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Sustainable Energy, Transportation, and Resilience in the Caribbean

A white paper for the Caribbean Forum on Sustainable Energy, Transportation, and Resilience

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Author

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Preface

The Caribbean Forum on Energy, Transport, and Resilience was held at the Bay Gardens Hotel, Rodney Bay, Saint Lucia, from June 26 to 27, 2019. It was hosted by the Organization of American States (OAS) and the Government of Saint Lucia, with support from the Organisation of Eastern Caribbean States (OECS) Commission. With the objective of exploring new technologies and combining them with existing regional experiences in sustainable urban development, the event had an overall goal to design a roadmap for the Caribbean smart cities of the future. The forum sought to further public-private exchanges among governments, energy and transportation experts, and the private sector. It addressed multiple aspects, such as technology innovation, policy and regulation, infrastructure resilience, and financing and brought together utilities, policy makers, physical planners, multilateral institutions, universities, and the private sector from across the Caribbean to build a blueprint for resilient energy and transportation infrastructure, and to exchange ideas, best practices, and technologies.

A total of 50 attendees from 15 countries of the region took part.

This whitepaper is a compilation of the presentations, discussions, group exercises, and semi-structured interviews that took place during the two days of the forum.

Executive Summary

In 2017, the Caribbean region was devastated by two Category 5 hurricanes, Irma and Maria. Hurricane Irma was the most powerful hurricane ever recorded over the Atlantic. Irma and Maria resulted in the deaths of at least 37 persons with thousands made homeless and key infrastructure for transportation, water, health, tourism, and education devastated. The islands affected included: Anguilla, Bahamas, Turks and Caicos Islands, British Virgin Islands, Barbuda, and Dominica. Dominica was one of the nations most severely affected during the 2017 hurricane season, having suffered damages totaling US$931 million and losses of US$382 million in the productive sector, the social sector and to infrastructure, amounting to 226 percent of the country's 2016 gross domestic product (GDP). The identified recovery needs for reconstruction and resilience interventions amounted to US$1.37 billion. The infrastructure most affected by the passage of the hurricanes was related to transportation and energy. Enhancing resilience in these two critical infrastructure sectors is essential in reducing the time and cost of post-disaster recovery.

Investing in renewable energy (RE) generation not only has significant benefits to the environment and in lowering the regional fuel import bill but it also adds resilience to the energy system. The modular nature of RE systems ensures both a diversification of the energy generation mix and also a spatial diversification of the generating sources. This significantly increases the resilience of the energy system. The region does face technical challenges as it relates to the deployment of distributed roof-top solar photovoltaic systems. Hip roofs are more resistant to the effects of high wind speeds associated with tropical cyclones. These roofs are designed with a pitch angle exceeding 22o– not optimal for solar generation in the region, which requires a flatter roof or a smaller pitch angle. The region has a unique option for financing of RE projects. The Citizenship by Investment Program (CIP) is active in five countries in the region, including Antigua and Barbuda, which has utilized funding from the CIP for the construction of a utility scale Solar PV system.

Five Power Utility archetypes were presented at the forum. A formal cooperative group exercise approach was used to study and discuss the archetypes, which were composed of the existing scenario used as a baseline and other innovative models that attempted to synthesize and foster synergy between a greater RE and EV adoption and increasing the overall resilience of the energy and utility grid ecosystem. The archetype that the forum participants found to be most suitable for the region was the Mobility Utility, the archetype in which the power utility company leases EVs to private and commercial entities. The EV lease also consists of a bundled special electricity tariff. In this archetype, the vehicle-to-grid (V2G) services are fully utilized as the power utility owns the EV and its battery. The attendees stressed that the Mobility Utility archetype could be suitable for the region as a number of utilities are investor-owned, with access to the financing required to adopt the Mobility Utility model. The archetype would greatly appeal to commercial and fleet users and would encourage growth in the Micro, Small, and Medium Enterprise (MSME) sector. Regionally, utilities already have considerable experience engaging local contractors and service providers and with this archetype utilities would be granted access to the lucrative automotive market. This would have the potential to increase MSME involvement and engagement in the automotive sector through better coordination and financing from the utility.

Antigua and Barbuda has implemented a number of measures to enhance the resilience of its energy system since the hurricanes of 2017. These measures include: investing in more RE generation and increasing spatial diversification; adopting a 100% Green Vision for Barbuda; strengthening the country's transmission and distribution infrastructure; and the institution of an integrated planning committee that includes private and public sector stakeholders that meet and coordinate resilience planning and implementation before the start of the hurricane season.
Barbados has been synonymous with electric

vehicles in the region and has gained valuable experience in the second life of EV traction batteries. An EV battery replacement workshop was created with financial assistance from grant funding. The EV workshop removes degraded EV batteries and replaces them in golf carts. There are other regional applications for the second life of EV batteries, which include using them as energy storage for pollution free power generation at carnival-related events and for agriculture.

At the forum, it was highlighted that regional resilience planning and preparation should include activities related to the mitigation of the effects of the Sahara dust and the sargassum seaweed. The sargassum seaweed has wreaked havoc on regional marine life and on the tourism industry, and has also affected the operation of desalination plants in Antigua and Barbuda. Desalination accounts for 60% of water sourced in Antigua and Barbuda. The Sahara dust has been detrimental to the health of persons in the region, inflicting and exacerbating respiratory and cardiovascular related diseases. At the forum it was highlighted that the Sahara dust has affected power output from solar PV systems and has contributed to an increase in maintenance of wind turbines.

The electrical interconnection of OECS member states via submarine cable as a means of fully utilizing planned and potential geothermal energy resource was highlighted. The discussion then evolved into one focused on a more generalized system of energy sharing and trading, a Regional Integrated Energy Market (RIEM) that would offer trading in energy commodities, energy services, and energy related technologies. The RIEM would be designed using an open market framework that would allow for fair and transparent trading and competition, and would foster agreements and arrangements that are inclusive of all the members. Hydrogen was identified as a potential energy carrier for the RIEM instead of electricity.
The MSME sector is critical to the prosperity, productivity, and sustainability of the region. MSMEs account for more than 60% of GDP in some CARICOM member states and create about 45% of jobs in CARICOM. At the forum, it was highlighted that the Caribbean Small Business Development Centers (CSBDC) program was designed and implemented to strengthen the institutional framework of MSMEs in the region. The CSBDC was identified to address the issue of enhancing resilience and post-disaster business continuity among regional MSMEs. The CSBDC should also provide special technical assistance to MSMEs, focused on the sustainable energy market in the region.

The Need for Energy Resilience

The Caribbean region has always been susceptible to the devastating effects of tropical cyclones. This annual, persistent threat has instilled in the region and its people an admirable level of resilience to its adverse effects. However, with the increased severity of the effects of climate change the tropical cyclones are now more powerful and frequent.

In 2017 the region was devastated by three hurricanes, two of which developed into Category 5 hurricanes, Irma and Maria – Hurricane Irma being the most powerful hurricane ever recorded over the Atlantic. In their wake, Irma and Maria left at least 37 persons dead in the region, with thousands made homeless and key infrastructure for transportation, water, health, tourism, and education devastated. Between 70 and 95 percent of houses were damaged in Anguilla, the Bahamas, the Turks and Caicos Islands, the British Virgin Islands (BVI), Barbuda, and Dominica. (1) The economic loss to the region was as devastating. The 2017 hurricane season resulted in an estimated loss of 826,100 visitors to the Caribbean, compared to pre-hurricane forecasts. These visitors could have generated US$741 million and supported 11,005 jobs. (2)

The level of devastation that the passage of hurricane Maria inflicted on the island of Dominica was unprecedented: total damages of US$931 million and losses of US$382 million translated to 226 percent of the 2016 gross domestic product (GDP). The identified recovery needs for reconstruction and resilience interventions amounted to US$1.37 billion. (3)

An analysis of the infrastructure damage and losses in Dominica revealed that the transportation and electricity subsectors entail the highest recovery cost (Figure 1). Further investigation of the electricity sector revealed that:

- Electricity service failed due to widespread damage to the electricity transmission and distribution network, with 75% of the network being down.
- 80% to 90% of transformers were damaged or could not be repaired.
- There was damage to three generating units at the Fond Cole location.(4)

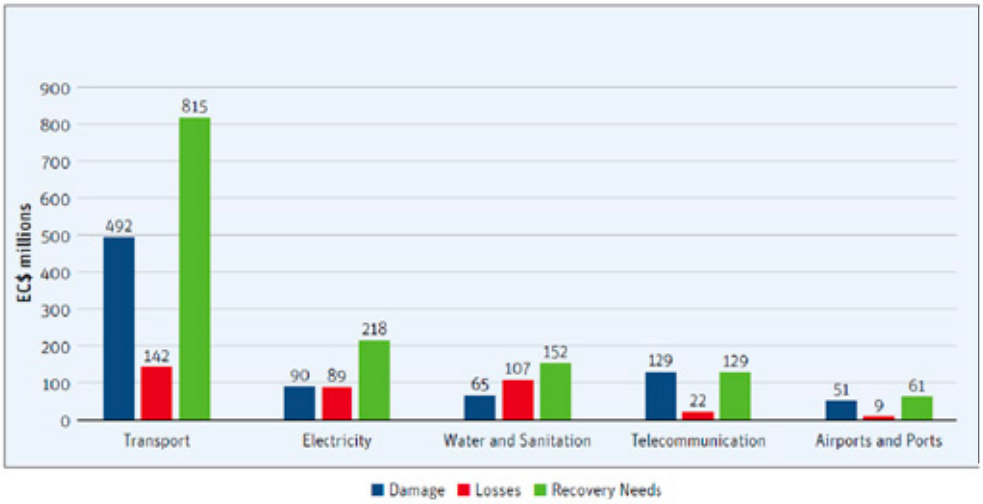

Figure 1 - Damages, Losses, and Recovery needs for Infrastructure subsectors in Dominica. Source: Post-disaster needs assessment hurricane Maria.

The damage and losses in the electricity sector are indicative of the inherited centralized generating and distribution model that is common in the region.

Renewable Energy in the Caribbean

The Caribbean region is renowned for its sun, sand, and sea. The region is also rich in indigenous sources of renewable energy, including solar, wind, geothermal, hydro, tidal, and ocean energy.

It is estimated that the Caribbean holds 2,525.9 MW of potential solar energy, 800.4 MW of potential wind energy, and 3,770 MW of potential geothermal energy. Collectively, clean energy sources could displace approximately 2.7 million barrels of oil per year in the region, (5) which continues to commit to renewable energy deployment by adopting and enacting ambitious RE polices and targets. Table 1 gives a status on the RE supply-side capacity for CARICOM member states.

