COUNTRY ASSESSMENT REPORT

- The Commonwealth of Dominica -

A Green Industrial Development Model for Dominica

with focus on

Utilisation of Geothermal Resources for Transitioning to a Hydrogen-Based Economy

Kenesjay Green Limited

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Disclaimer

The contents of this publication are for use as a guide to green industrial development planning, identifying possible future areas for investment and outlining opportunities for the island state of Dominica in its utilisation of its geothermal resources for new productive economic activities.

This report is not part of a feasibility study, but reflects government policy and commitment to develop (i) a Green Eco-Industrial Park (GEIP), as expressed in its National Resilience Development Strategy, (ii) a Low Carbon Resilient Development Strategy, and (iii) Government's engagement with the Green Climate Fund for the development of a GEIP.

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Foreword

Dominica abounds with natural resources. It is known as the Caribbean's Nature Island because of its unspoiled natural beauty – lush forests and varied fauna. However, as with most island territories, the country has already experienced significant impacts from climate change – the most devastating being seen in 2017 with the passage of Hurricane María, which resulted in loss of life and approximately one billion USD in damage to agriculture and infrastructure.

Having seen the direct effects of such impact, and with an appreciation that such events are likely to intensify and increase in frequency, the island has embarked on an initiative to become the world's first climate resilient country. The intent is to restore and improve livelihoods and harness available resources in a structured and sustainable approach to mitigate future negative impacts, thereby permitting a more aggressive and appropriate response where any impacts are realised.

The country's geothermal resource has long attracted academic interest, and more recently, some physical development. However, the harnessing of the island's full geothermal potential as a driver for wide-ranging, green-oriented economic diversification had not been extensively considered. With the implementation of the country's resilience strategy and green development thrust, more focused and considered attention has been placed on the possible utilisation of this resource.

This Country Assessment Report considers geothermal resources in the northern region of Dominica. It integrates findings and recommendations from multiple sector-specific studies and reports with best-practice approaches for realising green industrial development opportunities. The document pays specific attention to opportunities for the development of green hydrogen, consistent with the available resources, and indicates a pathway for Dominica to become a catalyst for green energy integration in the Region.

Acknowledgements

This document was produced as an initial outcome of a Memorandum of Understanding between KGL and The Climate Resilience Execution Agency for Dominica (CREAD) which was signed at the 26th United Nations Climate Change Conference (COP26) in Glasgow.

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In particular, the following persons are acknowledged for their inputs:

- Francine Baron – Chief Executive Officer, CREAD
- Samuel Carrette – Resilience Development Planning Consultant, CREAD
- Michael Savarin – National Programme Coordinator, Green Climate Fund, Ministry of Planning, Economic Development, Climate Resilience, Sustainable Development and Renewable Energy

Abbreviations

APS	Announced Pledge Scenario
BNEF	Bloomberg New Energy Finance
CARICOM	Caribbean Community
CCUS	Carbon Capture Utilisation and Storage
CEP	Caribbean Energy Policy
CO_2	Carbon Dioxide
COP	Conference of the Parties
CREAD	Climate Resilience Execution Agency for Dominica
CRRP	Climate Resilience and Recovery Plan
CVQ	Caribbean Vocational Qualification
DASPA	Dominica Air and Sea Ports Authority
DGDCL	Dominica Geothermal Development Company Limited
DOMLEC	Dominica Electricity Services Limited
DOWASCO	Dominica Water and Sewerage Company Limited
EE	Energy Efficient
EGS	Environmental Goods and Services
EIA	Environmental Impact Assessment
EIP	Eco-Industrial Park
EPA	Environmental Protection Agency
ESG	Environmental, Social, and Governance
ETC	Energy Transmission Commission
GGGI	Global Green-Growth Institute
GCF	Green Climate Fund
GEIP	Green Eco-Industrial Park
GHG	Greenhouse Gas
gpd	Gallons per Day
GW	Gigawatt
H_2	Hydrogen
HIF	Highly Innovative Fuels
ICT	Information Communications Technology
IEA	International Energy Agency
INDC	Intended Nationally Determined Contribution
IRC	Independent Regulatory Commission
IRENA	International Renewable Energy Agency
IS	Industrial Symbiosis

ITMO	Internationally Transferred Mitigation Outcomes
ITU	International Telecommunication Union
IUCN	International Union for the Conservation of Nature
KGL	Kenesjay Green Limited
LAC	Latin America and the Caribbean
LCCRDS	Low-carbon Climate Resilience Development Strategy
LCDP	Low-carbon Development Pathway
LCOE	Levelized Cost of Energy
LCOH	Levelized Cost of Hydrogen
LNG	Liquefied Natural Gas
LOHC	Liquid Organic Hydrogen Carriers
LPG	Liquefied Petroleum Gas
MPECSRE	Ministry of Planning, Economic Development, Climate Resilience, Sustainable Development and Renewable Energy
MW	Megawatt
MOU	Memorandum of Understanding
NDC	Nationally Determined Contribution
NREL	National Renewable Energy Laboratory
NZE	Net Zero Emissions
OAS	Organisation of American States
OECS	Organisation of Eastern Caribbean States
PCF	Product Carbon Footprint
PEM	Polymer Electrolyte Membrane
PLAR	Prior Learning Assessment and Recognition
PPCR	Pilot Program for Climate Resilience
RE	Renewable Energy
SIDS	Small Island Developing State
SLM	Dominica Sustainable Land Management
SMR	Steam Methane Reforming
t/yr.	Metric tonnes per year
TVET	Technical and Vocational Education and Training
TWh	Terawatt-hour
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States Dollar
XCD	East Caribbean Dollars

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Executive Summary

The negative impacts of climate change faced by the Caribbean region pose both immediate and longer-term threats to lives and livelihoods across the island chain. Dominica as a Small Island Developing State is highly susceptible to the negative impacts of climate change due to its central location in the Caribbean archipelago and given its dependence on the agricultural and service sectors.

Dominica experienced the extenuating effects of climate change with the passing of Hurricane María in 2017 which devastated most of the island and resulted in the loss of life. As the country recovered and rebuilt in the wake of the hurricane, the Government of the Commonwealth of Dominica was spurred into leading the efforts to improve the island's resiliency against the negative effects of climate change. A new ambition was forged, to ensure that the island pursues development pathways that will position it towards becoming 100% renewable energy powered and the world's first climate-resilient country.

Dominica is well-positioned to achieve this goal as renewable energy sources already account for approximately 37% of power generation. Of more significance, is the expansive geothermal renewable energy potential which is estimated to be in the range of 300MW to 1390MW. This resource remains largely untapped except for a 10MW geothermal power plant in the Roseau Valley which is currently underway. Over the last decade, there has been a general reduction in the cost of renewable energy production and a converse increase in the demand for renewable energy. Geothermal energy has emerged as an attractive renewable energy option because it provides a constant energy supply at high availability – an advantage over the intermittent solar and wind renewable options. These factors create an enabling environment that promotes the exploration and development of Dominica's vast geothermal resource. Exploratory drilling has only been completed for the Roseau Valley in the southern part of the island and not for the northern reservoirs. Accessing public funding and grants is one option to help offset the high capital costs that will be associated with exploring the northern region.

The development of the geothermal resource will improve the efficiency of the power generation system and promote economic growth. The key opportunities identified include:

- Provision of self-generation capability for production of green hydrogen and its derivatives within a green eco-industrial estate,
- Provision of supplemental power to the grid to displace diesel generated power to remove the nation's reliance on imported fossil fuels and reduce the carbon footprint, and
- The trading of excess renewable power to neighbouring islands such as Martinique and Guadeloupe.

Dominica's abundant geothermal resource affords the possibility for the island to play into the green hydrogen market. Interest in green hydrogen has gained unprecedented momentum in recent years and has been accelerated by the Covid-19 pandemic. Green Hydrogen is a critical enabler to

decarbonise carbon-intensive industries as the world journeys to a net-zero future and can play a key role in Dominica achieving its sustainability goals. The regional and international green hydrogen demand is expected to increase exponentially by 2030 to an estimated 90GW. This would be accompanied by a decline in green hydrogen production cost which can become competitive with grey hydrogen as early as 2030 based on:

- the continued decreasing cost of renewable energy and electrolyser cost,
- technology innovation to improve performance and efficiency, and
- gleaned learnings from the large-scale deployment of electrolysers.

This increasing demand and reduced production cost coupled with hydrogen's versatility for use in new applications, would secure a vibrant, sustainable future green hydrogen market. Dominica has the transformative opportunity to become a green hydrogen producer by tapping into the renewable energy potential and exporting to countries with a high demand for green hydrogen. In essence, Dominica can serve as an industrial centre for renewable power generation, hydrogen production, and even further along the value chain into the petrochemical sectors including ammonia, methanol and e-fuels.

The concept of a green eco-industrial park has been globally accepted as an attractive sustainable industrial development pathway. A green eco-industrial park that integrates green hydrogen as part of the development framework can contribute significantly to the future sustainable development of the country. Such benefits would extend from direct foreign investment to job creation, improvement in infrastructure and opportunity for foreign exchange earnings through the sale of commodities.

