Assessment of the Carbon Neutrality of el Benemérito Cuerpo de Bomberos of Costa Rica

IQP Proposal

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Chapter 1: Introduction

In 2007, President Oscar Arias proposed an initiative to make Costa Rica carbon neutral by the year 2021, giving the country only 14 years to accomplish this momentous task. If Costa Rica achieves this goal, it will be the first carbon neutral country in the world. In a country that is carbon neutral, the net emissions from anthropogenic sources are zero, because the amount of carbon that is introduced into the atmosphere equals the amount of carbon that is later removed through other processes. There are two methods commonly employed to help achieve carbon neutrality. In the first method, the overall level of carbon emissions caused by human activity is lowered. This can be accomplished using green technologies such as solar or hydroelectric power plants instead of traditional methods that involve the burning of fossil fuels. In the second method, atmospheric carbon levels are reduced through carbon sequestration initiatives such as planting trees and through implementing greener technologies (Visser, 2008).

Even before President Arias' proposal, the nation was one of the most environmentally sustainable countries on Earth. In 2007, over 90 percent of Costa Rica's energy was acquired from renewable, low-emission sources such as wind, solar and hydroelectric plants. In addition, 3.2 million acres of Costa Rica's land is made up of protected conservation areas. Costa Rica's emphasis on low-emissions sources of energy and its ability to sequester carbon in conservation areas allow the nation to limit carbon emissions and maximize carbon sequestration. However, these advantages do not make carbon neutrality easily attainable. With a growing population, the number of vehicles on the road and the demand for electricity are increasing. Therefore, carbon emissions will continue to grow unless steps are taken to mitigate them (Long, 2011).

Many organizations in Costa Rica, both public and private, have recently joined the effort to move towards becoming carbon neutral (Brierly et al., 2011). One example of such an organization is the national fire department, known to Costa Ricans as "El Benemérito Cuerpo de Bomberos." Since 2007, the Bomberos have shown a commitment to becoming more environmentally sustainable through programs designed to reduce the amount of solid waste they produce (Perkins et al., 2008). The Bomberos

now aim to reduce their carbon emissions to help Costa Rica achieve the goal of carbon neutrality set forth by former President Arias.

The Bomberos are responsible for all fire protection and emergency services throughout Costa Rica. As of 2012, sixty-three Bomberos fire stations are active across the country. These fire stations are staffed twenty four hours a day by several hundred professionally employed firefighters (El Benemerito Cuerpo de Bomberos, 2012). In addition, over one thousand volunteer firefighters supplement the capabilities of these full time firefighters (Perkins, 2008). The process of firefighting is associated with high levels of carbon emissions (Campbell, 2012). Therefore, if a large, carbon intensive organization such as the Bomberos were to achieve carbon neutrality, it would be major step forward in Costa Rica's plan to become the world's first carbon neutral nation. The Bomberos could become a model for similar organizations both in Costa Rica and abroad to reduce their carbon footprint. In addition, the Bomberos' unique position as role models in communities across the country could raise awareness and inspire action among the populace about the issue of carbon neutrality.

The goal of this project is to work with the Bomberos on formulating strategies to reduce their carbon footprint over the next decade. Achieving this goal will require completing four objectives: evaluating the Bomberos' current carbon footprint using MINAE guidelines, determining explanations for the results of the assessment, identifying strategies for reducing the organization's carbon footprint, and presenting our recommendations to the Bomberos in the form of a yearly action plan.

The government of Costa Rica has declared that its carbon neutrality initiative will consider carbon emissions defined in the Guidelines on Inventories of Greenhouse Gases released by the Intergovernmental Panel on Climate Change (IPCC) (United Nations Environment Programme, 2012). These guidelines include carbon emissions from sources throughout society. Using this document, we will identify the carbon emission sources that are applicable to the Bomberos. In addition to reviewing the IPCC's guidelines and Costa Rica's laws, we will research carbon neutrality programs in other organizations to gain a better understanding of the carbon footprint caused by the Bomberos. Additionally, we will perform an audit on the organization using guidelines provided by the Costa Rican Ministry of the Environment (MINAE). Using the audit

results, our project will quantify and analyze the current carbon footprint of the Bomberos. Once we have quantified the organization's carbon footprint, we will perform observations and interviews during visits to at least five fire stations that have been chosen by our sponsor. These visits should produce explanations for the carbon footprint of the organization based on their daily practices, equipment and standard operating procedures. This information in conjunction with the calculated carbon footprint of the organization will facilitate the identification of potential methods that will reduce their carbon emissions.

An action plan will help the Bomberos reach carbon neutrality by 2021. This plan must balance the benefits of particular strategies for reducing carbon emissions with the feasibility of implementing such methods. For this reason, our approach incorporates t our sponsor's strong belief that their firefighting capability must not be compromised by any carbon reduction initiative. Our team will make recommendations for the Bomberos that take into account the financial and logistical capacity of the organization and will produce the greatest reduction of carbon emissions with their available resources.

Chapter 2: Background

The concept of carbon neutrality forms the centerpiece of our background research. Carbon neutrality is simple in theory, but becomes highly complex in application. This chapter reviews the history, international standards, and assessment methods to understand the nuances – and controversy – of carbon neutrality in Costa Rica. We begin with a brief introduction to the concept of carbon neutrality.

2.1 - Carbon Neutrality

This section provides a general overview of the topic of carbon neutrality. In addition to defining carbon neutrality, we discuss the controversy that is associated with its implementation. Lastly, we provide historical background on the international initiatives taken to combat rising carbon emissions.

Definition and Overview

A state of carbon neutrality is reached when the net transfer of carbon into the atmosphere due to human activities over a given time is zero. Carbon neutrality does not require that a country or organization emits no carbon. Rather, it requires that any atmospheric carbon emissions are balanced out by activities that subsequently remove carbon from the atmosphere. A point of confusion that surrounds carbon neutrality is the types of gases that are considered to be carbon emissions. The narrowest approach only considers the release of carbon dioxide (CO_2). However, the widest definitions include methane (CH_4), hydrofluorocarbons (HFC's), perfluorocarbons (PFC's), and even gases that do not contain any carbon. These discrepancies derive from the fact that the effect a greenhouse gas (GHC) has on the atmosphere is usually reported in equivalent units of carbon dioxide (Wiedman, 2007). In this case, the term "climate neutrality" is more applicable when considering all greenhouse gases. In fact, the Costa Rican government's own literature uses this term at times instead of carbon neutrality. The following statement comes from the Costa Rican Ministry of Environment and Energy's 2008 Summary of the National Climate Change Strategy:

> "The Costa Rican Climate Neutrality Strategy is defined as a balanced zero or negative national inventory of emissions by sources and absorption by sinks of all anthropogenic activities from the different sectors considered by the IPCC Guidelines on Inventories of Greenhouse Gases. This strategy seeks to have zero impact on the climate" (Dobles, 2008).

As can be seen, carbon neutrality is not mentioned in the Ministry's list of national environmental objectives. Instead, the document uses the term "climate neutrality." The theory behind the two terms is the same; however the range of the emissions analyzed provides the difference. For this reason, the two terms are commonly used interchangeably; in Costa Rica, carbon neutrality and climate neutrality are both used to refer to the standards set forth by the government. However, this can cause a misunderstanding if two parties are using different classifications of carbon emissions. In order to determine the extent of an organization's carbon neutrality, the carbon emissions of the organization must be quantified. This quantity is known as the carbon footprint.

Carbon Footprint

The concept of a "carbon footprint" is the most common and direct way of evaluating an organization's carbon emissions. The term carbon footprint originated as a modification of the phrase "ecological footprint," which is the calculation of human need or demand in relation to available land (Matthews, 2008). A carbon footprint is commonly defined as the amount of carbon released into the atmosphere by the activities of an individual or organization (Wiedman, 2007). As with carbon neutrality, whether a carbon footprint includes non-carbon greenhouse gases depends on the organization that calculated the footprint. The variations in how the term "carbon footprint" is defined leads to differences in the methods used to calculate carbon footprints.