CARICOM Country	Installed RE supply-side capacity, including generation under construction (2018)/MW
Antigua and Barbuda	6.00
Bahamas	1.70
Barbados	32.10
Belize	102.00
Dominica	7.30
Grenada	2.30
Guyana	44.00
Haiti	40.00
Jamaica	189.00
Montserrat (UK)	1.00
Saint Kitts and Nevis	16.40
Saint Lucia	3.10
Saint Vincent and the Grenadines	16.50
Suriname	194.00
Trinidad and Tobago	> 0.1
Total	**655.41**

Table 1 Supply-side installed and under construction renewable energy generation (as of 2018).
Source: Renewable Energy Caribbean & New Energy Events

Renewable Energy and Resilience

The combination of renewable energy generation and microgrids would significantly increase the resilience of the electric grids in the region. The modular nature of renewable energy systems naturally adds resilience to the electricity grid by diversifying the sources of power generation and allowing for spatial diversification of the energy sources. When RE is combined with community microgrids that allow for the islanding of the community electrical grid from the parent electrical grid, communities are able to use their distributed RE generation when the parent electrical grid is down due to a natural disaster or otherwise.

Distributed Solar and Hurricane Resistant Roofs

The style and the materials used are critical considerations when designing a roof to survive the high winds of a tropical cyclone. In order to lessen the effect of the uplifting forces on the roof from a tropical cyclone, the roof pitch should not be less than 22o.(6) A hip roof has been found to be more resistant to the winds of a cyclone than a gable roof.(6)

Figure 2 Hipped Roof design. Hipped roofs are better suited to withstand the strong winds associated with a tropical cyclone. Source: art-profy.com

For CARICOM countries, the optimal angle to install PV systems to maximize power generation ranges between 11 and 19 from the horizontal. It has become a challenge to maximize solar PV output from roof installations that were designed with a high pitch angle as a requirement for survivability from high winds. A prosumer who wishes to maximize PV output may be forced to look at ground-mounted PV systems. With space restrictions in small islands, however, this may not be feasible. The use of a flat concrete roof can both provide the ability to survive tropical cyclones and act as an excellent flat platform to install roof mounted solar PV. However, the cost associated with a concrete roof can be much higher than that of an equivalent wood or steel roof.

Regional Financing for Sustainable Development

The Caribbean region has been the beneficiary of grant funding and other financial assistance from international donor agencies and developmental partners. Regional and international lending agencies have also been actively working with regional governments to finance projects related to sustainable development and resilience.

The Citizenship by Investment Program (CIP) could be used to fund sustainable development projects in the region, the forum underscored. CIP programs in the region offer a choice of one of two pathways towards citizenship: a minimum cash investment in real estate; or a donation to a government- managed fund that is used to support infrastructure and economic development. Table 2 offers a summary of the existing CIPs in the region. The forum also revealed that the Antigua and Barbuda CIP has been providing financial support for installation of a utility scale solar PV system in the country.

Table 2 A summary of Citizenship by Investment Programs in the region. Source: imidaily.com

		Real Estate Minimum Investment (Single Applicant)		Donation Minimum Investment (Single Applicant)	
Country	**Number of countries to which visa-free travel is available**	Real Estate (US$)	Real Estate Government Fee (US$)	Donation (US$)	Donation Government Fee (US$)
Antigua and Barbuda	140	$400,000	$57,500	$100,000	$32,500
Dominica	122	$200,000	$33,500	$100,000	$8,500
Grenada	131	$350,000	$58,000	$200,000	$8,000
Saint Kitts and Nevis	141	$200,000	$42,547	$150,000	$7,500
Saint Lucia	130	$300,000	$59,500	$100,000	$9,500

Transportation in the Caribbean

Globally, transportation is one the largest consumers of energy, with consumption in the sector expected to rise to more than 3 billion tons of oil equivalent (TOE) in 2030 (Figure 3).

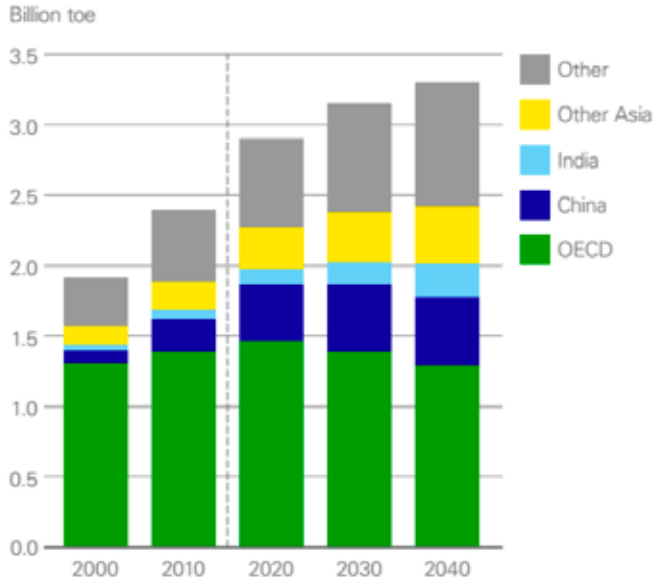

Figure 3. Final energy consumption in transportation. Source: BP Energy Outlook 2019 edition

In the Caribbean region, energy use for transportation varies from state to state. For the smaller countries, the percentage of end energy usage can exceed 40% (Figure 4).

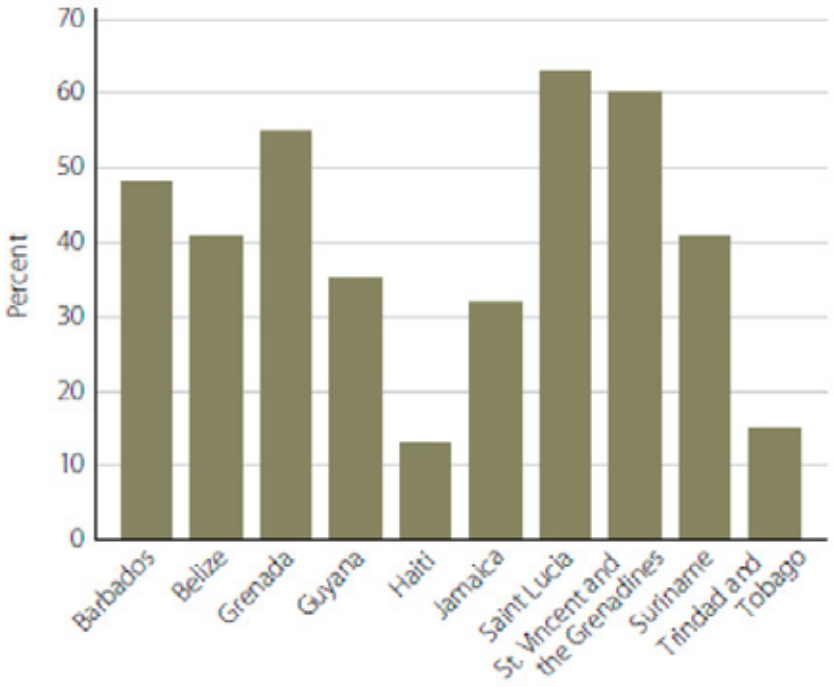

Figure 4 Transportation Share of Total End-Use Energy Consumption in Selected CARICOM Member States, 2014. Source: C-SERMS Baseline 2015

Transportation's impact in the region has been overlooked because of the sector's complexity and because of the general lack of available data related to the sector.(7)

The promotion of hybrid and electric vehicles capable of cutting fuel consumption by 47% and 73%, respectively, could greatly benefit the CARICOM region. Electric vehicles (EVs) are significantly more energy-efficient than their internal combustion engine (ICE) counterparts, converting approximately 60% of grid power to energy at the wheels.(7) With the recent closing of the oil refinery in Trinidad, all CARICOM member states now import liquid fuel for transportation. This recurring cost consumes significant amounts of the region's valuable foreign exchange. Adopting EVs would not only lower the liquid fuel importation bill because of the higher efficiencies of EV when compared to ICE vehicles but would also allow for the EVs to be charged using indigenous sources of RE available in the region. Combining RE and EV technologies is the most effective way currently available for addressing the Nationally Determined Contributions (NDCs) that the countries in the region have committed to in the sectors of transportation and power generation.

Social Consideration and the EV Transition

The upfront cost of an EV is much higher than that of an equivalent internal combustion engine (ICE) model. To attain cost parity between EVs and ICE vehicles and to encourage greater EV adoption, some countries of the region have decreased the taxes and duties imposed on EVs – incentives that have been successful at encouraging the adoption of EVs, albeit they have reduced the tax revenue that governments collect from the purchase of new vehicles. This has affected government funding for social and other programs, especially for islands with a smaller Gross Domestic Product (GDP). Guadeloupe collects considerable tax revenue from the sale of liquid fuel, especially to taxis. Transitioning to EVs and away from ICE vehicles would curtail this revenue stream. Montserrat's working population is around 1,200 persons, with 20 of them directly employed at liquid fuel filling stations. The forum revealed that for small populations the transition to EVs can result in significant unemployment, in this case 2% if the filling stations are closed because of the EV adoption. The discussion at the forum underscored the importance of aligning a re-training or training program for transportation sector workers to match the transition to EVs.

Public Transportation

The lack of reliable, efficient, and safe public transportation systems in most countries in the region was highlighted at the forum as having had a negative effect on tourism and other service sectors. Persons employed in these sectors require transportation late at night due to the long working hours and shifts and are unable or chose not to use public transportation but more costly private transportation. The forum underscored the importance of investing in electric buses for the public transportation system. Electric buses would reduce greenhouse gas (GHG) emissions and have a lower total cost of ownership (TCO).(8) Also highlighted was the opportunity to incorporate the emerging vehicle-to-grid (V2G) technology, wherein the large traction batteries of the electric bus can be used to feed power back into a small community or into the grid in times of natural disasters, or whenever the power grid is unavailable.

Utility Models

The interface that connects the resilience of an energy system, sustainable energy adoption, and sustainable transportation in the form of electric vehicles is the Electric Utility. An Electric Utility that embraces electrification of transportation and diversifies and decentralizes its energy sources by increasing distributed renewable energy generation increases its overall resilience as well. The adoption of Electric Utility models capable of harnessing the potential of the synergies between renewable energy and electric vehicles would not only enhance its resilience but would also foster greater economic growth and innovation. Innovative Electric Utility models (9) were modified taking into consideration the nuances of the energy systems and policies in the region. These models were presented at the forum, and their relevance and efficacy for the region were discussed and investigated during a formal cooperative group exercise. The models and the outcome of discussions are presented below with the forum attendees identifying the existing barriers, opportunities, financing options, and social aspects associated with each model.

