INVESTIGACIÓN

Potential of renewable energy production: an assessment of Costa Rica's decarbonization plan

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Abstract

As part of a comprehensive strategy and country's future sustainable carbon footprint achievement, Costa Rica in 2019 launched an initiative to become the very first carbon-neutral economy in the world by the year 2050. To accomplish this ostentatious goal, the country has developed the National Decarbonization Plan. This strategy is based upon 10 robust focus areas which are ambitious in nature thus providing an international blueprint for a net-zero emission economy. This study critically analyzes the gaps, challenges, and proposes academic based recommendations for the sustainable implementation of the plan. In-depth research was conducted on Transport and Sustainable Mobility Scope covering focal areas; 1, 2 and 3. Furthermore, five internationally renowned experts who reviewed prior the plan were also consulted. As of 2020 there is not an effective public transportation service in the GAM where lives more than 40% of the entire country's population. Almost, 90% of the High-Capacity Network vehicle infrastructure does not comply with parameters of the National Transportation Plan in terms of the available number of lanes; in the absence of changes, the percentage of routes with major traffic problems will go from 48% in 2017 up to 86% in 2025. The authors also conducted additional research, but in this scenario, a COVID-19 impact lens was applied to reassess the future of the plan. Several of these presented challenges include, the non-approval of new necessary laws, national fiscal debt, bureaucracy, and the recent emergency caused by Covid-19. However much this plan is revolutionary, it is a positive stride towards sustainable development which fosters global peace and nature-based economic stability. The general objective of this essay is to inquire about the state of the art in the teaching of economics, through a literary review of recent contributions to the subject. In particular, the specific objectives of this study are to describe

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the general panorama in the implementation of recent educational models; study the role that research plays in university institutions; and identify the challenges that arise in the teaching of economics.

Key words:

Decarbonization, Renewable energy, Sustainable Development, Carbon footprint

Introduction

Costa Rica is an independent state in Central America, a small country just in the middle of the continent. It has a population of approximately 5 million people living in its territory. In this small developing country, around 99% of its electricity comes from renewable sources such as rivers, heat from volcanoes, wind, sun, and biological waste. However, there is still a long journey to fully achieve a net-zero emission economy by 2050. Strong policies must be enacted to boost the advancement of this plan in addition to all sectoral inclusion in decision makings irrespective of age, gender or political affiliation (OECD, 2018).

According to Yépez-García & Dana (2012), the paradox of Costa Rica's reality in terms of renewable sources is that it still continues to import petroleum. This is because 70% of all energy consumption requires non-renewable energy and the main reason is that the transportation system is designed to be 100% dependent on fossil fuels. With all these clean energy alternatives Costa Rica has due to its tropical geographical location, the country can transition to electricity-run instead of fossil fuels. The negative effects of fossil fuels directly impact the environment and causes immediate variations in climate change (Monge-González, 2016). For this reason, Costa Rica considered tackling fossil fuels as a priority and center of progress. That is also the reason as to why the first key actions of the national decarbonization plan focuses on transportation and sustainable mobility.

A petroleum dependent economy must improvise mechanisms which make such economic activity sustainable without harming the future nor compromising the planet. This is in line with any other economic activity, it will always have its pros and cons but the model of operation is what makes clean energy alternative a catalyst of transformational growth (Le et al., 2019). For a developing country like Costa Rica, it should strongly diversify its economy and explore other green energy alternatives. Tropical countries have a variety of options such as hydro energy, the use of windmills etc. these alternatives when implemented correctly, they can help Costa Rica to achieve its decarbonization plan for 2050.

Three of the focus areas on which the government of Costa Rica intends to consolidate efforts and projections on achieving the objective of the decarbonization of the country by 2050, are under the transportation and sustainable mobility category. For this reason, the government has set forward the task

of working on some short-, medium- and long-term goals for each of these 3 focus areas that constitute a small part of the entire national decarbonization plan.

This is also a mandate from of the Paris Agreement Article 4.19 which Costa Rica ratified. The article urges all stakeholders of the agreement to prepare and communicate transparently on all strategies directed towards reducing greenhouse gas (GHG) production (Bataille et al., 2020; Yeeles, 2019).

The selection and scope of this research has been delimited because the transportation and sustainable mobility portion constitute a very important part of the dependency on fossil fuels. Additionally, it is also within this area that Costa Rica can start sooner as a country to transform its future and achieve the goal of improving development and climate change and having a country running on 100% renewable energy. Carbon emission constitutes the highest percentage GHG emission, and it is also in this area where there cost effective alternatives which can be applied to reverse the latter.

Methodology

The proposed investigation in this study is a qualitative research characterized by analyzing existing scientific perspectives and critics. This research methodology was applied by Lester (1998)which is a key prerequisite for success; 2, to analyze and explain the critical success factors for new product development. This approach involves critically analyzing existing science, following the sequences of how things happen, establishing a correlation of events and finally providing productive conclusions which generate knowledge.

