ENERGY MIX, FUTURE SOLUTIONS AND THEIR ENVIRONMENTAL-SOCIAL IMPACT

Principal Investigator:
PEng. Emily A. Cheung
Principle Student Investigator:
Edelysse M.D Nicolaas
Student Co-Investigator:
Arwin C. Fingal

TESLA UNIVERSITY, ARUBA
JUNE 2022

TABLE OF CONTENTS

ABBREVIATIONS 4

1. INTRODUCTION 6

2. COVID-19 IMPACT ON FOSSIL FUEL DEMANDS 10

3. ENERGY MIX IN EUROPE 12

3.2 SWEDEN'S SUCCESS IN RENEWABLE ENERGY 13

3.2.1 Green Electricity Certification 13

3.2.1 The Growth of Renewable Energy in Sweden 13

3.2.3 Policies Aiding the Growth of Renewable Energy in Sweden 13

3.3 EU STATES THAT MET THEIR RENEWABLE ENERGY TARGETS FOR 2020 15

3.4 THE NETHERLANDS RENEWABLE ENERGY 16

3.4.1 The Netherland's Progress in Renewable Energies 16

3.4.2 Climate lawsuit 16

3.4.3 Climate agreement 17

3.4.4 Local support 17

3.4.5 Scenario studies 18

4. ENERGY MIX IN CARIBBEAN ISLANDS 22

4.1 Belize 22

4.2 Curacao 25

5. ENERGY MIX IN ARUBA 27

5.1 Potential Renewable Energy in Aruba 27

5.2 Liquified Natural Gas 28

5.3 Aruba Energy Status 28

6. CURRENT ENVIRONMENTAL, SOCIAL AND ENERGY CHALLENGES 30

6.1 The Ownership Structure of Utility 31

6.2 Lack of Institutional Capacity 31

6.3 Transaction Cost 31

6.4 Inconsistent and Short-term Policies 32
6.5 Lack of Knowledge and Awareness 32
6.6 High Initial Cost 32
6.7 Availability of Funding 32
6.8 Small Market Size 32

7. FUTURE SOLUTIONS, ENVIRONMENTAL & SOCIAL IMPACT 33
7.1 Societal Changes 33
7.2 Structural Changes 34
7.2.1 Educational institutions 34
7.2.2 Independent Entity 35
7.2.3 Policies 35
7.3 Infrastructural Changes 35
7.3.1 Electrical Vehicles 35
7.3.2 Renewable energies 36
7.4 Energy Efficiency Awareness 36
Establish 37
Educate 37
Expand 37
Review 37
7.5 Impact on Environment 38
7.6 Impact on Society 38

8. CONCLUSION 40

REFERENCE PAGE 42

ABBREVIATIONS

AVP	Arubaanse Volkspartij (dutch) (political party)
BAU	Business As Usual
BCG	Boston Consulting Group
CBA	Central Bank of Aruba
CBP	Centraal Plan Bureau (dutch)
CEO	Chief Executive Officer
CO2	Carbon Dioxide
COVID-19	Coronavirus Disease 2019
EE	Energy Efficiency
EU	European Union
EUR/€	Euro
EV	Electrical Vehicle
GDP	Gross domestic product
GHG	Green House Gas
HFO	Heavy Fuel Oil
IEA	International Energy Agency
IPP	Independent Power Producer
LNG	Liquid Natural Gas
MEP	Movimiento Electoral di Pueblo (papiamento) (political party)
MW	Megawatt
NGO	Non-government Organization
NOx	Nitrogen oxides

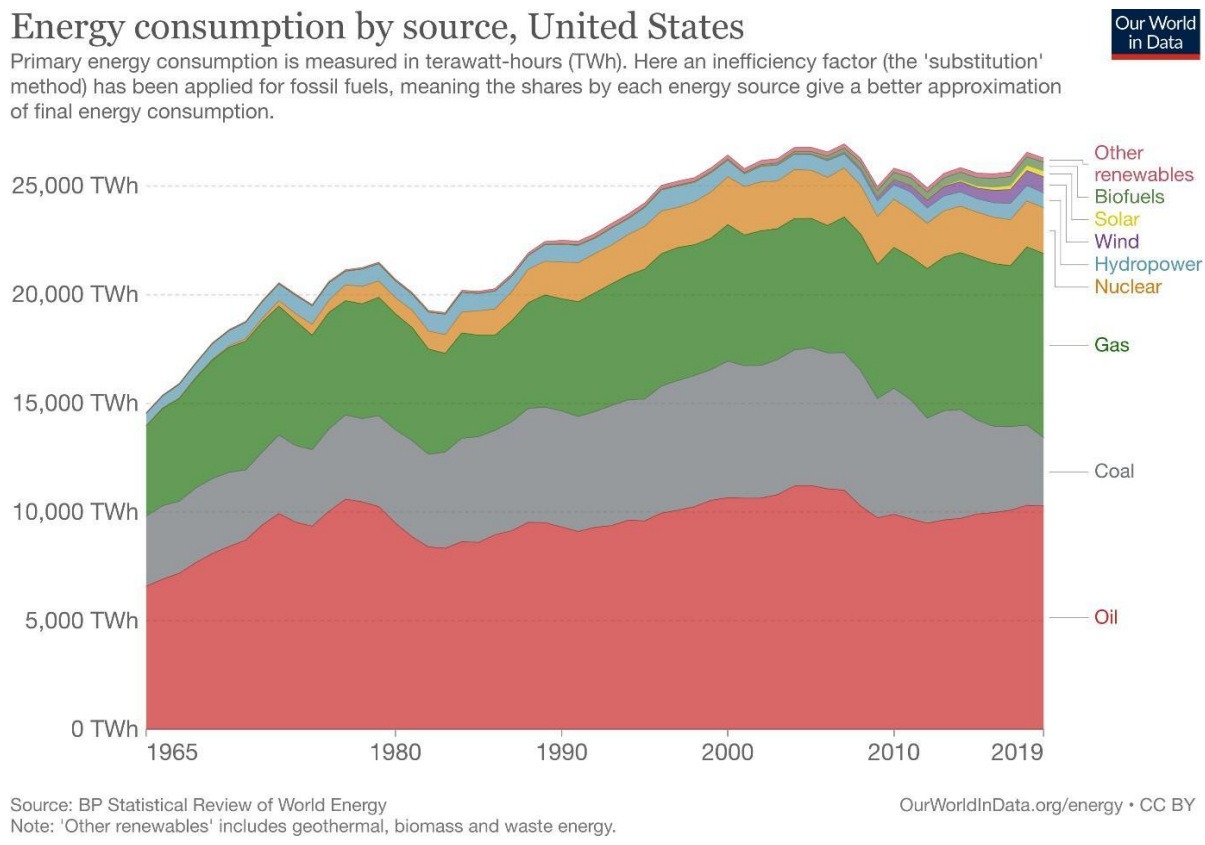
NREL	National Renewable Energy Laboratory
NSES	National Sustainable Energy Strategy
OCT	Overseas Countries and Territories
POR	Pueblo Orguyoso y Respeta (papiamento)
PV	Photovoltaic
PP	Percentage Points
RAIZ	‘Roots’ (political party)
RE	Renewable Energy
RED	‘Democratic Network’ (political party)
SDG	Sustainable Development Goal
SIDS	Small Island Developing State
SOx	Sulfur Oxides
STEM	Science, Technology, Engineering and Mathematics
TNO	Toegepast Natuurwetenschappelijk Onderzoek (dutch)
UN	United Nations
WEB	Water- en Energiebedrijf (dutch)

1. INTRODUCTION

On August 25, 2015, the former president of the United States remarked during the National Clean Energy Summit at Las Vegas, Nevada: “For decades, we've been told that it doesn't make economic sense to switch to renewable energy. Today, that's no longer true”[1].

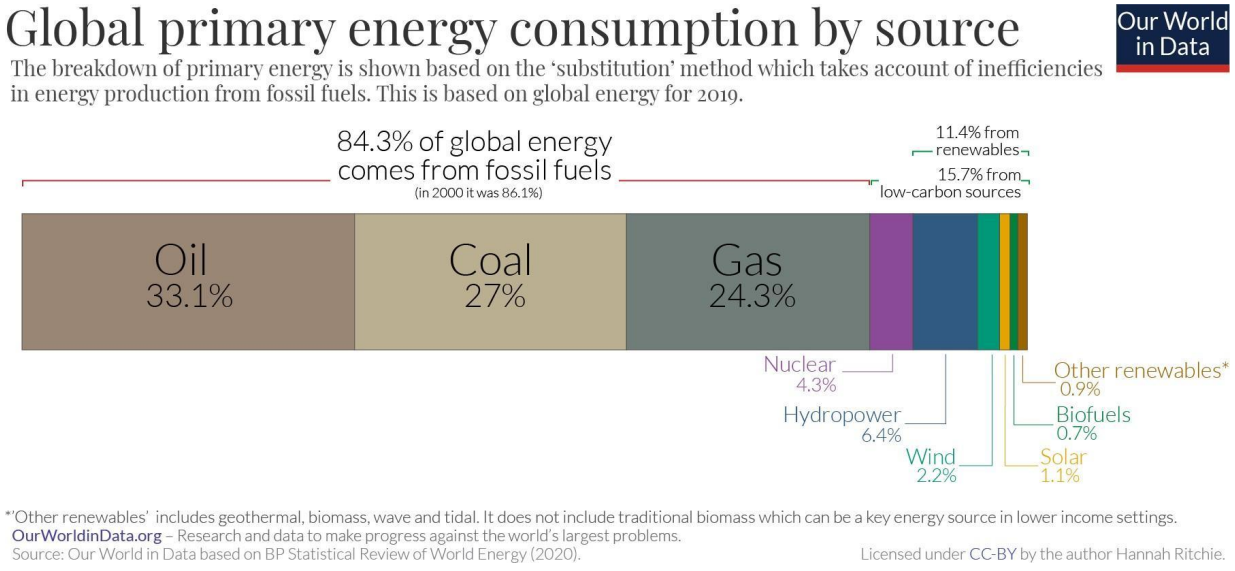
This remark questions if indeed this switch is taking place and at what pace. It has been over seven years since this remark was made, and based on this current research it is noticeable that the realization of switching to renewable energy (RE) in the United States of America is not increasing but slightly decreasing. Refer to Figure 1.

Figure 1: Energy Consumption Graph United States of America from 1990 - 2019 Source: Our World in Data



The world's energy consumption by source for 2019, clearly indicates that RE is being used but not as much as world leaders have been promoting and campaigning about. 84.3% of global energy comes from fossil fuels and only 11.4% comes from renewable sources. Refer to Figure 2.

