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ECLAC SUBREGIONAL HEADQUARTERS FOR THE CARIBBEAN

Science, technology and innovation for sustainable development

Lessons from the Caribbean's energy transition

Laverne Walker
Jônatas de Paula

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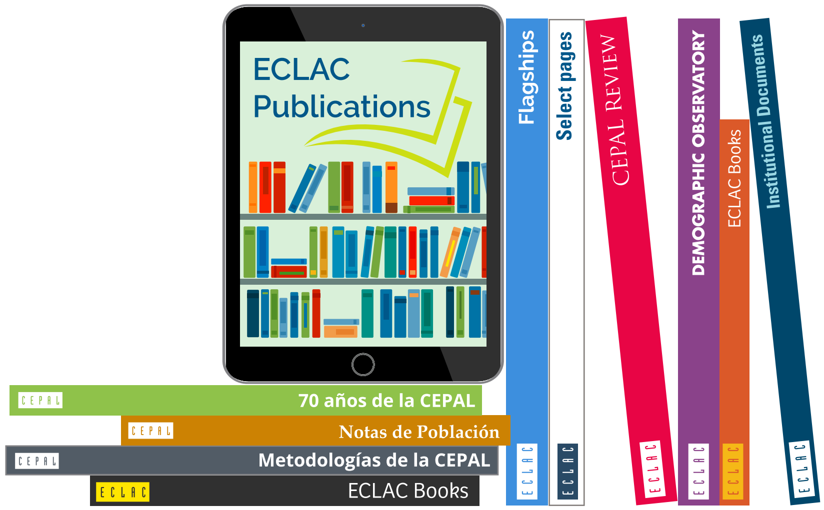

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Abbreviations

BBD	Barbados Dollar
BNEP	Barbados National Energy Policy
CADSTI	Caribbean Diaspora for Science, Technology & Innovation
CARICOM	Caribbean Community
CCST	Caribbean Council of Science and Technology
CCREEE	Caribbean Centre for Renewable Energy and Energy Efficiency
CSEC	Caribbean Secondary Examinations Certificate
CSEII	Caribbean Sustainable Energy and Innovation Institute
ELPA	Electric Light & Power Act
FTC	Fair-Trading Commission
GII	Global Innovation Index
GoB	Government of Barbados
GoJ	Government of Jamaica
IGNITE	Innovation Grant for New Ideas of Entrepreneurship
ILO	International Labour Organization
IPP	Independent Power Producer
IRENA	International Renewable Energy Agency
IRRP	Integrated Resource and Resilience Planning

IRP	Integrated Resource Plan
JIPO	Jamaica Intellectual Property Office
JSEE	Jamaica Society of Energy Engineers
JPSCo	Jamaica Public Service Company
LCOE	Levelized Cost of Electricity
NDC	Nationally Determined Contribution
NELRP	National Electricity Loss Reduction Plan
NIHERST	National Institute of Higher Education, Research, Science and Technology
NTEI	National TVET Engineering Institute
OECS	Organisation of Eastern Caribbean States
OTEC	Ocean Thermal Energy Conversion
PV	Photovoltaic
R&D	Research and Development
ROFR	Right of First Refusal
SAMOA	SIDS Accelerated Modalities of Action
SIDS	Small Island Developing States
SIPP	Security Interest in Personal Property
STEM	Science, Technology, Engineering and Mathematics
STI	Science, Technology and Innovation
SWH	Solar Water Heaters
UTech	University of Technology, Jamaica
UWI	University of West Indies
VRE	Variable Renewable Energy

Abstract

Science, Technology and Innovation (STI) is important in advancing sustainable development across the globe. STI is understood to be an important tool for supporting the transformation of productive structures; the rational use of natural resources; and the delivery of health care, food, education, energy, and transport. One approach available to countries to promote their sustainable development agendas is the advancement of STI to support the adoption of renewable energy technologies. The continued reliance on fossil fuels in the Caribbean is one of the factors hindering the rate at which countries within the subregion are developing. Taking this into account, this study assesses whether the advancement of STI is driving the energy transition in the Caribbean subregion and draws lessons on how STI can better support the subregion's sustainable development agenda. The study first examines the STI landscape in the Caribbean subregion to determine its importance to sustainable development. It then addresses the main area of the research, that is whether STI is driving the energy transition in the subregion. Additional findings on STI related issues in the context of the energy transition are presented from two Caribbean countries, Barbados, and Jamaica. The study concludes by outlining recommendations for advancing STI within the Caribbean subregion.

Introduction

With the adoption of the 2030 Agenda for Sustainable Development in 2015, the global community committed to ending poverty, protecting the planet, ensuring prosperity and fostering peace through partnerships by 2030. Numerous assessments have sought to document countries' experiences as they move towards integrating sustainable development approaches into national development agendas (Jansen, 2003; Cobbinah, Erdiaw-kwasie and Amoateng, 2014; Sachs, 2015; Sachs and others 2019; OECD, 2022). One point these assessments have in common is that there is no one-size-fits-all methodology that countries can follow in advancing their sustainable development agendas. Countries face different circumstances, opportunities, and challenges in transitioning to inclusive and environmentally sound development. Despite this, common entry points have been articulated in supporting the transformation towards sustainable development (UN, 2019). These include:

- Governance: good governance[1] is understood to be critical to sustainable development (World Bank Group, 1992; Roy and Tisdell, 1998; Thomas, 2001). Achieving good governance requires that States are transparent when making decisions; accountable to the public; prioritize policy coherence; establish appropriate institutions; address sectoral silos within the public sector; and update the legislative and regulatory frameworks supporting identified national priorities (World Bank Group, 1992; Roy and Tisdell, 1998; Gnosh and Siddique, 2015; UN, 2019; UNCTAD, 2021a).
- Economic policy and financial flows: the development of a broad range of economic and financial instruments, and smarter policies on trade, investment, industry, education, and innovation are understood to be important in supporting a country's development (UNCTAD, 2021a). Further, minimizing the volatility of financial flows is important in ensuring resilience against shocks (UN, 2019).

[1] Governance refers to the way in which political and administrative authority is exercised in the management of a country's economic, social and environment resources affairs. Accessed on 12 August 2022 (World Bank Group 1992).

- Human capital and an engaged citizenry: human capital[2] acquired through education and employment are important to shaping productive capacities and advancing development (Barro, 2001; Janseen, 2003; Hanushek, 2013). As such, it is important that societies bear the cost of adequately educating the youth before they join the labour market (UNCTAD, 2021 b). Having an empowered educated population willing to contribute to a country's developmental agenda is important for advancing human ingenuity for innovation (UN, 2019). Countries can, through engendering behavioral change, empower their citizens to become more innovative.[3]
- Science Technology and Innovation: it has long been acknowledged that Science, Technology and Innovation (STI) play a significant role in economic development (Dahlman, Ross-Larson and Westphal, 1987; Brooks, 1994; Mormina, 2019). Successful integration of STI into a development paradigm requires moving beyond the existing fragmented and disconnected approaches of scientific research and technological innovations to a more holistic and integrated approach that addresses countries development priorities and needs. STI systems should penetrate and be implemented through different sectors such as health, agriculture, energy, nutrition, marketing, management, and finance acting as drivers in achieving sustainable development (Maiwada and Jamoh, 2022).

Of the entry points identified above, this study assesses STI's importance in achieving sustainable development. The study used the energy transition, with specific focus on the electricity sector, to identify lessons and best practices due to its strategic and underlying relevance to sustainable development in the Caribbean. More specifically, the study seeks to address whether the advancement of STI in the sub region is driving the energy transition in the Caribbean. Building on the specific findings related to STI in this context, this paper concludes with recommendations for advancing STI in Caribbean SIDS.

This paper is structured as follows:

- Section I analyzes the subregional STI landscape, including the assessed role and importance of STI to sustainable development;
- Section II presents the main findings of the research and explores specific STI national circumstances in the context of the energy transition in Barbados and Jamaica; and
- Section III presents conclusions and recommendations.

A. Methodology

This study seeks to explore the importance of STI for sustainable development in the Caribbean.[4] Data and information to support the research were obtained through desktop reviews and open-ended interviews with professionals working in the fields of STI and renewable energy (referred to in this study as "experts") in countries of the Caribbean subregion.

To guide the study, exploratory interviews were initially undertaken with regional experts to better define the scope of the research. Once defined, open-ended interviews were conducted with 30 national and regional experts in the fields of STI, energy or both encompassing the following institutional affiliations: government officials, universities, vocational schools, development banks,

[2] Human capital refers to the economic value of a worker's experience and skills, through increasing productivity and profitability. From - Productivity, human capital, and educational policies. OECD. Accessed on 27 July 2022: https://www.oecd.org/economy/human-capital/.

[3] Laws and regulations, taxes and fines are strong signals of the importance society places on certain behaviors.

[4] For the purpose of this paper, data where available was obtained from the following countries: Antigua and Barbuda, Bahamas, Barbados, Belize, Dominica, Dominican Republic, Grenada, Guyana, Haiti, Jamaica, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago and Turks and Caicos Islands.

development partners, intergovernmental agencies, private sector, utility companies, and renewable energy plant operators.[5] The effort of covering several institutional affiliations was to benefit from a wide-range of perspectives.

To support a wider regional perspective, experts from the following seven countries were interviewed: Barbados, Belize, Jamaica, Saint Lucia, Saint Vincent and the Grenadines, Trinidad and Tobago, and Turks and Caicos Islands. Barbados and Jamaica were selected to explore how common regional elements identified in the research appear in country-specific circumstances. Interviews were conducted from 22 June to 13 July 2022.

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5 For a full list of interviewees see Annex I.

I. Science, technology and innovation in the Caribbean subregion

A. Science, technology and innovation in the sustainable development agenda

Countries with robust STI based socio-economic policies and strategies generally have an advantage in global competitiveness, leading to economic growth and development (Mormina, 2019; UNCTAD, 2019; Walsh et al, 2020). STI, along with effective governance, have become fundamental tools for supporting the transformation of productive structures; the rational use of natural resources; and the delivery of health care, food, education, energy and transport (UNCTAD, 2018; Broughel and Thierer, 2019; Walsh, Murphy and Horan, 2020; ECLAC, 2021). Realizing the full potential of STI depends on a host of actors, including scientists and engineers in both the public and private sectors, entrepreneurs, financiers, policymakers, and educators, among others (UN, 2019).

Box 1
Defining science, technology and innovation

Science is a branch of knowledge that is concerned with the observation and classification of facts and the formulation of general truth (Anaeto and others, 2016). Scientific knowledge fuels the technological capacities necessary to support a production and service-based economy (Powell and Snellman, 2004).

Technology considers the systematic application of collective human rationality to solve problems through the assertion of control over nature; it is a subset of knowledge used to fulfill human purposes in a specific and reproducible way (Anadon and others, 2016; Anaeto and others, 2016). Technology is often described as an engine of growth which could have negative or positive implications.

Innovation is a process of discovering better ways to arrange productive resources to address individual or social needs (UNCTAD, 2019). It can be achieved through the introduction of new ideas, products or processes that support development opportunities and occurs through investment in knowledge and through linkages that enable actors to learn by interacting (UNCTAD, 2019, Alleyne, 2019).