A carbon footprint can be measured by assessing carbon emissions produced by an entity. Carbon emissions occur in two major categories. The first category is large scale electrical power generation, which includes coal and natural gas fired power plants. The majority of Costa Rica's electrical power is generated via hydropower and

only five percent of electricity produced in the country in 2006 produced carbon emissions (Environmental Entrepreneurs, 2008). The Bomberos do not have any control over the generation of electricity by power plants; for this reason, reductions in the carbon emissions from Costa Rica's power grid are beyond the scope of this project. Instead, we can only seek to reduce the electrical consumption of the Bomberos. Another major source of GHG emissions is vehicles and heavy equipment. Most forms of mechanized transportation in the world involve the combustion of fossil fuels. Often, it is difficult for an organization to reduce their carbon emissions caused by fuel use because they are limited by what equipment is available for purchase. Costa Rica's transportation sector runs primarily on diesel fuel (Environmental Entrepreneurs, 2008). The majority of the Bomberos' carbon footprint will likely be caused by emissions from their fire trucks and other emergency vehicles.

With the variety of ways carbon can be emitted, a four-tier system is generally used by auditors to estimate and analyze carbon footprints. The tiers cover different boundaries used in calculating carbon emissions. The tiers are shown below in Figure 1.

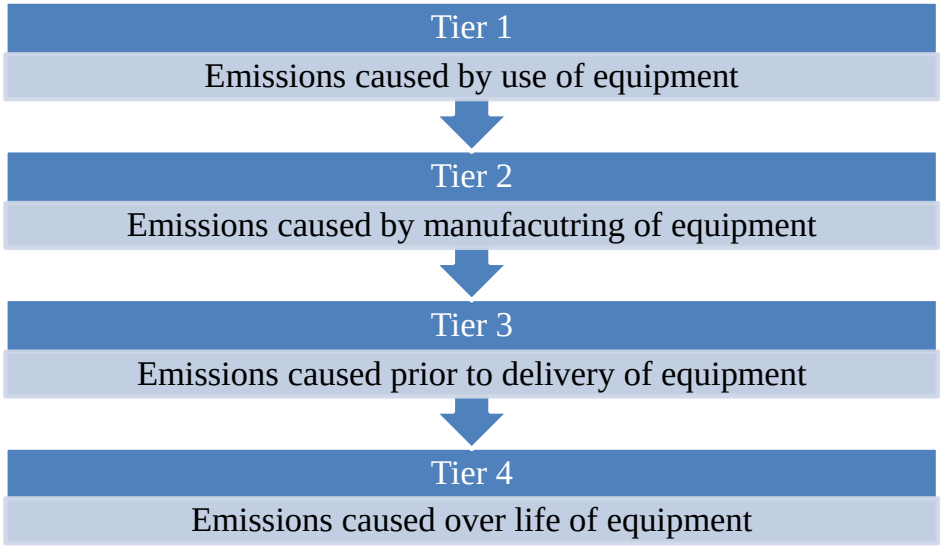

Figure 1: Diagram of Four-tier System used to Calculate Carbon Footprints (Matthews, 2008)

A product can be analyzed using any of the tiers; the tier used depends on the focus of the study and the resources available to the auditor. In the first tier, only emissions produced directly by the operations of the organization are considered. This includes emissions from building heating systems or emissions produced by energy used for lighting, computers and other office necessities. In the second tier, the emissions from the manufacturing of the products used in the first tier are taken into consideration. Usually, this tier contains energy-intensive processes that would cause the release of carbon gases. The third tier consists of all of the emissions from the extraction of raw material to the delivery of the final product. This tier is often called the “cradle to gate” tier. Lastly, the fourth tier considers not only all emissions from the “cradle to the gate” tier but the additional output caused by the delivery, use, and end-of-life aspects of the product as well. For this reason, tier four is often referred to as “cradle to grave” tier. The emissions included in the fourth tier consist of all carbon emitted during any phase of an item’s “life.” This tier consists of a massive amount of data and is often used when calculating a Life Cycle Assessment (LCA) for a product (Matthews, 2008). However, LCAs and carbon footprints are not synonymous. General Life Cycle Assessments consider not only carbon emissions, but all byproducts created by a product. LCAs are used for determining the overall sustainability of an item by taking every possible environmental impact that a product has into consideration. A Life Cycle Assessment must be performed on a product by product basis. Therefore, a massive amount of life cycle assessments would need to be performed for organizations that use hundreds of different types of equipment such as the Bomberos. This would require an enormous amount of resources and time. For this reason, LCAs are not included in the calculation of a carbon footprint of an organization.

Controversy Surrounding Carbon Neutrality

Discrepancies have arisen regarding the methods used to calculate and assess an organization’s level of carbon emissions. In particular, a considerable amount of confusion surrounds the tools used in the measurement of carbon footprints. Numerous carbon emission assessment tools exist for determining the size of a carbon footprint. These calculators operate using different definitions and assumptions about what

constitutes a carbon footprint. For this reason, each calculator includes unique equations. Furthermore, most carbon emissions calculators are specialized for a particular industry. Despite this, there is still considerable variation among calculators within a specific industry (Padgett, 2008). Differences in accounting mechanisms allow the same data to be input into different tools and produce drastically varied results. Murray (2009) examined this phenomenon by comparing a number of calculators. He accomplished this by creating a hypothetical footprint and trying to input the same information into each calculator. The study showed that the different calculators tested produced results that varied up to 3.5 tons. These discrepancies could be solved by adherence to a single international standard (Murray, 2009).

Attempts have been made to address the discrepancies in assessment tools. For example, in 2011 the government of Australia passed legislation on a carbon neutral program guideline. Furthermore, an additional piece of legislation was passed to ensure that regulators have the ability to amend the guidelines at any time (Australian Government, 2011). Each country that is attempting to become carbon neutral, including Costa Rica, has set its own standard for what this entails. However, differences in these national standards have caused considerable ambiguity for organizations.

In addition, the verification of carbon emission offsetting has created significant controversy. Carbon emission offsetting is defined the act of balancing an organization's carbon emissions through either carbon sequestration or the purchase of carbon credits (Direccion de Cambio Climatico, 2012). These carbon credits are the credits in a system that is created within a nation, rather than the international credit system that was established with the Kyoto Protocol. Organizations can purchase carbon credits from their respective government or accredited parties. When a party purchases a carbon credit, their money may be allocated to help fund the research of technology that promises to cut down carbon emissions. The money may also be put toward carbon sequestration programs that actively remove carbon from the atmosphere. One carbon sequestration method commonly employed is the planting of trees in areas that have previously been deforested. These newly planted trees sequester carbon from the atmosphere and, in theory, offset the carbon emissions produced by an organization.

There has been disagreement on whether carbon credits or other offsetting methods are accurate. The major problem with these programs is that they often take significant amounts of time before they begin to substantially reduce carbon gas levels. However, this lag time is not always taken into account when calculating the amount of carbon emissions that have been offset.

The verification process for determining carbon neutrality is equally as controversial. Depending on how carbon credit money is used, there is no reliable method for an organization to determine if its carbon emissions have been balanced out by sequestration initiatives. If an organization invests in projects for sustainable, non-carbon intensive development, their emissions will not be offset for many years after their initial investment. Instead, the organization can only hope that its current carbon emissions will be offset via the elimination of future carbon emissions. Consequently, it is possible for an organization to emit large amounts of carbon dioxide yet still earn the label of carbon neutral by investing a considerable amount of money in technologies that may remove carbon from the atmosphere in the future. Therefore, the carbon neutral label has an emphasis on the offset of emissions rather than the reduction of emissions (Murray, 2009). To counteract the ambiguity of carbon credit use, nation's that are striving to achieve carbon neutrality are strict on the matter of official national and international methods for offsetting and carbon credit participation. Companies that act as the intercessor between the companies and the application of carbon credit funds must be accredited. Accreditation can come from the IPCC or from specific government ministries (Instituto de Normas Tecnicas de Costa Rica, 2011). Along with this, in order to monitor that an organization is implementing its proposed carbon neutral changes, appropriate government agencies perform scheduled audits.