This approach was also used by Fui-Hoon et al. (2001), on capital execution management of successful factors. Where they conducted a sequential systematization of events and this was aligned to scientific data to interpret patterns in the industry. The ideology is built on something which already exits and then later develop theories of change based on scientific analysis. This paper systematically analyzes the Costa Rica's decarbonization plan for 2050, identifying challenges, relating to other scientific interpretations of such futurist plans and then finally provides suggestive recommendations of improvements.

Subjects

The subject of study is the Costa Rica decarbonization plan with the aim to become the first zero-emissions country in the world, the impressive potential of Costa Rica to create new renewable energy production makes this goal possible to achieve. The country has enacted new legislative laws, regulations, initiatives, and streamlining lifestyle of its inhabitants. The strategies in this plan are multilateral thus, an inclusion prospects of all sectors, stakeholders and beneficiaries are key to the success of the decarbonization plan. Additionally, the actions taken must also be consensual and all opinions and perspectives especially from the academia is very resourceful in providing sustainable models and research.

Techniques and instruments

Qualitative research and analysis on existing documents from different international critics and authors own perception of the decarbonization plan's progress. A thorough research was conducted on Costa Rica's Decarbonization Plan. Since the plan is very "political and futurist" in nature, several views were analyzed from international critics on the plan such as the World Bank, Organization for Economic Co-operation and Development, Interamerican Development Bank, Nature Climate Change, and Figueres (2020), on research related to the topic. These were the baselines used to develop the conclusions and recommendations in this research.

Object of study and definition of the problem

Costa Rica's Decarbonization Plan is a document with 10 robust focus areas covering all sectors with their contribution effects. The plan also makes projections of how these effects will be mitigated on a short-medium and long term goals (Ministry of Environment and Energy, 2018). This research seeks to analyze the challenges which may affect the long-term implementation success for 2050. Based on the results of these analysis, the article also provides conclusions and recommendations to not only researchers in the academia but also to the decarbonization plan itself.

Scope definition

For this research we are delimiting the assessment to the focus area in the national decarbonization plan related with transportation and sustainable mobility. The plan is quite extensive to exhaustively study all focal areas in detail. For this reason, the authors have concentrated more on the analysis of transportation and sustainability scope, emphasizing on focal areas 1, 2 and 3.

The authors also agree that these focal areas are key in streamlining the rest of the focal areas. Additionally, they also represent the highest GHG emission, therefore primary mitigation strategies will enable Costa Rica to achieve its decarbonization plan 2050. This is because transport systems are what determines the behavior of the rest of economic activities. When emission from the transportation system is not controlled and steered towards a renewable energy-based system, GHG emissions will always skyrocket, and mitigation strategies will become more complex.

Analysis method

The research was inducted by consulting official government publications, national and international research publications. A desk review analysis was conducted studying different primary data sources as

mentioned in (techniques and instruments) section. These are scientific reviews and studies which were done on the decarbonization plan with the objective to assess it and evaluate its propensity to achieve the said objectives by 2050.

The authors furthermore conducted additional research but, in this scenario, a COVID-19 impact lens was applied to reassess the future of the decarbonization plan. According to Kanu (2020), the COVID-19 economic impacts for developing countries will greatly affect economic activities and increase unemployment rates (Table 1). This is irrespective to which continent the country is located, for as international trade in most countries are still banned to contain the transmission. There should be a balance on health policies and economic policies each country adopts.

Table 1.
GDP, unemployment rate and Fiscal deficit projections through 2021.

Double-hit scenario	**2018**	**2019**	**2020**	**2021**
Gross domestic product	**2.7**	**2.1**	**-4.9**	**1.5**
Unemployment rate	10.3	11.8	17.0	15.5
Fiscal balance[1]	-5.8	-7.0	-9.1	-7.7
Primary fiscal balance[1]	-2.3	-2.8	-4.0	-2.1
Gross public debt[1]	53.2	58.5	68.8	73.1
Single-hit scenario	**2018**	**2019**	**2020**	**2021**
Gross domestic product	**2.7**	**2.1**	**-4.1**	**2.7**
Unemployment rate	10.3	11.8	15.9	13.9
Fiscal balance[1]	-5.8	-7.0	-8.9	-7.1
Primary fiscal balance[1]	-2.3	-2.8	-3.9	-1.7
Gross public debt[1]	53.2	58.5	67.9	70.6

Source: Adapted from *OECD Economic Surveys: Costa Rica*, OECD, 2020
(http://www.oecd.org/economy/costa-rica-economic-snapshot/)

Relevance

As Costa Rica has effectively published the Decarbonization Plan for the country, several other countries, members of the Paris Agreement have showed their support over the initiative taken by the government. The Decarbonization Plan is an important document because it depicts solutions to the various unfavorable aspects affecting the Costa Rican society. These among others include the increase of transportation fleet, fossil fuel dependency, increased contamination, health impact on the population, high economic costs and reduction in livelihood quality as mentioned in the state of the nation's report *"Estado de la Nación"* (Programa Estado de la Nación, 2018). The analysis of the Focus Areas related to the Transportation and Sustainable Mobility will determine if Costa Rica is going through the correct path or if it needs to perform changes based on the current context of the country because of the Covid-19 pandemic.