Dominica is in the process of developing a supportive framework that will further the transition and realisation of a green hydrogen economy including the passage of requisite legislation, development of novel financial instruments, and the development of appropriate institutional frameworks with support from a number of key local, regional and global partners.

Based on the findings of this country assessment which considered the geothermal energy potential, the regional and global demand for hydrogen and its derivatives, the decreasing cost trends, and the Caribbean island's unique sustainable energy demand profile, two development pathways are being recommended:

- Development Pathway I – New Green-based Industrial Opportunities for Dominica. This pathway offers sustainable development via green eco-industrial parks and the production of green hydrogen, allowing for the development of the following areas:
    a. A Green Port and Ship Re-Fuelling Hub,
    b. Sustainable Agriculture,
    c. Data Processing High Tech Facilities,
    d. Green Ammonia and Derivatives,

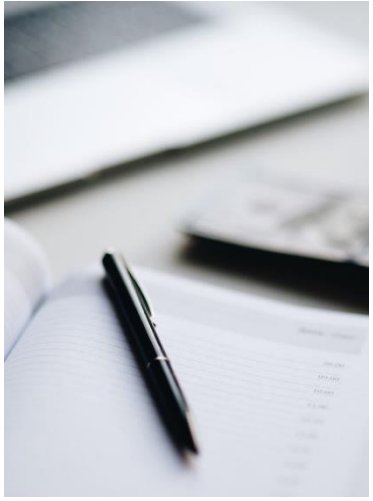
e. E-Methanol and Synthetic Renewable Fuel,

f. Global Hub for Training, and

g. Green Eco-Tourism.

- Development Pathway II – Dominica as a Catalyst for Regional Energy Integration and Industrial Development. This pathway leverages the geothermal resource for the export of green electrons to position Dominica as a leader in regional renewable energy integration. This may involve the export of renewable power to neighbouring islands such as Martinique and Guadeloupe and the export of green feedstock to Trinidad and Tobago to assist in decarbonising the petrochemical sector.

Dominica is well-positioned to harness its geothermal energy potential toward the development of its green hydrogen economy. It also has the opportunity to benefit from direct trade in green electrons. This would aid in realising local and regional targets for energy security and economic development, and mitigate the effects of climate change, thereby allowing the island to achieve its objective of becoming the first climate-resilient nation.



01

Introduction to the Country Assessment Report

- The Government of Dominica has prioritised efforts at becoming the world's first climate resilient country.
- A Memorandum of Understanding has been signed between CREAD and Kenesjay Green Limited to conceptualise and explore green-based development opportunities available to Dominica, including green hydrogen.
- Consultations and reviews have commenced in keeping with the scope of the MOU, with this Country Assessment Report being the first deliverable of the engagement.

01 Introduction to the Country Assessment Report

1.1 The Vision

The Government of the Commonwealth of Dominica has taken the lead in ensuring the island pursues development pathways which will position it towards becoming 100% renewable energy powered and the world's first climate resilient country. These initiatives, though aimed at developing different sectors of the economy, focus on ensuring environmental preservation of the island and the creation of developmental opportunities for its citizens.

One such initiative being pursued is the development of Green Eco-Industrial Parks (GEIP) to facilitate, inter alia, green hydrogen production and other green industries.

This report outlines what constitutes an enabling environment to facilitate green hydrogen production and aims to identify a development pathway for the onset of a green hydrogen economy.

1.2 Genesis of the Initiative

In November 2021 at the 26th United Nations Conference of the Parties (COP26), CREAD (with the collaboration and support of the Ministry of Planning, Economic Development, Climate Resilience, Sustainable Development and Renewable Energy (MPECSRE)) entered into a Memorandum of Understanding with Kenesjay Green Limited (KGL) for the completion of a Green Hydrogen Country Assessment. The MOU facilitates exploration of the various green hydrogen opportunities available to Dominica, and the various financing mechanisms available to realise those opportunities. Also to be considered is the attendant possibility of exporting excess geothermal generated renewable energy power to neighbouring Caribbean islands, a development which would catalyse regional grid integration and drive further low-carbon development toward a net zero region.

The MOU covers five (5) thematic areas over a three (3) year period, with the following short-, medium- and long-term objectives.

i. A Country Assessment of possible locations for the development of green eco-industrial parks,
ii. Exploration of key geothermal partnership arrangements,
iii. Logistic arrangements,
iv. Industrial production, and
v. Hydrogen supply chain.

Figure 1 following summarises the organisational synergies between KGL and CREAD which are expected to maximise the outputs from the several activities to be undertaken during the MOU delivery.

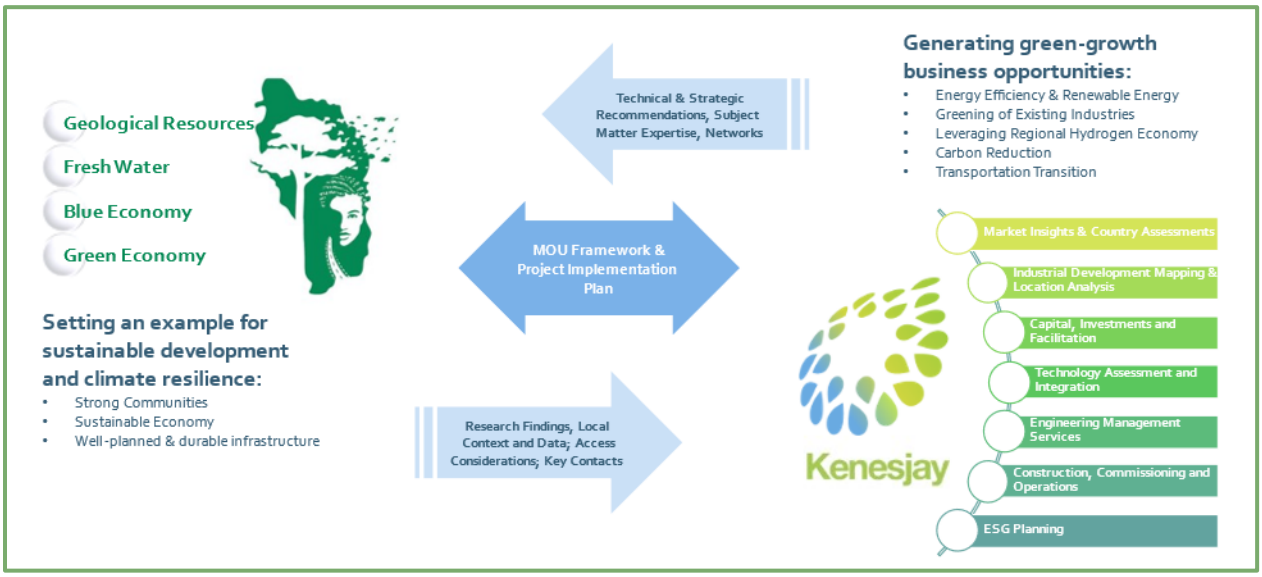


Figure 1: KGL and CREAD Organisational Synergies

1.3 Methodology

The approach taken to gather information for this country assessment included a country-specific desktop review of previous studies and an in-country data gathering exercise which allowed for discussions and exchanges with key government representatives, industry stakeholders and representatives from the private business community. Following these engagements, further research was undertaken to analyse regional and global trends and best practices which could inform the development of country-specific models and scenario planning for the Commonwealth of Dominica.

1.4 Focal Areas for Development in Dominica

The government of the Commonwealth of Dominica places great emphasis on energy transition. It has adopted a position that the government will seek to identify and develop the country's renewable energy resources not only in hydro and geothermal but also wind and solar. A list of the various public entities aligned to energy and resource development is presented following.

Table 1: Public Agencies Aligned to Energy and Resource Development

Government Agency
Ministry of Planning, Economic Development, Climate Resilience, Sustainable Development and Renewable Energy
Ministry of Environment, Rural Modernization and Kalinago Upliftment
Ministry of Tourism, International Transport and Maritime Initiatives
Ministry of Finance and Investment

Government Agency
The Climate Resilience Execution Agency
Dominica Electricity Services Limited (DOMLEC)
Independent Regulatory Commission (IRC)
Dominica Geothermal Development Company Limited (DGDCL)

Additionally, for any national development to occur in a desirable manner, there must be direction by the Government through the creation of policies and frameworks to create enabling environments for sustainable growth and succession planning.

Key among these policies are:

- the National Energy Policy of the Commonwealth of Dominica (2021),
- the National Resilience Development Strategy 2030,
- the Climate Resilience and Recovery Plan,
- the Low-Carbon Climate Resilience Development Strategy (LCCRDS), and
- the Dominica Disaster Resilience Strategy.