History of International Action on Carbon Emissions

The threat of climate change and the need to reduce carbon emissions has gained longstanding recognition by the international community. Since the early 1970s, over a dozen global conferences and summits have been convened to address the issues posed by increasing greenhouse gas emissions and their negative impact on the global environment. The first of these conferences was held from June 5 to June 16,

1972 in Stockholm, Sweden. This conference, known as the United Nations Conference on the Human Environment (UNCHE), was unprecedented in its scope and magnitude and represented a major shift in global perception of environmental policy. In total, representatives from 113 nations as well as hundreds of non-governmental and intergovernmental agencies were in attendance. As a result of this conference, global awareness of the potential dangers associated with rising carbon emissions increased profoundly (United Nations Environment Programme, 2012). However, the conference was only a basic attempt to lay the groundwork for future international cooperation on addressing environmental issues. As a result, the Stockholm conference advocated extremely broad policy goals and failed to take more comprehensive actions (Handl, 2008).

Despite the groundbreaking nature of the Stockholm conference, it failed to produce tangible negotiations about climate change policy. It was not until twenty years later in 1992 at the Rio Earth Summit that an effort was made in devising international standards to combat rising global emissions. At this summit, the first international agreement seeking to "prevent dangerous anthropogenic interference with the Earth's climate system" was established (United Nations, 1997). This agreement, known as the United Nations Framework Convention on Climate Change (UNFCCC) called on its participants to diminish the growing level of carbon dioxide and other greenhouse gases that were threatening to destabilize the Earth's climate. Though the UNFCCC was nonbinding, it required all nations that participated in the convention to create their own set of national policies and to take action against lessening emissions. In addition, industrialized nations that participated in the Organization for Economic Cooperation and Development (referred to as Annex I nations) were obliged to assist developing countries in establishing their own environmentally friendly programs through financial contributions to the Global Environment Facility (United Nations Framework Convention on Climate Change, 2012). Despite the fact that nearly every country (including the United States) signed this agreement, it largely failed in its goal to motivate nations to adopt environmentally conscious policies as carbon emissions continued to rise over the subsequent decade (Levin & Bradley, 2010).

Because of the failure to produce an international agreement to curb greenhouse gas emissions, the member states of the UNFCCC decided that a stronger directive was needed to spur international action to limit carbon emissions. After several years of additional conferences and negotiations, an international agreement to set substantial goals from emissions reduction was finally agreed upon in 1997 in Kyoto, Japan (McKibbin & Wilco, 2002). This agreement, known as the Kyoto Protocol, was fundamentally different from its predecessors because of its binding nature. While the United Nations Framework Convention on Climate Change merely encouraged industrialized nations to drawback carbon emissions, the Kyoto Protocol required its signatory nations to do so. In total, 37 industrialized nations in addition to the European Union accepted this agreement. However, the world's largest producer of carbon emissions – the United States – declined to make any binding international commitments to reducing its carbon footprint at that time and did not agree to the conventions laid out in the Kyoto Protocol. Despite this, participating nations pledged to reduce carbon emissions by an average of 5% below 1990 levels in the five year period between 2008 and 2012 (United Nations Framework Convention on Climate Change, 2012).

The Kyoto Protocol additionally established several mechanisms to ensure that participating nations are capable of fulfilling their pledges to reduce their carbon footprint. To assist nations reach their goals in a fiscally-responsible manner, the treaty established a system of emissions trading, or a so-called "carbon market." If a nation produces fewer emissions then it pledged initially under the protocol, they are able to sell their remaining "emission units" to other nations who have exceeded their limit. This system rewards nations who exceed their responsibilities with a potentially large financial incentive. Furthermore, the Kyoto protocol has established Clean Development Mechanisms (CDMs) and a Joint Implementation (JI) system to further assist signatory nations reach their emission goals in a financially responsible fashion. These mechanisms, along with obligatory reporting, registry systems and compliance, help track the progress of member nations' efforts to reduce carbon emissions (United Nations Framework Convention on Climate Change, 2012).

Intergovernmental Panel on Climate Change

One of the foremost authorities on carbon emissions and the role they play in climate change for the past two decades has been the Intergovernmental Panel on Climate Change (IPCC). The IPCC was established in 1988 by the World Meteorological Associated and the United Nations Environment Programme to assess the scientific, environmental and socio-economics implications of climate change. In addition, the IPCC was asked to formulate feasible strategies reverse the effects of anthropogenic climate change. In its first assessment report published in 1990, the IPCC concluded that anthropogenic climate change is a major problem that will persist for centuries. This report served as the foundation for the negotiations at the 1992 Rio Summit that ultimately led to the formation of the UNFCCC. In 1995, the IPCC issued its second assessment report on the state of anthropogenic climate change. The findings in this report played a major role in the adoption of the Kyoto Protocol in 1997. To this day, the IPCC serves as the major source of information on climate change to the UNFCCC (Intergovernmental Panel on Climate Change, 1995).

The IPCC regularly issues guidelines to the global community on determining greenhouse gas emission levels as well as effective strategies to reduce them. To accomplish this, the IPCC has established four criteria that should be used to evaluate potential environmental policy strategies. The first criterion the IPCC defines is environmental effectiveness. This criterion stipulates that the efficacy of the policy must be evaluated. In particular, it must be determined whether the policy or strategy selected is capable of producing the environmental objective. Secondly, one must look at the policy's cost-effectiveness. This criterion not only looks at the financial cost that a policy will incur but also at its social impact. Thirdly, certain "distribution considerations" must be taken into account. In other words, the policy must contain a satisfactory level of fairness and equity to all stakeholders. Lastly, the IPCC states that institutional feasibility, or the likelihood that the suggested policy will be implemented and be accepted as practicable and effective, must be taken into consideration. These four criteria can be applied at any level; they can be used to evaluate a number of policies ranging from the organizational level to government institutions. However, it should be noted that these are not the only four criteria used to evaluate suggested environmental

policies. However, these are four criteria that are generally accepted and are frequently used by the IPCC (Bosch et al., 2008).

The Intergovernmental Panel on Climate Change has additionally developed an international guideline for governments to use in order to determine the levels of greenhouse gas emissions in an area. According to this document, global carbon dioxide emissions must be reduced by at least 50% by the year 2050 in order to avoid the worst possible impacts of man-made climate change. In particular, the IPCC has focused on three major causes of emission. The first cause of emissions includes those produced by transportation. These emissions are considered to be those caused by all vehicles, including aviation and marine vessels that carry passengers or freight. Depending on the scope of evaluation, this can refer to transportation at a local or international level. The next cause of emissions defined by the IPCC is waste production. This criterion can be difficult to study because waste is usually transported away from the area being audited to a landfill. The third source of carbon emissions considered by the IPCC is “out-of-boundary” emissions. This category includes emissions produced by the generation of power and heating. Much like waste production, it is difficult to accurately determine the contribution of “out-of-boundary” sources to overall greenhouse gas emissions. Lastly, when attempting to define the carbon footprint of a region or organization, it is important to take greenhouse gas emissions associated with food, water, fuels and building materials into consideration. Even though these factors do not contribute as much as the other three factors considered, they can constitute a large portion of greenhouse gas emissions (Intergovernmental Panel on Climate Change, 2010).

In sum, the Intergovernmental Panel on Climate Change has established a number of guidelines that are meant to assist governments when formulating their own environmental policies. Before any policy is implemented, the IPCC recommends that its effectiveness, cost, feasibility and “distribution considerations” be taken into consideration. Additionally, the IPCC has also established guidelines for determining the carbon emissions produced by a given area. However, their guidelines are subject for interpretation. Therefore, Costa Rica is faced with the challenge of formulating its own

policies that will enable them to achieve their goal of reaching carbon neutrality by the year 2021.

2.2 - Costa Rican Carbon Neutrality Standards

In 2012, the ministry of environment (MINAE) issued their own standards and a recommended process for organizations to become carbon neutral. The document outlines the emissions to be considered for carbon neutrality: carbon dioxide, nitrous oxide, methane, perfluorocarbons, hydrofluorocarbons, and sulfur hexafluoride. The MINAE's document is based on the IPCC's Guidelines for National Greenhouse Gas Inventories (United Nations Environment Programme, 2012). In Costa Rica, an organization can declare itself a participant in the carbon neutrality program and only its emissions from the previous year will be factored into its carbon footprint. However, in order for an organization's carbon footprint to be verified, it must be audited by an accredited official enlisted with the Costa Rican Accreditation Entity (ECA). The only exception to this rule is when the verifier is accredited in another country and approved by the MINAE. The certification of the carbon neutrality procedure is done according to INTE 12-01-10:2011. This document was formed by the technical standards of Costa Rica (INTECO) and serves as a guideline for achieving carbon neutrality. The three general categories for climate emission offsetting are Certified Emission Reduction (CER), Voluntary Emission Reduction (VER), and Costa Rican Compensation Units (UCC). CER and VER are practices accepted on the international level. UCC involves a carbon credit system created by MINAE. If a company wants to register actions performed under these standards, it must file a claim with the National Forestry Financing Fund (FONAFIFO). MINAE is the authoritative power for granting the title of "C-Neutral' and is responsible for policing proper marketing use. The company or organization will be registered in the MINAE database and the national industrial property registry as carbon neutral until an emissions audit has been failed (Ministerio de Obras Publicas y Transportes, 2012).

