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FOR THE CARIBBEAN

The enhancement of resilience to disasters and climate change in the Caribbean through the modernization of the energy sector

Adrián Flores
Leda Peralta



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This document has been prepared by Leda Peralta Quesada, Associate Environmental Affairs Officer; and Adrián Flores Aguilar, consultant of the Sustainable Development and Disaster Unit of the Economic Commission for Latin America and the Caribbean (ECLAC) subregional headquarters for the Caribbean.

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Acronyms

ADEME	French Environment and Energy Management Agency
AMI	Advanced metering infrastructure
BIEE	Database of Energy Efficiency Indicators for Latin America and the Caribbean
CARICOM	Caribbean Community
CARILEC	Caribbean Electric Utility Services Corporation
CCCCC	Caribbean Community Center for Climate Change
CCRIF SPC	Caribbean Catastrophe Risk Insurance Facility Segregated Portfolio Company
CDB	Caribbean Development Bank (CARIBANK)
CDM	Comprehensive Disaster Management Policy and Strategy
CDEMA	Caribbean Disaster Emergency Management Agency
CDERA	Caribbean Disaster Emergency Response Agency
CEC	Certificate of environmental clearance
CHENACT	Caribbean Hotel Energy Efficiency Action Program
CO ₂	Carbon dioxide
CROSQ	CARICOM Regional Organization for Standards and Quality
C-SERMS	Caribbean Sustainable Energy Roadmap and Strategy
CWR	Carbon War Room
DRM	Disaster risk management

ECERA	Eastern Caribbean Regulatory Authority
ECLAC	Economic Commission for Latin America and the Caribbean
EE	Energy efficiency
EMA	Environmental Management Authority
ESD	Energy for Sustainable Development in the Caribbean
GCF	Green Climate Fund
GDB	Grenada Development Bank
GDBS	Grenada Bureau of Standards
GDP	Gross domestic product
GEF	Global Environmental Facility
GFDRR	Global Facility for Disaster Reduction and Recovery
GIZ	German Development Cooperation
GNEP	Grenada National Energy Policy
GoG	Government of Grenada
GoTT	Government of Trinidad and Tobago
GRENLEC	Grenada Electricity Services Ltd
GSWMA	Grenada Solid Waste Management Authority
GT	Gigaton
GW	Gigawatt
GWH	Gigawatt-hour
HPE	High-performance building envelope
IDB	Inter-American Development Bank
IEA	International Energy Agency
IPP	Independent power producer
KG	Kilogram
KWH	Kilowatt-hour
LCOE	Levelized cost of energy
MEEI	Ministry of Energy and Energy Industries
MEPS	Minimum energy performance standards
MW	Megawatt
NADMA	National Disaster Management Agency
NAWASA	National Water and Sewerage Authority
NZEB	Nearly zero-energy buildings
ODPM	Office of Disaster Preparedness and Management

OECS	Organization of Eastern Caribbean States
OPEC	Organization of the Petroleum Exporting Countries
PURC	Public Utility Regulatory Commission
RE	Renewable energy
REEBC	Regional Energy Efficiency Building Code
RIC	Regulated Industries Commission
RPS	Renewable Portfolio Standards
SECBI	Sustainable Energy Capacity Building Initiative
SIDS	Small Island Developing States
TTBS	Trinidad and Tobago Bureau of Standards
TTEC	Trinidad and Tobago Electricity Commission
TWH	Terawatt-hour
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change
UNISDR	United Nations Office for Disaster Risk Reduction
UNOPS	United Nations Office for Project Services
USAID	United States Agency for International Development
UTT	University of Trinidad and Tobago
UWI	University of the West Indies
VRE	Variable renewable energy
WRAP	Wind Resource Assessment Program

Abstract

The Caribbean region is prone to disasters due to its geographic location. The exposures and resulting impacts of these disasters are aggravated by persistent social, economic and environmental vulnerabilities. Compounded with the region's current dependence on imported fossil fuels and financial constraints, this study seeks to stimulate discussions around the complementarity of energy with every societal sector as well as its links with disaster risk management, and promote government-wide management that integrates energy policies, disaster management and climate change impacts. In a context of high vulnerability to recurring disasters and the impacts of climate change, the study provides alternatives to enhance the overall resilience of energy systems in the region and take advantage of the investment and policy complementarities between climate change adaptation and disaster risk management.

The energy sector plays a crucial role in all stages of the disaster risk management cycle; especially considering that all societal service systems rely on the energy sector for everyday activities, as well as for emergency response and recovery (e.g., telecommunications, health, and infrastructure). Addressing the resilience of energy systems as a component of disaster risk management, and in response to climate change, requires considering all the components of the power supply value chain. Therefore, this study proposes to promote the resilience of the energy sector in the Caribbean through four main activities: (i) risk assessment, (ii) removal of barriers, (iii) modernization of the energy sector, and (iv) monitoring and verification. Fortunately, the region shows great potential for substantial improvements in this direction due to a broader interest of stakeholders to modernize energy systems to increase efficiency (namely in the areas of transportation and building), access and cost-effectiveness.

These activities should be deployed in line with relevant national policy frameworks (i.e., national development plans, energy policies, building policies, among other regulations and planning instruments), availability of technical capabilities, and financial resources, among others. Despite the similarities of the energy systems in the Caribbean, degrees of progress vary by country. Hence, individual assessments (e.g., disaster vulnerability and resilience, resources potential, governance

conditions) should be carried out to determine the most suitable policy mix, including available technologies and measures to enhance resilience of energy systems to disasters and climate change. Many Caribbean countries have already advanced in this assessment by identifying challenges, gaps and renewable energy potential, and establishing energy use targets. However, it is observed that energy-related measures are poorly considered in the early stages of the disaster risk management cycle. Business models are readily available, and the cost of technology is decreasing annually, the challenge seems to lay in the implementation of policies and in the identification of optimal governance mechanisms that allow the integration of climate change adaptation and disaster risk management agendas.

Moving forward also requires countries to be able to identify, design and implement feasible projects. It is also necessary to continue institutional capacity building efforts, with emphasis on project design and management, and provision of specialized energy-related tools for technicians and technocrats. This is especially relevant considering that important investments are required to transition to sustainable energy, while government spending in Latin America and the Caribbean reveals wasteful practices and inefficiencies that cost the region 4,4 per cent of its annual GDP (IDB, 2018). The situation is exacerbated in infrastructure projects, where the region is marked by suboptimal project selection. In addition, there is room for improvement in planning of infrastructure. In this line, the IDB also identifies opportunities to improve efficiency through better spending. Improved design and management would enhance project sustainability and quality. It should also aim at incorporating climate change impacts, energy efficiency and renewable energies as cross-cutting themes that have multidimensional impacts, and thus, require multisectoral interventions.

Climate change and disaster risk management do not concern only ministries of environment and disaster management agencies, but must be considered by all national institutions in their plans and budgets as they pose threats to every sector. It is strongly recommended to incorporate issues of disaster reduction and climate change adaptation in every new/upgraded public investment, and consider incorporating mandatory multi-hazard analyses as a requirement for public funding. It is highly recommended that a deeper integration between energy, climate change and disaster management policies is achieved. To accomplish these goals, technical assessments and implementation strategies should be targeted more decisively, and the deployment of national and regional energy projects should be intensified. Engagement with regional and international stakeholders, including South-South cooperation, can contribute with technical assistance, capacity building and funding. Sharing of best practices, information, national studies and assessments will support ongoing initiatives and reduce the duplication of efforts.

Introduction

Energy is an essential factor for sustainable development and poverty eradication, as recognized by a wide variety of regional and international development instruments.¹ However, access to and promotion of sustainable energy remain persistent challenges in the Caribbean. The region continues to be heavily dependent on imported fossil fuels, which impacts national finances, restricting investment capacity and development opportunities, while posing major threats to environmental damage and longterm ecosystem resilience.

The Caribbean Small Island Development States (SIDS) face a variety of technical, institutional and regulatory barriers that often hinder the implementation of renewable energy (RE) and energy efficiency (EE) initiatives. In the management of RE and EE governments also face many challenges such as: limited technical and human resources, data gaps, outdated/ineffective/inadequate policies and regulations, overlapping/competing mandates, outdated/inadequate tariffs, inefficient administration and maintenance, and consumer education/awareness, among others. These factors result in the highest electricity costs in the world, low quality power services, high technical and non-technical energy losses, and burdensome investment requirements that cannot be easily absorbed by individual countries.

An important opportunity to overcome some of these issues is exploring and exploiting the region's potential for green growth, along with measures to promote low emission and climate resilient development initiatives, which can result in lower investment and operation costs and create economies

¹ The Sustainable Development Goals consider energy, in varying degrees, in at least six goals, including energy (goal 7). It is also considered in decent work and economic growth (goal 8), industry, innovation and infrastructure (goal 9), sustainable cities and communities (goal 11), responsible consumption and production (goal 12), and climate action (goal 13). Goal 17 refers to partnerships, and considers the importance of capacity building and partnerships to boost the capacity of developing countries to achieve the ambitious agenda. The S.A.M.O.A. Pathway (as well as its previous iterations – the Barbados Program of Action and the Mauritius Strategy of Implementation) also has a section devoted to sustainable energy, as well as energy considerations in other goals, such as oceans and seas and sustainable transportation.

of scale, thus facilitating financing opportunities. The Caribbean Sustainable Energy Roadmap and Strategy (C-SERMS) recognizes the potential, benefits and obstacles faced by the region and also calls for regional energy integration. However, existing initiatives, strategies and policies for EE and development of RE sources have not fully explored to opportunities offered by regional linkages and integration. The region still requires a new roadmap for integration, especially considering that national systems would have to be upgraded/modernized and regulations harmonized. In addition, a regional dialogue process is needed to identify common goals and priorities, and to secure high-level political involvement.²

Interconnection opportunities are also hindered by small, outdated and isolated national grids, which result in important energy losses, high operation costs, low quality power services, difficulty to incorporate renewable energies, reduced resilience to disasters and climate change, and inability to meet residential and industrial energy needs (current and future). These barriers combined with limited public investment capacity have deterred the use of RE and EE technologies.

The Caribbean's great potential for using RE sources is widely acknowledged, and EE measures are often referred to as the first fuel, as they offer quick and low-cost reductions in energy costs. In addition, several regional and international organizations have highlighted the importance of assessing the electric grids to modernize them and increase their technical capacity to incorporate RE. This could result in lower tariffs, increased efficiency, and cleaner and smarter grids, which would yield wider benefits such as energy security, business continuity and increased resilience to disasters and climate change impacts.

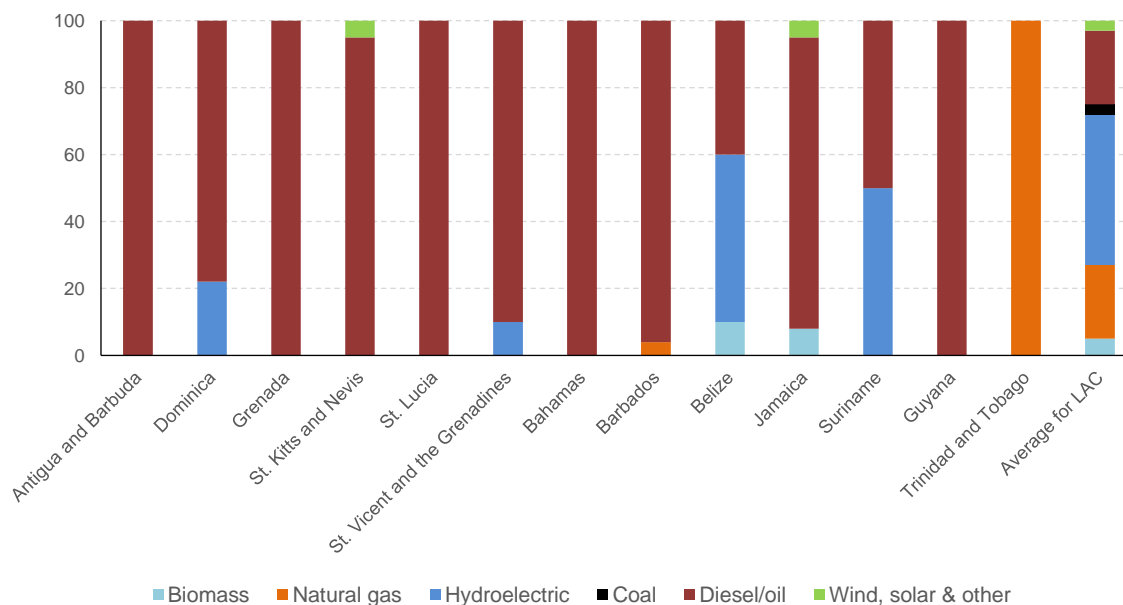
To address the challenges associated with the energy sector, this study insists on the benefits of the convergence of energy, disaster risk management (DRM) and climate change policies. This requires coordinated actions among Caribbean states and regional partners towards a broader understanding of sectoral interactions and the ubiquity of energy to achieve the modernization of energy systems. The modernization would upgrade power grids in the context of climate change and disasters, increase the penetration of RE and enhance EE. RE plays a very important role in the convergence of policies issued to address the challenges of the energy sector and the regional climate change and disaster risk management agendas. The privileged geographical location and topographical conditions of the region provide great potential to deploy almost all the RE technologies known to date to diversify the energy mix and to stop relying on fossil fuels as a main source of energy. Although the penetration of RE sources into the energy mix has increased over the last years there is a huge potential still to be fully deployed. Additionally, the transition of Caribbean economies from agriculture to the industry and services sectors over the last years opens a great window of opportunity to deploy sustainable energy measures (e.g., EE in core sectors such as buildings, transportation, industry, and tourism services) that could influence energy systems in a prompt and affordable way. Lastly, the vulnerability of Caribbean energy systems to climate change and disasters demands a redesign of power grids and the incorporation of technological advancements for the improvement of the services. Decision makers and managers should overcome the current energy paradigm and promote the diversification and distribution of energy sources, the enhancement of demand-side EE, regional electricity interconnection, and behavioral change among consumers.

² Considering that this study seeks to boost South-South cooperation, it is worth highlighting the experience of Central America in the integration of its electric systems. The Electric Interconnection System of Central America (SIEPAC for its acronym in Spanish) is fully integrated, and grew to include Colombia and Mexico. The system has already provided benefits in three core areas: (i) integration of six electric systems, creating one energy market, (ii) reduction of greenhouse gas emissions, and (iii) integration of telecommunications systems of Central America, Colombia and Mexico through submarine cables. Evidently island states face an additional set of physical challenges; however, it is worth exploring the experience, and how the countries set up a shared agenda and a common work program.

Most countries have national energy policies and have integrated the Sustainable Development Goals (SDG) in their development instruments. The C-SERMS also provides an important policy framework for energy integration. Although the region has advanced from a policy point of view, (reformed or new) regulations and implementation are still lagging. Trinidad and Tobago has committed to increase the contribution of RE to their energy supply by 10 per cent by 2021, while Grenada seeks to accomplish 20 per cent contribution of RE to all domestic energy usage by 2020. However, diversification is still pending in both countries, and an important boost is required to achieve the established targets.

In addition to the observed delays in both countries, in the case of Grenada, the accomplishment of this target, as well as the country's search for sustainable energy and its reduction of GHG emissions could be seriously hindered by the discovery of gas and oil in their territorial waters. According to Prime Minister Dr. Mitchell, "Grenada can be a massive supplier of oil and gas"; although the international and economic community agree that fossil fuels will peak between 2020 and 2040.³ A renewed focus on extractive industries and an approach to sustainable energy based on fossil fuels extraction would be counterproductive to the country's search for sustainability, and counterintuitive in face of the threats posed by climate change on SIDS (especially sea level rise), notwithstanding economic gains. In contrast, as a region, Pacific SIDS are pushing for a regional treaty to ban or phase out fossil fuels.

Figure 1
Installed generation capacity in Caribbean countries
(percentage of total capacity)



Source: IMF, 2016.

³ The most conservative projection is presented by the International Energy Agency, which considers that oil and gas consumption will not peak before 2040, despite the Paris Climate Change Agreement. Several oil companies and the OPEC agree with this forecast. However, even companies like BP and Shell have adjusted their projections; the former shifted peak projections from mid-2040 to mid-2030, while Shell forecasts oil peaking by 2025 and gas by 2035. This perspective is shared by organizations such as the Carbon Tracker Initiative and the Imperial College's Grantham Institute, that expect fossil fuels to peak by 2020.

It should also be noted that the goals remain low in a context of global and accelerated adoption of RE. Countries like Costa Rica, Iceland, New Zealand and Norway are committed to becoming carbon neutral between 2030 and 2040. Several SIDS, such as The Cook Islands, Niue and Tuvalu have set a goal of 100 per cent renewable energy by 2020; and Fiji, Vanuatu and Solomon Islands for 100 per cent renewable energy by 2030.

A. Background: Caribbean energy sector and disaster risk management

Small Island Developing States (SIDS), including the Caribbean, are prone to disasters due to their geographic location, and impacts resulting from climate change increase their exposure to natural threats. In addition to natural conditions, risks are aggravated by unresolved physical, social, economic and environmental vulnerabilities, and exacerbate the effects and impacts of disasters and climate change, increasing development constraints. For example, compared to Europe and Central Asia, SIDS are expected to lose on average 20 times more of their capital stock yearly in disasters. The expected annual losses in SIDS are equivalent to almost 20 per cent of their total social expenditure, compared to only 1.19 per cent in North America and less than one per cent in Europe and Central Asia (GAR 2015). In the LAC region, more specifically Caribbean SIDS, the cost of disasters with respect to the size of their economies is greater than in South and Central America. Thus, Caribbean countries face a potentially greater reversal in economic and social improvements due to disasters. In addition, their portfolio of investments could be affected by spending shifts that force the diversion of resources destined for productive sectors and social spending into reconstruction efforts. Furthermore, disaster and climate change-related costs are expected to continue escalating due to population growth, rapid urbanization, increasingly exposed assets, environmental degradation and climate change. It is estimated that fast-growing middle-income countries suffer annual direct losses equivalent to 2.9 per cent of GDP, and low-income countries 1.3 per cent of GDP, while high-income countries' direct losses are approximately 0.8 per cent (GFDRR, WB & Swiss Confederation 2014), highlighting the importance of financial protection and resilience building.

Until the 1990s, public policies on disasters, which also consider the increasing effects of climate change (e.g., sea level rise), in the LAC region were focused on response and preparedness. The lack of stable financing for DRM and an emphasis on response and rehabilitation have resulted in an approach largely focused on ex-post actions. This approach has also been driven by international development assistance and national financial constraints. However, this tendency has been slowly changing as countries learn from past experiences, acknowledge the role played by adequate financing, and recognize the overarching value of investing in each DRM pillar (risk identification, risk reduction, preparedness, financial protection and resilient reconstruction). This increasing interest to have a more integral approach to disasters demanded to review all the sectors in society and economy that play an important role either because they increase vulnerability or enhance resilience to disasters. The energy sector is one of these.