Archetype 1 – Current Status

This archetype reproduces and generalizes the current structure and interaction of existing power utilities in CARICOM. It should be noted that there exist a number of unregulated utilities in the region and a number of countries without a feed-in tariff for RE generation. Additionally, the energy and transportation landscape among nations is diverse. Trinidad and Tobago is a net exporter of energy and the other nations are net importers. The transportation needs of the larger countries with larger urban populations and longer travel distances are greatly different from those of the smaller countries with smaller urban populations and shorter travel distances. It is also worth highlighting that with the closure of the oil refinery in Trinidad and Tobago in 2018, all CARICOM countries now import their liquid transportation fuels. The diversity in the transportation and energy requirements of countries of the region is reflected in the diverse collection of opportunities and barriers identified during the group exercise at the forum.

Policy

The absence of an enabling policy environment for the introduction of non-utility based distributed RE generation for certain countries in the region, among them Trinidad and Tobago and Guyana, was highlighted. Countries with the required policy framework that allows for distributed RE generation and their associated tariff structures – including Barbados, St Lucia, and Grenada – were presented as templates and case studies for countries without a policy framework. The forum attendees concluded that the region should adopt or develop policies to promote diversification of energy sources, adoption of EVs, and adoption and implementation of microgrid systems and related technologies.

Financing and Market Development

The forum pinpointed the need for a greater variety of and more competitive financing options for domestic and commercial RE systems, EVs, and their associated EVSE and energy storage systems. The high upfront purchase cost of EVs when compared to internal combustion engine (ICE) vehicles was identified as a major barrier to EV adoption. To reduce the high upfront cost of EVs, one fiscal solution suggested was to reduce or remove the associated taxes and duties on EVs. This fiscal measure has been implemented in a few countries of the region but it was pointed out that this measure significantly reduces government revenue from taxation and is not sustainable over the long term. Forum participants indicated that with rapidly decreasing costs of EVs, RE systems, and energy storage systems, the region stands to benefit from the cost reduction in the near future. The eco-tourism sector was identified as a direct beneficiary of any reduction in the cost of RE systems and EVs and as a result positive market growth is expected.

Technology and Implementation

The forum identified technology issues associated with the adoption of RE systems and EVs. These include under-developed or non-existent public charging infrastructure and a lack of technical studies to investigate the impact that a large number of electric vehicles charging and a large penetration of variable RE would have on the electricity grid. The susceptibility of overhead power transmission and distribution lines to tropical cyclones was also highlighted.

Technology has great potential for addressing the technical problems related to energy and transportation in the region. Increased distributed RE generation would increase energy security and resilience. Greater EV adoption would reduce importation of liquid transportation fuel, reduce the overall vehicle maintenance and operation cost, and increase the resilience of the transportation sector. The charging of EVs using indigenous RE sources, rather than imported liquid transportation fuels for ICE vehicles, eliminates fuel supply interruption that may occur during natural disasters and increases the resilience of the transportation system.

Social Aspects

The forum underscored the social benefits associated with increased RE and EV adoption, including: lower urban emissions, lower urban noise pollution, and increased resilience in the energy and transportation sectors, contributing to a higher level of post-disaster recovery and business continuity. The forum featured discussions that identified a need for more technical training on EV maintenance and repair, first responder training on EVs, and an increase in institutional capacity at key government ministries related to energy and transportation. Job losses in the automotive sector, including at petrol stations, were identified as linked to increased adoption of EVs. However, it was agreed that training related to EV maintenance and repair and the installation of EVSE could open up additional job opportunities, including for persons who may have lost traditional automotive sector jobs.

Archetype 1
The Existing Utility Model

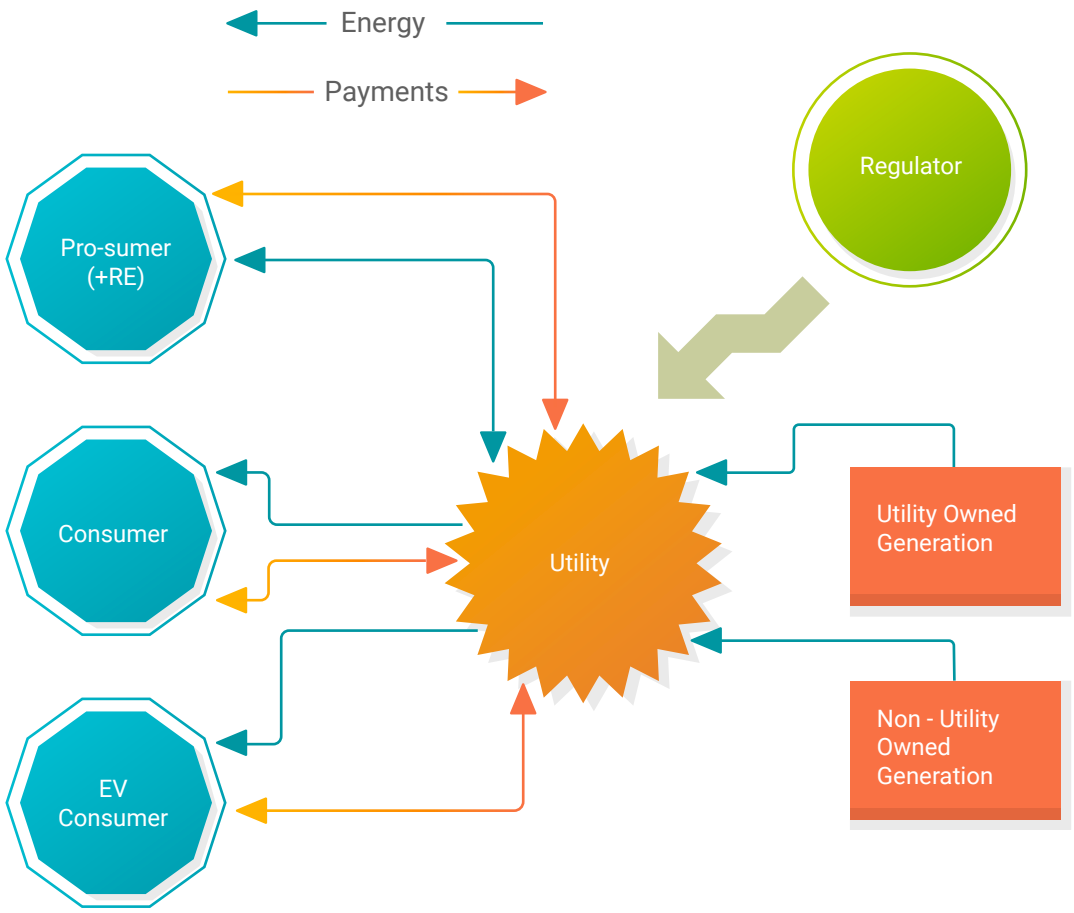

Figure 5: Archetype 1 - The Existing Utility Model

The existing barriers, opportunities, financing options, and social aspects, identified at the forum with respect to the existing electric utility model archetype, are provided below. This particular model was used as a baseline study.

Barriers	Opportunities	Social and Financing
Limited and inadequate financing options for domestic and commercial RE systems	First responder training for EV accidents	Second-life use for EV batteries Buried transmission and distribution cables
Absence of enabling national legislation for the interconnection of RE sources	Limited spatial diversification of electricity generating sources	Increased distributed energy generation
Limited and inadequate government financial and tax incentives for RE systems and EVs	Incorporating energy storage is costly	Move towards microgrid systems
Uncoordinated public information and awareness campaigns	Increased penetration of RE generation	Improved legislative and regulatory frameworks
Lack of institutional capacity in key public sector institutions	RE offers the potential for fixed and stability pricing structure when compared to volatile fossil fuel prices	Opportunities for employment in the emerging RE sector
Uncompetitive feed in tariff for RE	Decreasing storage prices Fast pace of RE technology development and cost reduction	Training programs focused on the RE sector
Outdated or non-existent building codes that accommodate RE technologies and electric vehicle supply equipment (EVSE)	Diversification of energy resources	Environmental benefits from both RE and EV adoption
Higher upfront purchase costs for EVs	Technical training on EV systems, EV charging systems, and EV technologies	Stable energy prices
Underdeveloped and non-existent public charging infrastructure	Opportunities for new businesses and for economic growth, especially in the eco-tourism sector	Non-technical losses based on social issues
Public concerns over EV battery life	Decreased vehicle maintenance and operation costs of EVs when compared to ICE vehicles	Less noise pollution
Lack of technical studies on the impact of EV charging on the electricity grid	Investing in a technology that is global and long-term	Lower emissions in urban areas
Concerns over the availability of trained and certified EV automotive technicians	Increased resilience in the transportation sector	Potential job losses in the traditional internal combustion engine (ICE) sector and the liquid fuelling stations
		Concern over prolonged power outage after a storm
		Unacceptable levels of post-disaster business continuity