Several supporting frameworks and projects are also being pursued to guide specific elements of the development approach:

- Portsmouth Citizens Planning Commission,
- Dominica Sustainable Land Management (SLM) Project,
    - (Project 1) Community Vulnerability Maps and Adaptation Plans,
    - (Project 2) Pilot Program for Climate Resilience (PPCR),
- Invest Dominica Authority,
- Intended Nationally Determined Contribution (INDCs), and
- Readiness Proposal with the Ministry of Planning and Economic Development for Commonwealth of Dominica for the Green Climate Fund (GCF).

Additional details on the aforementioned policies and frameworks are included at **Appendix I** and **II** respectively.

02

About The Commonwealth of Dominica

- Dominica is situated within the Lesser Antilles island arc of the Caribbean archipelago, and has one of the highest concentration of volcanoes in the Caribbean region.
- The country is a Small Island Developing State (SIDS) susceptible to the considerable impacts of climate change given its agro- and service-based economic structure.
- The Government of Dominica, through its National Development Strategy and related initiatives, is working towards making Dominica the world's first climate resilient country.
- Several supporting mechanisms and agencies have been established to drive these activities, and maximise the potentially wide-ranging benefits from pursuing a green industrial programme utilising the island's vast natural resources

02 About The Commonwealth of Dominica

2.1 Introduction

Dominica is situated within the Lesser Antilles island arc of the Caribbean archipelago and has one of the highest concentration of volcanoes in the Caribbean region. Dominica is a Small Island Developing State (SIDS) susceptible to climate change and its impacts. Through its national development strategy and aligned efforts, the Government is working towards making Dominica the world's first climate resilient country. The following provides a macro-level view of the country.

2.2 Country Fast Facts

Dominica's land mass totals 750 km^2, and sits between the French-colonised islands of Guadeloupe to the north and Martinique to the south. Its 72,000 inhabitants speak mainly English, with a local French Patois dialect. Accepted currency includes East Caribbean Dollars (XCD) and the United States Dollar (USD).

The terrain of the island is mountainous, having been formed by the work of nine (9) volcanic peaks. Within some of these are craters and calderas, which when filled with water, create lakes such as the infamous 'Boiling Lake'. The island experiences quite a significant quantity of rainfall annually and is drained by hundreds of rivers. Given its geologic origin, the island is rich in alluvial and volcanic soils which supports its heavily agricultural-based economy.

In addition to agro- and agro-processing industries, the economy of Dominica is also supported by offshore finance systems and the service industry centred around tourism; mainly eco-centred tourism and cruise ships. Private sector development in the agriculture, agri-business and tourism/eco-tourism sectors are important drivers of economic growth, enterprise development and poverty eradication (see ***Figures 2*** and ***3***).

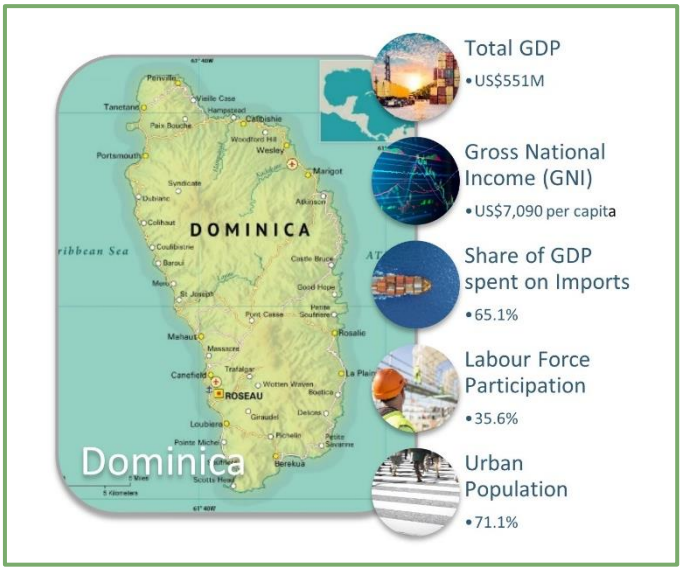


Figure 2: Economy Highlights – Dominica

Source: Developed from NREL, 2020a

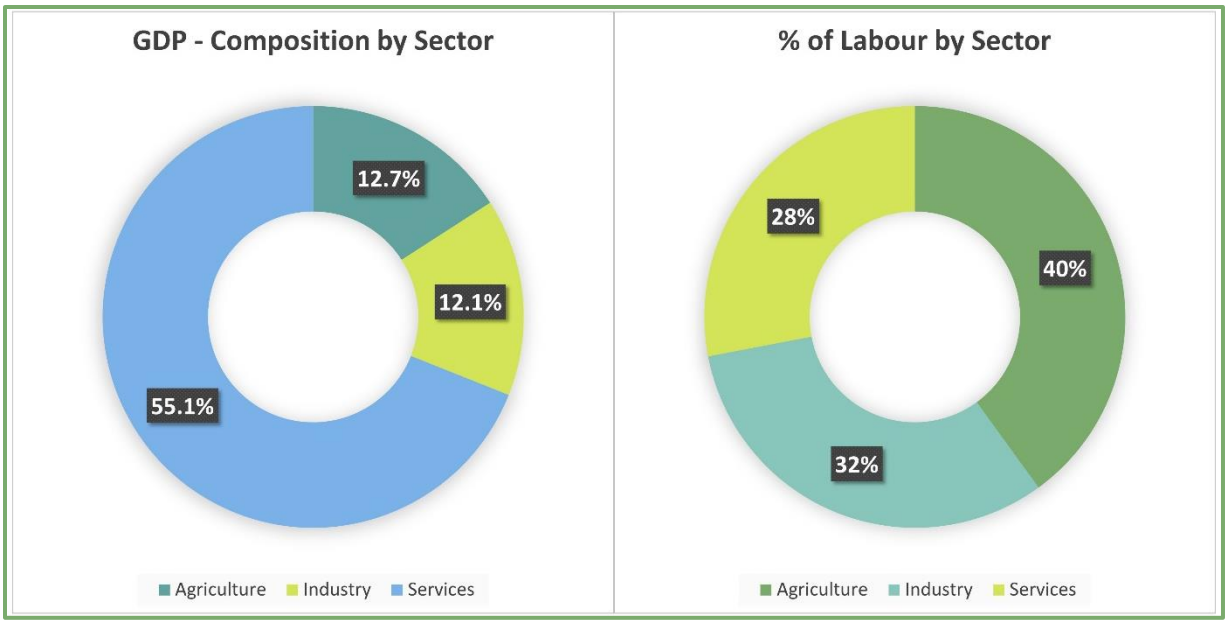


Figure 3: Gross Domestic Product Composition and Labour by Sector

Source: Generated from CIA, 2022

2.3 Political Structure

Dominica is a parliamentary democracy. Representatives in its unicameral House of Assembly are elected on a 5-year cycle, with Senators' seats being filled via appointment. Local governments have primarily administrative functions.[1] The political landscape is stable, with a rating of 1.35 points in 2020 (-2.5 being weak, and 2.5 being strong)[2].

2.4 Infrastructure – Transportation Network

2.4.1 Airports

In Dominica one can find two airports – Douglas-Charles Airport and Canefield Airport, with the former being the larger of the two and the most frequented. Although the island does not possess its own International Airport, air passengers destined for Dominica are routed through Antigua and Barbuda, Barbados, St. Maarten, Guadeloupe and Puerto Rico.

2.4.2 Sea Ports

There are currently three (3) deep-water harbour ports in Dominica[3]:

[1] ECLAC, 'Dominica - Political and electoral system', *Economic Commission for Latin America and the Caribbean*, 2016 <https://oig.cepal.org/en/countries/71/system> [accessed March 2022].
[2] theGlobal Economy.com, 'Dominica: Political stability', *theGlobal Economy.com*, 2022, <https://www.theglobaleconomy.com/Dominica/wb_political_stability/> [accessed March 2022].
[3] DASPA, 'Seaports', *Dominica Air and Sea Ports Authority*, 2022 <https://www.domports.daspa.dm/> [accessed March 2022].

- Roseau
    - Cruise Ship Berth – Depth of water 13 meters (42 ft.),
    - Ferry Terminal – Depth alongside 3.7 meters (12 ft.) – *Transportation hub to and from the neighbouring islands of Guadeloupe, Martinique and St. Lucia*,
- Woodbridge Bay (Cargo Port)
    - Main Wharf – Minimum depth 10 meters (32 ft.),
    - Inner Main Wharf – Depth of water 7.9 meters (26 ft.),
- Portsmouth
    - Port of Portsmouth – Depth of water 7.1-9.1 meters (26-30 ft.),
    - Cabrits Cruise Ship Berth – depth of water 11.9-14.9 meters (35-49 ft.).

2.4.3 Land Transportation

The road network of Dominica runs primarily along the coastline and along some river valleys. The major roadways are classified by two distinct lane highways and connect the country's capital in the south of the island to the northeast town of Portsmouth. The majority of the road conditions are very pristine due to new construction which took place post hurricane María with the assistance of the People's Republic of China.

