Green Sector Development and Job Creation in Costa Rica

Interactive Qualifying Project Proposal
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List of Acronyms

BTU- British Thermal Unit; 1055 Joules

CDM- Clean Development Mechanism

CICR- Cámara de Industrias de Costa Rica

CO_2- Carbon Dioxide

CFE- Comisión Federal de Electricidad

G7- A group of the six greatest, economic powers including the United States, Japan, Germany, France, United Kingdom, Italy, and Canada

GDP- Gross Domestic Product

GW- Gigawatts; 1,000,000,000 Watts

IPCC- United Nations Intergovernmental Panel on Climate Change

IPP- Independent Power Producers

KW- Kilowatts; 1,000 Watts

LED- Light emitting diode

MW- Megawatts; 1,000,000 Watts

NDRC- National Development and Reform Commission (in China)

PRC- The People's Republic of China

PROINFA- The Incentive for Alternative Sources of Energy Program (in Brazil)

RuGBC- The Russia Green Building Council

SU- Shenyang University

US- United States

Chapter 1: Introduction

Burgeoning with tropical rainforests and volcanoes, the Latin American country of Costa Rica has exploded as a center for ecotourism as well as environmental awareness and preservation in recent years. To the rest of the world, it is a place of scenic landscapes with picturesque beaches, wildlife, and 3.2 million acres of preserved forests. In order to protect these famed natural resources, Costa Rica continues to initiate environmental reform (Long, 2011). Driven to a greener future by concerns for global climate change, resource depletion, and environmental destruction, Costa Rica along with other developed and developing nations united within the Kyoto Protocol to limit carbon emissions from 2008 to 2012 (United Nations Framework Convention on Climate Change, 2012). Aspiring to lead, Costa Rica has challenged itself with the additional goal to achieve carbon neutrality by 2021 (Long, 2011). But it is not easy being green, and this is a concept that Costa Rica knows all too well.

Although Costa Rica's alternative energy initiatives are impressive, with ninety percent of its electricity generated by renewable energy, there are significant challenges that hinder it from achieving its green objectives (Long, 2011). The rapidly growing industrialized and transportation sectors in Costa Rica are responsible for a rise in carbon emissions and consumption of fossil fuels. Current waste management systems cannot keep pace with the increase in pollution caused by the expansion of the industrial and transportation sectors. Development and integration of new technologies in green sectors of the Costa Rican economy is challenging as there is a lack of training programs to produce skilled workers for such technologies. For the purposes of our project, we will define a green sector as a part of the economy that contains businesses that operate with energy efficiency, utilize renewable resources as opposed to non-renewable, and strives toward carbon neutrality (Strietska-Ilina et al., 2011).

The sponsor of this project, the Cámara de Industrias de Costa Rica (CICR), is the representative body of industry in Costa Rica that supports the competitiveness of member companies. This agency also promotes the sustainable development of the industrial sector (Cámara de Industrias de Costa Rica, 2012). The CICR aspires to improve industrial sectors of the Costa Rican economy with particular regard to renewable energy, energy efficiency, and carbon neutrality. One way they wish to further improve green sectors of the Costa Rican

economy is to emulate countries like China, Russia, Mexico, and Brazil, which have already made significant progress in becoming economic powers. Taking into consideration their most effective energy policies, Costa Rica can advance in all the aforementioned areas by promoting skills for a productive green jobs sector.

The development of the skills necessary for green jobs is essential to the evolution of innovative green sectors within a nation. With the transition to a greener economy, Costa Rica has the opportunity to bring about a mass creation of new jobs and a redistribution of the workforce; however, the real challenge arises from providing the workforce with proper expertise and training. New industries are likely to require workers trained in a number of different areas including environmental awareness to job specific technical skills, with some workers as specialists and others more broadly trained (Strietska-Ilina et al., 2011). Government investment and intervention can aid in the expansion of industrial sectors to become green and ensure a nationwide commitment to sustainability. In order to expand green sectors, government agencies can promote nationwide education and environmental awareness. It is imperative that Costa Rica collaborates at the governmental, industrial, and individual levels to make strides towards its goal of carbon neutrality.

To learn how Costa Rica can expand its green job sectors, we will study China, Russia, Mexico, and Brazil. Our literature review will consist of a broad overview with respect to green sectors as specified by our sponsor. These nations serve as models to demonstrate the methods and challenges involved in promoting green economies. They are especially noteworthy because their economies are fast-growing and influential in the global energy market. In the past, these nations have lagged in development as compared with the G7 countries, a group that includes the United States, Japan, Germany, France, Britain, Italy and Canada (Deloitte, 2011). According to economists, China, Russia, and Brazil are predicted to surpass the G7 as the largest global economies by 2050 based on GDP and productivity growth (Jain, 2006). These three countries are enacting policies that are intended to lead them to a more sustainable future, utilizing renewable energies and reducing carbon emissions. China, Russia, Mexico, and Brazil are countries similar to Costa Rica in that they are enacting green policies and standards. Additionally, Mexico has recently focused effort into reforming its green initiatives and reducing its dependence on fossil fuels. Using these four countries as models for green sector economic

development, we will provide recommendations for strategies to create green jobs and prepare employees in these sectors in Costa Rica.

Chapter 2: Literature Review

This chapter begins by defining terms relevant to the project and creating working definitions for use in this project. We provide information regarding our sponsor, followed by four comparative case studies – China, Russia, Mexico, and Brazil, to assess whether strategies employed by these nations can be applied in Costa Rica. Each case study addresses how the respective country successfully created green jobs. The last section discusses the current status of Costa Rica's green industry and compares that baseline to the case studies.

2.1 The Greening of the Global Economy

A "green" economy, or one which generates neither pollution nor waste and efficiently utilizes energy, water and materials, is emerging globally. There is an increase in jobs that support renewable products and are more sustainable (Renner et al., 2008). This is due in part to climate change and the challenges created by global warming as well as the need to meet emission reduction targets set by the United Nations Intergovernmental Panel on Climate Change (IPCC) (Bolin, 2007). Over the last two decades, the main drivers of the greening of the global economy have been the rising price of fossil fuels, technological advancements, government policies, economic growth and the demand for more sustainable human behaviors (Eyraud et al., 2011). The demand for a more sustainable environment has resulted from human activities such as building houses and businesses that have created environmental problems by relying on fossil fuels, generating pollution, waste, and deforestation. The information released from highly publicized IPCC reports have contributed to the shift in the flow of global investments towards renewable energy generation, energy efficiency and carbon neutrality. The trend of global conversion to green production and consumption has begun to and will logically continue to create numerous new green jobs.