Research Findings

Costa Rica Decarbonization Plan:

Figure 1.
Decarbonization plan by sectoral distribution and focal area.

Source: Adapted from *National Decarbonization Plan: Costa Rica Bicentennial Government 2018-2050*, Ministry of Environment and Energy, 2018 (https://unfccc.int/sites/default/files/resource/NationalDecarbonizationPlan.pdf9

Transport and Sustainable Mobility

Focus Area 1: Development of a mobility system based on safe, efficient, and renewable public transport, and active mobility schemes.

Transformational vision.

- In 2035 30% of the public transport fleet will be zero emissions and the Electric Passenger Train will operate on 100% electric.
- In 2050 the public transport system (Buses, Taxis, Electric Train of Passengers), it will operate in an integrated way, it will replace the car particular as the first mobility option for the population in the Grand Metropolitan Area (GAM).
- In 2050, 85% of the public transport fleet will be zero emissions.
- By 2050, Compact Cities will have been consolidated in the main urban areas of the GAM and main secondary cities of the country, with a 10% increase in travel in modes not motorized.

Focus Area 2: Transformation of the light duty vehicle fleet to zero emissions one, nourished by energy that is renewable and not of fossil origin.

Transformational vision

- By 2025, the growth of the motorcycle fleet will stabilize and will adopt standards to migrate to a zero emissions fleet.
- In 2035, 30% of the fleet of light vehicles - private and institutional will be electric. By 2050, 95% of the fleet - will be zero emissions.
- By 2050, new mobility models and schemes will have been consolidated shared.
- By 2050, the country will have an extensive electric recharging network throughout the country and with complementary infrastructure for zero technologies emissions (e.g., hydrogen stations).

Focus Area 3: Promotion of a freight transport fleet that adopts modalities, technologies, and sources of energy, aiming to achieve zero or the lowest emissions possible.

Transformational vision

- By 2022 Limon Electric Freight Train (TELCA) in operation.
- By 2030 20% of the fleet operates with LPG.

- By 2035, sustainable logistics models have been consolidated in the main ports and urban areas of the country.
- By 2050, freight transport will be highly efficient and there will be reduced emissions by 20% compared to 2018 emissions.

Energy, Green Building, and Industry

Focus Area 4: Consolidation of the national electric system with the capacity, flexibility, intelligence, and resilience needed to supply and manage renewable energy at competitive cost.

Transformational vision

- By 2025, have an integrated intersectoral planning of the electrification process for various uses in the country.
- By 2030, the electrical matrix will be able to operate 100% with energy renewable.
- By 2050, electrical energy will be the primary energy source for the transport, residential, commercial, and industrial sectors.
- By 2050, institutional processes will be digitized, and they will facilitate efficiency and competitiveness.

Focus Area 5: Development of buildings of different uses (commercial, residential, institutional) under high efficiency standards and low emission processes.

Transformational vision

- By 2025 place a 10% increase in the use of wood, bamboo, and other local materials in buildings.
- By 2030: 100% of new buildings are designed and built adopting low-emission and resilience systems and technologies under bioclimatic parameters.
- By 2050: 50% of buildings, commercial, residential, and institutional institutions will operate with low emission standards (high electrification or use of renewable energies in cooking processes and water heating).

Focus Area 6: Transformation of the industrial sector through processes and technologies that use energy from renewable sources or other efficient and sustainable low and zero emission sources.

Transformational vision

- By 2030 the sector will have innovative production models of "Cradle to cradle" or circular economy in main productive chains of Agro-industry, services, construction, among others.

- By 2050, the industrial sector will have changing energy sources to decoupling the growth of its activity from that of its emissions.

Integrated Waste Management

Focus Area 7: Development of an integrated waste management system based on separation, reuse, revaluation, and final disposal of maximum efficiency and low greenhouse gas emissions.

Transformational vision

- By 2025, 10 Municipalities implement a national strategy for composting.
- By 2040 100% coverage of sanitary sewerage and treatment wastewater in high population density areas.
- By 2050 100% coverage in the other priority areas.
- By 2050 100% of the territory has solutions for the collection, separation, reuse, and disposal of waste.
- By 2050 20% of the rivers of the GAM have been restored.