Disasters expose pre-existing vulnerabilities and inequalities, and disproportionately affect marginalized populations. Current characteristics of the energy sector in the Caribbean⁴ increase not only its own vulnerability but that of reliant sectors (e.g., telecommunications, health, response and

⁴ Caribbean energy systems are mainly characterized by the presence of single utilities, centralized generation, fossil fuel reliance, low transmission and distribution efficiency, and high electricity tariffs, among others.

recovery). The effects of disasters and climate change on energy systems vary from affectations to infrastructure (e.g. generation plants, transmission and distribution networks), to disruptions in supply, and changes in demand patterns. These impacts can reverse achievements in sustainable development, especially when financial protections are missing and when DRM still follows a silo approach.⁵ In this sense, DRM and energy are inextricably linked between them and with other sectors. This situation requires stakeholders to plan and incorporate measures all along the energy supply chain and in articulation with areas such as climate change and environment, to name a few. Having resilient energy systems could allow governments and stakeholders to minimize the impacts of disasters and climate change and thus improve human well-being and avoid recurring recovery and reparation costs.

B. The role of energy systems in enhancing resilience to disasters and climate change

Promotion and use of EE and RE is a global trend that responds to environmental concerns and needs for enhanced productivity and innovation. In addition to seek transition to modern economies, governments should consider the transition to modern energy systems for two main reasons: 1) energy systems provide core services at all time, not only during the attention of a crisis, and 2) well-designed and modern energy systems could help reduce the vulnerability of societies and economies to the impacts of disasters. In addition, specialized agencies consider that investments in resilience can yield a triple dividend by "(i) avoiding losses when disasters strike; (ii) unlocking development potential by stimulating innovation and bolstering economic activity in a context of reduced disaster-related background risk for investment; and (iii) through the synergies of the social, environment and economic co-benefits of disaster risk management investments even if a disaster does not happen for many years" (ODI, GFDRR & WB 2015).

The modernization of energy systems has direct synergies with other areas, for example, climate change, natural resources conservation, environmental degradation, poverty alleviation, and land use planning and zoning, among several others. The strong synergies between climate change, DRM and energy emerge mainly, but not exclusively, from the available technology alternatives, and are better leveraged with sound policy development and access to reliable information. Both mitigation and adaptation, for example, can reduce the likelihood and severity of a risk by working to improve the response of the energy sector's infrastructure to natural threats, while also improving its day-to-day efficiency and cost-effectiveness. However, synergies also entail important challenges, for example:

- Increased low-carbon electrification and the subsequent displacement of oil by electricity may reduce exposure to global fuel supply disruptions (*i.e.*, caused by extreme weather events and water stresses). Nevertheless, the expanded generation and transmission and distribution infrastructure can create new exposures that need to be evaluated.
- Although RE could help reduce water demand compared to other generation technologies, new water challenges related to water-intensive concentrating solar power and bio-energy production may emerge. Furthermore, variable renewable energy (VRE) production is vulnerable to risks of source supply intermittency (*e.g.*, wind and solar) that may be aggravated by climate change. On the other hand, these sources are often associated with a more distributed generation, creating a profusion of electricity sources and a greater ability to localize and buffer disruptions. Expanded regional renewable grid interconnections may also present resilience benefits as well as challenges which need to be

⁵ As demonstrated in countries affected by tropical storms and hurricanes. ECLAC has corroborated this pattern through the assessment of the effects and impacts of hurricanes in The Bahamas (2015, 2016 and 2017), Belize (2016), and especially during the hurricane season of 2017 (Anguilla, The Bahamas, British Virgin Islands, Sint Maarten and Turks and Caicos Islands).

evaluated on a case-by-case basis. Infrastructure is also subject to risks from high winds, flooding and heavy precipitation, which highlights once more the importance of building codes and land-use planning/zoning.

Improved demand-side management and EE can lead to greater responsiveness to changes in both demand and supply and reduced water demand. More efficient power plants use less water for cooling, while demand-side EE offsets the need for electricity capacity additions and, in turn, additional water for cooling. However, new smart grid infrastructure may be exposed to new risks.

The provision of energy services in face of these potential benefits and challenges draws attention to some important requirements: major public and private investments in the energy supply chain (e.g., modern infrastructure, demand-side efficiency), integral governance frameworks (e.g., energy, DRM, climate change), adequate capacities, and reliable data and information. Additionally, policies need to be context specific (i.e., regional, national, local) and every possible co-benefit (i.e., energy and non-energy) should be taken into consideration.

In this regard, stakeholders must address the issues that hinder resilience of energy systems, most importantly, to modernize the energy sector, not only as a response to the threats of disasters and climate change, but as a sign of progress, human well-being and sustainable development. Resilience in this sector is hindered by incomplete or outdated regulations that do not create an enabling environment for EE/RE to flourish; unsolved market failures; suboptimal planning of infrastructure projects, including construction in risk-prone areas and lack of infrastructure maps; and unclear energy integration plans. In addition, the LAC region suffers from policy implementation issues. Fragmentation, duplication, and weak monitoring, evaluation (of impact) and follow-up are still common challenges (IDB 2014, 2014b & 2018). Planning is also subject for improvement, as it should play a central role in any policy, project or strategy. The content of a policy is as important as the implementation process.

Fortunately, Caribbean countries are at a turning point. Global commitment, resources availability and political willingness provide them with an excellent opportunity to turn the challenges of disasters into alternatives for a sustainable and resilient transformation of the economy and society. However, the region faces several challenges associated with the convergence of policies advocated to climate change, DRM and energy. These challenges require to be addressed, not only to remove the barriers for the penetration of such measures and technologies, but also to tackle aspects such as ageing grids, present and projected peak demand of electricity, scarcity of financial resources, and other associated issues. The following sections analyze the main components of the process in light of three persisting barriers, namely, governance frameworks, data gaps and information quality, and capacities.

1. Components of a resilient energy sector

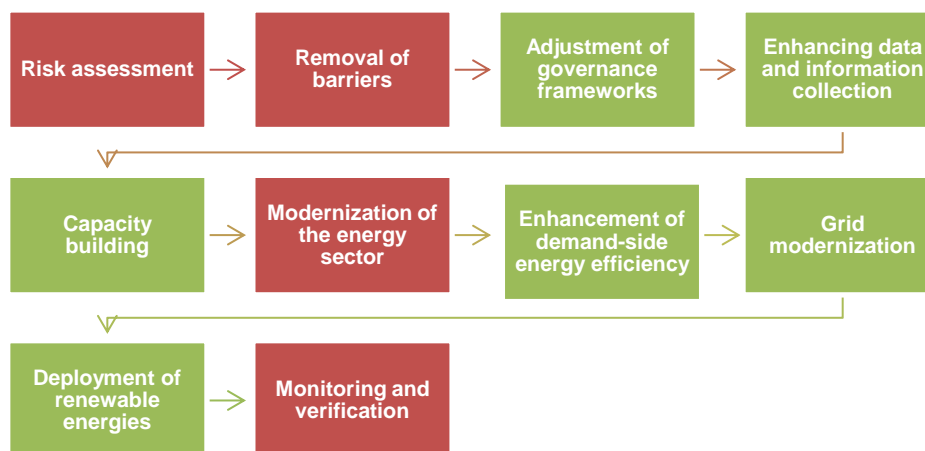
To achieve the resilience of energy systems to disasters and climate change is a complex process. Resilience building can be better attained through the multi-sectoral synergies between adaptation and mitigation. Both types of approaches, as well as other pertinent measures, should necessarily take into consideration local conditions, such as priorities, governance frameworks, available funding, infrastructure, capabilities, access to information, and awareness.

To assist stakeholders in the simplification of this process, this study suggests a structure based on a phased approach. The components presented were informed by inputs from the pillars of action of DRM by the GFDRR and by several best practices, mainly in the energy sector (Annex 1).

This phased-approach is designed for mid to long-term initiatives and should not be seen as a generic one-size-fits-all solution, but a compendium of basic critical requirements that should be explored and expanded by technicians and policy makers. In this regard, the adoption and implementation of the components will depend on decision makers and stakeholders to properly assess

local current conditions and define clear goals and targets to guide sectoral long-term plans. Based on all of the above, the guide comprises four components, namely risk assessment, removal of barriers, modernization of the energy sector, and monitoring and verification (Figure 2).

Figure 2
Components of a resilient energy sector



Source: Elaborated by the authors.

C. Scope, objectives and methodological approach

The objective of this study is to identify key elements that would allow the integration of climate change adaptation, energy sustainability and disaster risk management strategies. The main premise is that stand-alone policies do not take full advantage of natural complementarities between these three fundamental development issues, and silo approaches reduce the potential impact of interventions and make suboptimal use of scarce modernization resources. The study profiles the current condition of electric grids in the Caribbean with emphasis on starting a regional discussion regarding the challenges and opportunities to promote energy efficiency and intensify the deployment of renewable energies in the context of building resilience to disasters and climate change impacts. In addition, two case studies (*i.e.*, Grenada and Trinidad and Tobago) were completed to identify opportunities and challenges at the national level. In order to attain the main objective, the study undertook the following activities:

- Meet with relevant stakeholders of the Caribbean energy sector to gather data and information.
- Meet with national stakeholders of the energy sector to gather specific national data for two country cases, namely Grenada and Trinidad and Tobago.
- Meet with national stakeholders of the disaster risk management and climate change sectors to gather information about the role of sustainable energy in building resilience to disasters.
- Meet with regional and international organizations to discuss the links between energy, climate change and disaster risk management in the region.
- Identify opportunities and challenges to modernizing electric grids in the Caribbean with special attention to introducing RE in the context of building resilience to disasters and climate change.

- Present best practices, international experiences and critical requirements to guide a grid modernization process that considers EE and deployment of RE.

The methodological approach of this study involved the following steps:

- Review of documentary materials from RE, EE and grid modernization to propose alternatives to enhance resilience to disasters and climate change in the Caribbean.
- Review of documentary materials from grid modernization best practices to identify the phases involved.
- Elaborate a phased approach for the modernization of the energy sector in the Caribbean in the context of enhancing resilience to disasters.
- Review documentary materials from national entities (*i.e.*, ministries) and regional and international organizations (*i.e.*, CARICOM, CARILEC, CDB, ECLAC, GIZ, IDB, and OECS, among others) in order to assess the local and regional governance conditions.
- Undertake two case studies to identify opportunities and challenges at the national level.
- Conduct field visits to Grenada and Trinidad and Tobago to gather relevant information and meet stakeholders (June 2017).

I. Risk assessment

According to GFDRR the management of disasters should be founded on five pillars: risk identification, risk reduction, preparedness, financial protection, and resilient recovery. This study focuses in ex-ante phases, namely risk identification, risk reduction and preparedness, as they provide great opportunities to address the underlying vulnerabilities that lead to the occurrence of disasters and avoid damage and losses. This section provides a general overview of the pillars, as well as some measures to build resilience based on ECLAC experience in disaster assessments in the region. The proposed activities are not exhaustive and the adequate mix of actions should be customized based on each country's context and capabilities.⁶

Table 1
Pillars of action of disaster risk management

Pillar 1	Risk identification	Improved identification and understanding of disaster risks through building capacity for assessments and analysis
Pillar 2	Risk reduction	Avoided creation of new risks and reduced risks in society through greater disaster risk consideration in policy and investment
Pillar 3	Preparedness	Improved capacity to manage crises through developing forecasting and disaster management capacities
Pillar 4	Financial protection	Increased financial resilience of governments, private sector and households through financial protection strategies
Pillar 5	Resilient recovery	Quicker, more resilient recovery through support for reconstruction planning

Source: Global Facility for Disaster Risk Reduction (GFDRR), "Strategy 2013-2015. Managing Disaster Risks for a Resilient Future"
Note: Pillars in grey signal the focus of this study.

⁶ For additional information on measures to mainstream DRM in development instruments, see ECLAC (2017), "Mainstreaming disaster risk management strategies in development instruments."

Risk identification focuses in two aspects. First, it considers the assessment of multiple threats, including frequency, intensity and magnitude. Second, it identifies exposed infrastructure, services, communities and other elements, as well as their vulnerabilities. By identifying the risks, it is then possible to foresee the potential effects and impacts of a disaster in a society, environment, and its economy. Implementation of geoinformatics technologies including data generation, public access, mapping and modelling, could better guide this process. The Caribbean region has made important advances in identifying the main types of threats that affect nations, and some countries like Belize and Jamaica have assessed exposure and potential damage and losses in specific areas or for particular sectors. However, sectoral and geo-referenced inventories of exposed assets and nation-wide assessments of exposure and potential costs are still lacking in most countries, or are not publicly shared. These infrastructure maps/inventories would help prioritize intervention, relocation and/or retrofitting activities to target exposed assets. Additionally, they would help design and/or implement routine maintenance programs. As evidenced in ECLAC disaster assessments, lack of regular maintenance is a main cause that exacerbates the damage caused by disasters. Energy infrastructure located near the shoreline or other bodies of water should be a priority for intervention, and damage and loss projections should be conducted to appraise the potential setbacks that the sector could suffer.

Another instrument to identify risks is through the assessment of disasters. Disasters expose strengths and areas that need improvement. The outcomes of the assessment give an opportunity to plan better for potential hazardous events and make the necessary changes to better adapt or even to prevent similar disasters from happening in the future. Instruments such as ECLAC disaster assessment methodology are intended to provide a comprehensive assessment of the social, economic and environmental effects and impacts of a disaster in a community.⁷ Partnering with organizations like ECLAC in the evaluation of disasters could allow for a better understanding of the hazards. The assessment of disasters could be substantially improved by having detailed and updated economic statistics and national accounts. This requires the allocation of more financial resources to the offices of statistics and improvements in sectoral data (see chapter iii, Removal of barriers).

Besides producing information, inter and cross institutional sharing of data, community-based DDR and other knowledge are vital. This pillar is fundamental for risk reduction and preparedness, as it can inform policies and decision makers with specific information on social, economic, environmental and physical vulnerabilities of populations and infrastructure. Information and reliable data should also be readily available for all actors and in terms of raising awareness to hazards, risk areas, and communicating other measures to manage the risk of disaster.

Risk reduction is an on-going and dynamic process that requires permanent attention, and should always be accompanied by non-structural strategies, such as poverty alleviation and adequate territorial planning.

When risk exposure and its potential harmful effects are identified and understood, it is then possible to take actions to reduce such risk. In this pillar, instruments such as policies and investment programs are critical to reducing existing risks and preventing new ones from arising. In this regard, it is necessary to also consider the effects associated with climate change. Depending on the type of risk, it could be reduced, or at least reduce the exposure of a community or asset to a particular threat. Structural and non-structural prevention and mitigation measures are core components of this pillar.

In this regard, deeper levels of resilience require diversifying power generation, so that the failure of a single power station would not result in a total loss of electricity to the community. In addition to diversifying the energy matrix and forms of distribution, it is fundamental to consider the role of RE in disaster response and recovery, especially to provide backup power to critical sectors, such as water, health and

⁷ Requirements for sectoral information are detailed in the Disaster Assessment Methodology (ECLAC, 2014). The handbook provides an extensive list of sectoral baseline data that could be used for decision making and policy design.

telecommunications. The geographic dispersal of power-generation assets would substantially reduce the risk of total loss of power generation capability in future disasters. Additionally, by placing consumers closer to sources of power generation, it would make communities less reliant on far-flung power lines that remain highly vulnerable to extreme weather events resulting in wind damage, floods, and/or landslides.

This phase also requires retrofitting of infrastructure that cannot be rebuilt in the short term, which considers hard measures (dykes, seawalls, and elevated infrastructure), as well as green infrastructure solutions, such as coastal protection, coral reef and mangrove restoration, as well as water shed management including re-forestation.⁸

Although not directly related to energy management, two fundamental issues determine the strength and effectiveness of disaster risk reduction (DRR): land use planning and enforcement of building codes. Despite their relevance in building resilience to disasters and climate change, these two issues remain to be addressed in most of the region. Based on ECLAC experience, it has been observed that absent or inadequate land-use planning result in some of the most extensive hurricane and storm-related damage. Infrastructure close to the shoreline and without protection tends to be more severely affected. In addition to large events, these structures are also affected by the cumulative effects of low-severity, high-frequency events, and inadequate maintenance. This situation is exacerbated by non-compliance with existing building codes. It should be noted that, in the process of adoption or elaboration of building codes, it is crucial to include special considerations for essential/critical infrastructure, most notably that related to transportation, food storage/supply chain, health, education, water, power and telecommunications. These are essential services required during and in the immediate aftermath of a disaster, and therefore, require additional protection given the volume of persons that may use the facility (health and education) and/or the importance of the service provided, in particular in face of the emergency context (transportation, water, power and telecommunications).⁹

Even if risks can be identified and addressed, it is not possible to eliminate them. Therefore, preparedness refers to the knowledge and capacities developed by governments, businesses and communities to anticipate, respond to, and recover from the effects of a natural hazard or disaster. This pillar should contribute to an organized transition from response to recovery, as all procedures should be systematized, shared and harmonized to allow a unified management of the emergency. Most Latin American and Caribbean countries have focused their efforts in this pillar through warning systems, contingency plans, and emergency response. At the same time, this has resulted in reduced attention to other areas of disaster risk management, highlighting the need for strengthening other pillars. The degree and quality of preparedness will be closely linked to a sound analysis of risks and to existing warning systems.

Regarding preparedness in the energy system, it is recommended to identify the most common types of damage and stockpile important components and parts. In The Bahamas, prior to every hurricane season, the utility company stockpiles on poles, as overhead damage is one of the most recurring issues.

Although renewable energies are the recommended source for backup power, many institutions still rely on generators in the aftermath of a disaster. Therefore, it is important to ensure that generators are functional and that the island/community has access to fuel. Energy-intensive sectors, like telecommunications, need special provisions to ensure continued access to energy, especially considering steep demand increases during and after disasters. This situation calls for a coordinated energy strategy for disaster response, in which all sectors participate, identify their priorities, and assign responsibilities and investments.

⁸ In the assessment of the effects and impacts of Hurricane Earl in Belize, it was noted that an extensive and healthy coral reef, as well as mangrove coverage in some areas of the country, dissipated wave energy and provided important protection to communities and infrastructure located close to the shoreline. Once more, this situation highlights (i) the deep linkages between disaster risk management and climate change policies, and (ii) the benefits that healthy ecosystems provide for sustainable development.

⁹ The IDB highlights the importance of critical infrastructure and discusses a policy framework for the Latin America and Caribbean region in the study "*Policy Evaluation Framework on the Governance of Critical Infrastructure Resilience in Latin America.*"

II. Removal of barriers

A. Adjustment of policy and governance framework

Discussions with stakeholders in the context of the elaboration of this study evidenced key salient issues that could be hindering moving on to a more dynamic deployment of national RE projects: governance frameworks, enforcement, and institutional and human capital. The most relevant challenge of adjusting governance frameworks is coordination among a diversity of institutions and regulations. This is a main reason why local input is crucial in the design of policies and implementation strategies: local stakeholders have in-depth knowledge of their sector, are aware of the challenges faced, and can identify institutional and/or regulatory bottlenecks. Thus, understanding the governance of the sector is a *sine qua non* requirement to design (or reform) policies and plans.

Governance frameworks refer to modern energy policies and plans that include measurable RE and EE targets, assign responsibilities, establish timetables and communication and accountability mechanisms, allocate resources (financial and non-financial), and be based on sound budgetary provisions. They should promote multi-stakeholder participation and provide moments for policy learning.