The United Nations Environment Programme describes green jobs as work in agricultural, manufacturing, research and development, administrative and service sectors that contributes to preserving and restoring environmental quality (Renner et al., 2008). This includes the creation of jobs that reduce energy, minimize waste and pollution, and protect ecosystems and biodiversity, while at the same time providing sufficient wages, safe conditions, and rights for workers. Green innovation is the business sector's attempt to stay at the cutting edge of

technology while increasing its profitability. This is because use of green technology is increasing in businesses, making it necessary for them to utilize this new technology to stay competitive. However, while researching green jobs, we must be cautious of "green washing", which is when companies or their representatives market their organizations as being environmentally friendly or reducing energy consumption when in fact they do not (Renner et al., 2008). Not all green industries and technologies are green; some do not actually protect or improve natural ecosystems (Porfir'ev, 2012). Government legislation is especially important to provide funding for green projects, goal setting, and policies (Renner et al., 2008).

2.2 Key Terminology

Slogans such as "go green" appear in many common establishments today, such as supermarkets, college campuses, clothing stores, hotels and businesses alike. Merriam-Webster defines *green* as "tending to preserve environmental quality (being recyclable, biodegradable, or nonpolluting)" (Merriam-Webster, 2012). Given the vagueness of the term "green," it is necessary to develop a working definition. Therefore, we define green as a quality that describes a product, process, sector, business, energy, job, industry or technology that provides measureable and verifiable benefit(s) to the environment through energy efficiency, reduction of carbon emissions and/or the use of renewable resources. Examples of green industries include utilization of wind power, hydropower, solar energy, fuel cells, pollution controls, recycling, organic and sustainable farming; which is harvesting a resource without depletion or damage of the resource (U. S. Department of Labor Bureau of Labor Statistics, 2012). Green skills will be defined as the attributes and abilities of an employee necessary to work in any green industry. For example, the skills necessary to be a technician or engineer that uses green technology are green skills (Teschler, 2011). When working in green industries, companies have the obligation to run such that the environment is protected (Renner et al., 2008). Our research requires practical evidence that the companies we identify as green and providing green jobs in our case studies do in fact have measurable data to support such a conclusion.

2.3 Cámara de Industrias de Costa Rica

Since the Càmara de Industrias de Costa Rica was established in 1943, the organization has represented the industrial sector of the Costa Rican economy. The mission of the CICR is to develop sustainable industries (Càmara de Industrias de Costa Rica, 2009). It is committed to increasing the competitiveness of its member companies within local and international markets. The organization provides services for business management systems and corporate development within the establishment of the Institute of Entrepreneurial Excellence in 2004. This branch of the CICR focuses on providing services to member businesses (Càmara de Industrias de Costa Rica, 2012). Recent initiatives of the CICR have addressed the problem of record fuel and energy prices by presenting an "Energy Manager" training program to member businesses, and by informing employees of energy efficiency strategies and management programs (Càmara de Industrias de Costa Rica, 2012). In supporting a sustainable industrial sector for Costa Rica, there is an environmental aspect to this industry development. In promoting the industrial sector, advancements have increased carbon emissions and developed more energy efficient strategies to accommodate the evolving economy. As a result, the CICR has investigated techniques for improving renewable energy, energy efficiency, and carbon neutrality. For this investigation, the stakeholders are the individual companies and businesses that comprise the membership of the CICR, and their stake is to increase their competitiveness in a more sustainable economy.

2.4 Lessons Learned from China, Russia, Mexico, Brazil

The CICR is researching other countries to learn from their green sector development and apply similar strategies to create jobs in Costa Rica. China, Russia, Mexico and Brazil in particular can provide Costa Rica with successful case studies of developing countries advancing economically while promoting sustainability and green job growth. What sets China, Russia and Brazil apart from other nations is their remarkable economic growth. Rates of economic expansion in these developing countries have surpassed those of the world's traditional superpowers. In the past ten years, the US economy increased by 20% whiles the economies of Brazil, Russia, and China grew at rates of 36%, 69%, and roughly 250% respectively (Biggemann & Fam, 2011). When considering GDP and productivity growth, specialists project that these three countries will overcome the G7 – United States, Japan, Germany, France, United

Kingdom, Italy and Canada—as the biggest economies in the world by 2050 (Jain, 2006). The trend indicates they will be in the top ten world economies in the future (Biggemann et al., 2011; Jain, 2006). Mexico is an effective case study because it is of a similar socioeconomic and geographic background as Costa Rica. As emerging economic forces in the world economy as well as energy producers and consumers, these countries have implemented green sectors and jobs in their economies and play an important role in shaping environmental policies and standards abroad (Zhang et al., 2011).

2.4.1 China

The People's Republic of China (PRC), the fourth largest country in the world, at 9.6 million square kilometers, is the most populous country providing the world's largest labor force with a population of 1.34 billion people. China has the third largest GDP, 11.4 trillion U.S. dollars, and the tenth fastest growing GDP, with an annual growth rate of 9.2% in 2011 (Central Intelligence Agency, 2012a).

The green sectors of China's economy are evolving in part as the result of political initiatives. Disestablishing the State Power Company's monopoly over power production, the People's Republic of China Plan for the Reform of the Electric Power Industry, in 2002, reallocated the power sectors to five independent power producers, or IPPs. Continuing the reform on the power sector, the PRC initiated a transition to renewable energy in order to further expand clean energy use. As a means to accomplish this task, the structure of energy management was renovated resulting in the establishment of the National Development and Reform Commission, or NDRC, as the primary energy policy regulator (Su et al., 2010). In 2006, the NDRC instituted the Renewable Energy Law defining the process for the development of renewable energy and cost-cutting methods such as reduced taxes and subsidies for power companies. In an effort to minimize the difference in cost between renewable energy and conventional energy, this legislation created a feed-in tariff causing the users of the renewable energy to pay an additional fee; therefore, minimizing the reluctance of power companies to convert (Su et al., 2010).