Source: Authors' compilation.

The contribution of STI to sustainable development stands out clearly in the 2030 Agenda for Sustainable Development. For example, Goal 9 —"Industry, Innovation and Infrastructure"— speaks to fostering innovation and technological progress for promoting inclusive and sustainable industrial development. Goal 17 —"Partnerships for the Goals"— advocates for partnerships to support the development of STI particularly through the operationalization of a technology bank and a STI capacity-building mechanism to support developing countries (UN, 2015; UNCTAD, 2019).

The SIDS Accelerated Modalities of Action (SAMOA) Pathway6 acknowledges that access to appropriate reliable, affordable, modern and environmentally sound technologies are necessary to achieve sustainable development objectives and foster an environment supportive of incentives for innovation and entrepreneurship (UN, 2014). Noting this, in 2018 during the mid-term review of the SAMOA Pathway, Caribbean States reiterated the importance of STI in supporting development.[7]

STI is not new to the Caribbean subregion. Historically, countries such as Barbados and Jamaica have made great strides in technological developments. Jamaica in the 18th and 19th centuries was the first country to generate electricity and construct a railway outside of Europe and North America (GoJ, 2022), whilst Barbados is known as being the birthplace of rum. Presently the country in the subregion with the most advanced STI framework and innovation system is Cuba.[8] Cuba's STI System is overseen by the Ministry of Science, Technology and the Environment and has resulted in greater efficiency and closer ties with productive and service activities (Rojo Perez and others, 2018). This is recognised particularly through its health care systems and health research. Acknowleding Cuba's leading STI performance in the Caribbean, this study focuses on countries within the subregion whose innovation system are not as advanced.

Regionally, the Caribbean Community's (CARICOM) Science and Technology Policy in 1988 was one of the first intergovernamental initiatives promoting STI. Two years later, the Caribbean Council of Science and Technology (CCST) was established.[9] In 2000, during a CARICOM Heads of Government meeting, the CCST was designated "as the agency for coordinating and implementing CARICOM's policies and programmes in Science and Technology."[10] The CCST is currently housed within the Office of the President of the National Institute of Higher Education, Research, Science and Technology (NIHERST) in Trinidad and Tobago, which serves as its Secretariat. More recently, the Strategic Plan for the Caribbean Community 2015-2019 defined Technological Resilience as one of its Strategies, however inadequate access to data hindered the implementation of the plan (UNESCO, 2021).

B. Existing science, technology and innovation landscape of the Caribbean

1. Institutional framework

Despite attempts to advance STI in the past decades, progress within national institutional frameworks —such as the establishment of thematic ministries or the strengthening of specialized institutions— seem to have slowed down considerably in more recent years in the Caribbean. Out of 13 States and Territories analyzed as part of this study, 54% had referenced either Science, Technology or Innovation in the name of a Ministry (table 1). When compared with a similar figure produced as part of the

6 Resolution A/RES/69/15 adopted in November 2014.

7 San Pedro Declaration. Caribbean SIDS Regional Preparatory Meeting, San Pedro, Belize, 7-9 August 2018.

8 According to Lundvall and others (2009) a national innovation system is understood to be an open and evolving system that allows for relationships within and between organizations, institutions and socio-economic structures which determine the rate and direction of innovation emanating from science and experienced-based learning.

9 The CCST was established to promote cooperation in the transfer of science and technology to further the social and economic development of its member countries. Accessed on 25 October 2022: https://www.niherst.gov.tt/projects/collaboration-ccst.html.

10 The CCST has defined a Regional Policy Framework for STI, however, it was never tabled for endorsement by the Heads of State and remains largely un-implemented.

UNESCO Science Report 2015, the 2022 data show a 29% decrease in ministries in which STI is referenced in the name. Barbados and Jamaica were the only two States with dedicated STI ministries in 2022. Five of the States assessed had specialized STI agencies whilst six States have an STI Policy either in draft or adopted. However, only three States (Jamaica, Guyana and Trinidad and Tobago), have formally adopted STI Policies. Most of the countries with a defined National Development Plan acknowledged within the Plan the importance of STI in achieving social and economic development.

Table 1
Overview of STI institutional framework in select CARICOM States

Country	Ministry	Strategic Planning Document	Vision	Policy	Additional Body
Jamaica	Ministry of Science, Energy and Technology	Vision 2030 (2009)	A secure and prosperous future by 2030	The National Science, Technology and Innovation Policy- Catalysing National Development (2022)	National Commission for Science and Technology
Barbados	Ministry of Education, Technology and Vocational Training; Ministry of Industry, Innovation, Science and Technology (MIST)	National Strategic Plan of Barbados 2006-25	A fully developed society that is socially just and globally competitive	Implementation Strategy and Action Plan to Promote a STEM Education, Innovation and Employment Program (2016, white paper)	Department of Science, Market Research and Innovation
Bahamas	Ministry of Education and Technical and Vocational Training	National Development Plan Vision 2040 (2016,draft)	A Nation Moving Forward, Upward, Onward Together		Bahamas Environment Science and Technology Commission (BEST)
Trinidad and Tobago		National Development Strategy 2016-2030 (Vision 2030) (2015)	First world nation status by 2030	National Science and Technology Policy	National Institute of Higher Education, Research, Science & Technology
Guyana		Green State Development Strategy Vision 2040	An inclusive and prosperous Guyana that provides a good quality of life for all its citizens	National Science and Technology Policy for Guyana (2014)	National Science Research Council (Act 1974)
Belize	Ministry of Education, Culture, Science & Technology	Horizon 2030- National Development Framework of Belize (2011)	An energetic, resourceful and independent people looking after their own development in a sustainable way	Formulation of a National STI Strategy and Action Plan (2014/15 draft)	
Saint Lucia	Ministry of Education, Innovation, Gender Relations and Sustainable Development	Updated Medium Term Development Strategy (MTDS) 2021-2026 (under development)		Science, Technology and Innovation (STI) Policy (2020 draft)	

Country	Ministry	Strategic Planning Document	Vision	Policy	Additional Body
Dominica	Ministry of Trade, Commerce, Entrepreneurship, Innovation, Business and Export Development	National Resilience Development Strategy 2030 (2020)	Developmental paradigm which seeks to climate proof the key pillars of national policy		
Grenada	Ministry of Economic Development, Planning, Tourism, ICT, Creative Economy, Agriculture and Lands, Fisheries & Cooperatives	National Sustainable Development Plan 2020-2035 (2019)	A resilient and prosperous nation realising its full potential through sustainable economic, social, and environmental progress		
Saint Vincent and the Grenadines		National Economic and Social Development Plan 2013-2025 (2013)	Improving the quality of life for all Vincentians		
Suriname		Suriname Multi-Year Development Plan 2022-2026	2050 Suriname will have a just society in which its values are fulfilled		
Antigua and Barbuda	Ministry of Creative Industries and Innovation				

Source: Authors elaboration, based on online research and adaptation from UNESCO 2015 Science Report.

Despite the fact that many Caribbean governments have committed to advancing STI in their countries, many remain challenged in how this can be achieved. National innovation systems within the subregion have been noted as being underdeveloped (Nurse, 2014). Evidence of this is apparent from the Global Innovation Index (GII)[11] for the year 2021 with only three Caribbean countries ranking within the top 100 of countries assessed. They include Jamaica ranked at 74; Dominican Republic ranked at 93; and Trinidad and Tobago ranked at 97.[12]

Interviewees noted the importance of a legislative and regulatory framework in creating an enabling environment to support the development of STI. However, such frameworks were deemed to be largely absent or weak. They acknowledged that most STI Units and/or Departments continue to be plagued by small staff and even smaller budgets, making it difficult to effectively implement their mandates. For instance, Jamaica's newly adopted 10-year National Science and Innovation Policy outlined the issue of small STI Units and the underfunding of STI as constraints.[13]

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[11] The Global Innovation Project, launched in 2007, seeks to determine metrics and methods that can capture the level of innovation in certain economies. Countries are scored based on five input pillars (institutions, human capital and research, infrastructure, market sophistication, and business sophistication) and two output pillars (knowledge and technology outputs, and creative outputs) Accessed 23 August 2022: https://www.globalinnovationindex.org/about-gii#history.

[12] Global Innovation Index 2021. Accessed 23 August 2022 https://www.globalinnovationindex.org/userfiles/file/reportpdf/GII-2021/GII_2021_results.pdf.

[13] "The National Science, Technology and Innovation Policy – Catalysing National Development" was developed through a consultative process and formally adopted in 2022. This new STI Policy, seeks to "mainstream STI across all sectors and services at the national level by facilitating the design, coordination and implementation of the multisectoral processes that will promote STI

2. STI in the educational system

Respondents noted that some countries in the region were beginning to place more emphasis on Science, Technology, Engineering and Mathematics (STEM), particularly at secondary and tertiary levels. However, it was stated that in many instances there were insufficient STEM teachers, and where they did exist, many were not adequately trained. As such, greater emphasis should be placed on training teachers in traditional STEM subjects, as well as new and emerging ones.

Countries such as Barbados, Jamaica and Belize were reassessing the role of technical and vocational schools in supporting transition to new technologies. At the secondary school level, figure 1 outlines the number of students sitting Caribbean Secondary Examinations Certificate (CSEC) STEM related exams for the period 2018 and 2019. At the tertiary level, figure 2 depicts the number of students registered in STEM related courses across three campuses of the University of the West Indies during the period 2015 - 2020.[14] The figure depicts a steady trend in enrollment over the time assessed with the exception of the Mona Campus where a slight decrease in enrollment was observed. To increase the skillset of the workforce in Antigua and Barbuda and the Organisation of Eastern Caribbean States (OECS), the University of the West Indies opened the Five Islands Campus in 2019 in Antigua. The Campus consists of four schools, one of which is Science, Computing and Artificial Intelligence.[15] Technical and vocational institutions working to realign the curricula to countries' changing priorities, and the resultant shift in workforce expertise needed, are the Sir Arthur Lewis Community College located in Saint Lucia, and the Samuel Jackman Prescod Institute of Technology located in Barbados.[16] Further, the University of Technology (Utech), Jamaica has the oldest engineering school in Jamaica and through the Faculty of Engineering and Computing has steadily produced engineers for the sub-region as well as computer scientists and graduates in animation.

Despite these advancements, respondents emphasized that more investment is required to raise the quality and types of educational programmes offered within the subregion with the focus being on both academic advancement and technical and vocational training. This will allow more schools to achieve international accreditation and for the development a skilled and competitive workforce capable of providing services nationally, regionally or internationally (Alleyne, 2019).