2.3 - El Benemérito Cuerpo de Bomberos de Costa Rica

The national firefighting organization of Costa Rica is known as “El Benemérito Cuerpo de Bomberos.” The Bomberos have a highly structured operational structure, so any efforts to reduce the organization’s carbon emissions must take this system into account. As of the year 2012, there are over 1,500 professional and volunteer firefighters spread out among sixty-three fire stations in Costa Rica. Their mission is “to protect Costa Rican society when life, property and the environment are threatened by fires and emergency situations, based on the highest principles in human and ongoing pursuit of excellence” (Benemerito Cuerpo de Bomberos de Costa Rica, 2012c). Every fire station has a designated coverage area that is based primarily on response time, risk level and population. This enables the Bomberos to fulfill their vision of being able to handle all threats to life, property and the environment from fire and other emergencies in Costa Rica (Benemerito Cuerpo de Bomberos de Costa Rica, 2012c).

The firefighters are able to effectively carry out their vision, in part, because of the Office of Communications (OCO). When a 9-1-1 call is determined to be the responsibility of the fire department, the call is forwarded to the OCO. The OCO then determines the resources to send to the site of a fire based on the phone call received. Additionally, the location and status of emergency vehicles are controlled by this office. This enables the Bomberos to allocate emergency services where they are needed the most in a timely manner (Benemerito Cuerpo de Bomberos de Costa Rica, 2012a). The records of the allocation of resources and the distance the emergency vehicles travel that are kept by the OCO may be useful in our analysis of the carbon emissions of the Bomberos. Of course, there are several other departments within the Bomberos that will be able to assist in research that will determine how their organization can become carbon neutral.

The Bomberos are administrated by a Board of Directors called the Costa Rican Board of Fire Service. This board consists of five members. The National Insurance Institute appoints three of these members while the Bomberos appoint the remaining two. The board is headed by a president, who is elected by the group. The Board serves a central role in the administration of the Bomberos; its responsibilities include authorizing the creation of jobs, and issuing regulations for optimal performance.

Furthermore, the board approves the budget and appoints the internal auditor and General Director of Fire. The General Director of Fire plays an important role by acting as the “face” of the organization and representing the National Fire Department to both national authorities and international institutions. The individual who holds this position allocates the department’s resources and works closely with the board. The General Director also submits a strategic organizational plan, an annual operating plan, and a budget plan to the board for approval (Benemerito Cuerpo de Bomberos de Costa Rica, 2012d).

The General Director is assisted by operations headquarters in carrying out his or her duties. There are a total of seven operation headquarters located throughout Costa Rica. An operations headquarters is composed of nine fire chiefs, each which is in command of a single fire station. An operations headquarters is subdivided into three zones, with each zone consisting of three chiefs. The chiefs of each zone help to determine the resources that a station in their needs based on the population size and the perceived risk of the zone. A flow chart depicting the organization of an operations headquarters in shown below in Figure 2.

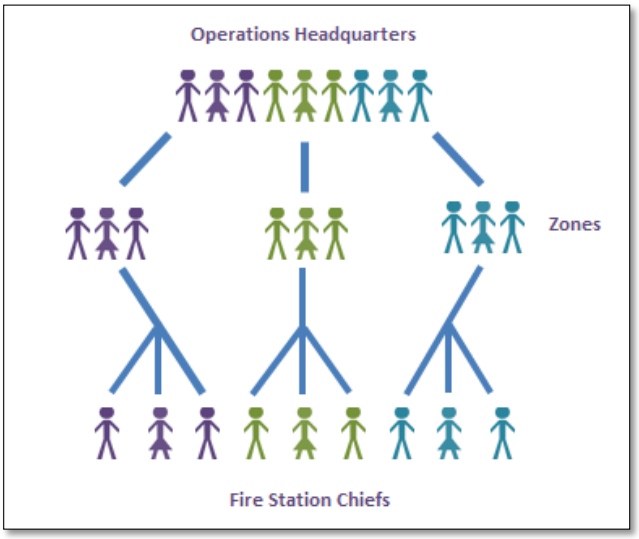

Figure 2: Flow Chart of Bomberos Chain of Command

Maintenance of firefighting equipment for all stations is controlled by the Department of General Services. This department is divided into four areas that specialize in the upkeep of specific areas of the fire stations. The emergency vehicle division repairs fire trucks through the coordination of the Fault Services Office and the Workshop Area. Modifications and extensions to fire stations, along with annual repairs are made by the building maintenance division. The radio communications unit ensures that all portable, base and mobile radios are functioning properly. The fourth division of the Department of General Services is the unit procurement and material resources unit. This division is unlike the other three in that rather than performing routine repairs, this unit ensures the distribution of materials to fire stations as decided upon by the Operations Headquarters. The materials being distributed range from extinguishing units to kitchen supplies. Once these devices are installed, the Department of General Services ensures that the new materials are working properly (Benemerito Cuerpo de Bomberos de Costa Rica, 2012d).

The Department of Fire Engineering promotes the prevention of fires across Costa Rica. This department works within the fire stations and at the site of a fire after it has been extinguished. Engineers research the site of origin of the fire in order to determine its cause. Within the fire stations, engineers ensure that fire stations meet the codes set forth by the Manual of General Technical Provisions on Human Security and Fire Protection. Engineers may also provide consultation to the building maintenance division before construction begins. Furthermore, the Department of Fire Engineering tests operating equipment, such as fire hydrants, and rates service drills, such as evacuation and rescue drills of the firefighters (Benemerito Cuerpo de Bomberos de Costa Rica, 2012d).

Comment [rek1]: What happened to the diagram you had of the Bomberos structute?

Comment [J2]: Professor Kinicki:
The diagram of the structure is Figure 6 and has been placed in the text of the methodology were we talk about the structure's role on our methodology. We can move it here if you think that would flow better.

Challenges faced by the Bomberos in becoming Carbon Neutral

While the Bomberos consistently put forth their best effort to protect Costa Rica, they will inevitably face several challenges in attempting to become a carbon neutral organization. Among these challenges is the geography of Costa Rica. Many of the mountainous areas do not have modern, paved roads for travel, making it difficult to maneuver fire trucks in these settings. This means that it will take firefighters longer to

get to the site of the fire because the route from their station to the fire is not direct. This causes the fuel consumption to be higher than it would be in areas with well-paved roads because the distance that the firefighters must travel is farther. In addition, firefighters are distributed around the country based on population density. There are fewer firefighters located in the mountains where less people live. As a result, the firefighters working in these rural districts have a large span of rough terrain to protect, as well as extinguishing any forest fires that occur. As a result, the Bomberos' network can become strained if there are multiple fires at once. This could mean that several stations must send firefighters to the site of a fire in order to have enough force to put it out. The more emergency services required, the more carbon emissions given off by the fire trucks departing for the site of the fire. Furthermore, as the population of Costa Rica grows, more issues arise – a densely populated city will have more fires than a smaller city. This may lead to more firefighters being hired, which will increase the amount of electricity used at the fire station, and again, increase fuel usage when traveling to site of a fire. However, as explained in the next section, it is not required that an organization completely eliminates their carbon emissions to be considered carbon neutral (Argun, 2009).

2.4 - Case Studies

This section presents three case studies that focus on previous attempts undertaken by various entities to reduce their carbon emissions. To get a broad understanding of the strategies that have been used previously, we look at entities of different sizes. In particular, we discuss the European Union, Dell and CAL FIRE.