Archetype 2 - The Smart Utility

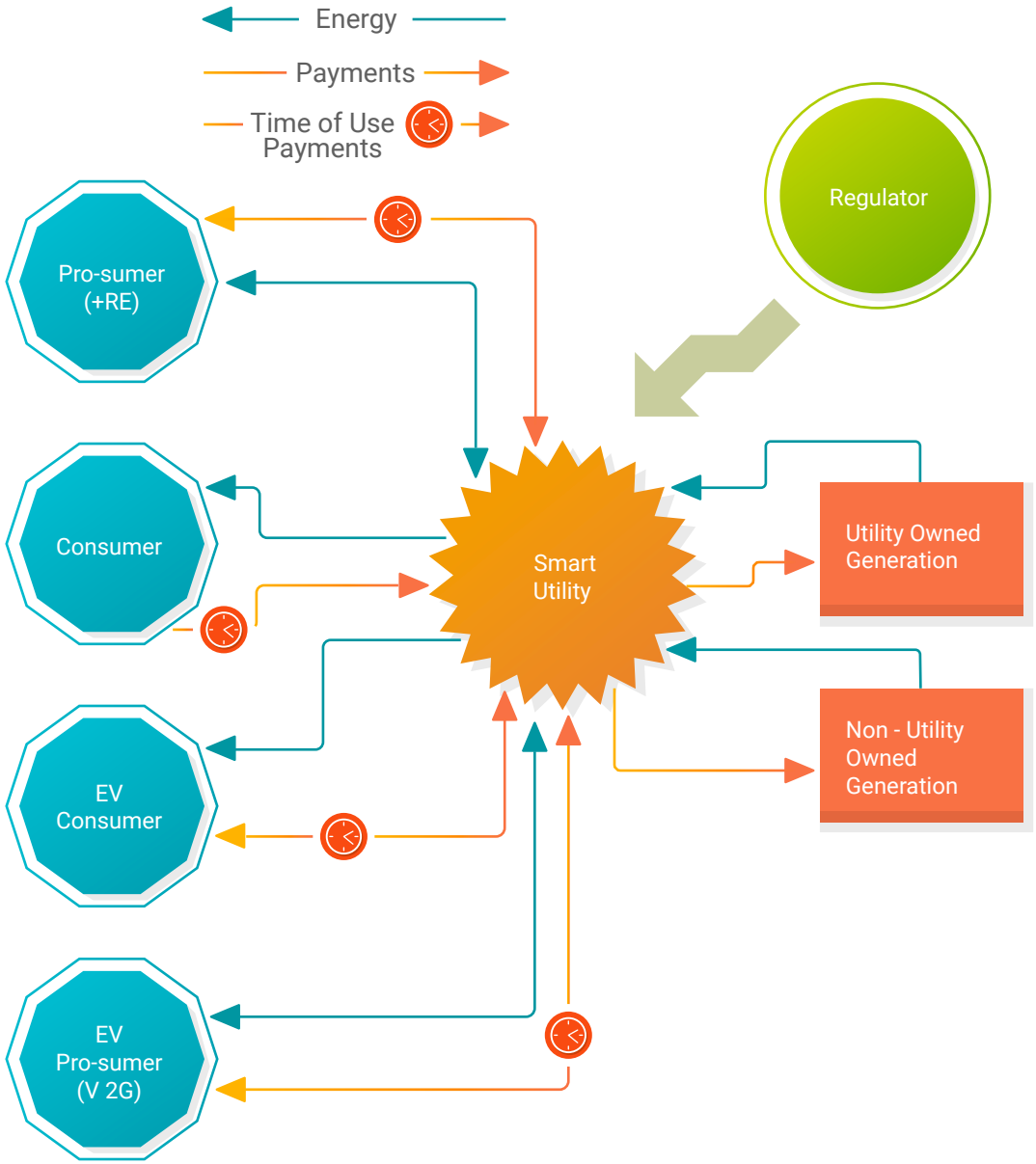

Figure 6: Archetype 2 - The Smart Utility

In this archetype, the utility implements a time-of-use (ToU) tariff for all its customers. Under an existing feed-in tariff scheme for domestic and commercial RE systems, EV owners have the option of participating in a vehicle-to-grid (V2G) program in which the utility uses the available battery storage in the EV for ancillary grid services. This archetype is characterized by the complete utilization of the existing advanced metering infrastructure (AMI) technology and incorporates customer data collection and analysis. Variations of the Smart Utility archetype can be found in the US cities of Chicago and Los Angeles and in the city of Victoria in Australia.

Policy

The forum revealed that a number of power utilities in the region would be unable to adopt the Smart Utility archetype because of outdated legislation and policies. It was highlighted that most utilities in the region do not currently have a time-of-use (ToU) tariff and in some cases implementing a ToU tariff would require legislative change. Significant legislative challenges are also associated with feeding electricity into the grid from the traction batteries of an EV and the adoption of an associated tariff structure for the V2G program.

Financing and Market Development

It was also revealed that the Smart Utility archetype would require significant financial investment for the large-scale deployment of AMI technology and its associated ancillary technologies, which include data collection and storage and big data management. There is also the additional cost of a bi-directional V2G-enabled charger for the EV to participate in a V2G program. The archetype is also potentially vulnerable to cyber-attacks and would require additional financial investments to mitigate or alleviate those threats. The forum identified investor-owned utilities in the region to be best suited for this archetype as they would have access to financing to adopt the model. This archetype has the potential to increase market growth for the power utility by encouraging the adoption of distributed RE and EVs through a ToU and V2G tariff arrangement. The archetype also allows the utility to operate as an energy service company (ESCO) and utilize tax and other incentives.

Technology and Implementation

Adoption of the Smart Utility archetype would facilitate better decision-making and planning through real-time monitoring and evaluation by the AMI technology. It would also cut costs and increase efficiency because field technicians would no longer be needed to collect data. With distributed RE generation and energy storage in the form of the EV traction batteries now prevalent, energy resilience would increase with increased adoption of RE generation and EVs that the archetype facilitates. The archetype also has the potential to handle the grid effects associated with the intermittency of a large penetration of RE generation as the utility can now coordinate EV charging based on the availability of RE generation. This is important, given the ambitious RE targets that most countries of the region have set in their Nationally Determined Contributions (NDCs). The forum flagged the possibility of stranded generation and other utility assets that may occur if this archetype is adopted.

Social Aspects

The forum revealed the training gaps that exist within regional utilities associated with the use and implementation of AMI technology. The archetype also requires the support of multiple stakeholders, including government ministries, the utility, the regulator, and the utility customers. It was noted that getting these stakeholders to reach agreement in a timely manner could prove to be challenging. The forum highlighted the need for public awareness campaigns to promote energy efficiency and conservation best practices among the utility customers and facilitate better utilization of the archetype from the user perspective and, ultimately, from the utility perspective. The forum highlighted the concern that EV users would have regarding battery degradation associated with participating in the V2G program and the potentially inadequate monetary benefits associated with the V2G tariff that may not fully compensate the EV users for any accelerated battery degradation.

Presented below are the barriers, opportunities, financing options, and social aspects that the forum participants identified for the smart utility archetype.

Barriers	Opportunities	Social and Financing
Intermittency associated with a high penetration of RE	Increased resilience when combined with energy storage	Reduced duties on EVs and their associated electric vehicle supply equipment (EVSE)
Modifying the infrastructure assets and investing in AMI technology to accommodate the high RE penetration	The u se of abundant, indigenous, and varied RE sources	EV and RE systems Tax Incentives
RE demand/market uncertainty	Investing in new and emerging technologies that allow for greater energy security	Carbon credits
Convincing the utility, the customer, regulator, and other stakeholders that this	Modular deployment of RE assist with grid management issues	Disincentives to discourage the purchase of less efficient and more polluting vehicles
Archetype is the model to adopt	Monitoring and evaluation through the use of AMI technologies allows for better decision-making and planning	A Smart Utility requires smart users. An effective education campaign should be designed, to educate consumers and maximises the efficacy of the archetype
Reservations amongst regional utilities about moving into this new space	Real-time and immediate information available as opposed to technicians going to the field to collect data	Environmental and social concerns such as reducing GHG emissions and improving quality of life
Outdated legislation and regulations	Utilities can operate as energy service companies (ESCO) and utilize tax and other incentives	Job losses during transition phase to fully electric
High capital and investment costs associated with AMI technology, data collection, and storage and analysis of large data sets	Market growth for the Utility	Stranded utility assets
Upfront cost of the EV and the associated bi-directional (V2G) charger	Increased revenue for electric utilities	Disposal of used lithium batteries
Cost associated with data security infrastructure and management	Green Climate Fund and other international funding agencies focused on adaptation, mitigation, and resilience	Improved quality of life
Archetype vulnerable to cyber-attacks	Regional investor-owned utilities are capable of providing their own financing	More predictability and secure energy supply before and after disasters
Energy security achieved by partially decoupling from fossils		Improved safety of people and property

Archetype 3 - The EV White Label

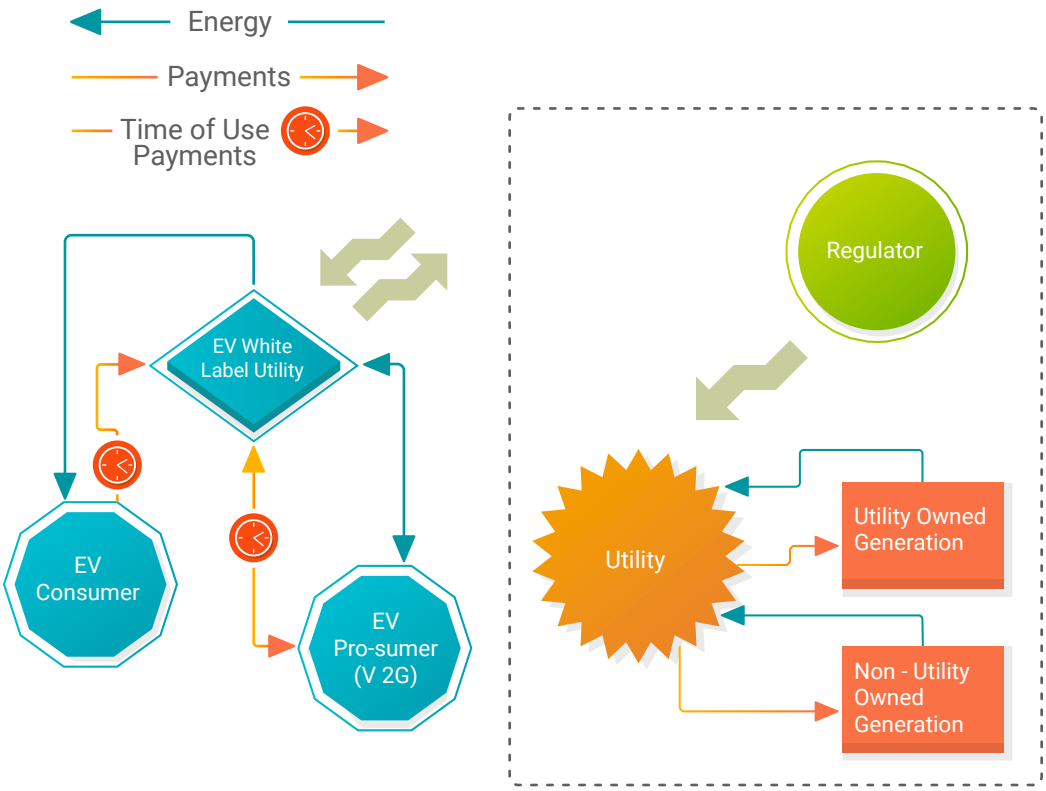

Figure 7 Archetype 3 - The EV white label

Policy

Regarding the Smart Utility archetype, reference was made to legislative and regulatory challenges related to adoption of the model in certain countries of the region – challenges centered on tariffs associated with time of use and the feeding back of electricity into the grid from RE sources and from the EV traction batteries. The challenges also exist in the EV White Label archetype in addition to the EV dealer being involved in selling electricity. The addition of the EV dealer to the existing list of stakeholders involved in this archetype, including the regulator/government ministry, the utility, and the utility and EV customers, calls for a unique governance and management framework to manage the complexity of the archetype ecosystem.