Leading the world in carbon emissions, China's fossil fuel driven economy must undergo significant reform in order to be environmentally-friendly. By 2020, China strives to achieve its self-set carbon reduction goals: decrease its level of carbon dioxide emissions from per unit of

GDP in 2005 by 40-45%, increase non-fossil fuel primary energy consumption by 15% from the 2005 level, and increase the forest area by 40 million hectares to serve as a carbon sink (Qin et al., 2010). Acknowledging the necessity to combat climate change, the Chinese government instituted a number of laws to provide guidelines for China. The Scientific and Technologic Actions on Climate Change, a governmental plan outlining developments in science and technology, set out to advance the technologies required to implement renewable energy sectors. In addition to advancing the renewable energy sector, the Medium and Long Term Development Plan for Renewable Energy of 2007 increases energy conservation and reduces the amount of carbon emissions in China. As part of the Clean Development Mechanism (CDM) initiative created by the Kyoto Protocol, China led the way in early 2011 having 42.74% of the CDM projects in the world (Balme, 2011).

Government intervention contributed to the evolution of several green sectors of the economy, but the photovoltaic energy industry has had success in both providing renewable energy and jobs. The photovoltaic energy production has increased from 0.07GW in 2006 to 0.29GW in 2009, and China is responsible for 30% of all photovoltaic panel production in the world. This energy sector has the highest potential for job creation in China The photovoltaic sector generates jobs directly through the creation of manufacturing jobs and indirectly through the need for technicians in the installation process (Cai et al., 2011; Furchtgott-Roth, 2012). With an automated process, such as the use of photovoltaic panels, a specialized, educated, and qualified labor force is necessary. The government report on solar energy in 2007 predicted that the photovoltaic industry would create roughly 100,000 jobs by 2020. The disadvantage that China faces is having to import half of the polysilicon used to produce quality and affordable photovoltaic panels as a result of limited research and development. Caused mainly by troubles with control of the power grid, China exports a majority of the panels it produces because using them costs double that of traditional power (Furchtgott-Roth, 2012). As a result, China exports the major of photovoltaic panels that it produces. Another inefficiency in this sector is the fossil fuel use in producing the photovoltaic panels. Improving the education of managers and engineers can help promote the growth of manufacturing and production processes and increase the renewable energy use within these process; however, China's education system has limited development restricting its success in this endeavor (Cai et al., 2011; Su et al., 2010; Geng et al., 2012).

As a rapidly growing economy with an increase in GDP of approximately 10% yearly, China's annual primary energy consumption rose 9.8% each year between 2001 and 2007. China is advancing its industry more rapidly than any other developed or developing country (Eisen, 2011). With coal accounting for 60% of the energy production in China before 2000, it is imperative that more efficient energy policies are employed before resource supplies are depleted (Chang et al., 2003). As of 2008, the Chinese government increased regulations regarding the consumption of energy within civil buildings constructed after 2008 (Wang et al., 2011). With an energy saving code under reform, these new regulations encourage construction companies to use efficient technologies and materials, and emphasize the importance of management to maintain maximum efficiency in daily operations. Reforming civil building regulations from 1980, China's energy savings in buildings increased by 30% in 1986 and 50% in 1996. Currently, the goal is to increase these energy savings by 65%, and the regulation codes are still in development. This energy savings strategy focuses on electricity consumption and heating utilizing solar energy for space heaters and LED lights for electricity savings. China had the highest level of solar water heater installation in 2008 (Fang, 2011). The future of green jobs comprises vocational education and training within the technical fields of improving building efficiency design, mass transit design, and other engineers for renewable technology design (Strietska-Ilina et al., 2011).

In an effort to improve sustainability and environmental awareness, the Chinese government designated Shenyang University (SU) as a model for environmental practices and a center for green education. Using an energy evaluating audit, a joint committee of administrators, faculty and students from SU identified a list of areas where the university could initiate environmental reforms. The university implemented a variety of sustainable initiatives including the collection of waste water, solar heating for ground pumps, improving insulation of buildings, reviewing quotas of energy consumption, and the replacement of outdoor lighting with compact fluorescent bulbs, LED lighting. With LED use alone, the university saved 1 million KW per year. Furthermore, green education is a main component of the model university. As part of the education system, research and development departments investigate advances in sustainable technologies and create opportunities for jobs for students at the University. By including specialized classes for environmental awareness, the updated curriculum for engineers and managers provides them with concern for the environment within their occupation. The general

student body is also educated on the details and significance these environmental issues. Finally, SU established a country exchange program with Japan's Nagasaki International University where students are immersed in a partner country's culture by travelling and studying abroad. As a result, students return with an understanding and experience of Japan's attempts at developing green sectors (Geng et al., 2012).

2.4.2 Russia

As the largest country in geography and the ninth most populated, Russia is in a position to be a world leader in energy policy and green standards. However, some experts believe that Russia's actions have demonstrated that it has had little regard for the environment (McGraw Hill, Inc., 1994; Frost & Sullivan, 2008; Rowe, 2011). Russia's economy has changed since the Soviet Union collapsed, from an isolated, centrally planned economy to one that is market based and integrated in the global economy (Central Intelligence Agency, 2012b). When Russia first started approving policies that would develop its green sector economy after the dissolution of the Soviet Union in 1991, the plans were limited. The Concept of Russian Energy Policy in New Economic Conditions was created in 1992 followed by the Main Directions of Energy Policy of the Russian Federation until 2010 was introduced (Zhang et al., 2011). Russia has had difficulty putting into place their green initiatives, mandating in 2003 that only 1% of electricity be generated by renewable resources by 2020 (Frost & Sullivan, 2008). Russia also did not have technology marketing agencies, demonstration experience, or long-term financing organizations to support its initiatives (Zhang et al., 2011; Berger, 2012). Vladimir Putin, the Russian Premier, approved the policy titled Electricity Sector on the Basis of Renewable Energy Sources for the Period up to 2020, establishing more technical indicators of renewable energy development (Zhang et al., 2011). The Energy Strategy of Russia was updated in 2010 for the period up to 2030, demonstrating the government's new commitment to changing Russia towards more sustainable resource use (Ministry of Energy of the Russian Federation, 2010).