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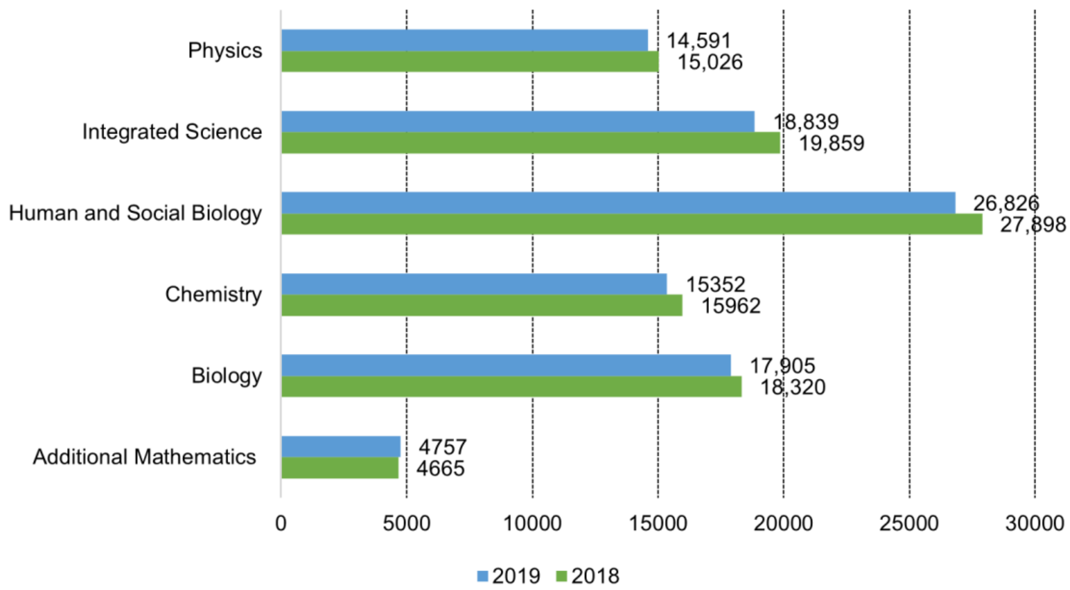
as central to the transformation and development of Jamaica." The Policy is defined by five (5) goals and articulates eight (8) short- and medium-term priority areas.

The three campuses of the University of the West Indies being referenced are the Cavehill Campus located in Barbados, Mona Campus in Jamaica and St. Augustine Campus in Trinidad. According to UWI, under the university's business model which has been approved regionally, all programmes are costed and split into 80% support from governments (mostly the campus governments) and 20% from students. From University of the West Indies.

15 The University of the West Indies, Five Islands Campus.

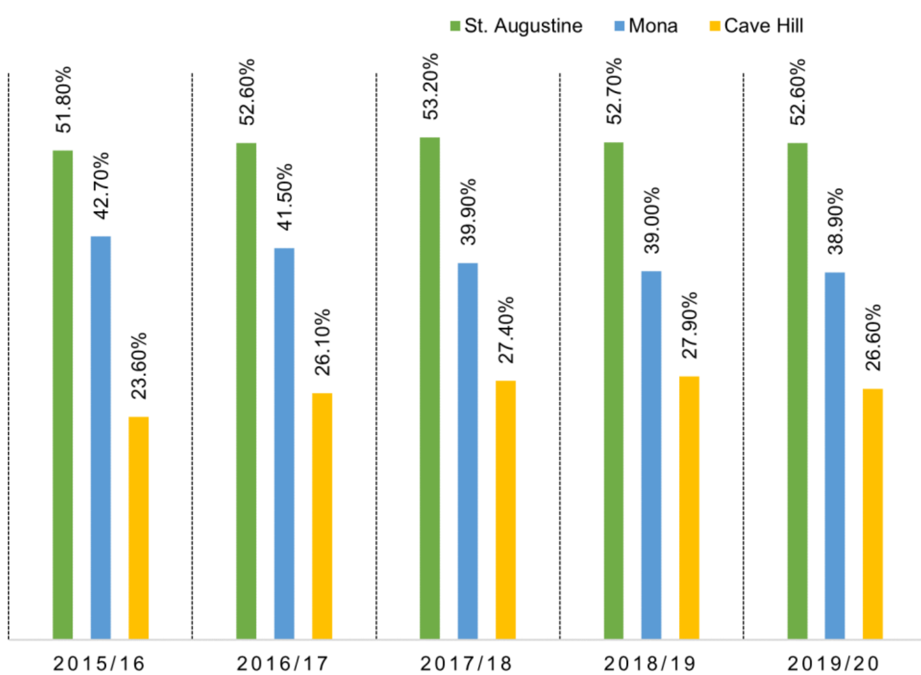
16 These include courses in animation and design, robotics, and sustainable business and innovation.

Figure 1
Number of students sitting STEM subjects at CSEC between 2018 and 2019



Source: Authors' compilation from Caribbean Examination Council Website: May-June Sitting: Regional Comparison of Subjects by Grade Distribution 2018-2019.

Figure 2
Percentage of students enrolled in STEM courses at UWI between 2015-2020

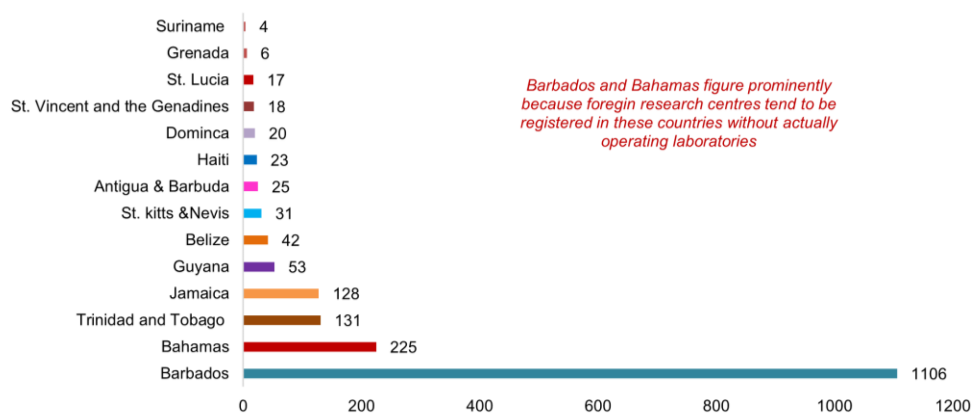


Source: Authors' compilation from UWI's Statistical Compendium for three campuses: St. Augustine, Mona and Cave Hill for the period 2015-2020.

3. Research and development

Respondents indicated that inadequate funding for research and development (R&D) in the subregion was a major constraint to innovation. This is corroborated by data that shows that investment in R&D by both the government and private sector continues to be inadequate (UNESCO, 2010, 2015 and 2021). Whilst some countries such as Jamaica, through the Jamaica Intellectual Property Office (JIPO), have advanced in developing their intellectual property infrastructure, others continue to struggle. For developing countries, such as those in the Caribbean subregion, the process of logging patents nationally and internationally can be both expensive and an administrative burden, leading to many innovators deciding to forego the patent process. It was also noted that the Caribbean subregion is culturally not known to sell ideas. All of this is corroborated by the small number of patents logged for Caribbean countries by the US Patent and Trademark Office. Between 2015 to 2019, Dominican Republic, Jamaica, Trinidad and Tobago, the Bahamas, and Barbados (see figure 3) accounted for most of the patents awarded by the US Patent and Trademark Office to Caribbean countries (UNESCO, 2021).

Figure 3
Number of IP5[17] Patents granted to Caribbean countries between 2015-2019



Source: UNESCO Science Report 2021: The Race Against Time for Smarter Development. S. Schneegans, T. Straza and J. Lewis (eds). UNESCO Publishing: Paris.

However, most of the patents logged from Barbados and Bahamas were logged by foreign firms which do not operate laboratories in these countries. Notwithstanding, there is evidence that some countries are beginning to prioritize R&D. For example, in Barbados' move to revamp its manufacturing industry, the Ministry of Industry, Innovation, Science and Technology plans to design five high quality food laboratories to support the development and testing of products, as well as an International Robotics Centre aimed at attracting investment from international robotics companies focused on exports.[18] Jamaica's newly adopted National Science, Technology and Innovation Policy places a lot of emphasis on strategies and actions to increase R&D within the country (GoJ, 2022). Organizations such as the Caribbean Diaspora for Science, Technology & Innovation (CADSTI), which seeks to promote and support science and engineering research, can also play a role in the advancement of R&D within the subregion.[19]

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[17] IP5 is a Forum of the 5 biggest Intellectual Offices in the World.

[18] Manufacturing sector to undergo transformation, published 9 June 2022 News article on Loop News. Accessed on 26 July 2022 at https://barbados.loopnews.com/content/manufacturing-sector-undergo-transformation.

[19] CADSTI is an international body of professionals interested in the development of the Caribbean region. CADSTI seeks to facilitate the economic and social development of the Caribbean Region by mining and harnessing the diverse, dispersed and largely untapped talent of the Caribbean Diaspora in the areas of science and engineering. Caribbean Diaspora for Science, Technology and Innovation. Accessed 16 September 2022: https://caribbeanscience.org/cadsti/.

Another encouraging development is the revival of national innovation awards in some countries within the subregion, where contestants compete for prizes and the attention of investors, venture capital and opportunities for further product development. These contests have taken place in Jamaica, Barbados and Trinidad and Tobago with prizes ranging between US$ 2,500 and US$ 20,000 in Jamaica (UNESCO, 2015). At the regional level, there are a few innovation initiatives available to innovators such as the Anthongy N Sabga Caribbean Awards for Excellence[20] which provides an award and financial support annually to a successful laureate in the area of science and technology. There are also several business model competitions that are supported by the private sector and organisations such as the Caribbean Climate Innovation Centre, which target university students and provide cash prizes and mentorships.

The Innovation Grant for New Ideas to Entrepreneurship (IGNITE) promoted by the Development Bank of Jamaica is an example of public sector support to start-ups and innovative businesses.[21] Despite respondents noting the importance of incubators and accelerators in supporting young innovators and entrepreneurs in bringing product ideas to market, they also stated that these continue to be underfunded in the subregion.

[20] The Anthongy N Sabga Caribbean Awards for Excellence seeks to recognize significant Caribbean achievement, encourage and support the pursuit of excellence by Caribbean persons, for the benefit of the region. Anthongy N Sabga Awards, Accessed 15 September 2022 http://ansacaribbeanawards.com/the-award/.

[21] The Development Bank of Jamaica, established in 2000 and solely owned by the Government of Jamaica, seeks to support locally owned businesses by providing access to financing, support services and a partial guarantee facility. Development Bank of Jamaica, Accessed 25 August 2022: https://dbankjm.com/.

II. An assessment of STI in the Caribbean energy transition

A. Energy transition and sustainable development in the Caribbean

Energy is essential to advance sustainable development in all countries and a resource necessary for societies and individuals' realization of their full economic, social and cultural potential. The 2030 Agenda includes a dedicated Goal on energy: SDG 7 "Ensure access to affordable, reliable, sustainable and modern energy for all". The Caribbean subregion performs well in energy access indicators: access to electricity is almost universal and access to clean fuels and technologies for cooking is higher than 80% in almost every country.[22] However, the subregion's heavy reliance on fossil fuels makes the adoption of sustainable energy a priority for the sustainable development agenda in the Caribbean.