Figure 2: Global primary energy consumption by source 2019 Source: Our World in Data

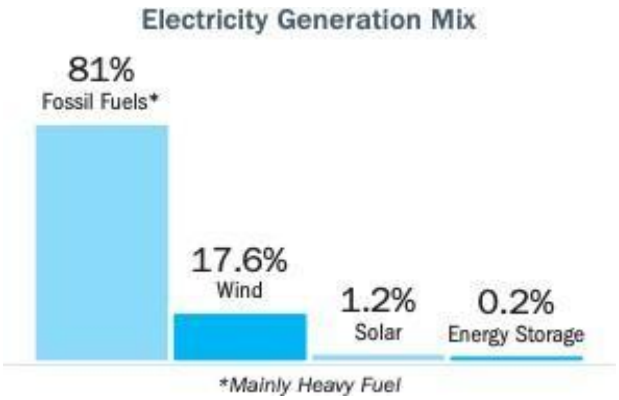


Late 2019, COVID-19 slowly emerged from Wuhan, China, infecting the world economy, isolating millions of citizens, closing borders and shutting down day-to-day businesses. This pandemic has negatively impacted the world economy but in another way, it has given the world a chance to breathe clean air. Demand for oil has been hit particularly hard. In March and April 2020, as global air travel stopped completely, global trade slowed, and government-enforced confinement measures limited public movement in many countries—oil demand temporarily dropped by more than 20%, the equivalent of 20 million barrels per day [2]. In contrast to fossil fuels, renewable energy production continues to grow.

Caribbean Islands are also disproportionately dependent on imported fossil fuels for power generation, the transportation sector, and the tourism industry. Nearly 81% of the energy supply comes from oil(refined) products [3]. The constant change in oil prices on the international market is a threat to the economy of the Caribbean region and the majority of these islands do not have natural resources such as crude oil or natural gas reserves. World Bank Data shows that fossil fuels still cover more than 95% of energy needs in the region (2014) [4]. For Caribbean islands, the import of oil can cost up to 10% of their GDPs. Therefore, energy

import is expensive for the government but also for the citizens who pay some of the highest electricity bills in the world. Islands of the Caribbean are facing challenges like; not meeting existing and future energy demand, low efficiency, old power generation equipment, isolated grids, high electricity bills, and rising and unstable fuel prices. While the island of Aruba has made significant progress in diversifying its energy system, the island remains reliant on imported fossil fuels (more than 80% of the island's electricity is generated using heavy fuel oil), making it vulnerable to global oil price fluctuations, which have a direct impact on electricity costs. As mentioned before, more than 80% of the electricity is generated using fossil fuels, 17.6% comes from wind energy, 1.2% from solar power, and 0.2% from energy storage [5].

Figure 3. Aruba Energy Snapshot Source: National Renewable Energy Laboratory (NREL)



Caribbean islands are ideal for the implementation of RE due to the abundance of clean natural resources such as sun, wind, and water in the region. It is possible for these islands to be almost 100% free from fossil fuels. This is why Caribbean islands should move towards a “greener” future for their economies and citizens. What can be done to drive these islands to be less dependent on fossil fuels? What are the impacts on the environment and society? This research by Tesla University provides a comparative analysis of the energy mix and its history in Europe and the Caribbean region. It also provides the implementation of future solutions to promote RE usage and improve energy efficiency on Aruba. It will explore the possible environmental and social impact of the future solutions.

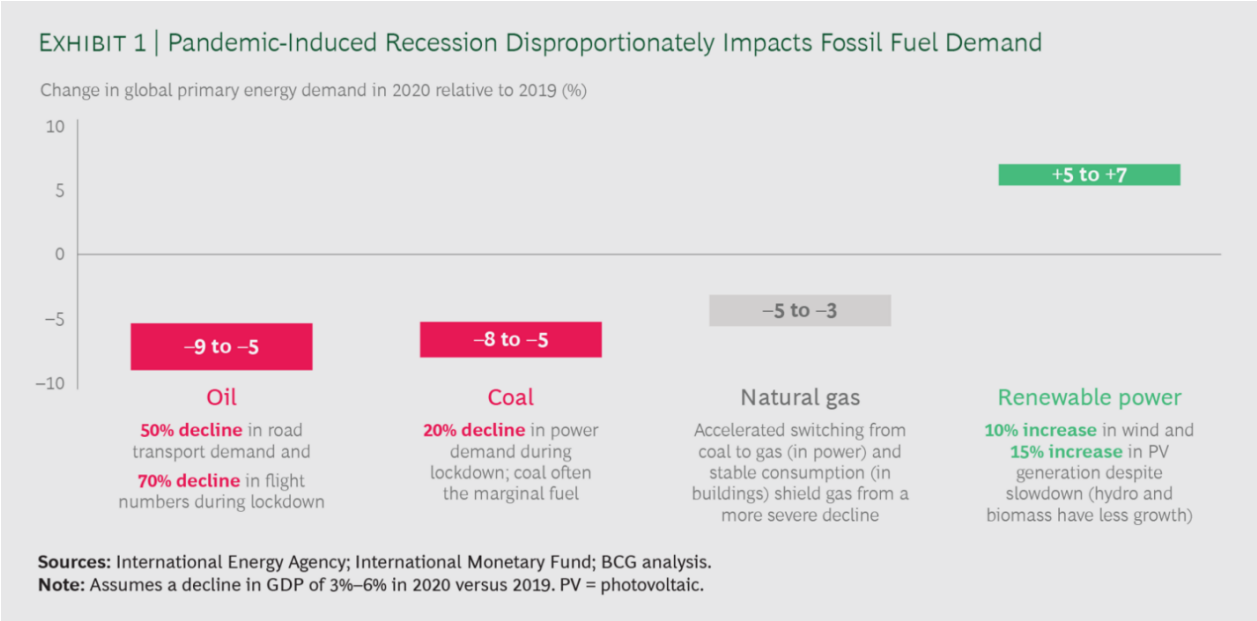
To better understand the energy mix, future solutions, and their environmental and social impact, it is important to elaborate on the current global situation not only on renewable energy but everything that influences it, such as the pandemic, economy, politics, and government policies, culture, etc.

Before continuing, it is important to understand what the energy mix is. The term “energy mix” refers to the combination of the various primary energy sources used to meet energy needs in each geographic region. It includes fossil fuels (oil, natural gas, and coal), nuclear energy, and many sources of RE (wood and other bio energies, hydro, wind, solar and geothermal). These primary energy sources are used, for example, for generating power, providing fuel for transportation, heating, and cooling residential and industrial buildings.

2. COVID-19 IMPACT ON FOSSIL FUEL DEMANDS

As mentioned in the introduction section, RE production continues to grow. The expansion of wind and solar has fallen below pre-crisis expectations, but the International Energy Agency (IEA) still projects that global wind and photovoltaic (PV) power generation will increase by more than 10% and 15%. Because renewables are a must-run source of power with near-zero marginal generation costs, this growth is further squeezing conventional operators. Refer to Figure 4, which illustrates pandemic-induced recession impacts on fossil fuel demand.

Figure 4. Pandemic-Induced Recession Impacts. Source: IEA,BCG

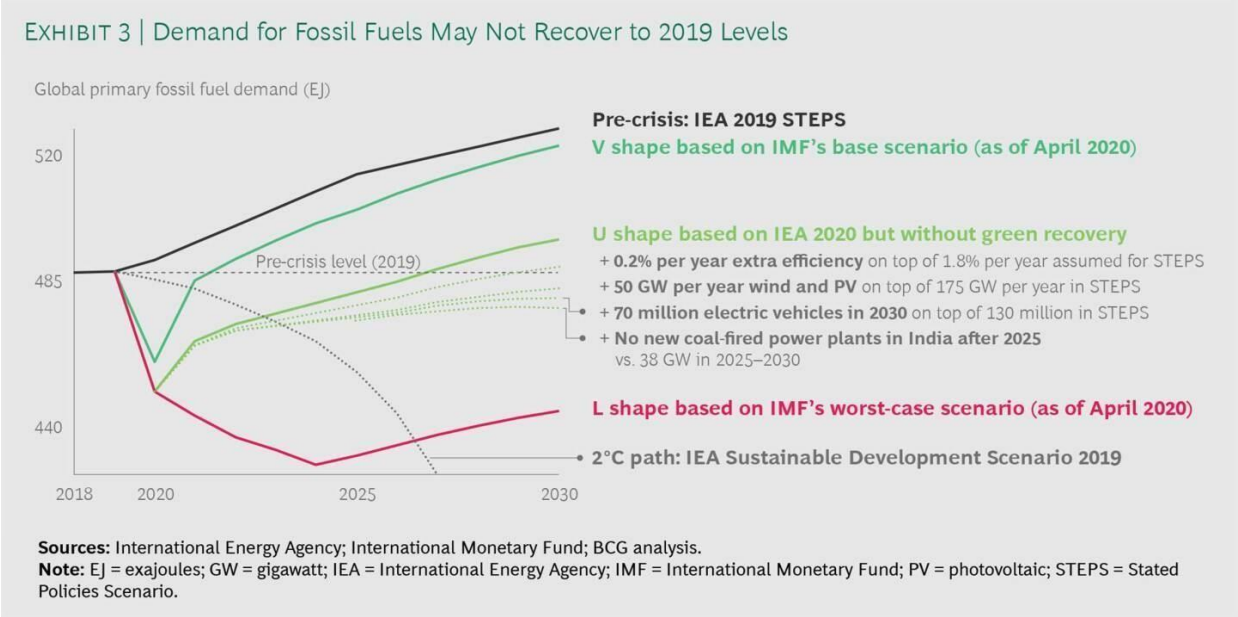


In Figure 4, Despite the ongoing pandemic, only renewable energy has seen an increase.

As per BCG analysis in June 2020 [2], several effects could lessen COVID-19's impact on fossil fuels. Firstly, a recession-induced erosion of investment capacity could slow efficiency gains and the expansion of renewable power, electric vehicles, and other low-carbon technologies.

At the same time, historically low fossil fuel prices may create challenges for low-carbon projects around the world. Renewable power costs, on the other hand, continue to fall, with the cost of new wind and PV projects falling below the cost of existing coal plants in some regions. It is unclear whether some of the recent transportation restrictions will result in longer-term behavioral changes in business and long-distance travel. Several countries are launching green recovery programs that combine post-pandemic economic stimulus funding with a shift toward lower carbon dependency, and the European Union's flagship Green Deal could significantly accelerate the deployment of low-carbon technologies—with potential spillover to non-EU countries.

Figure 5: Demand for Fossil Fuels May Not Recover to 2019 Levels 2019 Source: IMF,BCG



While the data in Figure 5 remains a scenario, the BCG analysis suggests the possibility that the fossil fuel demand has already peaked.