Financing and Market Development

At the forum, it was also noted that the EV White Label archetype may be difficult to implement in the smaller countries of the region, primarily because the smaller countries do not all have authorized car dealers or the authorized car dealers may not have access to the financing required to adopt this model. However, this is not the case for the larger territories of Trinidad and Tobago and Jamaica. Business conglomerates in Trinidad and Tobago and Jamaica have subsidiaries involved in automotive sales and repairs, which include authorized car dealerships, supermarket chains, commercial banks, and industrial equipment sale and services. These conglomerates have access to the financing and internal support and resources required to adopt the EV White Label archetype. The adoption of the archetype by the conglomerates would boost business and stimulate market growth in the subsidiaries, given the natural synergies between subsidiaries and increased adoption of EVs. An example of these synergies is the fact that the supermarket chain business can provide the public charging infrastructure for EV customers purchasing EVs from the automotive business subsidiary.

Technology and Implementation

There is some concern that the V2G program would not be optimized to provide the benefits of the ancillary services for the power utility, since the program is administered by the EV dealer. Depending on the agreement made between the EV dealer and the utility company, a separate electricity meter may have to be provided by the EV dealer to administer the electricity tariff and V2G program. This adds to the complexity of the model, with an EV customer now having to deal with two separate electricity tariffs and perhaps being unable to reap the aggregate benefits of one electricity tariff that may also include RE generation.

Social Aspects

This archetype would address EV owners' concern about accelerated battery degradation that may be associated with participating in a V2G program administered by the EV dealer with the approval of the EV manufacturer, and battery warranty and repair and replacement services can then be offered. This would encourage more EV owners to participate in the V2G program and reap the additional financial benefits associated with the program. Greater V2G participation would also improve the overall resilience of the utility power system. The forum highlighted that the archetype requires a long-term contract between the EV dealer and the EV user for the electricity tariff. This can be a concern for private EV users preferring the option of owning their vehicle for a short period of time.

The barriers, opportunities, financing options, and social aspects that the forum participants identified for the EV White Label archetype are detailed below.

Barriers	Opportunities	Social and Financing
Outdated legislation and regulations not suited for archetype	Economic growth resulting in job creation	Tax incentives from the government
Concerns over the sustainability of the model as a business	Increased rate of transition to EVs	Time-of-use tariff
Managing the complexity of the contractual arrangement	Potential for greater public sector growth through state-owned utilities Potential for better load and demand planning	Re-training and increased job opportunities associated with increased EV uptake
Additional complexity when integrating with charging network	Increased resilience of the utility grid	Greater EV user confidence to foster volunteering for the V2G/V2H program as the EV manufacturer is involved
Long-term contract required	Increased availability of mobile sources of power through the V2G/V2H program in times of power outages	
	EVs can work with microgrid	

Archetype 4 - The Mobility Utility

In this archetype, private and commercial EV users no longer purchase an EV but lease it from the power utility along with a special electricity tariff. In this Archetype, the V2G/V2H services are fully utilized, given that the power utility owns the EV and its battery.

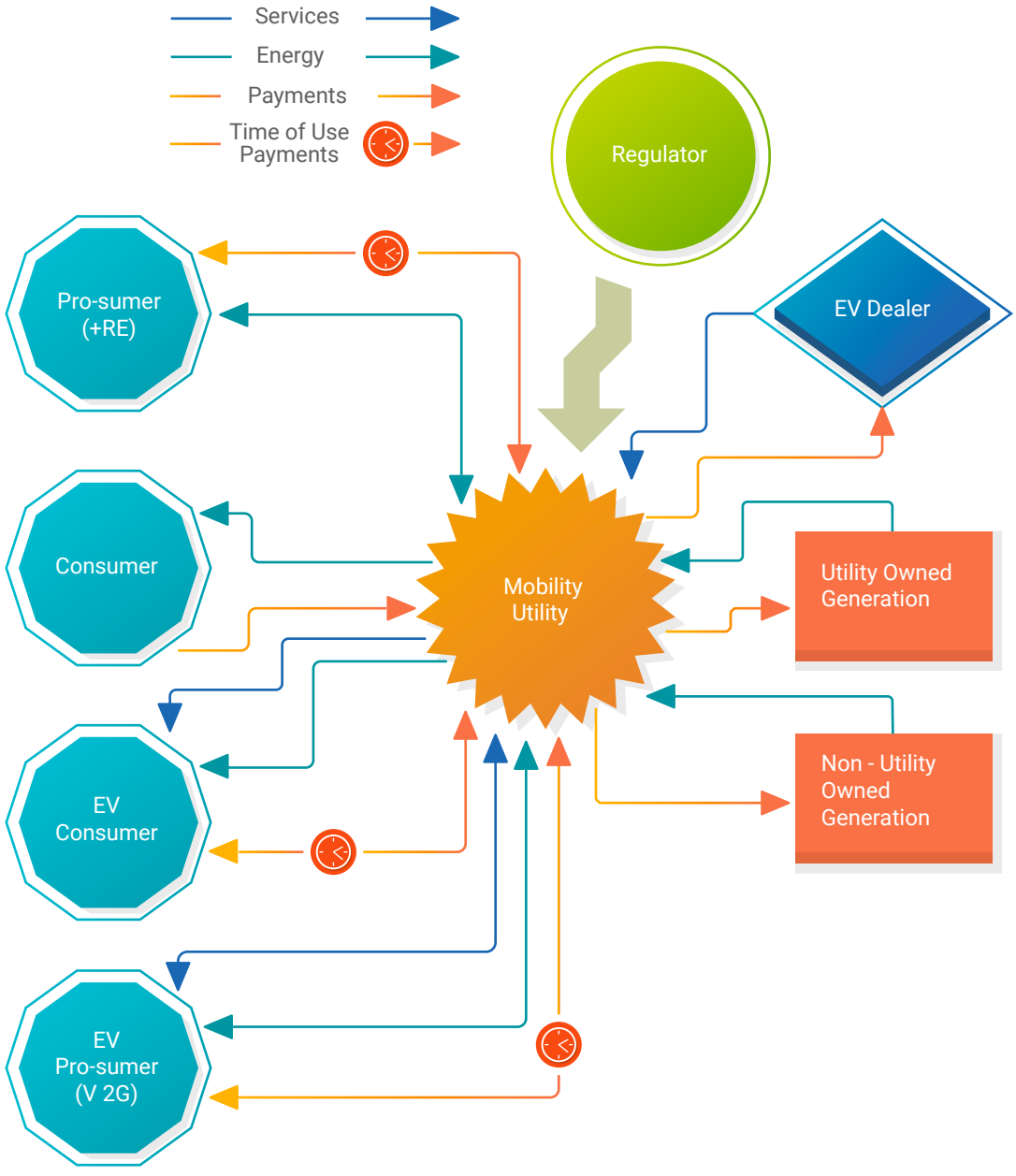

Figure 8. Archetype 4 - The Mobility Utility

Policy

One of the regulatory challenges associated with the Mobility Utility archetype revolves around the regulator/government ministry granting the utility approval to engage in offering an automotive leasing program and a special electricity tariff for participating in the EV leasing program. Regulatory challenges still exist for the feeding in of electricity from the V2G program and a time-of-use program, if it is non-existent; but there is no RE feed-in tariff challenge if an RE feed-in tariff is already in existence. The governance framework is not as complex as in the case of the EV White Label archetype, as the utility has now adopted the role of an EV dealer and is now central in the archetype.

Financing and Market Development

The forum identified this archetype as being better suited to the investor-owned utilities in the region rather than to the fully state-owned utilities. The investor-owned utilities would have access to the financing required to implement the archetype and are faster to respond to market opportunities than the fully state-owned utilities.

The utility adopting the archetype would provide the financing to purchase the EVs and then lease them to private and commercial entities. This eliminates a major EV adoption-related barrier – the higher upfront cost of EVs compared to ICE vehicles. The archetype has the potential to make EV ownership more affordable and more accessible for businesses and private users; and to contribute to EV market growth.

Maintenance and repair of the leased EVs can be carried out by the EV dealer or manufacturer from which the utility purchases the EV; otherwise, the utility can contract the services of trained and qualified local automotive service and repair businesses to carry out the service and maintenance. Utilities in the region regularly engage local businesses to provide services and equipment and are expected to be able to utilize local business to service and repair the EVs. If it is economically viable, the utility has the option of investing in the training of local automotive technicians for EV systems to create a pool of locally-trained and certified persons to service and maintain the leased EVs. The availability of trained and certified local automotive technicians would contribute to the market growth of EVs. A similar approach could be taken with respect to the installation of EVSE. The installation of EVSE is already closely related to the utility's core technical competency and the utility can choose to engage its own staff or third-party businesses to install the EVSE. In this archetype, the utility can greatly benefit from building its own public charging infrastructure to support the leased EV fleet, and has access to the funding and technical competencies needed to do so.

Technology and Implementation

The complexity associated with multiple electricity tariffs in the EV White Label archetype is eliminated and one aggregate electricity tariff can be offered to the EV users, incorporating the associated benefits of RE generation. This is particularly important for businesses with a low carbon goal as they can now benefit from the synergy of installing RE sources and adopting an EV fleet. The bundling of the cost of leasing a vehicle and its fuel in the form of electricity would be appealing to businesses and fleet operators because this strategy can reduce operating costs while making the logistics associated with operating the business less complex.

The utility has full control over the V2G program and can optimize the program to provide ancillary services. Technical challenges associated with a large number of EVs charging on the grid at the same time and a high penetration of variable RE are managed directly by the utility, which can then adopt mitigation strategies that include smart meters and/or time-of-use tariffs.

Social Aspects

The forum participants stressed that the car leasing model would be unpopular with private vehicle owners in the region, where vehicle ownership is a status symbol and is viewed as an accomplishment, hence making it difficult for private users to accept the leasing model. It was reiterated that while jobs would be lost from the traditional automotive sector, including at petrol filling stations, new EV adoption-related job opportunities could offset those job losses.

The barriers, opportunities, financing options, and social aspects identified at the forum for the Mobility Utility archetype are detailed below.

