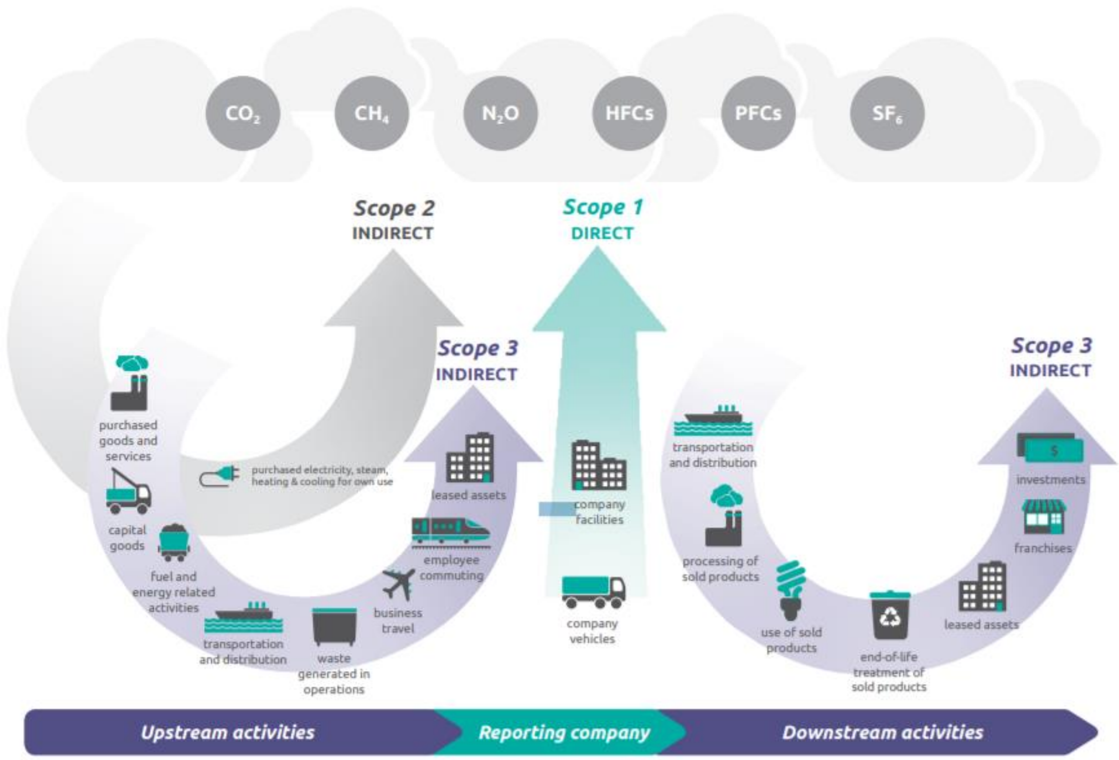

Figure 2: Scope of Carbon Emissions set by the GHG Protocol (World Resources Institute, 2011)

Scope I only involves direct emissions from sources owned or operated by the company, such as combustion of fossil fuel, electricity and heat generation, manufacturing processes, and emissions from any company-owned vehicles operated. Scope II involves indirect emissions that occur from “purchased electricity” consumption. Purchased electricity refers to electricity that is bought by the institution. Finally, Scope III refers to downstream emissions that occur as the consequence of the company’s actions. Typically, this involves waste-related consequences such as the emissions due to solid waste and wastewater produced by the organization (Apul & Franchetti, 2012). In calculating the carbon footprint of an organization, the GHG Protocol incorporates a general guideline that can be universally applied to any business in any sector or industry, with its steps outlined in Figure 3.

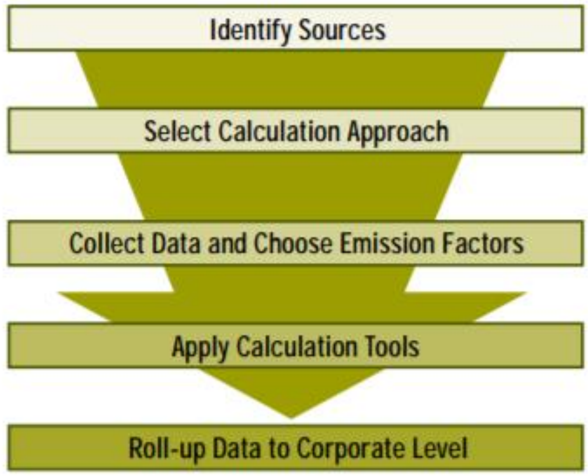

Figure 3: GHG Protocol's steps to calculating carbon footprint (World Resources Institute, 2004)

2.4 Costa Rican Center of Science and Culture

The Costa Rican Center of Science and Culture (CCCC) is an educational institution situated inside a former penitentiary within San Jose, Costa Rica. The CCCC is a museum complex, housing various attractions and subsidiaries within its campus, including The National Gallery, The National Auditorium, The Children's Museum, The Penitentiary Museum, Crea+, and The Tower. These different attractions, especially The Children's Museum, host numerous events or showcases which help to either highlight Costa Rican culture and tradition, or to provide a celebration of topics ranging from science and technology to history and art ("Centro costarricense de ciencia y cultura," n.d.). The center currently has nearly 230 employees, while welcoming almost 250,000 patrons in 2018. The CCCC essentially functions as a cultural center targeted towards tourists, but most importantly, towards the youth of San Jose through its various social programs that aim to support vulnerable children and teens at risk, academically or socially. The following statement comes from the organization's website, detailing one of its social projects:

> “One of them is the Kàllöm Project, an education proposal applied to the Children’s Museum that serves groups of children and adolescents, at vulnerability and social risk. Since its inception in 2010, the project maintains its objective in promoting values in children, to make them feel loved, respected, important, and that they can believe in themselves to achieve their dreams and desires in the future” (“Programas sociales del C.C.C.C.,” n.d.).

With the institution being a central marker for cultural, social, and educational awareness, the CCCC aspires to enhance its reach and become a leading example of environmental awareness, with the hope of inspiring other businesses within the country to conform to the carbon neutrality campaign.

2.5 Previous Work and Case Studies

The center hopes to become an icon in the field of reducing corporate environmental impact, specifically in the areas of climate change and the reduction of its carbon footprint. By striving for a small carbon footprint, the Center for Science and Culture hopes to act as a beacon that all other businesses can follow, demonstrating proper eco-friendly practices so that the whole of commercial Costa Rica can achieve carbon neutrality. However, the Costa Rican Center of Science and Culture is not the first business with hopes to surmount such a challenge as carbon neutrality. For any public organization or entity, public image is among the highest of priorities. Appearing favorably in the eyes of the consumer is often so important that a corporation will devote an entire branch to public relations, communications, and developing a specific company image. Public image affects a company’s ability to market, advertise, execute and expand. A more positive outward appearance will make stockholders happy, business easier to do, and keep consumers happy as well. However, an equally negative public image can have an equally destructive impact on a company’s operation. Take, for example, the massive fluctuation in the cost of the stocks in TESLA in September of 2018. Numerous questionable decisions by CEO Elon Musk caused stockholders to worry, and in return “the stock lost more than 11 percent on the week” (Salinas, 2018).

With public concerns growing over global warming, climate change, and the general abuse of the environment, companies are moving towards adopting environmentally conscious practices and implementing green initiatives throughout their organization. “Big business” is often the poster child for the cause of the environmental catastrophes the globe is facing today. Deforestation is often attributed to big business, where corporate greed results in acres upon acres being torn down to line the pockets of the bureaucrats. The image of a factory polluting the local water source comes up in the conversation about businesses going green because businesses are often considered the root of many of the problems faced today. Thus, it falls on the marketing department to combat these images to reassure the company’s consumer base that the company is nothing like the polluting image the consumer sees in their head. However, the move towards being green is not necessarily the easiest. Many steps must be undertaken in order to achieve this idea of carbon neutrality. Being environmentally conscientious does not have to be a discussion of moral obligation in contrast to corporate gain, for the two ideas are not mutually exclusive. A company can demonstrate great morality in the form of green initiatives while still maintaining a net increase in value.

There are a number of reasons corporations are adopting green initiatives, environmental projects, and eco-friendly policies. These changes allow a company to demonstrate on numerous fronts that the customer is important to them. By showing that the company is able to adapt and evolve in an ever-changing world, customers can feel as though they are not collaborating with or supporting a company with ideals that contrast their own. The customer can feel heard, and this allows company-marketing teams to spin such a concept and make the customer feel as though the company is the only one willing to listen. Companies want this sense of loyalty and trust between them and their consumer. The customer feels they have a say in the grand scheme of things, and that the disposable income they spend is also having a larger-than-life global impact. The customer can feel less guilty about purchasing a new, expensive luxury item when they feel the money is being used by a company they can trust to make smart and impactful decisions. The green adaptations a company makes accomplish three major factors in the field of marketing: keeping current customers around, having those customers spend more on the company, and attracting new customers. “Economic studies have shown that companies utilizing green technology and selling green products are seeing an increase in profits.” (Lorette, n.d.). Loyalty results in more cash influx, and thusly creates a margin of income between companies who, by going carbon neutral, can attract the more progressive consumer and their loyalty, and those companies who are simply behind in the times.

This section presents a glimpse at an institution similar to that of the Costa Rican Center of Science and Culture, and the progress it has made towards becoming carbon neutral.

2.5.1 Smithsonian Institution Sustainability Case Study

Considered “the nation’s attic”, the Smithsonian Institution is a collection of research centers, museums and archives that hold information, research and studies regarding the history of the United States of America and the world itself. In 2016, the Smithsonian performed a self-evaluation and devised a plan to document and adapt its sustainability for the present and future.

The Smithsonian Institute developed 10 individual goals for their sustainability project, each with vastly different targets and methods to approach. They broke down the idea of green initiative and carbon neutrality into numerous groups to be tackled: greenhouse gases, sustainable buildings, renewable energy, water usage, fuel and transportation efficiency, reusable materials, pollution, energy performance, electronic stewardship, and lastly climate change (Smithsonian Institution, 2016).

To begin their project, the Smithsonian Institute calculated and tracked their carbon footprint. As stated before, a carbon footprint is a measurement of the amount of carbon dioxide and other carbon compounds emitted as fossil fuels are used (Carbon Footprint, 2018). By calculating their carbon footprint, the Institute was able to determine where precisely the biggest emissions come from. Similar calculations were done for the energy used inside the building. These calculations allowed for optimal replacement of energy sources into new, renewable and clean energy. Following energy, water and waste became a priority. Water usage can be reduced, and waste can be reduced as well. By reducing the amount of waste and water used, the Institute also simultaneously helped cut down on pollution. To go along with the reduction of waste, the Institution planned to move towards using recycled goods in order to further reduce the impact of waste and pollution produced. Overall, the Smithsonian is looking to make an impact on the effects of climate change. The Institution would further invest in the research and understanding of climate change as a whole in order to produce information for the globe to give the world's population the knowledge to combat the seemingly insurmountable task of beating global warming.

The Smithsonian Institution based many of their goals and strategies on the idea of the LEED, Leadership in Energy and Environmental Design, certification. This certification is one of the many global standards used to rate, design and maintain environmentally green buildings, companies and practices. The LEED certification proposes an emphasis on maintaining environmental responsibility and offers a way for companies to be in charge of their own green techniques. However, the LEED certification is not the only way for companies to maintain a carbon neutral status. In fact, it is not the only certification a company can apply for and receive. There exists another certification that, similar to the LEED certification, can verify the carbon neutrality of a company. The INTECO certification process was the primary form of carbon neutrality that the Costa Rican Center of Science and Culture wanted to achieve, thereby being the primary focus of the research and design this project focused on.

2.6 Carbon Neutrality Certification Process

As of recently, many new types of green certification are being marketed at companies and organizations in order to publically brand themselves as accepting the green initiative. These certifications act as a way to mark progress towards carbon neutrality, and keep a company or organization on track to maintain environmentally conscientious practices. Such certifications include the LEED certification, European Green Building Certification, and the Carbon Neutrality Certification through the Instituto de Normas Técnicas de Costa Rica (INTECO).

2.6.1 Instituto de Normas Técnicas de Costa Rica (INTECO)

Specifically within Costa Rica, businesses can attain certifications through an organization called the Instituto de Normas Técnicas de Costa Rica (INTECO). INTECO acts as a private, non-profit subsidiary of the International Organization of Standardization (ISO), the international organization which develops standards such as the ISO 14001 ("INTECO," 2017). Thus, INTECO is the only organization within Costa Rica with the authority to provide and sell

ISO certifications to any business or entity within the country, in addition to also providing the standards that the institution itself has developed. INTECO provides several certification processes depending on the type of standard an organization is targeting; however, the main process applicable to the goals of the CCCC is the environmental management system assessment, through which different services can be provided, the most significant evaluation being a verification of carbon neutrality and GHG inventories (“Certifications,” n.d.). Once a request has been filled out and sent to the organization, INTECO will work with the company in order to draft several agreements that define the organizational scope and limits of the assessment. Once consent is provided by the business, INTECO will begin its certification process, as shown in Figure 4.

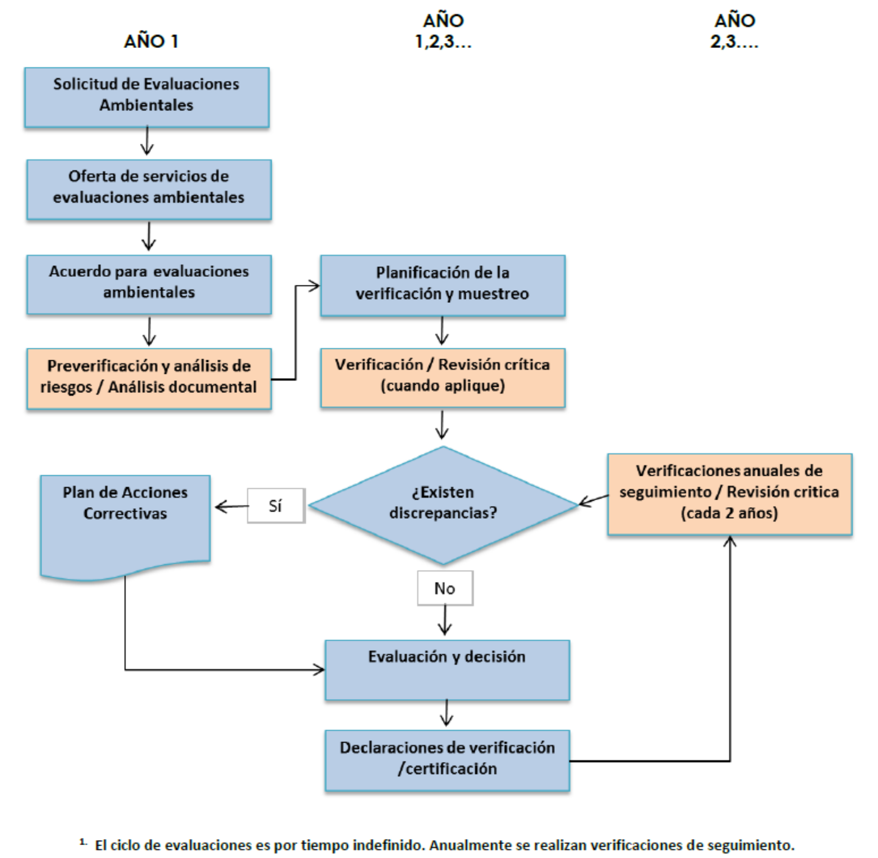

Figure 4: INTECO's Environmental Management Assessment Process (INTECO, 2018)

The assessment entails several stages, which includes a Pre-Verification/Risk Analysis stage where INTECO will begin to gather any relevant data and determine the sources/magnitudes of any errors, omissions, or misinterpretations in order to evaluate the risk of discrepancies within the business. If no discrepancy is found within the organization and the data provided, the second Verification stage will commence, in which on-site evaluations occur, on top of data collection and analysis, in order to determine any non-compliant areas in terms of the standard being targeted. With regards to carbon neutrality, the main standard that INTECO will use for its evaluation criteria is INTE 12-01-06, which details requirements of a GHG inventory calculation, the implementation of a GHG emissions reduction plan, and the requirements for carbon neutrality management and declaration (INTECO, 2018). Although slightly open-ended, this standard requires documentation and justification at every step, thus requiring the organization to have a system in place that details its GHG inventory, the relevant sources and calculation methods used, the specific emission factors utilized, and the company's methodology on how it will reduce its GHGs, as well as the justification behind such techniques. Finally, routine and consistent inventory reviews must be conducted to determine further opportunities of improvement (El Instituto de Normas Técnicas de Costa Rica (INTECO), 2016).

Once the Verification stage is complete, INTECO will move on towards it Evaluation stage, where if any non-compliances are found in regards to the evaluation criteria determined by the standard, the company is given 30 days to provide a Corrective Action Plan (CAP) on how the non-compliances will be addressed and mitigated, as well as any justification and evidence that the business can provide. With the Corrective Action Plan, and the assessment carried out in the previous stage, INTECO may then decide whether the company may be granted the certification that it desires. If a positive decision is made, INTECO will then provide follow-up reviews for the company to maintain its certification; in regards to carbon neutrality, a complete assessment is carried out every 2 years after the initial issuing of the certification (INTECO, 2018).

Chapter 3: Methodology

The focus for our project is to aid the Costa Rican Center of Culture and Science (CCCC) in determining their environmental impact through a carbon footprint analysis and by developing strategies tackling reduction and mitigation throughout the organization. To address these goals, we developed these following objectives:

1. Gauge the community's perception of the CCCC and how their role in the community translates to the goal of becoming role models for carbon neutral businesses
2. Identify key stakeholders' vision for the CCCC carbon neutrality campaign
3. Determine the CCCC's carbon footprint and identify any specific areas or institutions that contribute large amounts of emissions
4. Develop recommendations and strategies to implement in the future in order to quantify, manage, and reduce the CCCC's carbon footprint.
5. Attain certification rewarding their efforts for carbon neutrality through El Instituto de Normas Técnicas de Costa Rica (INTECO)

3.1 Gauging Public Perception

Before considering the Costa Rican Center of Culture and Science's carbon footprint, it is important to understand the potential scope and impact that the organization's neutrality campaign could have. This was achieved by analyzing public understanding on the topic of carbon neutrality and understanding how the public perceives the possible impact of a neutrality campaign. In this context, the museum patrons were considered in order to understand the exact relationship the organization has with the local community. This process was accomplished through a standardized interview, in which a specific script of predetermined questions is constructed in order to achieve data collection on a large scale (Berg, Bruce L. and Howard Lune, 2012). By maintaining consistent wording and ordering of the questions for each subject, data becomes comparable and certain patterns or trends can be scrutinized. By understanding public consciousness, later implementation strategies became easier to define in the context of the community's receptiveness towards specific modifications and changes within the CCCC.

3.1.1 CCCC Museum Patrons and Their Perspectives

One aspect of the CCCC's carbon neutrality campaign that must be considered is the scope of the organization's impact, as this will give the team a better understanding of the potential impact that the neutrality campaign could have on the local community. This was done through a survey targeting museum patrons, ideally local residents of the San Jose area who are aware of the role of the CCCC and how it interacts with the public. Although our project mainly focused on devising a plan for the CCCC to achieve carbon neutrality, understanding the general population's views on Costa Rica's green movement provided valuable information when the group is devising a proposal for possible solutions. The survey was designed to gain a greater perspective on the common citizens' knowledge of the current green policies already put in place by the government, as well as their thoughts on how more policies may affect their daily lives.

In addition, utilizing museum patrons as the subjects of this survey accomplished two goals: determining the public perception of the museum and their relevance within the community, as well as any general improvements within the organization that the public could recommend or would be receptive of. The survey encompassed various questions which ask participants to describe the relationship between the public and the museum, and to explore their awareness of carbon neutrality and how they would react to the CCCC implementing a neutrality campaign. Sample questions are found in Appendix A.1: Museum Patrons.

The questions in this survey allowed the team to gain a greater understanding of the common citizen's role in Costa Rica's campaign to go carbon neutral, which is important once the museum begins to expand its carbon neutrality campaign to the surrounding community. The team gained insight on the public's current view of the CCCC, as well as help perpetuate the green mindset Costa Rica hopes to inspire in all of its citizens. Understanding the organization within the context of the community gave the team better insight into how the CCCC could become a leading role model for local businesses to become carbon neutral and how the neutrality campaign could be marketed and translated into the local area.

3.2 Identifying Key Stakeholders' Ideals

The group of people most directly affected by the campaign to go carbon neutral are the employees at the CCCC. Whether at the top of the corporate ladder or a brand new employee, the alterations to policy, changes to the organization's operations, and any other encompassing features of our plan for the CCCC will be felt by each employee differently. Therefore, by analyzing the groups across the campus, we had the opportunity to fully understand exactly what impact our plan could have, and what changes our plan may need to have in order to accommodate each employee.

3.2.1 Upper Management Perspective

Before any work could be done to work on reducing the CCCC's carbon footprint, it was necessary to understand how the upper management perceived the carbon neutral plan. The

CCCC has multiple departments and areas within the campus, thereby providing several challenges in going carbon neutral if discrepancies existed between the team and the administration. Therefore, the directors and managers within the museum had to be consulted in order to gain a better understanding of their vision for the neutrality campaign. For this reason, semi-standard interviews with the upper management were conducted in order to obtain this information. Semi-standard interviews have prepared questions and topics, but are more interested in the conversation during the interview than the answers. The focus of these interviews is to understand the viewpoint of the subject (Berg and Lune, 2012). The unstructured part of the interview comes when the interviewer asks the subject to explain their reasoning behind the answer. This allowed our group to understand the key factors and ideas that the management perceived for the carbon neutrality project, and the possible methods we could use to achieve each goal.

Upon arrival in Costa Rica, the team interviewed Saúl Martinez, the Assistant Executive Director of the CCCC, and Carolina Mora, the environmental manager within the CCCC, to understand management perspective and how they would like to proceed going forward in terms of overall goals, as well as data collection and analysis. A tour was given to the team as well so that we had a better understanding of the physical processes within the center and how it operated. The questions we asked are referenced in Appendix A.3: Key Stakeholders. Subsequent meetings were held afterwards in which the team interviewed the two, in addition it to any other personnel relevant to the project.

The CCCC cannot achieve carbon neutrality without the museum's management and leadership buying in and understanding the long-term process of carbon emission reduction. We wanted to make sure we aligned our recommendations for strategies and implementation plans with the visions of the upper management to ensure the best results when converting the CCCC to a carbon neutral facility. Any discrepancies with our recommendations and the sponsors' goals for this project could severely undermine the process of establishing a solid foundation for the museum to begin working towards obtaining the carbon neutrality certification.

3.2.2 Determining Employee Impact on Carbon Emissions

Being the group of people who spend the largest amount of time at the CCCC, the employees of the institution can be categorized as the largest contributing factor to the carbon footprint. Their numbers exceed that of the executives, and their time spent on the campus is much longer than any patron is. Therefore, by analyzing and understanding the day-to-day operations of the average employee, we gained a more complete and thorough understanding of areas of the CCCC that require the most change. By gathering data, through anonymous standardized surveys, we gathered a more complete understanding of the employees, their impact on the effort to go green, and take into consideration how they feel about the changes, thereby allowing us to develop a more employee-friendly plan. Having the employees conform to the idea of going green is an extremely intricate and important process; even if upper management decides to go green or carbon neutral, it is a fruitless labor unless the entirety of the organization commits. The survey consisted of questions as referenced in Appendix A.2: Employee Questions.

These questions were designed to get a sense of the maximum impact that employees might have on the carbon footprint of the CCCC. As demonstrated by Figure 5 (from the epa.gov website),

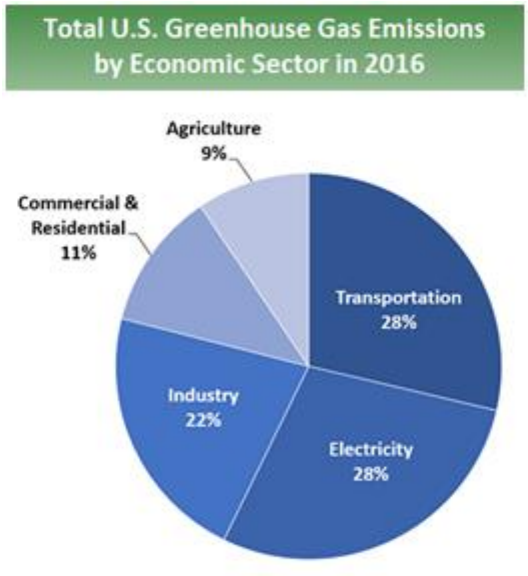

Figure 5: GHG Breakdown (from the EPA)

transportation is one of the largest contributors to greenhouse gases in the United States, (comparable to Costa Rica), meaning that an employee's daily commute to work contributes significant emissions to the carbon footprint of the CCCC. By incorporating this idea into the calculation of the carbon footprint, it becomes clear that in order to fully attain carbon neutrality, employee commitment is a necessity.

3.3 Calculating Carbon Footprint and Identifying Top Contributors

One of the main objectives upon arriving in Costa Rica was the calculation of the organization's carbon footprint and subsequent analysis of their specific emissions. Doing so required an assessment of the CCCC's building and different facilities throughout the campus in order to compile data regarding fuel and electricity use, as well as organization-related transportation. Different individuals and records within the organization had to be consulted in order to obtain specific numbers depending on the different scope of emissions the CCCC wanted to consider. All the data was gathered and presented to us by Carolina Mora. As aforementioned, Scope I emissions encompasses any direct emissions made by the organization, meaning any fuels combusted by, or energy supplies created by the organization (World Resources Institute, 2004). As such, data was collected regarding the combustion processes of the organization and how much fuel was utilized. Considering that the CCCC is a business, it is highly likely that the center does not generate its own fuel supply, but purchases and consumes electricity from an outside provider.