Most countries in the subregion spend a sizeable percentage of their Gross Domestic Product (GDP) and foreign exchange reserves importing expensive fossil fuels that are subjected to highly volatile international prices.[23] Although heavy oil and diesel-powered plants have a lower upfront installation cost relative to newly installed renewable technologies, in the long-run they become costly due to high fuel prices, draining resources that could be allocated to other sustainable development priorities. This dependence reduces the Caribbean's global competitiveness and has hampered its industrial development for decades. In an attempt to address this, and following a global trend, renewable energy targets have been set by all Caribbean countries. At the subregional level, CARICOM countries agreed in 2013 to achieve a collective 47% renewable energy target by 2027;[24] and sustainable

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22 Haiti is an exception: in 2020, only 46.9% of the population had access to electricity and only 5% had access to clean fuels and technologies for cooking (World Bank, 2020).

23 In 2015, 90% of fuel and oil were imported in Barbados, accounting for 6.9% of its GDP (Government of Barbados, 2021). Antigua and Barbuda imports almost 100% of its energy resources, for which it spends near 12% of GDP and one third of its foreign exchange (IDB, 2015).

24 Caribbean targets 47% renewables by 2027. Available at https://caricom.org/caribbean-targets-47-renewables-by-2027/ (Accessed 29 August 2022).

energy has been identified as one of the priority areas for Caribbean countries in the San Pedro Declaration and the SAMOA Pathway Midterm Review. Other regional policy frameworks[25] also acknowledge that the development of synergies between the STI and renewable energy sectors should be a sustainable development priority for the subregion.

Acknowledging the worldwide trend of electrification within the energy sector in relation to the increasing use of renewable sources,[26] this study focused on the electricity sector to assess whether the advancement of STI in the subregion is driving the energy transition in the Caribbean.

B. Main findings–assessment of STI in the energy transition in the Caribbean subregion

Energy experts interviewed for this study unanimously agreed that the advancement of STI ocurring in the Caribbean is not driving the energy transition in the subregion. The increase of installed capacity of electricity generation using renewable energy sources is due to the adoption of technologies that have been widely known and economically viable for years in the subregion, especially solar photovoltaic (PV) and wind power technology.[27]

In support of that conclusion, experts shared additional information that will be presented in this section as follows: (i) key elements that better explain the energy transition in the subregion; (ii) considerations on the pace of the energy transition; and (iii) key elements to be considered in raising the profile of STI in the Caribbean subregion in support of the energy transition.

1. Drivers of the Caribbean energy transition

Acknowledging a range of country-specific circumstances, respondents stated that a combination of economic and political factors have supported the incremental adoption of alternative renewable energy generation technologies in the subregion in recent years. These factors can be summarized below as three main points:

- Caribbean dependence on high-cost imported fossil fuels subject to volatile international prices: this is an underlying characteristic of the energy sector in the subregion, and which served as a backdrop to the recent changes in the electricity sector. The ongoing conflict in Ukraine and the current global energy crisis[28] were mentioned by respondents to illustrate the Caribbean's vulnerability to international shocks and the urgency for increasing the share of local renewable energy sources into the subregion's energy matrix. However, it was noted that the Caribbean energy insecurity is a longstanding factor that has hindered the subregion's sustainable development for decades;

[25] See the STI CARICOM Caribbean Regional Policy Framework for Action (CARICOM, 2007) and CARICOM Energy Policy (CARICOM, 2013).

[26] "Worldwide efforts to address climate change is leading to the rapid electrification of numerous end-users from transport to industry, driving a massive increase in power demand as well as the need to generate as much of it as possible from renewable sources. The result is a dramatic transformation of power systems globally. Electricity is the fastest-growing source of final energy demand, and over the next 25 years its growth is set to outpace energy consumption as a whole…The power sector now attracts more investment than oil and gas combined – necessary both to transform the generation mix and to upgrade ageing infrastructure". Available at https://www.iea.org/fuels-and-technologies/electricity (Accessed 29 August 2022).

[27] Few respondents noted that the more recent advancement of technologies related to hybrid and electric vehicles can potentially contribute to the energy transition in the subregion's transportation sector, which will become increasingly more integrated to the electricity grid. However, the penetration of these vehicles in the Caribbean remain relatively small.

[28] The war between Russia and Ukraine started in February 2022, leading to a worldwide inflation crisis. A UN briefing on three dimensions of the cost-of-living crisis aggravated by the conflict - rising food prices, rising energy prices and tightening finances - estimated in June 2022 that 53% of the countries in the Latin America and Caribbean region were severely exposed to rising energy prices. The brief states that "the largest countries in this region are not severely exposed, yet 19 countries face the perfect storm, the second largest group facing all three dimensions, after sub-Saharan Africa." Available at https://unsdg.un.org/sites/default/files/2022-06/GCRG_2nd-Brief_Jun8_2022_FINAL.pdf (Accessed 29 August 2022).

- Decreasing international costs of renewable energy generation technologies: respondents highlighted that this factor has opened a window of opportunity for the Caribbean subregion, particularly due to the declining prices of solar PV panels supplied from China. This stance of falling technology prices is supported by global data. The International Renewable Energy Agency (IRENA) points that newly commissioned utility-scale solar PV projects between 2010 and 2021 experienced a reduction of 88% in the global weighted average levelized cost of electricity (LCOE) (IRENA, 2022a).[29] Prices of wind power have also dropped worldwide in that period (68% for onshore and 60% offshore), which was characterized by IRENA as a "seismic shift in the balance of competitiveness between renewables and incumbent fossil fuel and nuclear options".[30] Respondents suggested that renewable technologies had already been cost-competitive in the Caribbean even before that period;
- Commitments to international agreements: this factor was referred to by experts as secondary, but it has been contributing to the drive for an energy transition. Despite the region's minuscule contribution to global greenhouse gas emissions, Caribbean SIDS have expressed a willingness to take on a leadership role in global mitigation efforts due to the region's extreme vulnerability to the effects of climate change. This disposition has been expressed in countries' commitments to the Paris Agreement through Nationally Determined Contributions (NDCs).[31] Respondents also noted that countries' commitments to cut emissions and pursue renewable energy targets allow access to funding of green technologies.

Although not driving the energy transition, concerns over climate resilience were frequently raised during the research. Climate resilience has become important for planning of grid modernization and expansion because of increasing vulnerabilities of infrastructure due to more frequent extreme weather events.[32] Increasing the share of renewable energy sources favours the development of distributed generation systems that are more resilient to climate change impacts and natural disasters, constituting itself an adaptation strategy (IRENA, 2021). To illustrate this shift, representatives of energy ministries and departments who were interviewed referred to the adoption of Integrated Resources and Resilience Planning (IRRP).[33] This tool promoted by CARICOM's Caribbean Centre for Renewable Energy & Energy Efficiency (CCREEE) seeks to plan for both the development of a more diversified energy matrix and for a more climate resilient energy infrastructure.

2. Pace of the energy transition in the region

Notwithstanding recent progress and the commitments towards the future transformation of the subregion's energy matrix articulated in adopted national energy policies, interviewees shared concerns that the change in the energy sector is not happening at a satisfactory pace. In 2020, the share of

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29 IRENA estimates that 47% of this reduction results from decreasing module costs, while hard and soft BoS (balance of system) costs – non-module hardware, batteries, land, insurance, labour, etc. – have increased their share in the total cost of the technology (IRENA, 2022a).

30 Ibid.

31 It was noted that renewable energy targets have been incorporated even before the Paris Agreement through numerous sectorial and climate change plans, policies and legislation at the national level across the region. Energy policies have played a key role in setting renewable energy targets.

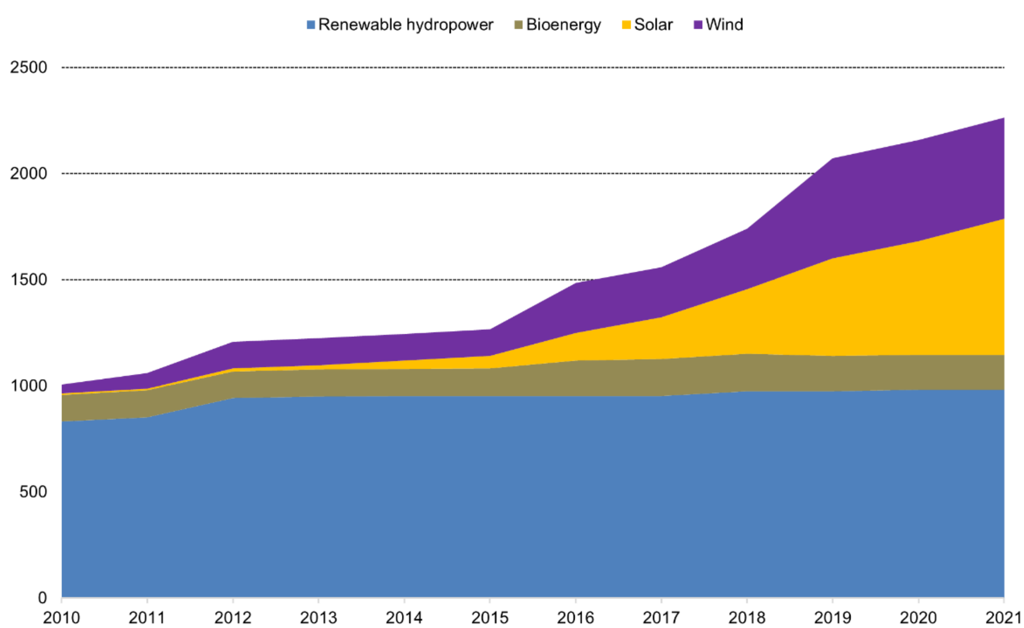
32 In 2019, damages, losses and additional costs in the Bahamas' power sector caused by Hurricane Dorian were estimated to almost US$ 200 million (ECLAC and IDB, 2020). Damages and losses caused by climate disasters in the energy sector represents a relatively larger share of infrastructure damages and losses in the Caribbean than in other subregions of Latin America. Between 1972 and 2010, energy accounted for an estimated 20% of all damages and 23% of losses in the infrastructure sector in the subregion, contrasting with 8% of damages and 21% of losses in the whole region (ECLAC, 2015).

33 "This planning approach iterates on the traditional integrated resource planning process that electricity sector utilities regularly undergo by integrating analyses of climate vulnerability. This process will help to raise the human and institutional capacity for systems modelling and planning in governments and utilities, which will enable them to reduce the impact of climate events on electricity systems at the national level.". CCCREE. Climate Resilience Programme. Available at https://www.ccreee.org/our-work/climate-resilience/ (Accessed 29 August 2022).

renewables in the global energy mix was calculated at 22.8% and only at 8.9% in the Caribbean[34] (World Bank, 2015), indicating a relatively disappointing change in the subregion. Many countries in the subregion —Antigua and Barbuda, Barbados, Dominica, Grenada, Guyana, and Saint Kitts and Nevis— pledged to decarbonize their energy matrixes by 2030, which will require sizeable investments in a very limited timeframe.

The countries where renewable energy accounts for the largest share of electricity capacity in the subregion are Belize (52.8%), Suriname (33.2%) and Dominican Republic (26.8%) (IRENA, 2022b). Whilst hydropower is traditionally the largest contributor to the region's renewable energy capacity, the generation capacity of that source has not significantly increased since 2010. Solar and wind, and to a lesser degree bioenergy, have been the sources providing incremental increases in the region's renewable energy capacity (figure 4).