Agriculture, land use change and nature-based solutions

Focus Area 8: Promotion of highly efficient food systems that generate low-carbon local consumption and export goods.

Transformational vision

- By 2030: Value chains of coffee, livestock, sugar cane, rice, bananas will apply emission reduction technologies both to farm level, as well as processing stage level.
- By 2050, the most advanced methods and technologies will be applied to achieve a sustainable, competitive agriculture, low-carbon, resilient and has the lowest levels of contamination.

Focus Area 9: Consolidation of a livestock model based on productive efficiency and reduction of greenhouse gases.

Transformational vision

- By 2025 Promote circular economy with cattle farms through implementation of the biodigester program.
- By 2030 70% of the cattle herd and 60% of the area dedicated to livestock implement low carbon technologies.

- By 2050 the livestock activity will use the most advanced technology in accordance with standards of sustainability, competitiveness, low emissions, and resilience to the effects of climate change.

Focus Area 10: The rural, urban, and coastal territory will be managed, oriented towards conservation and sustainable use, increasing forest resources and ecosystem services based on nature-based solutions.

Transformational vision

- By 2030: Maintain forest cover and increase to 60% at the same time this type of coverage does not compete with the agricultural sector.
- By 2050 4,500 hectares of green areas function as recreational parks in the GAM and a system of environmental-pedestrian networks is consolidated that serves as biological corridors and pedestrian corridors.
- By 2050 the rural and coastal landscape allows the restoration and protection other high carbon ecosystems (Mangroves, wetlands, peatlands, soils).

The current investigation has been outlined to concentrate on the assessment of the progress on focus areas related with Transportation and Sustainable Mobility, which is concentrated into the focus area 1, 2 and 3 of the Costa Rican decarbonization plan. Most of the ideas presented below in this research covers the above-mentioned specifics. However, it also gives a general overview of the strategies of change revolving the other focus areas.

Sustainable Mobility and Transportation

Costa Rica is midway to complete the fourth quarter of 2020, after a completely atypical year because of the COVID-19 effect. We can make a general analysis of what has been achieved so far or what has had to be adjusted after an unexpected and unknown situation as COVID-19. This is a scenario which almost all economies are experiencing irrespective of their economic status and location.

According to Ashraf (2020), the COVID-19 impact was unprecedented event, obliging governments around the world to scramble and enforce distinctive contingency plans. These among others included social distancing and closure of borders. Health of people is always a priority, however in unprecedented circumstances imposed by COVID-19 certain actions adopted by governments directly affect the sustainable operations of their economies. This was no exception in Costa Rica. The pandemic had generated an unfavorable economic effect on the reality of the country; therefore, we consider that the decarbonization plan has suffered an impact that makes it a necessity to adjust or a postpone some short-term goals. This is as an outcome which is evidently seen in the closure of various small and medium

enterprises (Herrera, 2019). Eventually, soon in the future the impact will also be experienced within multinational and international enterprises.

Progress that has been made in some of the proposed goals requires joint actions that need to be worked upon between the public and private sector. This kind of public-private alliance may be affected by the current country's political climate. There is a heated discussion currently across all sectors with different perspectives about the current governments intention to secure loans with the International Monetary Fund (IMF) (Woodroffe & Ellis-Jones, 2000; Koomen & Wicht, 2020). According to the Ministry of Finance (2020), clarifies that it has not modified the fiscal deficit projection for the end of 2020, which remains at 9.3% of GDP. Most of these resistances have been triggered to a greater extent by the COVID-19 control measures at a national and international level which has affected most of the economic activities and movements of people.

Focus area 1:

Development of a mobility system based on safe, efficient, and renewable public transport, and active mobility schemes.

Out of 17 actions proposed to achieve the decarbonization on focus area 1, all 17 action points have commenced immediately following the conception and approval of the first National decarbonization Plan progress report which was out in February 2019. Out of 9 goals proposed for 2021, 8 had already commenced, some of the progress was achieved as of February 2019. This focus area has legal dependencies to proceed with achieving results and due to the legal separation of powers approach stipulated in the Costa Rican Constitution. This requires additional negotiations where the Executive Branch requests and succeeds in convincing the Legislative Branch. These are the underlying legal approvals that are required to continue proceeding with the proposed national Decarbonization plan.

Furthermore, the Party that represents the President of the nation and his cabinet do not have a majority in the Legislative Branch, making this political polarization a barrier to achieve the proposed objectives. In other words, the executive branch plays a huge role in the determination of the success of the plan. This involves convincing other members in the Legislative Branch from other party affiliations to support and backup their motion in the parliament.