Barriers	Opportunities	Social and Financing
Inappropriate legislation and regulations for archetype	Dealing with the scenario of a large-scale adoption of EVs and most EV users charging up when the power returns after a storm or other prolonged power outage	Reduction of GHG emissions
Most jurisdictions do not have microgrids	Job creation, especially in the EV market	Opportunity for new partnership for utilities
Job losses in the traditional automotive sector	Opportunity for introducing more technical skills in schools	Greater opportunity for V2G as distributed generation backup
Difficulty in adopting the leasing mindset	Smart charging enables better load and demand management	Special financing options for small businesses, related to EVs and RE systems
Inadequate EV systems training for auto mechanics	Ability to define new regulations	Link to climate change to attract donor funding
Concerns over the disposal of degraded EV batteries	Economies of scale for vehicle maintenance	GCF/GGGI partnership
Limited and inadequate public charging infrastructure	Reduction of fossil fuel imports	Change in ownership paradigm
Concerns over the disposal of existing ICE vehicles that were replaced by EVs		Change to sustainable mindset

Archetype model for the region

The existing level of both RE and EV adoption and the accompanying policy and financial support varies among nations in the region. This is reflected in the list of barriers and opportunities from the baseline case. Additionally, it should be highlighted that RE adoption regionally is more advanced and more mature when compared to EV adoption.

Each archetype entails unique challenges and benefits when applied to the region. The forum attendees favored the Mobility Utility model. A number of utilities in the region are investor-owned, with access to the financing required to adopt the Mobility Utility model. The leasing of the EVs would greatly appeal to corporate and fleet customers especially when a bundled EV charging package is offered. This may not necessarily be the case for private vehicle owners, who view ownership of a car as an accomplishment and a status symbol. It was highlighted that this mindset would change as more cooperate and fleet customers participate in the leasing program. The Mobility Utility would be more difficult to implement for contexts in which the power utility is majority state-owned, considering that state enterprises in the region are generally slower to adopt or react to new business models and technologies. The opportunity for the Mobility Utility to encourage growth in the Micro, Small, and Medium Enterprise (MSME) sector in the region was also highlighted. Utilities have considerable experience engaging local contractors and service providers. Local contractors could now be used to install and maintain the electric vehicle supply equipment (EVSE) and maintain and service the EVs.

The EV White Label model would be difficult to implement regionally because, in most of the smaller islands, authorized vehicle dealers are non-existent or lack access to the financing opportunities required to implement the model. The EV White Label archetype is more relevant for the larger countries of the region, most notably Trinidad and Tobago and Jamaica, where some of the authorized automobile dealers are subsidiaries of larger conglomerates with other subsidiaries that include supermarket chains and commercial banks. These conglomerates have the potential to self-finance the EV White Label model.

Antigua and Barbuda - A Case Study for Energy Resilience

Hurricane Irma, the fifth strongest hurricane ever recorded in the Atlantic, hit the twin-island state of Antigua and Barbuda in September 2017. The cost of the damages and losses suffered was estimated at US$222 million, or 9% of GPD.(3) On the island of Barbuda, the electricity infrastructure was totally destroyed along with 95% of houses.

Land ownership in Barbuda is communal. Land is leased to individuals by the Barbuda Council, a local authority that manages the internal affairs of the island of Barbuda. The leasing arrangement for land on the island makes it difficult to use the land as collateral for home construction loans from local banks. This leads people to construct buildings that are cheaper and not in accordance with any building code best practice. The poor quality of building construction was identified as a contributing factor in over 95% of houses in Barbuda being devastated by hurricane Irma.

The Government of Antigua and Barbuda embarked on a rebuilding and reconstruction campaign after the 2017 hurricane season and has included a number of building and planning strategies that will increase the islands' overall resilience – especially for the power sector. These include:

- Power plants that are to be rebuilt will be relocated inland and not close to the coast as was the case.
- The development of a utility scale solar PV farm at a cost of US$4.5m.
- A 100% Green Vision policy for Barbuda. Electricity distribution and transmission cables are installed underground in certain locations.
- This includes the New Highway projects.
- An aggressive program of vegetation management around overhead distribution lines by the local power utility.
- More resilient grade 2 electricity poles are now used.
- The standard drilling depth that is required for electricity poles (10% the length of the pole + 2 feet depth) will be strictly adhered to.
- An increase in the number of bucket trucks in the power utility fleet.
- A larger inventory of distribution and transmission replacement infrastructure and equipment will be maintained.
- The installation of 10MW of solar PV generation distributed throughout the islands.
- Participation in a World Bank project focused on building resilience to climate change in the electricity sector.
- Solar and wind generation will be included in emergency shelters and police stations.
- A closer working relationship between the utility and the National Office of Disaster Services. An integrated committee has been formed and meets regularly, but more frequently before the start of the hurricane season.
- An annual electricity pole competition established by the utility to test and challenge the skills of the utility's linesmen.

Barbados - A case study of Electric Vehicles

Barbados boasts the distinction of having the largest market share of electric vehicles in the region. The total number of electric vehicles in Barbados exceeds 400. With 131,680 privately-registered vehicles, this represents a Battery Electric Vehicle (BEV) market share of 0.3%. In the larger BEV markets of the US and Europe, the equivalent market share was around 0.9% and 0.7% respectively in 2018.(10) The high market share of BEVs in Barbados can be attributed to a consistently high cost of liquid transportation fuel, an entrepreneurial and motivated private company involved in BEV sales, charging infrastructure and RE, and a progressive power utility company.

Barbados has had a remarkable experience with the secondary use of BEV traction batteries after their useful life in BEVs. With the assistance of grant funding, a battery replacement workshop was established and the technical capacity to remove and reuse BEV batteries was established locally. Used BEV batteries were initially utilized to replace golf cart batteries, but there are unique applications for used BEV batteries in the region, including for:

- Stationary power supply for carnival and carnival-related events, where they would replace the highly polluting diesel generators that are normally used at these events
- Flood lighting at construction sites and at events
- Agriculture applications, especially water pumps
- Off-grid street lighting when coupled with solar PV

The Sargassum Seaweed and Sahara Dust Threat

The forum discussions and presentations mostly revolved around strengthening resilience to the effects of tropical cyclones. However, discussions also highlighted the devastating effects that the sargassum seaweed and the Sahara dust have had on the region.

Sargassum Seaweed

Massive pockets of sargassum seaweed were first observed in the region in 2011 and have since been occurring annually with increased volumes. The quantity of sargassum peaked in 2018 with Barbados treating the event as a national emergency.(11) The situation has not improved, with satellite imagery and forecast for 2019 predicting even larger volumes than those of 2018.(12)

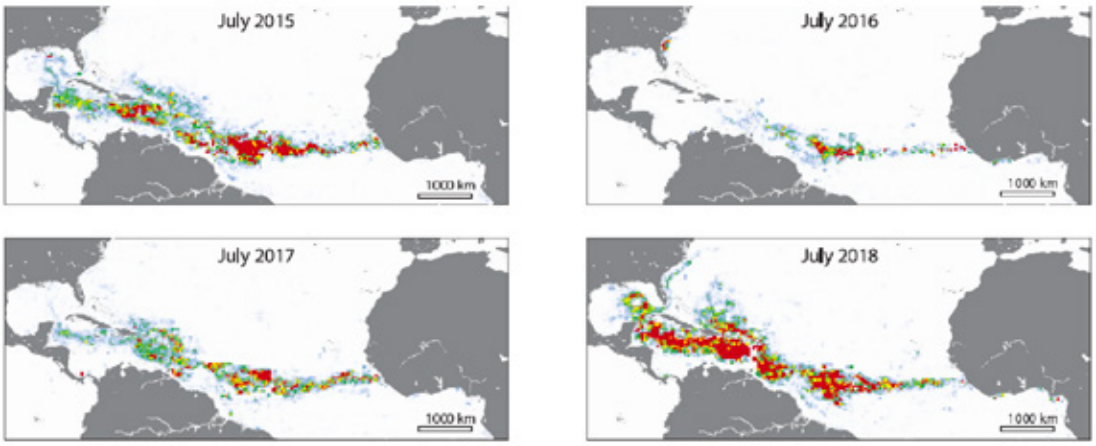

Figure 9. Sargassum distribution in the Gulf of Mexico and the Atlantic Ocean. Source: Wang et al. Science 365, 83-87 (2019)

Sargassum has been having a crippling effect on the region's tourism and fisheries industries and is affecting marine life, including sea turtles, dolphins, seagrass, and coral. The dwindling amounts of seagrass have increased beach erosion. The forum emphasized the need for the region to incorporate resilience planning and preparation to combat the now annual, escalating sargassum threat. Sargassum has also been affecting the operation and maintenance of water desalination plants in Antigua. Desalination accounts for 60% of water sourced in Antigua and the government is committed towards using desalination to provide 100% of the water needs of both Antigua and Barbuda. The effects of sargassum seaweed have contributed to the rising cost of supplying water from desalination, and must now be factored into the country's water desalination policy.

Sahara Dust

The arid regions of North Africa are estimated to emit about 800 Tg yr−1 of soil dust each year, 70% of the global total and six times more than the next largest source, Asia. (13) The effects of Sahara dust are most prominent in the Caribbean Basin. Figure 10 presents the mean dust concentration of Sahara dust in Barbados as compared to the levels in Miami.

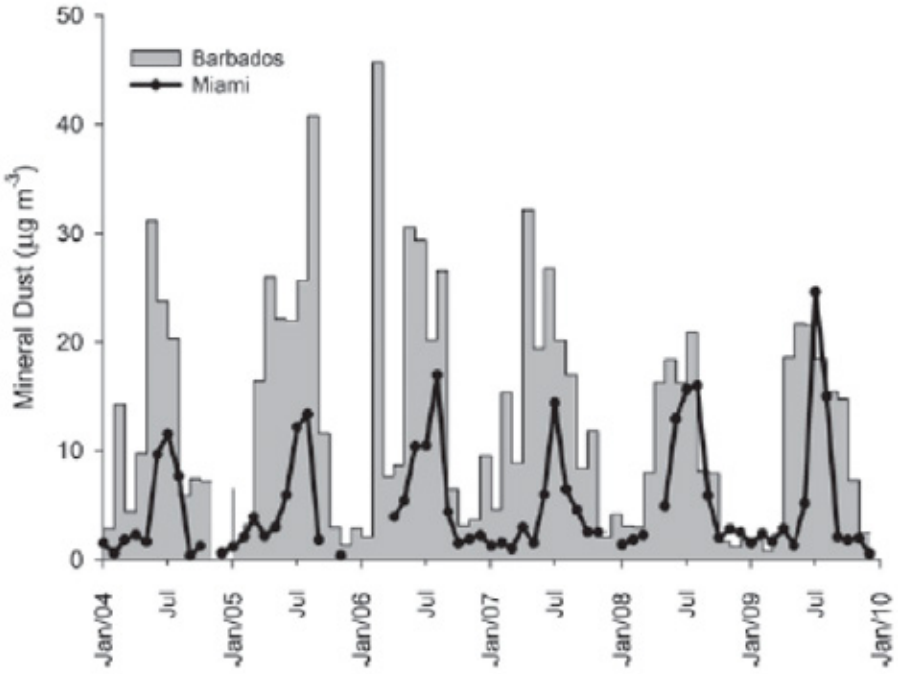

Figure 10. Monthly mean dust concentration at Barbados and Miami, 2004-2009.
Source: Prospero et al.