As the world's leading producer of oil and the second largest producer of natural gas, Russia's oil and gas resources are quickly being depleted, making it necessary for Russia to develop green industries and a renewable energy sector (Frost & Sullivan, 2008). Russia has abundant renewable energy sources such as solar, wind, hydroelectric, and geothermal, and the landmass that would facilitate the production of biomass-based energy sources (Frost & Sullivan,

2008). Although the Soviet Union was the first country in the world to build utility-scale wind turbines in the 1930s, much of Russia's equipment is obsolete and needs modernization. Although Russia's equipment is out of date, the wind energy sector employs between 10 and 450 people per year for each terawatt hour of electricity produced. Wind power in 2020 for Eastern Europe, including Russia, is expected to be 140,000 megawatts with 343.2 terawatt hours generated per year. This will potentially employ 270, 600 people (Renner, 2001). The development and use of photovoltaic cells is also a well-developed technology in Russia as a result of the Soviet space program; Sputnik 3 was solar powered and sent into orbit in 1958 (International Energy Agency, 2003). In addition to utilizing small amounts of wind and solar energy, following the end of World War II, Russia increased its hydroelectric power generation. Today, as one of the top five countries in large hydroelectric power it is Russia's primary renewable energy resource (Renner et al., 2008). However, hydroelectric power has many drawbacks including high cost, destruction of land/habitats, displacement of small or large populations and dependence on regular and sufficient precipitation (The U.S.G.S. Water Science School, 2012). Non-hydro renewable energy accounts for just over 1% of total primary energy supply (International Energy Agency, 2003; Business Monitor International Ltd, 2010; Power Engineering International, 2011). According to ExxonMobil, Russia and more particularly the area closest to the Caspian Sea, uses mostly oil, gas, coal, nuclear, biomass, waste and hydro, followed by an energy demand of 0 British Thermal Units (BTU) for renewables, which explains a general lack of statistics on green jobs created specifically in Russia (ExxonMobil, 2012). As of 2009, hydropower accounts for 5.6% of the primary energy demand in Russia (Business Monitor International Ltd., 2010). As of 2003, there were 100-150 Russian enterprises that manufacture renewable energy systems (International Energy Agency, 2003). Russia has the engineering and technical experience to expand its renewable sector to areas other than hydropower, but it lacks workers with managerial, financial, legal and market transaction skills to advertise and sell products (International Energy Agency, 2003). There is also a need for international partnerships and training programs that will provide workers with necessary skills.

For example, Russia has partnered with the U.S. to work on energy efficiency. As part of their collaboration, they have developed the Smart Grid project, which seeks to improve efficiency in electric power systems, both in San Diego, U.S. and Belgorod, Russia. The two countries have held technical workshops together, sharing lessons learned, and have worked on

developing smart cities through urban planning. (U.S. State Department: Bureau of European and Eurasian Affairs, 2012). In addition to this international collaboration, limited training programs exist in Russia that provide skills for workers in green sectors. For example, the Russia Green Building Council (RuGBC) has a green certification program that consists of a training and certification program that provides companies an ability to increase their knowledge in sustainability among their employees. This also includes a program that recognizes any of the company's specialists that have the skill set to provide professional services in sustainability. This certification program includes a workshop where participants learn key definitions dealing with sustainability and participate in activities where they understand the links between sustainability and building design, construction and operations strategies. These workshops help employees understand how to include concepts of sustainability into their work. Another workshop part of this program deals with energy efficiency for existing buildings where participants are trained on techniques to improve operations and reduce energy costs. Other workshops within this program help their participants understand the economics of green, green standards and project management (Green Building Council Russia, 2011). Also, the Climate Doctrine of the Russian Federation, a document developed at the request of the president of Russia, discusses training of professionals on the climate and its impact on the economy and environment. This includes training a highly skilled research staff, graduate students at Russia's leading academic institutions, intern scientists, professionals, postgraduate students, and diplomatic staff and advisers for international negotiations (Russian Federation, 2009).

2.4.3 Mexico

Political turmoil has impeded Mexico's ability to focus on expanding its renewable energy sectors. For example, in 1975, Mexico implemented the Energy Plan with the goal of shifting its reliance on oil for generation of electricity to nuclear and renewable resources by 2000. However by the year 2000, the country's electricity generated by renewable resources had decreased from 38% in 1975 to 26.5% in 2000 (Bazán-Perkins et al., 2008). As of 2009, the amount of electricity generated by renewable resources decreased once more to 14.6% (Cancino-Solórzano et al., 2010). The government decided on short term goals to meet the rising demands of electricity consumption as opposed to following the long term plan set out for the country by the Energy Plan (Bazán-Perkins et al., 2008). To combat this decline in renewable resources and

promote a more environmentally conscious nation, Mexico enacted the Renewable Energy Development and Financing for Energy Transition Law in 2008 to deter its economy from a heavy reliance on fossil fuels towards cleaner alternative energy sectors such as solar and wind energy (Center for Clean Air Policy, 2011). However, this has not deterred expansion of past investments in other renewable sectors such as hydroelectric and geothermal plants. These renewable energy sectors will be discussed in the following paragraph as well as developing green skills for workers in those sectors (Cancino-Solórzano et al., 2011).

Mexico's Constitution dictated in 1960 that the government will provide "electricity generation, transmission, distribution, and supply as public services", which brought forth the establishment of the Comisión Federal de Electricidad (CFE). This legislation barred private sectors from participating because at the time, the Mexican government had bought out the private sectors within the country (Center for Clean Air Policy, 2011). As the years passed, it became difficult for the CFE to keep up with the demand of electricity. In the 1990's when its loans defaulted, Mexico fell into debt. The agreement with its creditors was to prohibit government enterprises from increasing debt which has limited further expansion by the CFE in terms of renewable resources (Center for Clean Air Policy, 2011). This lack of funds has pushed Mexico to look towards private and international investment to expand renewable resource sectors that are currently undeveloped and hold a high potential for profitability.

Mexico's wind sector only generates 0.1% of total electricity production for the country. Although this percentage of electricity is small compared to total domestic energy production, Mexico houses the second largest wind farm in Latin America, the Venta II (Cancino-Solórzano, 2011). Mexico retains the possibility for greater expansion in wind energy, but limited funds have the government looking towards foreign investment and private organizations to finance development. In the past, the CFE has been able to establish wind farms such as the Venta I wind farm in 1994 which supplied 1.5 MW of energy. The Venta II was constructed in 2006 using foreign aid and generated 85 MW of energy. The CFE was reluctant to invest in wind farms, especially for the Venta II which was funded by loans from the World Bank and the Spanish Carbon Fund (Center for Clean Air Policy, 2011). The further development of wind farms includes plans for the Venta III, and all four Oaxaca parks which are estimated to generate 585 MW upon completion at the end of 2012 (Cancino-Solórzano et al., 2011).

Solar power is yet another renewable resource which the Mexican government seeks private and international investments. A solar power plant has been constructed in the Agua Prieta Sonora desert to generate 30 MW per year but it will not be operational and running until 2013 (Cancino-Solórzano et al., 2010). Mexico is the country with the third largest geographical capacity to generate electricity utilizing solar power because of the high availability of solar radiation. In regards to photovoltaic cells, Mexico's limited solar plants have been constructed using international investments from Spain and Brazil (U.S.A. Department of Energy, 2002).