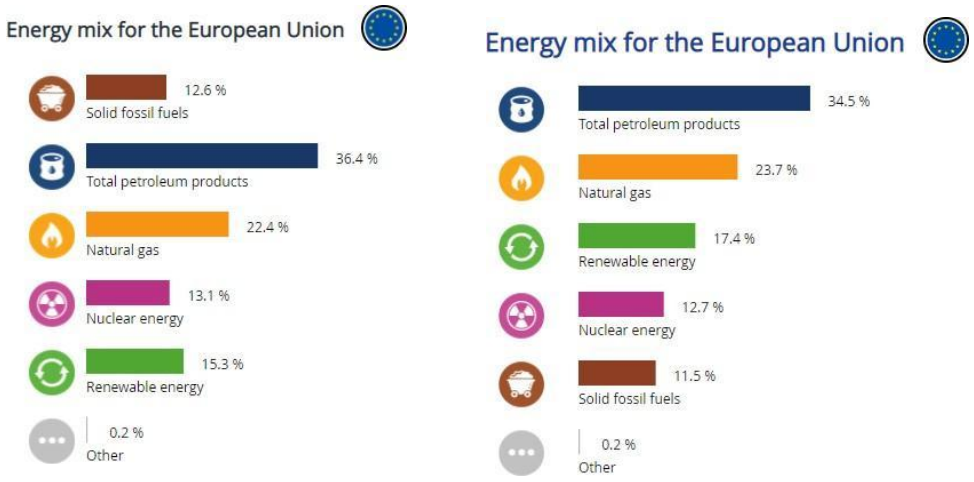
Despite the fact that the pandemic is still an ongoing situation, governments around the world are pumping trillions of dollars in direct stimulus funding into their economies. According to the Climate Policy Initiatives and given the scale of current stimulus funding, governments have a critical opportunity to design their stimulus programs in a way that accelerates progress toward net-zero carbon emissions by 2050. Continuing the discovery of the potential of a green recovery but perhaps learning more about some countries in Europe, such as Sweden that have managed to positively live utilizing renewable energy.

3. ENERGY MIX IN EUROPE

The energy accessible in the European Union is produced in the EU as well as imported from outside countries. As a result, in order to gain a good picture of the total energy available in the EU, energy output should always be considered alongside imports. In 2020, the EU produced 42% of its energy compared to 40% in 2019 whereas the rest was imported. The reduction in imports is partially related to the COVID-19 economic crisis [6].

In 2019, the energy mix in the EU was mainly made up of various sources: Petroleum products (including crude oil) (36%.4), natural gas (22%.4), RE (15%.3), and nuclear energy, and solid fossil fuels (both 13.1%). In 2020, the numbers were slightly different and these numbers are listed below in Figure 6.

Figure 6: Energy mix for the European Union 2019 vs 2020 Source: Eurostat



Europe has an abundance of renewable energy sources, and its states have evolved as leaders in promoting the implementation of renewable technologies in recent years. Efforts to strengthen the sustainability of Europe's energy systems are ongoing, with renewable energy objectives set for all European countries and the European Union (EU) members aiming to become "the world leader in renewables," according to European Commission President Jean-Claude Juncker.

Sweden takes the lead and generates more than half (54.5 %) of its energy from renewable sources. This is well above the 49% 2020 target. In Finland, Latvia, Austria, and Denmark, sustainable energy shares exceed 30% as illustrated in Figure 8.

3.2 SWEDEN'S SUCCESS IN RENEWABLE ENERGY

Sweden was the first country to meet its renewable energy targets set by the European Union (EU) for 2020. This was achieved eight years ahead of time due to the continuous input to renewable energy and efforts to sustain it.

Sweden has a rich supply of moving water and biomass, which contributes to the country's high share of renewable energy. Hydropower and bioenergy are the top renewable sources in Sweden – hydropower is mostly for electricity production and bioenergy is for heating.

3.2.1 Green Electricity Certification

The usage of renewable energy has also been encouraged by the government's energy plans. For example, the Electricity Certificate System is a market-based support system for renewable electricity production. Wind, solar, geothermal, or wave power, biofuels, or small-scale hydropower plants must be used in order to qualify. Electricity retailers are obligated to purchase a certain percentage of "green electricity" as part of their regular supply, while power producers are certified for the renewable electricity they generate [7].

3.2.1 The Growth of Renewable Energy in Sweden

The Swedish government, in collaboration with important stakeholders, has made enormous efforts to invest in renewable energy and use it in daily activities. Currently, renewable energy sources account for up to 54.6 % consumed in Sweden. Sweden's government aims to make the country carbon neutral by 2045 and to attain 100 % renewable energy by 2040. While hydropower (45 %) and nuclear power plants (30 %) generate the most renewable energy-based power (more than 75 %), wind turbines come in third, followed by biofuels and solar power [8].

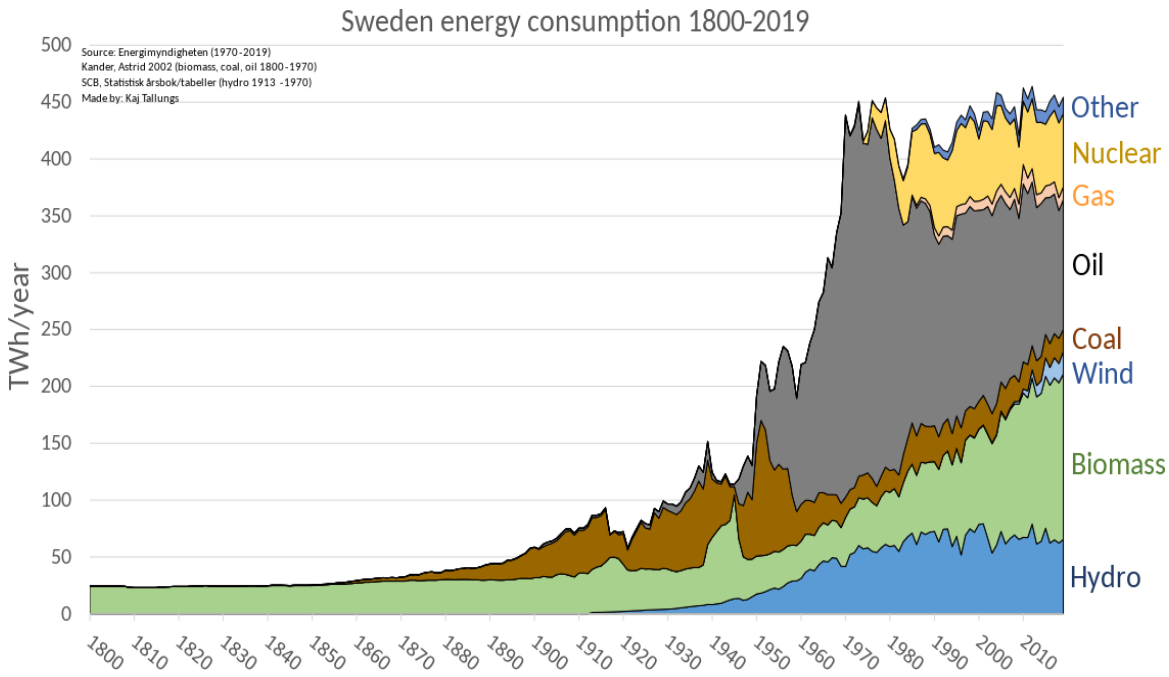
3.2.3 Policies Aiding the Growth of Renewable Energy in Sweden

Who and what is driving the growth of renewable energy in Sweden? Many factors are associated with the demand for power by industries, supportive policies, and the quick adoption of renewable energy technologies.

Sweden's high carbon taxes and low energy prices are assisting in the spread of renewable energy across the country. However, climate change has been a major cause of concern, as many businesses in Sweden are capable of emitting carbon dioxide. The carbon tax has been a great tool for Sweden to manage emissions issues while also providing incentives and opportunities for renewable energy alternatives. It is imposed on all types of fossil fuels based on their carbon content [8].

Sweden is known for its fast adaptation to technologies, and this has helped them to grow. So far, the risks associated with diving into new technologies have been properly managed and implemented in the proper management of renewable energy systems.

Figure 7: Sweden Energy Consumption 1800-2019 Source: Our World in Data

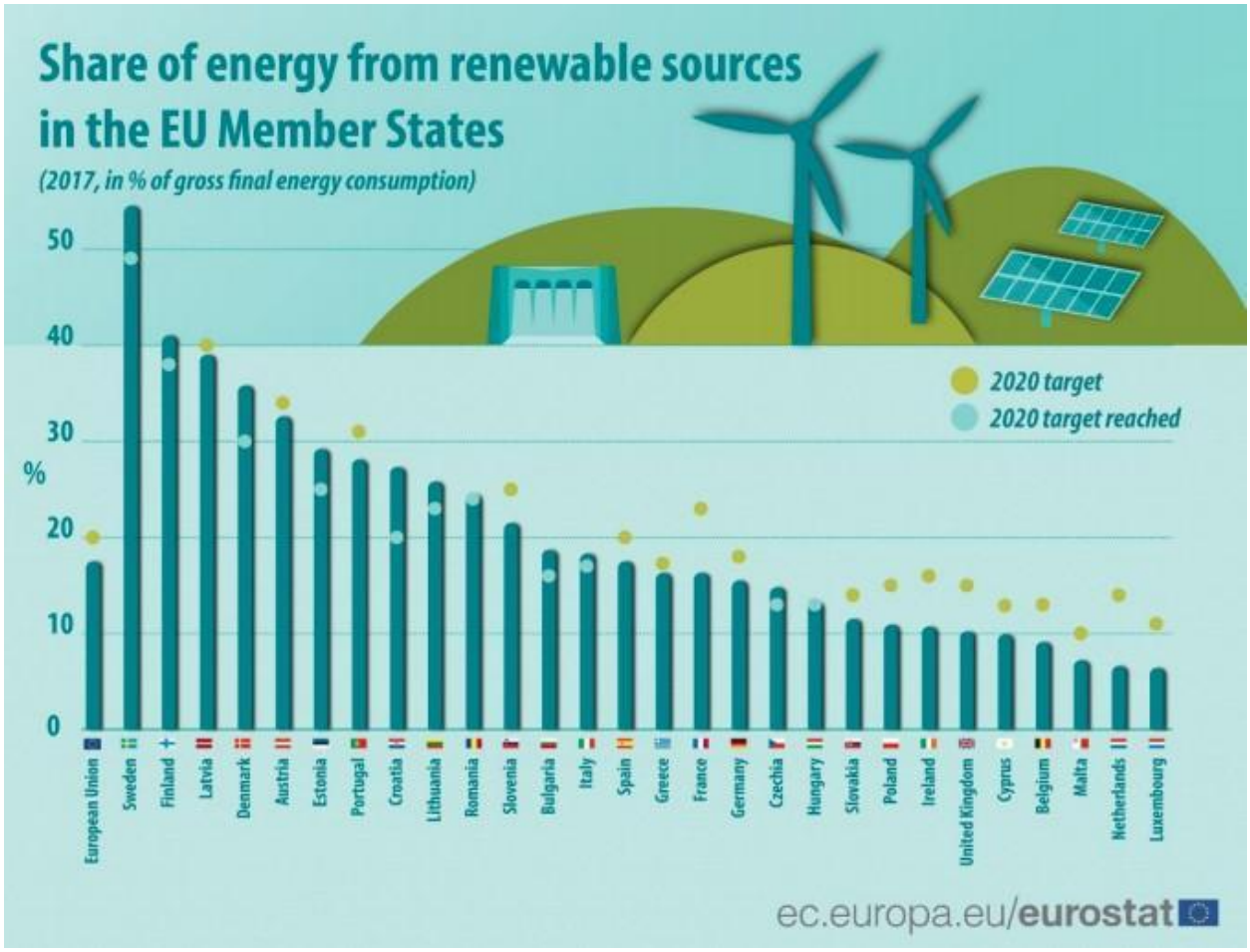


3.3 EU STATES THAT MET THEIR RENEWABLE ENERGY TARGETS FOR 2020

The following figure shows the share of energy from renewable sources in member states comparing the 2020 target with the 2020 target reached.

Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, Italy, Hungary, Lithuania, Romania, and Sweden have reached their 2020 target as shown in Figure 8.

Figure 8. Share of energy from renewable sources in EU Member States Source: Europa.eu



The Netherlands is the furthest away from its goal – 7.4 percentage points (pp) away from the 2020 objective. France is next (6.7 pp), followed by Ireland (5.3 pp) and the UK (4.8 pp) according to the data acquired from Eurostat.

3.4 THE NETHERLANDS RENEWABLE ENERGY

Aruba has been closely linked with the Netherlands, Curaçao, Sint Maarten, and the other Dutch Caribbean islands since 1634, when Dutch settlers established in the Caribbean. In 1986, Aruba became a constituent country within the Kingdom of the Netherlands and acquired the formal name the Country of Aruba. Aruba is one of the four countries that form the Kingdom of the Netherlands, along with the Netherlands, Curaçao, and Sint Maarten; the citizens of these countries are all Dutch nationals. Due to this close relationship, let's look into the Netherlands' statistics on their energy mix and the reason also why they are behind the EU Renewable Energy Goals.

3.4.1 The Netherland's Progress in Renewable Energies

The geographical location of the Netherlands is one limiting factor in the use of renewable energy. The Netherlands as a whole is not below sea level, although a large portion of it is. This geographical environment is not conducive to the usage of hydropower. Furthermore, many government subsidies to invest in renewable energy that exists in other countries such as Denmark and Germany do not exist in the Netherlands. Because the start-up costs for renewable energy projects are considered high, few Dutch citizens are motivated to pursue them. However, there has been some development in the generation and use of renewable energy in the Netherlands. The quantity of energy produced in the Netherlands from renewable sources climbed from 6.6 % to 7.38 % and 8.6 % in 2019 [9]. Nevertheless, The Netherlands is far behind the EU renewable energy goals.

3.4.2 Climate lawsuit

Although the Netherlands has long lagged in its climate measures, in 2015, dutch politicians were put under new pressure when the activist group Urgenda filed a lawsuit to get the state to implement climate measures in accordance with international conventions and its own legislation. In court, the Dutch state was ordered to reduce the country's greenhouse gas emissions in line with its human rights obligation by at least 25% from 1990 levels [10].

The state accepted the result, but on principle, it appealed the verdict. The case was brought up again in 2018, and the Dutch state was defeated once more. According to the court, the climate problem poses such a serious threat to people's lives and health that the state is obligated to reduce Dutch emissions as soon as possible. Activists in other countries have attempted similar lawsuits, but only in the Netherlands has the state been required to take climate action.

3.4.3 Climate agreement

To achieve a more proactive climate policy, in 2019 the Dutch government implemented a national climate agreement with proposals for measures to reduce greenhouse gas emissions by 49% from 1990 levels by 2030 and make the Netherlands climate neutral by 2050. Energy efficiency improvements in 1.5 million existing houses, fossil-free heating in all new homes, zero-emission regulations for all new cars by 2030, and an additional carbon tax for industry on top of the EU emission trading scheme are among the proposals. The government will also fund renewable energy development through 2025, with a goal of reaching a 70% renewable share by 2030 [11].

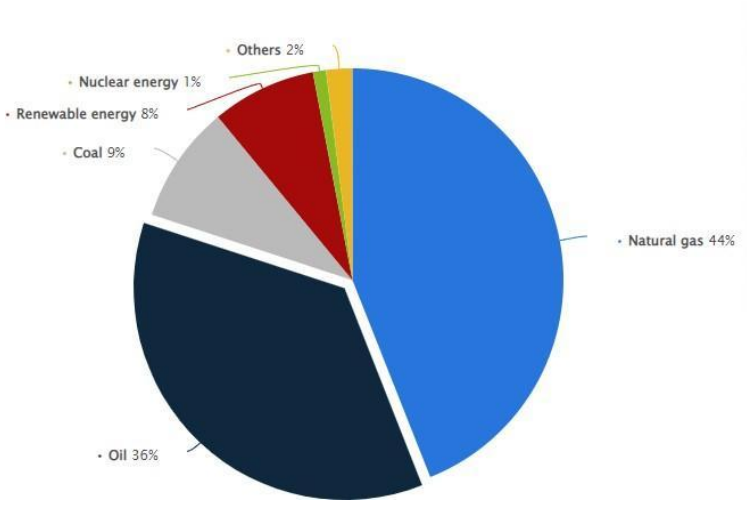
3.4.4 Local support

The climate agreement has been signed between the Dutch government and many stakeholders in society and business. Niels van der Linden, Vice president of Statkraft commented that it is critical to involve all stakeholders in the implementation of these types of measures. Not to mention the importance of involving local communities, thus the government is delegating responsibility to the regions and asking them to return with proposals on how to meet climate targets through local actions [12].

The green shift does not happen by itself, as it does in many other countries. Even in the Netherlands, there is resistance to the replacement of coal and gas with wind turbines and solar parks. People support renewable energy, but they do not want wind turbines in their backyard.

"We're a small and densely populated country and only have limited available land space. Our agricultural sector is among the largest in the world, and the Netherlands is the world's second-largest exporter of agricultural products. Because it's usually agricultural land that is leased to the power plants, a conflict arises between agricultural interests and the need for renewable energy," says Valerie van Hagen, *Wind & Solar Analyst at Statkraft.*

Figure 9: Dutch energy mix 2019 Source: Statica.nl



In Figure 9, the Dutch energy mix is represented by a pie chart. The primary source is natural gas at 44% followed by 36% of oil, while it is visible that the renewable energy percentage is relatively low for a country like the Netherlands.

3.4.5 Scenario studies

Nearly all countries around the world have committed to significant reductions in greenhouse gas(GHG) emissions in order to comply with the Paris Agreement target of limiting the global average anthropogenic temperature increase to 1.5-2.0 degrees Celsius [13],[14],[15]. The European Union aspires to be carbon-neutral by the middle of the century. In this framework [16], the Netherlands has initiated an energy transition in order to meet its European and international commitments. According to the Dutch Climate Act [17] [?], the Netherlands must have an energy system by 2050 that emits 95 percent less greenhouse gas than it did in 1990. Recent Dutch scenario studies found a wide range of potential future energy systems for the Netherlands, although the determinants of these scenarios are frequently unclear [19]. Most scenarios include multiple renewable energy alternatives, whilst the others have fewer. The presence or absence of certain climate

change mitigation alternatives and the abundance or shortage of specific low-carbon energy technology significantly impact the overall energy system costs. Policymakers, energy corporations, network operators, technology developers, non-governmental groups, and energy users all need information about the availability and practicality of options, as well as the implications of technology decisions.

In a recent scenario study, it is shown how under a strict GHG reduction objective, the Dutch energy system could change using two developed scenarios by experts, namely: ADAPT and TRANSFORM scenario. Both scenarios apply the Dutch Climate Act's aim of reducing GHG emissions in the Netherlands to a level that is 95 percent lower in 2050 than in 1990, effectively supporting the Paris Agreement goal of limiting average global temperature change to less than 1.5 degrees Celsius. The two scenarios also fulfill the Dutch Climate Agreement's goal of reducing GHG emissions by 49 percent by 2030 [11].

These two scenarios differ in how these two goals are attained, specifically in the intrinsic motivation and behavior of individuals and businesses. In the ADAPT scenario, the Dutch economy builds on existing infrastructure and strengths while maintaining a current lifestyle while reducing CO2 emissions significantly. In the TRANSFORM scenario, behavioral changes in Dutch society promote a drastic move to a more sustainable economy, making the Netherlands a less energy-intensive economy overall. While carbon capture and storage (CCS) can be used in the ADAPT scenario, it is not allowed in the TRANSFORM scenario due to high public resistance. Additionally, the TRANSFORM scenario limits biomass consumption much more than the ADAPT scenario.

In both scenarios, no coal-fired power plants are utilized after 2024, and the one existing nuclear power station is dismantled at the end of 2033, in accordance with Dutch government policy. It is possible to build a new nuclear power plant. Table 1 shows the assumptions for reducing GHG emissions in the two scenarios.

Table 1: Assumptions for GHG emissions

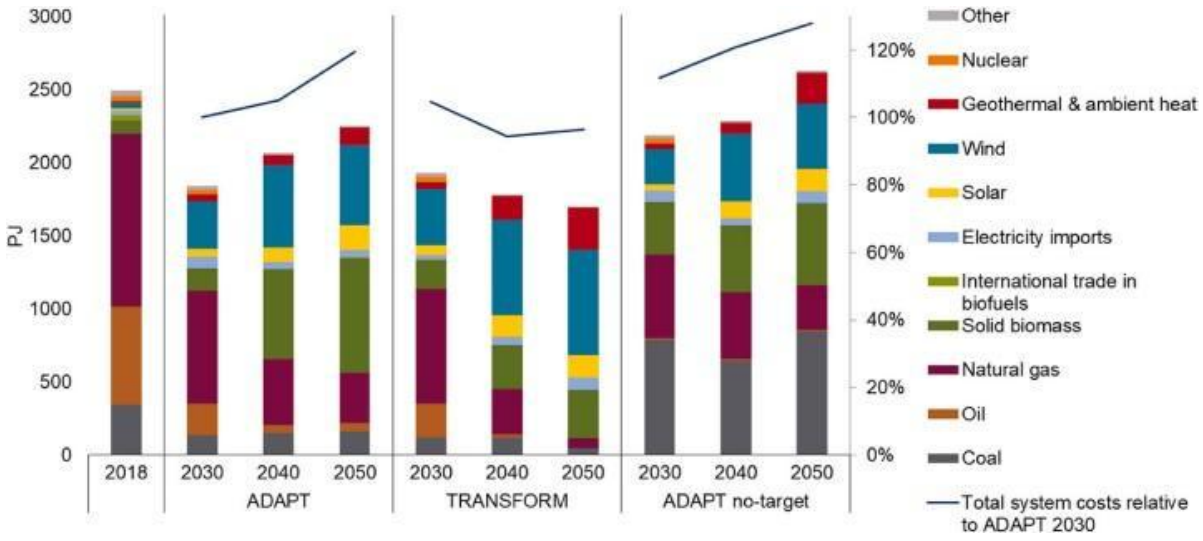
Assumptions for GHG emissions reduction for the ADAPT and TRANSFORM scenario. Values for 2040 are linearly interpolated.