2.5 Infrastructure – Utilities

2.5.1 Power/Grid Infrastructure

The Dominica Electricity Services Limited owns the exclusive rights for the transmission and distribution of power around the island. Power generation is primarily dependent on conventional fossil resources. Compared to 2015 (see ***Figure 4*** following) more updated 2019 data indicates some 63% as coming from diesel power and 37% from hydropower. There are small-scale wind projects of 230KW and 7MW of solar. This generation profile has resulted in a heavy reliance on the import of fossil fuels. The three hydro-electric plants have an installed capacity of 6.6MW. It is to be noted however, that due to the seasonal weather patterns experienced on the island, during the dry season there are recorded water flow issues, limiting surface run off to the dams for hydro-electric power generation. A planned 10MW geothermal project is underway in the southern Roseau Valley.

The transmission and distribution network throughout the island operates at 11kV and 230/400kV with a planned upgrade to increase to 33KV to better service the additional 10 megawatt (MW) geothermal power from the Dominica Geothermal Project. Although the country has an electrification rate of 99%[4], there are instances where there are a small number of off-grid power projects. In areas where solar PV

[4] NREL, 'Energy Snapshot Dominica', *National Renewable Energy Laboratory*, 2015 <https://www.nrel.gov/docs/fy15osti/62704.pdf> [accessed March 2022].

installations are the preferred choice of residents, DOMLEC offers the opportunity of net billing to its customers.

Total Installed Capacity	23.8 MW	
Peak Demand	16.8 MW	
Total Generation	100.7 gigawatt-hours	
Renewable Share	28.6%	
Transmission & Distribution Losses	8.2%	
Electrification Rate	>99%	
Average Electricity Tariffs (USD/kWh)	Residential	$0.384
	Commercial	$0.381–$0.411
	Industrial	$0.375

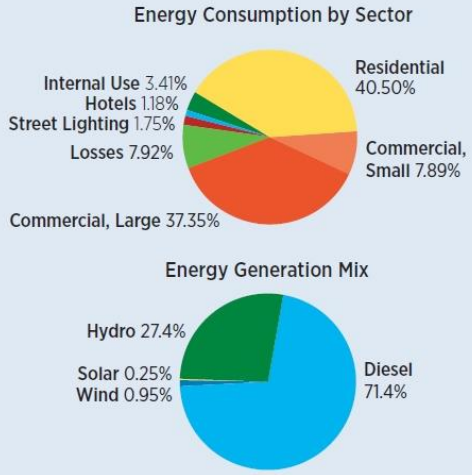


Figure 4: Electricity Overview of Dominica (2015)

Source: NREL, 2015

2.5.2 Water

Dominica Water and Sewerage Company Limited (DOWASCO) is a wholly owned Government company charged with the responsibility to provide potable drinking water and sewerage services to communities throughout Dominica.

DOWASCO has a total of forty-four (44) Water System Areas that utilise surface water drawn from the three-hundred and sixty-five (365) rivers and streams to provide water to over 95% of the population[5]. The average yearly rainfall ranges from 1,900 mm (coast) to 5,000 (inland)[6].

2.5.3 Telecommunications and Information Communications Technology (ICT)

As a country prone to the impacts of devastating hurricanes, the telecommunications infrastructure is one that is regarded as a national priority area and one that is always in need of repair. Currently the National Telecommunication Regulatory Commission regulates the sector and is directed by the Minister for State in the Office of the Prime Minister with responsibility for Telecommunications and Broadcasting. In 2021, the government made a commitment to the development of an ICT Centre of Excellence at the Dominica State College.

[5] DOWASCO, 'Water Quality', *Dominica Water and Sewerage Company Limited*, 2014 <https://www.dowasco.dm/index.php/water-quality> [accessed March 2022].
[6] World Weather and Climate Information, 'Climate and Average Weather in Dominica', *World Weather and Climate Information*, 2022 <https://weather-and-climate.com/average-monthly-Rainfall-Temperature-Sunshine-in-Dominica> [accessed March 2022].

A snapshot of the sector is provided in **Table 2** following, with additional details being included at **Appendix III**.

Table 2: ICT Sector Snapshot

Type	Liberalised Telecommunication Sector (both international and local providers)
Treaties	Signatory to the Eastern Caribbean Telecommunications Authority (ECTEL)
Telephone	Fully digital network
Radio	Only FM radio available
Television	Cable & Wireless LIME, Digicel Play, Marpin Telecoms
Mobile	Lime, Digicel
Internet	Cable & Wireless Dominica Ltd. (DSL), Digicel Play (Cable & FTTP), Marpin Telecoms (Cable)

2.6 Topography

Towards the centre of the island from north to south runs a range of high elevation points densely covered with forest vegetation broken in the centre by a plain. Dominica contains the highest concentration of active volcanoes in the Caribbean with a total of nine (9) volcanic hot spots fuelled by three separate magma chambers located in the north-west, south-east and south-west of the island[7].

Figure 5: Map of Dominica showing Highest Peaks

2.7 Sustainability Initiatives

2.7.1 Impacts of Climate Change

Dominica has always had a lengthy history of hurricane damage and with the increased effects of the changing climatic patterns globally, this Small Island Developing State has not been excluded. Implications include devastating weather phenomena including more intense hurricane events, longer hurricane seasons, flash flooding events and the erosion of coastlines and damage to coastal communities.

[7] A. Smith and others, 'The Volcanic Geology of the mid-arc island of Dominica, Lesser Antilles— the surface expression of an island-arc batholith', Geological Society of America, 496 (2013).

As part of the country's resilience plan towards the impacts of climate change there is an emphasis on the deployment of robust infrastructure.

2.7.2 Resilience Plans

The passage of Hurricane María, and the devastation left in its wake accelerated the country's response to climate change. To this end, focused attention was directed towards planning and implementation activities aligned with the strategic objective of making Dominica the world's first climate resilient country. The guiding framework for this initiative is outlined in the National Resilience Development Strategy 2030 and the Climate Resilience and Recovery Plan, which will govern all actions to be pursued during 2018-2030[8]. These actions align with the resilience platform including, inter alia:

- Optimising productivity – capital, labour and natural resources,
- Promoting adaptation and use of science and technology,
- Further broadening and deepening integration of Dominica into the region and the world,
- Attracting investments to achieve pro-poor economic progress, and
- Continuing to deepen and strengthen partnership with civil society, private sector and external development partners.

The Commonwealth of Dominica has identified its key pillars of national policy as economic diversification, sustainability and inclusive growth opportunities, increased areas of employment, social development and continued environmental and ecosystem preservation[9]. The associated objectives being:

- Risk management framework and low-carbon development pathway,
- Economic empowerment and innovations through sustainable climate financing,
- Sustainable human settlements/communities,
- Adequate social protection systems,
- Infrastructure resilience,
- Enhancing the resilience of ecosystems and sustainable use of natural resources, and
- Promoting food security and self-sufficiency.

Accordingly, all development initiatives being proposed for the Commonwealth of Dominica will be focused on helping to increase the country's resilience.

[8] Government of the Commonwealth of Dominica, *National Resilience Development Strategy 2030*, (Roseau: Ministry of Planning and Economic Development, 2020), <https://finance.gov.dm/national-development-strategies/strategies/file/31-national-resilience-development-strategy-dominica-2030> [accessed March 2022].
[9] Ibid.

2.7.3 Climate Resilience Execution Agency (CREAD)

In 2018, after the devastating passing of Hurricane María, the Government of Dominica established a statutory body to lead and provide oversights to strategic initiatives aimed at increasing the country's sustainability and climate resilience. By setting targets and measuring tools for progress, CREAD aims to steer the nation along the direction of the roadmap created to enhance the capacity of Dominicans to respond to the local impacts of global climate change[10]. By so doing, Dominica intends to set an example for the rest of the world on how to respond to the challenges of a changing climate, adopting the following model towards achieving that objective.

Figure 6: The Dominica Model for Climate Resilience

Source: Developed from CREAD, 2022b

2.7.4 The Green Climate Fund

Approved by the Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC) at its seventeenth session on 11 December 2011, this facility is the world's largest climate fund, mandated to support developing countries raise and realise their NDCs ambitions towards low-emissions, climate-resilient pathways.

[10] CREAD, 'About CREAD', *Climate Resilience Execution Agency for Dominica*, 2022a, <https://www.creadominica.org/about-us-1> [accessed March 2022].

Figure 7: Green Climate Fund Activities in Dominica

Source: Developed from GCF, 2022

Dominica has developed a transformative Low-carbon Development Pathway (LCDP) and is benefitting from financial, technical and capacity development support from the GCF. This LCDP is centred on the utilisation and commercialisation of Dominica's abundant geothermal resources, with the establishment of a Green Eco-Industrial Park, de-risking of private sector investments and institutional strengthening as key drivers of the LCDP. A number of supportive measures are being worked on including:

- The feasibility of developing GEIPs across the island,
- Geothermal Resource mapping targeted at the northern regions around Portsmouth,
- The development of new financing pathways such as Green Bond Listing, grant and concessional loan co-financing and access to Global Funds, and
- Readiness support for the enhancement of requisite policy, regulatory and governance frameworks.