Modern energy policies must be accompanied by a regulator responsible for creating an enabling environment for all stakeholders, and to ensure transparency, accountability and fair conditions. Several countries have established or are in the process of establishing national regulators. This is a crucial component for a decisive deployment of RE/EE, as regulators should develop guidelines, standards, tariff methodologies, and other regulations for all interested stakeholders.

Human capital refers mainly to staff mobility and capacity building. Inadequate or outdated civil service regulations often result in high staff mobility and overall instability. Also, it is imperative to provide opportunities for re-skilling, especially for staff new to the sector or transitioning from less strategic sectors. It is recommended to revise civil service schemes to improve employee confidence and retention, allow staff and institutional specialization, and improve institutional memory. This would also allow taking full advantage of the diversity of capacity building projects in the region, especially considering that the energy sector requires specialized training. In addition, this would improve project

quality, as national staff is knowledgeable of the country's challenges, ongoing projects and other local characteristics that could impact the project. For projects to be sustainable, implementing institutions must have in-house trained staff that can monitor and evaluate projects and ensure continuation. Monitoring and verification are fundamental to assess the effects of policies and projects. To this end, staff must be trained in sector-specific data collection and analysis tools and methodologies. Institutional memory and staff continuity would also allow to avoid duplication of efforts, especially those involving international and/or regional technical assistance and ensure continuation of initiatives or promote knowledge retention and organizational memory.

However, budgetary constraints limit the availability of resources for capacity building. In this regard, it is recommended to identify creative mechanisms to motivate continuous learning and improvement. The optimization of internal procedures would not only improve efficiency in the provision of public services but would also free time and allow staff to undertake research activities. Telecommuting is increasingly adopted by companies, as it is proven to increase productivity and motivation in employees, while reducing operative costs to the institution (including space, lightning and air conditioning). And online learning platforms flourish, democratizing access to education. Capacity building could be used to pilot telecommuting schemes, it would build trust and improve work planning, while motivating staff.

Considering best practices, it is also strongly suggested to create moments for policy learning.¹⁰ Plans and other programs are often drafted to follow a linear approach, but policy making and implementation are highly dynamic processes that are affected by socioeconomic and environmental events. Therefore, it is crucial to allow for policy improvements that seek to address unexpected or unplanned results, revisit expectations and ambitions, and introduce any necessary changes. Policy learning also fosters accountability, result-oriented planning and evaluation of impacts (as opposed to outcome evaluation).

Organizational charts that assign roles and responsibilities to government agencies should be clearly defined. Depending on the existing institutions, this chart and management scheme could be captured in a new agency or through *ad hoc* work programs and groups. These charts should also be built based on territorial and sectoral approaches that establish competences across sectors and government levels. A national steering body should be established to guide other agencies and stakeholders (*e.g.*, businesses, academia, communities and civil society). Key ministries/divisions such as of Planning, Natural Resources Management, Environment, Bureau of Standards, and Consumer Affairs have important roles in aligning sectoral needs and interests with national goals. Particularly the Ministries of Energy should lead the modernization of the energy systems while encouraging multi-sectoral interventions. This approach should be strongly supported by the Ministries of Finance in their budgeting and prioritizing role. Usually, government agencies, private sectors and other stakeholders have limited/dispersed roles and responsibilities that do not allow them to properly face the challenges and tasks inherent to the linkages between sustainable development, climate change, disasters and

¹⁰ In a context of rapid global changes and trends, and considering that social and productive sectors are highly dynamic, it is crucial to allow policy learning as an opportunity to improve policies and strategies. However, this opportunity must be explicitly expressed in the policy or strategy. According to The Innovation Policy Platform – created by the OECD and the World Bank –, policy learning “refers to the ways in which policy systems generate and use knowledge about the rationales, design, operation and impacts of policies and policy mixes. It takes place at all points in the policy cycle: direction-setting and orientation, policy mix definition, policy mix delivery, and monitoring and evaluation. As such, policy learning demands the organisational capabilities to frame issues in terms of problems and solutions, to take an holistic view and to anticipate future needs. The knowledge mobilised for learning processes can be grouped into the following types:
 Know how: the ability to do something;
 Know what: knowledge about facts;
 Know why: knowledge about principles and laws; and
 Know who: knowledge about who knows what.”

energy management. Although there are already positive efforts in this regard, most policy frameworks still do not reflect the linkages between DRM, climate change impacts and energy. This situation is further aggravated by suboptimal civil service schemes that hinder continuity between governments in terms of human capital and institutional organization.

Frameworks should include clear and measurable goals and targets to achieve considerable changes. These goals and targets should be established according to local conditions and capabilities (*e.g.*, financial and infrastructural, governance). The main purpose of the goals and targets is to define a horizon and to provide the framework to measure improvements. Appropriate work plans and/or action plans in each area of intervention with realistic and detailed baseline data and timeframes should be defined complementarily. In this regard, capacity building is crucial, as policy makers and technicians with strong project management skills are able to produce better quality policies and strategies. Therefore, it is highly recommended to increase access of public staff to training in project design and management, as well as on indicators design and implementation.¹¹ Sector-specific staff also requires training on energy-related issues, such as methodologies, indicators and best practices. Both international and regional organizations and South-South cooperation should help to bridge this gap.¹²

A general governance recommendation is the need to transit to an approach that understands climate change and sustainable energy as integrated multisectoral and inter-dependent subjects. Projects must be resilient to the impacts of climate change regardless of the implementing sector, especially considering that most infrastructure development in the Caribbean is located in the coast. Critical infrastructure and services, such as schools, hospitals, food production/storage/supply, transportation, and water and energy plants must be resilient to climate change and promote the use of RE/EE.

It is highly suggested that initiatives directed to the energy sector and to DRM are included in national development policies and strategies. They should not be seen as isolated topics but as core aspects inherent to the consecution of sustainable development. Specialized agencies agree that compartmentalized and stand-alone DRR projects are no longer sustainable practices, “it is therefore through development planning – from overall development strategies through to the work of sectoral ministries – that risk reduction efforts will have the most impact” (ODI & UNDP 2014). In this scenario, planning and budgeting play a crucial role in putting comprehensive risk management measures at the core of national and global development agendas so that disasters and the effects of climate change do not derail previous or future progress.

1. The compounding effects of disaster risk management and climate change adaptation

Given the socioeconomic and physical exposure of the Caribbean region to disasters and the effects of climate change, it is important to analyze the interactions between DRM and climate change strategies. In this context, the energy sector plays a crucial role. First, most island development is located close to the coastline. This results in important damage to infrastructure during hurricanes and storms. This calls for considering relocation and retrofitting of structures to adapt to threats such as sea/storm surge, strong winds, and increased rainfall, as well as sea level rise and degradation of coastal ecosystems. Second, the impacts of disasters on energy-related infrastructure often result in power outages, which deeply affect the normal activities of most socioeconomic sectors, namely: health, fisheries, food

¹¹ ECLAC has developed extensive experience on planning and statistics through the Latin American Institute on Economic and Social Planning (ILPES for its acronym in Spanish), the Division of Statistics, and CEPALSTAT, an online database of statistics, indicators and publications. The work has been developed for most Latin American countries and could be deepened in the Caribbean through technical assistance and sharing of best practices, handbooks and other guidelines, which are also available online.

¹² Platforms like UNITAR and Coursera offer an extensive catalogue of free and online courses on energy and other sustainable development issues.

storage/supply chain, telecommunications, and water and wastewater management, and could also delay relief and recovery efforts.

The energy sector exemplifies the strong relation between DRM and climate change adaptation. Public and private investments must be resilient to disasters and climate change, regardless of the sector responsible for the infrastructure being developed (health, food production, storage, supply and safety, education, housing, transportation and productive activities, among others). Development activities and projects no longer fit exclusively in DRR or CCA portfolios but these issues are so deeply intertwined that separated investments would not benefit from comprehensive resilience building. However, the overall lack of national information systems and/or technical guidelines makes it difficult to properly consider DRM in the preparation and evaluation cycle of public investment and development projects in general. A combination of improved data and strengthened technical capabilities is crucial to incorporating DRM in public investment projects. The incorporation of a multi-hazard DRM component throughout the lifecycle of a project would increase its resilience and sustainability, and contribute to protecting public investments, while ensuring continuity in the provision of public services and products.¹³

Assessments and research carried out by ECLAC (2015; 2016 and 2017) have identified a strong link between environment/natural resources management, climate change and DRM. It is also observed that, to the extent that a country has updated frameworks for climate change adaptation and mitigation, there are articulations with the principles and activities of DRM. Although climate change policies do not necessarily address DRM, most of the improvement measures proposed to adapt to or mitigate against the impacts of climate change would have beneficial effects on improving DRM. Climate change policies reflect a strong understanding of the linkages between natural resources including land use planning, environmental degradation, and disaster risk reduction. This link is also observed with the tourism, fisheries and agriculture sectors in countries that depend on them as productive activities. In this regard, climate change policies on adaptation and mitigation measures are required to be comprehensive and consider all sectors: transportation, housing, health, fisheries, agriculture, food production, storage, energy and water management. An overall improvement of resilience to climate change would undoubtedly have similar effects in strengthening the countries' DRM efforts.

Similarly, several development and sectoral policies recognize the importance of land use and territorial planning to increase resilience and adapt to/mitigate the effects of climate change. Adequate territorial planning would facilitate the identification of areas apt for different types of development (commercial, residential, industrial, conservation/preservation), as well as identify risk-prone areas or areas for sustainable resettlement. Even if some land use and climate change policies do not address DRM directly, there are complementarities, such as enforcing the use of building codes, elaborating hazard maps, promoting the use of renewable energies, expanding insurance in productive sectors such as food storage, agriculture and tourism, and improving multi-sectoral coordination. In this regard, the iLand project seeks to strengthen sustainable land management in the region towards climate change adaptation. The project is being implemented by the OECS and has two main components which underpin every relevant sector (housing, tourism, water security, and agriculture, among others). The first component focuses on providing policies, frameworks and practices to improve land management;

¹³ In Costa Rica, the Ministry of Planning (MIDEPLAN) assessed "*The Economic Impacts of Extreme Events, 1988-2009*." This systematization allowed MIDEPLAN to demonstrate the cumulative effects that both high-impact/low-frequency, and low-impact/high-frequency events have on socioeconomic development. Subsequently, as responsible for approving public investments in the country, the Ministry issued a directive to incorporate DRM in every public investment from the design/profile stage. In addition, MIDEPLAN developed a methodology to analyze natural threats in the design/profile stage of public investments. This measure demonstrates a comprehensive manner of incorporating DRM across sectors (mainstreaming). The methodology and other accompanying instruments are available online.

these activities include capacity building, use of building codes, and sharing strategies and tools. The second identifies critical interventions to reduce the risk of disaster; some activities include water security, flood mitigation/management, watershed and forest rehabilitation, ecosystem restoration and rehabilitation, slope stabilization, and drought mitigation.

The analysis of DRM governance frameworks also evidenced the importance of updated and readily available data and information for decision making. Although most development and sectoral policies acknowledge this need for data and identify important gaps, there are no clear guidelines for the generation and dissemination of DRM-related information. In addition, countries have institutions responsible for the study and monitoring of geological and hydro-meteorological hazards, but this information is not necessarily accessible or used to guide actions and decisions. Information of this nature is still being primarily used in the academic sectors and in early warning systems. Nevertheless, it should be noted that most countries already have acts/laws ensuring access to public information. Therefore, it is necessary to clarify the role of DRM in this regard and build upon the accomplishments of such acts/laws/regulations/enforcement procedures/successes. As expressed in most DRM instruments, it is recommended to implement DRM information systems, as well as technical guidelines to support sectoral and territorial engagement, ensure consistency in the collection of data, and promote sharing.

On this matter, it is also important to highlight the importance of consistently collecting sectoral baseline data, as it contributes not only to identifying and reducing risks, but also to assessing the effects and impacts of disasters. Sectoral baseline data would allow line ministries and other decision makers to identify exposed assets and vulnerable populations, and take actions to mitigate or reduce the risk of disaster. Similarly, such data could be used in the event of an emergency to prioritize the allocation of resources and explore options for resilient reconstruction. In addition, the consistent assessment of disasters, regardless of their magnitude or intensity, is an important indicator of the cumulative effects and impacts of disasters in national development and finances. This focus will also change the approach of the wider citizenry in addressing disaster preparedness and management.

2. Regional energy governance frameworks in the Caribbean

The regional governance of the energy sector in the Caribbean is founded primarily on the challenges posed by imported fossil fuels and on the region's potential for renewable energy. The strength of the region's approach lays in the adoption of a comprehensive Energy Policy that identifies the most pressing challenges and pairs them with sectoral actions and targets that would lead to a sustainable and efficient energy sector. Subsequently, the Caribbean Sustainable Energy Roadmap and Strategy (C-SERMS) was elaborated to "build on existing regional efforts and to provide CARICOM member states with a coherent strategy for transitioning to sustainable energy" (CARICOM, 2013). The Energy Policy aims at strengthening cohesion by establishing common goals and benefiting from a regional approach to sustainable energy, while the C-SERMS establishes a logical framework to attain the goals set in the policy; these two instruments have become the guiding pillars of the Caribbean energy strategy.

A regional approach has the potential of creating economies of scale, producing energy locally or wherever it is affordable, promoting investment in EE and RE, and reducing operational costs. Regional targets unite countries around a shared vision, and ensure that national strategies are in line with such common goals. However, despite the inclusion of sustainable energy in multiple development instruments, access to and promotion of sustainable energy remains a challenge in the Caribbean. New and existing initiatives for energy efficiency and development of renewable energy sources have not fully explored strategies and policies towards integration and regional linkages.

Recognition of past and current work should be incorporated to guide future initiatives also to avoid duplicities, inefficient use of resources (national and international), and conflicts between projects or targets. Although the initiatives have faced important challenges that limit the implementation of

their goals, they played a fundamental role in putting energy issues on the national and regional agendas, set the foundation for the region's vision on energy sustainability, and paved the way for complementary initiatives that sought to address the limitations encountered by initial projects. In addition, each program produced new information about the sector; therefore, certain issues have been widely surveyed and discussed, some include the Caribbean potential for renewable energy, challenges and barriers to implementation, potential for interconnection, and basic data requirements. Even though not all these issues have been completely solved, there is consensus on the importance of a more aggressive deployment of RE, better data gathering schemes, continued capacity building, and promotion of EE as a first fuel; therefore, subsequent projects have aimed at fulfilling these needs.

Despite the region's long-term commitment to sustainable energy,²⁴ *“regional and national actors in this field are not yet able to fulfill the political, organizational and technical requirements of this growing market. Private and public institutions also lack the qualified experts and managers needed to plan concrete projects and improve the energy policy framework in a way which will promote renewable energy and energy efficiency”* (REETA). In light of these challenges, the Renewable Energy and Energy Efficiency Technical Assistance (REETA) project seeks to strengthen the response and implementation capacity of countries to satisfy the region's RE and EE goals and demands. The project is executed in collaboration with CARICOM, which highlights the prominent role played by the Energy Unit.

In line with the objectives of the REETA project, the Caribbean Center for Renewable Energy and Energy Efficiency (CCREEE) also seeks to strengthen the implementation of national and regional commitments, and to promote RE and EE investments, markets and industries. Both projects observe that the region and individual nations have successfully created enabling environments for the promotion of RE and EE; however, implementation of these goals remains incipient.

Multiple studies and regional and international organizations have identified data as one of the most important constraints to implementing, and monitoring and evaluating policies. To this end, two main projects are currently being developed in the Caribbean.

As the C-SERMS Platform builds on the experience and lessons learned through the implementation of the Energy Policy and the C-SERMS, it seeks to explore potential partnerships and opportunities, develop and monitor plans of action, and calculate costs, and identify and raise funding. The implementation of the platform intends to:

- Centralize the data on activities, initiatives and programs of development partners in the Caribbean;
- Provide virtual space for working groups to meet/exchange information;
- Support the collection and management of energy data including statistical information on energy resources, electricity generation information, energy demand, utility information, energy pricing, and other relevant data for the sector.

Complementarily, ECLAC has recently launched the BIEE Program (spanish acronym for Database of Energy Efficiency Indicators for Latin America and the Caribbean) in selected English-speaking Caribbean countries. The project has already been implemented by ECLAC in 19 countries in LAC, including Dominican Republic and Cuba, and in 70 countries throughout the world. The BIEE program is based on the experience obtained by its equivalent in Europe, the ODYSSEE-MURE program, and seeks to produce a series of specific and methodologically consistent indicators that allow to measure, analyze and monitor the evolution of national energy efficiency policies and projects. The

²⁴ Energy related issues have been included in the Barbados Plan of Action (1994), the Mauritius Strategy of Implementation (2005), the SAMOA Pathway (2014), and the Sustainable Development Goals (2015), as well as in initiatives such as the United Nation's Sustainable Energy for All (2010).

main objective of the program is to create a database of indicators that measure the performance of energy efficiency policies in participating countries. The program follows a sectoral approach, which would result on energy efficiency information for seven key sectors, namely macro/energy balance, household, industry, services, agriculture, transportation, and energy. It consists of three stages: 1) compilation of basic data; 2) identification of EE indicators, and; 3) training for the interpretation and use of the indicators.

3. Disaster risk management governance in the Caribbean

The Regional Comprehensive Disaster Management Strategy and Programming Framework 2014-2024 (draft) elaborated by CDEMA recognizes the importance of risk management in the energy sector, as it is normally affected by extreme weather and climate. In addition, CDEMA has elaborated guidelines for safe schools and communities; these guidelines recognize the need for sustainable energy. This is also in line with the Caribbean Community Climate Change Centre's (CCCCC) understanding of the role of RE to build resilience to disasters and climate change (considering issues such as RE for desalination plants and rainwater harvesting). CDEMA is also promoting the use of RE for communications during emergencies.

Renewed engagement between the ACS, CDEMA and ECLAC has contributed to a harmonized approach to DRM, and has promoted exchange of knowledge and experiences amongst these agencies. The ACS, through the Directorate for Disaster Risk Reduction, fosters cooperation among disaster planning and relief organizations in the region. The Directorate convenes annual meetings to discuss the prevention and mitigation of risks, the incorporation of knowledge on prevention, and education and planning with respect to the effects of disasters. In addition, the organization is currently developing the Green Response project, which seeks to include and promote environmental safeguards in the disaster response process (Box 1).

ECLAC has strengthened its engagement with the region through the dissemination of the Disaster Assessment Methodology and the conduct of post-disaster assessments. The methodology follows a sectoral approach, which requires engaging a variety of sectors both in training activities and disaster assessments.¹⁵ The multi-sectoral approach allows highlighting the importance of baseline data adjusted to the specific requirements of each sector, promoting comprehensive post-disaster assessments, and informing reconstruction strategies based on generalized resilience building; it has also prompted agencies such as FAO and PAHO to adopt the methodology in their respective fields or work. ECLAC's recommendations for resilient reconstruction are based on the five pillars of DRM adopted in the Sendai Framework (risk identification, risk reduction, preparedness, financial protection, and resilient recovery), and seek to identify low-hanging fruits and feasible national undertakings that benefit from compounded projects. As presented previously, energy-related infrastructure is usually affected by disasters and has severe effects in other sectors; therefore, recommendations usually include a strong component to promote sustainable energy (RE/EE) in the form of decentralized plants, household adoption of RE technologies, use of RE for desalination and backup power, among others (for more information see ECLAC 2017).