	ADAPT		TRANSFORM	
	2030	2050	2030	2050
GHG reduction target for The Netherlands[a]	−49%	−95%	−49%	−95%
GHG reduction target for international aviation and shipping	0%	−50%	0%	−95%

[a] Applies to CO_2 and non-CO_2 GHGs for all domestic sectors, except GHG emissions from land use, land use change and forestry (LULUCF).

The results of these two scenarios are shown in the figure below.

Figure 9: Results of ADAPT and TRANSFORM scenario



Total energy supply in PJ (excluding energy for international aviation and shipping and non-energy use) and total relative system costs (ADAPT 2030 = 100%).

This figure illustrates the total primary energy supply for both scenarios. The ADAPT scenario without an emission target is also shown and for reference purposes, the primary energy supply in 2018 is listed on the furthest left. The observed decrease in primary energy supply in 2030 scenarios compared to 2018 is due to energy savings and reduced energy conversion losses in, among other things, electricity production (– for example, wind and solar replace less efficient thermal power plants) and transportation (– for example, electric vehicles replace vehicles with internal combustion engines). It is worth mentioning that the primary energy supply in 2030 for both scenarios is the result of cost-optimization of the energy system, whereas the current energy system is not cost-optimal because economic actors act rationally in their own interests and do not always have the optimal system solution in mind, have insufficient information, and markets are imperfect.

In the ADAPT and TRANSFORM scenarios, the energy mix shifts from fossil primary energy to renewable energy. Both scenarios show significant growth in wind and solar energy generation. More fossil fuels are still present in the ADAPT scenario, most notably coal for steel manufacturing and natural gas for hydrogen production, both in conjunction with CCS. Because of the scenario assumptions on biomass availability, the ADAPT scenario uses more biomass than the TRANSFORM scenario. This scenario analysis [19] provides valuable insights into the spectrum of options for a more sustainable energy system in the Netherlands in 2050.

The energy system optimization model OPERA was used to examine the technological, sector, and cost implications of two scenarios for future Dutch energy systems that would reach the Dutch government's national aim of near net-zero greenhouse gas emissions by 2050. While the relevance of a number of significant energy technologies and emission mitigation measures depends heavily on the scenario or their projected costs, the research provides many characteristics that the two scenarios obviously share. Electrification is one of the key possibilities for decarbonizing the Dutch energy system: depending on the scenario, its share in the total primary energy supply rises from 19 percent today to 41–71 percent in 2050. By that time, research suggests mostly all electricity will be generated by renewable energy sources, specifically, wind turbines and solar panels. It is also projected that hydrogen will become important for the transportation industry. Faster technological development through innovation and supporting policies that improve implementation can speed up the reduction in technology prices, which can lower future energy system costs. More research and development are required, not just for technological advancement, but also to promote wider deployment and behavioral change. This scenario analysis [19] illustrates how the energy transition might be influenced in order to make the future Dutch energy system more economical and sustainable.

4. ENERGY MIX IN CARIBBEAN ISLANDS

As mentioned earlier in this research paper, the utilization of renewable energy in the Caribbean has typically lagged below the norm worldwide. Even though just three Caribbean nations (Barbados, Cuba, and Trinidad & Tobago) actually produce petroleum, the World Bank estimates that oil supplied between 80-90% of the region's energy needs in 2015. There is not much evidence to imply that this altered significantly in the six years that followed. In fact, the region is most dependent on imported energy, making it extremely susceptible to fluctuations in the global market for fossil fuels. As a result, it is extremely difficult for several Caribbean nations to offer a consistent supply of electricity, and the average electricity price in the region is among the highest in the western world. The substantial reliance on imported energy has had a severe impact on the economic performance of many Caribbean countries, in addition to high rates and supply disruptions. This has led to below-potential growth and instability in the fiscal and external accounts. The irony in all of this is that despite efforts by some governments to rectify the situation, the region is gifted with an abundance of high-potential renewable energy resources that have, up until now, mainly gone untapped. By utilizing the natural power produced at various levels by solar, wind, geothermal, and hydroelectric sources, the area may significantly reduce its reliance on imported energy. This may prompt individuals who are not aware of the issues in the area to wonder why the Caribbean has been so stagnant to implement renewable energy. The key problem is that previously, most Caribbean islands were unable to afford the switching expenses due to the relatively high cost of the infrastructure required to implement national green energy programs. The financial difficulties that are prevalent in much of the region continue to be a significant obstacle in the pursuit of this goal even now, with green energy infrastructure and equipment being much more competitive.

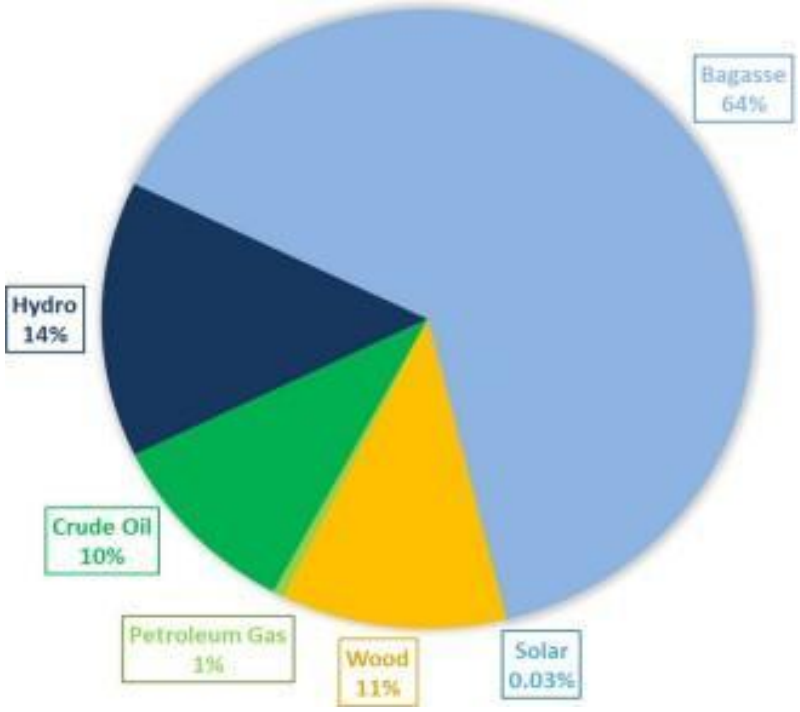
4.1 Belize

Belize is devoted to helping with global climate action and low-carbon development as a priority. The goal is to address climate change's effects as soon as possible, since rising temperatures, rising sea levels, wildfires, drought conditions, and altered precipitation and weather patterns strain Belize's energy infrastructure and have an impact on how energy is produced and used. In 2020, the coronavirus pandemic caused severe disruption all across the world, upending the effects and difficulties of climate change. In several countries around the world, the approach to the COVID-19 pandemic has resulted in significant economic downturns, both direct and indirect. Energy markets were significantly impacted, and in 2020, both global energy consumption and greenhouse gas emissions showed

significant decreases. The effects of both the COVID-19 outbreak and the climate change issue are already being felt in Belize's energy sector.

Nevertheless, Belize continues to have a strong ambition and leadership role in the transition to a low carbon economy while enhancing its climate change resilience through a variety of adaptation and mitigation strategies. Due to its geographical characteristics, Belize has a great deal of potential to take advantage of the opportunities associated with the deployment of renewable energy solutions, further diversifying its energy system and lowering its sensitivity to fluctuating oil prices. With a diverse domestic energy portfolio that includes renewable energy sources accounting for 89.4% of local energy output in 2020 and non-renewable energy sources accounting for the remaining 10.6%, Belize continues to set the trend in the region [20].

Figure 10 : Summary of Belize's Primary Energy Supply in 2020 Source: Belize Energy Report



In 2020, Belize's installed capacity reached a total of 131.7 MW. This sum is made up of 55.3 MW of non-renewable power and 76.5 MW of renewable energy, or 58% and 42% [20].

The existing policies, regulatory framework, sustainable energy strategy/action plan, and the Sustainable Development Goal 7 is contributing to Belize's success as one of the leaders in the Caribbean in the energy sectors. For Renewable Energy in Figure 11, policies or frameworks already in place are energy access, tax reduction or exemption, auctions, or reverse auctions. Energy efficiency, public demonstration, building codes, EE loan programs are some of the policies already in place regarding energy efficiency in Belize. The strategy and action plan developed in 2015 indicated Belize's potential for energy efficiency and renewable energy sources, and it serves as the guideline for achieving Belize's sustainable energy objectives in the electrical sub-sector. Based on a Business-as-Usual (BAU) vs a National Sustainable Energy Strategy (NSES) scenario for Belize, the document emphasized Belize's potential and targets. The energy-related targets established in the document are:

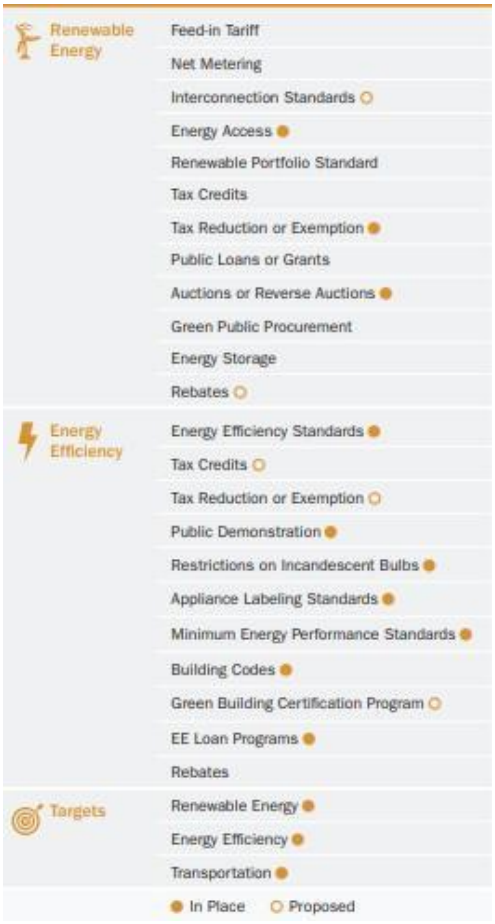
1. Renewable energy could represent 89% of the supply by 2033
2. Improve Energy Efficiency and Conservation by at least 24% by 2033.

The SDGs, provide a set of goals and measures to direct efforts made worldwide to combat poverty, ensure the prosperity of all people, combat climate change, and protect the environment (United Nations, 2017). SDG 7 – Affordable and clean energy – is one of the 17 SDGs that have been developed. "Ensure access to affordable, reliable, sustainable, and modern energy for all" is the overall goal of SDG 7. There are 5 energy-related targets listed under SDG 7 listed in table 2.