03

Review of Dominica's Renewable Energy Potential

- Dominica has over 90MW of renewable energy potential (excluding geothermal) given its location and geological structure.
- By far, the most significant resource is based on its geothermal potential, a minute portion of which (10MW) is currently being developed to augment grid capacity.
- Geothermal cost is heavily impacted by geothermal reservoir quality, productivity, properties and depth, and the several challenges and risks associated with its development need to be carefully considered.
- Impacts to Dominica's rich environment can be minimised by performing the requisite EIA, employing engineering and procedural measures to mitigate the consequences and implementing an effective monitoring system.
- Studies suggest that the Portsmouth area of Dominica has a high potential for binary power technology, utilising two potential sources of heat at Morne aux Diables and Mt. Diablotins.
- Consideration is being given to the utilisation of this geothermal resource for industrial development, as well as for export to the region.

03 Review of Dominica's Renewable Energy Potential

3.1 Renewable Energy Potential

Dominica is well known for its extensive geothermal resources. However, other renewable energy resources such as wind, solar, hydro are also abundant in nature.

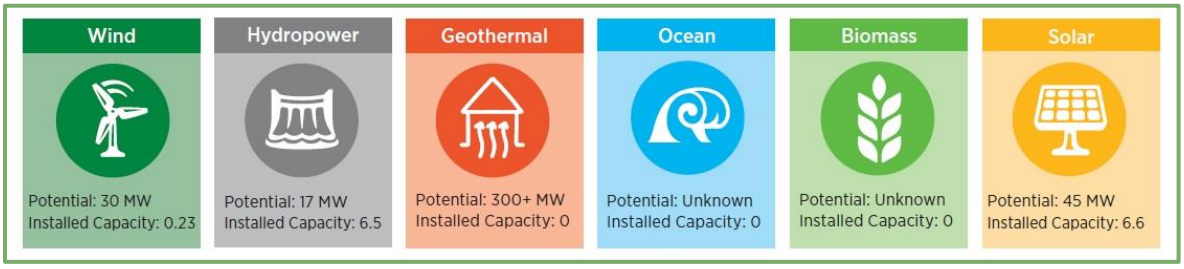


Figure 8: Renewable Energy Status and Potential of Dominica

Source: NREL, 2015

While some of these sources are already being utilised, additional research is required to quantify the potential from ocean energy and biomass.

3.1.1 Solar and Wind

The high mountainous terrain of the land has been the limiting factor to expansion and deployment of large scale solar and onshore wind technologies. Notwithstanding, there has been some rooftop solar installations on commercial and residential buildings, and solar lighting technologies have also been deployed for street lighting. Floating solar PV installations and offshore wind turbines are still areas that can be further explored to increase the renewable energy capacity of the country.

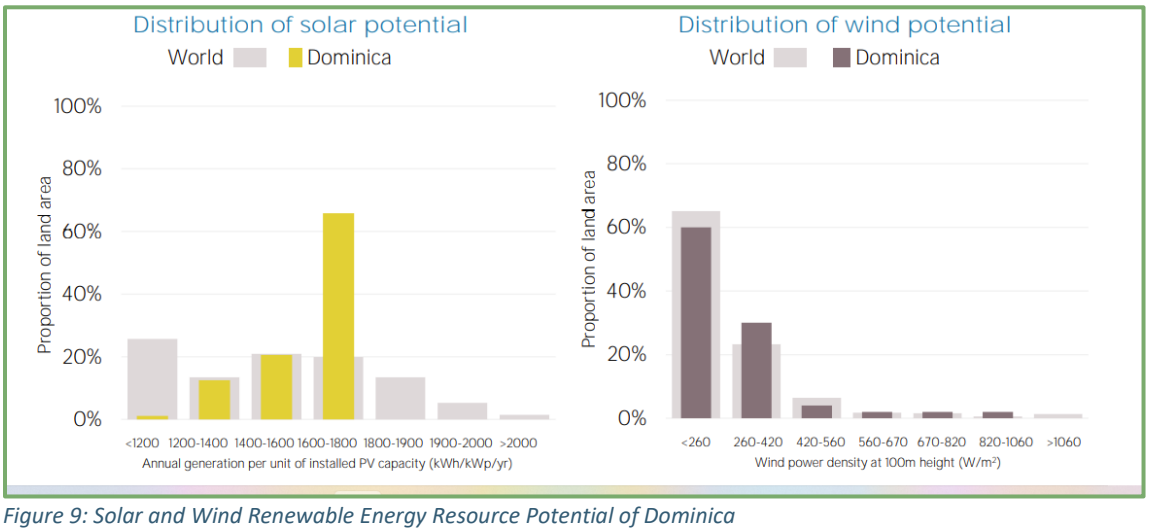


Figure 9: Solar and Wind Renewable Energy Resource Potential of Dominica

Source: IRENA, 2021a

3.1.2 Hydroelectricity

The damming of water contained in major riverways to create hydroelectricity has been utilised in Dominica since 1952. Trafalgar was the first hydropower planted erected, followed by the Padu Power Plant. In 2020 the total installed capacity of hydro in Dominica stood at 6.6MW[11] (see **Table 3** following). This represents approximately 37% of existing total generation capacity on the island. Dry season capacity stands at around 3.2 MW due to the significantly reduced rainfall during this period (See **Appendix IV**).

Table 3: Hydro-electric Plant Generating Capacity

Hydro Power Plant	MW
Laudat	1.24
New Trafalgar	3.52
Padu	1.8

All facilities are situated along the Roseau River and are operated by DOMLEC.

3.1.3 Geothermal

The Government of Dominica recognises the vast geothermal potential estimated in the range of 300-1390MW[12] that sits within its country boundaries. In 2003 geothermal energy resource studies were commenced in the south of the island specifically in the Roseau Valley. In 2008 further studies were continued which led to the formation of the Dominica Geothermal Development Company Limited (DGDCL) in 2016. The DGDCL is fully owned by the government and is currently spearheading the development of a geothermal power plant that will have a production capacity of 10MW.

3.2 Geothermal Technologies and Challenges

There are three common types of geothermal power plants used for electricity production using thermal heat transfer fluid to drive turbines for electrical production[13]. These are:

- Flash Steam – which use steam created by pressure differentials created as the hot water flows up through wells in the ground to power turbines/generators. This is the most common installation, and requires geothermal reservoirs with temperatures greater than 360°F (182°C).
- Dry Steam – which draw from underground resources of steam to directly drive turbine/generator units.

[11] DOMLEC, *Remaining Constant During Wavering Times – 2020 Annual Report*, (Roseau: DOMLEC, 2021), <https://www.domlec.dm/download/2020-annual-report/> [accessed March 2022].
[12] NREL, 'Energy Snapshot Dominica', *National Renewable Energy Laboratory*, 2015.
[13] NREL, 'Geothermal Electricity Production Basics', National Renewable Energy Laboratory, 2020b <https://www.nrel.gov/research/re-geo-elec-production.html> [accessed March 2022].

- Binary Cycle – which operate on water at lower temperatures of about 225-360°F (107-182°C), and use the heat from the hot water to boil a working fluid, usually an organic compound with a low boiling point. That working fluid is then vaporised in a heat exchanger and used to turn a turbine.

While these technologies are relatively well developed, there are several challenges and considerations which have to be factored when pursuing the development of geothermal resources. These span from the preparatory works, through to production and operation:

- Geothermal energy inherently possesses much larger upfront, initial costs when compared to other renewables,
- Geothermal drilling is still high risk, even with the technologies to date, and the possibilities of wells not having the right temperature, pressure or flow rates are quite high,
- Geothermal energy exploitation requires development at scale. Given the small markets within the local areas and the region there has been a general reluctance to invest in power not immediately required, and
- There is the potential for seismic and volcanic activity.

3.2.1 Geothermal Environmental Impact

Geothermal energy is considered a relatively clean renewable energy source, especially in comparison to energy produced from carbon-intensive fossil fuels. Studies have shown that while geothermal energy generally has a low impact, the environmental impact must still be carefully studied and accounted for. Environmental impact is associated with the preparatory (land development and site access), exploratory and production phases of geothermal energy development, with the most significant effect related to the exploratory stage. The extent of impact varies based on the geothermal reservoir properties and location.

Dominica is mountainous, has a rich bio-diversity, a perennial river system, and largely unexploited multi-layered rainforests. The island also boasts three National Parks and World Heritage Sites. Any geothermal development would need to commit to safeguarding Dominica's unique and enviable environment. The project developer should lead the efforts in minimising environmental impact, with support from Dominica's regulatory entities. An Environmental and Social Impact Assessment (ESIA) undertaken in accordance with the framework of the Geothermal Resources Development Act (2016) should identify the specific environmental concerns, key risks, extent of impacts and the requisite actions. Findings should guide the implementation of engineering and procedural controls to mitigate the consequences, in similar approach with the precedent established from the recently completed *Jacobs Dominica Geothermal Development ESIA Report* for the new 10MW geothermal power plant in the Roseau Valley. Learnings can also be applied to future geothermal projects.