The largest renewable energy sector that Mexico presently has is the hydroelectric sector. The largest hydroelectric plant in the country as of 2010 is Chicoasé which generates 2400 MW of electricity per year (U.S.A. Department of Energy, 2002). As of 2009, Mexico's hydroelectric plants generate 12% of the country's electricity (Cancino-Solórzano et al., 2010). The growth of hydroelectric power is slow because it is unfortunately limited due to a scarce amount of rivers, environmental concerns, relocation of rural communities, and droughts. Often, local groups petition the installment of hydroelectric plants until plans for their construction are cancelled (U.S.A. Department of Energy, 2002).

Another of Mexico's proficient renewables is geothermal energy. As of 2000, Mexico's geothermal sources have an estimated potential to generate 8,000 MWe of electricity which ranks second best in the world (U.S.A. Department of Energy, 2002). Having expanded upon their first plant in 1970, the CFE has increased the number of hydroelectric plants to four, each with a capacity of 960 MW as of 2004. Economic research projects have found that improving efficiency in the plants to generate more electricity can be raised from 960 MW to 2400 MW by 2020, but the lack of qualified workers, mechanized tools, and financing holds back this advancement (Bazán-Perkins et al., 2008). According to a 2004 Mexican Department of Energy statement, the CFE will not be producing any more geothermal plants for another ten years because of debt (Ruiz et al., 2008).

Mexico's plans to expand upon these renewable energy sectors and increase the efficiency of electricity generated. This will result in an influx of new jobs in which workers with the technical skills to operate energy harvesting machinery will be in high demand; however, the current supply of such workers is limited. To address educational training programs for green jobs, Mexico formed a guideline for industries to implement two separate committees. One committee is an administration who oversees policies for renewable energy sectors, for

example the Secretary for Energy. The other committee provides education and training to workers to meet the requirements for green jobs, as done by for example, the Institute of Electric Research (Diez, 2008). Mexico has had limited development in effectively implementing policies to promote green industries and job growth.

2.4.4 Brazil

Brazil's National Plan on Climate Change outlines the current environmental policy and objectives to counteract climate change in Brazil. This plan endeavors to perpetuate the utilization of ethanol and biodiesel in the transportation sector as well as to the global market for biofuels. Another objective is to promote the use of alternative energy sources in the nation's energy supply. It seeks to encourage economic improvement by increasing the competiveness of products made in Brazil while reducing the country's carbon footprint. Furthermore, it works to ultimately achieve zero illegal deforestation across Brazil (Strietska-Illina et al., 2011).

The Brazilian government began its green movement in 1975 with the establishment of the Brazilian Ethanol Program. It was initially spurred to decrease dependence on foreign fuel during an oil crisis. The program works by substituting petroleum and diesel fuels with ethanol made from sugarcane (Pimentel, 1980). This spurred the production of 5.6 million alcohol-powered motor vehicles between 1975 and 2000 and replaced up to 25% of the petroleum in the fuel tanks of over 10 million vehicles with ethanol (Pereira et al., 2012). Brazil now holds the second largest portion of the world's ethanol market in terms of production and exportation. It is estimated that the ethanol production industry has created over 700,000 jobs (Goldemberg et al., 2004). Additionally, since the launch of the program, ethanol use in transportation has been estimated as preventing the release of 800 million tons of CO_2 (Strietska-Illina et al., 2011). However, the carbon impact of biofuel production, including ethanol produced with sugar cane, is difficult to measure and a source of controversy. Converting forests to cropland, burning sugarcane, and the manufacturing of ethanol release greenhouse gases (Searchinger et al., 2011; Government of the State of São Paulo, 2004).

The burning of sugar cane has recently been outlawed by 2014 in an effort to further reduce the carbon footprint of the Brazilian Ethanol Program. This has caused the manual planting and harvesting of sugar cane to be replaced with automated processes. This will result in a shift in labor skills from nontechnical to highly skilled in mechanized operations. Some

companies are generating programs to train existing employees in these advancements instead of contracting new workers. Finally, the Sugar Cane Manufacturing Organization has established a program to aid the restructuring of the workforce by retraining rural sugar cane workers in reforestation and beekeeping (Strietska-Illina et al., 2011).

Hydroelectric generation is another source of renewable energy that is important in Brazil. Hydroelectric power produces 93% of the nation's energy. Brazil accounts for approximately 12% of the world's marketplace for hydraulic energy. The downside to hydraulic energy is that it makes the country very susceptible to drought-induced energy shortages (Pereira et al., 2012). The Incentive for Alternative Sources of Energy Program (PROINFA) is thought to be amongst the most significant programs for stimulating alternative energy production and use in Brazil and around the world. It has brought about the generation of 3,299 MW of power and created 150,000 jobs by 2009. The program did this by working with 144 power plants across 19 Brazilian states to utilize installed power from wind farms, small hydroelectric plants, and biomass power stations (Strietska-Illina et al., 2011). PROINFA implemented strategies such as feed-in tariffs and bidding for renewables to bring about the 3,299 MW of power generation and to strive for the ultimate project goal – renewable energy sources comprising 10% of electricity generation in Brazil by 2020 (Dutra & Szklo, 2007). Also, Brazil's Ten Year Expansion Plan has invested billions of dollars into the future development of wind energy, biomass, biofuels, and small hydroelectric plants (Pereira et al., 2012).

Solar energy is another promising but underdeveloped energy source in Brazil. In March 2009, the Provisional Measure No. 459 established the "My House, My Life" program. This program funded the creation of 1 million low-income family houses. In this project, the Federal Bank and Ministry of Environment called for the use of solar panels in construction. Between 2009 and 2010 this venture not only gave homes to those in need but also employed an estimated 800 project managers and 7,000 solar panel installers (Strietska-Illina et al., 2011). This legislation improved the quality assurance practices used in construction through training and the development of quality management criteria and accountability. Brazil has coupled initiatives for economic growth with regard for the environment to become a forerunner of renewable energy expansion.

As the second fastest growing economy in the world in terms of GDP, Brazil emits significantly less CO_2 than other developing countries per capita. In regards to CO_2 emissions

released, it ranks 18th in the world (Pereira et al., 2012). As a participant in the Kyoto Protocol, Brazil discovered that a major contributor to the greenhouse gas emissions in the nation is deforestation accounting for more than 80% of emissions (Fearnside, 2001). With the ultimate goal of zero illegal deforestation at the forefront, Brazil plans to have a 40% decrease in illegal deforestation from 2006 to 2010 and then implement two consecutive 30% reduction periods between 2010 to 2014 and 2014 to 2018. This action plan is projected to prevent the release of 4.8 tons of $CO_2$from 2016 to 2017 (Strietska-Illina et al., 2011). These restrictive measures will help to curb the rise in emissions that normally accompany economic development and industrialization.