Table 2: SDG 7 Energy-related targets. Source: Belize Energy Report 2020

Title	Target
7.1	By 2030, ensure universal access to affordable, reliable and modern energy services
7.2	By 2030, increase substantially the share of renewable energy in the global energy mix
7.3	By 2030, double the global rate of improvement in energy efficiency
7.A	By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology
7.B	By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States, and land-locked developing countries, in accordance with their respective programmes of support

Figure 11: Existing policy and regulatory framework: Belize Source: NREL



4.2 Curacao

Looking at another Caribbean Island which is closer to Aruba, Curacao also has a high potential to take advantage of the renewable resources. Renewable resources are abundant in the Caribbean region. 67% petroleum, 29% wind and 4% solar make up the electricity generation mix in curacao according to Curacao Energy Snapshot 2020 [21]. The island of Curacao has a total of 207 MW installed capacity of which 65 MW comes from wind and solar. Curacao aims for a 50% renewable electricity generation by 2035 including 6 MW from wind, 55 MW solar, and 7.5% from biomass. A 25% reduction in energy consumption before 2040 is also a priority for Curacao.

Figure 12: Electricity Generation Mix Curaçao. Source: NREL

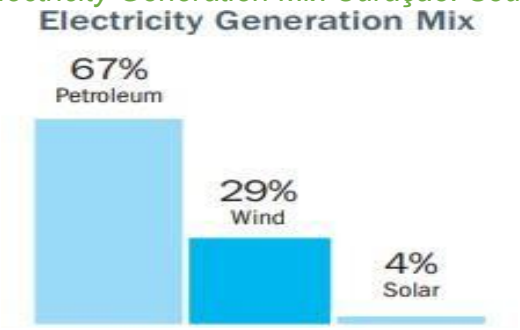


Figure 13: Existing Policy and Regulatory Framework Curçao. Source: NREL

Existing Policy and Regulatory Framework	
Renewable Energy	Feed-in Tariff
	Net Metering and Billing
	Interconnection Standards ○
	Energy Access (Electrification Rate)
	Renewable Portfolio Standard ●
	Tax Credits
	Tax Reduction or Exemption
	Public Loans or Grants
	Auctions or Reverse Auctions
	Green Public Procurement
	Energy Storage
Energy Efficiency	Energy Efficiency Standards ○
	Tax Credits
	Tax Reduction or Exemption
	Public Demonstration
	Restrictions on Incandescent Bulbs ○
	Appliance Labeling Standards ○
	Minimum Energy Performance Standards ○
	Building Codes ○
	Green Building Certification Program
	EE Loan Programs
	Rebates
Targets	Renewable Energy ●
	Energy Efficiency ●
	Transportation
	● In Place ○ Proposed

5. ENERGY MIX IN ARUBA

The tourism industry, offshore financial services, oil refinement (until 2012, when the refinery formally closed in September of that year), and transshipment industries make up the majority of Aruba's economy [22]. Aruba's government AVP (2009-2017) envisioned a more ecologically friendly economy and more use of sustainable energy, but this has since diminished with the change of government. As a Small Island Developing State (SIDS), Aruba has issues such as geographic isolation, vulnerability to external shocks, incapacity to depend on economies of scale, and vulnerability to the uncertainty and unpredictability of climate change. Through its Overseas Countries and Territories (OCT) status, Aruba is technically and officially affiliated with the EU. The goal of the association between the EU and the OCTs, according to the Treaty on the Functioning of the EU, is "to promote the economic and social development of the countries and territories and to develop close economic relations between them and the Union as a whole." Aruba received development assistance from the EU Commission through the 11th European Development Fund (EDF) for 2014-2020, with an estimated value of €13 million. Education, research, and innovation in sustainable development and renewable energy are top priorities for development finance. In 2011, The Government of Aruba had set an too ambitious goal of becoming 100% energy sustainable by 2020 as outlined in ‘The Green Gateway - Economic Vision and Policy 2011–2013' [23], yet failed to implement it due to different reasons like, parliamentary election of 2017,change of government and due to some projects that were not economically feasible at that time.

5.1 Potential Renewable Energy in Aruba

The Aruba Energy Snapshot by National Renewable Energy Laboratory gives an overview of the RE sources available on the island and also the potential for the island. It is noticeable that wind and solar have high potential but as for the rest of the RE sources, the potential is categorized as low.

Figure 14. RE Status and Potential Aruba. Source: NREL

It is important to mention that wave and tidal energy sources can be found around the island but the potential for waves is moderate and low for tidal. In-depth studies are missing in order to determine the real potential of these sources.

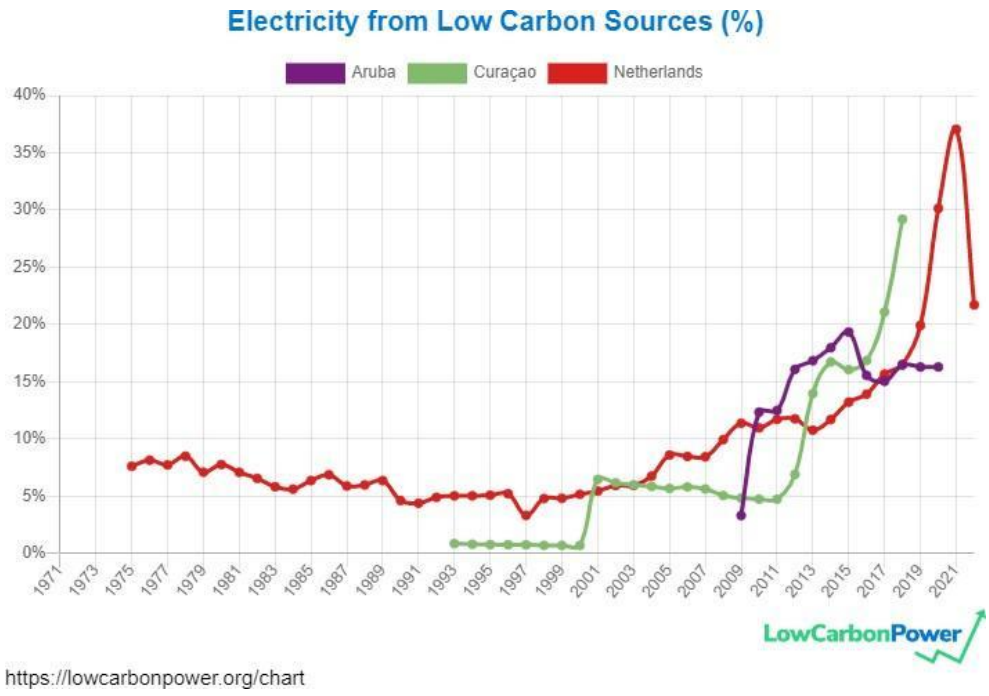
5.2 Liquified Natural Gas

While it's not a renewable fuel like solar or wind power, it could present a bridge toward a more renewables-based energy future. Natural gas is gas pumped from the Earth's crust that has been converted into a liquid. For Aruba, Liquid Natural Gas (LNG) will act as a transition fuel that eventually should lead to a mix of 50% renewable energy sources and 50% alternative fuels," said WEB Aruba CEO, Serapio (Laty) Wever. The LNG project in Aruba should introduce low-cost, stable energy to the island and enhance its environmental credentials. By moving to LNG from heavy fuel oil or diesel, there will be a significant reduction in harmful emissions: 30% in CO2, 75% NOx, 90% particulates, and 99 % SOx, the company Eagle LNG said.

5.3 Aruba Energy Status

Most recent (2020) data on the energy status in Aruba indicated that most of the electricity generation comes from fossil fuels (mainly from HFO) which is 81%, 17.6% comes from wind, 1.2% from solar, and 0.2% from energy storage. Comparing two very similar islands only 113 km apart, Curacao is doing much better in generating power from low carbon sources in the last 6 years as seen in Figure 15. Aruba was projected to be the leader in renewable energy for the Caribbean region, today that is no longer the case.

Figure 15: Electricity From Low Carbon Sources. Source: Lowcarbonpower.org



From once being a projected leader in the Caribbean to unimplemented policies and no progress in increasing the renewable energy share in the last 8 years, some questions remain. Why? What happened? Why did Aruba got left behind in the process?

6. CURRENT ENVIRONMENTAL, SOCIAL AND ENERGY CHALLENGES

For environmental issues, Aruba is confronted in a direct manner. Ocean acidification, nitrogen, sulfur, and phosphorus waste are a direct danger to coral reefs. Land use and biodiversity loss are felt in today's level of urbanization and habitat degradation. Clean drinking water and oil import are strongly in conjunction with each other; Aruba's tap water/potable water comes from a saltwater desalination plant that runs on fuel combustion. Due to the recent oil refinery's existence and the lack of a well-structured (chemical) waste regulation and public behavior education, Aruba has a massive waste load issue [23].

Aruba receives on a regular basis requests from the UN and other international bodies to provide information on its natural resources. However, it is crucial to have the information on hand and a reliable monitoring system built in order to satisfy these requirements and accommodate the recent advancements. At present, public environmental information support is diffused, scattered, or incomplete, as participants have their administration not yet in tune with new developments or still feel hesitant to exchange their in-house information.

The head of the Caribbean Development Bank stated in April of 2022 that Caribbean nations must speed up the transition to renewable energy to reduce reliance on fuel imports, the price of which has increased since the outbreak of the war in Ukraine [24].This speed up must include or increase the energy storage capacity for the island of Aruba

Aruba faces several challenges to its energy sector, which harm the island's people and potential for economic growth. In a publication by the Central Bank of Aruba (CBA), it is mentioned that Aruba and the Caribbean remain economically fragile with low productivity, and high public debt and unemployment. In the same publication, CBA identifies numerous challenges in the adoption and exploitation of renewable energy across the Caribbean, including but not limited to:

1. The lack of clear renewable energy legislation and regulatory frameworks;
2. Business model uncertainty of utility industries and (state-owned) organizations;
3. Inadequate financing due to high levels of public sector indebtedness and high initial capital investments for the private sector;
4. Infrastructural limitations due to limited economies of scale and stability of renewable energy grids.
5. Limited availability of adequate renewable energy technology skills [26]

It was concluded by this research after asking questions to important stakeholders, that there is an ongoing need for sharing of information and capacity building to better understand how these technologies may be applied in the region. Some other barriers to implementing renewable energies are:

6.1 The Ownership Structure of Utility

WEB & ELMAR owns the electricity generation industry, with a monopoly on generating power until 2025. The government is looking for ways to incorporate renewable energy generation into the energy mix, which might open the door for distributed IPPs to participate in electrical projects. WEB (Water en Energie Bedrijf) and ELMAR, a state-owned firm, have the sole permission to deliver electricity to the islands of Aruba. The selected utilities have exclusive rights to generate, transmit, and distribute power until 2025. According to the legislative Act, only WEB and ELMAR are authorized to grant licenses to IPPs seeking to generate and sell power to the grid [27].