Implementing an effective monitoring system and repository is crucial to limiting geothermal impact during exploration and production and preventing adverse effects. Monitoring should begin before commencing development of the field to establish a baseline for continuous comparison of geothermal data throughout exploratory and production phases. This facilitates quick and informed decision making and adds transparency to environmental governance.

The potential environmental impacts and an outline of mitigative measures are presented in **Appendix V**. Most environmental impacts are associated with high-temperature systems, mainly liquid dominated fields. Re-injecting all of the liquid waste deep into the well during production improves well performance and limits impact to the environment. The emission rate associated with a geothermal power plant is dependent on the specific geothermal well chemistry such as temperature and pressure, as well as the geothermal power plant technology employed. Some types of geothermal plants (flash-steam and dry-steam) can emit small quantities of carbon dioxide, hydrogen sulphide and trace amounts of methane, ammonia, mercury, boron vapour, and other toxic gases. The emission rate can be mitigated by the employment of the appropriate technology and design. Binary plants which operate as a closed-loop, retain the gases in the geothermal fluid for re-injection into the reservoir resulting in near-zero emissions.

3.3 Geothermal Development in Dominica

Dominica forms part of the Eastern Caribbean which comprise of a chain of volcanic islands where the thermal gradient lends itself to geothermal development.

The exploration, development and utilisation of geothermal energy will facilitate a more competitive and efficient power generation market for Dominica, enabling business growth. Geothermal power offers Dominica the opportunity for structural economic reform, enhancing both resilience of the economy and increased capacity to withstand climate change. Outlining opportunities, removing barriers and accelerating investments will enhance the country's competitiveness and unlock the potential for private-sector driven development.

Estimates suggest that the island can realise >20 times its projected power demand by utilising its untapped geothermal resource. However, exploratory drilling has only been completed for the Roseau Valley in the southern part of the island and not for the northern reservoirs. Studies suggest that the northern area has a high potential for binary power technology[14], with two potential sources of heat situated at Portsmouth:

- Morne aux Diables – a small volcano at the peninsula at the northern end of the island, and
- Mt. Diablotins – the highest mountain in Dominica.

[14] Rohrs Consulting, Inc., *Geothermal Resource Assessment of the Portsmouth Prospect, Dominica, West Indies*, (Roseau: Rohrs Consulting, 2009).

3.4 The Cost of Geothermal Electricity

Holistically, over the last decade, the cost of renewable energy has fallen, although more primarily for solar and wind projects. This generally decreasing cost, coupled with the global drive for climate change, has created a high demand for renewable power projects. Although geothermal energy has seen less significant cost reductions, it nonetheless benefits from the overall increase in global demand for renewable energy production given that it is a mature technology.

Geothermal cost is heavily impacted by geothermal reservoir quality, productivity, properties and depth. There is high risk and high cost associated with reservoir exploration and mapping. Other significant factors which impact cost include the power plant technology to be employed, the site topography, site remoteness and required infrastructure.

However, it remains as an attractive renewable energy option because it provides a constant energy supply at high availability – an advantage over the intermittent solar and wind renewable options. These considerations allow this source of energy to remain competitive.

Figure 10 provides geothermal energy production statistics for 2020.

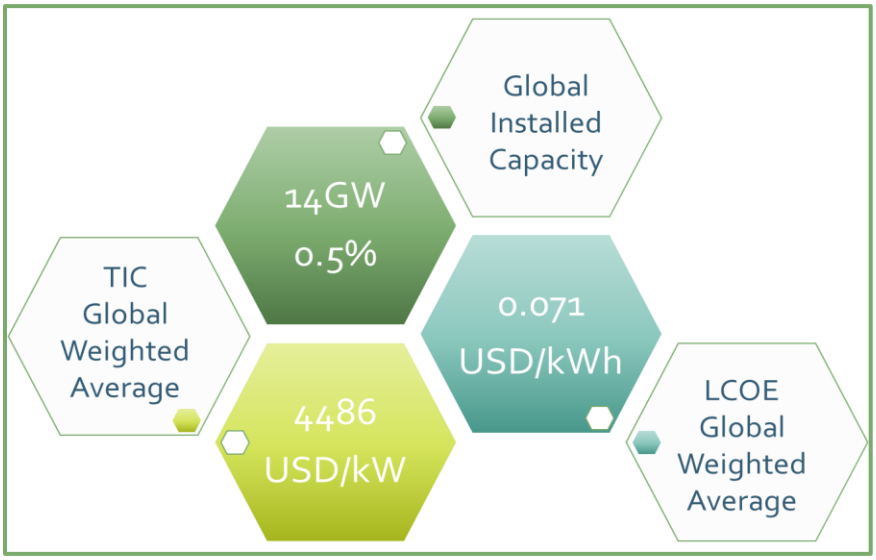


Figure 10: Geothermal Energy Global 2020 Statistics

Source: Developed from IRENA, 2021b

Further clarity on the Levelized Cost of Energy (LCOE) is presented in ***Figure 11***, which shows the variability in LCOE by technology and capacity for 2007 through to 2021.

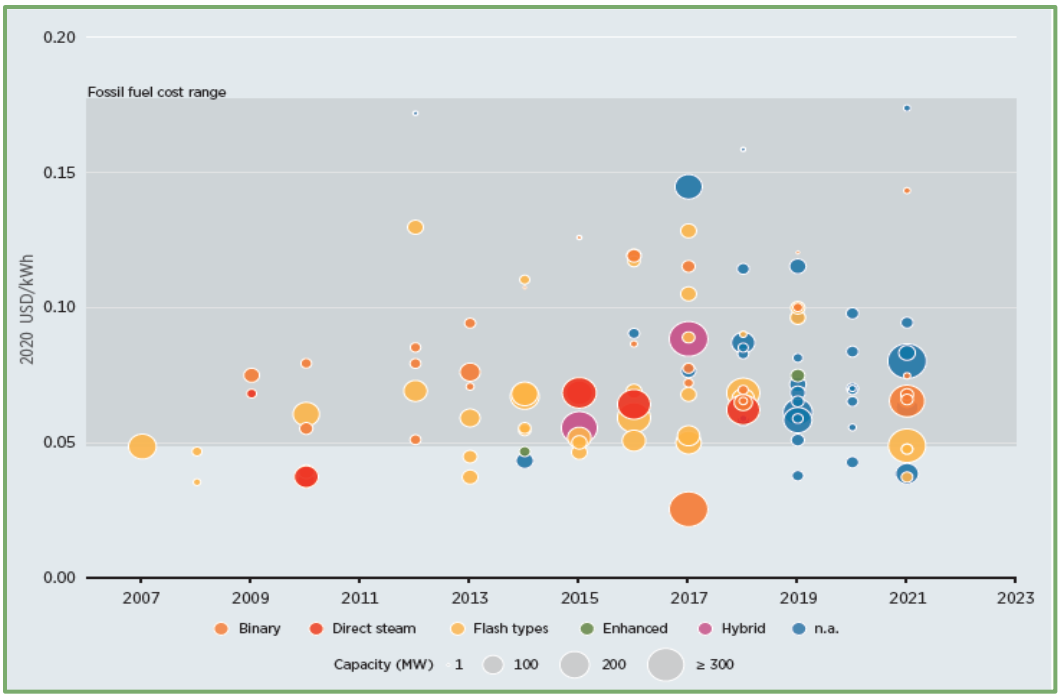


Figure 11: LCOE of Geothermal Power Projects by Technology and Project Size

Source: IRENA, 2021b

3.5 Potential Geothermal Power Applications

The nature of the available geothermal resource influences the technology that can be utilised in exploiting the available energy for power generation, as well as the direct-use applications which can be supported (see ***Figure 12*** following).

3.5.1 Application of Geothermal Power to Industrial Development

The range of applications lends itself to the establishment of multiple facets of industrial development, including dedicated self-generating capability to serve a micro-grid within an industrial park. Co-locating downstream industries in the vicinity of the geothermal energy plant allows for integrating embedded generation directly with the industrial and infrastructure load demand without the need for connection to the utility grid.

One of the main advantages of self-generation is the potential cost savings associated with power purchase and utility infrastructure upgrades. It is to be noted that Dominica currently has one of the highest electricity rates in the region at an estimated 0.375USD/kWh[15]. It would therefore be necessary for cost comparisons of electricity from the grid and a dedicated geothermal reservoir to be subjected to

[15] GCF, *Readiness Report - with the Ministry of Planning and Economic Development for Commonwealth of Dominica*, (Roseau: Ministry of Planning and Economic Development, 2019), <https://www.greenclimate.fund/sites/default/files/document/readiness-proposals-dominica-moped-strategic-frameworks.pdf> [accessed March 2022].

early feasibility studies to justify self-generation. But, it is anticipated that the cost of self-generation will be lower in the long term.