Financial institutions, such as the CDB, CCRIF SPC, and the IDB have also supported resilience building through CCA and/or DRM. The CDB has two main programs dedicated to resilience building: Disaster Risk Management and Climate Change, and the Community Disaster Risk Reduction Fund, which "provides communities and their partner organizations with grant funding to help them avoid or

¹⁵ The Disaster Assessment Methodology (2014) comprises three main sectors. In addition, it considers two cross-cutting issues, namely gender and environment.

- Social: affected population, housing, education, health and epidemics, and culture and cultural assets.

- Infrastructure: transportation, water and sanitation, power, and telecommunications.

- Productive: agriculture (including farming, livestock, poultry, and fisheries), manufacturing, commerce, and tourism.

reduce the impacts of extreme weather events, natural hazards and climate change” (CDB 2017a). Regarding CCRIF SPC, in addition to providing catastrophic risk insurance, it has recently launched micro-insurance products for organizations and collections of individuals in order to provide ex-ante support at the micro and meso levels. Jointly, the CDB and CCRIF SPC launched a Regional Risk Management project “to enable all Caribbean countries to take a more proactive approach towards country risk management, moving beyond planning for disaster risks such as climate change and events like hurricanes and earthquakes and recognizing the intrinsic linkages between disaster risk and other types of risks such as economic, technological and financial and the impacts of these on socioeconomic development” (CDB 2017b). Finally, the IDB supports a variety of DRM and CCA projects throughout the region, and has strengthened its support for post-disaster assessments, and has collaborated in developing and funding resilient reconstruction strategies.

Box 1
Green response to Disasters

Nnyeka Prescod^a

As the region has been, for the better part of the last two decades, attempting to address the issue of greenhouse gases and transitioning to low carbon economies, ensuring resilience in the face of the effects and impacts of climate change has become a critical activity. Consequently, it is posited that the pursuit of environmental sustainability and economic growth are not exclusive but are mutually interdependent goals that should be pursued.

In response to this scenario, the Association of Caribbean States’ (ACS) initiative Green Response to Disasters arose out of the need to include and promote environmental safeguards in the disaster response process. The Green Response to Disasters initiative presents an opportunity to explore the convergence of environmental protection and emergency management through the utilization of eco-efficient products and alternative forms of energy in the preparation stages and the 300delled periods immediately following the occurrence of a disaster.

The ACS is collaborating closely with the Office of Disaster Preparedness and Management (ODPM) of Trinidad and Tobago and the International Federation of the Red Cross and Red Crescent Societies (IFRC) to bring this initiative from concept to reality.

The project consists of three phases with the first phase – a diagnostic – already complete. The aim of the second and third phases is to create a repository of ecological and environmentally friendly products which can be utilized in lieu of non-biodegradable, polluting, carbon intensive commodities during the response and relief periods immediately following a disaster. Products listed within the repository will be guided by international best practice for ecological products as well as present opportunities for disaster shelter retrofitting with RE resources and/or waste to energy capacity. The ACS is seeking donor participation to implement phases two and three of this environmentally sustainable disaster response model.

Descendant from the completion of all three phases includes:

- i. Influencing organizational and national procurement policy for disaster relief merchandise within the pilot country, Trinidad and Tobago, whilst
- ii. Advocating the articulation of the use of environmentally sound practices within national disaster management and environmental policy, as well as
- iii. Replicating and up-scaling this initiative throughout the ACS Membership.

Establishing, maintaining and endorsing practical frameworks related to “Green Response” can only be achieved through the participation and coordination of stakeholder groups. In an effort to ‘green’ the relief effort, regional governments and the private sector can play a key role in pioneering, promoting and facilitating the utilization of eco-efficient and energy-efficient products.

^a Advisor Transport and Disaster Risk Reduction, Association of Caribbean States.

4. Next steps

Governance changes should prioritize the most critical areas within each country; this requires a detailed assessment of local conditions and capabilities, as mentioned in chapter ii.

A steering body to guide the modernization of the energy sector and supporting agencies should be designated. A main function of this body would be to coordinate institutions and their

priorities/interests, as well as drafting a joint work plan with clear roles and tasks. Clear work plans would increase efficiency and accountability. There are already positive examples in the region (*e.g.*, Saint Lucia and Trinidad and Tobago); however, in most cases there is no clarity about the roles and responsibilities of different governmental agencies. In addition, several countries face low or lack of continuity in their civil services, which affects institutional organization. These situations also impact the implementation of measures proposed in this study, as it supposes the convergence of three areas (*i.e.*, energy, DRM and climate change or environment) and requires specialized human capital and institutions. This steering body is expected to propose specific measures and to collaborate in creating the appropriate normative frameworks for their deployment (*e.g.*, national energy policies). Additionally, it is expected to create and enable a business environment that accelerates public and private investments in RE penetration, EE enhancement and grid modernization. It should also work as a bridge to promote regional cooperation to share and import best practices. Finally, the designated entity should seek to adapt local EE and RE targets to regional goals as much as possible (*e.g.*, C-SERMS).

As mentioned above, steering entities/bodies should work based on national energy policies that consider the incorporation of RE/EE technologies and measures. These energy policies should have goals and targets to achieve considerable changes in RE penetration, renewable electricity generation, EE enhancement, sustainable transportation/buildings, and emissions reductions. They should be established according to local conditions and capabilities (*e.g.*, financial, infrastructure and governance). The main purpose of the goals and targets is to define a horizon and to provide the framework to measure improvements in energy systems. Goals and targets should be accompanied by appropriate work plans and/or action plans in each area of intervention with realistic and detailed timeframes, baseline information, and performance indicators. Goals and targets should be accompanied with clear pathways and strategies to achieve them.

B. Enhancing data and information collection

Data and quality information are required to guide decision making, to monitor and verify future scenarios and improvements. Inadequate or insufficient baseline data could hinder efforts to make reliable assessment, identify and reduce risks, as well as to assess the effects and impacts of disasters on infrastructures (including that of energy systems), ecosystems and populations. Inadequate baseline data could also result in over or underestimations of the efforts needed. The generation and dissemination of information requires strong institutions providing leadership and guidance for the generation and use of resources, as well as a platform to keep it available to stakeholders.

Currently, data and information gaps in energy, climate change and DRM are a challenge in the region. CARICOM, for example has identified energy-related data gaps in areas such as energy consuming sectors (*e.g.*, electricity); greenhouse gas emissions; potential of renewable energies and EE, among others. Based on the CARICOM study (CARICOM, 2015), the four main energy-related data gaps faced by the region were identified as:

- *Lack of widespread calculation, understanding, awareness and communication of RE's cost-effectiveness:* Despite the cost-effectiveness of RE technologies in the Caribbean, many regional stakeholders continue to perceive these technologies as prohibitively expensive, posing a significant barrier to adoption in a region already facing high electricity prices.
- *Unavailability of RE assessments and technology feasibility studies:* Although many Caribbean countries have conducted initial assessments of resource potential for several technologies, detailed resource studies are required for specific project implementation. Where detailed resource assessments have not been conducted, they should be carried out and where

assessments have been conducted, they should be made publicly available and easily accessible. Compiling all completed assessments in a central location, open to all energy stakeholders, would facilitate knowledge sharing and avoid duplication of efforts.

- *Higher-resolution assessments for priority geographic locations not conducted and/or communicated:* National level assessments provide a valuable overview of available resources and can play a crucial role in indicating promising areas for deployment of specific technologies. However, for project development to move forward, assessments must be conducted at a higher resolution. Priority areas for more detailed assessments include those with the best resources and near population centers.
- *Analysis of opportunities for resource complementarity in integrated energy planning not conducted and/or communicated:* Many opportunities exist to deploy certain RE technologies in tandem, taking advantage of seasonal and diurnal variation to overcome some of the challenges typically posed by the variability of renewable resources. Assessments of complementary potential will facilitate smarter and more integrated energy planning, and will indicate opportunities for the most efficient and cost-effective RE deployment.

Other crucial pieces of information that do not exist, are not readily accessible or are not shared are: maps with geo-referenced infrastructure, sectoral statistics, hazard maps, and building codes.

The region has moved forward in this area through the launching of the Database of Energy Efficiency Indicators for Latin America and the Caribbean (BIEE). This initiative has been implemented in several Latin American countries by ECLAC, the GIZ, and the French Environment and Energy Management Agency (ADEME). The BIEE seeks to strengthen the capacity of energy authorities in Latin America and the Caribbean to monitor their EE, improve data reliability and in turn enhance evidence-based decision making on EE. The program consists of three stages: 1) compilation of basic data; 2) identification of EE, and; 3) training for the interpretation and use of the indicators.

During the data and information collection enhancement phase, responsible stakeholders should gather complete and reliable data in every identified area of intervention. The national steering body should be the authority in charge of coordinating multi-sectoral efforts towards these tasks. Collected data should be used to establish baseline scenarios, assess the current state and potential of the energy systems in the Caribbean to tackle climate change mitigation and adaptation, and measure future improvements and impacts of national and regional strategies. Table 2 presents the most important energy data and information required in this phase.

Table 2
Energy data and information gaps in the Caribbean

Area	Gaps
Energy systems	Assets and operations vulnerability and/or resilience to climate change/ disasters
Electricity	Updated power sector generation capacity plans and strategies Detailed data on power plants in operation Analysis of electricity end-users Grid and storage assessments and expansion plans
Building and transportation	Updated sector plans and strategies Energy statistics in the sector Fuel and electricity use Vehicle registration database
Emissions	Updated emissions reduction plans and strategies Updated greenhouse gas inventories Sectorial emissions data

Area	Gaps
RE and EE Potentials	LCOE+ (levelized cost of energy, plus externalities) Centralized database for RE assessments Assessments at higher resolutions for priority areas Analysis of opportunities for complementarity Energy audits Technology feasibility studies
Policy and Finance	Review of governance and administration effectiveness Review of policy effectiveness Identification of financial barriers to RE within each member state

Source: CARICOM, 2015.

Based on best practices, some of the most critical actions to assure proper gathering and treatment of information and data are:

- Coordinate information gathering and communication
 - In cooperation with existing initiatives, fill identified data and information gaps;
 - Provide open and user-friendly access to updated data;
 - Create and/or reform national data collection and tracking systems;
 - Establish guidelines for data and information collection, sharing and dissemination.
- Facilitate communication and outreach to the general public
 - Implement options for more-effective communication (e.g., educational programs, etc.);
 - Establish guidelines for data and information sharing with the public, private sector, academia, research institutes, and other stakeholders.

Additionally, specific measures for the energy sector in this regard are:

- Deployment of technical assessments
 - Identify technical assessments deployed in the areas of intervention and undergo new ones if gaps need to be filled;
 - Assess potential renewable technology uses (e.g., generation, solar cooling, solar water heating, geo-thermal);
 - Conduct energy audits of identified target areas;
 - Assess current grid and storage infrastructure capabilities;
 - Identify solutions to bridge gap between existing and projected grid and storage needs;
 - Communicate key findings regarding grid and storage capabilities and introduce energy management systems.
- Conduct and communicate electricity system modelled¹⁶
 - Deploy country-specific LCOE+ modelled of all-inclusive electricity generation scenarios (i.e., RE, fossil fuels, mixed);

¹⁶ The NREL offers several online tools. For more information visit www.nrel.gov/analysis/models_tools.html.

- Calculate electricity generation scenarios examining various generation mixes, EE measures and associated socioeconomic impacts (*i.e.*, co-benefits);
- Conduct load profile analysis for overlay with 34odelled scenarios to determine grid and storage transition needs.

C. Capacity building

The incorporation of new technologies and activities demands specialized skills and knowledge. Local and regional capacities must be created and/or improved to face the challenges posed by the modernization of energy systems in view of increasing resilience to disasters. Although the region is permanently supported by multiple capacity building initiatives, important knowledge gaps and barriers to institutional effectiveness remain, including duplication of efforts, high staff mobility, loss of institutional memory and expertise, and lack of coordination, which often hinder effectiveness. To address this situation government institutions and related stakeholders must develop shared databases, networks, and collaboration frameworks to guide institutional structure and operation.

Box 2

Environmental justice and access to information: Principle 10 and its ramifications

Luciana de Meira^a

The idea that decision-making with environmental implications needs to be participatory, open and inclusive has been underscored in international conferences and agreements for more than 25 years, since the United Nations Conference on Environment and Development was held in 1992 in Rio de Janeiro. On that occasion, governments agreed that: "Environmental issues are best handled with the participation of all concerned citizens, at the relevant level. At the national level, each individual shall have appropriate access to information concerning the environment that is held by public authorities, including information on hazardous materials and activities in their communities, and the opportunity to participate in decision-making processes. States shall facilitate and encourage public awareness and participation by making information widely available. Effective access to judicial and administrative proceedings, including redress and remedy, shall be provided" (United Nations, 1992). This statement is known as the Principle 10 of the Rio Declaration and seeks to enforce three interdependent rights: the right to have access to environmental information in a timely and effective manner; the right to participate in decision-making in environmental matters; and the right to have access to justice to ensure compliance with environmental laws and rights or to obtain redress for environmental damage.

Access to information and participation in decision-making is not only an important step in environmental democracy, but it also aims to improve the quality and acceptability of any decision, while enhancing the legitimacy and fairness of decision-making processes. Therefore, public participation in decision-making has been incrementally included not only on environmental legislation but also in sectorial laws such as energy policies. A recent achievement in this regard is the adoption of the first binding regional agreement to protect the rights of access to information, public participation and access to justice in environmental matters in Latin America. The final text accord has been finalized in the Ninth Meeting of the Negotiation Committee of the Regional Agreement on Principle 10 that took place in March 2018 in Costa Rica. The agreement will open to signature to all countries in Latin America and the Caribbean at the United Nations Headquarters in New York, from September 27, 2018 to September 26, 2020 and it is a remarkable step towards sustainable development and international cooperation in the region.

Source: Observatory on Principle 10 in Latin America and the Caribbean. Available at: <https://observatoriop10.cepal.org/en>.

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The convergence of the areas discussed in this study requires engaging stakeholders from all involved sectors, including project developers, financiers, engineers and technicians, policymakers, academia, and planners, involved communities and communication and out-reach experts. They must be informed about the general goals and targets, as well as about their roles and responsibilities. It is

crucial that they are aware of the technological and governance implications of the proposed changes. Capacity building efforts must focus on identifying opportunities for mutually beneficial partnerships.¹⁷

The region has a record of capacity building initiatives, for example, the development of OAS Sustainable Energy Capacity Building Initiative (SECBI) during 2014-2016. This initiative aimed at contributing to the development and use of sustainable energy technologies throughout the beneficiary countries and empower energy science education to achieve critical thinking skills required for today's labor market and future economies. It also addressed critical commercialization challenges related to expanding the development and use of sustainable energy alternatives as a means of injecting more affordable and less environmentally harmful energy technologies into the energy matrices of Caribbean countries (ECPA, 2014). Additionally, the United Nations Observatory for Renewable Energy in Latin America and the Caribbean currently offers a Capacity Building Program on Renewable Energy from which the region could benefit. It is aimed at promoting capacity building and knowledge exchange in the field of RE/EE to boost investments in this area. The program tackles areas such as energy and climate change, small wind energy, biogas, small hydro energy, PV energy, solar thermal energy, and EE in buildings. Regional and international capacity building initiatives abound, and the region has been widely supported through financial and technical assistance. However, weak civil service schemes and high staff mobility hinder stability and specialization, institutional memory, and project continuation. It is recommended to strengthen measures to promote continuity, retention and specialization of staff in highly technical fields, such as energy, climate change, and DRM.

The effectiveness of the energy sector in addressing the challenges of climate change relies on the performance of its institutions, which includes an understanding of each institution's roles and responsibilities. Efforts in the capacity building area must be directed at identifying opportunities for partnerships, simplifying the regulatory system and promoting research and development related to sustainable energy solutions in the region. In addition, local staff is better suited to identify priority projects and optimum options for implementation; therefore, it is crucial to build capacity in areas like project design, project management, and collection and interpretation of sectoral data, as well as specialized training on energy-related fields. Some of the most relevant actions during this phase are (CARICOM, 2015):

- Assess current human, institutional, and education/training/research capacity in the national scale to identify key gaps;
- Create a shared database of existing regional training materials, available training tools and curricula, and education programs;
- Collaborate with regional and international organizations providing capacity building in the areas of intervention;
- Encourage exchange of experiences and best practices among countries;
- Encourage development of national and regional professional networks;
- Facilitate training and education programs for key stakeholder groups, including: policymakers, financial institutions, job force, and private sector;

¹⁷ Identifying that the energy sector was male-dominated, that women's skills were undervalued, and that efforts and expertise were highly dispersed, ECLAC former staff Tanya Moreno Coronado started the "Network of Women in Renewable Energy and Energy Efficiency, in Mexico" (REDMERE for its acronym in Spanish). The group started in WhatsApp and has grown to include 237 women, which now require and have requested an online sharing platform. This effort highlights two issues: (i) it is highly relevant and recommended to use existing social media applications to promote exchange and engagement, and (ii) these communities of practitioners are very valuable spaces to network, identify experts, and promote integration within the field. The setup is simple, open and free but requires champions that foster engagement and participation.

For the energy sector, a specific measure in this regard is (CARICOM, 2015):

- Establish national RE and EE technology centers, based on available resources potential and technological experience.

In addition, it is highly recommended to strengthen civil service schemes that promote specialization and retention. In general, the region is affected by high mobility, which impacts staff and institutional specialization, replication and sharing of technical knowledge, institutional memory, and project continuation. Stable and specialized staff will contribute to identifying critical priorities and projects, ensuring continuation and collaboration between projects, improving regional and international interventions and technical assistance, and providing institutions with an important array of tools and other relevant knowledge.

III. Modernization of the energy sector

A. Enhancing demand-side energy efficiency

Efforts to address the challenges of the energy sector cannot rely exclusively on the incorporation of RE. Demand-side EE and other energy saving measures are crucial, as they consist of the most cost-effective and fastest way to lessen the environmental and socioeconomic costs associated with energy systems.

Demand-side EE is achieved when less energy input is used to deliver the same service or when the same amount of energy input delivers more services. This concept is relevant in light of climate change challenges in two ways: (i) the less energy used, the fewer emissions produced, and (ii) cost-effective EE achieves environmental benefits at low cost, and thus could reduce the economic costs of achieving climate change policy goals (*e.g.*, CO₂ emission reduction, resilience enhancement) (Prindle, 2009). Differently to incorporating RE technologies or modernizing the grid, EE improvements are convenient because they are often the cheapest and fastest ways to reduce the costs associated with energy systems (see box 3). The importance of demand-side EE also resides in its “compounding effect”: when a user demands one less unit of energy as a result of EE measures, the system saves much more than that unit of energy because related losses during generation, transmission and distribution are avoided. The two main sources of demand-side EE improvements are: a) greater technical efficiency from the implementation of EE technologies (*i.e.*, technological changes), and b) structural economic changes that result in the production and consumption of goods with lower energy intensity (*i.e.*, structural and behavioral changes) (IRENA and C2E2, 2015; OAS, 2014).