European Union Case Study

Over the past three decades, the European Union (EU) has been at the forefront of international efforts to combat rising carbon emissions. Under the auspices of the Kyoto Protocol, fifteen of the EU's member states (referred to as the EU-15) pledged to cut their individual carbon emissions by at least 8% below 1990 levels between the years 2008 and 2012 (European Environment Agency, 2012). However, the remaining twelve members of the European Union have yet to make a similar commitment. To

ensure that all participant states meet the goals that have been set forth, the European Environment Agency (EEA) employs a number of methods through which member states and other international agencies can monitor all emissions produced by anthropogenic sources. For example, the EEA compiles an annual report, known as the EU inventory, of the GHG emissions from each of its member states. This report uses the emissions data in conjunction with energy data obtained from Eurostat in order to calculate the amount of emissions created through energy production. Furthermore, the EU inventory also assesses the European Union's progress in meeting emission standards set forth by the UNFCCC and the Kyoto Protocol. Member states use the report to guide implementation of national programs that reduce greenhouse gas emissions (Levin & Bradley, 2010).

The European Union further strengthened its commitment to combating rising emissions and its negative effect on the environment by implementing the Climate and Energy Package in April 2009. The ultimate goal of this initiative is to prevent global temperatures from rising to no more than two degrees Celsius greater than pre-industrial era levels. To accomplish this, the European Union increased its commitment by aiming to reduce greenhouse gas emission levels to 20% of 1990 levels by the year 2020. Additionally, the European Union promised to further increase this reduction to 30% if other major greenhouse gas emitting nations also agree to play a large role in reduction efforts.

Thus far, the European Union has been successful in reducing carbon emissions through the establishment of standards and regulations based on the provisions of the Kyoto Protocol and the Climate and Energy Package. Between the years 1990 and 2010, the 27 European Union member states have been able to successfully decrease their collective emissions by 15.4%, the equivalent of 862 million tons of carbon dioxide. However, emissions have increased in recent years. Between 2009 and 2010, carbon emissions from the entire European Union have increased by a factor of 2.4%, or 111 million tons of carbon. Despite these recent increases, the European Union's efforts to reduce their carbon emissions have been successful. As stated previously, the European Union as a whole has pledged to reduce carbon emissions by at least 20% of 1990 levels by the year 2020. In spite of the recent increase in carbon emissions, the

European Union currently stands at less than 5% away from its emissions target with ten years remaining to fulfill its commitment. However, the ultimate success or failure of the European Union's efforts is yet to be determined. Regardless, this case study shows that reducing carbon emissions on a large scale is feasible (European Environment Agency, 2012).

Dell Inc. Case Study

In 2008, Dell Inc. made carbon neutrality a top priority. They replaced incandescent light bulbs with florescent ones and required part suppliers to list information on their environmental policies. Company leadership declared energy reduction as their top priority and offsetting previous carbon emissions as their second priority. Their objectives involved "reducing Dell's carbon emissions by 15% by 2012, partnering with customers to build the "greenest PC" on the planet, and expanding the company's carbon offsetting program 'Plant a Tree for Me'"(Thakurdas, 2009). As part of this program, Dell modified a typical laptop to reduce electrical consumption tenfold. Dell's carbon neutrality program not only benefited the company financially, but it also helped reduce their carbon emissions considerably.

Controversy arose against Dell's carbon neutrality program when it was discovered that the calculation of Dell's carbon footprint did not take fourth tier emissions into consideration. Instead, only the emissions from the internal operations of the Dell headquarters and the manufacturing facilities were included in the calculations. Another factor absent from Dell's calculations was the emissions produced from shipping parts from various locations to be assembled at Dell manufacturing facilities (Ball, 2008). As a result, Dell's calculations were not an accurate representation of the company's carbon footprint.

CAL FIRE Case Study

In 2007, the California Department of Forestry and Fire Protection, known as CAL FIRE, audited its carbon emissions and attempted to reduce energy use. CAL FIRE included 228 fire stations and 313 other facilities in the scope of the audit. To conduct the audit, every facility recorded its monthly consumption of electricity and

fuels. An external auditor then verified these records and converted the data into the amount of carbon dioxide emitted. This audit, however, did not include any analysis of the carbon footprint caused in the manufacture of any of CAL FIRE's equipment. Figure 3 shows the end result of the audit.

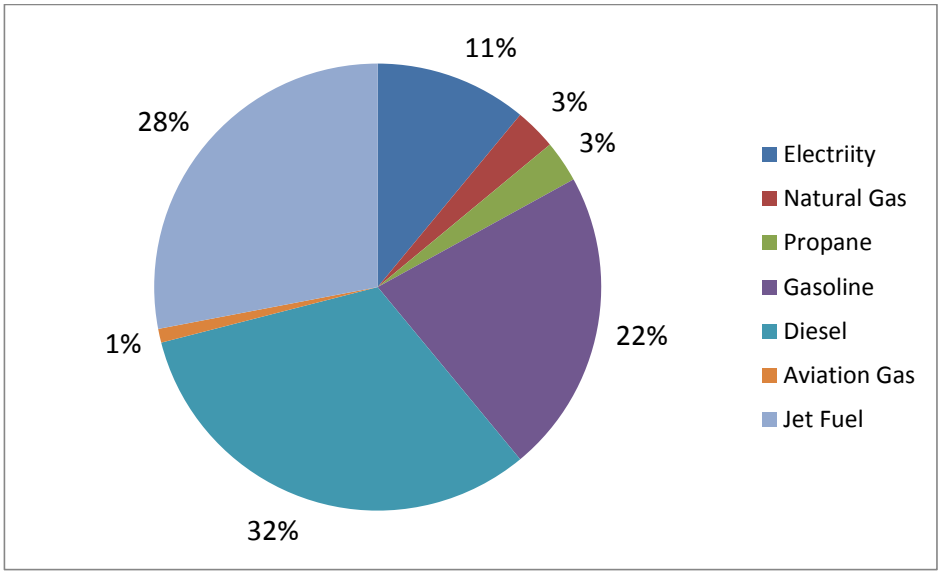

Figure 3: Breakdown of Carbon Emissions by CAL FIRE in 2006 (adapted from California Department of Forestry and Fire Protection, 2008)

CAL FIRE emitted over 42,000 metric tons of CO_2 in 2007. In total, over 80% of these emissions came from fuel usage. Nearly 30% of the total emissions came from CAL FIRE's aircraft used to fight wildfires and 55% came from gasoline and diesel consumed by fire trucks and other heavy equipment. Only 11% of CAL FIRE's emissions came from electrical usage. The ultimate conclusion CAL FIRE reached was that any meaningful reduction of carbon emissions would require a reduction in fuel demands and that currently no equipment exists that fulfills that role. The director of CAL FIRE clearly states that his department will not stop or reduce their operations in order to reduce emissions (California Department of Forestry and Fire Protection, 2008).

The CAL FIRE case study impacts our analysis of the Bomberos in two ways: the major source of carbon emissions in firefighting and the inability to eliminate that source. CAL FIRE determined that the vast majority of its carbon emissions was being caused by fuel consumption. The second major outcome of the CAL FIRE case study is that CAL FIRE could not see any way of reducing vehicular carbon emissions without jeopardizing firefighting capabilities. Therefore, this case study shows that reducing the carbon emissions of a firefighting organization can be difficult.

2.5 – Summary of Background

The Bomberos of Costa Rica have established the goal of reducing carbon emissions by 2021. However, the definition of carbon neutrality plays a large role in the actions the Bomberos will need to take. Carbon neutrality is simple in concept but complex when applied to actual organizations. The parameters used to calculate a carbon footprint can drastically change an organization's carbon emissions. Costa Rica has included many different gases in its scope of carbon neutrality and has designated the Ministry of the Environment as the agency in charge of overseeing the nation's effort to become carbon neutral. Through comparative case studies, we have established that carbon neutrality efforts usually take the form of reducing carbon emissions and the offsetting the remaining conditions. Lastly, we have learned from the CAL FIRE case study that the vast majority of carbon emissions produced by firefighting organizations are caused by the operation of emergency vehicles.