6.2 Lack of Institutional Capacity

An important barrier has been highlighted as a lack of capability and knowledge in the usage of renewable energy sources. Furthermore, there are flaws in project planning, unclear implementation activities, monitoring, and reporting, as well as other rules and other tactics. Additionally, there are significant data gaps that have an impact on the establishment of reasonable improvement targets as well as the ability to make educated decisions.

The Aruban government of AVP (2009-2017) had some established institutions on the island like; The Carbon War Room, Rocky Mountain Institute, and a TNO Caribbean branch that contributed with knowledge and data that are important for sustainable development of the island. The previous government had some important partnerships with leaders around the world in sustainability that helped carry the ‘Green Vision’ for Aruba, among them are Richard Branson, Prof. Dr. Wubbo Ockels (deceased), and former Vice President of the United States Al Gore. All of these work and professional partnerships have since been terminated under the administration of MEP/POR/RED (2017-2021) and MEP/RAIZ (2021-present) due to political and financial reasons.

6.3 Transaction Cost

Since interested parties must comply with regulatory burdens and confusing procedures, excessive bureaucracy is another key barrier to the development of RE. Further penetration is limited by the region's inability to integrate RE programs, which raises investment and operating costs. The lack of fiscal incentives to promote sustainable investments on the island is also a roadblock.

6.4 Inconsistent and Short-term Policies

Every 4 years in Aruba, a parliamentary election takes place. The observed voting pattern is that the same party will be in the office for 8 years and then it changes party but the pattern remains the same. It is observed and concluded that each time there is a new party in the office, the elected party will reverse the policies of the previous government. This causes the progress of the island to slow down.

6.5 Lack of Knowledge and Awareness

Even though the cost of RE technology has greatly decreased and numerous studies have shown that RE development has enormous economic and environmental benefits, many people continue to have doubts that occasionally come from unpleasant prior experiences. This leads to public resistance to a new energy system.

6.6 High Initial Cost

This obstacle exists in both the utility and private sectors, and it is most severe where traditional energy systems are already in place. However, it should be noted that some technologies have seen significant price drops over the previous few years, indicating further drops in the near and mid-term future.

6.7 Availability of Funding

The availability of financing is another significant impediment considering the high initial cost of RE equipment. The majority of financial institutions in the area don't offer enough financial solutions for RE investments, which leaves countries heavily dependent on funding from international development organizations.

6.8 Small Market Size

Caribbean countries lack the economies of scale that would result from several RE projects due to their small size and low energy demand. On numerous islands, the potential power production from renewable energy sources like geothermal energy is larger than the existing demand, which reduces the incentives for their development.

7. FUTURE SOLUTIONS, ENVIRONMENTAL & SOCIAL IMPACT

In this section, the transition pathway towards a 100% renewable energy system will be discussed.

However, in order to achieve this goal with the greatest result, it is necessary, as several studies have pointed out, to involve all levels and groups of the population in this transition in order to generate support and willingness to transition to a new system. The focus of the previous government AVP (2009-2017) was: achieving socio-economic progress through smart growth. In order to move away from the reliance on the volatile oil market, renewable energy is the key. In addition, in RED's (2017-2021) Vision Circular Economy 2030 document, this political party also envisioned a more sustainable economy for Aruba.

While the concept of achieving socioeconomic progress through smart growth might not be a problem, it becomes a concern when the human aspect is not appropriately incorporated and economic benefits become the primary focus. In the expansion drive for renewable energy, disagreements and friction occur in Aruban society such as protests against the construction of a new wind park and against the implementation of new LNG technologies. Culture and mindsets are significant "soft variables" that must be addressed in order to accomplish a successful transition to sustainable energy. As a result, efforts to include Aruban citizens in the transition must be prioritized.

"To improve is to change; to be perfect is to change often." -Winston Churchill

A better and desired future for the upcoming generation of Aruba requires changes. After a lot of literature review, some actions are identified that may help an easier transition to a new energy system.

7.1 Societal Changes

This section discusses the major cultural and behavioral changes that Aruban citizens will need to make. The island's community is currently misinformed and thus unconcerned about where they acquire their energy. However, the fact that the energy is not regular is a persistent source of aggravation for the general population and companies. So, the adjustments that must occur are a greater embrace of renewable energy/sustainability as well as recognition of the negative effects of the use of fossil fuels. This is significant since there should be no public resistance to the transition, as observed back in 2012-2013 with the protest against the Urirama wind turbine park project [28], and recently with the public rejection of the LNG project. Further, to counter the brain drain people should remain on the island and work towards improving their country. Aruban citizens should embrace the concept of becoming their own energy producers.

In order to make this change, the Aruban community needs to be better informed (by the government, universities, Non-Government Organizations (NGOs), and the private sector) on the potential for job creation. The community is in need of a platform for easy access to information, a better knowledge of the financial benefits of moving to a low-carbon power generation system, and spark the interest in STEM fields early in schools and universities. The Aruban community, educational institutions, Aruban government, NGOs, unions, and local associations need to carry this shared responsibility.

This will have an impact on the acceptance of a new energy system, it will also help reduce the fear of unemployment and the fear of costly renewable technologies due to the transition. It also reduces public resistance.

7.2 Structural Changes

The required institutional reforms, governance changes, regulatory changes, and infrastructure improvements will be discussed in this section.

Work to gain the trust and improve professional relations with institutions that once were established in Aruba relevant to the energy sector is vital.

7.2.1 Educational institutions

Educational institutions are significantly important in the change. Tesla University Aruba is the first technical university on the island and the university hopes to contribute to data gaps, relevant research for the energy sector, and diversify the knowledge economy of Aruba. Scholarships for programs at Tesla University for Aruban students were introduced under the administration by Minister Lampe (RED 2021) to stimulate STEM skills and to give opportunities to students who might not have the resources . Universities should offer professional training programs developed and delivered in partnership with regional and international organizations in which the government has an involvement. Develop educational programs that teach about energy transition, transition planning, sustainability, and renewable energy. This is already available at Tesla University Aruba. There is a need to immediately conduct comprehensive research on the energy sector where lies a data gap for Aruba.

7.2.2 Independent Entity

Within the actual political context, the only way to realize structural improvements in the field of sustainability is through an independent entity like Centraal Plan Bureau (CPB) Netherlands Bureau for Economic Policy Analysis which will determine long-term policies to guarantee that the objectives are realized without the influence of a changing government. It will reduce the constant change in policies that interferes with the development of Aruba. This strategy can be implemented in a short term.

7.2.3 Policies

Another way is to adopt and combine and adapt policies to aim which have proven to be successful in Europe and the Caribbean to aim for renewable energy growth in those countries, with data relevant to Aruba. Reconsidering incentives in the 2020 Vision Green Deck Report [29] that were in progress and were stopped by the current government.

It is by now, projected with no doubt that the future is renewable energy systems. For stakeholders and businesses in Aruba to survive, managers should consider exploring new business models that are aligned with these new systems.

7.3 Infrastructural Changes

In rising and developing economies, infrastructure is a vital engine of growth, employment, and improved quality of life. However, this comes with a cost. Infrastructure development and operations, such as power plants, buildings, and transportation, account for over 70% of worldwide greenhouse gas emissions according to an article written by Deblina Saha for the World Bank.

Does any of this indicate that construction should be less? No. However, low-carbon infrastructure is part of the solution.

7.3.1 Electrical Vehicles

After reviewing some studies on infrastructure for different SIDS, most of them talked about introducing electric vehicles (EV) to support infrastructure. The technologies of RE and EV are fundamentally connected. Integration of these technologies and the network that supports them is essential to accelerate the transition to a 100% RE pathway. All forms of EVs can help improve fuel economy, lower fuel costs, and reduce emissions. Awareness is important in the process in the near future when the market starts growing due to international development. This awareness will help users and important stakeholders on board with the same expectation to help with the RE transition.

7.3.2 Renewable energies

More RE projects (solar and wind) should be implemented combined with a spatial planning system. These emit far fewer carbon emissions than fossil fuels. Aruba has high potential in solar and wind, however, the potential of ocean energy should be deeply studied in the future.

As mentioned in the ‘Energy mix in Aruba’ section, while LNG is not a renewable fuel like solar or wind power, it could present a bridge toward a more renewables-based energy future. Previous research determined that LNG is a cleaner and more affordable energy supply than heavy fuel oil. In Jamaica, for example, the introduction of LNG significantly improved Jamaica’s economic stability in areas including diversified energy supply, and investments in renewable energy. The LNG facility stated that it created a new industry with new local jobs, including engineers, facility operators, maintenance staff, drivers, office workers, and more [30].

Local laws on Aruba do not require a Social and Environmental Impact Assessments for projects. This needs to be addressed so the community can have a clear overview of the influences the project has on Aruba and its people.

7.4 Energy Efficiency Awareness

A society's energy consumption is influenced by its social standing and access to technology. As a result, technological or social change can reduce the quantity of energy consumed by society. Reduced energy usage does not always imply a lower quality of life. Energy conservation can improve the quality of life in many circumstances by lowering environmental risks, increasing economic and national security, and saving money.

Utilities, NGOs and the government have a shared responsibility to raise awareness among the citizens of Aruba. This should be a long-term commitment of everyone involved.

Awareness can be done by the following:

- Provide citizens with tools that allow them to reduce energy consumption in their daily life.
- Convert the world of energy into an everyday matter to understand the impact of good use or bad use.
- Provide information targeted at changing habits: providing specific actions and explaining their benefits.
- Encourage the implementation of efficient behavior among all citizens, through standardization and everyday practices. It is essential to overcome the barrier of ignorance and reluctance towards change.
- Learn from citizens who act in a sustainable manner to promote energy efficiency actions that motivate the rest of society.
- Promote responsible actions on the part of government and businesses, which should serve as an example.

The proposed recommendations are based on an analysis by “Repsol Foundation” of the study's findings on Spanish society and its evolution in terms of energy efficiency, integrating the opinion of recognized experts in this field.

The strategy of implementation of low carbon energy mix generation can be summarized in 4 main steps:

1. Establish

Create strong institutional base

2. Educate

Educating the public and government. Create strong academic foundation

3. Expand

Expansion of investments for the island energy system.

4. Review

All of the first 3 steps must be executed alongside a review mechanism.

In the next two sections, the impacts of the proposed solutions on both the environment and society are discussed.

7.5 Impact on Environment

Producing and using electricity more efficiently reduces both the amount of fuel needed to generate electricity and the amount of greenhouse gasses and other air pollution emitted as a result. Electricity from renewable resources such as solar, geothermal, and wind generally does not contribute to climate change or local air pollution since no fuels are combusted [31]. At the same time, it is important to consider the non-zero impact of those alternatives when assessing their use at a specific location. The intensity of environmental impact would vary depending on geographic location, climate, and other factors. In order to maximize the use of the most abundant local resources and reduce overall impacts, careful decisions must be made about the deployment of specific technologies. Some renewable energy technologies, such as wind and solar, produce no greenhouse gasses while in use. However, the manufacturing, transportation, installation, maintenance, and decommissioning phases of the system life cycle might have unintended effects on the environment.