EE measures in the context of the enhancement of resilience to disasters and climate change should primarily, but not only, focus in building and housing sectors since they generally account for large amounts of electricity for cooling/heating, lighting. Many resiliency measures in the building sector overlap with EE measures. These measures can potentially benefit communities through lower operating costs and energy savings that can lessen demand and stress on energy infrastructure. (OAS, 2014; IRENA and C2E2, 2015). CARICOM (2015) defined three characteristics that effective EE-related policies should have:

- *Policies must be implemented as part of an appropriate policy mix:* Although certain policies have proven effective in rapidly increasing RE deployment in certain contexts, their design is not one-size-fits-all. Policymakers must identify a combination of policy measures that most effectively address existing circumstances, including technological maturity, affordable capital, and ease of integration into the existing system, among others.
- *Policies must be sustained:* To provide energy stakeholders with the stability and reassurance, policies must be sustained over time.
- *Policies must be flexible.* Given the dynamism of RE markets and technology developments, policies must be flexible enough to evolve in changing conditions.

1. Building sector

In residential, commercial and public service buildings, heating and cooling are major contributors to the emission of GHG. Buildings in CARICOM's residential and commercial sectors account for significant and growing shares of overall energy consumption, in countries like Belize (23.3 per cent) and Grenada (25.4 per cent) (CARICOM 2015). This trend continues to grow given the increase in the access of thousands of people to adequate housing and electricity and the relevance of the tourism sector.

Potential measures to enhance EE in this sector are encouraged mainly for new developments since buildings are usually replaced only at the end of their useful life. Decision makers should also seek to capitalize on reconstruction efforts after disasters. When this is not possible, retrofitting buildings is highly encouraged. Measures in this regard could also go hand in hand with adequate planning and land use. In fact, considering the low-lying nature of Caribbean countries, land use studies are fundamental in identifying the most apt and sustainable areas to locate infrastructure. Measures in the building sector include technological and structural options (see Annex 3).

The convergence of both structural and technological measures can be achieved through building energy codes and minimum energy performance standards (MEPS). These codes regulate the energy use in buildings, including: thermal performance requirements for walls, roofs and windows; energy performance of chillers and air-distribution systems; day lighting lamps performance; the electrical wiring system; RE; appliances; zoning of buildings, climate classification and building energy management systems; solar water heating; among others. EE enhancement in the building sector should follow three critical steps (CARICOM, 2015):

- Improvements on this sector should initially focus on efficiency standards for technologies that are low-cost and easy to deploy (e.g., cooling methods, natural ventilation systems, and lighting).
- Procedures for EE and RE technology upgrades in buildings should be streamlined to avoid the risk and expenses of bureaucratic processes.
- Development of tax incentives to encourage major customers to perform energy audits. These audits allow identifying the simplest and most-effective ways to reduce energy consumption and costs in a given building or business.

2. Transportation sector

The transportation sector is a core target for GHG emission reductions since it is accountable for around 14 per cent of total global emissions (IPCC, 2014). In many cases the sector is included as part of the energy sector when calculating CO₂ emissions due to the shared use of oil as a fuel. In later times, the integration of EE and RE technologies has brought both sectors closer together. Clean energies point to be the fuel of the future, and thus there is an increasing symbiosis of the sector with modern grid

technologies (*e.g.*, smart grids and EE storage devices). In this sense, efficiency in the transportation sector in this new era intrinsically means efficiency in the energy sector.

Energy use in the transportation sector is determined by a series of factors, including the type of fuel, existence of efficient and reliable public transportation, among others. From the EE enhancement perspective, there are a series of actions that range from technological changes to structural changes that could be implemented to help mitigate climate change (*e.g.*, fleet electrification, transport demand management)

Considering that transportation accounts for 36 per cent of the total primary energy consumed in the LAC region, as indicated by the International Monetary Fund (2016), the Caribbean transportation sector shows great potential for the implementation of EE enhancement measures. Improvements in government fleets' management and the incorporation of electric/hybrid/plug-in hybrid vehicles (EV/HEV/PHEV) into public and private fleets appear to be two of the most feasible alternatives for the region. In this regard, since 2003, member states tasked CARICOM to develop an Energy Policy that considered EE measures in the transportation sector. Additionally, ECLAC and Caribbean countries like Saint Lucia have given important steps forward to assess the feasibility and define the critical steps towards a fleet modernization in the region (see ECLAC, 2017). Although there are data gaps and governance issues that require prompt attention before moving forward, the region has shown great disposition and advancement in this direction. The reinforcement of public transportation could achieve great results for the enhancement of EE. Complementarily, public transportation is relevant for the region because it provides mobility to people who do not have access to a vehicle at less marginal cost. Decision makers and planners should consider measures in the public transportation sector that come in hand with land use and transportation planning strategies.

3. Next steps

Demand-side EE measures and other energy saving measures are crucial, as they consist of the least costly and fastest way to lessen the environmental and socioeconomic costs associated with energy systems. Nevertheless, there are local barriers that do not allow the public and private sectors to move further. The most critical steps towards promoting EE measures in the region are:

- Set standards
 - Designate local bureaux of standards (in case of absence);
 - Identify priority areas where regional standards can be set (*e.g.*, building codes; technology standards, fuel efficiency standards, research and development);
 - Design and enact local and/or regional standards in collaboration with other countries and stakeholders, especially considering the role and expertise of the CARICOM Regional Organization for Standards and Quality (CROSQ);
 - Ensure that domestic policy reflects and enforces standards.
- Support EE through targeted legislation
 - Identify key sectors for EE improvements
 - Identify opportunities and strategies for demand-side management;
 - Develop and enforce national building codes that promote EE;
 - Mandate appliance labelling and efficiency standards;
 - Offer fiscal incentives (*e.g.*, rebates, tax exemptions) for energy audits and purchasing of energy-efficient products.

- Implement policies to support the enhancement of EE in the building and transportation sectors
 - Conduct feasibility studies for demand-side EE enhancement;
- Establish linkages between EE enhancement and RE deployment to tackle both fronts more effectively.
- Collaborate with other Caribbean countries to find solutions to the common EE issues and develop/implement regional strategies.

Box 3

“How to save US\$36 billion worth of electricity (without turning off the lights)”

The Inter-American Development Bank (IDB) came up with this suggestive title to bring attention to the importance of incorporating EE measures in the region. This document sought “to contrast the potential electricity savings from efficiency with the additional generation capacity that the region will need if it does not become more efficient.” According to the author, there are two ways for Latin America (and the Caribbean) could generate 143,000 GWh of electricity in 2018: one option would cost around US\$16 billion; the other, US\$53 billion.

The document emphasizes the concept of energy intensity as a measure of the EE of a nation’s economy. Energy intensity is mostly calculated as units of energy per unit of GDP. When a country shows high energy intensity (e.g., Trinidad and Tobago) it is an indicative that a country needs more energy consumption to generate one dollar of GDP. Low energy intensity (e.g., Barbados) indicates that the country needs less energy consumption to generate one dollar of GDP. Among the factors that can influence an economy’s overall energy intensity are: climate, structure of sectoral energy consumption and the technology used by predominant industries.

Table 1

Energy efficiency opportunities in the Caribbean

Country	Energy intensity index	Estimated Savings (kWh of electricity/year for a 10% EE improvement (by 2018))	EE investment required (by 2018)	Construction of a 250 MW gas fired open cycle power plant
Barbados	1.08	130 GWh	US\$ 15 million	US\$ 49 million = 0.3 of a power plant
Guyana	8.7	105 GWh	US\$12 million	US\$39 million = 0.2 of a power plant
Jamaica	3.55	1000 GWh	US\$ 116 million	US\$ 373 million = 2 power plants
Trinidad and Tobago	5.73	980 GWh	US\$116 million	US\$ 373 million = 2 power plants

Source: IDB, 2008.

B. Incorporation of renewable energies

RE deployment is a widely discussed topic in the region and the overall potential for RE sources is high. Therefore, stakeholders should take advantage of the momentum created by international cooperation organizations and regional entities. Although estimations point out that the global energy supply will remain dominated by fossil fuels over the next decades, countries should seek to develop and disseminate cost-effective and efficient low- or zero-carbon emitting technologies (ECLAC, 2016). Nowadays, RE cost-effective supply is in continuous growth due to an increase in the investments and advancement in technologies and features. While the cost of RE technologies has decreased in recent years (i.e., between 33 and 80 per cent depending on the technology), they are still not comparable to subsidized fossil fuel energy sources. However, if we take into consideration the associated socio-

economic and environmental externalities of conventional energy generation, the opportunity cost to switch the energy paradigm is exposed.¹⁸

The first step decision makers should consider is to assess the type of RE technologies they want to incorporate into their energy mix. Each technology has its technical specifications and poses particular challenges in terms of structural and governance adjustments. In both cases, stakeholders should take into consideration the potential impacts of disasters on the RE assets. Air and water temperature, water availability and sea level are among the most important climatic factors that pose a threat to energy infrastructure (Table 3). To do so, similarly as with EE measures, proper integration between energy and land use and zoning policies should be done.

The contribution of RE to achieving the convergence of energy and climate change mitigation and adaptation targets is indisputable. In most integrated modelling scenarios, GHG emission reductions happen more rapidly through interventions to electricity generation than to any other sectors (*i.e.*, industry, buildings and transport). RE power plants accounted for more than 22 per cent of the total electricity generation globally in 2012, avoiding an estimated 3.1 Gt CO₂eq of emissions.¹⁹ In the absence of renewable-based power generation, the total emissions from the power sector would have been 20 per cent higher (IRENA and C2E2, 2015).

RE technologies are classified in two categories: (i) dispatchable (*i.e.*, biomass, geothermal and hydropower) and (ii) non-dispatchable or variable renewable energy (VRE) (*i.e.*, ocean power, solar PV and wind power). The former is constantly available and offers capacity factors close to those obtained from fossil fuels or nuclear power plants. Its “dispatchability” means that the source can be controlled in response to system requirements and variations in demand. Generation from the latter relies mainly on meteorological conditions. As a result, VRE capacity factors are limited and grid operators cannot fully plan the electricity generation from these sources. Only a percentage of the installed capacity is considered as statistically dispatchable and back-up capacity is required in power grids with a significant share of VRE (IEA, 2011).

In the case of dispatchable RE technologies such as geothermal and thermal, even if they are considered “renewable” the opportunity cost in terms of its sustainability is high. Therefore, the incorporation of these kinds of technologies is more complex and should be considered as long-term projects, instead of short or medium-term solutions to energy issues in the Caribbean.

On the other hand, VRE resources such as wind and solar PV allow a more flexible and cost-effective incorporation. However, since these resources are considered “non-dispatchable” they pose challenges related to voltage fluctuations. VRE has four characteristics that require specific measures to be integrated into current power systems: 1) variability due to the temporal availability of resources; 2) uncertainty due to unexpected changes in resource availability; 3) location-specific properties due to the geographical availability of resources; and 4) low marginal costs since the resources are freely available. VRE are intermittent and unpredictable, which in a centralization scenario could translate into complex power management obstacles. In that sense, since VRE allow wider range of conditions and provide ancillary services (*e.g.*, frequency and voltage control) they can be better matched with smart grid technologies, energy storage and more flexible generation technologies (*e.g.*, demand-side management and advanced metering infrastructure). Smart grid technologies explained in the next section could enable VRE integration, given their ability to reduce the variability in the system by allowing the integration of RE into diverse electricity resources. In addition, energy storage technologies can alleviate short-term variability up to several hours. Lastly, micro-grids and distributed generation are

¹⁸ In fact, the combination of increased investment, low cost, and technology development allows doubling RE shares in the world’s total final energy consumption within the next fifteen years.

¹⁹ No data available for the Caribbean.

two of the main applications for innovative technologies and operation modes for VRE since they can simultaneously improve the reliability, efficiency and performance of power systems, and due to the current high costs for power generation, VRE and grid integration technologies are economically attractive.

Transitioning towards higher shares of RE demand energy requires managers to re-think the design, operation and planning of power systems from a technical, economic and territorial point of view. Additionally, stakeholders should see to match supply and demand in a much more concerted and flexible way. To do so, the centralized generation paradigm, indifferently from the source, must be overcome.

Table 3
Potential climate impacts per asset class

	Thermal	Hydro	Wind	PV	Biomass (bio-energy)
Air temperature	X	X			X
Water temperature	X				X
Water availability	X	X	X	X	X
Wind speed	X		X	X	
Sea level		X	X	X	X
Floods	X	X	X	X	X
Heat waves	X		X	X	
Drought	X	X			X
Storms	X				

Source: WBCSD, 2014.

1. Next steps

Before making substantial changes to the energy generation paradigm there are important critical actions that decision makers should consider, especially to increase the deployment of RE. First, it is important to strengthen the policy commitment to RE and to mobilize funding. Second, institutional, technical and human capacity to support RE deployment has to be built across institutions and relevant actors. Finally, the crosscutting impact of RE on sustainable development must be harnessed by encouraging local and regional engagement, and promoting international cooperation on RE development (IRENA and C2E2, 2015). According to the C-SERMS the most important actions during this phase are:

- De-monopolize grid access and encourage IPP generation:
 - Facilitate dialogue among key stakeholders (*e.g.*, policymakers, utilities, users) to identify action plan for enacting reform;
 - Establish consistent and clear guidelines and rules of engagement to allow full incorporation of IPPs;
 - Establish independent regulatory bodies with capacity to design and enforce priority initiatives, policies, projects, and activities.
- Incentivize renewable generation through regulatory reform:
 - Develop policy mixes according to international and regional best-practices;
 - Develop model legislation;
 - Identify and implement support policies (*e.g.*, feed-in tariff, adopt a production tax credit, establish net metering/net billing, utilize auctions/tendering, develop dedicated rural electrification programs focused on renewable power);

- Identify and implement policy mechanisms specifically targeting areas/ populations with limited access to electricity;
- Create Renewable Portfolio Standards (RPS) to promote RE resources by mandating electricity supply companies to source a share of supplied energy from renewable energies;
- Develop an evolutionary approach to regulation for changing the generation landscape from existing assets to more intelligent and distributed approaches.

A modern energy policy that incorporates widespread use of RE and invests in energy efficiency would reduce risk in isolated communities, while reducing the country's expenditure on fossil fuels and production of greenhouse gas emissions. At the same time, a more stable grid would increase the resilience in areas such as health, water, and production. Territorial planning is another important area that requires attention as one of the first steps towards resilience.

C. Grid modernization

Due to the broad availability of RE resources and the wider need to decentralize generation systems (*i.e.*, to enhance energy access), Caribbean countries must overcome the current centralization paradigm. Although current grids could be, to some degree, compatible with available RE technologies (*i.e.*, mainly dispatchable RE), adjustments in their design and technical features are required if full RE potential is to be achieved. Additionally, after a disaster takes place, the bulk of the damage is absorbed by infrastructure (*i.e.*, especially overhead power lines, utility poles, transformers, as well as power generation stations), making the adjustments more imperative.

Given the characteristics of the region, namely multi-island states and small and dispersed populations, smart grids and distributed generation would contribute to increased resilience to disasters and climate change. According to ECLAC (2015 and 2016), settlements in the region are dispersed and contain small populations, which increases the costs associated with the provision of public utilities and the development of infrastructure, which extends for long distances to supply small communities. Dispersion of population also contributes to inequitable access to quality health, education and other social services. The provision of the services, however costly, is taken over by national governments, affecting the country's economic situation. These costs are exacerbated in times of disaster. Territorial planning is a fundamental tool to address such issues of physical vulnerability, and must be accompanied by social policies to reduce the gap in terms of quality of services and utilities. The following sections explore the characteristics and benefits of these systems.

1. Smart grids

The concept of smart grid comprises every definition that proposes changes to the current energy system paradigm. According to the European Technology Platform, smart grids are "electricity networks that can intelligently integrate the behavior and actions of all users connected to it generators, consumers and those that do both to efficiently deliver sustainable, economic and secure electricity supplies" (ETP, 2010). Modern smart grids are able to store, communicate and make decision in relation to the provision of electricity services even in the occurrence of a disaster. There is no standardized smart grid model; therefore their design depends on the objectives and capabilities of implementers. In that sense, they respond to local drivers of change and to local aspects in terms of energy mix, environment, legislation, regulation, markets, and customers, among others (Camarinha-Matos, 2016). Smart grids applications can be used in different stages of the electricity provision process (*i.e.*, transmission, distribution and demand-side), allowing the integration of RE-related measures with EE measures (see Annex 1) (Camarinha-Matos, 2016; Turballa and Lonchivar, 2016). Among the several advantages of smart

grids over traditional electric grids, the potential to mitigate and adapt to climate change stands out as the most important.

2. Distributed generation and microgrids

Although the centralized generation paradigm still permeates RE, the urgency to mitigate against and adapt to climate change impact, enhance energy access and security, and build resilience to disasters could boost the deployment of distributed generation throughout macro power systems. Distributed generation allows utilities and power users to diversify the energy sources from which the grid(s) is (are) nourishing. Although the installation of disperse power generators implies high investment costs, the capitalization of these systems could be balanced by the savings in transmission and distribution from high-voltage/centralized power generation systems. Other important benefits from the introduction of distributed generation are: (i) reduction of transmission and distribution losses; (ii) improvement of the power quality and reliability of supply; (iii) reduction in peak operating costs; (iv) system-wide reliability increase, and (v) enhancement of the energy markets through the integration of new stakeholders (*i.e.*, IPPs). Distributed generation in traditional transmission and distribution systems could translate into energy losses. Up until recent years distributed generation units have not been interconnected and have only been used as backup rather than primary energy source (Soshinskaya et al., 2013). Therefore, distributed generation units require their integration in an efficient manner to maximize its benefits and to avoid technical difficulties related to the control of a significant number of micro-sources (Suryanarayana, 2011).

Microgrids provide an optimal option to fulfil requirements of distributed generation. They are small scale, discrete electricity systems composed of interconnected power generation plants (*i.e.*, RE and fossil fuel), storage systems and energy management systems. They can operate either connected to the main distribution grid, off-grid (*i.e.*, islanding mode), or alternating. Despite potential implementation challenges (Table 4), the incorporation of microgrids allow power producers and costumers to increase the quality and reliability in the electric services (*i.e.*, reducing power losses by 7 per cent) in business as usual operations or during disasters. Additionally, they could help lowering electricity costs by 20–25 per cent. Such systems could also benefit local utilities since energy managers can repair them without affecting customer loads, providing load for use during peak power conditions, and lowering stress on the transmission and distribution system (Lasseter, 2007; Soshinskaya et al., 2013).

3. Next steps

Due to the broad availability of RE resources and the need to decentralize generation systems (*i.e.*, to enhance energy access), Caribbean countries must overcome the current centralized power generation paradigm. Although current grids could be, to some degree, compatible with available RE technologies (*i.e.*, mainly dispatchable RE), adjustments in their design and technical features are required if full RE potential is to be achieved. From a technical perspective, the integration of RE, especially VRE, into power grids requires a substantial transformation to:

- Allow for a bi-directional flow of energy from top-down (*i.e.*, from generators to users) to bottom-up (*i.e.*, end-users contributing to the electricity supply) that could ensure stability when installing distributed generation;
- Establish efficient electricity-demand and grid management mechanisms that allow reducing peak loads, and improve grid flexibility, responsiveness and security of supply in a context of increased systemic variability;
- Improve the interconnection of grids at the regional, national and local level, this would increase grid balancing capabilities, reliability and stability;

- Introduce technologies and procedures to ensure proper grid operation, stability and control (e.g., frequency, voltage, power balance) in the presence of a significant share of variable renewable energies;
- Introduce energy storage capacity to store electricity from variable renewable sources when power supply exceeds demand to increase system flexibility and security of supply.