Figure 4
Renewable energy electricity generation capacity in the Caribbean, by technology
(Megawatts (MW))



Source: Authors' compliation from IRENA (2022b).

3. Advancing science, technology and innovation to support the energy transition

Considering experts' perception that STI is currently not driving the energy transition and that change is happening very slowly, the study analyzed respondents' views on elements that can raise the profile of STI in the subregion to better support the transition. Three key factors were raised during the interviews:

(i) Regulatory and institutional frameworks: interviewees emphasized the need for additional legislative and regulatory reform in the sector to improve market conditions for investments in existing renewable technologies and to unlock opportunities for technology innovation. Changes in policies, legislation and regulatory arrangements across the region have already

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[34] Excluding Cuba, Dominican Republic and Haiti.

contributed to incremental uses of alternative technologies. However, additional reform is necessary to move the electricity sector away from vertically integrated monopolies towards more decentralized generation and distribution systems;

(ii) Human capital: this element was framed by experts as both a requirement for a faster technology transition in the energy sector and as an opportunity for job and income creation.[35] The energy transition is already requiring an increasing number of skilled workers able to plan, design, implement, expand, maintain, and safely manage end-of-life clean energy technologies. Interviewees highlighted the importance of educational institutions at secondary, tertiary and technical/vocational levels to address the fast-changing technology requirements in this sector. Private companies play an important role by funding on-demand courses, in-company training, apprenticeship, internship and scholarship opportunities in the renewable energy field;

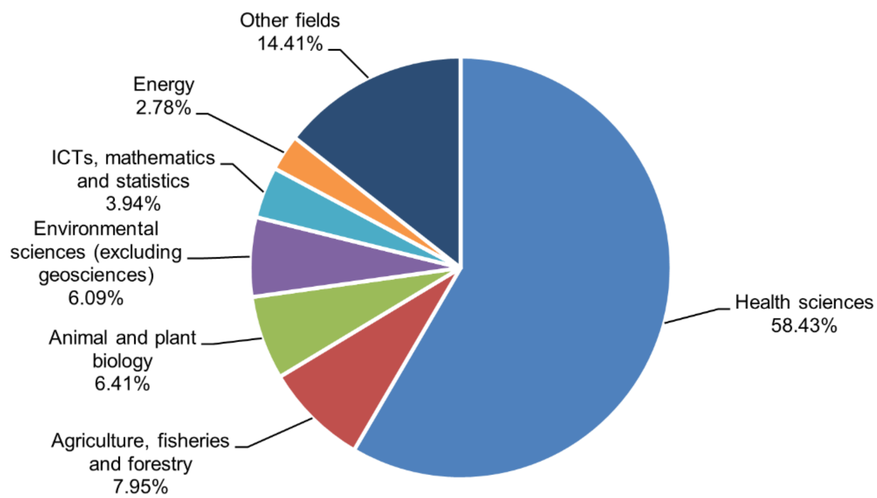
(iii) Research and development: interviewees indicated insufficient funding and coordination to support R&D in general and specifically in the energy sector in the Caribbean. There is a strategic need for research in technology adaptation and development of opportunities to promote innovation to address climate vulnerabilities of Caribbean energy systems. Regional and international collaboration were emphasized as common strategies to overcome national scale constraints. Governments often employ fiscal incentives as a strategy to support R&D. The need to better integrate R&D efforts with the private sector and to promote researchers' entrepreneurship skills was also highlighted. Initiatives such as incubators and accelerators in universities were characterized by interviewees as often underfunded and short-lived and/or lacking the capacity to fully support new technologies through concept, development, testing and market phases.

Box 2
Renewable energy as a field of scientific research

Scientific publications as an STI indicator can provide a valuable insight into the research output volume and prioritity areas of a country's academic institutions. Besides offering an opportunity for global comparison, this indicator has gained relevance in the Caribbean since 2015 with the influx of new universities, particularly in smaller states (UNESCO, 2021). An analysis of UNESCO bibliometric data on the volume of scientific publications from 2011 to 2019 in broad fields of science in the countries considered by this study show that energy represents only 2.78% of the total output. Health sciences and agriculture, fisheries and forestry concentrated more than 66% of all scientific publications in the same period (see figure 1). Energy had an increase of 24% between the periods 2012-2015 and 2016-2019, while Latin America saw an increment of almost 32%, and the world of almost 30% in the same periods. Trinidad and Tobago ranked first in the number of publications (67%), followed by Jamaica (14%), Suriname (6%), Dominican Republic (5%) and Barbados (5%). An analysis of the volume of scientific publications broken down by cutting-edge renewable energy technologies shows that Trinidad and Tobago has leadership in the following technologies: smart grid technology (over 39% of the countries' output), wind turbine technologies (17%) and geothermal energy (10%).

[35] IRENA globally projects that "solar will make up the largest share of renewable energy jobs in 2050, with 19.9 million jobs, followed by bioenergy (13.7 million), wind (5.5 million) and hydropower (3.7 million)" (IRENA and ILO, 2021).

Figure 1
Countries' scientific publications, by broad fields of science (2011-2019)



Source: Authors' compilation.

Source: Authors' elaboration using data from UNESCO Science Report (2021).

C. Country analyses

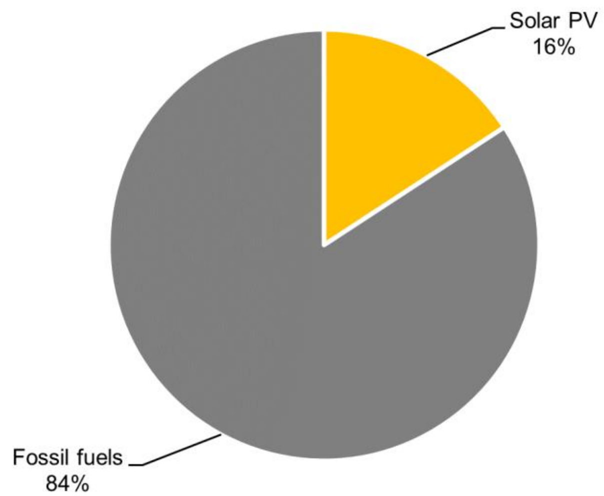
An assessment of STI and renewable energy in Barbados and Jamaica was undertaken as part of this study through interviews with experts and with the support of secondary data.

The sections below will firstly discuss each country's plans for the use of renewable energy technologies to achieve current policy targets and will introduce one key energy specific challenge raised during the interviews for each country's electricity sector —the challenge of energy storage solutions in Barbados and electricity loss in Jamaica. Secondly, they will present interviewees' viewpoints on the three elements listed above —regulatory frameworks, human capital, and research and development— to illustrate the interactions between STI and energy in these two different national contexts.

1. Barbados

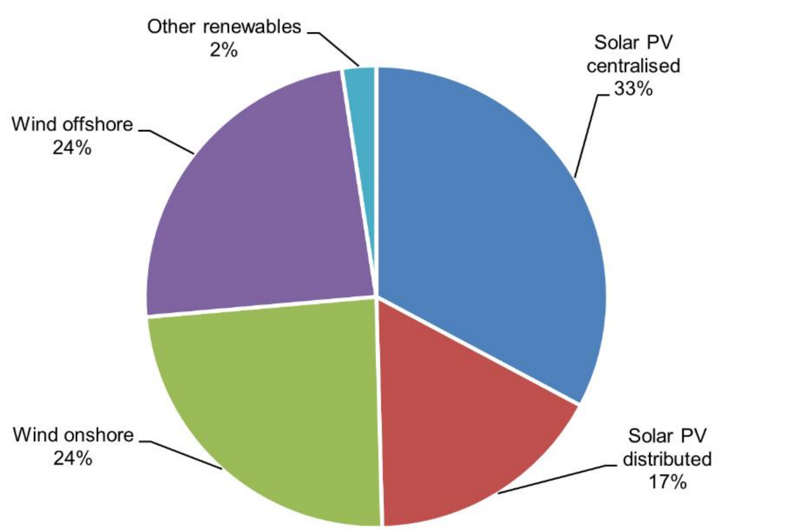
The Barbados National Energy Policy (BNEP) 2019-2030 sets a target of achieving 100% of renewables in their energy matrix by 2030 (Government of Barbados (GoB), 2019). As of 2021, only 16% of the Barbados' electricity installed capacity consisted of renewable sources (IRENA, 2022b), showing that the country has a limited timeframe to achieve an ambitious and fundamental technological change in the energy sector (see figures 5 and 6). The BNEP's 2030 energy mix scenario includes the following technologies: centralized and distributed solar power, onshore and offshore wind power, and other renewables (biomass and waste-to-energy). Electrification of transportation technologies —electric and hybrid vehicles— and energy efficiency technologies were, among others, key technologies discussed in the BNEP. The Policy estimated in 2019 that the capital cost of the energy transition would be 4.4 billion Barbados dollar (BBD) over the 2019-2030 period and would allow annual total energy savings of BBD 400 - 800 million and an estimated social benefit of BBD 3.9 billion.

Figure 5
Barbados installed electricity generation capacity in 2021, by technology[a]



Source: Authors' compilation from IRENA (2022b).
[a] It includes 0.02 MW of onshore wind power, 0.006% of the total. Given the relatively small percentage of that source, it is not represented in the graph.

Figure 6
Estimations of installed electricity generation capacity in Barbados for 2030, by technology



Source: Authors' compilation from Government of Barbados (2019).

STI and energy experts interviewed in Barbados consistently brought up batteries and other energy storage solutions as a key challenge for the country's plans. The BNEP's 2030 energy mix scenario includes 200MW of centralized and distributed storage capacity. However, achieving 100% of renewables requires the use of energy storage technologies on a scale that is currently challenging due to cost, as well as technological and commercial constraints.[36] The BNEP acknowledges that "significant investment in research and development of energy storage technology will be required" and signals that "the establishment of an industry in Barbados for the manufacture and maintenance of batteries for energy storage will be facilitated" (GoB, 2020). However, the Implementation Plan for the BNEP focuses only on implementing proven storage technologies and does not outline concrete policy measures to address the challenge of deploying the required amount of energy storage solution envisioned by the BNEP.

(a) Regulatory and institutional framework

The research indicates that Barbados has shown significant commitment to advancing the reformulation of its electricity sector's regulatory and legislative framework in the past years. Recent regulatory changes made possible an incremental adoption of new technologies into the country's generation capacity, allowing the planning for the transition to a new business model in the energy sector.[37] However, two key regulatory challenges were recognized to be slowing the pace of private investments on new generation and distribution technologies in Barbados, as detailed below.

Firstly, the current monopolistic conditions under which the Barbados Light & Power Company (BLPC) operates is seen as a bottleneck for the energy transition. Negotiations are under way to structure a new model where each service related to the electricity market —generation and storage, transmission and distribution, sales, system operation, etc.— is licensed independently. The new model is expected to include more private players and create more incentives for technology and business innovation in the system. This may trigger a stronger development of wind power technology that, despite its importance in the BNEP, has not yet been prioritized in the country when compared to solar.