Chapter 3: Methodology

Costa Rica is currently attempting to become the world's first carbon neutral nation by the year 2021. To facilitate this task, the Costa Rican government is asking that the nation's firefighting organization – known as the Bomberos - reduce its carbon emissions. In order to help the Bomberos with this task, our goal for this project is to work with the organization on formulating strategies to reduce their carbon footprint over the next decade. This goal will be accomplished through four objectives:

1. Evaluating the Bomberos' carbon footprint using guidelines provided by the Costa Rican Ministry of the Environment (MINAE)
2. Determining explanations for the result of carbon footprint assessment through visits to five fire stations selected by our sponsor
3. Identifying strategies for reducing carbon emissions
4. Presenting our recommendations to the Bomberos in the form of an action plan

These objectives along with the methods that will be used to accomplish them are represented in a flow chart in Figure 4.

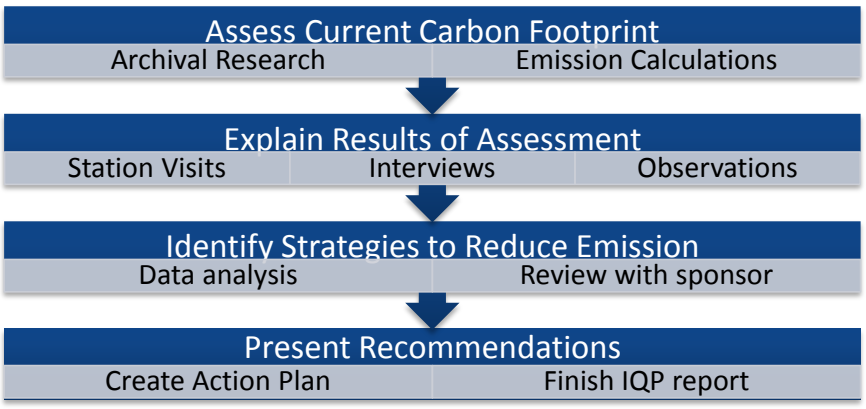

Figure 4: Flow Chart of Objectives and Methods

3.1 – Evaluation of the Bomberos' Carbon Footprint

Our first objective upon arriving in Costa Rica is to perform an assessment of the Bomberos' carbon footprint using guidelines provided by MINAE. The assessment will cover all emissions produced by the activities of the Bomberos. The carbon footprint will not account for emissions caused by the manufacture, delivery, or disposal of the organization's equipment. The exclusion of these emissions was determined by the Bomberos and was caused by a lack of time, resources, and expertise for us to perform detailed life-cycle assessments of equipment. The team will primarily consider emissions caused by energy consumption. The assessment will favor these emission sources because the chemicals used by firefighting organizations to extinguish fires do not release greenhouse gases and the only impact the use of such chemicals have on carbon emissions is due to the energy needed to pump them (Hodges, 2012). The assessment will divide the emissions of the Bomberos into two categories: emissions incurred while responding to an emergency and those produced by Bomberos working at their stations. The first category includes their fuel consumption while the second category consists primarily of the Bomberos' electrical usage. The assessment requires calculating the carbon footprint of each station in both categories of emissions. The specifics of the calculations will be derived from either the 2006 IPCC Guidelines for National Greenhouse Gas Inventories or MINAE guidelines. Appendix A contains relevant excerpts from these documents. The calculations will follow the general form of multiplying the amount of energy consumed by the amount of atmospheric carbon emitted per unit of energy consumed. For example, the carbon emissions from a fire station's diesel fuel consumption will be calculated by multiplying the liters of diesel consumed by the mass of carbon dioxide released per liter of diesel fuel, since the amount of carbon emitted per liter of fuel does not change from station to station. Only the amount of fuel consumed will vary and the efficiency of the Bomberos' equipment will affect the volume of fuel consumed. These calculations will be performed for each energy source (e.g. diesel, gas, and electricity) used by each station. We will need to determine the energy consumption of the Bomberos to perform these calculations. The team will do this by conducting archival research into the Bomberos' records of monthly fuel and electrical consumption. The liters of diesel fuel and gasoline delivered to each

station since the beginning of 2011 will be tabulated in a Microsoft Excel spreadsheet along with the total kilowatt-hours of electricity consumed by each station. The team assumes that the Bomberos consume all fuel purchased within a few weeks and are not retaining fuel for months on end. Adjustments will be made to this assumption if seasonal trends are identified in Bomberos' consumption of fuels. The required records are kept at the national headquarters in San Jose and will be accessible to us when we arrive. We will determine the specifics of these calculations once in Costa Rica. These specifics include the emission factors for petroleum distillates and electrical generation in Costa Rica. The calculations will result in a detailed breakdown of the raw carbon emissions of the Bomberos.

3.2 – Determining Explanations for the Results of the Carbon Footprint Assessment

The second objective of our project is to understand why certain stations may emit more carbon than others and how the habits and operational policies affect stations' carbon emissions. We will accomplish this objective through visiting Bomberos fire stations and gathering data on their practices and procedures. Senor Ramos has said that the team will be visiting the stations of Paquera, Heredia, Barrio Mexico, Ciudad Quesada, and the central station in San Jose. A map of the stations can be seen in below in Figure 5.

Comment [rek3]: You need to know what criteria was used in picking these five stations.

Comment [J4]: Professor Kinicki:
We will be adding this information once we talk to our sponsor in Costa Rica. Right now we don't know what reasoning was used.

Figure 5: Map of Stations Identified for Visits (adapted from Benemérito Cuerpo de Bomberos, 2012)

The stations are distributed around the country and will allow us to account for regional differences in the Bomberos' practices. Data will be gathered from at least five fire stations over the course of three weeks. The team will collect data using interviews from the chief of each firehouse and observations of procedures, habits, and machinery. The data obtained through these visits will provide explanations for the size of stations' carbon footprints. The interviews will be modified for each station to account for any trends identified in the carbon footprint assessment in the initial part of the project. The interviews will be conducted in Spanish. They will aim to gather information on the day to day practices the firefighters. The team will collect observation data based on the

Comment [rek5]: How much of energy use is related to domestic activities in the fire house? Cooking, washing clothes and keeping the fire house and the equipment clean. It seems you have day-to-day procedures and procedures at the site of a fire.

Comment [J6]: Professor Kinicki:
We identified this distinction in the previous section (3.1) with the following :
"The assessment will divide the emissions of the Bomberos into two categories: emissions incurred while responding to an emergency and those produced by Bomberos working at their stations"

findings from this initial interview. The questions will focus on the use and maintenance of the station's fire trucks and use of electrical equipment. Prior to the visits, Señor Ramos will receive the interview questions to ensure that they are appropriate and do not breach any government protocol (Berg, 2007). We plan on conducting a practice interview with a Bomberos at the headquarters before visiting the first station. A placeholder interview that gives the style of questions is presented in Appendix B.

The interviews will serve as a means of learning the chief's perspective on how the station's procedures affect its energy usage. We plan to collect information about the station's equipment, specifically the make, model, and age of its fire trucks. The team will ask if the trucks have any form of emission controls installed. The interview will also aim to gather information about the frequency of emergency calls and the condition of roads that the Bomberos use. The interview will take about twenty to thirty minutes and will take place at each firehouse we visit. After the end of each interview, we will ask the fire chief to accompany us on a tour of the station to gather observations.

Finally, observations will verify information gathered from interviews and provide additional qualitative information. The team will focus on the day to day habits of electricity and heating fuel use at each department. With the fire chief, we will investigate outdated machinery that may waste large amounts of energy due to inefficiency or cause excessive carbon emissions. The team will record the type of light bulbs used at the station and observe how often lights, computers and other electrical appliances are turned off. However, the time allotted to visit fire stations is limited. The group will conduct observations for two to three hours. Two members of the team will observe lounge and recreational areas while the other two will observe offices.

Comment [rek7]: This will not be easy because use will be diurnal and a function of time of day.

Comment [D8]: Professor: we understand this will not be easy so this tactic is likely to change once we arrive on site. It is our understanding that firefighters are not required to stay up during the night so energy use then should theoretically be limited. However, we will gather more information on this when we interview the fire chief at each station

Comment [rek9]: You could use a layout of a typical fire station.