In recent days, Costa Rica has experienced difficult moments at a political level that complicates the situation and the relationship between parties and branches to reach consensus on some of the action points. This challenge has been greatly fueled by the governments decisions to opt for an IMF loan to finance its budget and operations. In addition, the COVID-19 situation has put other priorities on the table leaving others behind. A vivid example can be highlight from the construction and financing of

an electric train system in Costa Rica. This has greatly lost popularity among the population. Due to a stagnant state of economic activities, people do not visualize the viability of business transactions and movements of people because of massive lockdowns.

Additionally, COVID-19 has increased the unemployment rate close to 24% in October 2020 (Chletsos & Sintos, 2020). The biggest group affected are from both formal and informal sectors because most companies are closing and there is also a massive lockdown on people's movements. This again makes it visible that there are other short-term priorities in place, than getting a new debt to have an electric train installed. Besides that, an important portion of the population agrees on the need of having an electric train system, but they consider this after COVID-19 because this is not the right moment. This simply implies that the population must carefully weigh in their basic needs versus economic wellbeing. However much acquiring the train is important to boost the economy and reduce GHG emissions, the population do not perceive the train ideology as a viable move now due to the current economic crisis.

Focus area 2:

Another Focus Area of the Transportation and Sustainable Mobility is the transformation of the light and duty vehicle fleet to a zero-emissions one, nourished by energy that is renewable and not of fossil origin.

Over 98% of Costa Rica's energy comes from renewable sources, the country uses fossil energy only as a backup system (less than 2% per year). Therefore the idea of modernizing the vehicle fleet with eco-friendly vehicle fleet makes more sense (Ajmi & Inglesi-Lotz, 2020; García-Valladares & Ituna-Yudonago, 2020). Additionally, this also provides evidence that by applying strategic plans and sectoral inclusion in decision making, Costa Rica can run effectively on green energy as stipulated in their decarbonization plan for 2050. Being a tropical country with lots of rivers and natural resources, Costa Rica has an added advantage on stepping up on its zero-emissions plan.

One of the most important accomplishments since the implementation of the decarbonization plan has been the application of a tributary benefits for zero-emission to car owners. According to Ebeling (2020), sustainable energy transitions will require a significant gradual degree of balance of conventional systems and the contemporary systems. Using a political tool such as advocacy for tributary incentives will motivate transformative change to modern systems.

Excellent Public Transport systems are vital and a great determinant to the sustainable development of cities. However, transportation system also requires a large amount of energy and of course this energy is ejected out in some form or the other into the atmosphere. The constant monitoring of new transportation system alternatives will enable to ensure its success because these issues will be prominent in the future due population increase (Alvarez-Risco et al., 2020).

In partnership with the Costa Rican Institute of Electricity (ICE), Costa Rica has become the third country in Latin America with more plug-in charge stations in the country with over 200 different charging locations. This is an integral part of the strategy to incentivize and promote clean transportation alternatives. This move is more than a promotional stunt because it has the ability to persuade environmental consciousness among responsible citizens (Masse et al., 2019).

In accordance with the Car importers estimations, by the end of 2020, there will be over 4,500 electric vehicles circulating, and the expectation at the end of the year 2022 is to have around 25,000 vehicles (Garza, 2020). The publication of the Electric Mobility Law at the beginning of January 2018, caused the number of electric vehicles in the country to double. A study conducted in Sa Paolo about the contributions of electric cars in reducing CO2 emissions confirms that there is a significant positive impact of GHG mitigation from electric cars (Costa & Seixas, 2014).

Nevertheless, there is great need for coordination and alignment of public policy objectives and incentive programs: to the extent that the institutions work in a coordinated manner and towards a common objective, public policies to promote the electric vehicle market will be more effective. In this sense, the involvement of governments at the national level (rather than at the ministry, city or municipality level) seems fundamental so that the incentive programs, in addition, are aligned with the policies that are defined as priorities for the country (Isla et al., 2019).

It appears that the country has a good baseline to achieve this goal, though, it still has a long way to go and many actions need to be reorganized and decisions must be made. The success of this phenomenon ideology entirely depends on multi-sectoral inclusion and the empowerment of beneficiaries. There is still resistance and lots of myths concerning how sustainable are electric cars for small and developing economies. Here is where the academia also plays a fundamental role in providing research which validates the notion about the implementation of an electric transportation system.

The decarbonization plan is in progress; nevertheless, the battery and electrical technologies are still expensive and hard to obtain, also accessible only to upper and medium-high classes. According to OECD (2020) research, the GINI index (an index which calculates the social inequality) Costa Rica is more likely to become an inequality country with an index of 48 points. The interpretation for this is that not everybody in the country has the same opportunities and access to essentials or nonessentials products and services.