Secondly, several interviewees stated that there is general discontent with the pace of approval of license applications for energy generation projects by the Fair-Trading Commission (FTC).[38] It is noted that there has been an exponential increase in the number of licence applications to the FTC in the past four years, following the provision by the Government of favourable tariff conditions to renewable energy sources sold to the grid. The resulting long waiting time has been addressed with the adoption of an online licensing system intended to make the process faster and more efficient. However, the FTC requires further capacity investment to speed up the roll out of new projects. This bottleneck impacts directly on investors' ability to access funding from commercial banks and reduces the incentives to adopt renewable energy technologies.

(b) Human capital

Tertiary educational institutions are understood to be relatively more aware in Barbados than in other countries in the subregion of their role as workforce development institutions and of the need to upgrade their curricula to the requirements of rising technologies, including renewable energy.[39]

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[36] Energy supply from variable renewable energy (VRE) – wind and solar - are inherently intermittent because they rely on conditions (daylight and wind speed) that do not respond to peaks in energy demand, therefore energy storage is necessary to maintain grid stability. The BNEP indicates that batteries, compressed air and pumped storage were the technologies considered for Barbados, but additional R&D should be required (GoB, 2019). Besides the technological challenges related to batteries, insufficient scale represents a barrier in accessing competitive prices in international procurement. At the 9th Summit of the Americas, the Prime Minister of Barbados expressed that the country needs the support to access that technology, because international suppliers often argue that Caribbean countries' orders are too small to be taken (GoB, 2022a).

[37] For instance, the new Electric Light & Power Act (ELPA) – one of the sector's key pieces of legislation – replaced in 2013 the century-old original Act of 1899. The new legislation allows independent power producers (IPPs) to generate electricity and to contribute with an increasing solar PV generation capacity. Under the new ELPA, IPPs have been supplying energy to BLPC under a licensing scheme, a measure that has facilitated the incorporation of solar PV technology into the country electricity matrix.

[38] The FTC has a mandate to regulate rates, ensure compliance, determine and monitor standards of service to utility service providers. The Utilities Regulation Act is available at https://www.ftc.gov.bb/library/CAP282.pdf (Accessed 29 August 2022).

[39] The BNEP places significant emphasis on policy measures for human resources institutions targeting capacity development and the Implementation Plan includes a capacity assessment to identify critical skillset gaps in the renewable energy sector.

However, interviewees mentioned that there is a deficit of training opportunities for renewable energy technologies other than solar PV. Wind technology constitutes the most critical gap and it is currently not prioritized by universities and technical schools, despite the significant contribution expected to the BNEP's 2030 energy mix scenario.[40] Several emerging occupations and skill sets in the renewable energy sector that are currently not available in Barbados were mapped by a report of the International Labour Organization (ILO). These include skills related to smart grid technology, energy storage, smart metering knowledge and training, and many others. The same report indicates that the private sector also plays a key role offering on-the-job training and supporting the development of syllabi in partnership with vocational training institutions (ILO, 2019). Finally, it is noted that the country has introduced income tax deductions to training in renewable energy systems for individuals or companies' staff.[41]

In 2010, CCREEE mapped in Barbados three institutions offering non-university degree courses related to renewable energy technologies: three vocational and professional certificate courses provided by the Samuel Jackman Prescod Institute of Technology; one course offered by the Barbados Vocational Training Board; and one associated degree by the Barbados Community College. These courses are dedicated to solar PV technology and electric vehicles maintenance. At the university level, two modules at the bachelor's degree level offered by UWI Cave Hill Campus are related to renewable energy technology (CCREEE, 2020b).

(c) Research and development

Transforming Barbados into a "centre of excellence for research and development in renewable energy" is one of the BNEP's objectives.[42] Based on the information obtained by this study, there is no evidence of strong policy coordination to achieve this goal. For instance, the Policy proposes concrete measures to include tertiary institutions in capacity development efforts, but it is silent regarding R&D. Moreover, the BNEP and interviews undertaken for this study indicate that the country prioritizes commercially proven technologies while leaving R&D of promising technologies, such as green hydrogen[43] and ocean thermal energy conversion (OTEC)[44], unaddressed. Fiscal incentives appear to be the government's preferred policy to support and promote R&D. In 2013, the government introduced a tax holiday for developers, manufacturers and installers and income tax deductions on investments in research and product development related to renewable energy.[45] The BNEP Implementation Plan mentions fiscal and financial support only to bio-energy technologies.[46]

The interviewees also highlighted that the private sector should be better integrated with institutions carrying out R&D to support the energy transition in the country. However, it was noted that most small and medium-sized enterprises do not have the necessary resources to effectively invest in R&D. It was further highlighted that the risk-averse behavior of commercial banks constrains riskier investments, such as in R&D.

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40 The Samuel Jackman Prescod Institute of Technology offers the Wind Energy programme on an on-demand base only. Samuel Jackman Prescod Institute of Technology. On-line Catalogue of Renewable Energy Educational Opportunities. Available at https://www.smartenergybarbados.com/wp-content/uploads/2021/02/samuel-jackman-prescod-institute-of-technology-pdf.pdf (Accessed 29 August 2022).

41 Renewable Energy and Energy Efficiency Fiscal Incentives Booklet for Individuals and Companies. Available at https://energy.gov.bb/download/fiscal-incentive-booklet/?wpdmdl=3168&refresh=62e5952b86ea71659213099 (Accessed 29 August 2022).

42 Overall Objective 17.

43 More information on hydrogen technologies is available at https://irena.org/publications/2020/Nov/Green-hydrogen.

44 More information on OTEC is available at https://www.irena.org/publications/2014/Jun/Ocean-Thermal-Energy-Conversion.

45 Renewable Energy and Energy Efficiency Fiscal Incentives Booklet for Individuals and Companies. Available at https://energy.gov.bb/download/fiscal-incentive-booklet/?wpdmdl=3168&refresh=62e5952b86ea71659213099 (Accessed 29 August 2022).

46 The Plan also addresses the need for a system to ensure the protection of intellectual property and patents for renewable energy technologies.

Box 3
The solar water heater industry in Barbados

The story of the solar water heaters (SWH) in Barbados is referred in the literature - and also mentioned several times by interviewees during this research - as a successful case of application of technology that led to the development of a local industry that turned Barbados into a manufacturing and export hub of SWH in the Caribbean. In response to the oil shock in 1973, local companies started manufacturing SWH to cope with rising energy prices resulting from a dependency of 95% of imported fosil fuels. The first company was founded in 1973 and, with the appropriate support and incentives that created a competitive environment, many others were created by early market pioneers. Bugler (2012) indicates that the initial barriers and challenges to the SWH industry in Barbados were: 1) development of an effective product through adaptation to suit local households' characteristics; 2) resistence from commercial banks to provide start-up capital to the initial manufacturers; 3) building consumer awareness of the product; 4) high upfront costs; and 5) sustainaing a favourable regulatory framework to ensure long-term certainty to investors and consumers. Some of these challenges are similar to those faced by solar PV technology, as indicated by interviewees during this research. In the case of the SWH, Bugler indicates that overcoming these barriers was possible with the support of local high-level government champions, appropriate financial support, regulatory certainty, and consumer acceptance. Table 1 indicates a list of additional factors that can be attributed to the success of the SWH industry in the country and can serve as inspiration for the current challenges of solar PV and other renewable energy technologies in the Caribbean.

Table 1
Key elements of the support framework for the solar water heater industry in Barbados

Direction of influence	Factors that helped stimulate growth of SWH industry
Private sector to consumers	• High-quality products • Consumer guarantee • Finance to spread upfront cost of SWH • Community engagement and job creation • Clear quality of life benefits • Strong marketing and communications
Private sector to government	• Demonstrated the potential of the technology • Cost-effective technology that saves millions of dollars
Government to consumers	• Involvement and participation through communications • Fiscal incentives (the Homeowner Tax Benefit) • Increased duty on gas and electric heaters
Government to private Sector	• Fiscal Incentives Act 1974 • Government purchase of SWH for new-build developments • Created an environment of regulatory certainty and gave continuous support

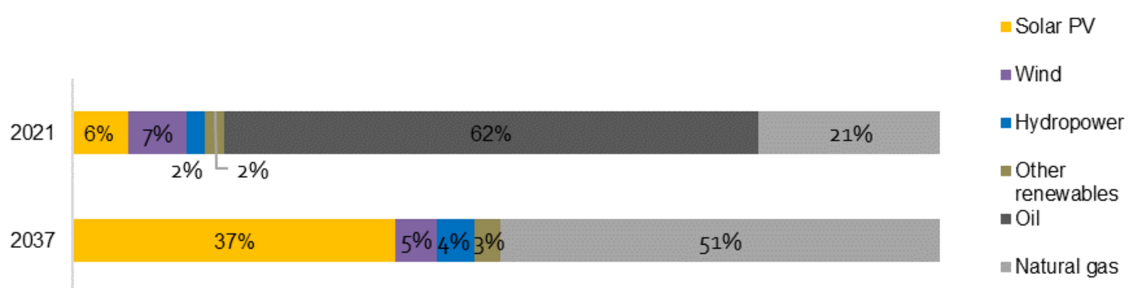
Source: Bugler, W. (2012), "Seizing the sunshine Barbados' thriving solar water heater industry". Inside stories on climate compatible development. Climate and Development Knowledge Network.

Source: Bugler (2012), (see table 1).

2. Jamaica

Jamaica's National Energy Policy approved in 2009 set a target of achieving 20% of renewable sources by 2030 (Government of Jamaica (GoJ), 2009). Since the approval of the Policy, the Jamaican Prime Minister announced that the country would increase that target to 50% by 2030.[47] As of 2021, 17.5% of Jamaica's electricity generation installed capacity consisted of renewable sources (IRENA, 2022b). The country's Integrated Resource Plan (IRP) approved in 2018 and updated in 2020 sets a planning scenario until 2037 with renewables accounting for 49% of the country's electricity matrix using the following technologies: solar, wind, hydropower, waste-to-energy, and biomass (GoJ, 2020). Differing from other Caribbean countries that pledged to go carbon-neutral by 2030, natural gas is expected to play a big role in replacing oil imports in Jamaica (see figure 7). The IRP calculates an estimate of USD 1.9 billion capital investment required to procure 1270 MW of wind and solar power generation over the document's planning horizon.

Figure 7
Jamaica installed electricity generation capacity in 2021 and estimations for 2037, by technology
(Percentage)



Source: Authors' compilation using data from IRENA (2022) and Jamaica's Integrated Resource Plan (Government of Jamaica, 2020).

Interviewees in Jamaica stated that the country's high rates of electricity loss[48] and high energy prices are two important and connected energy challenges. Respondents indicated that energy theft (or non-technical loss) is the main cause of electricity loss, which drives up even more the average tariffs. General disaffection with service provided by the Jamaica Public Service Company (JPSCo) is influencing the decison of end-users to go off-grid and invest in energy efficiency and renewable energy technologies. This is the case of many industrial consumers in particular seeking to become more competitive by reducing energy costs. At the same time, in 2017 JPSCo introduced a combination of machine learning and smart metering technologies to tackle the problem, since manual anti-theft measures were insufficient.[49] A National Electricity Loss Reduction Plan (NELRP) is currently being developed to address the problem.[50]

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47 Jamaica Information Service (October 2018) Jamaica to increase renewables target to 50% – PM Holness. Available at https://jis.gov.jm/jamaica-to-increase-renewables-target-to-50-pm-holness/ (Accessed 29 August 2022).