This indirect source of carbon emission constitutes Scope II emissions, which encompass energy consumption provided by a third-party vender (World Resources Institute, 2004). Therefore, it was necessary to acquire data regarding how much electricity was consumed over the reporting period and then plug this information into a spreadsheet to compile a total amount utilizing Equation 1:

$$Emissions = Electricity\ x\ EF$$

Equation 1: Electricity Emissions Calculation (USEPA, 2016)

where *Electricity* is defined as the amount of electricity consumed by the CCCC in the reporting year, while *EF* is defined as the emission factor, which reflects the amount of carbon emission per unit of electricity (usually kilowatts or megawatts). In all calculations, the emission factor is simply a set conversion ratio that determines the amount of carbon, or other GHG gases, produced per unit of the emissions source being analyzed. Typically, these factors are found in databases or compiled into lists by agencies such as the GHG Protocol or the United States Environmental Protection Agency. In terms of electricity, emission factors may vary depending on the type of method used in this calculation, being either location-based or market-based. The location-based method can be utilized when the organization attains its electricity from electrical grids, while the market-based method is utilized when the organization obtains power from specific renewable sources. The emission factors will vary, and thus it is crucial to understand how the CCCC obtains its electrical energy. This will be done by interviewing key stakeholders or personnel in the organization to obtain this information.

Another factor to consider when calculating the carbon footprint is the carbon emissions created from transportation. Transportation calculations fall under the Scope III emissions category, representing the indirect emissions caused by activities of the company (World Resources Institute, 2004). This constitutes either company-owned vehicles and the amount of travel which has occurred within the reporting time frame, or the daily transportation employees take in commuting to work. If there is a very large number of employees within the company, it is likely that this consideration might not be technically feasible, although it is possible that a sample of the employees can be taken and the data acquired from the sample can be normalized to represent the total carbon emissions of all employees. The equation that will be utilized to calculate the carbon footprint from the data depends on the method to be used. If the total distance traveled from commuting can be obtained, then Equation 2 would be applicable, as shown:

$$Emissions = Total\ Distance\ x\ EF$$

Equation 2: Carbon Emissions by Transportation based on Distance Travelled (USEPA, 2016)

where *Total Distance* is defined as the total distance per employee commuting to and from work, and *EF* is defined as the vehicle-specific emission factor. Using this method would require the knowledge of the methods in which employees travel to work, as the emission factors used in the calculation varies by transportation type, such as passenger car, motorcycle, or bus. If the amount of fuel used in commuting were to be considered instead, then Equation 3 would be applicable, as shown:

$$Emissions = Fuel\ Consumed\ x\ EF$$

Equation 3: Carbon Emissions by Transportation based on Fuel Consumed (United States Environmental Protection Agency, 2016)

where *Fuel Consumed* is defined as the total mass or volume of different types of fuel consumed, such as gasoline or diesel, and *EF* is defined as the fuel-specific emissions factor. This method would be preferable if knowledge was acquired over the total amount of fuel consumed during an employee's commute. It is likely that the Equations 2 and 3 may be interchangeable because the amount of fuel used depends on the distance traveled, however one may be preferable over the other in terms of the specificity of the emission factor. For example, using the fuel-based method would delve deeper into the varied types of fuel used, and will take into account default emission factors for each type. Alternatively, the distance traveled method may be broader as it groups together multiple vehicles under categories, and so these emission factors may not be as specific. Additionally, these factors may vary from country to country, so research was conducted to determine what emission factors could be applied to Costa Rican transportation. Assumptions made play a significant role in determining which equation to utilize.

The final factor to take into consideration when calculating the museum's carbon footprint is the waste generated by the museum and its activities. Factoring in the museum's waste determined the organizational scope of the GHG inventory, analyzing not just the activities of the museum and the environmental impact of those activities, but also the downstream effects of running the museum that might not be immediately apparent. Waste was broken down into two separate categories, solid waste and wastewater. Their calculation follows the same format previously prescribed for each factor mentioned above, where

$$Emissions = Waste\ Generated\ x\ EF$$

Equation 4: Carbon Emissions from Waste Generated (World Resources Institute, 2011)

but the emission factor used varies depending on the type of treatment used for each form of waste. For example, in terms of solid waste, the emission factor depended on whether or not the waste is disposed of in a landfill, or through composting, while the emission factors used for wastewater varied depending on if the water is piped from a lake or is treated in a septic tank. It is significant to understand the operations involved in waste disposal as this impact the emissions factors, which can cause large differences and skew the carbon footprint calculation if the wrong one is utilized. Establishing waste generated by the museum as the operational limit for the GHG inventory allowed us to factor in the more indirect emissions created that in the end allowed the team to fully take into account all of the activities and operations involved in running the museum, as waste can often be dismissed or ignored as a non-factor.

3.4 Developing Recommendations and Strategies

3.4.1 Initial Recommendations

Before the team calculated the carbon footprint, as data collection lasted the over the course of several weeks as the team waited for Carolina to gather the data, we researched methods to reduce the CCCC's waste and carbon emissions in ways that would remain consistent with the museum's vision for its carbon neutrality campaign. These were considered initial recommendations because the carbon emissions had not yet been determined. This consisted of potential techniques such as water reduction in the bathrooms, the installation of solar panels on the museum, conversion to LED lightbulbs, and approaches to clean up trash and contamination in the nearby river adjacent to the facility. By presenting such recommendations early in the timeline of the project, this gave the team an idea of how the sponsors wanted to approach the solutions to the emissions reduction plan. Which allowed the team to have a focused scheme once we were able to breakdown the biggest contributors to the museum's carbon footprint.

3.4.2 Emission Reduction Recommendations

After collecting data to calculate the carbon footprint, as well as data from the surveys and interviews conducted, we developed recommendations to present to the CCCC which would later be revised to better fit the needs and constraints of the organization. The carbon neutrality campaign has the potential to be multifaceted, possibly encompassing many different areas such as developing strategies to mitigate emissions, implementing long-term plans to obtain the INTECO certification, internal development to educate employees and staff about the importance of the campaign, and external marketing to communicate to the local community and businesses within it.

All recommendations were based on what the team uncovered in Costa Rica through the analysis of the carbon footprint, in addition to the surveys and interviews. Information gathered based on the public perception of the organization influenced what we recommended to the CCCC to market their carbon neutrality campaign and its importance to the community and local businesses. The calculation and analysis of the organization's carbon footprint allowed us to identify the top contributors of carbon emissions. As a result, the recommended emission reduction techniques prioritized the larger consumption areas within the facility. The installation of a long-term plan will allow the CCCC to achieve the INTECO certification, thereby establishing the organization as a frontrunner in the Costa Rican carbon neutrality campaign and providing a precedent for other Costa Rican businesses to follow. A timeline of the project is shown in Figure 6.

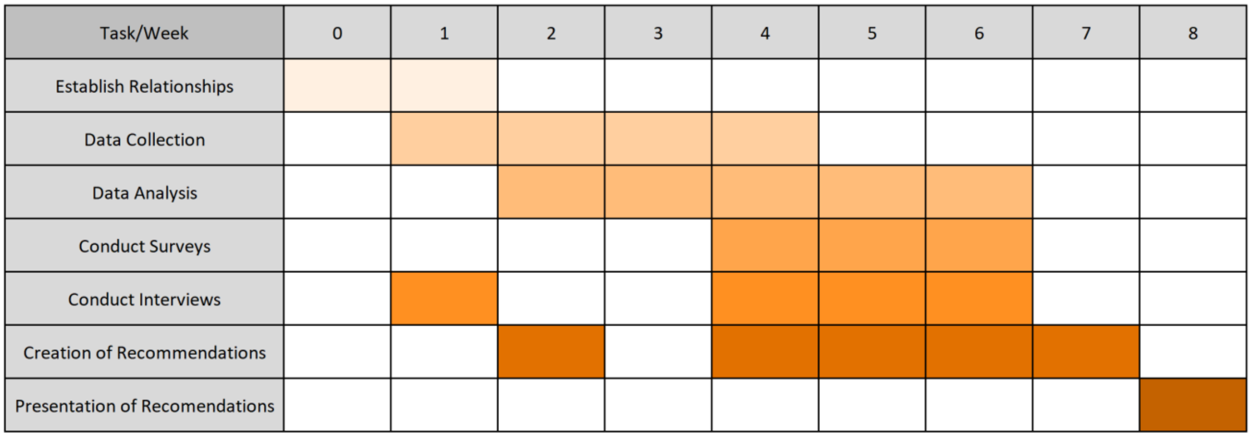

Figure 6: Gantt Chart of Project Timeline

Chapter 4: Results and Analysis

This chapter focuses on the team's results and subsequent analyses of the interviews and surveys given throughout the course of the project, as well as the carbon footprint calculations of the CCCC. Section 4.1 contains the findings and information gathered from the interviews we conducted with our sponsors, as well as representatives from the organization Amigos del Rio Torres. Section 4.2 contains the findings and analyses relevant to the surveys answered by the museum's employees and patrons. Section 4.3 focuses on the recommendations that we compiled to help reduce the museum's carbon emissions, while section 4.4 includes calculations performed to help provide quantitative justifications for a variety of the recommendations.

4.1 Observations and Interview Results

4.1.1 Initial Meeting and Observations

Upon first meeting with Saúl and Carolina, the team interviewed the two in order to gain further managerial perspective on the visions and goals of this project. A summary of the initial interview is found in Appendix B: Interview Answers. One of the largest takeaways from this meeting was that the sponsors did not want a "checklist" which would simply tell them the amount of trees to plant. Instead, Saúl and Carolina encouraged us to create a guideline with multiple options from which the Center could choose. This guideline would also include ways in which the community can be engaged with as well. Community engagement plays a key role within the museum's carbon neutrality campaign, as they would like to expand their efforts to help educate and incorporate the locals in helping to reduce their environmental impact. No specific work has been done by the museum prior to our project to contribute to its carbon neutrality campaign, and due to this, there is no specific budget set in place for the campaign. Instead, the sponsors would like to see the potential costs of the recommendations provided for the museum, and from there choose which ones could be deemed feasible for the museum to undertake. In order to support us, Carolina specified that she would be the main person to supply us with the raw data needed to calculate the carbon footprint, however this will take some time as she must consult the different departments and records scattered throughout the museum.

The team was also given a tour of the museum, allowing us to make several observations about the museum and its operations. From here, it was evident that the Children's Museum was a large consumer of electricity due to the sheer amount of exhibits and displays that relied on power, especially the many exhibits that focused on science or sustainability, ranging from topics such as magnetism and wind turbines to earthquakes and dinosaur history. Another significant area that caught the team's eye was the National Auditorium, a theater used to host many different events every year such as presentations, conferences, plays, and performances. In this context, many different arrays and sets of lights are used to accommodate for the multitude of events, and air conditioning is provided in the area in order to provide a comfortable setting for those in the audience. Thus, these areas could be taken into consideration by the team when examining the carbon footprint and ways to contribute to emission reduction.

The team was also given a tour of Mexico Park, which is on the museum's campus, as well as the surrounding river known as the Rio Torres. Upon viewing the river, it was evident that the river was extremely polluted, as it runs throughout the course of San Jose. Saúl and Carolina encouraged us to incorporate the land and the river into our recommendations, although they should not be the highest priority.

4.1.2 Initial Recommendations Presentation

After the initial meeting and while the team was waiting for the necessary data to be provided by the center; a list of initial recommendations was developed to be presented to the CCCC, in order to gather feedback. Beginning with broad ideas, feedback from our sponsor allowed the team to fully understand the center's vision for this project and how they wanted us to approach potential solutions. These initial strategies covered areas such as energy conservation, water conservation, and cleaning the river.

In terms of environmentally friendly energy alternatives, solar panels have evolved into the one of the most significant options on the market; providing a much better option to grid-provided electricity, which is generated from fossil-burning plants. Although there will be an initial steep cost, such as the solar panel installations, these costs will eventually be offset by the money saved and lack of carbon emissions produced from burning fossil fuels. In addition to the usage of solar panels in energy conservation, the implementation of LED bulbs has become almost interchangeable with the phrase "going green". The light bulbs offer high efficiency, low waste, and long life alternatives over incandescent or fluorescent bulbs. It is highly advisable to make the transition towards LED bulbs and a timeline and cost analysis were explored later to demonstrate the numerous reasons to switch.

To save water consumption at the CCCC, flush-efficient toilets are the best option. Flush-efficient toilets can save hundreds of thousands of gallons of water per year on flushes alone, providing a possibly better alternative to the toilets that are already in place throughout the Center. In addition to water conservation, the museum's upper management had initially expressed interest in starting a movement to begin cleaning the river. The most optimal way to cleanse the river from trash is using filters or nets to catch trash traveling down the river, as well as volunteer groups to clean up debris that has collected on the banks of the river. However, pollutants within the river may be impossible for the group to deal with as the types of contaminants and their sources would need to be known. Therefore, a broader, more technical and professional mitigation plan may be in order.

In terms of community engagement, the team formulated the idea of the museum hosting potential clean up days on its campus, helping to clean Mexico Park while also bringing in their trash and recyclables to be properly disposed of. To accomplish this, the museum could provide incentives to participants such as free museum T-shirts and an admissions fee reduction.

These findings were presented to the center in order to gather their feedback to be considered in the revision and development of the final recommendations once the carbon footprint was calculated, with the summary of the discussion being found in Appendix B: Interview Answers. In terms of energy conservation, the CCCC advised that a large-scale solar panel project would most likely be infeasible due to the costs and time commitment of such a project. However, it is possible that the museum could utilize solar panels on a smaller scale as a way to generate electricity for higher-demanding areas, such as the National Auditorium. Carolina also mentioned to the team that the museum has already begun the transition of switching all fluorescent light bulbs to LED lights, with the project beginning several years ago. As such, the sponsors were already keen to the idea of LED lights and the team could help to provide a cost-analysis on the benefits of the project. In terms of the potential of community clean up days, Saúl was wary to the idea due to the fact that the area surrounding the museum is dangerous. He went on to mention that the museum had previously held an incentive program, designed to assist the local homeless population. However, the museum was very cautious about this, as they did not want to give out monetary rewards that could be used for nefarious purposes.

Nonetheless, the idea of having different, museum-related incentives was an enticing proposition.

After presenting the initial recommendations, the team went about refining our strategies to better adhere to the sponsors' ideas and constraints. These ideas adapted and evolved, becoming more focused once the carbon footprint calculations were completed, and thereby giving us a stronger idea of the focus areas that needed attention within the museum.

4.1.3 Meeting with the Amigos del Rio Torres

Through connections from our sponsor, the group was able to meet with a group called the "Amigos del Rio Torres", or the "Friends of the Rio Torres". Their representative, Robert Faulstich, spoke to us about the group's actions and hopes for revitalizing the use of the river area and allowed us to gain a greater perspective of what the team can do to help Robert as part of our project. The group works on sections of the river all throughout San Jose, as well as other surrounding communities. Robert shared the organization's hopes and dreams for the river; he aspires that one day the community will be able to use the river as walking trail, hold community events with the focal point being the river and surrounding area, and one day swim in the river again. The river is important for San Jose and the other communities, due to the fact that many communities located downstream of the river feel the worst effects of the river's trash and pollution, negatively affecting their available water supply.

One of the greatest obstacles the organization faces is the public's knowledge of the river itself. Although the organization has hosted clean ups of the river for the past two years, the organization would also like to focus on raising public awareness of the river and its potential to be used by the community. Robert believes that this could begin as simply as helping people visualize the river and become more aware of its presence. With this in mind, devising a more precise idea that can be implemented into the solutions of this project has materialized into a proposal for a display or exhibit that targets visitors and educates them on the Torres River itself, as well as the group's visions for the future. Thus, the team switched its focus from pollution control to public awareness, as trash cleanup and restoration will become a much easier feat once the community becomes more mindful of the potentials of utilizing the river as a resource. In the end, the Rio Torres can be used by the museum and the Amigos del Rio Torres as a conduit to engage the community with its plans of raising environmental awareness.

4.1.4 Survey Results

In order to understand the organizational culture within the center, as well as the public's perception towards the center and carbon neutrality, two types of surveys were given out, one to the center's employees and another to the patrons that come to the center. 36 workers responded to the employee survey, while 14 visitors responded to the center's patron survey. Their answers can be found in Appendix C: Survey Answers.

In terms of the center's employees, it was evident that many that responded to the survey were environmentally conscious and attempting to perpetrate a "green" attitude within the center. Recycling and conservation of resources were major areas that employees participated in. A vast majority of the employees recycled at least on a frequent basis, while also taking numerous ways to mitigate their consumption of resources. For example, many acknowledged that they try to use electricity and water only when necessary, in addition to recycling and cutting down their usage of straws, papers, and other small resources that contribute to waste generation. This type of “green” attitude already prevalent in the center will allow implementation of the neutrality campaign to occur smoothly and without significant disruption.

However, knowledge of the carbon neutrality campaign, and how the center can take steps to become carbon neutral, was slightly more limited. Only slightly more than half of the employees were aware of the center’s carbon neutrality campaign, while the rest approved of the goal despite a lack of prior knowledge. When asked on how the center could take steps to achieve its certification, many proclaimed that waste management and recycling were important areas, with a minority suggesting more technological improvements and reforesting projects. Although the museum already has a waste management system in place, with trash being separated into four different categories, it is clear that many participants believe it can be improved upon and expanded throughout the center, encouraging even better practices in the employees and in the general public. Thus, this influenced the team’s mindset in regards to waste, focusing on other alternatives that could help reduce it and mitigate its carbon emissions, such as plastic alternatives and developing paperless practices. A major task for the team is to develop our recommendations in a way that provides the center with a solid groundwork to build off. The employees will become more aware and educated about carbon neutrality as the center begins to reduce its carbon emissions and engage in the certification process.

Once informed of the project, the employees agreed on a universal basis that carbon neutrality was important for the perception of the museum, as this would allow the center to become leading business role models within the country for environmental conservation. This will help to differentiate the center from other businesses in the area, encouraging them to take the initiative to support Costa Rica’s neutrality campaign, while also appealing to the center’s visitors and cultivating an environmentally friendly mindset within them. Overall, the organizational culture within the center is compatible with the carbon neutrality campaign. All employees were willing to help volunteer and contribute to the campaign, with some even suggesting training and awareness programs. Thus, the museum should have a very smooth transition in becoming a carbon neutral facility without negatively affecting employee operations and morale.

Much like the employees, a majority of the patrons perpetrated an environmentally conscious attitude, believing that they live an environmentally friendly lifestyle, which contributes to Costa Rica being a “green” leader. Nearly all patrons focused on the idea of recycling, with few mentioning reducing resource consumption and waste generation. Recycling and waste management was once again a frequent topic when the patrons were asked if they knew any ways in which the center was environmentally conscious. Due to this, it is clear that the center’s current waste system in place has caught the attention of the public, with many carrying a positive opinion and contributing to the good recycling practice that the center encourages. From the perspective of the patrons, recycling and waste reduction is evidently synonymous with being environmentally friendly. As such, these ideas would play a large role in the plans for the museum to involve the community in its carbon reduction plan. Several participants also believed that the museum could improve by promoting community projects that encouraged education and understanding. As a result, the center’s community engagement plan will likely focus on areas such as public awareness events that advocate “green” attitudes through direct involvement in community cleaning projects.

In addition, nearly two-thirds of the patrons did not view the museum as a leader in environmental conservation, although believed that it has the potential to become one. However, all patrons believed that becoming a carbon neutral institution would be positive for the center and possibly even very important, displaying a similar perspective that the employees had about the significance of this long-term project. It is evident that this type of endeavor is promoted by the museum's patrons, and as such, the center's plans to raise public awareness and consciousness will yield positive dividends by bolstering the public perception of the center while also advocating for involvement in Costa Rica's overall campaign.

4.2 Evaluation of the CCCC's Carbon Footprint

The raw data provided by Carolina is displayed in Appendix D: Raw Data. This includes relevant data in terms of electrical and water consumption, waste, the center's fuel consumption, commute distances for the employees, number of LEDs purchased, visitation numbers, and the number of employees. The center's carbon footprint can be broken down into 5 separate areas, each of which constitute a specific aspect of the center's operations that falls within the operational limit established by the team. This includes Scope I emissions, consisting of emissions created by direct fuel consumption and any vehicles under direct control of the center, Scope II emissions, consisting of the center's electrical consumption, and Scope III emissions, consisting of downstream emissions created by waste generated and indirect emissions created by the employees during their daily commutes. The carbon footprint calculation incorporates the 2018 period, setting a reference period for the museum to use in its future calculations.

The carbon emissions from each type of source were calculated according to the equations in Section 3.3: Calculating Carbon Footprint and Identifying Top Contributors, while the emission factors used by the team can be found in Appendix E: Emission Factors. Each separate calculation can be found in Appendix F: Calculations. A summary of each source's emissions are displayed in Table 1.

SUMMARY		
SECTOR	CARBON EMISSIONS (kg CO2)	CARBON EMISSIONS (tonne CO2)
EMPLOYEE COMMUTES	49199.22	49.20
ELECTRICTY	37220.38	37.22
WASTE	21794.53	21.79
WATER	13752.80	13.75
FUEL	13348.37	13.35
TOTAL	135315.29	135.32

Table 1: Summary of Total Emissions by Source through 2018

As shown, the calculated total emissions from the museum for 2018 was 135,315.92 kg CO2, or 135.32 tonne CO2. The yearly emission data was utilized for each source instead of a monthly breakdown because some of the records were inconsistent, and so a monthly breakdown would provide skewed results. However, the yearly emissions provided significant insight into which areas contribute the most to the museum's footprint and its subsequent environmental impact. This breakdown is provided in Figure 7.

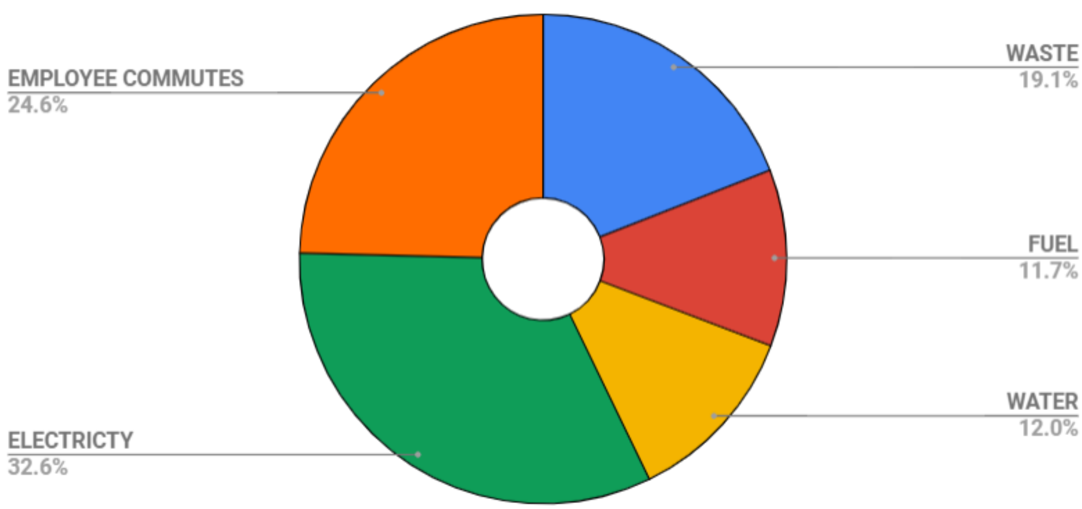

Figure 7: Percentage Breakdown of Total Emissions by Source Contribution

As shown by Figure 7, the center's top contributors to its carbon footprint are electrical consumption and the employee's commutes to work. Understanding why each emission type contributes a specific percentage plays a significant role into how the team will develop emission reduction recommendations, as this prioritizes specific areas and activities within the museum for the team to focus on.

As described in Section 4.1, the center's building is extremely large, consisting of many different exhibits and sections that consume a large amount of electricity, such as the Children's Museum and the National Auditorium. The National Auditorium is an especially large contributor, due to the large amount of lights within the theater, and the air conditioning required to maintain cool temperatures within the large area. A breakdown of the museum's electricity is shown in Figure 8.

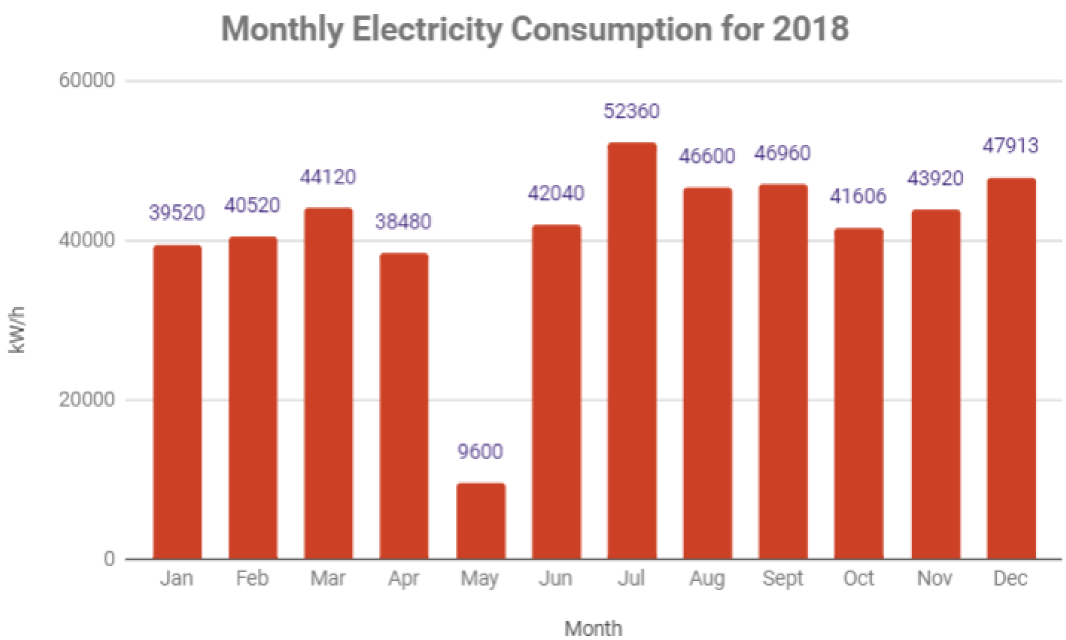

Figure 8: Museum's Electrical Breakdown by Month for 2018

As seen by the figure, the museum's electrical consumption fluctuates around 40,000 kWh every month, with the exception of May as there was a gap in the data provided, making it an outlier. The museum's energy usage corresponds approximately to the average energy consumption of commercial buildings, where 150 kWh is used for every square meter (Skanska, n.d.). For the center, which is approximately 3,000 square meters, this would mean that the museum has an estimated average usage per year is 450,000 kWh. As a result, this indicates that the center's actual yearly usage of 493,639 kWh is slightly more than the average commercial building. With such a large campus, the center must be able to power all of its operations and exhibits in order to provide its services, while also allowing the employees to maintain the center's normal activities. Thus, electrical consumption is the largest contributor to the museum's emissions.