In order to do so, the region must seek to incorporate the most up-to-date technical and design options available (see Annex 2). These options do not consist of generic solutions to be applied in every country but are alternatives to be incorporated in function of specific local challenges. Each country should undergo profound assessment and planning processes in coordination with national stakeholders to determine the best features the new grid should have. The selection of one or more of them should consider factors such as the current state of the grid, resources availability, goal and targets, funding, and local capabilities.

Among the suggested activities during this stage are (CARICOM, 2015):

- Undergo a grid assessment and determine the modernization requirements;
- Conduct baseline research for grid modernization potential;
- Assess potential contribution of technologies and measures to future energy and climate change mitigation and adaptation goals;
- Establish local standards, protocols and definitions for equipment (e.g. storage, smart meters), data transport, interoperability and cyber security;
- Expand collaboration in the development of regional standards to reduce costs and accelerate innovation;
- Increase the study of electricity consumption behaviour;
- Develop pilot projects on smart grids projects especially in the service (i.e., tourism) and residential sectors to incentivize their broad incorporation;
- Develop electricity usage tools and pricing practices to incentivize consumers to respond to changes in electricity markets and regulation;
- Promote adoption of real-time energy usage information and pricing that will allow for optimum planning, design and operation of distribution system in co-operation with customers;
- Determine policy approaches to strategically leverage investments and optimize outputs;
- Develop new policies and protection mechanisms to control and regulate privacy, ownership and security issues associated with detailed customer usage behaviour information;
- Develop safeguards for vulnerable customers who are less able to benefit from grid modernization projects;
- Find the linkages between grids modernization projects and energy efficiency initiatives (e.g., fleet electrification and NZEB).

Table 4
Challenges for the implementation of microgrids

Type	Challenges
Technical	Durability and efficiency of actual grids
	Effective functionality of communication and control software
	Dual-mode operation management
	Power and frequency control
Regulatory	Protection and safety
	Interconnection rules
Financial	Bi-directional power flow and ability to trade locally
	High costs of energy generation, storage technologies, and energy management systems
Stakeholders	Trust of constituents and conflicting self-interest
	Managing operations

Source: Soshinskaya et al., 2013.

IV. Monitoring and verification

The enhancement of resilience to disasters through the modernization of energy systems requires monitoring and verification to determine and evaluate the real reach of their impacts. Each phase of intervention requires a set of indicators that allow evaluators to measure performance in relation to a baseline scenario. It should be noted that monitoring and verification mechanisms must be incorporated from the design of the project, and include allocation of financial and technical resources, periodicity and accountability measures. Information should be shared, with other institutions and with the public, and be readily available for decision makers. It should also be used for policy learning, guiding changes or modifications based on progress or changes in conditions.

The United Nations 2030 Agenda for Sustainable Development indicators could be included as part of national sets to measure national goals. Some of them are: proportion of RE in the global energy mix; investment in energy infrastructure and clean energy technology; proportion of population with access to electricity; proportion of population with primary reliance on clean fuels and technology; RE share in the total final energy consumption; energy intensity level of primary energy. The BIEE project also represents an excellent platform to consistently obtain and update regional energy indicators.

In terms of DRM, ECLAC has developed an approach that could be very useful to ensure that resilience to disasters is achieved. Seven key elements were identified by the organization:

- Governance framework for DRM:
 - Instruments to promote DRM;
 - Articulation of DRM with climate change;
 - Access to information and public participation;
 - Standards for integrating recovery into development processes.

- Quality information for decision making on DRM:
 - Responsibility for technical guidelines;
 - Incentives to the generation and dissemination of information and knowledge.
- Integration of DRM in the project preparation and evaluation cycle.
- Territorial approach:
 - Decentralization of DRM processes;
 - Land-use planning.
- Sectoral approach.
- Macroeconomic policies:
 - Policies;
 - Management of funds;
 - Management of risk transfer mechanisms.
- Integration of DRM strategies and development.
 - DRM in the national development strategy;
 - Post disaster recovery, an opportunity for sustainable development;

V. Case studies

A. Trinidad and Tobago

1. Country profile

Trinidad and Tobago covers an area of 5,128 km² and has a population of around 1,360,000 inhabitants growing at an annual rate of 0.17 per cent. Population on Trinidad is concentrated in the western half of the island, whilst in Tobago in the southern half. As of 2016, the country had an estimated GDP of US\$ 43.57 billion. Trinidad and Tobago relies heavily on its energy sector for much of its economic activity. In fact, oil and gas typically account for about 40 per cent of GDP and 80 per cent of exports. The country produces more natural gas than crude oil (nine times) on an energy equivalent basis with gas contributing about two-thirds of energy sector government revenue. The government has been seeking to diversify the economy due to potential to do so (*i.e.*, democratic government and its educated, English speaking workforce). The country is considered a regional financial centre with a well-regulated and stable financial system. The Government of Trinidad and Tobago (GoTT) has targeted to increase investments in sectors such as tourism, agriculture, information and communications technology, and shipping. Factors such as low labour productivity, inefficient government bureaucracy, and suboptimal management, have held back a major economic development (Espinasa and Humpert, 2016).

2. Overview of the energy and disaster risk management sectors

Until now, the main normative element in the energy sector in Trinidad and Tobago, the Electricity Supply Act, is being revised and was not published by the time of elaboration of this study. The Ministry of Energy and Energy Industries (MEEI) is the main body governing the energy sector in Trinidad and Tobago. The ministry's Energy Research and Planning Unit has the responsibility to: 1) assess and refine energy industry strategy; 2) monitor effectiveness and progress of Local Content and Renewable Energy Strategies, and; 3) identify future areas for strategic emphasis that influence local energy sector developments. The ministry is responsible for the energy policies, strategic direction and planning of the national energy sector. The main regulator body is the Regulated Industries Commission (RIC).

The Environmental Management Authority (EMA) functions as Trinidad and Tobago's environmental regulator. It approves and monitors applications for energy related developments and provides a Certificate of Environmental Clearance (CEC) for all economic activities with potential impacts on the environment. Beyond these tasks, it is important to clarify how the EMA could be further involved in future RE/EE-related activities. Other important stakeholders are the Ministry of Public Utilities, the Trinidad and Tobago Bureau of Standards (TTBS) and the Trinidad and Tobago Electricity Commission (TTEC).

The Trinidad and Tobago electricity sector is characterized by an overwhelming reliance on fossil fuels. Although there is an increasing interest of the GoTT to incorporate RE, the fact that the country has an electricity surplus and that the tariffs are heavily subsidized, makes it difficult for stakeholders to accept the change of the current energy paradigm (Table 5).

Table 5
Overview of the energy sector in Trinidad and Tobago (2015)

Total installed capacity	75 MW (TTEC) 2,080 MW (IPPs)
Maximum demand	1,322 MW
Total generation	8,589 GWh
Renewable generation	0 MW
Renewable share	0 per cent
Losses	5.9 per cent
Electrification rate	97 per cent
CO2 emissions from electricity and heat generation	13.41 million metric tons
Electricity tariffs	Residential \$0.04 Commercial \$0.08 Industrial \$0.03

Source: IRENA, 2015.

In terms of DRM, the Office of Disasters Preparedness and Management (ODPM) is the main government agency in charge. The ODPM has the objective to build national DRM and climate change adaptation capabilities with other partners and coordinate response and recovery operations to protect the people, environment and economy and ensure resilience to disasters. The main legislative element is the Disasters Measures Act of 1978. Nevertheless, other aspects of the management of disasters are disseminated in more than twenty legislative elements (*e.g.*, amendments). The fundamental considerations of the Disasters Measures Act are:

- A comprehensive approach: strengthen preparation for, prevention and mitigation of response to and recovery from hazard impacts/ disaster
- A resilient community approach: Strategies for strengthening general public's ability to better cope with hazard impacts
- An all agencies approach: All relevant agencies understand their role and collaborate towards the same goal
- An all hazards approach: Focus on all hazards that impact the citizens and landscape of Trinidad and Tobago
- Enablers identified: All supporting activities, strategies, stakeholders and requirements for achieving all objectives

- Incorporation of legislative components: Ensuring alignment between policy and legislation

Another piece of legislation that could be triggered to boost the enhancement of resilience through the modernization of the energy sector is the Planning and Facilitation of Development Act (2014). Among other objectives, the Act has the objective to assist in the orderly, efficient and equitable planning, allocation and development of the resources of Trinidad and Tobago, taking account of all relevant social, economic, ecological and cultural factors so as to ensure that the most efficient, equitable and environmentally sustainable use of land is made in the interests of all people of Trinidad and Tobago. The Ministry of Planning and Development is the national planning authority, which has the responsibility to assure that land planning and land use is made in accordance to the national interest and considering the national normative. This document also assigns responsibilities to government agencies to develop building and retrofit codes, and standards, among other aspects.

Finally, Trinidad and Tobago has been working with CDEMA in the elaboration of a hazard mitigation policy draft; nevertheless, no further progress in this matter was identified.

3. Energy sector and resilience to disasters

Although Trinidad and Tobago is not a regional frontrunner in transitioning to a cleaner energy system, stakeholders have started to realize the importance of RE and EE, especially for the mitigation against and adaptation to climate change and, in general, for the improvement of human well-being in the islands. The IDB (2015) studied the potential and challenges to move forward in the direction of a cleaner energy paradigm. Unfortunately, although many ministries and related stakeholders have done a great job in advancing the clean energy agenda, advancements have been delayed in the legislative branch.

Until now, two of the most important legislative elements, the Trinidad and Tobago Electricity Commission (TTEC) Act and the RIC Act, make no provision for RE power generation by IPPs. The GoT currently seeks to establish an adequate legislative framework that allows harnessing the RE potential in the island. This supposes reviewing the dispersed legislation elements related to the energy sector, which as a result will impact the current roles and responsibilities the different government agencies have. To do so, the GoT has collaborated with the United Nations Environmental Program (UNEP) and other regional entities to update and improve the legislative and institutional frameworks. Among the main actions the government has taken towards this direction are:

- The Ministry of Planning and Development has been working on a strategy to de-carbonize the economy. It aims at tackling five main areas: EE and conservation; RE; solid waste management; sustainable transport; and environmental conservation (e.g., protection areas, carbon sinks).
- The adoption of feed-in tariffs (action supported by UNEP);
- National Wind Resource Assessment Program (WRAP);
- The MEEI with the support of the University of the West Indies (UWI) Engineering Institute developed a Renewable Energy Policy Framework for Trinidad and Tobago. It has the objective to provide optimum growth and development of the country's RE resources to maximize opportunities for clean energy and clean production and the development of a culture for EE and conservation. The Cabinet approved this Policy Framework in late 2010 and it has been incorporated in the Draft Policy Green Paper, which is currently being finalized (no update available in relation to this initiative);
- The TTBS has collaborated with the MEEI to revise the National Electrical Wiring Code with the intention to address compatibility issues involving RE power generation systems

and potential integration with the national grid. Parallel demonstration projects have also been commissioned;

- Elaboration of standard for solar water heater systems (*e.g.*, TTS 106:2012) and thermal solar systems and components (TTS/EN 12975-1:2012);
- Installation of RE technologies in community centers (*i.e.*, PV for external lighting);
- Installation of RE technologies in schools and supporting training programs (*i.e.*, solar PV and distillation units);
- National Energy Communication Campaign;
- Waste-to-energy assessment.

Solar and wind seem to be the most suitable RE resources in the country; however, other RE resources have also been considered. For example, wave and tidal energy deployment has been assessed with the collaboration of the Institute for Marine Affairs as part of public sector investment programs.²⁰ The main discussion in relation to RE deployment is the way it will be rolled-out (*i.e.*, centralized power generation or social-distributed generation). Stakeholders in Trinidad and Tobago, mainly the utilities, must determine the degrees of participation of IPPs.

In terms of EE, no detailed, comprehensive study has been made to assess the country's potential. The Energy Chamber identified that EE can be better tackled in power generation. As a result, financial incentives are being discussed to improve power generation and avoid losses. The GoTT is aware of the great potential other sectors have in terms of EE. In the industrial sector an EE study conducted on the Point Lisas Industrial Estate (2011) revealed significant potential for energy savings. Additionally, tax incentives to promote EE in the industrial and commercial sectors have been introduced. Finally, an Energy Service Company Certification Committee was established to certify and set criteria and standards for energy service companies. In the public sector, a pilot project was done with assistance from IDB to conduct energy audits in selected government buildings. In the residential sector, incandescent light bulbs were exchanged with more EE compact fluorescent lamps (CFL) in several communities. Also, a pilot study implemented by UWI measured the impact of switching to CFLs on the electricity bills of selected residents. Trinidad and Tobago is currently discussing adopting a building code that includes EE measures.

According to the MEEI, at this moment there is no appetite for microgrids because there is more than 99 per cent electricity coverage, but there is interest in smart grids technologies. In fact, from a technical point of view, TTEC grid is ready. The company has almost completed a full deployment of advanced metering infrastructure (AMI) to all its customers.

Governance frameworks in Trinidad and Tobago show weak linkages between DRM and the deployment of RE/EE technologies and measures. Even more, consulted stakeholders expressed that there is no deliberate effort from a sector of the government to do so. Despite some isolated initiatives (*e.g.*, solar shelters, smart house and soar bus at the UTT), stakeholders (*e.g.*, ODPM) advocate more for "small but meaningful" approaches such as solar instruments during crisis (*e.g.*, flashlights). The main legislative piece, the Disasters Measures Act (1978), is considered response-centric and can only be triggered when a catastrophic event occurs. In this sense, it does not include provisions for disaster risk reduction and resilience, including issues of sustainable energy. Additionally, as expressed by consulted stakeholders, there is also no involvement from the utilities to develop strategies to enhance the resilience to disasters. The ODPM is a very active stakeholder in the discussions related to the effects of

²⁰ Feasibility about tidal energy: Tidal differences are no considerable. They do not have sustained current to allow marine power. Only feasible between Trinidad and Tobago islands in the Galleons Passage.

climate change, especially as it is deeply linked to disasters; nevertheless, their involvement with RE/EE topics is limited.

4. Moving forward

The modernization of the energy sector represents a great opportunity for Trinidad and Tobago not only from the perspective of the enhancement of the resilience to disasters but from an economic one. The fact that the country is a leader in the energy sector opens a window of opportunity for decision makers to take that reputation and expertise to foster a regional transition to cleaner energy systems. As extracted from consultations with stakeholders, now the country has the will and technical capacity to lead the transformation, at least at the local scale.

During the last years the sustainability benefits of the transition have permeated the mindset of the relevant stakeholders making them move towards modernization. Complementarily, households and business appreciation of RE/EE is growing, prompting them to push for a paradigm change. However, according to stakeholders there are some important constraints (*i.e.*, threats and challenges) that affect the proper modernization of the energy sector in Trinidad and Tobago.

- Grid assessment: Although Trinidad and Tobago has a modern grid and certain assessments have been conducted, they are not available for other stakeholders to consult and to further guide a discussion on the next steps to take towards the modernization of the energy sector.
- Subsidized fossil fuel product prices: Electricity tariffs are so low that including RE could mean a direct increase. Fluctuations on fossil fuel prices help increase the popularity of RE initiatives; however, finding of new oil or gas sources discourage them.
- Data gaps: Data from the energy sector is rarely available to the public or unreliable. It is known that great amounts of data sets and documents are produced; however, this information is not always shared with other relevant stakeholders and even between government agencies. To have complete and reliable information and data is a first step to produce consistent strategies for the modernization of the energy sector in the country. This issue highlights the importance of improving or introducing guidelines for data and information collection, sharing and dissemination with different stakeholders.
- Consistency: What is important for one administration may not be important for the next. Therefore, the modernization of the energy sector must be undertaken as a national project, and strategies towards its achievement should be followed regardless of political orientations.
- Duplication of efforts: As a result of data gaps and lack of collective work, government entities and international organizations find themselves working in projects with similar objectives. The assignation of resources should be better directed to implement some of the initiatives already suggested.
- Engagement of stakeholders and public awareness: Some stakeholders need to be better engaged in the energy modernization process. Some cases (*e.g.*, EMA and ODPM) show that there is still no clarity on the roles the different stakeholders will have in the modernization process.
- Policy and legal frameworks: The adaptation/creation of suitable regulatory and legal frameworks to guide the modernization of the energy sector is slow and threatens the proper development of the process. No IPPs are currently allowed and no RE portfolio/quota defined in the national legislation, this situation restraints considerably the deployment of RE from actors other than TTEC.
- Human capital and local capacities: Small staffs and/or constant rotations restraint the evolution towards a new energy paradigm. Human capital should have the capabilities and

specialized knowledge to face the challenges set by the modernization of the energy sector (e.g. project design and implementation).

- Finance and markets: Initial investments for RE/EE projects are high, making investors' attraction not an easy task for local stakeholders. It is important that Trinidad and Tobago, as a regional leader in energy matters, takes an active position to create a regional market for cleaner energy technologies. More investment for the implementation of projects must be attracted into the region.
- Monitoring and verification: The country does not have adequate monitoring and verification tools and data to measure improvements. Key performance indicators as evaluation and monitoring tools should be established by responsible stakeholders.

As a first step to move forward in the modernization process, Trinidad and Tobago is required to advance the legislation related to mainstream RE/EE. Through this legislation stakeholders should have an understanding of the road the country will take as a whole. Additionally, it would allow them to have clarity about their roles and responsibilities in this process.

Entities such as the EMA should be better involved in the definition of environmental standards for the deployment of RE technologies and EE measures. The legislation should also progress to establish closer linkages between the energy sector and DRM. Regional initiatives such as the ECERA should be better leveraged to support local stakeholders. Additionally, the GoTT should take advantage of ongoing initiatives to improve capacity building and opportunities for technical assistance to complement local efforts (e.g., SECBI and United Nations Observatory for Renewable Energy in Latin America and the Caribbean).

In light of the challenges the enhancement of resilience pose, stakeholders should focus on EE measures since they are the less costly and easiest ways to make real impacts on the energy sector. Due to the low costs of electricity, the uptake of EE measures has been limited in Trinidad and Tobago. It is recommended working towards promoting and engaging other stakeholders in EE practices is an important step in transitioning to low emission and climate resilient development. Some of these practices are (IDB, 2015): 1) definition of standards for poor EE equipment (e.g., incandescent light bulbs); 2) lead regional initiatives for a harmonized approach on efficiency standards and labelling for domestic electrical appliances; 3) apply energy-related minimum building standards for social housing and public government buildings; 4) reducing the use of electricity for water heating; 5) encouraging the use of energy-efficient appliances and lighting; 6) reducing energy consumption in the social housing sector; 7) improving air-conditioning efficiency; 8) using more efficient lighting and controls; 9) using more efficient equipment and appliances in rooms and back-of-house 10) encouraging green hotel certification; 11) promotion of energy management for public institutions; and 12) engaging and motivating consumers to adopt no-cost, durable energy savings behaviors. The GoTT should also advance legislation in order to create a building code and to enhance EE in the transportation sector. In relation to the former topic, CARICOM REEBC and OECS building codes could represent good base documents to incorporate climate change resilience and EE into a local building code.