Due to the lack of data and research specifically on Aruba, the precise impact on Aruba remains unexplored.

7.6 Impact on Society

The proposed solutions create a new economic perspective for the Island of Aruba and the professionals of Aruba. From this new ‘green’ perspective, Aruba can derive a more resilient economic opportunity. It will give Aruba the ability to accelerate development based on its sustainable potential as a knowledge based economy, in which knowledge in engineering, technology, policy and sustainability can be shared or exported with the region and across the world. Aruba can create shared prosperity based on sustainability, which in its turn can contribute to a more equal community with opportunity for local and international professionals. In addition, this would fortify the economic outlook, because it mitigates Aruba’s dependency on the tourism industry. The citizens of Aruba can enjoy a decent and improved quality of life, harmonious environment and lower energy prices which categorize a modern society.

This untapped potential is what Aruba needs to accelerate the recovery process. The society is desperately looking for a new economic recovery plan, and a new social economic model that serves the future generation. The development of a new social economic model should provide short term effects and include a long term vision, in which

sustainable development should play a key role. By implementing the solutions such as those provided in this research, the society as whole from university students to community leaders could help shape this vision and determine the new social and sustainable economic model. The community will be capable of participating actively in a social dialogue regarding this new economic opportunity. Most importantly, the society as whole will begin to reflect on the needs of the future generation. This way of thinking will promote a climate justice approach to policy making that requires everyone to look beyond the short-term political cycle, to develop a vision that ensures that every citizen enjoys the right to development and that the well-being of future generations is not compromised by unsustainable development.

Some positive impact from this new perspective:

- Increase of employment
- Policymaking which serve the future generations
- Facilitate social dialogue regarding sustainable development, in which the community can participate so the vision can be carried by the majority of the population.
- New economic pillar
- Attracts responsible tourism
- Improvement and contribution on/to the following SGDs: 4.Quality Education,7. Affordable and Clean Energy, 8. Decent Work and Economic Growth, 9. Industry, Innovation and Infrastructure, 10. Reduced Inequalities, 11. Sustainable Cities and Communities, 12. Responsible Consumption and Production, 13.Climate Actions and 17. Partnerships For The Goals.

8. CONCLUSION

To conclude this analysis report, this section will connect the research objective with the analysis performed on the energy status of different countries. The objective of this report was to propose future solutions to improve the energy mix of Aruba and explore the way it impacts the environment and society.

The research started by defining what energy mix followed by an analysis of the current energy mix of the world. It was discovered that in 2019, 84.3% of the global energy comes from fossil fuel and only 11.4% comes from renewable sources. The coronavirus pandemic had a negative impact for everyone, but positive impact for the environment. The oil demand has dropped by more than 20% while renewable energy production continues to grow. The Caribbean Islands are still highly dependent on imported fossil fuel (81%). Further, it was proven that with the dependency on imported fossil fuels, the Caribbean is facing challenges. How can these islands fight these challenges? What can be done to drive these islands to be less dependent on fossil fuel? Geographical analysis proves that the Caribbean is abundant in renewable sources. This research suggests that the Caribbean islands should move towards a renewable and cleaner transition. This report looked at the energy mix and progress of countries who are members of the European Union, specifically Sweden and the Netherlands. Sweden has proven to be the leader in RE, due to its policies and fast adaptation to new technologies while the Netherlands is far from having RE as a majority in the energy mix share. Some important aspects were analyzed from the Netherlands due to the relationship with Aruba. Aruba is technically and officially associated with the EU through its OCT status. To have a better comparison, the energy mix and some policies data of Caribbean Islands Belize and Curacao were analyzed. Curacao is only 113 km away from Aruba, the question was, why is Curacao doing better than Aruba regarding the energy mix?

In 2009, the government of Aruba started to diversify the energy system by implementing a few RE projects. The dependency on imported fossil fuel dropped from 100% to 81% and Aruba had set a target to reach 100% RE in 2020. Today in 2022, the goal was not met. Another question arises… Why?

In the “Current environmental, social and energy challenges" section, the barriers were identified and discussed. The aim of this analysis report was to propose solutions to these challenges and also look at their impact on the environment and society. In order to improve

the energy mix and looking towards a 100% RE transition, Aruba needs some societal changes, structural changes, infrastructural changes and energy efficiency awareness. As for the impact on the environment, looking at the big picture, the good practice of these solutions will reduce greenhouse gasses emission but for the technologies, the impact will vary based on specific location. Due to data gaps the precise impact of some technologies for Aruba remains unknown. If implemented correctly, the proposed solutions will have a big positive impact on the society and will bring Aruba back on the path of being a leader for the Caribbean and the world regardless of its size.

REFERENCE PAGE

[1] "Remarks by the President at National Clean Energy Summit," *whitehouse.gov*, Aug. 25, 2015.https://obamawhitehouse.archives.gov/the-press-office/2015/08/25/remarks-president - natinal-clean-energy-summit

[2] J. Buchardt, P. Herold, J. Päivärinta, and S. Schönberger, "Have We Passed Peak Demand for Fossil Fuels?," Jun. 22, 2020.

[3] UN Economic Commission for Latin America and the Caribbean (ECLAC), "SUSTAINABLE ENERGY FOR ALL IN THE CARIBBEAN," *The Magazine of the Caribbean Development and Cooperation Committee*, 2016.

[4] "Fossil fuel energy consumption (% of total) - Latin America & Caribbean | Data," *data.worldbank.org*. https://data.worldbank.org/indicator/EG.USE.COMM.FO.ZS?locations=ZJ&view=chart

[5] National Renewable Energy Laboratory (NREL), "Energy Snapshot Aruba," Mar. 2015. [Online]. Available: https://www.nrel.gov/docs/fy15osti/62709.pdf

[6] Eurostat, "Shedding light on energy on the EU: Where does our energy come from?," *ec.europa.eu*, 2017. https://ec.europa.eu/eurostat/cache/infographs/energy/bloc-2a.html

[7] Sweden Sverige, "Energy use in Sweden," *sweden.se*, Dec. 23, 2015. https://sweden.se/climate/sustainability/energy-use-in-sweden

[8] Hive Power, "Renewable Energy in Sweden; What You Should Know.," *www.hivepower.tech*, Sep. 13, 2021. https://www.hivepower.tech/blog/renewable-energy-in-sweden-what-you-should-know

[9] Hive Power, "Renewable Energy in The Netherlands; What You Should Know.," *www.hivepower.tech*, Aug. 16, 2021. https://www.hivepower.tech/blog/renewable-energy-in-the-netherlands-what-you-should-know

[10] Urgenda, "Climate Case - Urgenda," *Urgenda*, 2018. https://www.urgenda.nl/en/themas/climate-case/

[11] "Climate Agreement," Government of the Netherlands, The Hague, Jun. 2019.

[12] N. van der Linden and V. van Hagen, "The Netherlands needs a strong commitment to renewable energy," *www.statkraft.com*. https://www.statkraft.com/newsroom/news-and-stories/archive/2020/country-series-the-netherlands-needs-a-strong-commitment-to-renewable-energy/

[13] United Nations Framework Convention on Climate Change (UNFCCC), “THE PARIS AGREEMENT,” The Conference of the Parties vol.21, Paris, Dec. 2015.

[14] Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.). IPCC, Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

[15] IPCC, “Global Warming of 1.5 ºC,” *Ipcc.ch*, 2018. https://www.ipcc.ch/sr15/

[16] European Commission, “A European Green Deal,” *European Commission*, 2019. https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

[17] Dutch government, “Klimaat Wet”,2019. https://wetten.overheid.nl/BWBR0042 394/2020-01-01; 2019.

[18] J.Sijm,L. Beurskens, M. Marsidi, R. Niessink, M.Scheepers, KEL. Smekens, A. van der Welle, H. de Wilde. “Review of energy transition scenario studies of The Netherlands up to 2050”. TNO, 2019. https://energy.nl/en/publication/review-of-energy-transition-scenario-studies-of-the-netherlands-up-to-2050/.

[19] M. Scheepers *et al.*, “Towards a climate-neutral energy system in the Netherlands,” *Renewable and Sustainable Energy Reviews*, vol. 158, p. 112097, Apr. 2022, doi: 10.1016/j.rser.2022.112097.

[20] Energy Unit, “2020 Annual Energy Report,” Ministry of Public Utilities, Energy & Logistics, Belmopan City, Belize., Dec. 2021. Accessed: Jun. 19, 2022. https://energy.gov.bz/2020-annual-energy-report/

[21] [21] https://www.energy.gov/sites/default/files/2020/09/f79/ETI-Energy-Snapshot-Curacao_FY20.pdf

[22] European Commission, “Aruba,” Sep. 19, 2019. https://ec.europa.eu/international-partnerships/where-we-work/aruba-nl_en

[23] “The Green Gateway; Economic Vision and Policy 2011 – 2013,” Government of Aruba; Ministry of Economic Affairs, Social Affairs and Culture, Oranjestad, Aruba.

[24] R. Ruud, “Opportunities and Challenges for Environmental Statistics in Aruba,” Central Bureau of Statistics, Aruba, Apr. 2014.

[25] B. Ellsworth, “Caribbean must speed renewable energy transition to manage oil shocks -official,” *Reuters*, Apr. 27, 2022. Accessed: Jun. 19, 2022. [Online]. Available: https://www.reuters.com/business/energy/caribbean-must-speed-renewable-energy-transition-manage-oil-shocks-official-says-2022-04-27/

[26] R. Peterson, Ed., “Fostering Economic Resilience: From Roots to Routes,” Central Bank of Aruba, Aruba, 2019.

[27] A. Fingal and D. Racic, “The Role of IPP in Power Generation in the Caribbean – Government Policy, Incentives, Current and Future Regulatory Environment.”

[28] Altovistalover, “Aruba residents go to court to stop construction of wind turbine park at Urirama,” *Save Alto Vista Aruba - No wind turbines at Urirama*, Feb. 05, 2013. https://savealtovistadotcom.wordpress.com/2013/02/05/aruba-residents-urirama-start-court- case-against-construction-of-wind-turbine-park-aruba/

[29] “2020 Vison; Green Deck,” Government of Aruba, Aruba, Jun. 2015.

[30] “New Fortress Energy,” *www.newfortressenergy.com*. https://www.newfortressenergy.com/operations/jamaica-facilities

[31] US EPA,OAR, “Learn about Energy and its Impact on the Environment | US EPA,” *US EPA*, Aug. 10, 2015. https://www.epa.gov/energy/learn-about-energy-and-its-impact-environment#impact