However, in Costa Rica both the medium and low class represents 65% of the total population. With this strong inequality gap in place, this also means that the acquisition capacity of both the low and medium class is very low. Hence, with this large representation of the entire population, it is not in the best interest to transition immediately to electric transportation systems. This will also slow down the plan and its transition to a zero-emission vehicle fleet.

Alternatively, there are more than 600,000 motorcycles circulating in Costa Rica and being one of the most preferred means of transportation by many Costa Ricans. They are used to get to job locations easily because a motorcycle can easily maneuver through a dense traffic compared to cars. In addition to this, it is important to note that they are cheap in terms of acquisition and maintenance. However, currently electric, and efficient motorcycles have not yet evolved as well as electric cars and the ones available on the market are considered a luxury which the working class cannot afford,

Additional challenges that could delay the implementation of the plan, are bureaucracy and private interests. The Costa Rican Oil Refinery company (RECOPE) is the legal entity in charge of regulating fuel prices and supplying it to the entire country. However, since its foundation in 1961, it remains also a government company with a robust infrastructure and over 2000 employees. It is not allowed to diversify and invest in other types of clean energy alternatives. This is one the biggest hinges to the progress of the decarbonization plan and it is government oriented. It becomes more complex when the Executive Branch must convince its Legislative Branch and the public to adopt to modern systems when the ones have failed to adapt.

Part of the decarbonization plan is to create a complementary infrastructure for other zero-emission technologies such as hydrogen stations and natural gas supply. This is where RECOPE should play a key role with excellent results, there must also be public transparency in the implementations of these investments into alternative zero-emission projects. In most cases these alternative projects do get approved in the parliament because of lack of quorum and distrust in public institutions. With these challenges in interplay, the clock ticks and the worry are that will the plan achieve its goals by 2050.

In addition to that public transportation is yet another relegated battle, one of the biggest challenges in the country is to have a contemporary and efficient public transportation system. This is because the current system through concessions seems not to help to move forward with the plan. The private concessionaires often oppose the use of new technologies such as electronic payment due to additional costs it pertains. The private concession strategies must be critically examined and streamlined so that we are all on the same page. Those which are not adaptive to new technologies their renovations should be cancelled or otherwise improve on the operations.

This becomes a concessionary priority to upgrade the buses fleet to a more effective one, it can as well be considered as a high investment for the same benefit thus improving public transportation system and reducing CO2 emissions. However, for this scenario, urgent actions must be taken, and the government must adopt new responsibilities and priorities to move forward with this relegated aspect.

Focus area 3:

On the Focus Area 3 of Transportation and Sustainable Mobility, covers the promotion of a freight transport fleet that adopts modalities, technologies, and sources of energy, aiming to achieve zero or the lowest emissions possible as part of the path to reach the goal in 2050. The main milestones are show below in a chronological order:

- 2022: Electric Freight Train of Limón (TELCA) will be operational
- 2030: 20% of the freight fleet will operate with Liquefied Petroleum Gas (LPG).
- 2035: models of sustainable logistics will be consolidated on the major ports and urban areas of the country.
- 2050: freight transport will be highly efficient and there will be 20% emission reductions compared to 2018.

Costa Rica has been working vigorously on the progress of the goals set in the decarbonization plan 2050. By February of 2020 one year after the presentation of the Decarbonization Plan, TELCA was instituted, and its implementation was on track. But prior to that, the feasibility studies were finalized as well and there was a first logistic trial as part of an alliance with the private sector.

In accordance with the newspaper *"La República",* the proposed project will cover a total length of 250 kilometers but to achieve this, it is necessary to improve the infrastructure, installation of the electric system and build at least 250 bridges. The initial phase of the dream of integrating Central America through an efficient freight rail system was also concluded. TELCA is an approximately $450 million project that aims to create a route from the Valle de la Estrella in Limón to the northern border, passing through the ports of the national Caribbean region (Canales, 2020).

Depending on the findings obtained from the feasibility studies, the Central American Bank for Economic Integration (CABEI) has the vision to expand the scope not only to cover the original length from Limón to San Carlos. The big aspiration is to also extend further the train until Nicaragua to have a regional train in Central America to consolidate the economic integration of the region.

As part of the benefits of TELCA implementations; the country will improve the following aspects:

- Security and infrastructure, by having less damage to the roads and therefore, less environment impact due to less trucks.
- Stimulate the tourism to the Caribbean by having less heavy traffic on the routes.

- Stimulate the employment within the region in the construction and operating phases, attracting investment in the area, including Free Trade Zones.

The usage of LPG is the next milestone in a chronological order after TELCA, to understand the impact and determine the scope, a discussion was held with one of the members of the National Chamber of Cargo Transportation (CANATRAC). The main concern about the project is related to the truck power provided by this technology. Taking into consideration the geographical conditions that Costa Rica has as a country in terms of being mountainous. The second concern discussed was related to the cost of performing the transformation of the trucks into LPG in which a high cost is involved. Unfortunately, it is not certain the benefits that it will provide to the companies considering that TELCA will also reduce the freights that are performed as for today (Brenes Maykall & Olivier Girot, 2019).