Comment [D10]: Professor Kinicki: We have not been able to find this information at this time. We will definitely try to find this information in CR and incorporate that into our final paper

3.3 – Identifying Strategies for Reducing Carbon Emissions

Next, we will use the data obtained from fire station visits and carbon footprint calculations to identify potential strategies that will reduce the carbon emissions of the Bomberos. We will accomplish this objective by first brainstorming a tentative list of recommendations for the Bomberos. These recommendations will be based on our observations of both efficient and wasteful practices that are employed at fire stations. Ultimately, our recommendations will seek to replace practices that are wasteful of

energy with more sustainable ones. Once we have established a tentative set of recommendations, we will then review them with our sponsor. This will be done through a second series of interviews to be held with both operative and administrative employees of the Bomberos. The organizational structure of the Bomberos can be seen below in Figure 6.

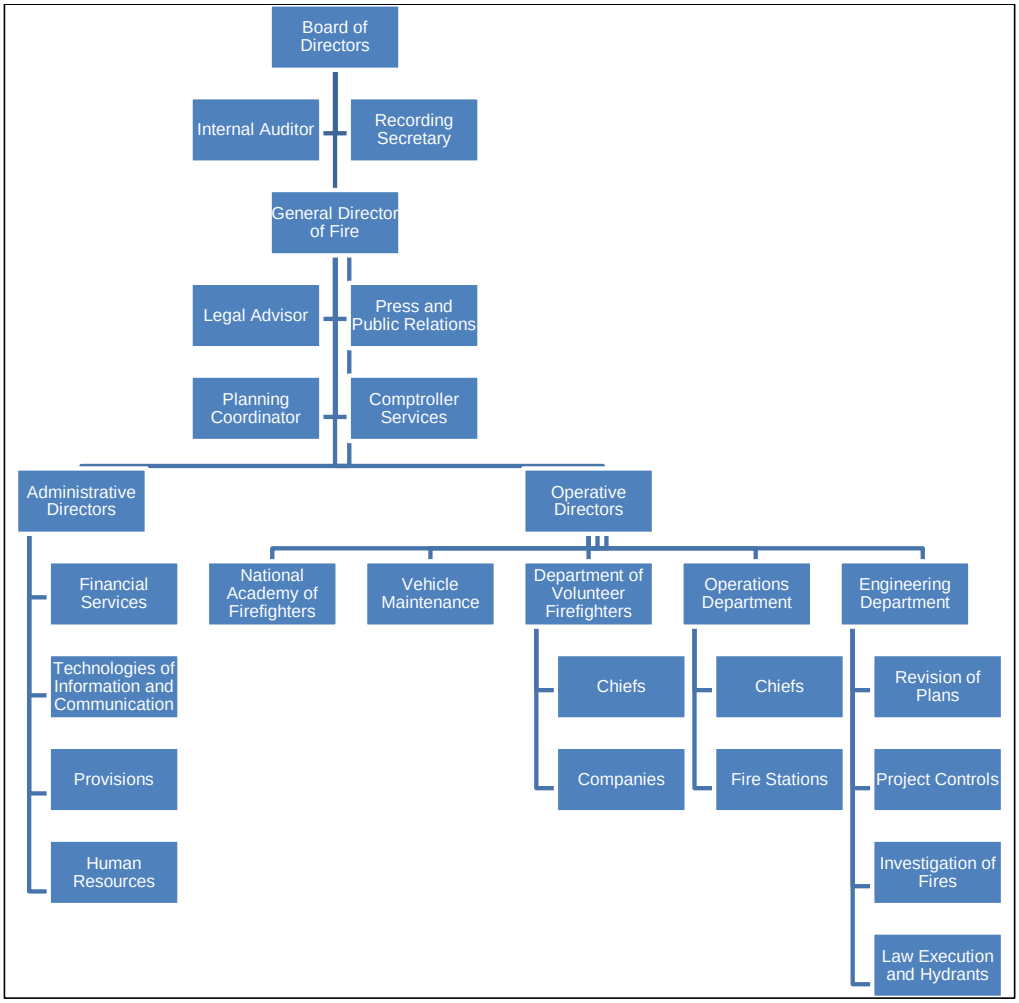

Figure 6: Organizational Structure of the Bomberos (Benemérito Cuerpo de Bomberos de Costa Rica, 2012d)

Ideally, we will interview at least four representatives from various departments which are relevant to the objective of becoming a carbon neutral organization. We recognize that the employees of the Bomberos have demanding schedules and that difficulty may arise trying to find a time when each of the four people can discuss the topic of carbon neutrality at length. With this in mind, the team plans to schedule these interviews in advance, ensuring that the participants can set time aside to meet with the group. Tentatively, the group plans on scheduling these interviews for the fourth and fifth weeks of the project. We have chosen to do these interviews at this time because we will have already prepared a tentative set of recommendations. The main goal of these interviews is to determine constraints that we will face such as budget and safety regulations. Therefore, we will be able to receive specific feedback from the Bomberos regarding the feasibility of our suggestions and be able to adjust them as necessary. If they were performed at an earlier time, we would not have collected enough data to receive any valuable feedback on our findings. Currently, our team has not yet asked specific people to be interviewed so that we can proceed in the case an individual is unable to attend. During the first week of the project, the team will consult with Sr. Ramos on which representatives to interview. We hope to interview a member of the Board of Directors, the Department of General Services, the engineering department, and the National Fire Academy. The board member can report the ideas discussed to the Board of Directors, who are then able to issue regulations to the entire organization on reducing carbon emissions. The Department of General Services, which is responsible for maintaining firefighting equipment, will be able to install and maintain new equipment that emit less carbon. The Department of Fire Engineering will oversee that all fire codes are being followed with any new procedures or equipment that is used. In addition, this interview will allow the group to verify that any recommendations do not jeopardize the safety of firefighters or civilians. Finally, the National Fire Academy will be able to train the upcoming firefighters to follow the carbon-reducing practices recommended at the completion of this project. Through these interviews, the team will be able to identify complicating factors that may compromise the feasibility of our suggestions. For example, the interview with a member from the board of directors will allow us to identify budget constraints that may hinder the effectiveness of our

Comment [rek11]: I believe if you go through these carefully you can deliberately target some before the fire station visits and some after. I believe this an important decision to make quickly so you can try to line up two or three that you really want before you hit the road.

Comment [D12]: Professor Kinicki: We added our reasoning for doing the interviews in weeks four and five above. For now, we will leave it as is but if you feel it would still be best after reading our reasoning above, we will change that (though it may not be in time for the Wednesday deadline)

suggestions. These interviews will be conducted in Spanish and will last for approximately half an hour. A tentative set of questions that will be asked during these interviews can be found in Appendix C. The questions that will be asked are subject to change depending on what is learned during the various station visits.

3.4 – Present Recommendations to the Bomberos

The last objective of this project will be to present our recommendations to the Bomberos in the form of an action plan. The recommendations made in this plan will have been modified to ensure that they fall within any constraints that the Bomberos face. This action plan will lay out the steps that the Bomberos should take on a yearly basis in order to reduce its carbon emissions over the next nine years. To ensure that our action plan will produce the desired results, all of the recommendations will be prioritized according to both potential impact and cost. This will allow the Bomberos to choose which recommendations to follow based on which ones will have the largest impact on reducing their carbon emissions relative to their cost. Depending on the outcome of the previous three objectives, this plan may include educating firefighters on how to reduce their carbon emissions and implementing policies that will help the organization do the same. This action plan will be incorporated into our Interactive Qualifying Project report.

Comment [rek13]: This will be constrained by budgetary issues. Not sure a real action plan is what you mean.

Comment [D14]: Professor: In our previous objective, we hope to have identified any constraints and incorporate them into our final recommendations. We have added a sentence to try to clarify this point

3.5 - Projected Timeline

The projected timeline for completing our objectives is shown below in Figure 7 below.