Operating as a 'self-generated island' (with no connection to the utility grid) would eliminate the high cost of upgrading the electrical infrastructure to the remote site location. Additionally, self-generation via a constant geothermal resource offers the advantage of having a reliable electrical supply that is not affected by grid supply interruptions. A self-generated island facility may also be more resilient to the impacts of climate change.

Reliability is one of the primary considerations for a self-generated facility that must be investigated early in the design. Having a connection to the utility grid provides the option to utilise grid power as a redundant backup to cater to the routine and emergency outages of the geothermal power plant. Alternatively, the geothermal plant can be designed with high reliability and embedded backup generation or storage. This should also be thoroughly investigated as part of early studies.

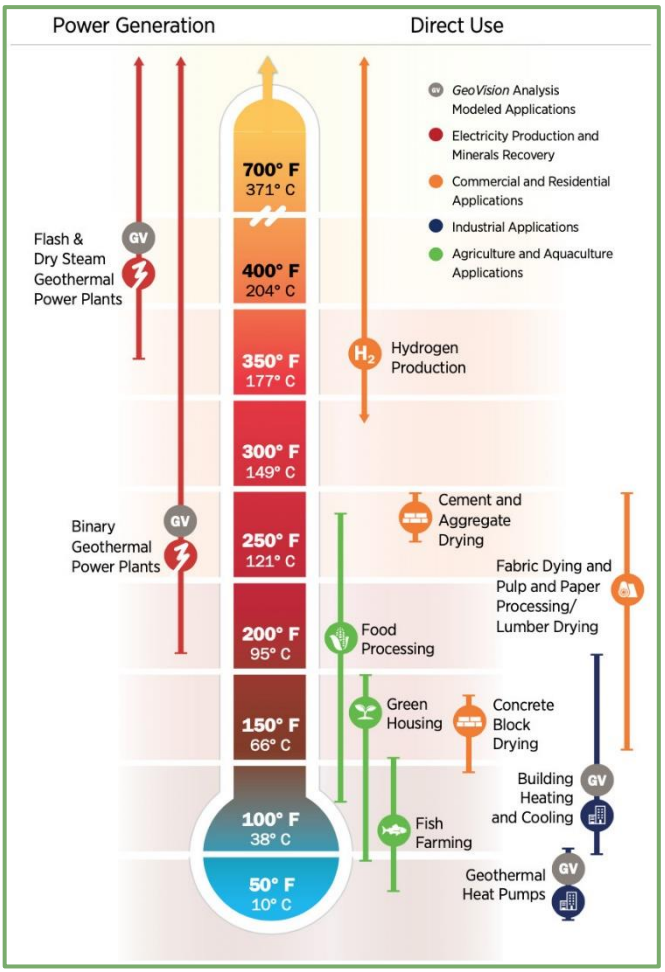


Figure 12: Geothermal Energy Uses

Source: Roberts, 2020

Another consideration is the level of involvement required by the utility provider. DOMLEC has a non-exclusive license for power generation. Self-generation of power for an industrial micro-grid can be considered by industry under the Geothermal Resource Concession in accordance with the Geothermal Resources Development Act, with the Independent Regulatory Commission (IRC) regulating any grid inter-connectivity. The concept of self-generation, at this industrial scale, would be new to Dominica. However, conceptually the arrangement would function in the same manner as other private establishments such as hotels and multiple-tenant housing arrangements, where self-generation is common. Notwithstanding, investigations and reviews would have to be undertaken to determine whether any change in regulations may be warranted to govern such industrial production and large baseload power users identified for the GEIP.

3.5.2 Power Export

The Portsmouth reservoir has high potential and may generate capacity above the potential industrial demand, even accounting for future needs. Accordingly, excess power over and above the needs of the GEIP can create value-add opportunities by being exported to regional markets with demand for sustainable, reliable, renewable energy, such as Trinidad and Tobago's industrial sector. Legislation allows for the construction of separate and distinct transmission infrastructure by the power exporting entity. Connections can also be made to the local grid for redundancy and enhanced overall resilience. The latter would require an assessment of the existing grid capacity and infrastructure. However there are advantages since this option can contribute to the displacement of power generated from fossil-fuel imports (currently 67% of the energy mix), thus increasing the nation's overall resilience.

Similar frameworks currently exist. The Government of the Commonwealth of Dominica has an agreement with a consortium of French industrial investors for the construction of a 50MW geothermal power plant to supply power via undersea cables to the French island of Martinique in the first instance. This will be followed by another 50MW plant for the provision of power to the neighbouring French territory Guadeloupe, and as part of these arrangements, provisions have been incorporated for Dominica's needs to be prioritised in the event of emergency, natural disaster and other exigencies.

3.6 Next Steps

Considering the general risks associated with geothermal exploration and development, there is need to undertake further feasibility and econometric studies to model the proposed project. The next phase of exploration will require a geological study to develop a resource map for the area under consideration in ***Figure 13***.

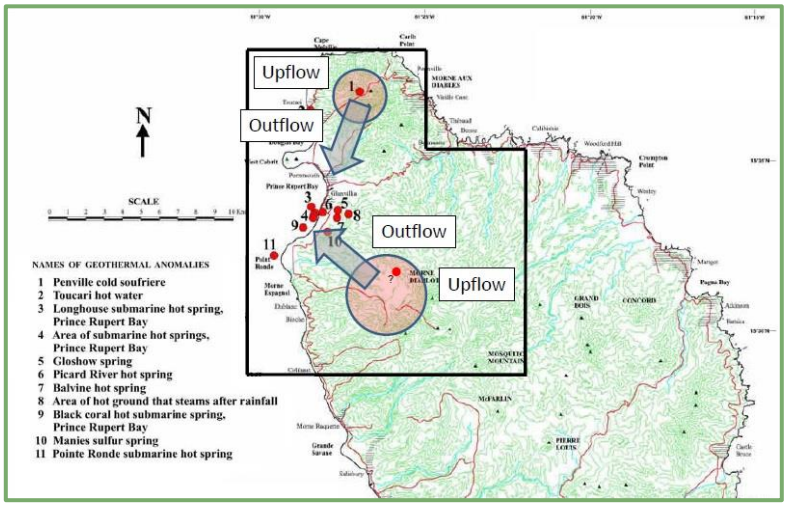


Figure 13: Area of Geothermal Potential in the Northern Area of Dominica

Source: Modified from Rohrs Consulting, Inc. (2009)

Accessing public funding and grants is one option to help offset the high capital costs that will be associated with exploring the northern region. Assuming resource availability, the other impacting factors will be the power plant technology to be employed and the site topography, site remoteness and road infrastructure.

04

Green Eco-Industrial Parks

- There is a global push towards decarbonising and detoxifying the environment through the replacement of fossil fuels with renewable sources of energy.
- The green eco-industrial park concept creates industrial development opportunities while ensuring environmental preservation occurs alongside commercial and local community symbiosis.
- In many emerging and developing economies, there is a lack of in-depth analysis of the drivers for eco-industrial parks.
- Notwithstanding, there is growing need for SIDS to adopt and implement the concepts behind green eco-industrial parks as the benefits lead to socio-economic advancements, energy security, waste and hazardous pollutant reduction and increased climate resilience.
- The success factors for green eco-industrial parks include master planning, technical assistance, strategic planning and development, green recruitment policy development and the use of public-private partnership ownership models.

04 Green Eco-Industrial Parks

4.1 Introduction

A pressing need and requirement of worldwide governments is to substitute fossil fuels with renewable energy sources phasing out the use of toxic substances and introducing new, cleaner technologies. In Dominica, the government has devised a national policy called a Low-Carbon Climate Resilience Development Strategy that is focused on developing Green Industrialisation and Green Eco-Industrial Parks.

4.2 The Green Eco-Industrial Park Concept

The green industry is described as industrial production and development that does not promote economic growth while it harms human health, harms the environment, deteriorates social conditions and depletes natural resources. To this end, an increasing number of Governments have developed and are developing strategies aimed at facilitating the greening of existing industries and developing green industrialisation that is timely, cost effective and environmentally friendly.

An Eco-Industrial Park (EIP) is described as an area where companies (manufacturing and services) cooperate with each other and the local community in a relationship known as industrial symbiosis (IS) - sharing and managing resources such as energy, water, materials and the environment to achieve resource efficiency, increased productivity, economic gains, environmental quality, sustainability and community growth.

4.2.1 Drivers of EIPs

An in-depth analysis of the driving factors behind EIP developments, specifically in developing and emerging economics, is lacking. Consequently, as individual countries seek to transition from fossil fuels to renewable energy, policies and action plans need to be specific to their respective case(s). The utilisation of clean energy sources through the development of EIPs is a vehicle that can be used to promote sustainable socio-economic outcomes.