In terms of employee commutes, 115 workers provided information about their daily commute separate from the initial surveys given, with a majority of workers within the museum traveling to work by either car or bus. The distances traveled for each mode of transportation (car, bus, and motorcycle) were extrapolated to consider the entirety of the museum's employees by multiplying each distance by a proportion based on the amount of employees that took each mode of transportation out of the 115 employees that answered. As such, although 115 employees provided their daily commute, the team was able to consider all of the center's employees. As mentioned in section 3.2.2, transportation is one of the largest sectors in contributing to a country's overall carbon emissions, and the same sentiment can be applied here to the museum's carbon footprint. Commuting contributes a large portion to the center's footprint due to the number of employees that must travel from all across the city to reach the CCCC. Approximately 93 employees lived more than 6 km away from the center, with 35 of those living more than 10 km away from the center. Thus, the amount of employees and their distance from the center contributes immensely to the considerable carbon emissions generated from the daily commute.

Most of the waste generated by the museum in 2018 consisted of non-traditional waste as shown in Appendix D, such as debris, wood, and miscellaneous scrap. This can likely be contributed to construction projects that the center undertakes, as well as the various pop-up exhibits and festivals that occur within the museum. Emissions generated from Scope III emissions also incorporated the emissions from the supply and treatment of wastewater. With the center having such a large campus and a considerable amount of visitation, sizable amounts of water must be supplied to the center in order to maintain bathroom and kitchen operations. Due to this, the emissions generated once this wastewater is treated was taken into consideration, adding to the amount of downstream waste created by the center's activities.

Finally, the smallest contributor to the center's total carbon footprint was the amount of fuel directly consumed by the museum. For its fuel, the center utilizes diesel in order to operate the four vehicles directly controlled by the museum, and in order to fuel the center's diesel plant. The diesel plant is used generally as backup or in order to help provide electricity for large events such as the Light Show, and thus does not play a large factor in the museum's operations. As such, the emissions created directly by the center's fuel consumption generated the smallest amount of emissions in comparison to all other source types.

4.3 Recommendations

Based on the analysis shown above, we focused on recommendations that would help the CCCC mitigate its carbon emission from water, electricity, and vehicular usage. We also wanted to help the organization Amigos de Rio Torres spread more knowledge on the importance of cleaning and keeping the river clean.

4.3.1 Efficient Lighting Sources

Lighting, especially in areas requiring constant application, is one of the most consistent contributors to a carbon footprint. Seeing as public area lighting acts as a constant drain of electricity, the connection can be made that higher electricity usage requires more consumption of energy, which for many businesses means the burning of more fossil fuels.

Incandescent Bulbs

Incandescent light bulbs were designed based on the simple idea of the connection between heat and light. As discovered by our ancestors, when objects burn, they simultaneously give off both heat and light. This premise is what supports the construction of the incandescent light bulb, which attempts to produce and contain heat, and by doing so, releasing light at the same time. Light is produced alongside heat because of how particles handle excessive energy. As particles are heated, they become progressively more excited, vibrating and moving around faster and faster. As particles build up more energy, it is eventually released in the form of photons, which translates to light energy. “Use enough electricity and the filament will heat up so much that it'll glow red or white hot and give off light. That's the basic idea behind the incandescent electric light” (Woodford 2018).

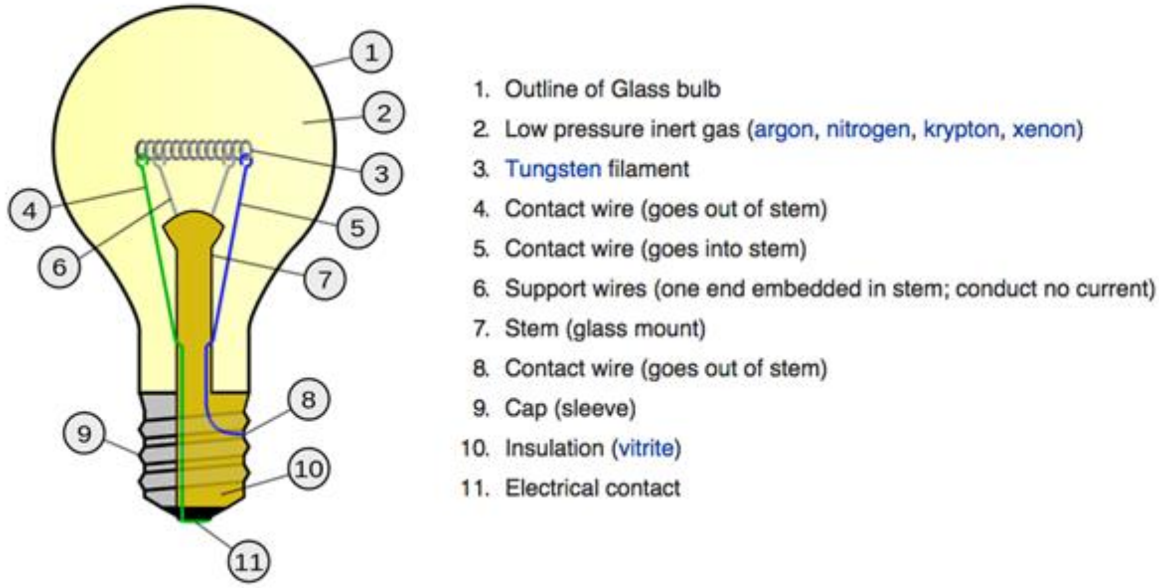

Figure 9: Inside a Standard Incandescent Bulb (Dikeou, 2014)

For a standard incandescent bulb, electricity comes up through the conductive base and travels through the contact wire. Electricity then flows through the filament, which is highly conductive, extraordinarily thin and incredibly short. This maximizes the amount of electricity flowing and allows for incredible amounts of heat to be generated. As the filament heats, it begins to glow, generating the light found in a light bulb. The gas inside the bulb is designed to prevent the filament from evaporating under the extreme temperatures inside the bulb.

The most glaring drawback to incandescent light bulbs is the overwhelming loss of energy. “The only trouble is that an incandescent lamp has to produce an incredible amount of heat to make a decent amount of light. Roughly 95 percent of the electricity you feed into a lamp like this is wasted as heat” (Woodford, 2018). Therefore, alternative options, which are more efficient at generating electricity, serve as an upgrade.

LED Bulbs

Light emitting diodes, otherwise known as LEDs, are small electronic devices that act as a one-way valve for electricity. These small electronic devices are made up of two semiconductor materials and placing them side by side. Because of how the LED is structured, electricity flows only in one direction. This one-way flow provides practical application of these diodes into the household devices. As electricity flows between the two semiconductors, light is produced. By utilizing an LED, the electricity flowing through the diode can be harnessed for the purpose of being a contained light source. "An electrical current is composed of electrons. The electrons, when flowing through the diode, drop down to a lower energy state. During the drop, energy is released in the form of photons, or small packets of light. The light bounces around in the plastic shell of the LED, and then escapes as visible light." (GPI Design, 2010).

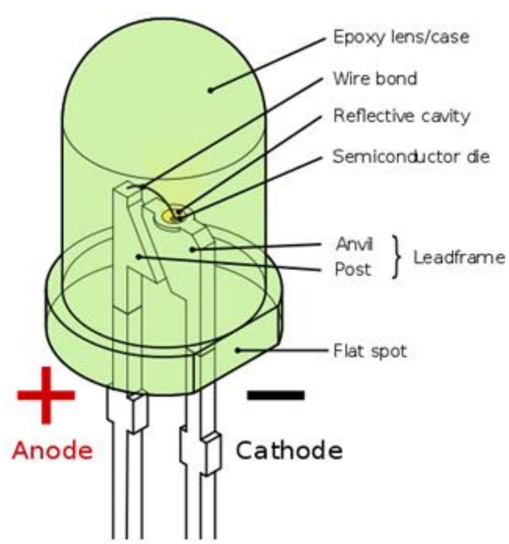

Figure 10: How an LED Bulb Works (GPI Design, 2010)

Because the LED makes light from electricity and not from heat (like a standard incandescent light bulb), it leads to numerous advantages over the competition. For one, since it takes far less energy to produce a simple electrical current, rather than attempting to heat the inner coil to produce light, the amount of energy used is vastly decreased. Along the same note, far less energy is wasted in the use of LED bulbs, as nearly all the produced electricity is used to generate light. While a standard incandescent bulb takes time to warm up and thus time to become bright, an LED bulb is actually near instantaneous, for as soon as the current begins flowing it begins producing electricity. “Most LED bulbs are unaffected by temperature or humidity,” while other options “may not work at all in temperatures below 10 degrees F” (Emergency Lights Co., 2014). LEDs also “do not contain toxic mercury and only emit 450 pounds of carbon dioxide or Co2 per year” (Emergency Lights Co., 2014). Lastly, the final advantage comes in the amount of control over the brightness. Since LEDs are entirely based on current flow, a dimmer switch is applicable in order to increase or decrease current flow, therefore allowing an individual light socket to be brighter or dimmer depending on, for example, time of day.

The economics of how LEDs are more energy efficient will be explored later in section 4.4 Return on Investment Calculations.

4.3.2 Sponsor a Forest Initiatives

Costa Rica has taken great pride in its reforestation of a once nearly decimated population of trees and forests within the country. These efforts are preliminary to any policies and initiatives put in place by the government towards progressing towards a carbon neutral country. With any effort in reducing carbon footprint, it is impossible to completely reduce any entity’s carbon footprint to zero, and as such planting trees and rehabilitating the growth of the natural environment is a solution that cannot be overlooked. Many organizations allow individuals or businesses to donate, or even sponsor a forest.

The group Reforest the Tropics (RTT) offers this option to sponsor a forest. The organization takes pride in planting over 500 acres of forests and their hopes are to continue making a "tangible contribution to global sustainability through education and applied research on carbon-offset farm forests in the tropics" (Reforest The Tropics). The organization offers an option to sponsor a forest, where for $15 (around ₡9000) one can plant a tree. The RTT also offers a plan specifically for businesses. Their plan has four steps, as detailed in the image below:

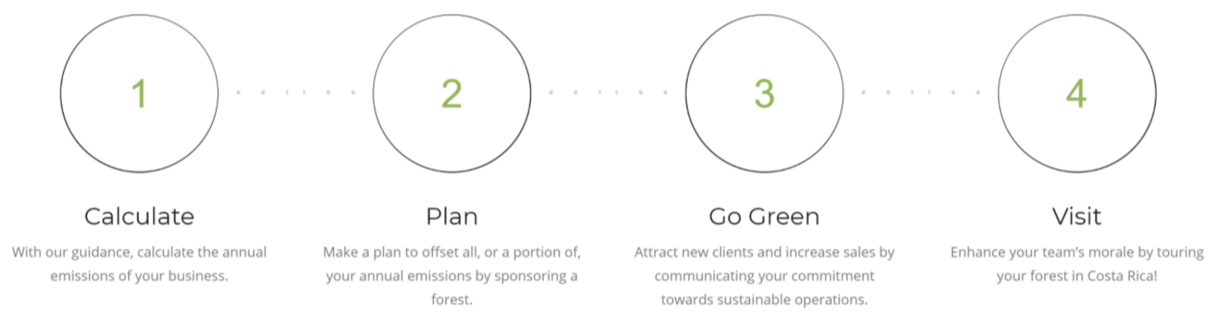

Figure 11: RTT Business Involvement Plan (Reforest The Tropics)

This plan would be attractive for a company like the CCCC, as the RTT will help them fully calculate their emissions and then assess just how many trees they would need to plant to fully equalize their emissions. Other organizations in and out of Costa Rica also strive to plant trees through donation or sponsorship; however it is the RTT's plan that give it distinction from other similar organizations.

Having the CCCC donate their money is not the end to this possible solution; as the museum could hold initiatives or programs throughout the year that allow patrons of the museum to get involved as well. Ideas that perpetuate the recycling or eco-friendly movements could be popular. For example, allowing patrons to donate towards planting a tree at a discount of $5 (around ₡3000) for bringing in recyclable cans or bottles. Similarly, having an educational display on forests, trees, and their importance to the ecosystem with an option to donate money to plant a tree in their name, as well as other programs that will promote the environmentally friendly mindset throughout the community, are all strong propositions.

4.3.3 Water Conservation

In order to help the museum reduce its water consumption, we chose to consider water efficient toilets, and after doing some research, we discovered that an old, average, toilet uses approximately 13 liters a flush, while the most efficient toilets in the market today use approximately 4.8 liters per flush (“Alliance for Water Efficiency,” n.d.). The team decided to recommend the most water efficient toilet available due to the demand of restrooms in commercial buildings; on average, about 25-30 percent of a commercial building’s water demand comes from domestic and restroom usages (“Types of Facilities,” n.d.). Although the center’s water usage from restrooms is only about 15 percent of their water consumption, we believed this was a more feasible solution for the start of their project.

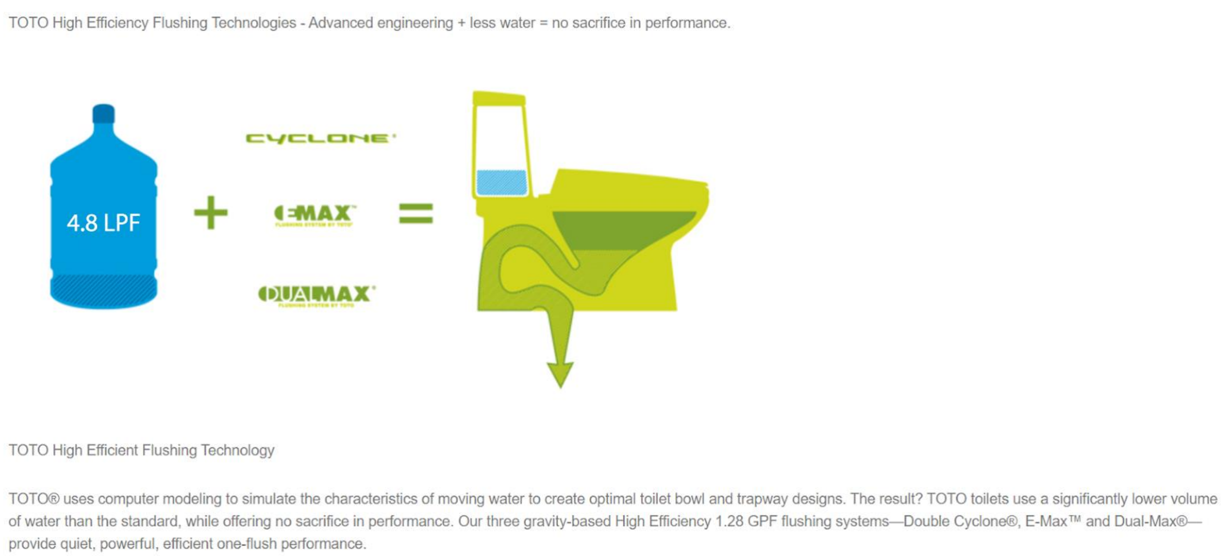

Figure 12: Brief TOTO Explanation

In San Jose, there is a TOTO brand distributor called Bella Vida Costa Rica (Bella Vida Costa Rica,). The distributor confirmed that they sell the "Entrada Close Coupled Elongated Toilet" that only uses 4.8 liters per flush. The price for this toilet is $268.00 or ₡160,800.00 per toilet. Per flush, this toilet will save 8.2 liters, which will quickly add up over time due to the sheer volume of bathrooms within the museum. In order to calculate that water usage from toilets, we asked the CCCC their patrons and employee numbers for normal business days and peak business days. For the patrons numbers, we overestimated the average on normal business days because it fluctuates greatly depending on the day and the season.

$$[\#of\ Employees\ working\ (offpeak)]\ x\ [\#\ of\ Days\ CCCC\ open\ per\ year]\ x$$
$$[\#\ of\ Flushes\ per\ day\ for\ Employees\ (Average\ of\ Male\ and\ Female)] = Flushes\ for\ Employee\ (offpeak)$$

Equation 5: Off-Peak Employee Flushes

$$[\#of\ Employees\ working\ (peak)]\ x\ [\#\ of\ Days\ CCCC\ open\ per\ year]\ x$$
$$[\#\ of\ Flushes\ per\ day\ for\ Employees\ (Average\ of\ Male\ and\ Female)] = Flushes\ for\ Employee\ (peak)$$

Equation 6: Peak Employee Flushes

$$[\#of\ Patrons\ (offpeak)]\ x\ [\#\ of\ Days\ CCCC\ open\ per\ year]\ x$$
$$[\#\ of\ Flushes\ per\ day\ for\ Patrons\ (Average\ of\ Male\ and\ Female)] = Flushes\ for\ Patrons\ (offpeak)$$

Equation 7: Off-Peak Patron Flushes

$$[\#of\ Patrons\ (peak)]\ x\ [\#\ of\ Days\ CCCC\ open\ per\ year]\ x$$
$$[\#\ of\ Flushes\ per\ day\ for\ Patrons\ (Average\ of\ Male\ and\ Female)] = Flushes\ for\ Patrons\ (peak)$$

Equation 8: Peak Patron Flushes

$$Flushes\ for\ Employees\ (offpeak\ +\ peak)\ +\ Flushes\ for\ Patrons\ (offpeak\ +\ peak)$$
$$=\ Total\ Flushes\ per\ Year$$

Equation 9: Calculations for Water Consumption

The variables in the equations above are shown below:

(# of Employee/Patron, # of Days CCCC is Open, Average # of Flushes)

Employee (peak): 230, 70, 2

Employee (off peak): 100, 242, 2

Patron (peak): 2230, 70, 1

Patron (off peak): 1301, 242, 1

We calculated that the CCCC has sixty toilets in its building and produces well over 551,542 flushes a year. This is almost 7.2 million liters of water flushed using the old toilets, whereas the new toilets will use less than 2.65 million liters at the same flush rate. That is a potential savings of well over 4 million liters per year, as shown in Figure 13

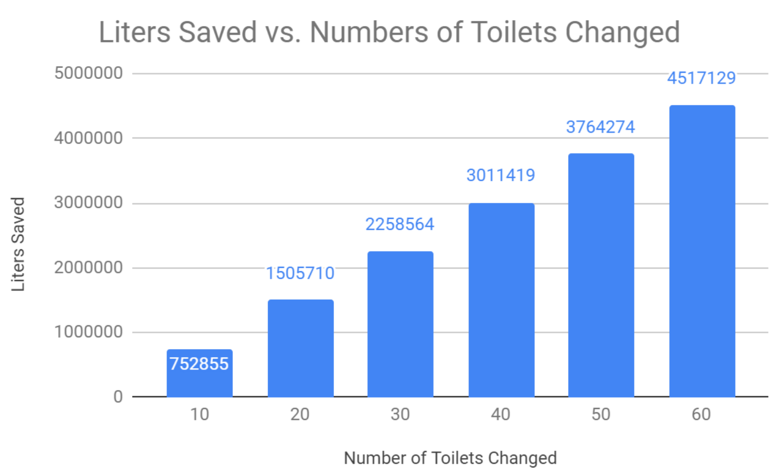

Figure 13: Liters Saved by the Number of Toilets Installed

The full details of these calculations can be found in Appendix F: Calculations.

4.3.4 Progressing Towards Going Paperless

Many companies, business, and even some museums are moving towards becoming paperless. This not only reduces the environmental impact the company is having, but it has also shown improvements in efficiency and workflow in the office space due to digitalization of documents and other items normally kept on paper.

The suggested solution specific to the CCCC would be to reduce paper use as much as possible and to change the paper normally used to an eco-friendly or recyclable alternative. This could be done in a variety of ways, one being the digitization of meetings and documents that could be sent over email or stored in an online database. The reduction of small transactions of paper in this way could help save paper that would be trashed or recycled anyways, as well as making documents easier to obtain by other employees, increasing efficiency within the office. Another possible solution would be to switch the current toilet paper to a recycled toilet paper, or more eco-friendly paper. While the paper will all end up in the same location, the recycled paper will have less of an impact on the environment during its production in comparison to regular paper. A last suggestion for the reduction of paper is to allow friendly competitions between employees for more ideas on how paper use can be reduced within the office, with small incentives available for the most feasible ideas.

4.3.5 Plastic Alternatives

As Costa Rica moves towards becoming totally carbon neutral one day, the elimination of single use plastics is something that is becoming more common in businesses and communities across the country. The detrimental effect plastic has on the environment and the massive quantities of plastic currently in use create massive landfills, where this waste can slowly decompose. In accordance with these new standards moving away from single use plastics, three solutions will be explained an offered to replace the plastics used by the CCCC.

The three types of recommended utensils are Plant Starch, Compostable, and Biodegradable utensils. Plant starch cutlery is made with 70% renewable materials and 30% fillers like polypropylene and talc (EcoProducts.). Plant starch products are not compostable, however the amount of fossil fuels used to create the product are less than plastic due to the recycled materials. The next product is Compostable utensils, which are generally comprised of "corn plastic", or annually renewable resources. Compostable materials have the advantage of being compostable, which means that the product does not go to a traditional landfill and will instead become part of a composting process that helps improve vital soil resources. With these utensils, however, they have to be sent to a commercial composting center, as opposed to a home compost (EcoProducts.). The last suggestion is Biodegradable utensils. The biodegradable utensils being suggested are made up of polystyrene, polyethylene and polypropylene, which can decompose at rates up to 100 times faster than traditional plastic (Transitions2Earth.). These products can also be disposed like a plastic product, into any basic trash receptacle. Using the costs from an online store, the approximate prices for bulk amounts of each product has been compared and is shown in the table below:

UTENSIL INFO	PRICE			
Plant Starch Utensils (Non Compostable)	**50 Count**		**1000 Count**	
6" SpudWare™ Plant Starch Spoon	$6.16	₡3,696	$110.55	₡66,330
6" SpudWare™ Plant Starch Knife	$6.16	₡3,696	$110.55	₡66,330
6" SpudWare™ Plant Starch Fork	$6.16	₡3,696	$110.55	₡66,330
Transitions2earth™ Sustainable Disposable Single Use Utensils (Biodegradable)	**500 Count**		**1000 Count**	
5 3/4" Transitions2earth™ Biodegradable Spoon	$36.23	₡21,738	$72.46	₡43,476
6 3/4" Transitions2earth™ Biodegradable Knife	$36.23	₡21,738	$72.46	₡43,476
6 1/8" Transitions2earth™ Biodegradable Fork	$36.23	₡21,738	$72.46	₡43,476
PrimeWare™ 6.5" Sustainable Disposable Single Use Spoons, Knives and Forks (Compostable)	**50 Count**		**1000 Count**	
PrimeWare™ 6.5" Compostable Spoon	$6.64	₡3,984	$114.34	₡68,604
PrimeWare™ 6.5" Compostable Knife	$6.64	₡3,984	$114.34	₡68,604
PrimeWare™ 6.5" Compostable Fork	$6.64	₡3,984	$114.34	₡68,604

Table 2: Plastic Alternatives Cost Comparison

With the table comparing the costs and characteristics of each product, the CCCC can take into account which product may best replace their current solution.

4.3.6 Solar Panels

One of the most significant energy saving alternatives is the installation of solar panels, generally providing a cost effective alternative to the traditional method of buying electricity from grid companies. The usage of solar panel electrical generation systems has significantly grown within recent years due to dramatic drops in prices, allowing more and more homes and businesses to convert to this energy alternative. Solar-electric systems contribute to the reduction in the carbon footprint due to their ability to generate electricity without producing any harmful byproducts, such as waste or emissions, through a natural process called photovoltaics, where light energy is converted to electrical energy. Solar panels consist of many photovoltaic cells where this process occurs, as shown in the figure below.

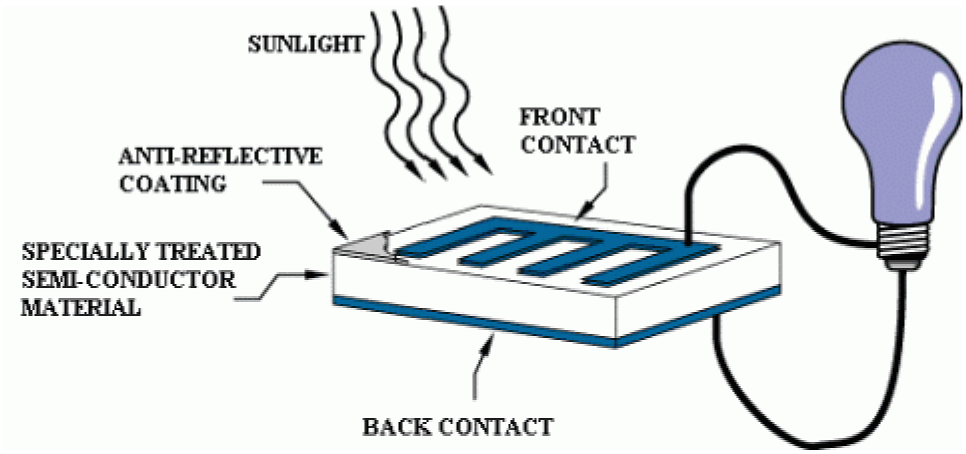

Figure 14: Operation of a Typical Photovoltaic Cell (Knier, n.d.)

Each photovoltaic cell consists two layers of semiconducting silicon, which has been modified with other materials to modify the charges of the silicon, generating an electric field due to the difference in charges. When particles of light called photons strike the silicon material, negative subatomic particles called electrons are knocked free from their respective atoms, being pushed by the electrical field out of the silicon and into metal conductive plates, where they are collected and transferred into wires. Once in the wires, the free electrons act as any other type of electricity (Dhar, 2017).

Utilizing photovoltaic cells and solar panels will avoid the traditional grid system, where fossil fuels are burned to produce electricity, generating large amounts of greenhouse gases and pollutants in the atmosphere. The location and excavation of fossil fuels is also an invasive process as well, which can be avoided by using solar panels to utilize energy from the sun (“Head to Head,” n.d.). Although there is an initial cost to implement the solar panel system, solar generation will save the museum money that would have been spent on buying electricity from a grid. For example, according to the International Renewable Energy Agency, the cost of electricity based on fossil fuel ranges from $0.05 to $0.17 per kWh (Dudley, 2018). Even if solar panels generate just a percentage of the total electricity needed by the museum, avoiding electrical consumption through the grid will be cost-effective as the museum will not be charged the electrical rate of that portion generated by the solar panels.