Although energy infrastructure in Trinidad and Tobago seems to be more resilient than other countries in the Caribbean due to the relative low natural vulnerability and the existence of several generation plants, stakeholders should seek to include climate change and disasters considerations in national energy legislation and policies. This includes integrating land planning and zoning more intensively into the policies directed to energy modernization and development. In this sense, RE roll out should consider a broad participation of IPPs to ensure increased generation and dispersion, and hence enhanced resilience.

Capacities have to be generated, mainly in entities such as the ODPM to include aspects of energy management during disasters. As the specialized agency, the ODPM could play an even more important role in collaboration with utilities and related stakeholders in identifying exposed assets and designing intervention strategies to reduce the risk of disasters. Also, the GoTT should leverage more the presence of regional and international entities such as the ACS, ECLAC and OECS to include the role of the energy sector in the building of resilience to disasters. Trinidad and Tobago should take advantage of projects such as OECS' iLand to move forward a more integral approach to DRM in the country. Finally, to assure that resilience enhancement is included in the normative framework, the GoTT should take advantage of the current revision of the energy act to incorporate a more integral perspective of the role of the energy sector in the development of the country.

B. Grenada

1. Country profile

Grenada consists of three islands: Grenada, Carriacou and Petite Martinique. The country covers an area of 344 km² and has a population of around 103,000 inhabitants that is growing about 0.54 per cent yearly. Approximately one third of the population is in the capital of St. George's; the island's population is concentrated along the coast. Grenada has a GDP of US\$ 1.028 billion generated by three sectors: services (*i.e.*, government services, education, banking and insurance, tourism, and communications) (76.6 per cent), industry (13.8 per cent) and agriculture (9.6 per cent). The switch from an agriculture-based economy to one based in services came as a result of hurricanes Ivan (2004) and Emily (2005), which damaged most of the nutmeg and cocoa cultivations. After the hurricanes, Grenada experienced a robust economic growth; however, it started to decline in 2006. Today, public debt-to-GDP is about 110 per cent, limiting public investments and social spending (Espinasa et al., 2016).

2. Overview of the energy and disaster risk management sectors

The institutional energy sector in Grenada is led by the Ministry of Finance, Planning, Economic Development, Trade, Energy and Cooperatives through the Department of Energy and Sustainable Development. The ministry is responsible for overall energy policy, legislation and regulations on imports and sale of oil products, whilst the latter is responsible for energy and electricity markets. It leads the development and implementation of RE policy and the promotion of new and EE technologies. The Grenada Bureau of Standards (GDBS) is the body in charge of providing standards and certification to ensure good quality RE equipment is entering the market. Other relevant entities are the Ministry of Agriculture, Forestry, Fisheries and Environment and the Ministry of Communications, Works, Physical Development, Public Utilities and ICT. The former is involved in the planning and implementation of RE resources, whilst the latter oversees the electricity sector.

In terms of the policy and legislative frameworks, the Grenada National Energy Policy (GNEP) (2011) is the main guideline and roadmap to the development of a healthy energy mix in the country. The GNEP aims at four main objectives: 1) facilitate the integration of RE sources into the national energy mix; 2) guarantee the judicious development of the island's indigenous hydrocarbon resources; 3) guarantee social inclusiveness and equity to access to energy; and 4) build a more competitive, productive economy. The policy is guided by the principles of energy security, energy independence, EE, energy conservation, environmental sustainability, responsible resources exploitation, rational energy prices and energy equity and solidarity.

The GNEP established a feed-in tariff of EC\$ 45 cents for the deployment of RE, which represents the equivalent cost of the avoided diesel. It also created domestic duty concession on the purchase of equipment for solar PV, among other measures (annex 2). Finally, the document defined clean energy goals as follows: 10 per cent of all buildings equipped with RE technologies by 2015 (outdated); 20 per

cent of all electricity and transportation energy from RE sources by 2020; 20 per cent reduction of greenhouse gas emissions by 2020; and 100 per cent RE by 2030, among other goals. These goals were not accompanied by a strategy to achieve them and are now subject to review. Among the most relevant actions proposed by the GNEP is the revision of the Electricity Supply Act. The Act was finally reissued in 2016. The GoG has taken advantage of the ECERA in order to move forward in this matter as well as in other related topics (*i.e.*, technical cooperation, revision of tariffs). However, it is important to note that the accomplishment of these goals could be hampered by the country's potential incursion in fossil fuel extraction, especially affecting its GHG emissions and targets.

The GNEP has consideration for the role of energy in disaster management. Annex II - Energy Sector Diagnostic recognizes that "Grenada is vulnerable to disasters, such as hurricanes, floods, storm surges, earthquakes, volcanic eruptions and tsunamis". It further recognizes that "as a result of climate change and sea level rise, energy assets located in coastal areas (e.g. petroleum storage tanks and electricity generating plants) are becoming more vulnerable." Therefore, the GNEP highlights the core role of the GoG, GRENLEC and other stakeholders in assessing the risks and vulnerability of major energy infrastructure. The plan also highlights the importance of future planning decisions (*e.g.*, the placement of petroleum tank farms, wind farms and other generation, transmission and distribution facilities) to be influenced by these kinds of assessments.

Current installed capacity (52.41 MW) is enough to meet domestic energy needs; nevertheless, current maximum demand (31.8 MW) is expected to double by 2028 (Table 6), and renewable power generation remains limited (2.2 MW) with equally distributed shares of generation among customers and the utility. Hence, in light of current oil dependency issues, the government of Grenada is seeking to diversify its energy sources. The costs of utility-scale solar in Grenada are estimated to be between US\$0.21/kWh and US\$0.44/kWh; wind costs are estimated to be between US\$0.05/ kWh and US\$0.20/kWh (2014 data).

Table 6
Overview of the energy sector in Grenada (2016)

Total installed capacity	52.41 MW
Maximum demand	31.8 MW
Total generation	218,508,146 kWh
Renewable generation (solar)	2.2 MW (1.1 MW utility and 1.1 MW customers)
Renewable share	4.4 per cent
Losses	7.58 per cent
Electrification rate	>99.5 per cent
CO2 Emissions from electricity generation	138534.16Tonnes of CO2 Emissions/KWh
Electricity tariffs	Domestic: 0.4057 \$/kWh Commercial: 0.4375 \$/kWh Industrial 0.3207 \$/kWh Street Lights 0.3839 \$/kWh

Source: Espinasa et al. 2015, GRENLEC, 2017.

Grenada Electricity Services Limited (GRENLEC) is in charge of the provision of electricity services in Grenada. It has the exclusive license to generate, transmit, distribute, and sell electricity until December 31, 2073. WRB Enterprises of Tampa, Florida owns 50 per cent of the issued ordinary share capital of the company. The Government of Grenada and the National Insurance Scheme together own 21 per cent, employees own 4.5 per cent and the remaining 24.5 per cent is owned by approximately 1,600 Grenadian and Caribbean investors. GRENLEC has several generation plants, mostly diesel-

fueled, that function depending on the demand (Table 7). The company set an independent goal of meeting 35 per cent of electrical consumption from RE sources by 2016, independent of the energy goals set by the government of Grenada. Similarly to the government's case, there was no defined strategy to achieve this goal.

In relation to the management of disasters, the main stakeholder is the National Disaster Management Agency (NADMA). The NADMA has the responsibility to reduce the loss of life and property within the country by ensuring that adequate preparedness, response and mitigation measures are in place to deal with the impact of hazards. It is in charge of the coordination with all the pertinent agencies during a catastrophic event.

Grenada counts with a National Disaster Plan (GNDP), which includes some considerations related to the energy sector, especially related to assessment and attention of the electrical infrastructure during an emergency. Although the GNDP aims at enhancing resilience, no specific measures to the energy and land planning sectors is done.

Table 7
Power generation plants in Grenada

Type	Location
Diesel	Queens Park (45.9 MW) Carriacou (3.2 MW) Petit Martinique (0.5 MW). St George's University campus at True Blue (2.8 MW of standby generation capacity)
Solar PV	Grand Anse (148 kW) Dusty Highway Facility 48.48 kW PV (3 buildings) 52.92 kW PV (2 buildings) 143.64 kW PV (carport) Queen's Park Power Plant y Substation 102.06 kW PV (4 buildings) 30.24 kW PV (car port) 268.38 kW PV (ground mounted installation) Petite Martinique 31.59 kW PV (approx. 20 per cent of peak electricity demand) Fort Frederick Demonstration Project 1 kW Wind + 1.84kW PV St. Andrew's Anglican Secondary School (SAASS) 13.92 kW (rooftop installation)
Wind	Carriacou wind energy project (2 MW) ^a

Source: Espinasa et al. 2015, GRENLEC, 2017.

^a Although the infrastructure exists, the operations are currently off.

CDEMA has worked closely with the government of Grenada in the development of a policy framework for DRM. Together, they elaborated the Comprehensive Disaster Management Policy and Strategy (CDM). This policy takes into account relevant local conditions. It is designed to accomplish objectives such as: 1) enhancing the enabling environment for CDM; 2) improving DRM; 3) building robust disaster resilience; 4) mainstreaming CDM in all areas of national planning and development and 5) strengthening partnerships for CDM. The CDM was incorporated by the CDEMA and the GoG in the Work Program 2015-2019.

The policy recognizes the importance to address issues such as:

- Unsustainable land management practices, including inappropriate land use change, and land development in vulnerable locations, such as along steep slopes, river banks and coastal areas.

While all assets are prone to negative impacts in the latter areas, informal settlements are at greatest risk due to inadequate engineering and planning, aggravated by high exposure to hazard events (GRDRR, 2010; Roberts, 2012).

- Significant incidence of informal land tenure arrangements, particularly among poor and displaced individuals. This situation was brought to the forefront post Hurricane Ivan (2004), and seriously constrained allocation of financial resources from the international donor community in rebuilding homes and lives, hindering effective recovery.
- Inadequate engineering designs of building structures.
- Insufficient adoption of DRR practices in the prime economic sectors and at the community level.

Additional pieces of legislation that are triggered for the management of disasters are:

- The Growth and Poverty Reduction Strategy (2014-2018)
- National Environmental Management Policy and Strategy 2005
- Grenada National Climate Change Policy and Action Plan 2007-2011
- The National Hazard Mitigation Policy 2003 and Strategic Plan 2006
- The National Water Policy (Draft) 2007
- The National Gender Policy
- The National Physical Development Plan 2003
- Grenada National HIV/AIDS Strategic Plan 2009-2015
- The National Strategic Plan for Health 2007-2011

3. Energy sector and resilience to disasters

Grenada shows great potential to deploy renewable energies. Solar, wind and geothermal power appear to be the most discussed options to clean the energy sector. Several documents (*e.g.*, IDB, 2015 and IRENA, 2015) highlight RE potential and prospective project to be deployed by the country. IRENA (2015) in particular, deployed one of the most comprehensive readiness analyses for the island. However, by the time of elaboration of this study, the deployment of RE projects has slowed down due to lack of coordination between the GoG and GRENLEC caused by the enactment of the Electricity Supply Act. As a consequence, projects such as the Carriacou wind project supported by the European Union and the construction of a geothermal plant supported by the governments of New Zealand and Japan are currently on hold. In relation to the latter, the Caribbean Development Bank (CDB) approved a grant of US\$ 231,630 to the government of Grenada to build its capacity for planning and implementation of its geothermal energy development roadmap. The resources come from the GEF through the IDB Sustainable Energy Facility for the Eastern Caribbean with the CDB. Slim hole drilling is expected to take place in the near future. Nevertheless, access to the potential areas is difficult due to lack of roads and tenure issues. The GoG expects to hire a project manager to analyze further deployment. In this regard, it is recommended to revise the role and involvement of GRENLEC in the project.

The GoG also expects to harness local hydropower potential. To do so, the National Water and Sewerage Authority (NAWASA) is working together with the GIZ office in Grenada in the project "G-Hydro: Innovative electricity production in Grenada through In-Conduit Hydropower." The project seeks to initiate a pilot project for the installation of small hydro turbines in the portable water distribution systems. Two turbines will be installed and connected to the grid; their capacities are 15 kW and 40 kW.

The project is in an advanced stage of deployment, and the specifications for the equipment are currently under assessment.

GRENLEC continues deploying RE projects across the island, mainly solar PV. The design of a 400 MW solar PV installation in Petit Martinique is expected in the near future (75 per cent penetration for the island). Additionally, land has been secured for a 1 MW solar installation at the old airport in Pearls. The most relevant RE project not involving GRENLEC is the Energy for Rural Development bilateral project funded by the Government of Korea. The project aims to contribute to reducing energy cost for the targeted beneficiaries and to reducing the carbon footprint through the use of low emission systems. It is expected to contribute to the design and implementation of future and scaled-up project interventions with similar objectives. The project includes the purchase and installation of off-grid and grid-tied solar photovoltaic energy generating and storage systems/units and the training of beneficiaries in the use and maintenance of the systems. The beneficiaries of the project are: 1) twelve single-parent households in rural communities without access to electricity where the head of the house is female and at least one of the children is attending primary or secondary school; 2) twelve vulnerable elderly persons without access to electricity and unable to meet the cost of installing electricity in their homes; and 3) four small agro processors in rural communities whose operations can benefit from reduced operational cost through the use of renewable energy.

Other RE initiatives being deployed in Grenada that could have an impact on electricity consumption and resilience to climate change and disasters are:

- Market creation for small-scale biogas systems (MacBios): This project has been deployed with the cooperation of the GIZ and the German biogas technology supplier ÖKOBIT. It aims to create an enabling environment for biogas technology as a sustainable waste management practice while reducing the dependence on imports such as LPS and chemical fertilizer. Several biogas systems have been installed in Grenada in order to demonstrate its suitability for households and small farms.
- Solar water heaters: More than 4,500 solar water heater units were introduced in the country. Currently, the Grenada Public Service Co-Op Credit Union offers a tailored loan program to finance solar water heaters. In terms of incentives to purchase these technologies, only hotels enjoy duty free concessions.
- In 2011, the Grenada Solid Waste Management Authority (GSWMA) assessed the potential of a waste-to-energy project. The study identified a waste-to-energy project that would cost US\$ 48 million. Until now no further advancements have been made.

Further RE developments are also compromised due to land tenure issues (*i.e.*, access, elevated prices, competition, and legal uncertainty) that make it difficult to allocate sites for RE technology installations. Although the policy environment is adequate, current business models and market size do not contribute to making the technology affordable for widespread adoption. For example, if a hotel requests a local bank for a loan to purchase PV panels and equipment, there are no protocols in place that could allow the bank to calculate risk or the proper capitalization of the RE projects. As expressed by stakeholders, the Department of Energy and Sustainable Development cannot have a real impact in this regard since projects in this area are driven by stakeholders (*i.e.*, mainly GRENLEC), the budget of the government is limited, and transmission and distribution networks are not of public access. In this sense, the GoG is only seen as a beneficiary of such projects. Added to that, other relevant stakeholders (*e.g.*, private sector, etc) are not properly motivated to participate in such activities. In the case of marine power and waste-to-energy, although the discussion is already present, no concrete ideas have been proposed and the roles and responsibilities of the stakeholders still have not been defined.

In terms of EE, several policies and programs have been implemented: 1) demand-side EE programs; 2) joint UNDP, GoG and GRENLEC pilot project to replace sixty 100-watt high pressure sodium streetlights with 52-watt light emitting diode (LED) in Grenada and Carriacou; 3) involvement in the GEF two-year Energy for Sustainable Development in Caribbean Buildings Project; and 4) US\$ 2 million in 2012 from the Alliance of Small Island States-China Climate Change Adaptation Pilot Program to finance hardware, equipment, and training. The Grenada Development Bank (GDB) has been asked to take the lead to set the example for players in the financial landscape for EE. In 2015 the bank opened a line of credit to, among other things, support pilot projects of EE and RE in micro, small and medium-sized enterprises.

EE is also starting to be considered more intensively in the building sector. Grenada is part of the CROSO and they have been discussing the adoption of the REEBC in the country. Grenada is also looking to adapt equipment standards from other countries (*e.g.*, Barbados, Jamaica and Mexico) to their local reality. The Ministry of Works, Physical Development and Public Utilities modified the Physical Planning and Development Control Act; nevertheless, EE and RE aspects were not considered. Since 2011, the Grenada Hotel and Tourism Association has been managing a fund from the CARICOM Development Fund to support EE practices in the hotel/tourism sector. This effort shows the increasing willingness from transversal sectors to contribute to the inclusion of EE measures. Other relevant actions taken by Grenada in relation to EE are:

- The Carbon War Room has been approached to work towards EE in the government buildings with no clear engagement until now.
- USAID has been approached to develop a grid code and an EE act. A draft is expected by the end of 2017.

The GoG has taken an active position to modernize the energy system in all relevant sectors. There has also been an involvement of international organizations which have provided their expertise and resources in a consistent manner to help Grenada move forward in this regard. Nevertheless, there are barriers that hinder a more constant and effective progress. The most important barrier for the modernization of the energy sector in Grenada is the weak articulation between the GoG and GRENLEC caused by the intended changes in the legislation. This situation weakened the trust and collaborative work between stakeholders. Additionally, legislation has to be advanced in order to create a market for RE and EE. Energy customers, especially in the tourism sector, have shown their interest to incorporate energy-related measures; nevertheless, incentives to do so remain limited. In light of the aims to enhance resilience to disasters, robust distributed generation could be of great advantage to the country. Incentives should also be put in place to modernize the transportation sector. It is suggested for the GoG to take advantage of the initial efforts deployed by GRENLEC and private users to mainstream the incorporation of such technologies across the island.

In terms of the role of the energy sector in the enhancement of resilience, the only relevant experience is the role of NADMA in the discussion about the installation of a geothermal plant in the island. Similarly to the case of Trinidad and Tobago, NADMA has a discrete role in terms of the deployment of mitigation and adaptation measures (*i.e.*, RE/EE). They focus more in the promotion of education. They have worked together with the WB and Saint Vincent and the Grenadines in the deployment of Regional Disaster Vulnerability Reduction Projects aimed at improving the safety of buildings from the impacts of climate change and increase their public institutions' capacity to assess natural risks. Prospective projects linking the energy sector resilience are focused on the provision of RE technologies to shelters and the provision of solar tools during an emergency.

Grenada has an adequate policy framework that could potentially integrate the climate change, energy and DRM agendas. Nevertheless, the absence of a legislative framework hinders the deployment of specific actions and the assignment of particular roles and responsibilities to stakeholders.

4. Moving forward

Grenada has shown great willingness to explore possibilities to transition to a sustainable energy sector. To do so, the GoG has surrounded itself with a great number of regional and international organizations (e.g., CARICOM, GIZ and CDEMA). Other stakeholders such as GRENLEC have also assumed its role and taken over their responsibilities in this regard. Nevertheless, current articulation hinders the deployment of a more aggressive process of incorporation of RE. The liberalization of the energy sector stated in the Electricity Supply Bill raised internal concerns. Although the company continues deploying RE projects, other main developments such as the geothermal plant are on hold. As a first step, the GoG and GRENLEC should find ways to rearticulate their collaborative work. Both actors should find common ground in their interests to create a favorable environment for the modernization of the energy sector.