48 Electricity system losses in Jamaica were at 27% in 2020 (CCREEE, 2020a).

49 Machine Learning Helps Power Down Electricity Theft in Jamaica. Available at https://blogs.worldbank.org/energy/machine-learning-helps-power-down-electricity-theft-jamaica (Accessed 29 August 2022).

50 Gov't Gets Support from USAID To Address Electricity Theft. Available at: https://jis.gov.jm/govt-gets-support-from-usaid-to-address-electricity-theft/ (Accessed 29 August 2022).

(a) Regulatory and Institutional framework

Currently JPSCo is an integrated electric utility company and the sole distributor of electricity in Jamaica. Several IPPs —such as Wigton Windfarm, which owns the Caribbean's largest wind farm— operates and sells power directly to JPSCo. Jamaica has adopted over the past years several measures to implement a regulatory reform of the electricity sector to improve competition and efficiency in the grid.[51] Such reforms were intended to introduce changes to the system's ownership and regulatory structures, moving it from strictly single-buyer to an unbundled model, where generation, transmission and distribution are separated.

However, the research indicates that these changes have not yet been able to solve the issues of efficiency indicated above and which can hinder the country's plans to achieve 50% of renewables by 2030. Respondents noted that tenders to procure new grid scale electricity generation capacity were last held in 2016, as demand for electricity from the utility-operated grid is stagnant due to increases in self-generation. Policy makers expressed the wish to use the ongoing review of the 2015 Electricity Act to address key elements that are perceived to be stifling competition, such as JPSCo's Right of First Refusal (ROFR)[52], a license clause introduced in 2015 that provides certain preferential conditions to the utility. Further, private sector stakeholders and policy makers seem to be challenged by a dilemma. On the one hand, decade-long utility license schemes and other contractual conditions are intended to provide incentives for long-term capital-intensive investments required by the energy sector whilst, on the other hand, these conditions seem to negatively affect the market competition and curtail the adoption of fast changing renewable energy technologies by the stakeholders.

(b) Human capital

Respondents have indicated that a general challenge for human capital formation in Jamaica is the university fees, which reduce student's ability to complete their education. In the energy sector specifically, there is a perception that schools focus on training professionals to operate Jamaica's relatively outdated grid network, while rising cutting-edge technologies —such as artificial intelligence and smart grids— are not addressed. These technologies may become requirements to create more dynamic and decentralized energy systems capable of accommodating a larger share of renewables. Therefore, the availability of adequately trained professionals impacts on the grid modernization requirements. The research also indicated that universities struggle to find lecturers able to teach courses in more advanced technologies and STEM subjects. Collaboration with international institutions has been a strategy being explored to overcome local scarcity of these specialized professionals.

One case analysed found that the private sector can play a valuable role in relevant human capital formation. Wigton Windfarms created the Wigton Renewable Energy Training Lab in 2016 to train technicians in other renewable energy technologies such as: solar thermal and PV, fuel cells, concentrated solar power, energy consumption and measurement, small hydro and bio-energy. The company also offers funding opportunities through a scholarship programme at Utech, Jamaica, and the Northern Caribbean University.

In 2020, CREEE mapped in Jamaica four institutions offering vocational and professional certificate courses related to renewable energy technologies: Heart Trust/ National TVET Engineering

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51 For instance, the reform of the Electricity Act in 2015 provided for the establishment of the Generation Procurement Entity (GPE) with a mandate to undertake procurement of new electricity generation capacity through a competitive bidding process, based on recommendations of the IRP. The GPE is currently building capacity and developing guidelines to advance with procurement; a Request for Proposal (RFP) is expected to be promulgated in 2022. Available at: https://jamaica-gleaner.com/article/letters/20220622/letter-day-jamaicas-renewables-plan-track (Accessed 29 August 2022).

52 'Bad law' Policymakers want Right of First Refusal clause removed from JPS's electricity license. Available at: https://www.miic.gov.jm/content/bad-law-policymakers-want-right-first-refusal-clause-removed-jpss-electricity-licence#:~:text=The%20ROFR%20gives%20the%20single,subsidiary%20company%20of%20the%20JPS (Accessed 29 August 2022).

Institute (NTEI), Jamaica Society of Energy Engineers (JSEE), Vector Technology Institute, and UWI Mona Campus. These courses are dedicated to renewable energy and energy efficiency. At the university level, two bachelor's degrees offered by UWI Mona Campus and three masters' degrees, one offered by UWI Mona Campus and two offered by the Utech, Jamaica are either dedicated to or have core courses in areas related to renewable energy technology (CCREEE, 2020c).

(c) Research and development

Respondents highlighted that Jamaica's scientific and technological development had historical significance at the regional and international levels, but this had diminished over the past decades. Insufficient funding was noted as a main hindrance for R&D in the country. In the energy sector, interviewees indicated that the idea that renewable energy should become a R&D priority has been gaining public traction more recently in Jamaica, particularly with government's indication of more ambitious renewable energy targets for 2030. Notwithstanding energy insecurity being recognized as a key development challenge, the country's energy policy approved in 2009 did not identify nor articulate substantially how R&D in renewable energy can contribute to national sustainable development. The research indicates that solar PV, wind, OTEC, biofuels and waste-to-energy are technologies for which researchers currently have interest in Jamaican universities.

Collaboration is usually an approach adopted by research institutions to overcome limitations in R&D resulting from insufficient local resources and scale, a strategy adopted by the Caribbean Sustainable Energy and Innovation Institute (CSEII).[53] By engaging with other universities in the region[54] and other continents, the Institute sees an opportunity to promote Jamaica as a testing ground for research and development seeking to adapt renewable technologies to become more efficient in the Caribbean. Interviewees also acknowledged the importance of communicating better scientific outputs and raising the visibility of universities R&D efforts for the wider public and strategic stakeholders, particularly in the private sector. Although scientific advocacy was mentioned as both a challenge and an opportunity for advancing STI in Jamaica, limited funding was again identified as an obstacle. Other R&D challenges in the renewable energy sector highlighted during the interviews were the lack of adequate data for researchers and human capital deficiencies in universities.

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[53] More information on the Caribbean Sustainable Energy and Innovation Institute is available at https://www.utech.edu.jm /cseii/about.html.

[54] The Institute is part of the Regional Universities Network. The Network is comprised by the following members: University of the Bahamas, University of Belize, University of Guyana, Université d'État d'Haïti, University of Technology, Anton de Kom Universiteit van Suriname, University of Trinidad and Tobago, and the University of the West Indies. According to CARICOM, the initiative "is intended to function as a "network of excellence" for research and education on sustainable energy…. with focus on the enhancement of the knowledge and capacity that is required to support innovation within the sustainable energy and related sectors in CARICOM countries." Available at: https://energy.caricom.org/portfolio-items/regional-universities-network/ (Accessed 29 August 2022).

III. Conclusions and recommendations

This study sought to assess the importance of STI for sustainable development in the Caribbean by assessing whether the advancement of STI in the subregion is driving the energy transition. Whilst there is evidence that STI is perceived as being important to sustainable development in the subregion, it does not appear that it is an issue of high priority for many countries as its uptake continues to be slower than expected against agreed commitments such as the 2030 Agenda, and regional and national STI policies and strategies.

In relation to the energy transition, the study found that the advancement of STI ocurring within the Caribbean is not driving the energy transition in the subregion. The transition to renewable energy in the subregion in fact is being driven by three key elements:

- Dependence on high-cost of imported fossil fuels subject to volatile international prices;
- Decreasing international costs of renewable energy generation technologies; and
- Commitment to international agreements targeting greenhouse gas emissions reduction.

Notwithstanding recent progress and the commitments towards the future transformation of the energy matrix articulated in adopted national energy policies, experts interviewed shared concerns that the change currently seen in the subregion is not happening at a satisfactory pace.

In light of this, the three elements (regulatory frameworks, human capital and research development), which were analyzed as part of the research and found to be important to advancing the energy transition, were also understood to be important to developing STI in the subregion. The conclusions of this study elaborated below note that advancements in STI in the subregion can potentially benefit many aspects of sustainable development.

The lessons from the energy transition discussed in Section II highlighted that an enabling regulatory and institutional framework is important to promoting technological innovations. The steady increase of the share of renewables in the region —which for years remained stagnant— can be correlated with the adoption of several regulatory innovations across the subregion addressing:

interconnection policies and standards; net billing/net metering; and feed-in tariffs. The reform of electricity acts and utility regulations was also a significant driver of change. By developing an appropriate legislative and regulatory framework, governments reduce the risks associated with investments in new technologies and create better market conditions for larger long-term investments. As a result, private funding can also be made available to support innovative business ideas. Therefore, having the appropriate legislative and regulatory framework that keeps up with the fast pace of new technologies leads to higher productivity and higher efficiency, with spillover effects across different sectors. However, both STI and energy experts noted that the pace at which such systems are being put in place is very slow. The world of technological innovations is fast paced, with the risk of new technological innovations becoming redundant if mechanisms are not in place to support innovators and entrepreneurs. The study also noted that the institutional arrangements required to support the implementation of the legislative and regulatory frameworks continue to be fragmented, understaffed and underbudgeted.

The study noted that there is growing understanding that improvements in human capital increases economic productivity and as such it should be aligned to the changing technology needs of industries. Taking this into account, countries such as Barbados and Jamaica have begun to place greater emphasis on developing their workforce to one that is highly skilled. For example, the 2022 Budget Address of the Government of Barbados noted the importance of technology, innovation, and entrepreneurship to the areas of food security, manufacturing, renewable energy and information technology in diversifying the country's economy and in securing its ability to compete in the global economy (GoB, 2022b). In light of this, the Barbados government has embarked on a training revolution as articulated in the country's medium term economic strategy (GoB, 2022b). Notwithstanding the advancements taken by some countries in the subregion, the uptake of these new priorities to develop the region's human capital continues to be slow. New STEM based areas of focus need to be introduced in universities, as well as technical and vocational schools. Capacity development for tutors in STEM related subjects not only at the tertiary and vocational levels, but also at the primary and secondary school level is understood to be a growing priority, but investments are still insufficient. Further, the cost of a tertiary education remains prohibitive for many within the subregion. UNESCO (2021) noted a shortage of engineers in Jamaica, with only around 200 graduating each year, this impacting negatively on the private sector. Despite these constraints, oftentimes those who do graduate in STEM are unable to find jobs in the subregion and are forced to emigrate in search of opportunites in developed countries. Therefore, creating strategic alliances and linkages within the Diaspora and recognizing it as an untapped resource for national STI development across the Caribbean is critical.