By 2020, Brazil strives for a 40% reduction in greenhouse gas emissions from the emission levels of 1990 as well a reduction in deforestation in Amazonia. (Pereira et al., 2012). It wants to "eliminate net loss of the Brazilian forest cover by 2015" and "double the area of planted forests from 5.5 million to 11 million hectares in 2020 and eliminate net loss" (Strietska-Illina et al., 2011, pg. 226). The National Qualifications Plan, the Agroextractivism Program, is estimated to assist 2,532 individuals by instituting vocational training programs with a focus on environmental preservation in communities whose environments are endangered by the construction for the North-South railroad. Additionally, the National Forestry Plan invests in expanding and educating its workforce to manage and sustain the national forests. This includes assisting the indigenous populations, marketing local products, and updating the national forest information system (Strietska-Illina et al., 2011). These strategies have the potential to protect the national forests and also generate green jobs.

Brazil boasts the biggest economy, population, and landmass in South America. By 2025, its economy is projected to jump from the ninth to the fifth largest in the world (Pereira et al., 2012). Jointly with its economic growth, its efforts to counteract climate change were highlighted this past summer when Rio de Janeiro hosted the United Nations Conference on sustainable development, nicknamed Rio +20 (United Nations, 2011). Brazil has enacted legislation that has developed flourishing green sectors and led to green job creation.

2.5 Comparison to Costa Rica

Costa Rica is a developing nation committed to going green that has yet to fully establish the political and economic infrastructure needed to achieve this goal. Costa Rica's economy is shifting from being based in agriculture to one dominated by services and technology. Its traditional economic sectors include agriculture, forestry and fishing, resources and power, manufacturing, the service industry, and transportation. Currently, 67% of Costa Rica's GDP is from tourism and services including hotels, restaurants, tourist services, banks and insurance (U.S. Department of State, 2012). With this shift towards technology, it has challenged itself to achieve carbon neutrality by 2021 which will cost an estimated $7.8 billion, a daunting amount to a small country of 4.5 million inhabitants with a GDP of $55.35 billion (Long, 2011; Central Intelligence Agency, 2012c). In 2005, Costa Rica released approximately 12 million tons of carbon dioxide and sequestered approximately 3.5 million tons (Long, 2011). Presently, an impressive 90% of its electricity is produced from renewable resources. In 2003, about 85% of electricity came from wind power, hydropower, and geothermal sources, whereas 15% was produced from oil imports (Nandwani, 2006). While Costa Rica does use numerous renewable resources, there are about 200 new vehicles on the road in Costa Rica every day, increasing carbon emissions (Long, 2011). Despite Costa Rica making strides to combat climate change, there is still a gap in the development of sustainable economic sectors and the proliferation of green jobs.

In response, our research will focus on the application of strategies utilized by China, Russia, Mexico, and Brazil to develop green sectors of their economies in Costa Rica in terms of feasibility, profitability, and effectiveness. The case studies demonstrate that sustainable energy-related development is typically backed by government legislation and investment as well as international collaboration with regard to energy-related projects and research and development. We will focus on how Costa Rica can utilize the most effective green strategies and provide individual companies and businesses with the necessary tools and knowledge to improve their own practices. The CICR has already begun the process of educating member companies through training sessions. Since "there is no organized coordination mechanism between academia and the public and private sectors to respond to the skills needed for becoming carbon neutral or creating a green economy," (Strietska-Ilina et al., 2011, pg. 255) we examine how to provide

Costa Rica with the skills to utilize the identified strategies. By studying the examples posed by China, Russia, Mexico, and Brazil, we will apply the successes of each case study in terms of the advancement of green sectors and jobs to Costa Rica.

Chapter 3: Methodology

The goal of this project is to recommend strategies for the potential generation of green jobs in Costa Rica based on comparative analysis of economic green sector development in China, Russia, Mexico and Brazil. The objectives are to:

1. Identify lessons learned and strategies that have worked for China, Russia, Mexico and Brazil.
2. Establish a baseline assessment of the Costa Rican green industry.
3. Develop recommendations for strategies that could benefit Costa Rica and present our recommendations in the form of an implementation plan to the CICR.

This chapter outlines our plans to meet these objectives.

3.1 Objective 1: Lessons Learned

To determine what has been successful (created green jobs) in China, Russia, Mexico, and Brazil, we will continue to evaluate these countries as models by conducting thorough research utilizing library and Internet resources. We will research each country to learn what its strengths and weaknesses are as they relate to respective green sectors. These green sectors include photovoltaic, hydroelectric, wind, geothermal, and biomass. Researching the four target countries as case studies will provide information to make recommendations to the CICR on how Costa Rica can further develop its green economic sector and create future green jobs.

Upon arrival in Costa Rica, we will conduct archival research comprised of reviewing documentation catalogued by the CICR regarding the case studies, Costa Rican green job statistics, and government policies pertaining to green sector development. In addition to archival research, we will interview professionals in the CICR, as referred to us by Bernhardt Johst, our on-site liaison from CICR, who have researched China, Russia, Mexico and Brazil or who have worked directly with organizations in one or more of these nations. This is a snowball sample which is a sample chosen through a series of referrals. They will provide us with information on the current status of green job creation in each of those countries. We will either travel to our referred contacts' businesses or set up a conference call. While conducting these interviews, we will split up into teams of two that will consist of an interviewer and a secretary to transcribe the proceedings. The proficiency of the participant in English will determine whether the interview will be held in English or Spanish. We will request permission to record

the interview and notify the participants that the recording will not be published and will only be reviewed by our project team. We will then ask questions that determine how each country began building its green industry and the lessons learned from each country's successes and/or failures (see Appendix A). These standardized interviews will yield insight into the economies and green job creation in each country in a consistent manner (Doyle, 2004).

3.2 Objective 2: Baseline Assessment of Costa Rican Businesses

To establish a baseline of green jobs in Costa Rica, we will refine a series of questions to be used when interviewing professionals and experts in various companies (see Appendix B). We define a *baseline* as the current status of green jobs in Costa Rica in order to create a reference point from which to improve. These interviews differ from those conducted in the first objective because instead of pertaining to the case study nations, they target Costa Rican businesses.