Therefore, in the end there will be an eventual Return on Investment, where the amount of money saved from switching to a solar panel system will offset the initial investment cost. The Return on Investment for solar panel installation is further explored in Section 4.4, with the full calculations and steps found in Appendix F: Calculations. Not only this, but occasionally Costa Rica has implemented tax exemptions for entities that utilize solar panels, thereby adding to the cost effectiveness of solar panels as well.

There are two types of solar panel systems, grid-tied systems and off-grid systems. In grid-tied systems, consumers have solar panels installed, but are still connected to the traditional electrical grid system. Through this, solar panels generate electricity to power the house, but when it reaches 100% of the power demand, energy is sent to the grid, allowing them to utilize the energy and compensate the homeowners for however much excess electricity is generated. In off-grid systems, the electricity generated is stored in a battery storage bank, which is then accessed to power the house. Thus, any excess energy is stored in the bank and can be utilized in the event of no sun ("Our Solutions," n.d.). If the museum were to switch to solar panels, it is highly likely it will be a grid-tied system, as it is seemingly impossible to generate all of the Center's electrical demand due to its extremely high-energy consumption.

The economic benefits, in addition to the amount of emissions saved, are calculated and shown in Section 4.4: Return on Investment Calculations. Through this, the museum will be presented with the amount of money saved from switching to solar panels over specific time periods and the payback period for a large range of solar panels installed.

4.3.7 Carpool Incentives

One of the ways in which the museum can decrease its carbon footprint is by reducing the emissions created from daily employee commute. As shown in Section 4.2, employee commute accounts for 24.6% of the museum's total emissions, leaving much room for improvement. One of the most significant ways that the museum can mitigate this issue is by implementing incentives that encourage employees to carpool with one another in an effort to reduce the emissions that each individual may create if traveling alone. For example, four employees carpooling together would vastly decrease the emissions created if each employee traveled by car alone. Benefits for such a program would have the potential to have a positive impact on both the museum and its employees. For the museum, carrying out an incentive program could reduce the need for parking spaces, potentially saving the money needed to build more parking spaces outside of the museum. In addition, employee morale and productivity may increase as carpooling can help alleviate commute-related stress that a worker may potentially feel. For the employees, carpooling helps to save money that would have been used for gas or public transportation, in addition to the incentives that the museum may implement (USEPA, 2005). Carpooling also provides flexibility, as it does not have to be limited to those that simply drive a car. Those that participate in the program can pick up other employees as well that would normally take the bus or ride their motorcycle, further reducing the carbon emissions that would have been generated.

The carpooling incentives that are set in place will depend on what the museum chooses, however several exist which are typically common for companies that implement this program. One type of incentive could be preferred parking, where employees that carpool have designated parking spots which are closer to the museum and attended to by others. Having this sort of incentive is beneficial, as employees would not need to worry about parking space and will gain a benefit from participating in the program. Other types of incentives may be set in place as well, which may include rewards or prizes. For example, employees that participate in the program may be given discounts to other local businesses, free merchandise, or prizes that may be worth up to a certain amount of money. These types of incentives would depend on the size of the program, and the amount of money the museum would be willing to invest into the program.

In order to achieve such a program, various steps must be put into the place before the museum can fully carry it out, as shown in Figure 15.

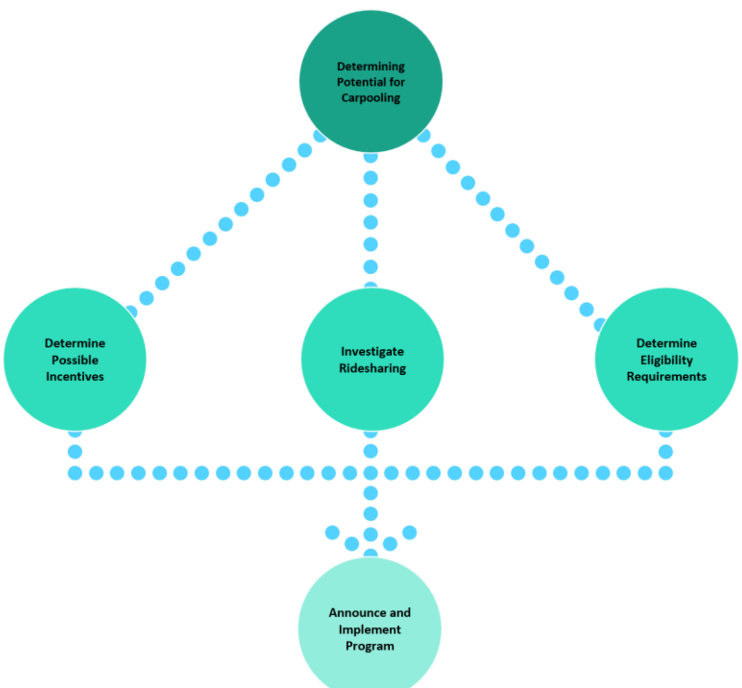

Figure 15: Steps for Carpool Incentives Program Implementation

First, the museum must determine the interest among the employees for a carpooling program. This should involve compiling all employees' schedules, locations, and transportation patterns, as well as asking them whether they would be interested in participating in such a program. The employees can also be consulted on what kinds of incentives they would desire to have for their participation. If enough interest is generated, then the next step is to determine possible incentives, which can include either the ones mentioned above or any ideas that the employees may suggest. Investigating ridesharing opportunities is important as well, as employees that operate under the same schedule and are relatively close to each other can be paired up in the program. This can be accomplished by compiling the employees' schedules and locations, as suggested in the first step. Having a registration process for the program is important as well, as this will allow the museum to determine who is eligible for the program and to keep track of those participating. Those that participate in the program can be given tags to hang in their car that can easily identify them if incentives such as designated parking exist. It is also important to establish which employees would be driving their cars, and which ones would be picked up by them. Having a registry is necessary as this can prevent any type of fraud from employees that are not in the program but claim they are. Once the registration process has been established, the museum can finally announce and implement the program. Announcing the program and its benefits can be accomplished in a variety of ways, such as by holding a orientation meeting, sending out company emails, or hanging up flyers throughout the museum. It is important to be able to communicate effectively to all the employees what the program is, so that all the employees are aware.

The scope of the carpooling incentive policy will depend on how much money the museum wants to invest into such a program, as well as how the museum wants to approach it.

Listed above are suggestions on how the museum can implement the program; however, the actual operations of it will largely depend on the museum and personnel in charge of performing and maintaining it.

4.3.8 Biodiesel

In terms of fuel consumption, the museum currently purchases diesel, which is used to fuel the museum's diesel plant, as well as to fuel the vehicular fleet operated by the center. In order to reduce the emissions generated by these operations, the museum can switch over to the usage of biodiesel in place of petroleum diesel. Biodiesel is a "cleaner" fuel alternative that is functionally similar to diesel, produced from either vegetable oil or animal fat, which can typically be used in diesel engines, thus acting as a direct replacement to the fuel ("Diesel vs. biodiesel vs. vegetable oil," 2014). The usage of biodiesel helps to reduce the overall emissions created by diesel engines up to 75%, providing an environmentally friendly alternative that also improves the condition and longevity of the engine. In addition to reducing emissions, biodiesel acts as a cleaning lubricant that breaks up deposits created by diesel in the tank walls and pipes, thereby allowing engines to run smoother and easier (Singha, n.d.).

Biodiesel is also extremely flexible, as it can be mixed with regular diesel at many different ratios in order to provide different combinations of performance, emission reduction, and convenience ("Diesel vs. biodiesel vs. vegetable oil," 2014). For example, a mix with only 5% biodiesel (called B-5) would help to reduce emissions with only being slightly more expensive than regular diesel, while a mix with 100% biodiesel (called B-100) would significantly reduce the emissions created from burning the fuel, but at the expense of costing much more than regular diesel.

Shown below is a figure that compares the emissions created by the museum's direct fuel consumption in 2018 with what the fuel emissions would look like the museum used B-100 biodiesel instead of diesel during that same time period. The process of calculating the carbon emissions created by biodiesel are shown in Appendix E: Emission Factors.

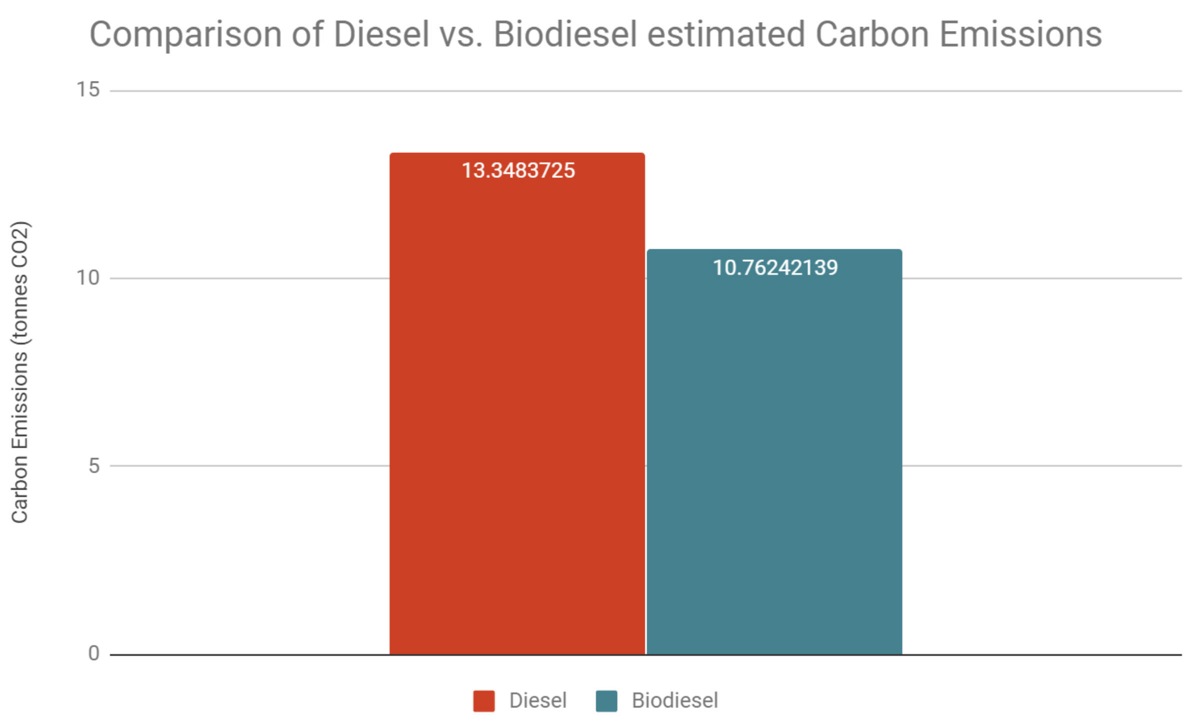

Figure 16: Reduction in Emissions used in Fuel Consumption with Biodiesel

As shown, utilizing biodiesel would reduce the museum's yearly emissions by nearly 3 tCO_2e. However, the downside to utilizing biodiesel is its cost and availability specifically here in Costa Rica. B-100 typically costs about 85 cents more per gallon than petroleum diesel, however the Center has the option of buying other biodiesel blends that will be cheaper but provide a smaller reduction in emissions. Availability may be an issue because regular gas stations do not provide biodiesel, and so the museum will have to search for providers within the country that specialize in selling in biodiesel. One such company is Energías Biodegradables de

Costa Rica, a biodiesel supplier found in the Cartago Province ("Biodiesel para Costa Rica," n.d.).

Because there is no actual yearly savings or Return on Investment, this recommendation will cost the museum more money than it already spends on petroleum diesel, and thus will depend on how willing the museum is to tolerate the extra expenditure with the benefit of reducing its Scope I emissions.

4.3.9 The Torres River (River Awareness)

After speaking with a representative from the Amigos de Rio Torres, or "Friends of the River Torres" organization, we decided the best way to include the river into our project was with the implementation of a special event or the addition of a permanent exhibit about the River in the Children's Museum. We believe an exhibit will be the most efficient way for the Center and the Amigos de Rio Torres to find an adequate balance that will work for both groups.

This exhibit will help bring awareness to the importance of restoring the previous conditions of the river and maintaining it at a usable state. The river runs through the entirety of San Jose, and thus it is important for the entire city to ensure the river's cleanliness. While in the end the museum will determine what an exhibit about the river would look like, we have taken feedback from Robert Faulstich and other members within the Amigos de Rio Torres organization and have created a list of potential information and design ideas the museum can incorporate. One of the most important aspects in raising awareness would be to help the public visualize the river and its aspects in an informative and captivating manner. Shown in Figure 17 is a map of the river running through San Jose.

Figure 17: Map of the Rio Torres in San Jose (Rico, 2013)

Two versions of this map could be present within the exhibit, with one map being more focused on detailing features of the river such as elevations, political boundaries, and land usage, while another map can be designed with the children demographic in mind. This type of map could incorporate features such as historical or cultural landmarks, voice recordings of older citizens' memories of the river, and a photography exhibit highlighting historical and contemporary pictures of the river. Information in either exhibit can describe the current conditions of the river and the steps necessary to help restore the river to its former condition. The most important aspect of this exhibit is to capture the attentions of children and adults, helping them to visualize the river and understand the reasons why restoration is such a relevant project for the San Jose community.

Raising public awareness about the river will be very important as part of the museum's community engagement plan, contributing to the carbon neutrality campaign while also assisting the Amigos de Rio Torres organization in accomplishing their overarching goals. Collaboration between the two will be vital to this project, and thus we encourage the museum to continue communicating with Robert and the organization to build upon these base ideas in potentially designing the exhibit.

4.3.10 Community-Wide Initiatives

Environmental cleanup is no small task, and therefore no single organization or company can tackle it alone. To make a lasting impact, the CCCC not only needs to take its own steps forward, but also serve as a trailblazer to guide the community into working towards the same goals. In order to establish a deep community investment, the team developed a few ideas for incentives to inspire the surrounding area in San Jose to commit to the carbon neutrality campaign.

The idea of holding citywide park clean-ups is not unique to the CCCC. Following an meeting with our sponsors, we found that these have been attempted in the past by other companies. By getting the CCCC involved, and specifically the Museo de los Niños, the clean-ups can reach the younger generations and instill in them the idea of environmental responsibility and that they can make a lasting impact. The Museo de los Niños can reach a huge demographic. Using small incentives, the CCCC incorporates the community in its campaign to reduce its environmental impact. Small rewards such as clothing, snacks, picnics, or even reduction on cost of admission can prompt schools, families, and the community as a whole to participate in keeping their neighborhoods clean.

4.4 Return on Investment Calculations

In the context of the recommendations, the museum will need quantitative justifications to invest in larger-scale projects, such as the installation of water-conserving toilets, the installation of solar panels, and the transition to LED lights. In order to accomplish this, the team performed a Return on Investment and Payback Period analysis. The Return on Investment determines the percentage of savings generated over a set period since the point of investment, as described by Equation 5.

$$Return\ on\ Investment\ (\%)\ =\ [(Savings)\ /\ (Cost\ of\ Investment)]\ x\ 100$$

Equation 10: Return on Investment

An ROI of less than 100% indicates that the amount of savings generated due to the investment over the period has not exceeded the initial investment cost, while an ROI greater than 100% indicates that the savings have broken even with the investment cost, and so a net positive profit is now being generated. Utilizing this analysis will allow the team to determine the conditions of each major project that would be economically feasible for the museum. On the other hand, Payback Period details the amount of time in years it will take for the project to generate the same amount of money that was initially invested into it, as described by Equation 6.

$$Payback\ Period\ =\ (Investment\ Cost)\ /\ (Savings)$$

Equation 11: Payback Period Equation

With this, the museum will have an idea on how long certain projects will take before they become economically profitable. This section will detail the ROI and Payback Period Calculations performed by the team. Based on the calculations shown below, we created two calculators to show the return on investment and payback period for the purchases of LED light bulbs, solar panels and toilets. All the data and calculators can be found in Appendix F and G respectively.

4.4.1 LED Light Bulbs

Electricity comprises a large portion of what makes up a carbon footprint, and lighting contributes in turn a noticeable portion to that percentage. The easiest way to minimize this overwhelming proportion is to cut back on the amount of electricity used in lighting. One such way to do so is to swap all standard incandescent bulbs with LED energy efficient bulbs. However, the switch from standard to LED bulbs is not just environmentally friendly; the switch is also economically friendly.

To compare the bulbs, research was done into a baseline stat for comparison. This came in the form of bulb lifetime. When comparing equivalent wattages between a standard incandescent and an LED, an LED has a lifetime nearly five times longer than that of a standard. That means, over the course of the lifetime of one LED, a company would need to buy five replacement bulbs. This factor was taken into account when comparing the costs of running the bulbs.

When comparing the costs over the course of the lifetime of one LED bulb, switching one standard incandescent bulb can save upwards of $63.98 in comparison. That means, if the CCCC were to switch its estimated remaining 1,438 bulbs, the CCCC could save $92,004.97 over the course of a 11,000 hour lifetime. To put that more effectively, a standard incandescent bulb is cheaper to operate for the first 265 hours of operation. However, after that time, an LED becomes much more cost effective. Assuming the lights are only on for the hours of operation (8:00 AM to 4:30 PM on most days, or 8.5 hours a day), and a brand new LED will cost the exact same amount as an incandescent bulb after about one month of operation. After that first month, LED bulbs will be costing less than a standard incandescent bulb. If the CCCC chose to switch from standard bulbs to LEDs, depending on wattage necessities and where they purchase from, it would take about one month to fully recuperate the cost to switch.

The data was calculated using a few assumptions. The amount of light bulbs calculated to be left to replace was based on the number of bulbs already replaced (given by sponsor) and the rough estimation of 40% still needing replacement. The electricity cost was given by our sponsors, assuming the CCCC uses less than 200 kWh per month. This, however, only affects the price of electricity. Meaning, if the museum uses more than 200 kWh per month, the savings per LED increases, as LEDs use less electricity and therefore take longer to exceed the 200 kWh a month (which results in the price increase). The cost per bulb was researched and averaged from numerous prices listed on American websites, meaning that the cost per bulb may be slightly different. Lastly, the calculations were done using the lowest wattage bulb the CCCC uses, a 6 watt bulb. For heavier wattage bulbs, the cost is much higher per bulb. The savings per bulb remains proportional, however, for the price of incandescent bulbs of higher wattages use much more electricity and thus balance out the drastic increase per unit of LED bulbs.

4.4.2 Solar Panels

In the context of solar panels, we wanted to give the museum an array of options to choose from in terms of how many they would like to install. For this, we determined the costs and yearly savings for specific solar panel numbers, which was needed for the ROI and Payback Period calculations, as well as the percentage of the museum’s 2018 electricity consumption that would be generated. In order to calculate the ROI and Payback Period of the installation of solar panels, several data was utilized based off costs specific to Costa Rica, as well as several assumptions. Firstly, the costs of installing each solar panel was taken off CRSolar’s website, a

Costa Rican solar panel company which priced one solar panel at approximately $2,936, with each subsequent additional panel being added at a discounted price. This discount increases with every additional panel, so that eventually at 100 solar panels, the total cost is $87,086, or $870.67 per solar panel. This type of discount greatly encourages businesses to purchase large quantities of solar panels. These prices were taken with the inclusion of installation, study of engineering forms, and labor costs. CRSolar also gave the estimated amount of kWh supplied by each solar panel every month, at about 38.3 kWh (CRSolar, 2019). The estimated energy generation is based off the Costa Rican national average time of insolation, or direct exposure to sunlight, being 4.57 hours. Next, the electrical rate for El Grupo ICE, one of the main electrical companies in Costa Rica that supplies electricity to the museum, was utilized. For the purposes of these calculations, the new approved rates commencing in 2019 were used. The first 200 kWh is supplied at a rate of $0.1548 / kWh, while after 200 kWh any additional kWh is supplied at a rate of $0.2791 / kWh (Rico, 2019). The yearly savings was estimated based off this rate, which is why the yearly savings do not increase at a linear rate, as the first 200 kWh generated by the panels generate a different savings compared to the energy generated after 200 kWh. This will affect the ROI and payback period calculations, as the initial installation cost does not increase linearly due to the discounted prices, while the yearly savings generated does not increase linearly due to ICE's electrical rate based on the amount of electricity consumed. Due to this, the ROI calculations are nonlinear with the amount of solar panels installed.

From the ROI numbers, the yearly savings was calculated based off how much energy a specific number of solar panels generated, as this meant that amount of energy would not be bought from ICE. Once the savings was calculated, the ROI was determined for 2, 5, and 10 years utilizing the equation shown above. A condensed summary of the ROI and Payback Period is shown in Table 3. A greater ROI for a specific number of solar panels for 5 years indicates that over a 5-year period, a larger amount of savings was generated in relation to the initial investment cost in comparison to the other number of panels installed.

Number of Solar Panels	Return on Investment after 5 Years	Payback Period (Years)
1	12.12	41.27
5	28.07	17.81
10	46.50	10.75
25	62.32	8.02
50	68.58	7.29
75	70.80	7.06
100	71.94	6.95

Table 3: Condensed Solar Panel ROI / Payback Period Breakdown

As shown by the table, the museum will get a greater Return on Investment when it installs a larger amount of Solar Panels, as the Payback Period decreases, meaning that it will take less time for the project to break even with the initial investment cost. The full calculations can be found in Appendix F: Calculations, which includes an even greater amount of number of solar panels installed, in addition to the yearly savings found for each number, the yearly electricity generated, and the amount of emissions saved. A greater amount of solar panels, although more costly, will be more efficient in the long run because the emissions saved also increases with a greater amount of solar panels. A calculator was developed to streamline the presentation of this data can be found in Appendix G: Calculators. When looking at the amount of electricity generated, it is noticeable that even with 100 solar panels, only 9.31% of the museum's electricity demand is generated. However, it should be kept in mind that within Costa Rica, there is a 15% limit on the amount of energy from the total energy demand that can come from a self-generating source ("Costa Rica - Solar Energy Products," n.d.). Thus, even though generating 9.31% of the museum's electricity demand may be considered a small amount, in the context of the 15% limit, this can be considered a significant amount, given that the ROI for 100 solar panels is smaller compared to the ROIs for installing less panels.

4.4.3 Toilets

As mentioned in Section 4.3.1 “Water Conservation”, the toilets chosen for the center are the most water efficient toilets on the market. The water efficient toilets only use 4.8 liters per flush in comparison to the average 13 liters per flush. These toilets will help save the CCCC over a million liters of water a year. We approximated that there are 60 toilets throughout the CCCC, and more than 551,000 flushes a year. All of the calculations take into account a range of toilets purchased from ten to sixty toilets by increments of ten. The cost of each toilet is $268.00 USD (United States Dollars) or 160,800 CRC (Costa Rican Colones). Return on Investment calculations (ROI) is the division of the Savings over the total costs, multiplied by 100. It shows a percentage of how much money you have saved based on your initial investment over the given time period. The return on investment was calculated for each increment of toilets over a two, five, and ten year span, ranging from 11.68% to 803%. Table 4 shows the ROI for each increment of toilets over a five-year span.

# Toilets Installed	Return on Investment after 5 years (%)
10	29.30
20	66.30
30	114.50
40	179.88
50	273.65
60	419.37

Table 4: ROI Calculations for Toilets over a 5-Year Span

The payback period ranges from 17.12 years to 1.25 years incrementally as well. A full breakdown of the calculations for the CCCC's water conservation can be found in Appendix G.

Chapter 5: Deliverables

5.1 Carbon Management/Reduction Recommendation

The major deliverables for our project consisted of a carbon management/reduction recommendation sheet, in addition to several Excel sheets that display various calculations and calculators created for the convenience of the museum. Quantitatively, this consists of the carbon footprint calculations and analysis performed by the team. The museum's carbon footprint, 135.32 tonnes of CO_2, along with the carbon emission breakdown provided the backbone of the project. The breakdown highlighted the largest emission contributors within the operations of the museum, providing guidance for the team to develop strategies to reduce the center's carbon footprint.

The carbon footprint shaped the recommendations to target the largest contributors, being electrical consumption and employee commute. This pushed the team to develop solutions to target electricity through upgraded light and solar panel calculations. The return on investment for these recommendations can be found in Appendix F: Calculations. Other calculations were developed in order to provide targeted solutions to other problem areas, including water, waste and fuel consumption. The recommendations include that of water efficient toilets, the idea of becoming a paperless institution, removing non-essential plastics from business operation, and carpool incentives for the employees to partake in. The non-essential plastics generally fall under the guise of plastic utensils, in which non-plastic alternatives are a possible replacement for the CCCC to make use of in the cafeteria.

The deliverable for this consists of the carbon footprint calculations/analysis, a list of recommendations, return on investment for these recommendations, and a feasibility chart. These can all be found in Appendices F, G, and H respectively.

5.2 Community Engagement Recommendation

The center not only wanted to improve its own impact on the environment, but also involve the entirety of the local community and serve as a leader in the terms of environmental conscientiousness. Considering this, the WPI team devised a few recommendations that could incorporate the community and expand the carbon neutrality campaign beyond the museum's campus.

One of the biggest areas of focus was the Rio Torres, the river that runs around the center and continues up and down a large part of San Jose. After meeting with Robert from the Amigos de Rio Torres, the team concluded that one of our recommendations to be provided must include an effort to raise awareness and spark community interest in the restoration of the river. The recommendation provided details for a possible exhibit to be placed in the museum, as well as ways to continue working with the Amigos de Rio Torres. By building a relationship with the Amigos, the CCCC can establish other possible projects along the way on top of the previously recommended museum exhibit, since the museum can act as a liaison between those with the drive to make change and the youth of San Jose.

Other community engagement plans include that of small community-based projects, with minor incentives to show that working towards a greener future is a rewarding process. Recommendations include park clean-ups, reforestation movements, and other small projects that the community and other businesses can get involved in. The goal of these is to allow the CCCC to branch out, and make its name known as a leader in developing an environmentally conscious community. The projects can involve communities and businesses alike, working side by side and sponsorships from other local companies and restaurants in an effort to expose all parties to the ways in which they can have a positive impact on the world around them. The proposed plans can be viewed are explored in more detail in Sections 4.3.9 and 4.3.10.

5.3 INTECO Certification Help Sheet

Another deliverable given to the CCCC was a help sheet developed by the team for the certification from INTECO. This help sheet was designed to make moving forward with the process clean cut, simple to follow, and easy for any new employees to jump into and be on-board. The help sheet breaks down the certification procedure into its most basic pieces, discussing the process leading up to certification. The initial stage involves the request process, where information will be collected and analyzed from the CCCC, and the completion of various agreement forms. Following the Pre-Verification Step, the help sheet begins discussing the actual process of acquiring the verification. This prepares the CCCC for the interviews, data sampling, facility visits and other on-site evaluations that begin in this stage of the verification.