However, according to TELCA, the use of LPG and sustainable logistics models are only a part of the solution. According to the Transportation and Mobility report of *"Estado de la Nación"* in 2018. Costa Rica has within the main road infrastructure of the Great Metropolitan Area (GAM) an average of 5,000 heavy vehicles entering the area. Along with this factor, 90% of the High-Capacity Network vehicle infrastructure does not comply with parameter of the National Transportation Plan in terms of the number of lanes available; in absence of changes, the percentage of routes with major traffic problems will go from 48% in 2017 up to 86% in 2025 (Costa Rican Government, 2020).

Circumstances referred to above requires a substantial load of investment to perform changes. However, due to the Covid-19 pandemic situation, the country has been compelled to critical economic situations that may lead to an economic recession in the upcoming years. The proposals to change the consumption of diesel to LPG will also create an impact to the Costa Rican Tax System. This is because a significant portion of the resources comes from the fuel tax. By gradually changing or eliminating the use of fossil fuels, the country will need to find alternative fiscal sources to cover the portion not collected due to the implementation of novel transportation systems.

Results

The transportation system plays a crucial role in determining the amount of energy a country produces this is because transport is a basis to the movement of not only people but also most economic activities. Costa Rica has an approximately of 70% of energy consumption still dependent on fossil fuels because of its transportation structure and system.

Research Findings has also demonstrated that as of 2020 there is still not an efficient public transportation service in place within the GAM, where its habitants are more than 40% of the country's entire population. With such a dense population highly concentrated in the cities, there must be an efficient and effective

public transportation systems in place which empowers habitants to use them as compared to private transport.

Approximately people spend more than two hours per day on traffic to move approximately 10-20 km distances to get to their jobs. This is not sustainable at all, not only for the environment but also the metal wellbeing of a person.

Effective train system is currently obsolete and has a significant delay in its modernization because it has not been active for about almost 20 years ever it was reactivated in 2014. This still indicates a long journey the new modernization must overcome prior to being adopted and accepted by the public.

There is a substantial polarization between interest of the public transportation union and the government to obtain the approval of the required laws. One the biggest hinges is lack of a consensual quorum, it seems that there exists a divergence of interest between the government and public transportation unions. However, it is ideal to have a common goal for the success of the decarbonization plan.

Electric-powered train system is not affordable for foreign companies under the current concession environments, so there is a dependence on getting credits to build and implement this project. Either the government has to device alternatives in terms of incentives which boost the procurement of electric train or directly procure these assets as a state initiative.

There are currently more than 5,000 trucks daily circulating through the GAM, impacting the mobility of the public and private transportation and other alternative transportation solutions. Solutions must be robust and considering all options and stakeholders.

Around 90% of the High-Capacity Network vehicle infrastructure does not comply with parameters of the National Transportation Plan in terms of the number of lanes available; in absence of changes, the percentage of routes with major traffic problems will go from 48% in 2017 up to 86% in 2025.

The road infrastructure issues are also affected by the composition of the vehicle fleet, which is getting bigger and older each year. The heavy trucks fleet higher than 3,500 kilograms have expanded around 4% annually since 2007 and 2016.

The logistics services and heavy transportation vehicles are key to the economy, but they do not have the right infrastructure to connect the main ports and the country borders to the GAM. This is also because over 35% of heavy trucks transit through San Jose whereas 30% goes out of San José and pass through defined established routes. Only 5% transit within San José internally.

The Costa Rican Tax System receives a significant portion of the resources collected through fuel and vehicle consumption. Therefore, by gradually reducing the consumption of fuel into an economy of decarbonization, the country will need to find alternative fiscal sources to cover the portion not collected due to the implementation these novel systems.

Proposed Solution

Encourage multilateral and collaborative work with different unions either public or private to create a plan on renewing the actual fleet of busses to be electric in the coming years. This will enable a smooth transitioning into the modernization of the public transportation systems.

Develop a transparent project to understand if resources are being invested in a good way to build the electric train system in the GAM. Communication and transparency are key to public management and stakeholders must be willing to apply transparency prior, during the implementation and project finalization.

Guarantee access to new eco-friendly technologies with a model of special credits or benefits for medium and low class. The strategy applied must be inclusive enough to consider the low and medium class. This implies applying progressive incentives based on one's economic capacity.

Re-verify that the public-private alliances to not discourage the country's energy capacity and the creation of more charging points. The public-private alliance must be strengthened to revive the current lost public trust.