It is well known in the region that the annual Sahara dust contributes to a number of health-related issues, including respiratory and cardiovascular-related diseases. The Sahara dust also provides favorable conditions for localized severe showers and storms similar to the severe flooding experienced in Trinidad in July 2018. It was also highlighted at the forum that the Sahara dust has been known to cause a reduction in the output of both utility and distributed solar PV installations. Sahara dust also contributes to the maintenance cost of PV installation and wind turbines as well. The forum revealed as well that improved resilience planning and preparation for the harmful effects of the Sahara dust is important for the general health of persons and for effective and efficient operation of renewable energy sources.

Interconnection and Resilience

The discussion also covered the interconnection of the member states of the Organisation of Eastern Caribbean States (OECS) via submarine cable for the purpose of importing and exporting electricity – a topic that drew considerable interest at the forum and at other past events. (14) The OECS member states have considerable geothermal resources, with geothermal projects at different stages of development.(15) The potential geothermal resources of most member states exceed their current peak demand (Figure 11). This excess geothermal capacity and its inherent dispatchable nature have driven the concept of an interconnection involving submarine power cable connecting member states. Distances between member states range from approximately 40km to 60km, except for the distance between St Vincent and Grenada (Figure 12). It is important to note that these distances are estimated values and represent the shortest distances in most cases and do not consider the bathymetry, geography, onshore transmission line locations, nor environmental aspects associated with the placement of submarine cables.

Interconnecting the OECS member states via submarine cables would significantly enhance the resilience of their individual energy systems. Such interconnection would provide:

- A higher efficiency, as power could be sourced from locations where it is cheaper to generate.
- A shared generation reserve capacity, which reduces the localized reserve requirements and decreases fuel use and its associated greenhouse gas (GHG) emissions.
- A larger system that is more robust and can easily accommodate a large market share of RE.
- Enhanced energy security and resilience for the territories participating in the interconnection. Obtaining energy from the network and the diversity of the energy sources within the network adds to the resilience and security of the energy supply.
- Increased competition, which leads to innovation and competitive pricing.

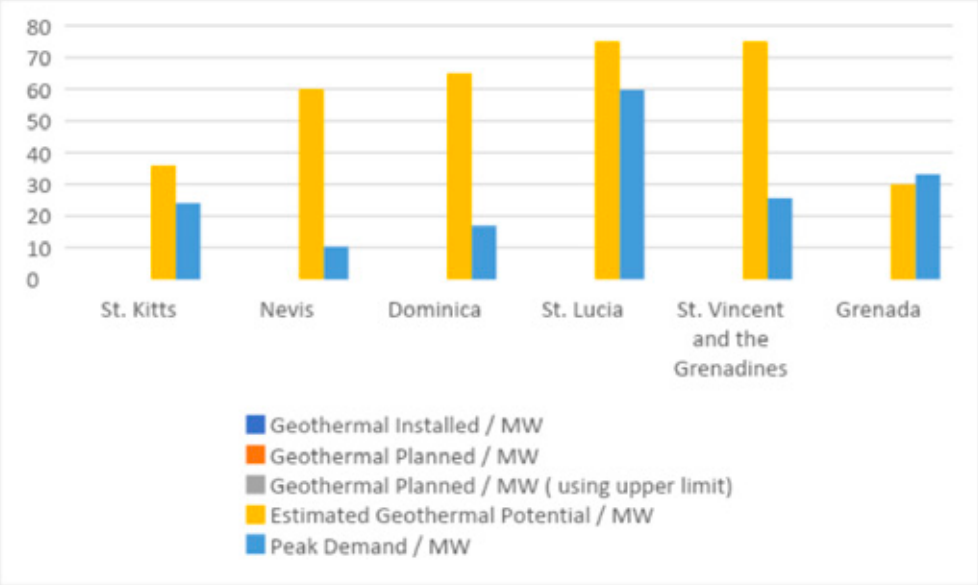

Figure 11 Geothermal Resource and Peak Demand (MW) for selected OECS countries. Source: Author

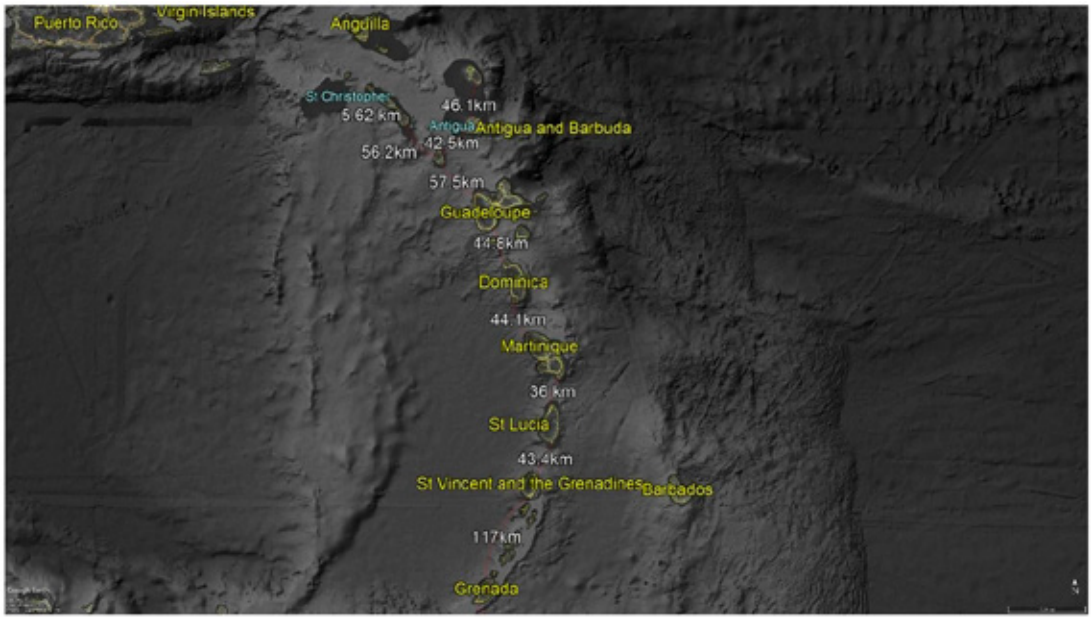

Figure 12. Distances between OECS member states. Source: Google Earth

A Regional Integrated Energy Market

Forum discussions on the interconnection of geothermal resources among OECS member states evolved into a discussion focused on a Regional Integrated Energy Market (RIEM). The proposed RIEM would include the OECS member states and extend to all CARICOM member states. The RIEM would offer trading in energy commodities, energy services, and energy-related technologies. The RIEM would be designed using an open market framework that would allow for fair and transparent trading and competition, and would foster arrangements that are inclusive of all the members. Moreover, the RIEM would discourage bilateral energy-related agreements between individual member states within the RIEM.

Hydrogen, not electricity, was considered to be the most effective energy carrier for the proposed RIEM, primarily due to the challenges and high costs associated with storing and distributing electricity between islands. Hydrogen distribution can be effected using steel pipes similar to those used for natural gas distribution. Hydrogen would be generated by RIEM members that have excess generating capacity in the form of geothermal or other renewable sources and also from natural gas-based generation, as is the case with Trinidad and Tobago. The hydrogen would be piped within the interconnected network and distributed and sold where there is the demand for energy. The hydrogen can be burnt for power generation or be used for transportation, in the form of fuel cells for electric vehicles.

The RIEM design and implementation would require: (16)

- Political agreement among all prospective RIEM states
- Greater regional cooperation and governance
- The creation of a region-wide common regulatory framework and body designed to regulate the RIEM
- Investment in hydrogen production facilities and submarine hydrogen distribution pipes
- Modifications to natural gas generators to accommodate hydrogen as the fuel
- Replacement of existing diesel generation sets with generators that use hydrogen
- An agreement between RIEM members and other regional and international stakeholders for the financing and revenue-sharing arrangement for the interconnection infrastructure of the RIEM to allow for trading in energy commodities
- Investment in onshore hydrogen distribution network and infrastructure to allow for fueling of hydrogen fuel cells for ground transportation.

The RIEM could be designed and developed using the Central American Electrical Interconnection System (SIEPAC) project as a template. Commissioned in 2013, the SIEPAC is an initiative to create an integrated regional electricity market among six Central American countries: Guatemala, El Salvador, Honduras, Costa Rica, Nicaragua, and Panama. Central America being similar to the Caribbean with its abundant geothermal resource, the SIEPAC was developed to fully utilize the hydropower resource of the six Central American countries by achieving economies of scale, made possible by a multinational market.

The electricity market structure among SIEPAC member countries is as varied as it is in the Caribbean region and the SIEPAC has been able to introduce efficiency gains through economic dispatch, shared reserve margins, and exploitation of complementarities in demand and supply. (17) The success of the SIEPAC affords the Caribbean region the opportunity to exchange knowledge and experiences with the Central American region in the development of the RIEM.

Micro, Small, and Medium Enterprises (MSMEs) and Resilience

Micro, Small, and Medium Enterprises (MSMEs) are critical to the prosperity, productivity, and sustainability of the region. The MSME sector in the region:

- Accounts for more than 60% of GDP in some CARICOM member states;
- Creates about 45% of jobs in CARICOM member states;
- Provides transportation and other tour guide services for tourists and commuters;
- Plays a leading role in the production and marketing of agricultural produce and in construction, equipment repairs and maintenance, technical services, food, and the retail trade; and
- Dominates in some manufacturing subsectors, such as wood products, garments and sewn goods, and handicraft items.(18)

When presented with a list of 15 possible obstacles, MSMEs in developing countries most frequently cited electricity and access to finance as the top two obstacles. (Figure 13)

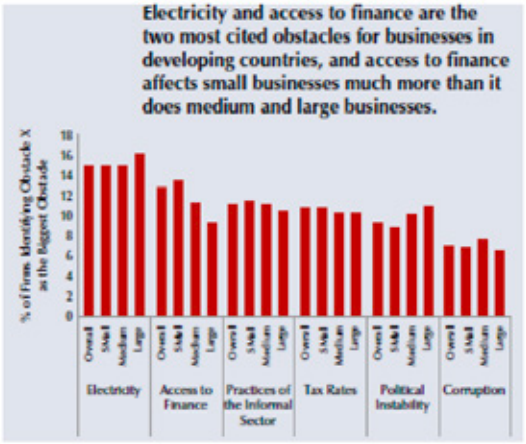

Figure 13 Source: World Bank/IFC 2010

Other challenges faced by regional MSMEs, highlighted during the forum, include:

- The absence of easily accessible mentorship programs for MSMEs
- Unavailability of technical training to prepare MSMEs to become investor-ready
- The high cost of office space
- The high lending fees charged by commercial banks and other lending institutions

To address the most significant challenge facing MSMEs, i.e., high electricity costs, it was proposed that MSMEs invest in RE, specifically solar energy. The distributed solar installation of MSMEs can then be interconnected to Community Energy Storage systems. This would be able to capture excess solar generation during the daytime and reduce the electricity cost and also significantly contribute to post-disaster business continuity of MSMEs by enhancing their energy resilience. Regional and local financial institutions along with regional governments should make special financing instruments available for funding RE systems for MSMEs.