Following the preverification and the verification steps, the INTECO help sheet discusses the process for achieving certification from INTECO. The process is simplified to a simple loop, stating that the CCCC must submit a corrective action plan (abbreviated as CAP) that will address any and all discrepancies found during the pre-verification and verification processes based upon the evaluation criteria set forth by the carbon neutrality standard. Following the submission of the CAP (which may or may not contain recommendations developed by the WPI team), INTECO will make their decision based on the agreed upon evaluation standard/criteria.

Follow-up visits, following certification, are conducted annually to ensure compliance with the CAP and evaluation standards. These follow-up visits determine whether the CCCC will have its certification renewed for that year. Similarly, carbon footprint analyses are performed biennially.

The INTECO help sheet also provides the Carbon Neutrality Standard Requirements for certification, ensuring that the Center understands the specific criteria that INTECO will be looking for during the certification process. This section of the help sheet influenced the final section, which provides detailed steps of action that the CCCC should be prepared to take in order to obtain and maintain the certification, as well as prepare themselves for the annual visits from INTECO. The final section provides a seven-step plan of action for the CCCC to adhere to following the departure of the WPI team. With this information, as well as the other deliverables, the CCCC should be well equipped moving forward with the certification process. A copy of the help sheet can be found in Appendix H: Final Deliverables.

5.4 Calculators

In addition, calculators were developed which will allow the museum to be able to calculate their own carbon footprint, based off yearly numbers, and to estimate the reduction in emissions by implementing various recommendations, such as water efficient toilets, solar panels, and LED light bulbs, as shown below.

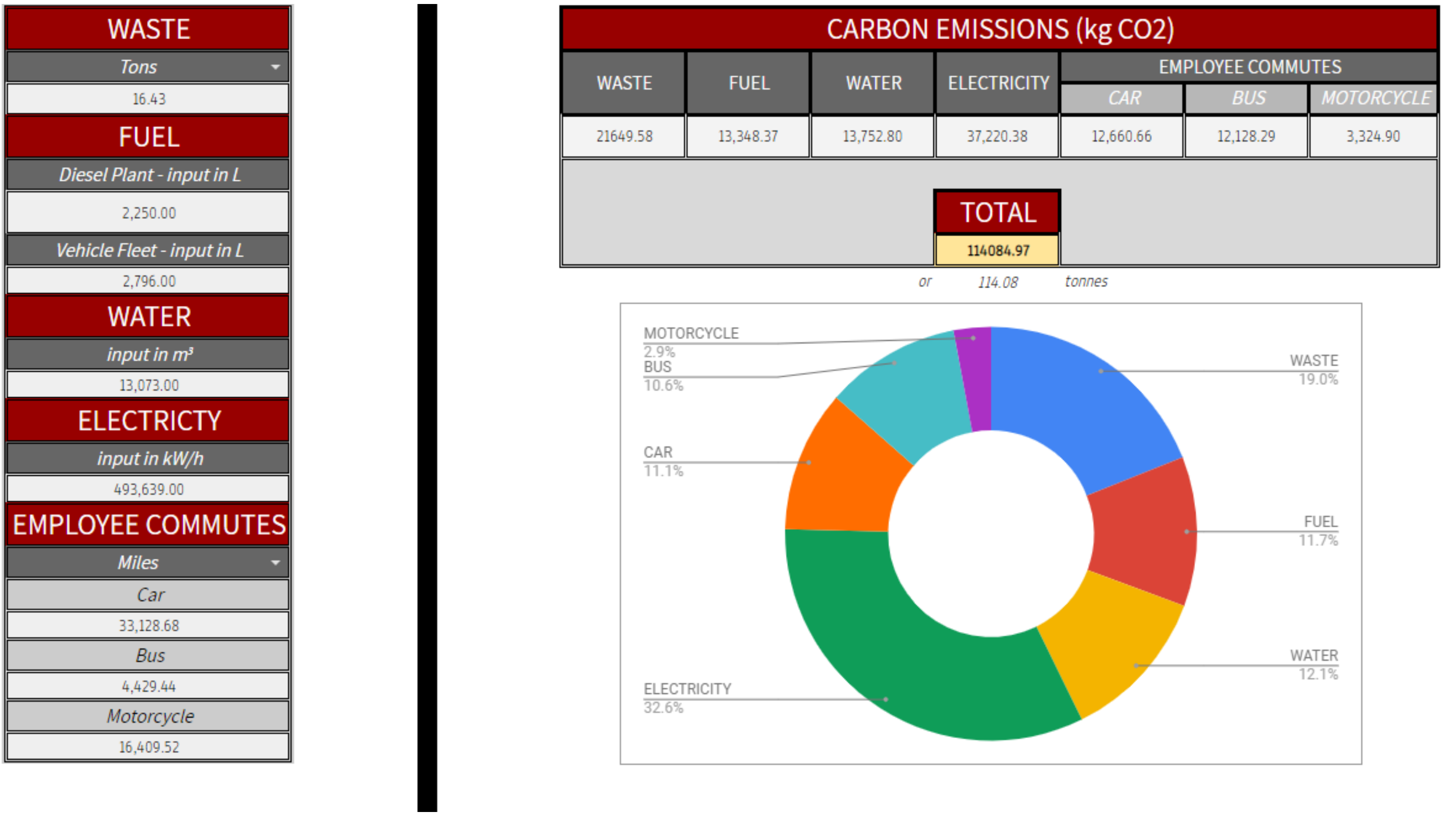

Figure 18: Carbon Footprint Calculator

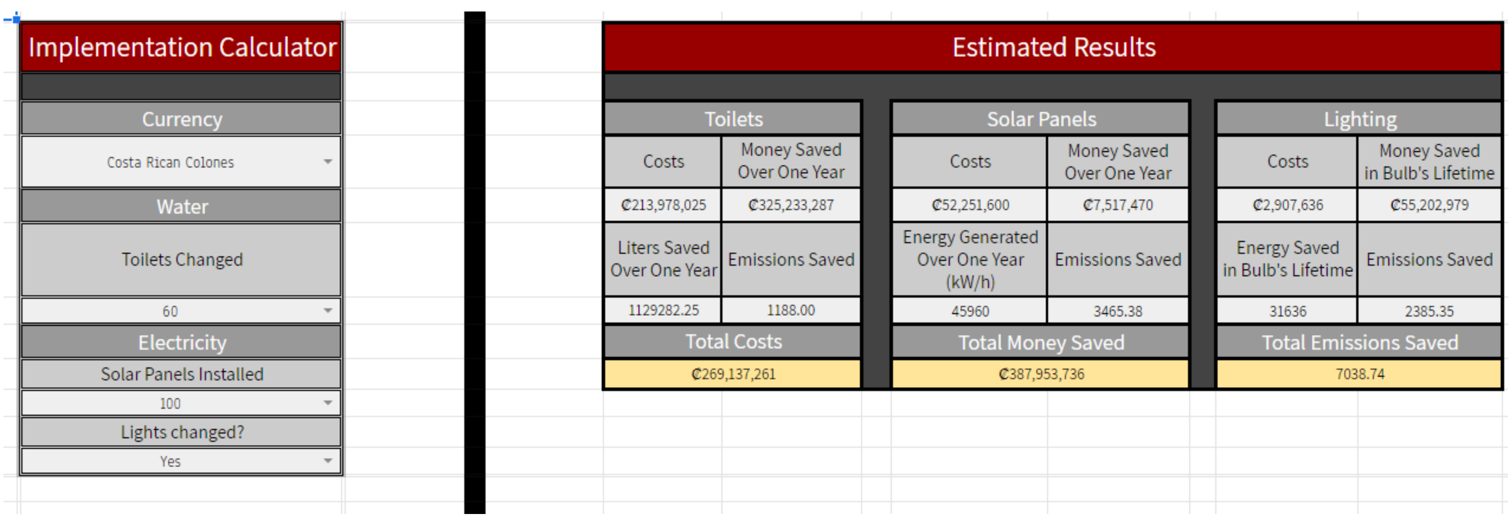

Figure 19: Implementation Calculator

Chapter 6: Conclusion

The goal of the project was to analyze the carbon footprint of the Centro Costarricense de Ciencia y Cultura (CCCC), and devise a plan of action for the center moving forward to reduce their carbon footprint, while adhering to the conditions laid out by the Instituto de Normas Técnicas de Costa Rica (INTECO) in order to acquire and maintain the standard level of its carbon neutrality certification. By accomplishing these tasks, the team provided the museum with the means to act as a representative leader for other businesses in the area to show that becoming a carbon neutral is a feasible and worthwhile investment. The team decided to conquer each step of this project's goals differently.

The first objective was to calculate the carbon footprint. By doing so, target areas of issue became noticeable, such as electrical consumption and daily employee commute, allowing the WPI team to evolve its initial recommendations to more accurately fit the issues of the center itself. However, simple recommendations were not enough. The team desired to show the cost effectiveness of each proposed idea, and so return on investment (ROI) calculations were performed in order to show what investment each recommendation would require, and how quickly the suggestion could pay for itself. Many longer-term projects, such as solar panel and toilet installation, varied in cost effectiveness, with payback periods up to several years, while other recommendations did not generate any profit, as they simply required the museum to spend more money on being more environmentally friendly than they currently are. This data is the most helpful for the CCCC, for it allows the center to carefully judge and analyze which suggestions they choose to implement, and in what order.

After developing the list of possible ways to reduce the center's carbon footprint, the team began working on ways to assist the CCCC in achieving INTECO certification. This came in the form of a concise help-sheet, in which detailed steps were given for the entire process of securing and maintaining the certification. This sheet will allow the center to understand how to proceed following the team's departure.

It should be noted that several limitations existed throughout the course of completing these objectives. Unfortunately, data could not be compiled from every employee in terms of daily commute, as data was gathered from only 115 employees out of 228. Although this data was extrapolated to consider all of the employees in the center, this number is only an approximation, and as such the carbon emissions generated by employee commute is only an estimate as well. In addition, several datasets provided could not be incorporated into the carbon footprint due to their complicated and incomplete nature. For example, data was provided on the quantity of paper recycled in the museum; however, this could not be incorporated because the weights were not known of each variety of paper, such as business cards and pamphlets. While data on electrical consumption was provided, no exact breakdown existed on how much energy was used by each section within the museum, and so the team was unavailable to target specifically different sections of the museum.

While carbon neutrality is end goal for the museum, a long-term project will consist of a combination of strategies that seek to reduce the center's emissions and sequestration techniques such as reforestation that will absorb carbon from the atmosphere. The final deliverables given to the center detail all the research, solutions, and future endeavors that the CCCC may need in the field of carbon neutrality. While currently achieving total carbon neutrality is a demanding endeavor, as it is impossible for any entity to completely zero-out their carbon emissions, this project provides the foundation in this process which can be expanded upon by anyone else seeking to contribute to the museum's neutrality campaign.

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Appendix A: Interview Questions

Appendix A.1: Museum Patrons

These sets of questions are targeted towards the museum patrons of the Costa Rican Center of Culture and Science. No specific age requirement is aimed for, although attaining perspectives from younger and older patrons will give us a more diverse pool of answers. The goal of these questions in a survey format is to determine how the community perceives the cultural center and their significance within it, and if there are any general recommendations or changes that the locals would be receptive towards. Through this, the team will understand how the CCCC will be able to become leading role models within the country in its carbon neutrality campaign.

- Do you consider Costa Rica a “green” country, with respect to the environment?
- Do you live an environmentally friendly lifestyle?
- How can you help take care of the environment?
- How frequently do you visit the museum?
- Do you know in what ways the Center (Children’s Museum) is an environmentally friendly institution?
- How can the Center (Children’s Museum) become a better environmentally friendly organization?
- Do you see the Center (Children’s Museum) as an environmental leader?
- How important is it for the Center (Children’s Museum) to become an environmental leader?

Appendix A.2: Employees

These sets of questions are targeted towards the employees of the CCCC. These questions were designed to get a feel of the biggest ways that employees have an effect on the carbon footprint of the CCCC, and how receptive they would be towards the organization becoming carbon neutral.

- Do you know of the Center's program to go Carbon Neutral?
- What aspects does the Center need to improve to obtain the certification for Carbon Neutrality?
- How will becoming a carbon neutral institution impact the Center?
- List 5 activities that you do at work to conserve resources and what resources do you conserve? (Water, Paper, Lights, etc.)
- Do you recycle at work?
    - How frequently?
- How will you get involved in the carbon neutrality program at work?

Appendix A.3: Key Stakeholders

These questions are designed in the context of a semi-standardized interview, aimed towards the key personnel and upper management of the CCCC (Berg, Bruce L. and Howard Lune, 2012). Through this, the team will be able to determine the specific goals the key stakeholders envision for the project, clarifying any vague topics, and allowing the team to determine specific individuals to consult for quantitative data.

- Who can we speak with to gain information regarding the gas, energy, and water consumption from the facilities?
- Can you estimate what the budget will be for the carbon neutrality campaign?
- What do you know about the certification ISO 14001?
- Why do you think it is the certification of choice?
- Can you describe what expectations of our project you have from our time working together?
- Have any other businesses gone carbon neutral within the area?
- Have you begun any sort of work on building towards carbon neutrality?
- We've begun devising a plan to interview the general public and museum patrons about the organization's carbon neutrality goal to gain community perspective. Do you think this is necessary or will be relevant to the project?

Appendix B: Interview Answers

Initial Meeting with Saúl Pereira and Carolina Mora

Interview Summary

January 8, 2019
Centro Costarricense de Ciencia y Cultura

Can you describe what expectations of our project you have from our time working together?

Saúl and Carolina responded that they don't necessarily want a "checklist" of sorts, for example telling them the amount of trees that they need to plant. Rather they would like to encourage more creative ideas in terms of going carbon neutrality, such as creating a guideline in terms of what to do and how to go about it. They had also mentioned about how they would like to encourage inclusivity with the community in the campaign and incorporate them too.

Can you estimate what the budget will be for the carbon neutrality campaign?

Saúl said that they have a budget in place for the projects that the museum undertakes, however there is nothing set in stone in terms of the carbon neutrality campaign. Thus, it is more likely that the team will devise a plan to present to them, from which they can pick different ideas that the museum can afford.

Have any other businesses gone carbon neutral within the area?

Saúl said that companies in San Jose such as Florex and Banco Nacional.

Have you begun any sort of work on building towards carbon neutrality?

Carolina said that technically, no concrete work has been done yet in terms of going carbon neutral. However, they have installed a waste campaign throughout the museum in which trash is separated into 4 different categories. Several small initiatives have been set in place, however nothing has been 100% effective.

We've begun devising a plan to interview the general public and museum patrons about the organization's carbon neutrality goal to gain community perspective. Do you think this is necessary or will be relevant to the project?

Saúl said that if we think utilizing these interviews is necessary, then we can go ahead with the questions. It all depends on us, however the museum may be able to help in terms of facilitating the interviews.

Do you have any knowledge on what ISO 14001 is and how to obtain it?

Carolina had told the team that the museum was aware of the certification, which the main certification that the museum is targeting, and that they had already compiled several documents on how to obtain the certification which will be sent to the team.

Who can we speak with to gain information regarding the gas, energy, and water consumption from the facilities?

Carolina said that she will be the one compiling all the necessary data that the team needs, and that she will be slowly sending us the data as she gets it from the needed departments.

The interview was followed up with a tour of the museum, in which several areas of interest were discussed with the team which could factor into the project.

Light Show

Saúl and Carolina had mentioned that the museum hosts a light show every year around December, in which thousands crowd the streets in front of the museum in order to see the display. These lights are all LED.

National Theater

Saúl and Carolina had brought the team to the National Theatre, mentioning that the Theatre is the biggest consumer of energy within the museum. This is due to the amount of lights and displays within the auditorium, as it hosts many events throughout the year.

Rivers and Property

Saúl and Carolina gave the team a tour around the immediate area surrounding the museum, including a look at the nearby river and the park. They mentioned that these properties should be taken into consideration for the campaign, however it is not exactly the largest priority of the museum. The team got a look at the river, which could be seen filled with trash and pollution.

Follow up Meeting with Saúl Pereira and Carolina Mora

Interview Summary

January 10, 2019
Centro Costarricense de Ciencia y Cultura

Would it be possible to host a sort of community clean up day which could help clean the river surrounding the museum?

Saúl mentioned that the river is very large, running throughout most of the city, and so a clean up day might not be necessarily effective, and that several companies already do try to help clean the river. In the end, Saúl said it might be better to start on a smaller scale and focus here near the museum.

How would you feel about the idea of possibly having a community clean up day in the park near the museum and to have incentives for people to come in and bring in their trash/recyclables?

Saúl had mentioned that a community clean up day at the museum might not necessarily be the best idea considering that the immediate area around the museum is dangerous. He mentioned that the museum has hosted an incentive program to help out the homeless nearby, however this was a wary program as they did not want to give out money which could then be used to fuel drug use. Both, however, were intrigued by the idea of having different types of incentives for the community, such as T-shirts and reduced museum entrance fees.

Has the museum looked into the possibility of solar panels?

Carolina mentioned that a full-scale project of solar panels for the entire museum would be extremely costly, and so that idea is not feasible. In addition, they did not want to affect the aesthetic and appearance of the museum, as they feared solar panels might have a negative effect on appearance. However, it might be possible to use the solar panels to help power sections of the museum, such as the National Theatre.

What types of lights does the museum use?

Carolina mentioned that the museum uses fluorescent light bulbs, however several years ago they began transitioning their lights to LED. All the major attractions have switched over to LED usage, such as the Light Show, however not all of the museum has transitioned yet and they are still in the process of doing so.

Are there any carpooling incentives in place within the museum?

Saúl had mentioned that the city already has in place a type of carpooling system, where on certain days, cars with license plates ending in specific digits were not allowed to be on the road. This system, as explained by Saúl, is used to help reduce traffic congestion and pollution. However, the museum does not necessarily have its own carpooling incentives, and it could be something that could be looked into. But, this could be hard since many employees come from all around the area and so it might be hard to try to coordinate something due to the employees' locations.

Appendix C: Survey Answers

Employee Surveys

1. Do you know of the Center's Program to go Carbon Neutral?

36 responses

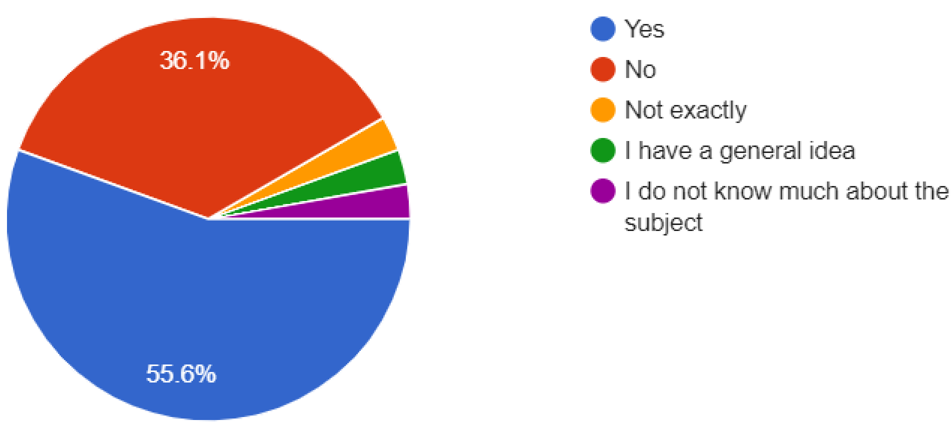


Figure 20: Employee Survey (1)

2. What aspects does the Center need to improve to obtain the certification for Carbon Neutrality?

30 responses

Waste Management
Don't give out straws and create a better system to actually separate waste.
Instead of looking at it as only to get a certification, It's an opportunity to develop an economic activity without impacting the environment, Carbon Neutrality is not one of the Center's main projects so on occasions (like important events) the Center does not worry about taking care of the environment.
Use less paper and more support to technologies that will help
The usage of vehicles
Encourage more recycling campaigns
Do not develop emission-producing activities
Reforesting, Assessing different types of energy, Saving resources such as water and work materials: paper & electricity
The most important aspects that will work apply to how we recycle and put the necessary landfills in the carbon neutral plan

Figure 21: Employee Survey (2)

Insist that more employees recycle

Commitment

Use fewer objects of technology

To raise awareness for the population that works on site about this project and its focuses

Recycling, education to the officials, giving the program the respect and space it deserves

set more the issue of recycling

Implement more garbage dumps and encourage people to recycle inside the institution

Use of clean energies

To train on it

a collection center to classify and reuse waste in an appropriate manner

Solar plants and collection centers

Figure 22: Employee Survey (3)

a collection center to classify and reuse waste in an appropriate manner

Solar plants and collection centers

recycle better

storage centers, solar plants, filters and water saving plants.

Should focus more on the collection of recycling, that it is appropriate

The Center performs "planting projects" when they cut trees from the Center

Recycling

Improve on the aspect of neutrality

the center must improve with respect to empathy, in every way.

Install screens to reduce the use of air conditioning

A collection center where waste can be classified

A waste collection center

Figure 23: Employee Survey (4)

3. How will becoming a carbon neutral institution impact the Center?

28 responses

It will help the Center have a better brand and educate its business partners and patrons

Better Image for the Center

It will improve our positioning in the consumer market.

Recognition

A positive image

Benefits such as cleaning, energy saving, and encouraging visitors

Will give us a modern, ecological image. Gives us a different status from others. The future is in sustainability and being carbon neutral so we are working towards that now

It will have a positive impact. We will have better actions and contribute to helping the environment, on the other hand we will have a better image and urge other companies to join the cause. The example will also help the local population and visitors to generate a national culture responsible for the theme.

Very positive impact since it will be a bonus for the company and the environment

Figure 24: Employee Survey (5)

I don't know

Gain a better status and set an example for other companies

Give the institution a prestigious name and become an example for other institutions to follow

A model to other centers and its visitors

It will impact in many ways, since it is an educational center and a recognized institution.

In a positive way, knowing that, since the institution would have many points in favor of the environment and clean places

This being an institution of non-formal education, it teaches present and future generations as an example

be a model for other companies

Example for other companies

Figure 25: Employee Survey (6)

first for their missions to the children and teach them the importance of recycling, and second to help the planet
would be an example institution for the country and other companies
Set a better example as an institution
The Center will be an example institution for other institutions
Harmony with the environment, prestige
Doing so will improve the environment
It will be convenient to attract more diverse public
Having a better image for visitors
It can serve as a model for other companies
it would be an example or model for other institutions

Figure 26: Employee Survey (7)

4. List 5 activities that you do at work to conserve resources and what resources you conserve? (Water, Paper, Lights, Etc.)

29 responses

Recycle

1) Recycle Paper
2) Turn off Lights
3) Only use water when necessary
4) Only print important documents
5) Use my own bottle for water instead of buying one

1) Only use water once I am done brushing my teeth
2) Use all the blank space on pieces of paper and recycle when done
3) Don't use disposable straws
4) Use my own cup for coffee instead of disposable cups
5) Try to do all my work with natural light

1) Avoiding the use of paper
2) Turn off all the lights when I leave the bathroom
3) Turn off the monitor whenever I'm not at my work desk
4) Unplug all the electrical appliances I am not using
5) Turn off the lavatory faucet/pile of plates (when applicable) and try to communicate to my other colleagues the importance of these practices

Figure 27: Employee Survey (8)

1) Don't turn on lights
2) Recycle Paper
3) Reuse Folders
4) Reuse Paper

1) Water
2) Lights
3) Paper
4) Plastic

1) Power Saving
2) Not using lights
3) Avoid printing
4) Shutdown the computer unless I'm using it

An intelligent usage and not abusing: water, electricity, printing of paper, furniture, materials and work equipment

1) Recycle and reuse paper (reuse file folders)
2) Recycle plastic
3) Only use electricity when there is not enough light
4) Water is not wasted (extra water from the working day is given to plants and pots)

Figure 28: Employee Survey (9)

1) Keep the lights off in my room and use natural light until visibility is too low.
2) When in the bathroom, I make sure all the faucets are closed
3) When getting soda, I never ask for a cover or a straw
4) Reuse paper (such as permission ballots that have already been scratched off)
5) Divide the garbage in the recycling bins

1) Conserve water usage
2) Don't use lights when applicable

1) Disconnecting devices at night (especially lights)
2) That the water pressure in the bathrooms is not as high so that it is not wasted (the water flow may be less)

Turn off the lights that are on unnecessarily

1) Close the faucets while they are not being used
2) Turn off the lights if there is enough natural lights
3) Recycle the right way

Figure 29: Employee Survey (10)

1) Close the faucets when they aren't needed (water)
2) Turn off the lights (light)
3) Reuse paper
4) Separate waste (garbage)
5) Reduce noise pollution

1) Bringing cutlery from my house
2) Separating the waste
3) Using a metal straw
4) Drying my hands in the air
5) Bringing a cloth bag in case it's needed

Reuse paper, recycle garbage, turn off the light when it is not needed, implement more recycling bins, do not throw water and use the papers in some activity with groups

Water, I use what I need,

Waste sorting

Recylce

recycle, save water, manage paid lights, motivate other people to take up and care for the planet

Figure 30: Employee Survey (11)

reuse paper, not leaving open taps or using water unnecessarily, using only the lights that are needed.