IRENA (2010) broke down the main steps stakeholders in Grenada should follow to advance in the modernization of the energy sector. In light of the challenges set by disasters and climate change, these steps were complemented.

- Set up an independent regulator for the electricity market. The GoG should make sure PURC is put in place within the established timeframes to assure the balance of forces between stakeholders in the country is achieved. Once a regulatory framework is established, it is expected that stakeholders will feel more motivated and engaged to take part of RE/EE projects;
- Finalize the concessionary agreement for geothermal and conduct appropriate environmental and social impact assessments (including road access to the chosen site).
- Allocate suitable lands for RE development in zones with high renewable potential and low vulnerability for disasters.
- Finalize the review of the current interconnection policy to promote business models that can increase the deployment of renewables.
- Fill legislation gaps in the DRM area.
- Develop GDBS' capacity to provide standards for EE/RE equipment.
- Support T. A. Marryshow Community College in developing a curriculum and training technicians in RE/EE technologies.
- Develop the capacity of the meteorological office to carry out comprehensive RE resource assessments.
- Source concessionary credit lines for the GDB so that it can make soft loans available for investment in RE/EE technologies. Develop the capacity of lending agencies to assess associated risks;
- Develop a business model to design and install stand-alone RE systems, especially in the household sector.
- Promote solar pumps for farmers;
- Encourage building codes to be updated.
- Encourage the uptake of solar water heaters for domestic and commercial water heating through an enabling policy framework.

VI. Final considerations

Sustainable energy boosts the momentum for the modernization of energy systems to face the challenges posed by disasters and climate change impacts in a comprehensive manner. The impact of climate change is not the only issue that should drive decision makers to switch to a more sustainable energy paradigm. There are country-specific drivers of change that could encourage the faster adoption of one RE technology over another. These drivers of change are influenced by priorities for development and include political, social, environmental and economic factors. An important driver is the need to reduce (or eliminate) dependence on fossil fuels. However, more ambitious and long term drivers also surface, among the most important are: 1) development of energy markets; 2) increase reliability of the electricity sector; 3) increase in domestic energy production from RE sources; 4) reduction of electricity price volatility; 5) self-sufficiency; 6) updating normative frameworks for self-generation and distributed RE; 7) grid modernization; 8) diversification of the energy generation mixes and promotion of innovation and new businesses in domestic enterprises; 9) regional and local interconnectivity, and 10) low emissions.

In a context of global mega trends that seek to boost innovation to improve productivity and quality employment, the Caribbean could use this opportunity to spearhead research and innovation on EE and RE for small economies and island nations. According to ECLAC and ILO (2018), the transition to sustainable energy is expected to create one million new jobs in Latin America and the Caribbean through 2030, opening opportunities for specialization and creation of innovations and business models that build on the Caribbean experience and respond to the particular characteristics of SIDS.

Regarding DRM, it is of great importance that the response-centric approach of the governance frameworks is being overcome and that the mitigation and adaptation perspectives are better incorporated into policies and enforcement mechanisms. As mentioned, the energy sector has an important role in every stage of the DRM cycle. The region shows great signs of moving in the right direction by incorporating RE/EE in the later phases of the attention to disasters and climate change impact. Now, it is important for stakeholders to incorporate them in planning and early stages so that a more integral convergence between DRM and modernization of energy systems is achieved. In this

sense, the momentum enjoyed by EE/RE initiatives in the broader context of the deployment of sustainable energy systems places an excellent opportunity for stakeholders to integrate the climate change, energy and disasters management agendas.

The challenges posed by disasters and climate change severely threaten development gains and further limit investment capacity. However, they also offer an opportunity for improved investments and financial management through multi-purpose projects that foster development and resilience and make efficient use of scarce resources. Nevertheless, research indicates that “it remains the exception rather than the rule to integrate DRR and climate change approaches in the respective legal frameworks, where both areas are legislatively mandated” (ODI & UNDP, 2014). An important obstacle is that responsibility for each field is usually placed in different institutions with separate budgets; climate change issues are usually overseen by the ministry of environment, while DRM is responsibility of specialized agencies and/or the ministry of defense. However, this obstacle could be used as an opportunity by countries with limited institutional, technical and financial capacity that seek to strengthen inter-institutional collaboration, make more efficient use of resources and improve their planning process. A shift from sector-focused projects is desirable to avoid silos, incentivize collaboration, and seek resilient investments, regardless of the funding/implementing sector.

The goals and activities supporting climate change adaptation and disaster risk management are complementary and tend to overlap, climate change adaptation (CCA) is also a fundamental component of disaster risk reduction. In addition, the nature of both challenges calls for strong collaboration with other sectors (water, energy, transportation, public infrastructure, agriculture, and planning, among others) to achieve widespread benefits and efficiently use resources. Prominent examples are healthy coral reefs, wetlands and other ecosystems that reduce vulnerability to climate change and increase resilience to disasters by acting as a first line of defence but are severely threatened by urbanisation and the effects of climate change.

Another important opportunity to mainstream resilience is through public investments. It is recommended to adapt public investment procedures, so that any new public development incorporates disaster risk reduction from its feasibility or pre-design studies to its completion. The analysis of projects should use a multi-hazard approach to address all identified risks. This task should be undertaken by the entity responsible for approving public investments and should be done in coordination with the Ministry of Finance. The assessment of the effects and impacts of disasters—regardless of the magnitude—would be an important input to demonstrate the impacts of disasters on public finances, and hence, justify the need to incorporate disaster risk reduction in every public investment.

Investments to adapt to climate change and mitigate its effects can also contribute to reducing climate-related disaster risk through early-warning systems, coastal protection infrastructure, information systems for data generation and sharing, and environmental conservation. In addition, CCA strategies often include the use of hard measures such as seawalls, dykes and elevation of critical infrastructure; all these measures promote disaster risk reduction. Similarly, both fields underscore the importance of implementing and enforcing sound land use plans, and diversifying national energy matrices as critical requirements to increase overall resilience.

Governments should seek to work more actively with regional and international partners such as ECLAC, CDEMA and ACS, among others, in creating the capabilities and awareness so that the linkages and benefits from the integration of these areas are better understood. Initiatives such as ACS Green Response to Disasters could be an excellent first approach in this regard. Additionally, it is imperative to build and/or strengthen national human and institutional capabilities in terms of project design and management. Climate change mitigation and adaptation should not only be seen as temporary opportunities to receive resources and/or technical cooperation, but as core topics guiding the long-

term strategic planning and operations of government agencies in the Caribbean. Cooperation entities also play an important role in this direction. The region requires that more implementation projects are proposed and deployed. To this end, project management capabilities should be strengthened, not only to optimize the impacts of the projects, but to ensure the relevance of international cooperation and technical assistance.

The components of a resilient energy sector should be deployed according to local financial and technical capabilities. To do so, individual assessments should be carried out to determine the path and pace to adopt the most suitable technologies and measures to mitigate and adapt to climate change, and build resilience to disasters and climate change. Additionally, it is important that existent information and data is properly shared. Stakeholders in the Caribbean, mainly government agencies and utilities, have made great efforts to elaborate technical documents (*e.g.*, grid assessments). These documents are rarely socialized beyond the boundaries of the responsible agency. It is of great importance for all the stakeholders to build from common knowledge to come up with better solutions and strategies to face the challenges of the energy sector in the context of climate change and disasters.

It is highly recommended that local efforts are framed in terms of a potential interconnection scenario. In the long run, the Caribbean should seek to leverage the potential of each country with the intention to deploy sustainable energy systems. Also, countries in the region may benefit from strengthening their ties of cooperation in order to achieve local and regional targets and goals and to assure a proper evolution of the energy sector. As extracted from consultations with stakeholders, international organizations have a broad presence in the region; however, their support is almost restricted to the deployment of local assessments or to propose policies. Almost no implementation is supported. Thus, funding and technical cooperation entities should be engaged more consistently to support the implementation of projects. This requires for countries to express in a clearer way their intentions in terms of the particular path to be followed and the prospective projects they seek to deploy.

Resilience building is, undoubtedly, a multidimensional topic involving many sectors (*e.g.*, education, tourism, telecommunications, and security). The imminence of climate change and disasters requires a more comprehensive approach from all governmental agencies and sectors of the society and economy in order to address it properly and boost the impact of each strategy through integrated interventions. The challenges posed by disasters and climate change in the Caribbean, and the momentum enjoyed by both fields signal that international assistance and any new projects must be risk and climate sensitive in order to access the full range of development benefits and avoid unsustainable investments. The opportunities for collaboration abound and are especially relevant considering national financial constraints and international assistance limitations.

Climate change and disasters share a resilience-building agenda that clearly evidences the links between both fields but also with other sectors, such as land use and zoning, energy, water and wastewater management, transportation, health, and planning to name a few. Climate change, disasters and development are inextricably linked, causing unplanned climate change and disaster risks to seriously threaten development achievements, especially considering that disasters expose and exacerbate pre-existing vulnerabilities and inequalities, and disproportionately affect poor and marginalized populations. On the other hand, comprehensive planning processes that consider both issues are expected to be more efficient in the use of resources and to have multisectoral/overreaching societal benefits, as well as to be more sustainable and integrated with other sectors. In addition to improving collaboration and integration among sectors and institutions, this climate- and risk-sensitive approach would improve financing and focus on supporting investments that make wider contributions to sustainable development.

Table 8
Funding options for the Caribbean

Entity	Description	Areas supported
Global Environmental Facility (GEF)	Through GEF-6, the World Bank's (WB) Global Environmental Facility (GEF) counts with a US\$ 1,260 climate change mitigation fund that could support Caribbean countries. The GEF can support the development, adoption of policies, strategies, legislation/regulations, capacity building, and financial or organizational mechanisms that accelerate mitigation technology innovation and uptake. GEF-6 Program 1 has the goal to "promote the timely development, demonstration, and financing of low-carbon technologies and mitigation options"	EE; RE; Sustainable transport.
Green Climate Fund (GCF)	Within the UNFCCC has the objective to catalyze funds to multiply the effect of its initial financing by opening markets to new investments from the public and private sectors. It "aims for a 50:50 balance between mitigation and adaptation investments over time". According to the GCF, only revenue-generating activities are candidates for funds. Another criteria for funding are: (i) impact/result potential (to fund's objective), (ii) paradigm shift, (iii) needs of the beneficiary country, (iv) country ownership and institutional capacity, (v) economic efficiency of the project and (v) financial viability (for revenue generation) (GCF, 2016).	Low-emission energy access and power generation; Low-emission transport; Energy efficient buildings, cities and industries; Sustainable land use and forest management; Enhanced livelihoods of the most vulnerable people, communities, and regions; Increased health and well-being, and food and water security; Resilient infrastructure and built environment to climate change threats, and; Resilient ecosystems
Carbon War Room(CWR)	The Carbon War Room aims at providing market-based solutions to climate change and focuses on solutions that can be implemented using proven technologies under current policy landscapes. CWR often participate in projects or operations where goods and/or services are procured by an entity or government. The CWR launched the Ten Island Challenge to "accelerate the transition of Caribbean island economies from a heavy dependence on fossil fuels to renewable resources". This project intends to impact the Caribbean islands in terms of CO2 and costs reductions. It also expects to increase private investment on the islands, improve EE, and reduce each island's dependence on imported fossil fuels.	Renewable, distributed electricity; Freight and Trucking; Buildings EE, and; Fuel efficient ships.
OPEC Fund for International Development	The Organization of the Petroleum Exporting Countries (OPEC) established the Fund for International Development (OFID) in 1976 in order to stimulate economic growth and alleviate poverty in developing countries. OFID's resources consist of voluntary contributions made by the organization's member countries and the accumulated reserves derived from its various operations. In order to optimize the impact of its contributions, the OFID cooperates with bilateral and multilateral agencies of its member countries, the regional development banks, the World Bank Group, and the specialized agencies of the United Nations, as well as a host of non-governmental organizations.	Energy; Transportation; Finances; Agriculture; Water and sanitation; Industry; Health; Telecommunications; and Education.
Caribbean Development Bank (CDB)	It provides funding as co-financer to the public and private sectors through the Basic Needs Trust Fund (BNTF). The energy sector is a transversal topic at the CDB for the period 2015-2019 (ECLAC, 2016). Projects under the BNTF are likely to have limited adverse and site-specific environmental and social impacts that are readily identified and for which mitigation and management measures are known and available (CDB, 2016).	Promoting RE for more sustainable, affordable, and accessible energy, and for a green energy economy; Promoting energy infrastructure to provide cleaner and more reliable power supply and; Promoting sector reform, good governance and capacity strengthening.

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Annexes

Annex 1

Review of best practices

Table A.1
Components of the modernization of the energy sector

Source	Document	Phases/Objectives
CARIBANK	Energy policy and strategy implementation	Promoting EE for more affordable and stable energy costs, and for establishment of a green economy Promoting RE for more sustainable, affordable, and accessible energy, and for a green energy economy Promoting energy infrastructure to provide cleaner and more reliable power supply Promoting Sector Reform, Good Governance and Capacity Building.
IMF	Caribbean energy: macro-related challenges	Legislative, Regulatory, enforcement, institutional human and technical capacity Improving EE Diversifying the Generation Mix Awareness and stakeholder engagement/ownership
Worldwatch Institute	Sustainable Energy Roadmaps: Guiding the Global Shift to Domestic Renewables	Opportunities for EE Renewable energy resources Grid and storage solutions Social, economic and environmental analysis Policy assessment Financing options
CARICOM	Caribbean Sustainable Energy Roadmap and Strategy (C-SERMS)	Energy system analysis (production and consumption, electricity sector, transportation sector, CO2 emissions) Identifying Potential (renewable resource potential; EE potential, infrastructure needs) Policy Assessment (governance and administration, RE and EE support policies and goals, emissions reduction policies and goals) Regional partners (government, private sector, donors etc.)
California Energy Commission	RE Roadmap	Support commercialization of RE options Enable RE grid integration Support end-user adoption of RE Support appropriate market mechanisms and policies that enable sustainable RE growth
State Government of Victoria	Victoria's RE Roadmap	Transformation in the wholesale electricity market toward RE. Reducing barriers to continued development of distributed generation and energy storage. Public awareness, community ownership: Encouraging household and community development of renewable generation, products and services. creation in Victoria Government support for RE development, with a focus unsustainable job Sustained institutions, application and enforcement of regulations Research and development, Review cycles to accommodate new and emerging technologies as the Caribbean region are in most parts technology buyers

Source: Elaborated by the authors.

Annex 2

Types of smart grid projects and their function

Table A. 2
Types of smart grid projects and their function

Project type	Hardware	Systems and software	Function
AMI	Smart meter, in-home displays, servers, relays, communication equipment	Meter data management system, communication software, workforce management systems (WMS)	Revenue collection, reduction of electricity theft, outage notification, service and maintenance scheduling
Customer side systems	Smart appliances, routers, in-home display, building automation systems, thermal accumulators, smart thermostat, electric vehicle (EV) charging infrastructure, batteries, inverters	Energy dashboards, energy management systems, energy applications for smart phones and tablets, energy billing, EV billing and charging for smart grid-to-vehicle (G2V) charging and discharging vehicle-to-grid (V2G) methodologies	Broad range, but can include energy use awareness, support for demand response (DR), control of individual appliances, provision of smart G2V and V2G, management of heating and cooling devices
Distributed energy resources (DERs): DG	Power-conditioning equipment for bulk power and grid support, communication and control hardware for generation and enabling renewable and non-renewable generation technology that may or may not be connected to the main grid, such as CHP, wind, solar and others		Control, management and monitoring of variable and dispatchable DG assets, system-impacts (e.g. line voltage) management
DERs: Storage	Power-conditioning equipment for bulk power and grid support, communication and control hardware for generation and enabling storage technology, as well as conversion into other energy carriers (e.g. power to gas)	Energy management system (EMS), distribution management system (DMS), geographic information system (GIS)	Control, management and monitoring of storage assets
DERs: Demand response (DR)	AMI systems, targeted customer appliance control devices or system		Shift the load to decrease peak demand, increase customer awareness and choices, improve system flexibility, counteract system events, avail cheaper time-of-use (TOU) tariff options and take advance of TOU pricing
Substation automation	Automated re-closers, switches and capacitors, remote-controlled DG and storage, transformer sensors, wire and cable sensors installed within the substation	GIS, DMS, outage management system (OMS) and WMS	Optimize substation and support upstream and downstream use of assets
Distribution automation	Automated re-closers, switches and capacitors, remote-controlled DG and storage, transformer		Operation and management of the grid during normal, outage or maintenance conditions,

	sensors, wire and cable sensors		minimizing impacts on customers
Control centre systems	Information and communication technology (ICT) equipment such as data storage, monitors, communications security and back-up systems and supporting systems to GIS, DMS, OMS, WMS		Provide visual representation of system status and ability to manage operation and maintenance
Crosscutting: ICT integration	Communication equipment (power line carrier, worldwide interoperability microwave access, long-term evolution, radio frequency mesh network, cellular), routers, relays, switches, gateway, computers (servers)	Enterprise resource planning software, customer information system	Collect, transmit and analyze electricity system data for specific purposes
Asset management	Sensor technology on some or all assets, communications	Models and methodologies to assess healthy and safe loading for devices and circuits	Manage and optimize asset utilization and maintenance

Source: Elaborated by the authors.

Annex 3

Measures to enhance EE

Table A. 3
Measures to enhance EE in the building sector in the Caribbean

Measures	Type	Detail
Design (as part of building codes)	Technological/ infrastructural	High-performance building envelope (HPE)
		Efficient Heating, Ventilation, and Air-Conditioning systems (eHVAC) (e.g., day-lightning)
		Reduced thermal bridging
		Air tightness
		Use of the thermal mass
		Energy-efficient lighting and heating
		Natural refrigeration
		Solar power heaters
		Insulation
		Cool roofs
		Window sealants
Legislation. Regulatory, Enforcement	Structural	Building codes and minimum energy performance standards Equipment and appliance standards for most common appliances in the household and business sectors (e.g., air conditioners, refrigerators, televisions, heaters, ovens, clothes dryers, computer hardware, and heavy machinery) Institutional, human capacities
Tradable Allowances	Structural	Tradable certificates for EE improvements (i.e., white certificates).
Subsides	Structural	Subsidies or tax exemptions for investment
Government programs	Structural	Energy audits that provide energy assessments to determine home energy usage and efficiency measures
		Energy advice programs
		Weatherization programs that provide EE measures to low-income residents free of charge (e.g., adding weather stripping to doors and windows, installing insulation, and tuning heating and cooling units)
		Public education and awareness programs to provide residents, communities with information about cost-saving efficiency measures
Government Provision of Public Goods or Services and RE and EE technologies	Structural	Public procurement of efficient buildings and appliances with the goal to demonstrate successes, reduce technology and certain practices' costs, and to foster economies of scale

Sources: Makhijani, 2013; IPCC, 2014, IRENA and C2E2, 2015.



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