Seek for alliances (overseas investment) with eco-friendly car manufacturing companies that see Costa Rica as a good opportunity to implement and promote ecological transport models. There are companies interested in promoting biodiversity conservation and an alternative proposal for eco-friendly vehicle fleet is a win-win to both.

Authorize RECOPE by law, the mandate to study and supply the country with other energy sources and gradually detach from oil dependency. This can be done by a constitutional statute.

Complete the construction of key projects of the road infrastructure and look for alternatives to connect the Interamerican Route with the High-Capacity Network vehicle infrastructure that is currently available, especially within the GAM area. Some of the key projects are the San Jose - San Ramon route, Route 27 extension, the San José - Cartago road corridor and vehicular overpasses in "*Circunvalación*"

Encourage, along with Local Governments the development of planned infrastructure means of mobility that do not generate emissions, by promoting the use of non-motorized vehicles inside the city, as well as guaranteeing safety to be able to move within the city under these means.

Implement a National Work from Home Strategy with public-private alliances, to reduce the emissions generated by means of transportation with motorized vehicles and provide incentives to companies that prefer people who share transportation to travel to their facilities.

Generate specific lanes and schedules for the heavy vehicles to transit around the main High-Capacity Network, to reduce the transit time between the origin and destination, working in a strategic way with the electric trains to prevent the long distances trail by truck.

Strengthen the Ministry of Transportation (MOPT) and reduce the decentralized bodies of the ministry to have greater agility in procedures and avoid contradictions between institutions that can affect the execution of the Decarbonization Plan.

Conclusions

The Transportation and Sustainable Mobility in Costa Rica has become a key factor of the growth of the country and the welfare of the population, as it is a situation that affects the society in different aspects such as transit time, health impact on the population due to contamination, high economic costs, and reduced quality of life. Based on the criticism of these conditions, Costa Rica has proposed a National Decarbonization Plan to revert the situation and aim to be a modern, green, emission free, resilient, and inclusive economy.

Since the definition and release of the plan, Costa Rica has begun with the implementation and reports progress on 82% of the actions by February of 2020 at the first year of the National Decarbonization Plan. On the first 3 Focus Areas related to Transportation and Sustainable Mobility, the country has made great achievements with important milestones such as the 100% completion of the feasibility studies by INCOFER of the electric train, start the pilot project of electric buses, creation of exclusive lanes per sectors for public transportation, publication of the Electric Transportation Plan, installation of fast charging centers for zero emissions vehicles and the progress of the feasibility studies of TELCA, which will provide a more efficient transportation of cargo.

Even though Costa Rica has made progress over the plan, it also faces great challenges to keep moving forward to the set goals. The country must make investments over the High-Capacity Network vehicle infrastructure, solve polarization between interest of Transportation Unions and the Government and look for alternative fiscal sources to cover the resources not captured within the Tax System as the population will gradually reduce the consumption of fuel. Besides these critical challenges, the country is facing an unstable situation derived by the Covid-19 pandemic that has changed the panorama and actions plans to be implemented. The use of resources and communication strategies to keep the focus of the progress must be effective enough to build public trust.

Nevertheless, Costa Rica as a country and its citizens can overcome these critical challenges with determination and continue to achieve the proposed goals. The Decarbonization Plan will be the foundation of a brighter and more sustainable economic model that will provide a step forward among the countries of the Paris Agreement and around the world.

Recommendations

Three different types of recommendations have been defined for this publication.

For next related investigations

Determine and assess the impact of the Covid-19 pandemic over the entire implementation of the decarbonization plan and possible delays caused by retraction of the economy. This will develop robust understand of the entire plan.

Assess the global progress of the intended Nationally Determined Contribution (NDC) of the Paris Agreement to monitors each country's mitigation plans ever since 2016. This shows that Costa Rica at least as developed a blueprint to show their contributions however much the journey is still long.

Assess the progress of Costa Rica over the focus areas and gather visibility of additional investigations from experts over the transportation challenges. Since the decarbonization plan is an extensive document most research only pick on a few areas for analysis. However, more research maybe done on the transportation focal areas.

Recommendations of the decarbonization plan

Due to the actual country context, include the effects of the Covid-19 pandemic and remediation plan for the implementation. The decarbonization plan must be updated with either new goals and an extended timeframe because currently the global economy has negatively been impacted by COVID-19 and Costa Rica is no exception. Most the activities in the plan will have to be financed using other alternative mechanisms different from the initial strategy.

With a risk-based approach, include a risk assessment to mitigate challenges faced in the implementation of the plan per focus area. The document itself does not clearly identifies nor highlight risk assessment of each focal area.

Include legislation enhancements to prevent blockades within the implementation of decentralized bodies of the Ministry of Transportation and Transportation Unions. In addition to lockdowns caused by COVID-19, Costa Rica suffered from serious resistance involving blockades for weeks in relation to IMF loan negotiations.

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