Recycling

Reuse paper, reduce water consumption, use energy-reducing lights

Use old soda bottles to drink water, turn off bathroom lights

light, turn them off when you do not need them. Separate materials, close faucets and pipes well

1) Keep the lights off when not needed
2) Utilize paper only when necessary
3) Close the faucet while I brush my teeth
4) I do not flush when it is not really necessary

Figure 31: Employee Survey (12)

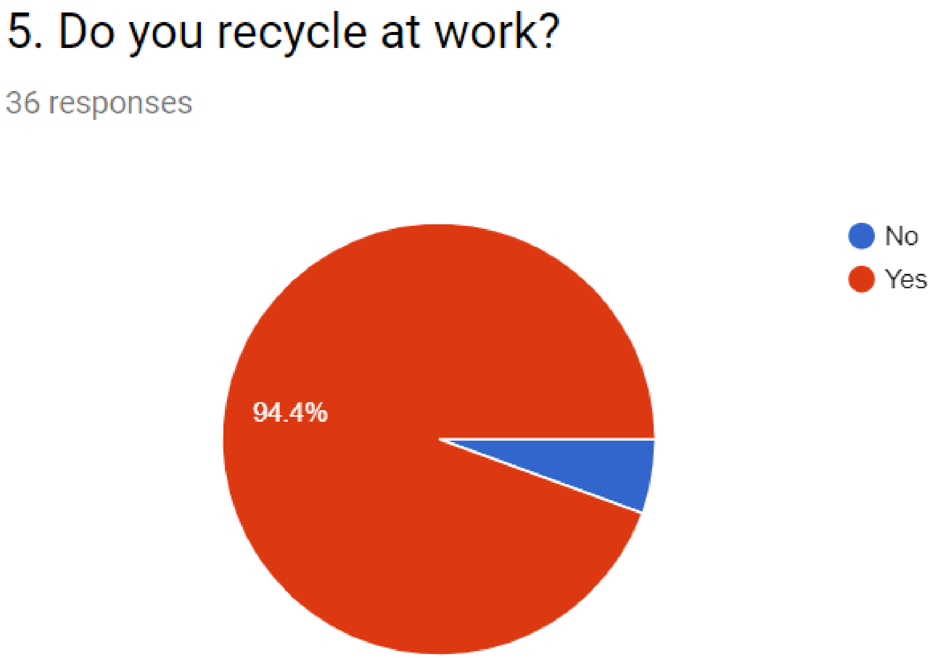


Figure 32: Employee Survey (13)

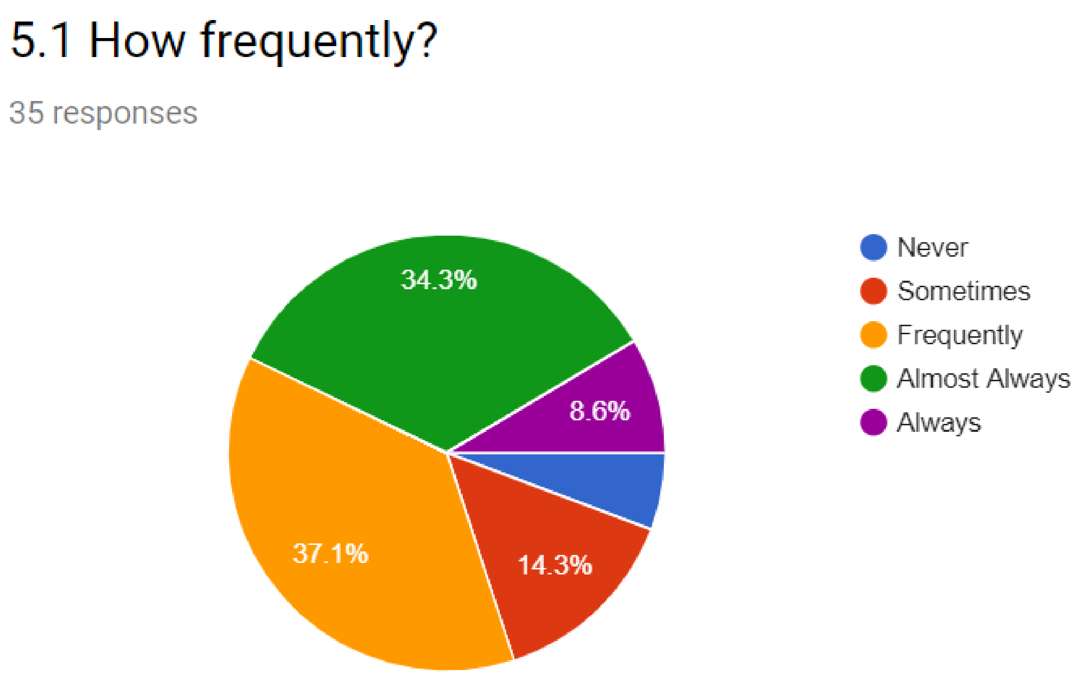


Figure 33: Employee Survey (14)

6. How will you get involved in our carbon neutrality program at work?

25 responses

- Recycling
- Participate in the implementation of the proposals in my department
- Educational Programs
- In any activity that needs help
- Being a part of the group that drafts a process to achieve the certification
- Carrying out awareness-raising activities towards the subject
- Following the rules given to us for this effort
- Collaboration
- Helping in what is requested of me, even picking up any garbage around me
- Telling people the importance of recycling
- Providing the knowledge on how to improve the health and help training others in our program

Figure 34: Employee Survey (15)

Attending training and following protocols that are incorporated into the program

As a student of communication, I would contribute ideas or support for advertising campaigns

None

participating in campaigns

Volunteer

helping to achieve in-home projects or part of the museum to improve the environmental impact of the museum to the country.

Recycle more

Attending meetings, collaborating

Motivation

recycling, giving workshops, making this something mandatory and regular, for the compliance of all

Figure 35: Employee Survey (16)

Making an energy reduction campaign

Being a part of it

Volunteer for the campaign

Figure 36: Employee Survey (17)

Clientele Surveys

1. Do you consider Costa Rica a "green" country, with respect to the environment?

14 responses

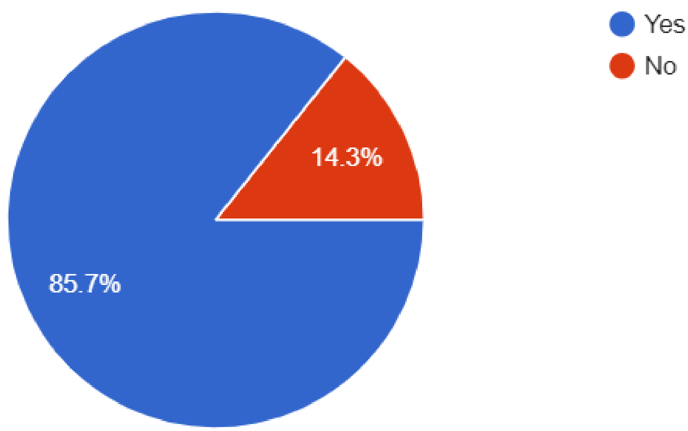


Figure 37: Clientele Survey (1)

2. Do you think you live an environmentally friendly lifestyle?

14 responses

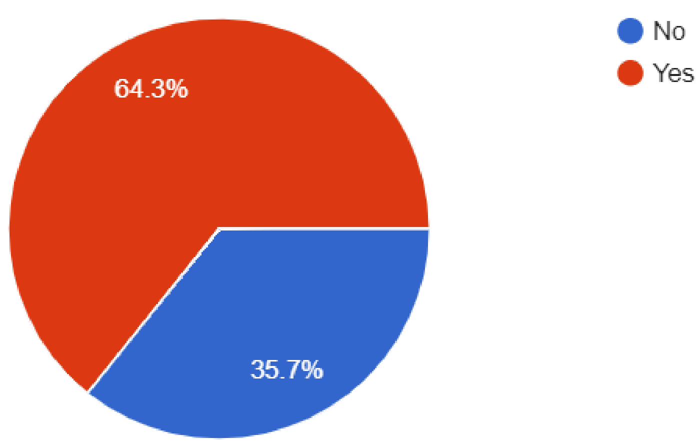


Figure 38: Clientele Survey (2)

3. How can you help take care of the environment?

13 responses

- Recycling
- -recycle, reuse, drive a prius!
- By recycling, by using less water, by turning off electronics and the lights when they're not in use, by helping to clean outside and pick up trash
- Recycle, use less plastics, monitor water and electricity usage, drive less
- More recycling, Walking and biking more, Use more natural light
- Recycle more, monitor water and electricity usage, cut down on plastics
- To know the different ways to recycle and to conserve the environment

Figure 39: Clientele Survey (3)

- Recycle every day and do not generate a lot of waste
- Recycle, Composting, up-cycling (creative reuse), environmentally friendly transportation - public transportation/biking, etc.
- Recycling, Saving energy, and not contaminating
- avoiding types of contamination and using less plastics
- recycling, turning off lights, pick up trash

Figure 40: Clientele Survey (4)

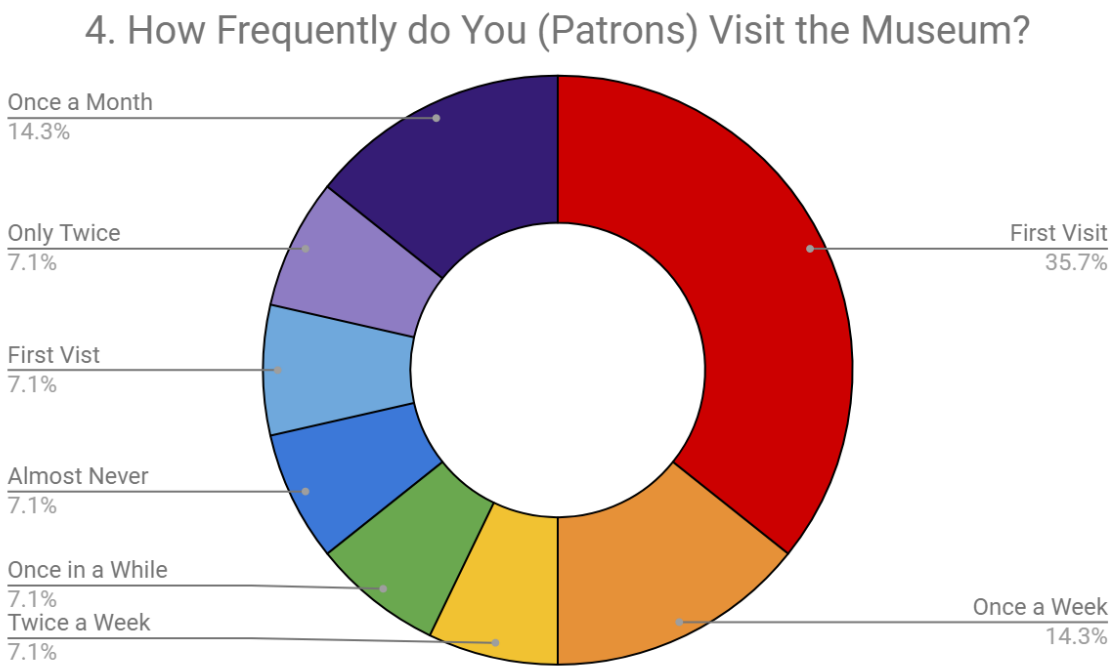


Figure 41: Clientele Survey (5)

5. Do you know in what ways the Center (Children's Museum) is an environmentally friendly institution?

13 responses

- No
- Not yet I just got here!
- The museum has a recycling/trash separation program, some bathroom faucets have water-saving taps installed
- Yes, they have the 4 barrels for different recycling
- Natural lighting
- Yes, they have the 4 barrels for various recycling
- They generate a environmentally green culture
- They Recycle, inspire the children to be more responsible with recycling materials and think of a better environment for Costa Rica
- Educating its visitors
- Creating landfills for recycling
- different receptacles for trashes

Figure 42: Clientele Survey (6)

6. How can the Center (Children's Museum) become a better environmentally friendly organization?

13 responses

Solar panels

I don't know

encourage patrons to be environmentally conscous, put trash in its place, reuse, recycle

Reduce electricity and water usage, train employees and educate the children about the environment

Better waste management

I don't know anything

Figure 43: Clientele Survey (7)

I believe they are good right now

Promote voluntary environmental projects in areas that don't take care of the environment- like the southern neighborhoods of San Jose, and this one. Work together with the government to promote cleaning projects, etc. Keep working with adolescents and adults to better our environment.

Making propaganda (for others)

Manage more of recycling collection, giving talks to motivate more people

less plastic waste

Figure 44: Clientele Survey (8)

7. Do you see the Center (Children's Museum) as an environmental leader?

13 responses

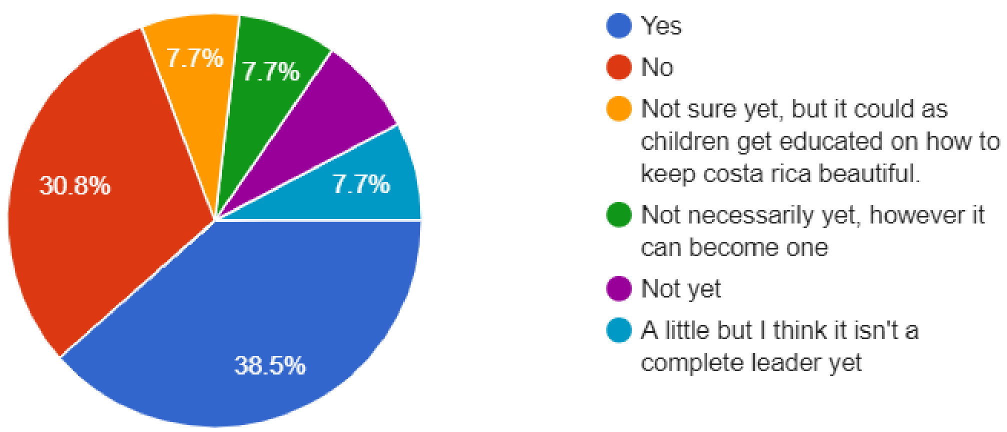


Figure 45: Clientele Survey (9)

8. How important is it for the Center (Childrens' Museum) to become an environmental leader?

14 responses

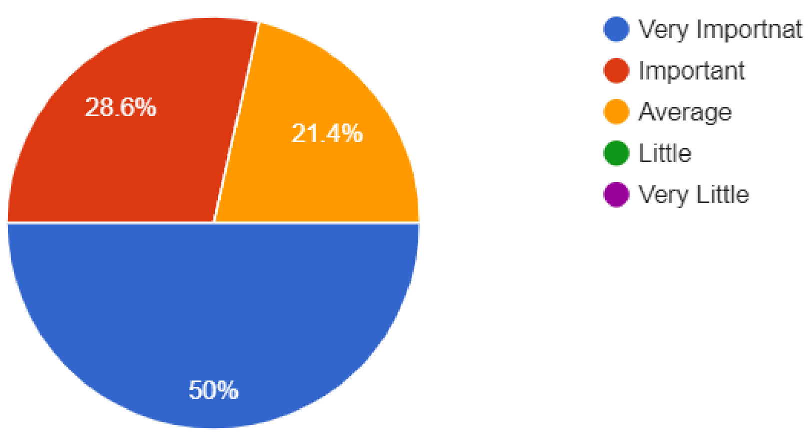


Figure 46: Clientele Survey (10)

Appendix D: Raw Data

Non Traditional Waste

Date	Quantity	Note
21/04/2017	Unknown	Waste Collection
23/11/2017	Unknown (approx. 6 tons)	Debris and Debris
27/11/2017	1.17 tons	Domestic Waste
27/11/2017	1.46 tons	Domestic Waste
4/12/2017	2.24 tons	Domestic Waste
5/12/2017		
15/01/2018	Unknown	Wood and Branches
15/01/2018	Unknown	Scrap / debris float / styreophome / paint cans - expired products
16/01/2018	Unknown	Wood / lamps / scrap / tree and decoration Communications.
6/9/2018 7/9/2018	10.54 tons	Debris / woods / debris / floats
7/11/2018	6 tons	Miscellaneous Waste

Table 5: Raw Data (1)

Waste Generated

Needs to be separated trash cans in offices too

IDENTIFICATION OF ENVIRONMENTAL RESIDUES - TABLE # 2

Generating Source	Residue / Waste Generated	Type: Waste / Disposal	Treatment / Final Disposition	Output Frequency
Administration / Common areas	Paper	Residue	Recycling	Weekly
Administration / Common areas		Scrap	Landfill	Daily
Administration / Common areas	Plastic	Residue	Recycling	Weekly
Administration / Common areas		Residue	Landfill	Daily
Productive Areas		Scrap	Landfill	Daily
Administration / Common Areas / Productive Areas	Paperboard	Residue	Recycling	Weekly
		Scrap	Landfill	Daily
Administration / Common Areas	Glass	Residue	Recycling	Weekly
Administration / Common Areas / Productive Areas	Aluminum (paper)	Residue	Landfill	Daily
	Aluminum (paper)	Scrap	Controlled Destruction	Bi-Weekly
Administration / Common Areas	Organics	Scrap	Landfill	Daily

Table 6: Raw Data (2)

Generating Source	Residue / Waste Generated	Type: Waste / Disposal	Treatment / Final Disposition	Output Frequency
Food Areas / Cleaning	Various Cleaners	Scrap	Controlled Destruction	Bi-Weekly
	Soap Powder	Scrap	Controlled Destruction	Bi-Weekly
	Liquid Soap for hands	Scrap	Controlled Destruction	Bi-Weekly
	Fumigators	Scrap	Controlled Destruction	Bi-Weekly
Food Areas / Cleaning	Dispersion	Scrap	Controlled Destruction	Bi-Weekly
	Gloves	Scrap	Landfill	Daily
	Cover for Hair	Scrap	Landfill	Daily
	Cover for Shoes	Scrap	Landfill	Daily
	Cover for Beard	Scrap	Landfill	Daily
Food Areas / Cleaning	Wipes	Scrap	Controlled Destruction	Bi-Weekly
	Metal Containers	Residue	Controlled Destruction	Bi-Weekly
	Burnt Oils	Residue	Recycling	Weekly

Table 7: Raw Data (3)

Generating Source	Residue / Waste Generated	Type: Waste / Disposal	Treatment / Final Disposition	Output Frequency
Doctor's Office	Various Solids	Scrap	Sterilization / Controlled Destruction	Monthly
Security	Weapons	Scrap	Controlled Destruction	N/A
	Bullets?	Residue	Recarga	Every 2 Years
Operations	Debris	Scrap	Landfill	N/A
Operations	Light bulbs / Fluorescent lamps	Scrap	Landfill	N/A
Operations	Fossil Fuels	Scrap	N/A	N/A

Table 8: Raw Data (4)

Paper Consumption			
Unit	**Type**	**Quantity**	**Period**
National Gallery	Business Cards	300	2017
	Business Cards	200	2018
	Brochure	300	2018
Human Resources	Blocks (internal tickets)	125	2017
	Blocks (internal tickets)	20	2018
Museum Management	Boards	60	2017
	Boards	60	2018
Acquisitions	Blocks (internal tickets)	100	2017
	Blocks (internal tickets)	76	2018
Cellar	Reams of bond paper	300	2017
	Reams of bond paper	260	2018
Educational Support	Varied	Varied	According to the demand for activities

Table 9: Raw Data (5)

Fuel Consumption	
Diesel purchases to feed TAN Diesel Plant and Museum	
Quantity (liters)	**Date**
200	May-16
200	ago-16
200	Nov-16
600	Sep-17
400	ene-18
400	May-18
600	ago-18
600	Sep-18
250	Oct-18

Purchase of diesel or gasoline for vehicular fleet (average)		
Period	**Quantity (Liters)**	**Number of Vehicles**
Monthly	233	4

Table 10: Raw Data (6)

Quantity of Fluorescents purchased in 2015,2016 and 2017		
It requires the completion of an Inventory to change the luminaire. It is necessary to quantify the fluorescent lighting that is possessed and the lack of change, according to the remodeling processes of the Center.		
Description	**Quantity**	**Year**
lamp led floodlights 20w for outdoor jeta ecoled 20w 6500k 1700lm 120 / 240v	12	2015
luminaire type led bar lamp syl 5036smd2 (7050lm) 120w 2x4 diffuser # 1	5	
TOTAL 2015	**17**	

Table 11: Raw Data (7)

Description	Quantity	Year
luminaire jeta eco80 led80w 6.5k, 6400lm	4	2016
led swimsuit rgb 24x2w 110-240v ip67	18	
luminaire jeta eco80 led80w 6.5k, 6400lm	4	
luminaire jeta 80 w	17	
dimerizable led light bulb a19d-led / 6.5w / 6 light bulb a19 dim 6.5w 100-127 6500k	10	
ultra led reflector par38 16w 120v dim 830 e27 cat 950874800	300	
led reflector par30 ln 10w 6000k 810lm 100-240v cat 95030110a osram	24	
gu10 bomb led smdled 3w 6500k gu10-smled / 3/6	30	
led reflector ilukon mr16 5w 6000k 360lm 100 / 240v cat 95016035a	50	
tube glass eco led t8-18w 6500k 120 / 240v	30	
led bulb ilukon a19 6w 6000k 500lm e27 100 / 240vca ce	350	
reflector par20 6w -6000k 500lm 40grados 100 / 240vac e27 ce	30	
pendant luminaire 315 e048 2x32w + 2 tubes fo32 / 841 t8 4100k	4	
led light for rail 30w 3000k tr8030wh-led white 2800lm	48	
lamp ul 517 line eo 24 2x17 gysum d # 4	11	
TOTAL 2016	**948**	

Table 12: Raw Data (8)

Description	Quantity	Year
luminaire sylvania led deltawing ul 48 4smd2 6000lm 4k	4	2017
luminaire led lamp ul517 2smd2 4980lm 4kd1 gybe	15	
fixed recessed luminaire pinhole yd-415 / b white color	40	
led luminaire ul517 2smd2 4980lm 4kd1 pdbe	15	
3w mr16 3000k smtled bulb	40	
outdoor lamp with emergency ballast 120vac 30w, with be arqdeco r502	3	
jeta luminaire, led 70w reflector type 6400lm and 6500k	9	
luminaire sylvania led deltawing ul 48 4smd2 6000lm 4k	4	
jeta luminaire, led 70w reflector type 6400lm and 6500k	9	
rectangular outdoor lamp with emergency ballast 120vac 30w, with be arqdeco r502	3	
luminaire ledavance 3.3w 3000k	50	
led bulb a60dim e27 6w520lm 5.0k bl	50	
led bulb ilukon a19 6w 6000k 500 lm thread e27 100-240v	200	
gu10 led bulb, smdled 3w 6500k gu10-smdled / 3/6.	200	
led reflector ilukon mr16 5w 600k g5.3 38g 95016035a.	200	
ultra led reflector par38 16w 120v dimmer 830 fl40.	100	
led tube 18w 2300lm 5000k cri8 120-277 ul	50	
led reflector ilukon par20 6w 6000k 500lm 40g 100-240 ce	200	
TOTAL 2017	**1192**	

Table 13: Raw Data (9)

Monthly water consumption in m3 (year 2018)												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
15	12	11	18	13	15	11	11	10	4	11	18	149
750	954	1104	1138	982	796	1076	1120	1180	1005	1295	1524	12924
765	966	1115	1156	995	811	1087	1131	1190	1009	1306	1542	13073

Table 14: Raw Data (10)

Monthly electricity consumption in kW / h (year 2017)												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
0	0	0	0	0	0	0	0	0	0	0	9240	9240
4240	3960	5200	6840	10880	6840	8080	8800	6080	3960	9840	10240	84960
26400	31840	30880	33120	33760	33920	42080	38880	40160	35360	38720	38560	423680
30640	35800	36080	39960	44640	40760	50160	47680	46240	39320	48560	58040	517880

Table 15: Raw Data (11)

Monthly electricity consumption in kW / h (year 2018)												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
2360	1480	1640	640	1200	920	960	800	1560	640	1320	1033	14553
3240	3040	5040	3760	8400	6880	7240	5480	5560	5760	6760	10400	71560
33920	36000	37440	34080		34240	44160	40320	39840	35206	35840	36480	407526
39520	40520	44120	38480	9600	42040	52360	46600	46960	41606	43920	47913	493639

Table 16: Raw Data (12)

2018										
Month	Between 90 cm y 14 years	Adultos > 15 years old	Less than 90 cm	Seniors	Courtesy	Special	Exonerac 50%	Exonerac 100%	Workshop/Rally/Free Children	TOTAL
January	9409	15055	1438	440	196	115	40	31	0	26724
February	3675	6640	1025	254	135	59	0	24	0	11812
March	2768	6308	1164	250	155	45	147	186	(*)1152	12175
April	4171	6560	1174	164	88	75	81	87	30	12430
May	4250	8919	866	155	0	71	472	201	0	14934
June	6100	9694	1060	221	87	215	548	634	0	18559
July	24676	35034	4803	1462	72	481	200	119	(**)3595	66847
August	8702	13197	2138	460	109	215	394	344	(***)1686	25559
September	6498	9222	1371	0	214	77	286	744	0	18656
October	5132	6807	1239	232	120	84	195	266	0	14075
November	4447	5402	707	196	181	47	144	75	0	11199
December	4776	7451	1076	308	169	65	144	160	0	14149
January	84604	130289	18061	4142	1526	1549	2651	2871	30	247119
(*)	Free children, refers to the number of children who entered for free by the March promotion									
(**)	Art City Tour 179, children only exhibition 1582 and adults only exhibition 2013, total only exhibition 3595, they are not added because they do not enter the museum.									
(***)	children only exhibition 756 and adults only exhibition 930, total only exhibition 1686, they are not added for not entering the museum.									

Table 17: Raw Data (13)

Work Department	Females	Males	Total
Human Resources	5	4	9
Accounting/Financial	3	9	12
Commercial Areas	5	3	8
Internal Audits / Executive Management	2	4	6
Communication & Press	4	11	15
Customer Service Mangement	2	0	2
Supply and Acquisitions	4	3	7
National Gallery	2	2	4
Educational Support	5	1	6
General Services	9	13	22
Engineering and Maintanence	1	8	9
Museology	3	7	10
Kitchen Staff	6	0	6
Security & Surveillance	0	14	14
Information	0	3	3
Museum Operations	53	38	91
Logistics and Gift Shop	2	1	3
Innovation and Technology	0	1	1
Total Contributors of the C.C.C.C	106	122	228

Table 18: Raw Data (14)

Appendix E: Emission Factors

Emission Source	CO2 Emission Factor	CH4 Emission Factor
Waste / Landfill	0.00	0.0581 (kg CH4 / kg waste)
Diesel (Electrical Generation)	2.676492 (kg CO2 / L)	0.0003612 (kg CH4 / L)
Diesel (Company-Owned Vehicle)	2.613 (kg CO2 / L)	0.00
Water Supply	0.344 (kg CO2 / m^3)	0.00
Water Treatment	0.708 (kg CO2 / m^3)	0.00
Electrical Consumption	0.0754 (kg CO2 / kWh)	0.00
Car	0.382166 (kg CO2 / mile)	0.00
Bus	2.738108108 (kg CO2 / mile)	0.00
Motorcycle	0.20262 (kg CO2 / mile)	0.00

Table 19: Emission Factors

The emissions factors for carbon dioxide (CO2) and methane (CH4) are listed in the table shown above. Most sources generate only CO2, while waste generates only CH4 (which must then be standardized to CO2 as shown in Appendix F: Calculations), and Diesel used for electrical generation generates both CO2 and CH4.