Based on the findings from our case studies, our sponsor will determine which businesses to examine. We will visit or conference-call five to ten target companies in specific industries that will comprise our snowball sample. The sample will include small, medium, and large companies, as decided by the CICR. At each business, we will interview executives in specific green sectors determined by our sponsor, utilizing standardized interview questions in addition to in-depth qualitative interviews (Doyle, 2004). One person will conduct the interview, while another teammate records the proceedings. The proficiency of the executives in English will determine the language of these interviews. At the start of each interview, we will ask if we can record the interview and inform the participants that the recording will be used afterwards solely for our note taking purposes. We will ask targeted and follow-up questions to obtain as much information from each company's representative(s) as possible. This information will identify Costa Rica's areas of success in terms of green job development and where it might need to improve.

In addition to interviewing experts and managers, we will administer surveys to engineers and technicians to assess the skills currently required to perform their jobs successfully (see Appendix C). The responses to the survey will provide a baseline of current employee skill sets, education, and training.

At the same time, we will catalog relevant green job training programs offered by Costa Rican universities and trade schools to provide quantitative and qualitative analysis of the current state of relevant training programs. After the research, interviews, and surveys are completed, we will then recommend strategies for how job skills might be adapted, developed and/or strengthened to accommodate potential new green sector jobs.

3.3 Objective 3: Development and Presentation of Useful Recommendations

After developing our list of recommendations, we will conduct a focus group with the members of CICR and other officials and experts (at the suggestion of the CICR) to obtain feedback about the strengths and weaknesses of the recommendations and revise them accordingly (see Appendix D). There will be a moderator to oversee the conversation between the members of the focus group, a secretary that will make observations of the proceedings, and two secretaries that will take minutes of the discussion. If time does not allow us to conduct a focus group, we will instead have informal meetings with these individual members to review our recommendations. Based on the results of the focus group or meetings, we will incorporate the advice of the participants into the final recommendations.

Finally, we will present the recommendations to the CICR. This document will be in the format of a pamphlet or booklet that could easily be implemented by employers interested in strategies for creating green jobs. The document will contain suggested improvements tailored to Costa Rican businesses. This will include lessons learned from the case studies as well as mistakes made that should be avoided in order to maximize the successful growth of jobs in Costa Rica's green sector.

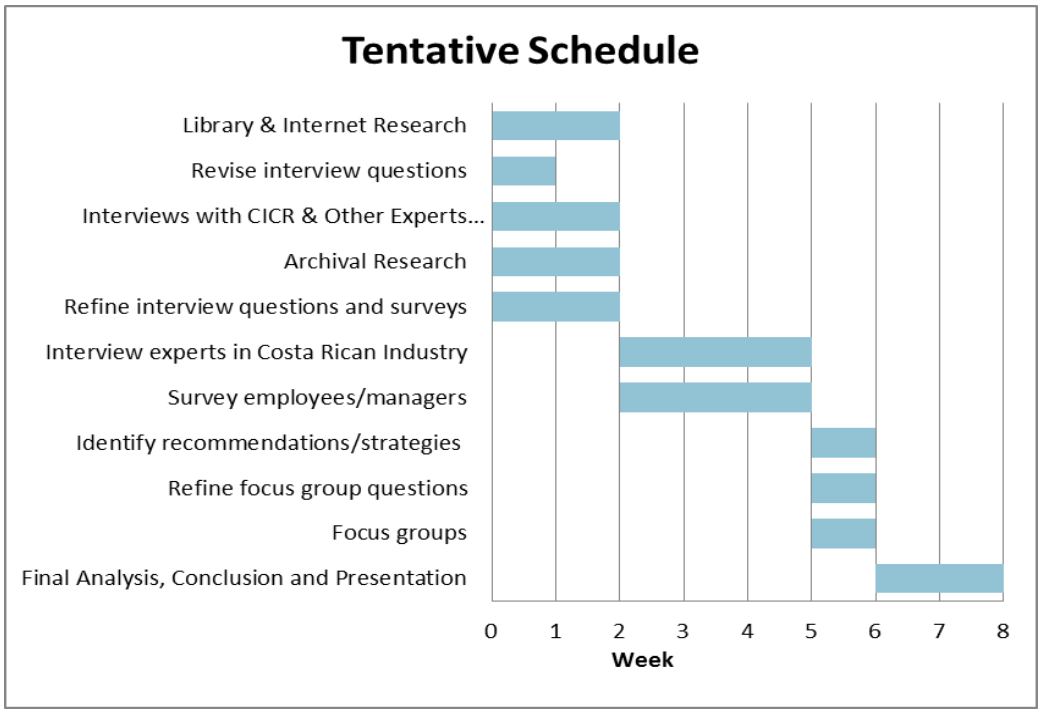

Figure 1: Projected timeline depicted in Gantt chart

The Gantt chart in Figure 1 depicts our tentative schedule. The horizontal axis has the number of weeks we will be in Costa Rica and the vertical axis outlines our objectives and tasks. Our first three tasks, research, designing interview questions, interviews with the CICR and other experts, and archival research will be completed during the first two weeks on site. Then we will refine the interview questions and surveys. For approximately three weeks, we will interview executives in Costa Rican industry and survey employees and managers. We will conduct a focus group to revise our recommendations and strategies for Costa Rica for approximately one week. We will complete any final analysis and conclude the project during the last week with a final presentation to CICR on December 13th, 2012.

Chapter 4: Conclusion

With the visible effects of climate change and the goal of carbon neutrality by 2021 at the forefront, Costa Rica is making strides in environmental reform and integrating green initiatives into emerging industry. The goal of this project is to develop strategies for the potential expansion of green jobs in Costa Rica based on the analysis of economic green sector development in China, Russia, Mexico, and Brazil.

In chapter 2, we discussed general concepts related to our project and provide initial insight into the green initiatives taking place in China, Russia, Mexico and Brazil that will serve as case studies for our work in Costa Rica. From the collected information, we synthesize effective strategies for the improvement of green industry and green job development while providing a preliminary outline of the gaps present in Costa Rican industrial sectors.

In chapter 3, we described how we plan to assess the current state of Costa Rican green sectors, which will allow our group to make recommendations for green job implementation. This process will include conducting further research on the case study countries as well as of records provided by the CICR, interviewing Costa Rican companies to establish the current standard in green industry, and surveying skilled workers on their education and training levels. This process will culminate in a focus group in which experts from green industries gather to critique our initial draft of recommendations. Upon revising our list of recommendations, we will provide the CICR with a pamphlet on strategies for green job creation. We hope that this will serve as a resource that will help Costa Rican businesses implement policies for green sector development and job creation. In conclusion, we are very grateful to the Cámara de Industrias de Costa Rica for providing us with this project.