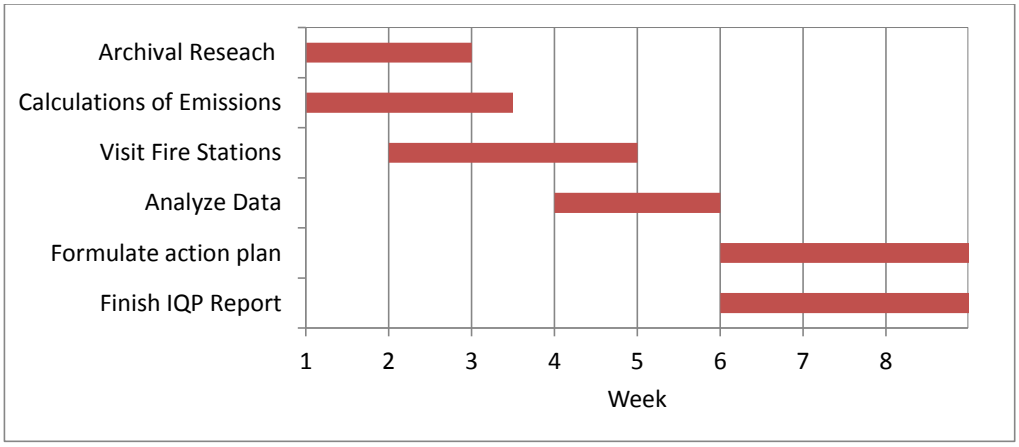

Figure 7: Gantt Chart of Tentative Timeline for Our Project

The first two weeks of our project will consist mostly of our initial assessment of the Bomberos. During this time period, we will perform a large amount of archival research on the fuel and electricity consumption of the Bomberos. In addition, we will also investigate the geography of the 63 fire stations along with the frequency of emergency calls each station receives. If time permits for greater than five fire station visits, this research will allow us to strategically choose which additional stations to visit in order to obtain sample data that is representative of fire stations with different carbon efficiency, terrain, and population density. In the second, third and fourth weeks, we will visit the fire stations selected by our sponsor. During this time, we will assess the carbon footprint of the fire stations through observations and interviews. In the fourth and fifth weeks, we will begin analyzing the data that we have collected through our various methods. In this time, we will formulate a tentative list of recommendations and conduct interviews with various administrators to identify any complicating factors. Lastly, in weeks six through eight, we will finalize our recommendations into an action plan that will enable to Bomberos to shrink their carbon footprint. Our final action plan will be

included in the Interactive Qualifying Project report, which will be written over the course of our eight weeks in Costa Rica. Particular attention to the completion and editing of this report will take place during the final two weeks of the project.

Chapter 4: Conclusion

Costa Rica has set a goal to achieve carbon neutrality by the year 2021. Carbon neutrality does not require the elimination of all carbon emissions; rather, it requires that all emissions be offset through programs or technologies that remove carbon from the atmosphere. Though the scope of emissions considered is often debated, Costa Rica has decided to include all greenhouse gases in its carbon neutrality initiative. To help achieve Costa Rica achieve this goal, the Bomberos have been given the task to reduce its own carbon emissions. The goal of this project is to formulate an action plan that will enable the Bomberos to gradually reduce their carbon emissions.

Past research has shown that firefighting is a very carbon intensive process. If a large, carbon intensive organization such as the Bomberos were to achieve carbon neutrality, it would be major step forward in Costa Rica's plan to become the world's first carbon neutral nation. The Bomberos could also become a model for similar organizations both in Costa Rica and abroad that are trying to reduce their carbon footprint by successfully reducing their emissions. In addition, the Bomberos' unique position as role models in communities across the country could raise awareness and inspire action among the populace about the issue of carbon neutrality.

We are thankful for the opportunity to work on this project and we look forward to working with the Bomberos this semester.

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Comment [LM15]: I think this would be considered a print resource- list publisher (which might be IPCC) and remove link. Check this throughout- anything that downloads as a pdf should probably be cited as a print resource

Comment [CCC16]: Professor Mathews: These sources are not print resources. The way we have this and other similar documents from the IPCC cited, a reader can easily find the exact section we use. However, if we cite the full document, we are not sure that it could be found easily. We will look into this more in the near future.

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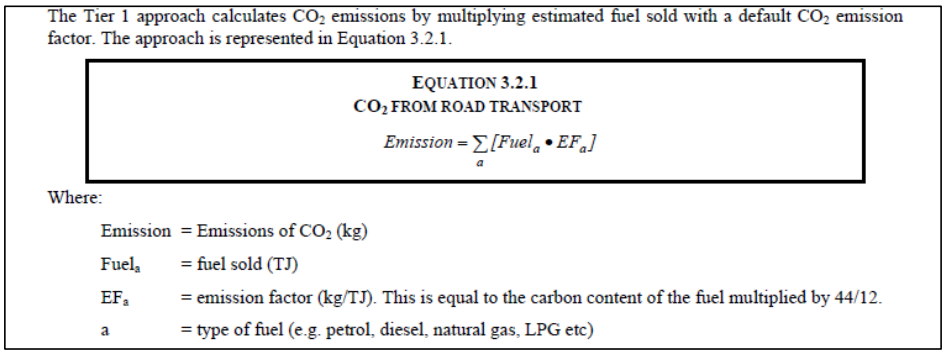
ANCE/0,,contentMDK:21841841~menuPK:4125923~pagePK:64168445~piPK:64168309~theSitePK:4125853,00.html

Appendix A – Calculation Guidelines

1. Factor de emisión X ton de combustible/electricidad = ton CO_2 equivalente
2. Ton totales de CO_2 equivalente = sumatoria de las ton CO_2 equivalente para cada material evaluado (combustible, gas, etc)

Figure 8: Carbon Footprint Calculation Used by the Ministry of Public Safety of Costa Rica (retrieved from Ministerio de Seguridad Pública, 2012)



The Tier 1 approach calculates CO_2 emissions by multiplying estimated fuel sold with a default CO_2 emission factor. The approach is represented in Equation 3.2.1.

EQUATION 3.2.1
CO_2 FROM ROAD TRANSPORT

$$Emission = \sum_a [Fuel_a \bullet EF_a]$$

Where:

Emission = Emissions of CO_2 (kg)
$Fuel_a$ = fuel sold (TJ)
EF_a = emission factor (kg/TJ). This is equal to the carbon content of the fuel multiplied by 44/12.
a = type of fuel (e.g. petrol, diesel, natural gas, LPG etc)

Figure 9: Excerpt for the IPCC's 2006 Guidelines for Greenhouse Gas Inventories (retrieved from Intergovernmental Panel on Climate Change, 2006)

Appendix B – Preliminary Interviews

Tentative Interview Questions for Station Chiefs

The goal of this interview is to identify practices of the Bomberos that are either energy efficient or wasteful. All responses to these questions are confidential. No names or any other information that could be used to identify the interview subjects will be published in order to protect their identities.

The questions below are preliminary and serve only to indicate the general direction of questioning. Specific questions will be developed once in Costa Rica. Italics indicate talking points.

1. What are the conditions of the roads most often used to respond to emergencies?
   (Paved versus dirt, condition)
2. How many kilometers on average do you travel responding to an emergency?
3. What is the age and make of each fire truck/engine? Also, please say if the vehicle is 2-stroke or 4-stroke and if it is equipped with a catalytic-converter (leave blank if unknown)?
4. How often is the tire pressure checked on each truck?
5. How often is the oil changed on each truck?
6. On average, how many meals a shift do firefighters at the station eat that were cooked at the station?
7. What are the types of light bulbs at your station?
   (Incandescent, Compact Fluorescent (CFL), Halogen, LED)
8. How do you spend your time at the station when not responding to an emergency? *(for example: watching television, using a computer, cooking, etc. Need percentages in responses)*
9. How often are fire trucks at your station used in parades or other public demonstrations?
10. How much time every day is spent idling fire trucks at your station?

Appendix C – Secondary Interviews

Tentative Interview Questions for Administrators

The goal of this interview is to determine the feasibility of recommendations and to identify any constraints we must take into account. All responses to these questions are confidential. No names or any other information that could be used to identify the interview subjects will be published in order to protect their identities.

The questions below are preliminary and serve only to indicate the general direction of questioning. Specific questions will be developed once in Costa Rica. In the questions below, "[RECOMMENDATION]" indicates that this question will be asked for each applicable recommendation we have formulated.

1. How would budgetary constraints affect the implementation of [RECOMMENDATION]?
2. How would implementing [RECOMMENDATION] affect the training of new firefighters?
3. Would [RECOMMENDATION] require retroactive training of current firefighters?
4. How much time would [RECOMMENDATION] take to implement?
5. Do you have any suggestions or comments that you feel would improve our recommendations?