The Emission Factor used for Waste was taken from the Instituto Meteorológico Nacional de Costa Rica (IMN) (Instituto Meteorológico Nacional, 2018). Any factor taken from this source contains emission factors specific to Costa Rica.

The Emission Factor used for Electrical Generation through Diesel was taken from emission factors supplied by the GHG Protocol (Greenhouse Gas Protocol, 2017). These emissions supplied by the GHG Protocol are international emission factors, and as such they are not Costa Rican specific.

The Emission Factor used for Diesel usage in the museum’s Vehicular Fleet was taken from the IMN (Instituto Meteorológico Nacional, 2018), meaning this diesel usage factor is specific to Costa Rica.

The Emission Factors used for Water were taken from the Department of Environment, Food and Rural Affairs from the UK (Department for Environment, Food and Rural Affairs, 2018). These numbers are based off of UK numbers, but are assumed to be applicable to Costa Rica. This was used because there were no Costa Rican specific numbers for wastewater treatment when the water is discharged and then treated by a treatment factory. No specific international numbers were also supplied by the GHG Protocol. As such, these numbers were taken from the UK government’s standards.

The Emission Factor used for Electricity taken from the IMN (Instituto Meteorológico Nacional, 2018), meaning that the electricity emission factor is specific to Costa Rica.

The Emission Factors used for the employees Commute were taken from the GHG Protocol (Greenhouse Gas Protocol, 2017). The GHG Protocol was used for these emission sources because the GHG Protocol provides emission factors based on both vehicular type and type of fuel. Because the type of fuel used was not known for each employee, emission factors based off of vehicular type were used instead. As such, these factors are international and not Costa Rican specific.

Appendix F: Calculations

Carbon Footprint

For the carbon footprint calculations, the amount of each source of carbon emissions (used in the timeframe of 2018) was multiplied by its specific emission factor in order to determine the carbon emissions generated by that source for 2018. However, some sources, such as waste, generate some other gas, such as methane (CH4) which is not carbon. As a result, this must be multiplied by a CO2 equivalent factor that standardizes the emissions of that gas to carbon emissions. This number was taken as 25 in order to standardize CH4 to CO2, as stated by the Intergovernmental Panel on Climate Change ("Global Warming Potential Values," n.d.)

Waste

Waste (tons)	Waste (kg)	Landfill Emission Factor (kg Ch4/ kg waste)	CO2 Equivalent (kg CO2/ kg Ch4)	Carbon Emissions (kg CO2)
16.54	15004.8399	0.0581	25	**21794.53**
	Conversion from tons to kg	Emission Factor from IMN		Calculated by Multiplying Waste in kg by the Landfill Emission Factor and the CO2 Equivalent

Table 20: Calculations (1)

To calculate the emissions generated by waste, first the amount of waste was converted from tons to kg. Then, this new amount of waste was multiplied by its emission factor specific for the use of landfills. Because this type of waste treatment generates CH4, a CO2 Equivalent of 25 kg CO2 / kg CH4 was used to to standardize the emissions to carbon.

Fuel Consumption

DIESEL PLANT

Diesel Consumption (L)	CH4 Diesel Emission Factor (kg CH4/L Diesel)	CO2 Equivalent (kg CO2 / kg CH4)	CO2 Diesel Emission Factor (kg CO2/L Diesel)	Carbon Emissions (kg CO2)
2250	0.0003612	25	2.676492	**6042.42**
	Emission Factor from GHG Stationary Combustion		Emission Factor from GHG	Calculated by adding the product of the Diesel Consumption multiplied by the CO2 Diesel Emission Factor to the product of the Diesel consumption mulitplied by the CH4 Diesel Emission Factor and then the CO2 Equivalent

Table 21: Calculations (2)

To calculate the emissions generated by fuel consumption from the diesel plant, the diesel consumption was multiplied by its CH4 emission factor, and then multiplied by the CO2 equivalent factor to standardize this to carbon. The usage of diesel also generates CO2 in addition to CH4, so a separate CO2 emissions factor was multiplied with the diesel consumption, and then added to the amount of CO2 equivalent to the CH4 generated.

MUSEUM'S VEHICULAR FLEET

Diesel Consumption (L)	Emission Factor (kg CO2/ L)	Carbon Emissions (kg CO2)
2796	2.613	**7305.95**
	Emission Factor from IMN	*Calculated by multiplying the Diesel Consumption by the Emission Factor*

Table 22: Calculations (3)

To calculate the emissions generated by fuel consumption from the museum's vehicular fleet, the diesel consumption was multiplied directly with its CO2 Emission Factor, thus giving the carbon emissions generated in 2018.

Water Consumption

Water Consumption (m^3)	Water Supply Emission Factor (kg CO2 / m^3)	Water Treatment Emission Factor (kg CO2 / m^3)	Carbon Emissions (kg CO2)
13073	0.344	0.708	**13752.796**
	Emission Factors taken from 2018 DEFRA Emission Factors Spreadsheet; specific to UK, assume applies to Costa Rica as well		*Calculated by adding the product of the Water Consumption multplied by the Water Supply Emissions Factor to the prduct of the Water Consumption multiplied by the Water Treatment Emissions Factor*
	Still used method supplied by GHG Protocol		

Table 23: Calculations (4)

To calculate the carbon emissions due to water consumption, two processes needed to be considered, the emissions created from supplying the water to the museum, as well as the emissions created from wastewater treatment afterwards. Thus, the museum's water consumption was multiplied by the Water Supply Emission Factor and also by the Water Treatment Emission

Factor. These two emissions were then added together to find the total carbon emissions generated.

Electrical Consumption

Electrical Consumption (kW/h)	Emission Factor (kg Co2 / kWh)	Carbon Emissions (kg CO2)
493639	0.0754	**37220.38**
	Emission Factor from IMN	*Calculated by multiplying the Electrical Consumption by the Emission Factor*

Table 24: Calculations (5)

To calculate the yearly emissions created by electrical consumption, the museum's electrical consumption for 2018 was multiplied by its emission factor.

Employee Commute

CAR

Total Distance Traveled (Miles)	Emission Factor (kg CO2 / Mile)	Carbon Emission (kg CO2)	** Under assumption the cars used by employees use gas and NOT diesel*
57975.19	0.382166	**22156.15**	
	Emission Factors from GHG Transport Vehicle Distance	*Calculated by multiplying the Total Distance Traveled by the Emission Factor*	

Table 25: Calculations (6)

BUS

Total Distance Traveled (Miles)	Emission Factor (kg CO2 / Mile)	Carbon Emission (kg CO2)	** Under assumption that buses use diesel for fuel*
7751.52	2.738108108	**21224.50**	***Based on assumption that 25 people per bus at a time**
	Emission Factors from GHG Transport Vehicle Distance	*Calculated by multiplying the Total Distance Traveled by the Emission Factor*	

Table 26: Calculations (7)

MOTORCYCLE

Total Distance Traveled (Miles)	Emission Factor (kg CO2 / Mile)	Carbon Emission (kg CO2)
28716.66	0.20262	**5818.57**
	Emission Factors from GHG Transport Vehicle Distance	*Calculated by multiplying the Total Distance Traveled by the Emission Factor*

Table 27: Calculations (8)

To calculate the emissions generated by employee commute, the emissions were calculated based on each mode of transportation. This was broken down into Car, Bus, and Motorcycle, each having its own carbon emission factor. Thus, the distance traveled in miles for the entire year for each type of transportation was multiplied by its specific Emission Factor. Afterwards, the emissions created from Car, Bus, and Motorcycle usage were added together to find the total Carbon Emissions (which was 49199.22 kg CO2 or 49.20 tonnes CO2).

LEDs

Cost of Energy per kWh (first 200)	0.1548	
Cost of Energy per kWh (additonal)	0.2791	
# of Fixtures left to replace	1438	
Hours per day lights are on	10	
Days a month the lights are on	23	
Cost of Standard Bulb	1.97	
Average Lifetime of Standard	2250	
Standard Bulb Wattage	40*	
Cost of LED Bulb	3.37	
Average Lifetime of LED	11000	
LED Bulb Wattage	6*	
Amount of Equivalent Standard Bulbs	4.8	
Cost of Equivalent Standard Bubls	9.63	
Hours of Operation	8am-4:30pm	8.5 hours
Equivalency Wattage*	LED	Standard
	2-4 W	25 W
	5-7 W	40 W
	8-10 W	60 W
	9-13 W	75 W
	13-18 W	100 W

Table 28: Calculations (9)

The above numbers consist of the cost of electricity from the electric company, how many bulbs are left to be replaced throughout the campus, how many hours during the day (average) that the lights would kept on and the hours of operation of the center (minimum), the amount of days per month the CCCC is open for business, the cost in USD for a standard bulb, its average lifetime (hours of operation before the bulb fails), the most commonly used wattage for the standard bulb, and the same information for LED bulbs (where the wattage covers equivalent fixtures). The amount of equivalent bulbs is found by dividing the LED lifetime by the standard lifetime to see how many bulbs are required in standard to last the same amount of time. The cost of equivalent then takes that number and multiplies it by the cost of an individual standard to find the total cost for supplying the same amount of lifetime as a single LED. The chart shows what wattage of LED is required to match that of a standard bulb.

	COST IN DOLLARS		
	Cost to Run per Lifetime (for one Standard vs LED)		
	lifetime(wattage)($/kWh) + initial cost		
Equivalent Light Bulbs	[11000(40)/(1000)]*(0.1548)+4.8(1.97)	$77.57	
LED	[11000(6)/(1000)]*(0.1548)+3.37	$13.59	
	Total Savings Across the Campus		
	Difference(# of Fixtures)		
	63.98(1438)	$92,004.97	
	Time Lapse Cost		
	Setting the following equations equal to each other:		
Standard Bulb Cost	time(40/1000)(0.1548)+1.97		
LED Bulb Cost	time(6/1000)(0.1548)+3.37		
		time = 265.998	hours
	time/(hours of operation)		
	265.998/8.5		
		31.29 days	≈ 1 month*****

Table 29: Calculations (10)

Here, the equation to find the cost to pay for the lifetime of one LED is used. To do so, the lifetime (total hours the bulb lasts) is multiplied with the wattage of the bulb (40 for standard, 6 for LED), combined with a dividing conversion factor of 1000 (to change wattage into kilowattage), and added to the initial shelf cost of the bulb (3.37 USD for LED, and 9.63 USD for the equivalent 4.8 standard bulbs).

The total costs are then subtracted to give the savings of $63.96 over the entire 11,000 hour lifetime of 6 W LED. That savings is then multiplied by the total fixtures left to replace in the campus, being 1,438, to get a total savings (if all bulbs are replaced) of $92,004.97 across the entire 11,000 hour lifetime.

The next section, Time Lapse Cost, compares the running costs of standard and LED. In each equation, a variable of time was declared. This time takes the place of the lifetime of the bulb. The other variables are the same from the previous calculations. However, for this calculation, the two individual equations are set equal to one another. The variable of time is solved for. This value represents how many hours of operation (from a brand new bulb) it takes for a standard bulb to cost the same as an LED. Before the value of time is reached, the standard bulb is cheaper to own and operate because its initial cost is significantly lower than that of an LED. However, after this point, an LED becomes cheaper to operate because of its lower wattage and therefore lower run cost. The time is calculated to be 265.998 hours, or roughly 31.29 days (assuming lights are only on the hours of operation at the center). This number is useful to acknowledge because looking at it, the bulbs cost the same to run on a monthly basis. Meaning that, as electric bills are generally due on a monthly basis, the cost to operate is the same and would have no impact on operational costs. And, following that initial month, the replacement begins saving money.

	COST IN COLONES	$1=600 colones
	Cost to Run per Lifetime (for one Standard vs LED)	
	lifetime(wattage)($/kWh) + initial cost	
Equivalent Light Bulbs	[11000(40)/(1000)]*(92.88)+4.8(1182)	₡465,408
LED	[11000(6)/(1000)]*(92.88)+2022	₡815,208
	Total Savings Across the Campus	
	Difference(# of Fixtures)	
	38.388,72(1438)	₡5,520,297,936

Table 30: Calculations (11)

The same calculations were performed using Costa Rican colones instead of USD for the ease of the team's sponsors. A conversion factor of $1 being equivalent to 600 colones was used.

Difference over 11,000 hour lifetime (dollars)**
$63.98
Total Savings Across all remaining fixtures in one 11,000 hour lifetime***
$92,004.97
Time it takes for standard to be more expensive to operate than LED
265.998 hours
*Savings difference increases as wattage of the type of bulb increases
**Difference number represents lifetime savings of one LED bulb
***These calculations were made assumming lowest wattage bulbs, and under 200 kWh per month
****Using prices and data numbers from the website linked below.
*****This number shows that by the end of the month (when bills are paid), it is more cost effective to be using LED bulbs

Table 31: Calculations (12)

These calculations were performed under a few assumptions. Minimum wattage bulbs were used. As wattage increases, so does the cost gap between standard and LED. This means it takes slightly longer to reach that intersection point. However, the savings on a larger wattage increases over time, as the wattage gap also increases (as can be seen in the chart provided in the first section), this time in favor of the LEDs.

Solar Panels

This section is dedicated to displaying and analyzing the costs, yearly savings, emissions savings, Return on Investment, and Payback Period for a wide range of solar panels that the museum can possibly install. This ranges from 1 to 100 solar panels, increasing at increments of five.

	Area Taken up By 1 Solar Panel (m^2)	
	1.635	
	Energy Generated (kWh) by A solar panel in one month (Average)	
	38.3	
	Energy Generated (kWh) by One Panel Per Year (Average)	
	459.6	
	Emission Factor (kg CO2 / kWh)	
	0.0754	
	Cost of Electricity (for 2019)	
First 200 kWh	$0.1548	
After 200 kWh	$0.2791	
Labor Cost		
	Size taken from standard US size	
	Under assumption solar panel does not create any carbon emission	
	Energy generated taken from CRSolar Website	
	No import tax	

Table 32: Calculations (13)

First, several assumptions had to be made in order to gather several needed rates. CRSolar's website was used to obtain the estimated amount of electricity that would generated by one solar panel. This number was 38.3 kWh per month, or 459.6 kWh per year, for every solar panel. The amount of electricity generated will depend on the amount of sunlight that the panels are exposed to, however this number was based off of the Costa Rican average of daily direct sunlight, which is 4.57 hours. The emission factor of 0.0754 kg CO2 / kWh that was used in the carbon footprint calculations for electrical generation was used to estimate the amount of emissions saved with the amount of electricity generated by the solar panels. This will not be entirely exact as the emission factor is subject to change throughout the years, however this will give a rough estimate for the center to view. The area taken up per solar panel was also taken as 1.635 square meters, as the center will need to know the amount of space they will need to install the solar panels (Zientara, 2019)

Number of Solar Panels	Area Taken up by Panels (m^2)	Total Emissions Offset by Panels	Estimated Energy Generated (kWh) in One Year
1	1.635	34.65	459.6
5	8.175	173.27	2298
10	16.35	346.54	4596
15	24.525	519.81	6894
20	32.7	693.08	9192
25	40.875	866.35	11490
30	49.05	1039.62	13788
35	57.225	1212.88	16086
40	65.4	1386.15	18384
45	73.575	1559.42	20682
50	81.75	1732.69	22980
55	89.925	1905.96	25278
60	98.1	2079.23	27576
65	106.275	2252.50	29874
70	114.45	2425.77	32172
75	122.625	2599.04	34470
80	130.8	2772.31	36768
85	138.975	2945.58	39066
90	147.15	3118.85	41364
95	155.325	3292.11	43662
100	163.5	3465.38	45960

Table 33: Calculations (14)

Once the set area was found, the area taken by each solar panel could be calculated by multiplying the area per solar panel by the number of solar panels installed. The Total Emissions Offset by the Panels was taken by multiplying the Estimated Energy Generated per year by the

2018 Emission Factor. The Estimated Energy Generated was calculated by multiplying the energy generated per solar panel by the amount of solar panels installed.

Number of Solar Panels	Percent of 2018 Electricity Generated	Percent of Emissions Offset
1	0.09	0.09
5	0.47	0.47
10	0.93	0.93
15	1.40	1.40
20	1.86	1.86
25	2.33	2.33
30	2.79	2.79
35	3.26	3.26
40	3.72	3.72
45	4.19	4.19
50	4.66	4.66
55	5.12	5.12
60	5.59	5.59
65	6.05	6.05
70	6.52	6.52
75	6.98	6.98
80	7.45	7.45
85	7.91	7.91
90	8.38	8.38
95	8.84	8.84
100	9.31	9.31

Table 34: Calculations (15)

Once the amount of electricity generated per year was calculated, these numbers were divided by the Museum's 2018 Electrical Consumption (493,639 kWh) in order to determine what percentage of the museum's total consumption would be generated. The total amount of emissions offset from each number of solar panels was also divided by the emissions generated by electrical consumption in 2018 in order to determine the percent of the museum's emissions due to electrical consumption that would be offset.

Number of Solar Panels	Cost	Yearly Savings	Cost (Colones)	Yearly Savings (Colones)
1	$2,936.00	$71.15	₡1,761,600	₡42,688
5	$6,336.00	$355.73	₡3,801,600	₡213,438
10	$10,586.00	$984.42	₡6,351,600	₡590,654
15	$14,836.00	$1,625.80	₡8,901,600	₡975,477
20	$19,086.00	$2,267.17	₡11,451,600	₡1,360,300
25	$23,336.00	$2,908.54	₡14,001,600	₡1,745,123
30	$27,586.00	$3,549.91	₡16,551,600	₡2,129,946
35	$31,836.00	$4,191.28	₡19,101,600	₡2,514,770
40	$36,086.00	$4,832.65	₡21,651,600	₡2,899,593
45	$40,336.00	$5,474.03	₡24,201,600	₡3,284,416
50	$44,586.00	$6,115.40	₡26,751,600	₡3,669,239
55	$48,836.00	$6,756.77	₡29,301,600	₡4,054,062
60	$53,086.00	$7,398.14	₡31,851,600	₡4,438,885
65	$57,336.00	$8,039.51	₡34,401,600	₡4,823,708
70	$61,586.00	$8,680.89	₡36,951,600	₡5,208,531
75	$65,836.00	$9,322.26	₡39,501,600	₡5,593,354
80	$70,086.00	$9,963.63	₡42,051,600	₡5,978,177
85	$74,336.00	$10,605.00	₡44,601,600	₡6,363,000
90	$78,586.00	$11,246.37	₡47,151,600	₡6,747,823
95	$82,836.00	$11,887.74	₡49,701,600	₡7,132,647
100	$87,086.00	$12,529.12	₡52,251,600	₡7,517,470

Table 35: Calculations (16)

This table displays the numbers relevant to the ROI and Payback Period calculations. Each cost was taken from CRSolar’s website. It should be noted that the cost per solar panel decreases with the amount of solar panels installed, as CRSolar offers discounts which encourages businesses to install large amounts of solar panels at reduced costs. Due to this, the costs increase at a nonlinear rate. The yearly savings was calculated by multiplying the amount of electricity generated by the solar panels by the electrical rate given by ICE. The first 200 kWh is supplied at a rate of $0.1548 / kWh, while after 200 kWh any additional kWh is supplied at a rate of $0.2791 / kWh (Rico, 2019). Thus, the first 200 kWh generated by the solar panels are multiplied by $0.1548 / kWh, while anything else generated is multiplied by $0.2791 / kWh. Due to this rate, the yearly savings increases in a nonlinear fashion.

Number of Solar Panels	ROI ----->	2 Years	5 Years	10 Years	Payback Period (Years)
1		4.85	12.12	24.23	41.3
5		11.23	28.07	56.14	17.8
10		18.60	46.50	92.99	10.8
15		21.92	54.79	109.58	9.1
20		23.76	59.39	118.79	8.4
25		24.93	62.32	124.64	8.0
30		25.74	64.34	128.69	7.8
35		26.33	65.83	131.65	7.6
40		26.78	66.96	133.92	7.5
45		27.14	67.86	135.71	7.4
50		27.43	68.58	137.16	7.3
55		27.67	69.18	138.36	7.2
60		27.87	69.68	139.36	7.2
65		28.04	70.11	140.22	7.1
70		28.19	70.48	140.96	7.1
75		28.32	70.80	141.60	7.1
80		28.43	71.08	142.16	7.0
85		28.53	71.33	142.66	7.0
90		28.62	71.55	143.11	7.0
95		28.70	71.75	143.51	7.0
100		28.77	71.94	143.87	7.0

Table 36: Calculations (17)

In order to calculate the Return on Investment (reported in %), the savings generated over the specific time frame was divided by the initial cost of the installation and then multiplied by 100. So, to calculate the ROI for 2 years, the yearly savings for that specific number of solar panels is multiplied by two, and then divided by that number of solar panel's specific installation cost. This was done subsequently for 5 and 10 years. A high ROI indicates that over that specific time period, a large amount of savings was generated in comparison to the installation cost. An ROI over 100% indicates that the yearly savings have broken even with the installation cost, and now a net positive profit is being generated. The Payback Period is taken as the installation cost divided by the yearly savings for that amount of solar panels, indicating the number of years needed for the yearly savings to equal the same amount spent during the initial installation. As shown by this table, as the number of solar panels installed increases, the ROI will increase and the Payback Period will decrease, indicating that in the long run, a larger amount of solar panels will be beneficial for the museum.

Water

Below is the calculations for the ROI and Payback period of water consumption used by the current toilets at the CCCC and the ones we recommend switching to. Reference equations #-# for estimated total flushes per year calculation. Total liters of water used is a multiplication of estimated total flushes by the liters used based on each toilet's consumption. The liters saved is the difference of the number of liters produced by solely the old toilets subtracted by of the number of liters produced with x amount of toilets changed plus the liters produced from the remaining old toilets.The cost of water per year is the same difference equation applied using the price of water per liter in Costa Rica and the number of liters produced. Labor costs in Costa Rica could not be found so we used the national average of replacing a toilet in the United States of America as a baseline, knowing that average labor costs in Costa Rica is not as high as in the USA. Total costs are the summation of the labor, product and water costs for the year, while savings is the amount of money the center saves not purchasing the extra liters of water. Return on Investment calculations (ROI) is the division of the Savings over the total costs, multiplied by 100 to get a percentage. It shows a percentage of how much money you have saved based on your initial investment over the given time period. The payback period is the inverse of the ROI calculation without the percentage multiplication to give the organization a sense of how many years it takes for the savings to break even.

	Estimated based on Daily peak employee #		**Estimated based on Daily Attendance #'s**	
	Peak Employees	Off-Peak Employees	Peak Patrons	Off-Peak Patrons
	230	100	2230	1301
Avg Flushes a Day Per Person	2	2	1	1
# Days Per Year	70	242	70	242
Flushes/Yr	32200	48400	156100	314842
Estimated Total Flushes per Year	551542			
Estimated Water Usage per Flush	Old Toilets	New Toilets		
	13	4.81	Liters per Flush	
Total Liters Used	7,170,046	2,652,917		

Table 37: Calculations (18)

# Toilets Changed			
	Liters Produced Yearly		Liters Saved
0	7170046		0
10	6417191		752855
20	5664336		1505710
30	4911482		2258564
40	4158627		3011419
50	3405772		3764274
60	2652917		4517129

Table 38: Calculations (19)

	Cost per Toilet	$268.00	
	USD => CRC	$1 => 600c	600
Number of Toilets Bought	Total Cost (Not Including Labor Cost)	Cost in (CRC)	
10	$2,680.00	₡1,608,000	
20	$5,360.00	₡3,216,000	
30	$8,040.00	₡4,824,000	
40	$10,720.00	₡6,432,000	
50	$13,400.00	₡8,040,000	
60	$16,080.00	₡9,648,000	

Table 39: Calculations (20)

	Money Saved				
Avg Cost of Water per Liter	$0.48	₡288			
Current Exependitures on Water from Toilets (USD)	(CRC)	Number of Toilets Purcl	Number of Liters Saved	Money Saved (USD)	Money Saved (CRC)
$3,441,622.08	₡2,064,973,248	0	0	0	0
$3,080,251.76	₡1,848,151,057	10	752855	$361,370.32	₡216,822,191
$2,718,881.44	₡1,631,328,866	20	1505710	$722,740.64	₡433,644,382
$2,357,511.12	₡1,414,506,675	30	2258564	$1,084,110.96	₡650,466,573
$1,996,140.81	₡1,197,684,484	40	3011419	$1,445,481.27	₡867,288,764
$1,634,770.49	₡980,862,293	50	3764274	$1,806,851.59	₡1,084,110,955
$1,273,400.17	₡764,040,102	60	4517129	$2,168,221.91	₡1,300,933,146

Table 40: Calculations (21)

Labor Costs	(USD)	(CRC)		
0	$0.00	₡0		
10	$3,700.00	₡2,220,000	National Average to Replace (	$370.00
20	$7,400.00	₡4,440,000	National Typical Range to Rep	$218 - $522
30	$11,100.00	₡6,660,000		
40	$14,800.00	₡8,880,000		
50	$18,500.00	₡11,100,000		
60	$22,200.00	₡13,320,000		
Total Cost (Price of Toilets + Labor + Price of Water Used)	(USD)	(CRC)		
0	$3,441,622.08	₡2,064,973,248		
10	$3,086,631.76	₡1,851,979,057		
20	$2,731,641.44	₡1,638,984,866		
30	$2,376,651.12	₡1,425,990,675		
40	$2,021,660.81	₡1,212,996,484		
50	$1,666,670.49	₡1,000,002,293		
60	$1,311,680.17	₡787,008,102		

Table 41: Calculations (22)

Savings per Year (Depending on # of toilets Changed) (**Savings**)	(USD)	(CRC)
0	$0.00	₡0
10	$361,370.32	₡216,822,191
20	$722,740.64	₡433,644,382
30	$1,084,110.96	₡650,466,573
40	$1,445,481.27	₡867,288,764
50	$1,806,851.59	₡1,084,110,955
60	$2,168,221.91	₡1,300,933,146

Table 42: Calculations (23)

ROI (Savings/Total Cost)*100 (Per # of Toilets Perchased)	2 Years	5 Years	10 Years
0	0	0	0
10	11.72	29.30	58.60
20	26.52	66.30	132.60
30	45.80	114.50	229.00
40	71.95	179.88	359.77
50	109.46	273.65	547.29
60	167.75	419.37	838.74