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Appendices

Appendix A: CICR Interview Questions

This interview is concerning green sector development and job creation in one or more of the following nations: China, Russia, Mexico, and Brazil. Through the completion of this interview, confidentiality of all participants will be maintained by the interviewers and participants' names will not be released without their permission. All data will be handled carefully to ensure privacy.

1. May we please record this interview? It will be used strictly for our notes not for publication.
2. In our report, may we quote your responses?
3. In what way are you associated with China, Russia, Mexico, or Brazil?
    a. Have you worked directly with one or more of these nations?
        i. Through research
        ii. Joint policy creation
        iii. Trade relations
        iv. Through technical workshops
        v. Studying in one of those nations

    If so, please elaborate with particular emphasis on renewable energy, energy efficiency, carbon neutrality, and the current status of green job creation and relevant training programs.
4. How did China, Russia, Mexico, or Brazil develop its green industry?
    a. What are the successes?
    b. What are the failures?
5. Can you elaborate on green job creation and worker training program in one or more of these nations?
6. What can Costa Rica learn from the development of green industry and job creation in one or more of these countries?

Appendix B: Business Interview Questions

This interview is concerning green jobs and relevant training in Costa Rica. Through the completion of this interview, confidentiality of all participants will be maintained by the interviewers and participants' names will not be released. All data will be handled carefully to ensure privacy.

7. May we please record this interview? It will be used strictly for our notes not for publication.
8. What is the name of your company?
9. What is your mission statement?
10. What industrial sector is your company a part of?
    a. What does your company specialize in in terms of products or services?
11. How many employees does your company have?
12. In your own words, please define green.
    a. Please define green jobs.
    b. Please define skills for green jobs.
13. What has your company done to train workers in "green" practices?
    a. Describe any training programs.
    b. Describe training programs you would like to have your workers go through.
14. What technical skills do you require that your workers have?
    a. Engineers
    b. Managers
    c. Technicians
    d. Laborers
15. What skills do your workers lack that you wish they had regarding renewable energy, energy efficiency, and/or carbon neutrality?
16. Are your workers a majority of highly skilled workers or low skilled workers? What levels of education do you require your workers to have?
17. How are green jobs distributed in your company? (i.e. engineers, technicians, administrative positions)
18. How eco-minded is your company?

a. Has your company set any standards for reduction of carbon emissions?
b. Has your company set any standards for recycling or waste management?

19. What improvements can be made in your company to increase energy efficiency or energy savings?
    a. What difficulties are you encountering in implementing strategies in this area?
20. Has your company incorporated the use of renewable energy into its processes?
    a. How can your company do so in the future?
    b. What difficulties are you encountering that limit your use or production of renewable energy? For example, education, cost, awareness, resources.
21. In what way do you think you can make a contribution to sustainability in your company?
22. Do you have any suggestions as to changes that can be made within your company regarding green jobs and training programs?
    a. Workers
    b. Suppliers
    c. Customers

Appendix C: Survey Questions

This survey is concerning green jobs and relevant training in Costa Rica. Confidentiality of all participants will be maintained by the reviewers of this survey. All data will be handled carefully to ensure privacy. We appreciate you taking time to complete this survey. Please deposit it in the box labeled "WPI CICR" in the lobby.

1. Gender:
   □ Male □ Female
2. Age:
   □ Younger than 21 □ 21-30 □31-40 □41-50 □51+
3. Where you born in Costa Rica?
   a. □ Yes □ No
   b. If no, where were you born?
   _____
4. What company do you work for?
   _____
5. How many employees does your company have?
   _____
6. What is your occupation?
   _____
7. What field is most closely related to your position?
   □ Engineering □ Technician □ Human Resources
   □ Quality Assurance □ Research and Development
   □ Marketing/Sales □ Management □ Facilities
8. What is your highest level of education?
   □ High School
   □ College/University degree
   Please specify degree:

□ Bachelor's degree

□ Master's degree

□ PhD

If university please specify: _____

Where is this university? _____

□ Vocational school

□ Other

Please specify: _____

9. Do you have any certifications?
    a. □ Yes □ No
    b. If yes, please specify: _____
10. Has your current employer conducted any training programs or informational sessions?
    a. □ Yes □ No
    b. If yes, do these training programs or sessions concern any of the following areas? Check all that apply:
        □ Carbon neutrality
        □ Recycling
        □ Becoming more energy efficient/Increasing energy savings
        □ Technical skills
    c. If no, do you think they should have training programs? In what areas? Check all that apply:
        □ Carbon neutrality
        □ Recycling
        □ Becoming more energy efficient/Increasing energy savings
        □ Technical skills
        □ Use of renewable energy
        □ Other

            Please specify_____
11. What does the word "green" mean to you?
12. What has your company done to "go green?"

13. Does your company produce green technologies? If so please specify.
14. Do you utilize any of the following renewable energies in your position?

    Check all that apply:

    □ Wind Power

    □ Photovoltaic Panels

    □ Hydroelectric Power

    □ Geothermal Energy

    □ Biofuels

    □ Biomass

    □ None

    □ Other

    Please specify: _____

15. Are there specific areas of your business that can be run more efficiently?
    a. □ Yes □ No □ Unsure
    b. If yes, what are these areas?

    _____

    _____

    _____

    _____

16. What skills do you utilize on a day to day basis?
17. Do these skills contribute to your company being green? Please elaborate.

    _____

    _____

    _____

    _____

Appendix D: Focus Group Questions

Set up: One group member will moderate the focus group while three other group member will act as secretaries. The list of recommendations we have developed will be provided to the participants of the focus group (members of the CICR) prior to the focus group. We will also provide hard copies of our recommendations during the focus group for the participants to refer to. Confidentiality of all participants will be maintained by the interviewers and participants' names will not be released. All data will be handled carefully to ensure privacy.

1. After reviewing our list of recommendations, which ones stand out in terms of:
    a. Feasibility of implementation?
    b. Likelihood of success?
    c. Probability of significant impact?
2. After reviewing our list of recommendations, which ones appear:
    a. Impractical for implementation in Costa Rica?
    b. Unlikely to be successful?
    c. Too costly?
3. Discuss strengths of our recommendations:
    a. Do you have any suggestions that could add to the strength of our recommendations?
    b. Are there any other opinions or advice you would like to share in relation the list of recommendations?