At the forum it was highlighted that MSMEs should invest in solar PV for electricity production and be connected to a community microgrid. While addressing their most significant challenge, the high cost of electricity, this would also have the potential to improve post-disaster business continuity. Prolonged power outages can follow in the aftermath of a tropical cyclone, due to damaged or destroyed overhead power distribution and transmission lines. MSMEs with solar PV, designed and installed to withstand category 5 hurricanes, can have power available almost immediately after the passage of the storm and do not have to wait until the larger utility grid is restored. This can be most beneficial to MSMEs with perishable goods including agricultural produce and fish. The forum pinpointed the need for regional and local financial institutions along with governments to make special financing instruments available for funding RE and microgrid systems for MSMEs.

Small Business Development Centers (SBDC)

The Caribbean SBDC project seeks to provide MSMEs in the CARICOM region with improved access to sustainable and effective assistance services, based on the US Small Business Development Center (SBDC) model. The SBDC model focuses on enhancing cooperation among public and private sector entities and academia to maximize resources, synergies, and complementarities to benefit a range of actors in the MSME sector. Further, the program seeks to promote and sustain private sector development through an improved administrative and policy environment, including support to MSMEs that will lead to increased employment, economic inclusion, and reduced poverty.(19)

The forum highlighted the need for the Caribbean SBDC to enhance its focus on post-disaster business continuity by increasing the resilience of the energy supply of MSMEs. This can be accomplished by including resilience in the Caribbean SBDC's six priority areas. Policies to increase resilience could be included in the adjustment of the regulatory framework to address the needs of MSMEs, which can be made aware of the importance of energy resilience to their businesses and an introductory training on commercial RE systems delivered. Public /private partnerships can be developed to provide access to special financing for MSMEs to make their business more resilient.

The forum also highlighted that the Caribbean SBDC should provide special technical assistance to MSMEs, focusing on the regional sustainable energy market which includes both the technology and service sectors. By improving the efficiency and effectiveness of regional sustainable energy, MSMEs will increase RE adoption and contribute towards energy resilience.

Conclusion

Resilience planning and preparation are essential in mitigating the annual existential threat the region faces from hurricanes. Post-disaster analyses of the 2017 hurricane season reveal that the energy and transportation sectors are significantly impacted and require the most investment to fully recover. Resilience in the power generation sector can be achieved by investing in renewable energy (RE) generation. Including RE generation in the energy mix diversifies the energy sources, contributing to energy security and resilience. RE generation can also provide spatial diversity of the power generation sources while also helping to make the energy system more resilient. Incorporating RE generation and community microgrids can allow communities to remain powered even when the larger power grid is down.

The use of electric vehicles (EVs) in transportation not only reduces pollution in highly populated urban areas but also reduces the overall end use of energy in transportation. This is because EVs are up to three times more efficient than internal combustion engine (ICE) vehicles. EVs can be charged from indigenous RE sources in the aftermath of a disaster, and this can be advantageous as there could be an interruption in the importation of liquid transportation fuel. The synergy when RE generation and EVs are combined not only adds resilience to both the energy and transportation sectors and reduces emissions but also has the added economic benefit of reducing the importation of fuels used for power generation and transportation.

The power utility is the interface where transportation in the form of EVs and energy in the form of RE converge. Adopting an innovative utility model that harnesses the natural synergy of combining RE and EVs would not only improve resilience but also encourage local economic growth. The Mobility Utility model, wherein the utility finances the purchase of EVs and then leases them to customers as part of a bundled package that includes a special electric rate, was proposed at the forum to be the most pragmatic and relevant model for the region.

During the EV transition there will undoubtedly be job losses in the traditional automotive sector, especially in areas such as those associated with repair and maintenance of ICE vehicles as well as at petrol filling stations. It is imperative that training in the maintenance and repair of EVs and in the installation of electric vehicle supply equipment (EVSE) be delivered in parallel with the EV transition. Furthermore, jobs created in these emerging areas can provide additional job opportunities including for those displaced by the EV transition.

The establishment of a Regional Integrated Energy Market (RIEM) can increase energy security and resilience, increase energy efficiency, reduce the cost of electricity, reduce emissions, and stimulate economic growth. The Central American Electrical Interconnection System (SIEPAC) can be used as a template and case study for the establishment of the RIEM.

Recommendations

The forum provided an opportunity for attendees to highlight and discuss relevant and urgent issues pertaining to energy, transportation and resilience. The organic synergies that exists between these three areas emerged during the discussions and presentations at the forum. This section provides additional recommendations that would help nurture these synergies.

Renewable Energy and Resilience.

Countries in the region continue to make strides towards achieving their national and international commitments to reduce GHG emissions in the power generation sector by investing in renewable energy (RE) generation. Driven primarily by the detrimental effects of climate change, revised and more aggressive RE generation targets are being proposed.

The majority of the RE generating capacity is utility scale with a small portion of commercial and domestic distributed generation. Utility scale RE generation does increase the resilience of the energy system by diversifying both the fuel mix and spatial distribution of the generating sources, however, resilience is further enhanced when distributed RE generation is deployed in both the domestic and commercial sectors. There should be a greater focus towards encouraging a greater adoption of RE generation in the commercial and residential sectors. This can be achieved by reinstituting or implementing favorable domestic and commercial feed in tariff structures and providing access to special RE equipment and installation financing mechanisms focused on domestic and commercial customers. The aforementioned initiatives should be available for a finite period of time as they can have an adverse effect on the revenues stream of the smaller power utilities in the region.

Utilities, regulators and governments should encourage the implementation of community micro-grids. The initial phase of an implementation plan should include pilot community microgrids at police stations and other national security locations, hospitals and health centers and disaster management operation centers.

Citizen by Investment Program (CIP)

The St. Kitts and Nevis (SKN) Citizenship by Investment Program (CIP) is the oldest of its kind in the world. The innovation and success of the SKN CIP program has contributed to the development and adoption of the four other CIP programs in the region. For countries in the region that currently do not have a CIP a national conversation centered around the offering of a CIP should be encouraged and the case of Antigua and Barbuda where CIP funding has been used to fund RE projects highlighted.

Transportation

All countries in CARICOM have made commitments towards the greater utilization of RE for power generation. These commitments are supported by national policies that promote and encourage the use of RE technologies. The transportation sector in the region, however, lacks the support of national policies as most countries in the region do not have a national transportation policy.

Each country in the region should develop a national Sustainable Transportation Policy (STP). The STP should directly correlate with the country's national Sustainable Energy Policy (SEP). The STP should not only focus on ground transportation but also include indigenous maritime transportation. Many countries in the region are multi-island states and there is significant inter-island maritime trade that exist between nations.

The transition to electric vehicles (EV) should begin with public transportation and government fleets. This will improve the air quality in urban areas and allow persons using public transportation who are unable to afford an EV to benefit from improved air quality and its associated health benefits. This would partially address the equity issues identified with EVs and their associated health benefits being accessible to only the high-income portion of society.

The EV transition should also incorporate the training or retraining of auto-mechanics and electricians to repair and maintain EVs and to install EV charging infrastructure. This would help buttress the traditional automobile and liquid fueling station sectors that would incur revenue and job losses with the increased adoption of EVs.

Utility Models

The forum revealed that the Mobility Utility and the EV White label models are best suited for the region with the Mobility Utility being the preferred choice. The Mobility Utility allows for private and commercial EV users to lease EVs from the utility along with a special electricity tariff. The upfront cost for the EV is financed by the utility, this alleviates a major barrier to EV adoption, the high upfront cost when compared to internal combustion engine (ICE) vehicles.

The Mobility Utility model is better suited for investor owned utilities that are innovative, adaptable and market driven. To implement the model in the region legislative and regulatory amendments would be required in most countries. Political support along with cooperation among the regulator, the utility and the state are essential in implementing the model. A campaign highlighting the benefits of the model and EVs in general should be directed towards the corporate community and a market analysis conducted to ensure the financial viability and sustainability of the model. The regional association of power utilities, CARILEC can be an instrumental partner in assessing the willingness, suitability and readiness of regional utilities in pursing the model.

Sahara Dust and Sargassum Seaweed

There is a need to quantify the adverse effects the Sahara dust has on the power generation of utility scale solar photovoltaic (PV) and Wind Turbine installations in the region. This would include investigating the decrease in power output and the increase in maintenance and operation cost due to the dust. The proposed study can be accomplished by using on site ground base measurement equipment to measure the Sahara dust concentration at the power generation sites, the use of satellite imagery and models to determine when the dust would arrive and the logging of the power output data. Mathematical modelling or Machine learning can then be used to analysis the data and produce a model that can predict the expected power out given a specific concentration of Sahara dust particles. The additional operational and maintenance work that is carried out during the Sahara dust should also be documented and analyzed to produce an expected annual cost. These studies can be carried out with the assistance of the regional universities.

Desalination plants that are planned for the region should plan and design systems to mitigate the effect of the sargassum seaweed on its operation. This would entail creating a warning or monitoring system to alert desalination plants of large volumes of sargassum approaching.

Interconnection and the Regional Integrated Energy Market (REIM)

The integration and interconnection of energy markets and energy sectors can transform the region into being more globally competitive and also mitigate the effects of climate change and global economic and energy downturns. There would be greater energy security and resilience, regional and global trade and development and growth in the local SMEs sector. Establishing such a regional energy market would be arduous and lengthy endeavor as it could be potentially more complex that any existing regional bodies and institutions. However, high-level discussions on the Regional Integrated Energy Market at the Council for Trade and Economic Development (COTED) in CARICOM and other regional political gatherings along with the accompanying technoeconomic studies is a critical initial step towards stimulating regional and national discussions on the RIEM.

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