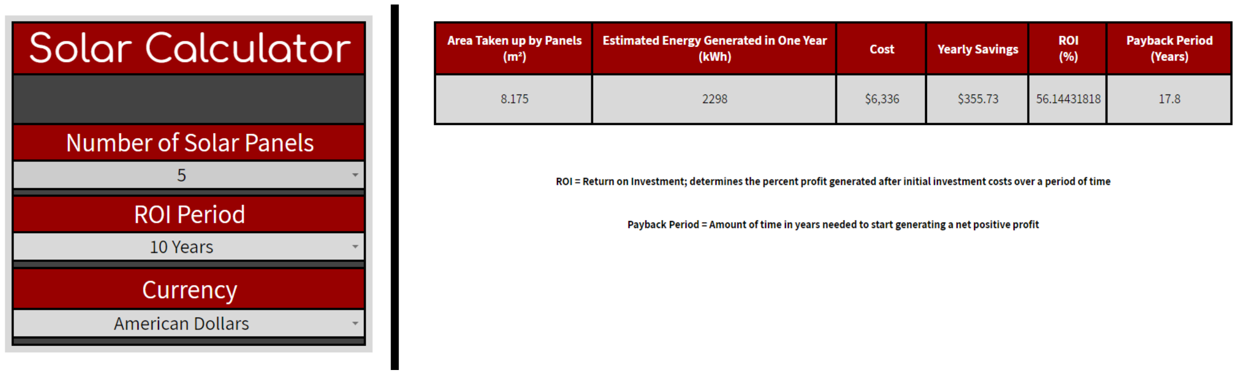
Table 43: Calculations (24)

Payback Period (Total Cost/Net Profit)	Years
0	0
10	17.07
20	7.54
30	4.37
40	2.78
50	1.83
60	1.19

Table 44: Calculations (25)

Appendix G: Calculators

Solar Panels

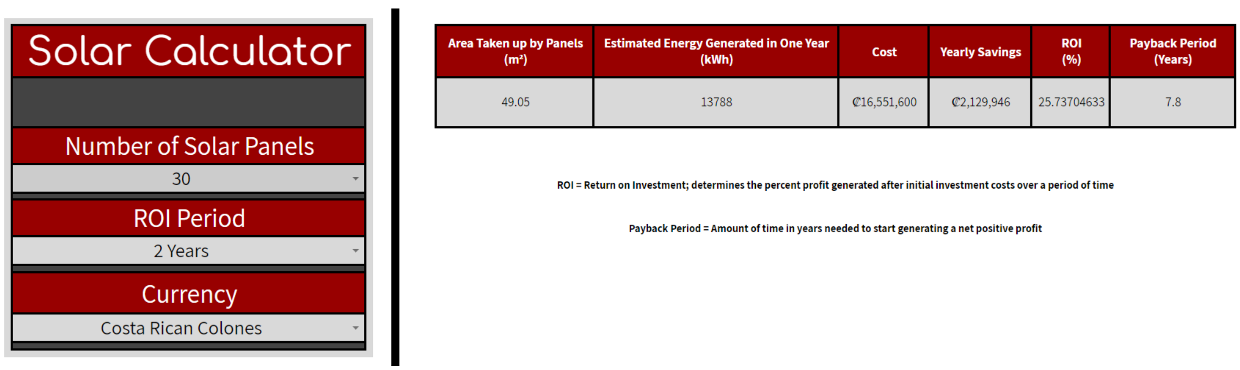


Area Taken up by Panels (m²)	Estimated Energy Generated in One Year (kWh)	Cost	Yearly Savings	ROI (%)	Payback Period (Years)
8.175	2298	$6,336	$355.73	56.14431818	17.8

ROI = Return on Investment; determines the percent profit generated after initial investment costs over a period of time

Payback Period = Amount of time in years needed to start generating a net positive profit

Figure 47: Calculators (1)



Area Taken up by Panels (m²)	Estimated Energy Generated in One Year (kWh)	Cost	Yearly Savings	ROI (%)	Payback Period (Years)
49.05	13788	₡16,551,600	₡2,129,946	25.73704633	7.8

ROI = Return on Investment; determines the percent profit generated after initial investment costs over a period of time

Payback Period = Amount of time in years needed to start generating a net positive profit

Figure 48: Calculators (2)

Water

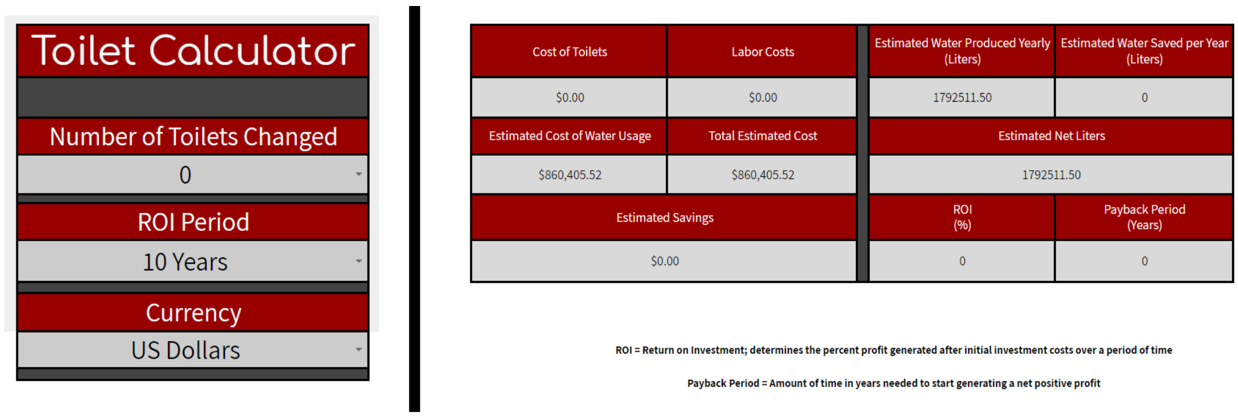


Figure 49: Calculators (3)

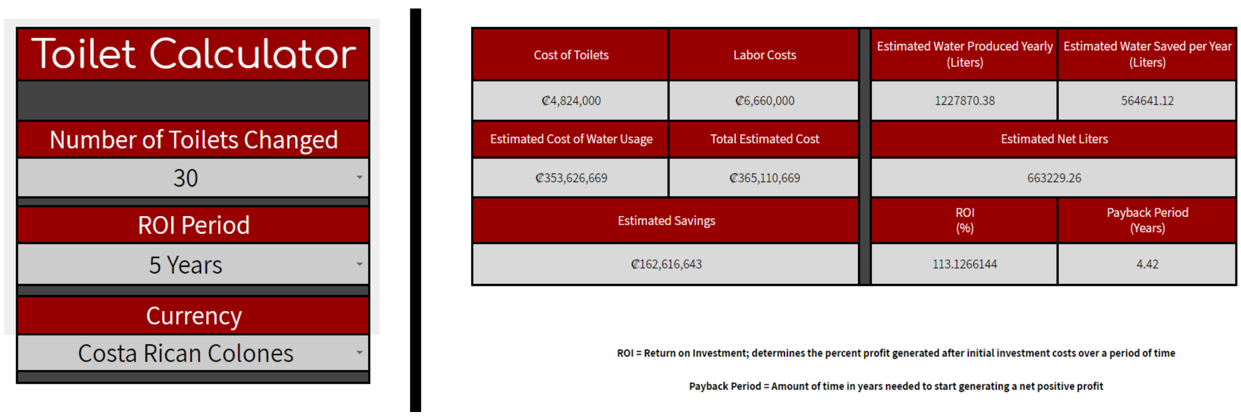


Figure 50: Calculators (4)

Appendix H: Final Deliverables

Recommendations Chart

Option	Impact on Program Goal	Technical Feasibility	Economic Feasibility	Sustainability	Organizational Culture Feasibility
Upgrade Lighting - LED	High	Medium	Medium	High	High
Sponsor a Forest Initiative	High	High	Medium	Medium	High
Water Efficient Toilets	High	Medium	Low to Medium	High	High
Going Paperless	High	Medium	Medium to High	High	Medium
Plastic Alternatives	High	High	Low	High	Medium
Solar Panels	High	Medium	Low	High	High
Carpooling Incentives	Low	Medium	Medium	Medium	Medium
Biodiesel	Low	Medium	Low	Medium	High

Table 45: Final Deliverables (1)

INTECO Help Sheet

A How to Guide:

Achieving a Carbon Neutrality Certification through INTECO

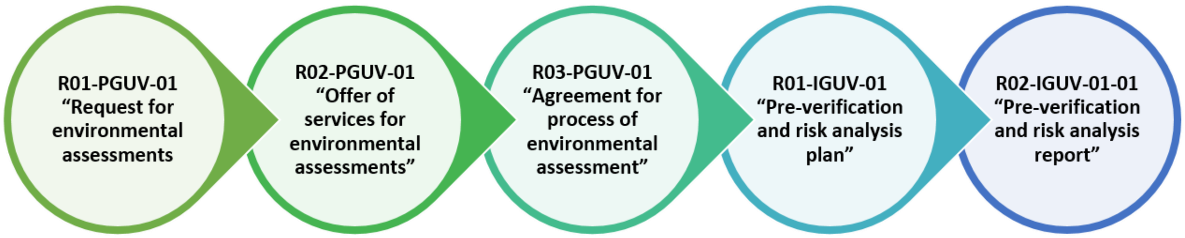
How does an entity achieve certification through INTECO?

INTECO's environmental assessment procedure goes through several stages which compares the current circumstances within the organization to a set specific standard that the organization is trying to achieve. This standard determines the evaluation criteria which is referenced for organizational compliance throughout the evaluation process. If an organization is compliant, then it will be granted the certification. If not, these areas of discrepancies are identified and the organization must submit a corrective action plan in order to show quantitative commitment towards the standard. (For the purposes of carbon neutrality, INTECO's INTE 12-01-06:2016 standard is referenced)

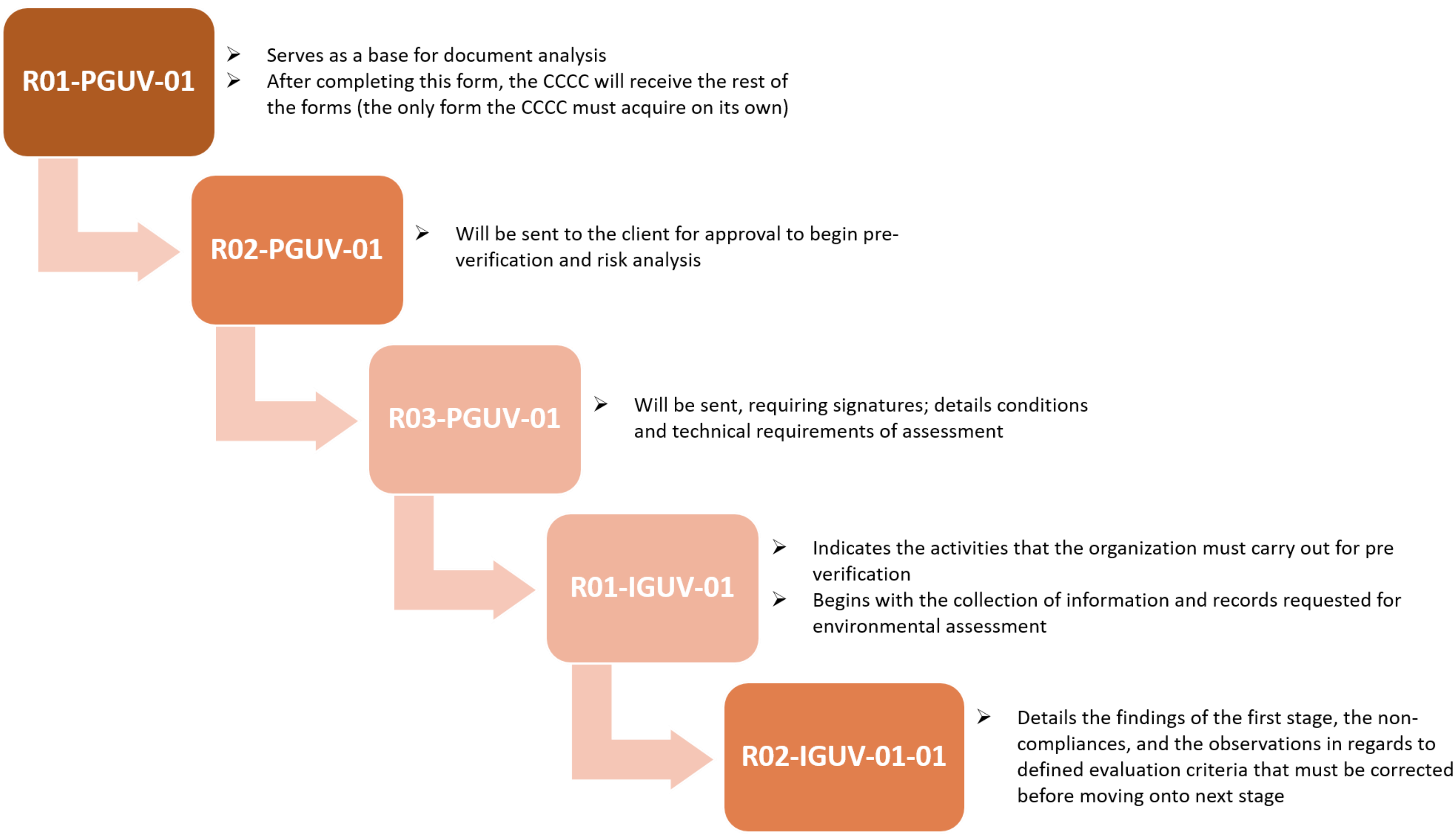
***It is IMPOSSIBLE for any organization to completely reduce their carbon emissions to ZERO. Carbon Neutrality is a COMBINATION of reducing emissions and the corresponding offsets from removing carbon from the environment (most commonly done with vegetation).**

Primary Steps:

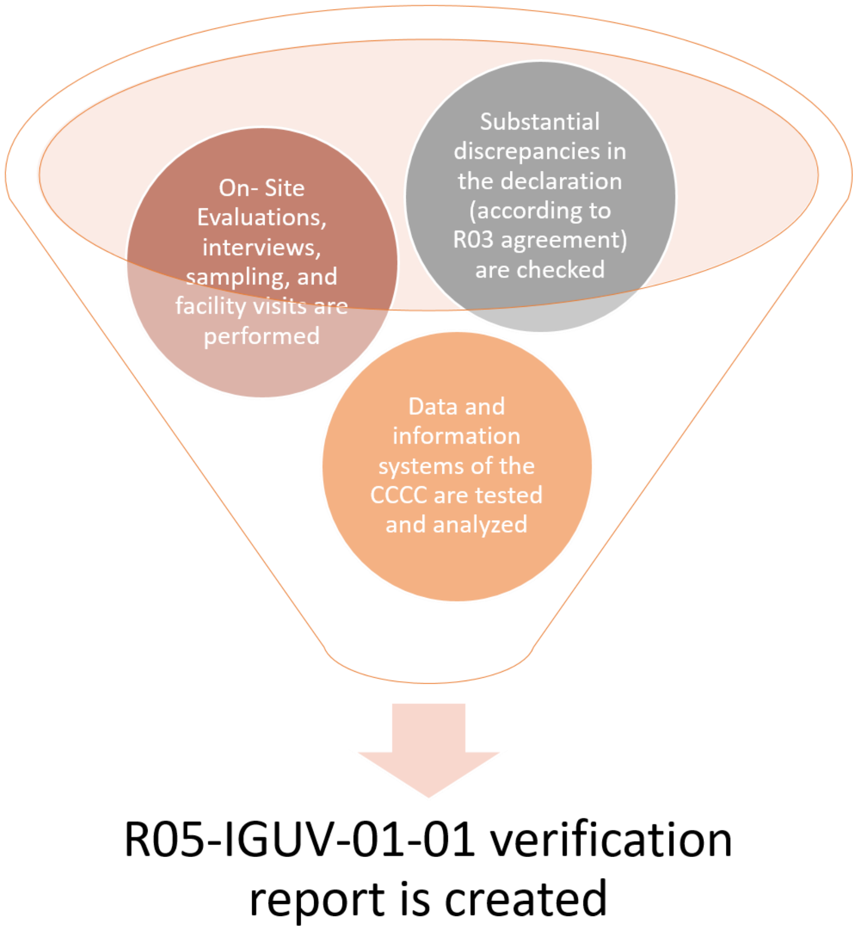
Pre-Verification



Pre-Verification Stage shouldn’t exceed 12 Months



Verification

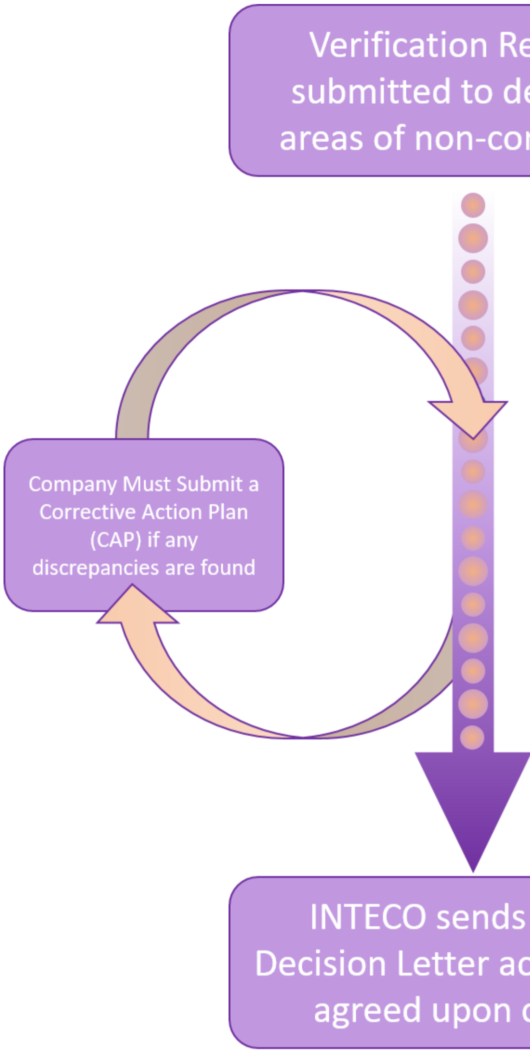


Verification process is planned by the evaluation team based on the R03 agreement and findings from the pre-verification stage

In this stage, it is checked if substantial discrepancies in the declaration according to the Agreement, performs on-site evaluations, interviews, sampling, visits facilities, analyzes and tests information systems and data from organization

Culminates in a verification report **R05-IGUV-01-01** presented to the organization, detailing any discrepancies or non-compliances in accordance to agreed evaluation criteria

Evaluation and Decision



In the event of discrepancies during verification, the organization has a max period of 30 days to submit a Corrective Action Plan (PAC) with evidence of changes and corrections; in cases of substantial discrepancies, evidence of closing actions will be submitted too

If the information provided is deemed sufficient, the team will give evaluate it and give its recommendations; if not, it can request for an extension in the period of the organization

In some cases, INTECO may require an evaluation at the client's facilities to close the action plan

The team member that reviewed the PAC will deliver a proposal to the person in charge of Coordination with **R03-IGEC-05-01 "Report on evaluation and decision of environmental assessment"**

INTECO has 15 business days to make final decision and send out a **Decision Letter** according to the agreed upon evaluation standard/criteria

Follow-Ups

Follow ups will be performed annually to ensure the organization is compliant with the evaluation criteria

The result will go through the evaluation and decision process at INTECO, where a final positive or negative decision is made about the granting/renewal/maintenance of the respective declaration

For footprints, a critical review is carried out every 2 years

For carbon footprint of activities, follow up is not required unless the activity is carried out again

Carbon Neutrality Standard Requirements:

In order to achieve the carbon neutrality certification from INTECO, the museum will have to be analyzed based on the evaluation criteria established by the certification, as described in Verification and Evaluation/Decision stage. Listed below are the requirements for INTECO's carbon neutrality certification, which consist of three different categories.

INTECO INTE 12-01-06:2016: Standard to demonstrate Carbon Neutrality

Definition

- Carbon neutrality defined by INTECO as:

$$\Sigma E - \Sigma R - \Sigma C = 0$$

  - E = Measurement of net total emissions/removals over year within operational limit of organization

- R = Further reduction of Greenhouse gas (GHG) emissions achieved by actions within organization
- C = Further reduction of GHG emissions achieved directly by actions outside of organizational limit, or indirectly by purchase of carbon credits

This standard establishes requirements for 3 different areas: the GHG Inventory, the Emission Reduction Plan, and Carbon Neutrality Management.

GHG Inventory Requirements:

- First, the GHG Inventory must clearly establish and document the **organizational / operational scope**
  - Define organization's objective
  - Determine **organizational limits**; whether **whole organization** or **part of it is** considered
  - Determine **operational limit**: identify direct / indirect emissions for energy
  - Identify other **GHG sources**
- **Identify** and **document** GHG emissions (direct and indirect) from energy consumption, as well as other indirect emissions
- **Must identify calculation methods**: in this case, it is multiplying with GHG emission factors
- **Identify emission factors**: must be updated, come from credible origin, appropriate, take into account uncertainty, consistent w/ intended use of GHG inventory
- Results must be reported in **single unit** (tonne CO_2e); emissions of different GHGs that have different Global Warming Potentials must be converted to tCO_2e (use GWPs from Intergovernmental Panel on Climate Change's website)

Requirements for Emission Reduction:

- **Reduction management plan**
  - Must **implement** management plan and **record** all reductions
  - Must include
    - **Statement of Carbon Neutrality commitment**
    - **Objectives** of GHG **reduction** in terms of **tCO_2e**
    - **Resources foreseen** to achieve/maintain reductions, including **assumptions** and **justifications**
    - **Estimate** of GHG **reduction**, **activities**, **personnel responsible**
  - Must establish **procedure** to periodically **monitor** and **evaluate** management plan
- **Documentation of plan**
  - Must have:

        - **Means** to achieve reduction
        - **Justifications** for methods, including **calculations** and **assumptions**
        - **Period of time**
        - **tCO2e reduced** from actions during **reporting period**
    - Quantifications must be done for each source **independently**
    - Must **define** and **quantify productivity/efficiency ratio** to evaluate GHG performance over time

Carbon Neutrality Management Requirements:

- Shall **develop, apply,** and **document** procedure to recalculate base year or subsequent GHG inventories
- Must **establish** and **maintain** GHG information management that:
    - Provides **routine** and **consistent** reviews, ensure **consistency** w/ **future** use of GHG inventory, **identify** and **treat** errors/omissions, **document** and **file** GHG inventory records
- Procedure for managing GHG information should consider the following:
    - **Identification** and **review** of person in charge of GHG inventory, implementation of **training** of employees, identification and review of **GHG sources/sinks**, review of **quantification methods**, **development** and maintenance of robust data collection system, **internal audits**, **periodic review** of opportunities to improve management process

Once the Carbon Neutrality Standard is achieved, the museum will have to devise a **report** to declare its **Carbon Neutrality** to third parties

- Must include:
    - Description of organization, objective/scope including operational/organizational limits, description of processes and sites that generate GHGs
    - Period of time
    - Direct, indirect, other indirect GHG emissions, quantified separately
    - Explanation of any changes in base year
    - Description of quantification methods
    - Documentation of GHG emission factors used
    - Description of impact of uncertainties in accuracy of GHG data
    - Description of GHG reductions obtained in scope of carbon neutrality
    - Results and conclusions to demonstrate Carbon neutrality

What the CCCC can do to achieve certification:

1) Establish a systematic method to **collect** and **document** museum's data
    a) Can be accomplished by keeping track of data on a monthly basis (such as electrical consumption, water consumption, etc.)
        i) As a result, the museum should **implement** a system that frequently inputs relevant data
        ii) The easiest way to accomplish this is through an Excel sheet of data that Carolina and others she trains are able to update and maintain
    b) The updated data can be used in frequent GHG inventory audits, which can help to showcase reductions in the museum's GHG emissions
2) Conduct a GHG inventory **calculation**
    a) The WPI Team calculated a carbon footprint analysis of the museum for 2018
    b) However, the museum must continue performing calculations every year
        i) For this, the museum can either reference the WPI Team's work OR it can contact third party businesses that perform GHG inventory audits on a professional basis
            (1) Having another business do it may be easier because the third party business will have all the up-to-date emission factors that might be hard to locate by the museum for future calculations
                (a) However, this can take longer than if the museum did it themselves and may cost money
            (2) Will not require any work from the museum besides supplying the necessary data
    c) The calculations made by the WPI team should be looked at for understanding which GHG sources in the museum should be taken into account and how a carbon footprint is calculated
        i) If the museum wants to calculate the carbon footprint themselves, they should use an Excel sheet modeled after the WPI team's that inputs yearly data and the emission factor for that year
    d) If a professional business is contacted, various businesses include:
        i) Carbon Footprint
            (1) https://www.carbonfootprint.com/
        ii) Enviro Access
            (1) https://www.enviroaccess.ca/?lang=en
3) **Document** every step of GHG inventory calculation
    a) INTECO's certification requires that every step of inventory is documented, as described above, as it is important to visualize the calculation methods and what factors were utilized

    b) If a third party professional audit is used, they will provide steps, calculation methods, emission factors, etc.

4) Establish strategies to **reduce** GHG emissions
    a) Set **goals** in reductions by specific years, and how these will be reached
        i) For example, the Smithsonian Institute set goals so that by 2025, its emissions will be reduced by 40% based off of electrical consumption and fuel usage, while emissions based off of indirect activities will be reduced by 20%
    b) This can be accomplished through the recommendations provided to the CCCC by the WPI team
    c) The CCCC will have to pick from the recommendations which projects to pursue
5) Perform **yearly** GHG inventory audits
    a) Yearly emissions audits are important as they help to document the museum's progress and milestones in reducing their GHG emissions
    b) These yearly audits can be accomplished significantly easier if a system is in place that keeps track of relevant data on a regular basis
    c) The museum must keep track of its yearly emissions in order to show progress in reducing its carbon footprint
6) Staff Training
    a) In order to make the carbon neutrality process easier, Carolina can train other staff members to help her
        i) This could include training to supply data in a better way so Carolina does not have to spend time finding data by herself
        ii) Train employees about carbon neutrality and how the carbon footprint is calculated
7) Contact INTECO
    a) Must send in application form in order to begin process of attaining carbon neutrality certification
    b) Carolina already has the form; can be found on INTECO's website on the page "Verificación de Gases Invernadero"