The study also noted that the continuous low investment in R&D by the public and private sectors in the subregion continues to hinder its sustainable development agenda. This issue is not new having been highlighted numerous times in the literature. Advancements are slowly taking place in some countries, such as Jamaica, which has in the last few years established more laboratories focusing on R&D (GoJ, 2022). Also, in 2019, Jamaica committed for the first time in its national budget JAM$ 200 million (US$ 1.5 million) in competitive seed funding for academic research projects (UNESCO, 2021). The Barbados Investment and Development Coorporation located within the MIST, is home to the BLOOM project[55], the first clean tech cluster in CARICOM. Established as a public-private partnership, the cluster hub provides shared resources and services,and a marketspace for partnerships between the private sector and academia on joint projects, solutions and marketing.[56] Despite these best practices, the region still has a long way to go in relation to investing in R&D. Some of technologies that require further investments are, energy storage solutions, green hydrogen and OTEC. Tax

[55] BLOOM was developed with the support of the Government of Barbados and the United Nations Industrial Development Organisation, with funding from the Global Environment Facility.

[56] Barbados BLOOM Clean Tech Cluster presented as role model for a global program. Available at: https://www.ccreee.org/news/barbados-bloom-clean-tech-cluster-presented-as-role-model-for-a-global-program/ (Accessed on 27 October 2022).

incentives targeting R&D activities and import duty reductions for imported technologies seem often to be used in the absence of more robust policies designed to promote STI development a result of inadequate funding.

Reference was made many times in the study to the important role that key stakeholder groups working together can play in advancing the STI agenda. The collaboration of a leading private developer of solar PV projects in Barbados with the Samuel Jackman Prescod Institute of Technology and the Barbados Community College in the development of solar panel installation courses shows that private companies can use their expertise to improve technical training provided by educational institutions, which will in turn also benefit their own workforce (ILO, 2019). The need for greater integration of effort is even more significant to small economies of the Caribbean which require partnership arrangements among the public sector, private sector and educational institutions to overcome challenges related to limited scale and resources. Despite this, respondents noted that partnerships to advance technological innovations among business firms, academia and the public sector continued to be very low. All respondents stated that the key stakeholder groups all had a role to play in advancing STI in their country, and they indicated that more could be achieved if they worked more closely together. Initiatives promoting scientific entrepreneurship and business education have been praised for creating collaboration and improving researchers' position to identify and access funding opportunities, which can benefit both the private sector and research/educational institutions.

The following policy recommendations are being proposed based on the findings and conclusions of the study:

- *Support initiatives that promote an STI Culture in the subregion:* there is a need to demistify STI through awareness raising. Articulating STI's importance to a country's national development, as well as highlighting successes, can also help in raising its profile. Support of this can be achieved through the engagement of national and regional civil society groups and with the active engagement of educational institutions. Advocacy and outreach are known to successfully promote behavioral changes. Within the subregion, the education system is still excessively formal, and with a job market that often rewards risk-averse behavior,the practice of Caribbean institutions can be seen to be discouraging of innovation. Changing attitudes can lead to societies more willing to innovate and in which innovators are better supported by financial institutions to undertake R&D and get new products to market. Changing the perceptions of the general public will require the mainstreaming of STI into daily lives, continuous investment in awareness raising of the general public, and changes to the school curriculum, among other initiatives. Greater emphasis should be placed on using STI to solve national issues and problems, which the general public find relatable. Such an approach should promote within societies more analytical and strategic thinking; traits necessary for technological innovation. Science fairs, innovation awards and grants, competitions and hackathons[57], STEM related scholarships and other measures should be incentivized early and at all education levels and should be promoted nationally, regionally and internationally. Scientific advocacy and initiatives which increase the visibility of successful R&D initiatives within the wider public also have strategic importance in informing of the value and benefits of investing in scientific investigation. These initiatives need to be implemented in articulation with clear STI Policy Instruments.
- Mainstream STI at all levels of education*:* to ensure that the subregion has a strong STI culture that enables the development of a knowledge-based society and a skilled workforce that

[57] Hackathon is "an event in which computer programmers collaborate intensively with one another and sometimes with people in other specialties over a relatively short period of time to create code usually for a new software product or service". Available at https://www.merriam-webster.com/dictionary/hackathon (Accessed 29 August 2022).

allows the Caribbean to compete globally, there is need to encourage more students into STEM from a very early age. Warde and Sah (2019) suggest one way in which this can be achieved is through STEM curriculum reform at all levels, as well as STEM teacher training. The proposed reform of school curriculum should not only focus on increasing the number of students moving into STEM related careers but should also reassess how other more traditional subject areas such as public administration, business and law can support the STI agenda. Capacity building for lecturers in the field of STEM-related topics is also important.

- Create an enabling institutional environment: growth in STI in the subregion requires a strong enabling environment both nationally and regionally. At the national level, governments should work on revising existing legislation that create bureaucratic hurdles to investors and stifles market competition. They should instead put in place new regulatory frameworks that support innovative business models and investment in STI. Such investments will allow for greater opportunities for job creation through the establishment of research institutions, start-ups and innovation clusters. At the regional level, governments should support mechanisms promoting enhanced integration and coordination.

- Increase STI funding: advancing STI requires increased investments. Investment in STI within the subregion continues to be low, despite many countries noting it as a priority. The subregion will not see a return on STI if it does not increase its investment. Whilst it is not currently realistic for Caribbean governments to invest 0.1% of national GDP in STI, governments should begin to make allocations to support the advancements of STI in their national budgets. Such budgetary allocations should support staffing of STI Units and Departments and ensure that these units can successfully implement their mandates, including supporting the advancement of national innovation systems in partnership with several stakeholders. Venture capital coming from commercial financial institutions are usually aligned with market needs and not always available to fund research and development at an early stage. Therefore, governments could also consider establishing measures whereby a small portion of funds from approved initiatives could be directed to research institutions for research and development. Funding STI however is not the sole responsibility of governments but also lies with other stakeholder groups. Where necessary, incentives and other fiscal instruments should be introduced to incentivize the private sector to step up and participate in national efforts to raise investments in STI. However, these fiscal measures should be conceded rationally and in articulation with STI policies seeking to achieve specific and measurable goals. Banks, credit unions and other lending institutions should also be encouraged to introduce policies and programmes which support young entrepreneurs in obtaining funds to promote their innovations.

- Develop Partnerships: there is a need for increased engagement between governments, the private sector, research institutions and academia in relation to STI. Due to the small economies of the subregion, stakeholder groups should be encouraged to work more closely together, especially as they all have a vested interest in countries' national development. Such partnerships should support increased learning, as well as investments and should be adaptable to the changing environment of innovation systems as new information and knowledge becomes available. More support to incubators, accelerators and start-ups can be achieved through increased partnerships between key stakeholder groups, such as the private sector and universities. Regional and international partnership arrangements, as well as south-south partnerships supporting research and technical cooperation should also be encouraged. The Diaspora can contribute by supporting connections and partnerships to add value to national R&D and business innovation. Another partnership arrangement that is often overlooked is the need for enhanced coordination among government agencies. STI is cross sectoral and as such when defining and implementing STI policies and strategies, it is important that different government agencies engage and coordinate with each other.

- Develop monitoring and evaluation frameworks: additional investment in STI cannot be justified if countries are unable to assess its impact to the development of national economies, especially in a context where funds are scarce and allocations need to be cost-effective. The development of monitoring and tracking mechanisms to track implementation of STI policies, action plans and the application of fiscal incentives can serve as a basis for justifying increased spending in R&D, incubators, accelerators and other STI aspects, especially if the general public can see the benefits of these investments.

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Annex

Annex 1

Table A1
List of experts interviewed

No.	Country/organisation	Name	Designation
1	Caribbean Centre for Renewable Energy and Energy Efficiency	Mr. Gerald Lindo	Sustainable Energy Expert
2	Ministry of Energy and Business, BARBADOS	Mr. Delano Scantlebury	Project Director (ag), PMCT, Energy Division
3	Ministry of Energy and Business, BARBADOS	Ms. Destine Gay	Senior Technical Officer, Programme Monitoring and Coordination Team (PMCT), Energy Division
4	Ministry of Industry, Innovation, Science and Technology, BARBADOS	Mr. Mark Hill	Chief Executive Officer
5	Energy Unit, ST VINCENT & THE GRENADINES	Mr. Lance Peters	Director of the Energy Unit
6	Science & Technology Unit Ministry of Education & National Reconciliation, ST. VINCENT & THE GRENADINES	Ms. Inga Creese	Coordinator of Science and Technology (Ag)
7	Caribbean Development Bank	Mr. Joseph Williams	Sustainable Energy Unit
8	Barbados Chamber of Commerce and Industry, BARBADOS	Mr. Andy Armstrong	BCCI Chair Green Committee/Marketing Director, Armstrong Agencies Ltd.
9	Barbados Chamber of Commerce and Industry, BARBADOS	Mr. John Marshall	BCCI Green Committee/ Vice President Operations Harris Paint Group
10	Barbados Chamber of Commerce and Industry, BARBADOS	Mr. Neilsen Beneby	BCCI Green Committee/Renewable Energy Manager EMERA
11	OECS Commission	Ms. Judith Ephraim	Programme Director- Sustainable Energy
12	OECS Commission	Mr. Crispin d'Auvergne	Programme Director - Climate Change & Disaster Risk Management
13	Wigton Windfarm Limited, JAMAICA	Ms. Michelle Chin Lenn	Project Manager
14	Development Bank of Jamaica Ltd, JAMAICA	Ms. Deborah Newland	General Manager, Strategic Service Division
15	Ministry of Public Utilities, Energy and Logistics BELIZE	Mr. Ryan Cobb	Energy Director
16	E Governance and Digitilization Unit, BELIZE	Ms. Alexia Peralta	Director
17	National Commission on Science and Technology, JAMAICA	Dr. Olive-Jean Burrowes	Executive Director
18	Soloricon	Dr. James Fletcher	Managing Director
19	Caribbean Electric Utility Services Corporation (CARILEC)	Mr. Thomas Mitschke	Advisor for Energy Solutions
20	UWI Ventures Limited, TRINIDAD AND TOBAGO	Mr. Julian Henry	Chief Operations Officer
21	Ministry of Home Affairs, Transportation, Broadcasting, Energy and Utilities and Telecommunications Commission- TURKS AND CAICOS	Mr. Eric F. Salamanca	Acting Energy and Utilities Commissioner
22	Regional STI expert	Dr. Robert Stoddard	Consultant/Project Manager
23	Caribbean Academy of Science	Dr. Arnoldo Ventura	Council Member
24	Ministry of Science, Energy and Technology, JAMAICA	Mr. Brian Richardson	Chief Technical Director – Energy

No.	Country/organisation	Name	Designation
25	Ministry of Science, Energy and Technology, JAMAICA	Mr. Todd Johson	Principal Director
26	Faculty of Science and Technology, Mona Campus University of the West Indies, JAMAICA	Dr. Randy Koon Koon	Lecturer - Department of Physics
27	Faculty of Science and Technology University of West Indies St. Augustine Campus, TRINIDAD & TOBAGO	Dr Ricardo Clarke	Deputy Dean Graduate Studies, Research and Innovation
28	University of Technology, (UTech) JAMAICA	Dr. Ruth H. Potopsingh	Associate Vice President-Sustainable Energy Head, Caribbean Sustainable Energy and Innovation Institute (CSEII)
29	Technical, Vocational and Educational Training Council, BARBADOS	Mr. Henderson Eastmond	Director
30	Samuel Jackman Prescod Institute of Technology, BARBADOS	Mr. Ian Drakes	Principal

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