EIPs contribute to multiple desirable outcomes, including:

- Climate resilience, where new risks and hazardous events related to long-term changes and shifts in weather patterns can be anticipated and mitigated,
- Natural, clean environments, derived from the promotion of collective environmental initiatives that decrease waste, and increase resource efficiency, and the quality and sustainability of the environment and community,

- Low-carbon economies and zones, where green technologies are adopted to reduce carbon emissions and environmental pollutants and waste, and strengthen the production efficiency and competitiveness of locally manufactured green goods and services,
- Sustainably managed ecosystems,
- Clean, affordable and reliable energy sources,
- Reduction in waste and material use,
- Green economy transition and expansion, and
- Awareness to the local community (through training and outreach).

Critically, eco-industrial development applies 'economies of systems integration', where business collaboration has the potential to benefit from economies in the supply of services and facilities, thereby achieving greater efficiency and economic gains.

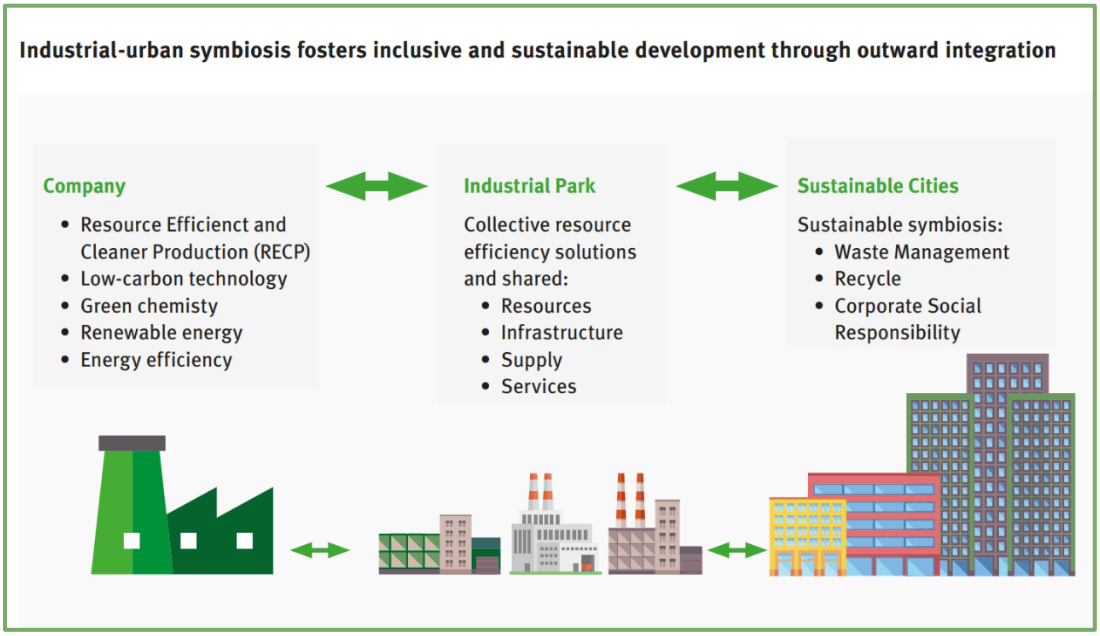


Figure 14: Linkages and Integration Patterns of Eco-Industrial Parks

Source: UNIDO, 2016

As these efficiencies are realised, so too is the robustness of the resilience model strengthened, driving even further linkages and integration among the various stakeholders.

4.3 Success Factors for Green Industrialisation

UNIDO's International Framework for Eco-Industrial Parks provides in-depth comparative analyses from the results of case studies of EIPs and identifies key factors that should be considered when developing or transitioning to an EIP.

4.3.1 Ownership

Industrial parks managed by public-private partnerships and the private sector show a higher average performance than industrial parks managed solely by the public sector. This seems to suggest that industrial parks perform better if they are run like a private business or public-private partnership, rather than a government-managed initiative.

4.3.2 Technical Assistance

Technical assistance requires a synergy and strong focus on the dissemination of knowledge among stakeholders, peer-to-peer learning and sharing of experiences between industrial parks and their regulating authorities.

4.3.3 Strategic Planning and Management

Strategic planning and effective management of industrial parks are essential to achieve the desired economic, social, and environmental performance levels. These activities require the retention of an experienced, multi-disciplinary team to address technical and socio-economic requirements.

4.3.4 Master Plan

Site Master Planning is important. It affords a more orderly and structured layout, allows for more planned placements of industrial infrastructures and related industries, and reduces or avoids ad hoc placements of future tenants. This helps a park to attract investment and create a competitive industrial environment.

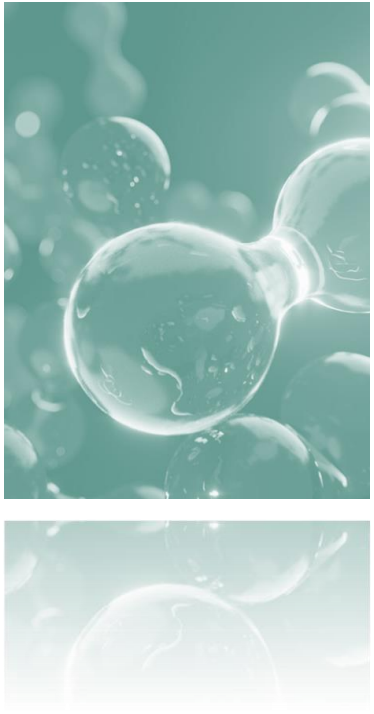
4.3.5 Green Recruitment Policy

Consistent with the Master Planning exercise, would be the need to document and articulate a Green Recruitment Policy which would outline to prospective tenant companies:

- The promotion of renewable/cleaner energy sources,
- The construction of infrastructure in reference to national green building standards,
- The requirement for preparation of eco-design, cleaner production and waste treatment plans prior to project commencement,
- The implementation of energy saving and emission reduction regulations,
- The participation in industrial symbiosis, and
- The investment in environmentally friendly and energy-efficient technologies.

In developing and emerging countries there are many difficulties which arise during the development of green industrialisation or greening industries. These difficulties are primarily due to lack of funding, political will, experience and/or regulations and their enforcement.

Nonetheless, good practices bring good benefits. UNIDO's analyses of case studies of many countries with EIPs or some version of an EIP provide an understanding of the environmental, social and economic benefits of green industrialisation and show that using EIPs are a viable solution to develop green industrialisation and increase greenness in industries. Dominica therefore appears well positioned to pursue such development, given that several of the enabling mechanisms exist in the country.



05

The Global Push for Green Hydrogen: Opportunities for Private Sector Investment

- Green hydrogen provides the opportunity to decarbonise the hard-to-abate sectors such as crude oil refining and ammonia and methanol production by providing hydrogen produced through renewable energy with an overall low product carbon footprint.
- The current estimated 300MW installed hydrogen electrolysis capacity globally is expected to increase exponentially by 2030 to an estimated 90GW.
- The overall green hydrogen production cost would continue to decline and can begin to become competitive with grey hydrogen before 2030 based on the continued decreasing cost of renewable energy and electrolyser cost, technology innovation to improve performance and efficiency, and gleaned learnings from the large-scale deployment of electrolysers.
- The dynamic collaboration between public and private sector entities is needed to drive Dominica's green hydrogen economy deployment and to attract investment to finance the transition.
- Dominica has a transformative opportunity to serve as an industrial centre for renewable power generation, hydrogen production, and even further along the value chain into the ammonia and methanol production markets.

05 The Global Push for Green Hydrogen: Opportunities for Private Sector Investments

5.1 Introduction

Green hydrogen's increasing importance is linked to global climate change and the need to significantly reduce greenhouse gases (GHG). These emissions are driving weather conditions towards extremes, with implications ranging from biodiversity loss and species extinction to worsening health and poverty for millions of people worldwide. The effort towards achieving Net Zero, as outlined in the Paris Accord, requires the identification of new sources of energy which, in their generation and use, do not add to the elevated levels of emissions already in the atmosphere. Green hydrogen's attraction is based on its ability to satisfy several of these requirements. Dominica's abundant geothermal resource affords the possibility for Dominica to play into the green hydrogen market. The geothermal power can be the energy source for development of production facilities for hydrogen and its derivatives located within a green eco-industrial park.

5.2 About Green Hydrogen

Hydrogen is the simplest, most abundant element in the universe. It is very light and has the lowest molecular weight of all elements. Hydrogen is also odourless, colourless, and tasteless. Moreover, hydrogen is highly permeable, flammable, and easily ignited. In addition, hydrogen has a high energy content by weight, but the energy density per volume is low at standard pressure and temperature. This directly impacts storage and requires hydrogen to be compressed and stored under pressure or converted to cryogenic liquid hydrogen.

Hydrogen in its pure form is carbon-free regardless of the method of production and emits only water when burned. This makes it attractive to tackle climate change as there are no associated greenhouse gas emissions. The many colours used to describe hydrogen relates to the carbon footprint associated with its method of production and source material.

Consequently, there is no universally accepted colour spectrum for hydrogen that has even been described using a rainbow of up to nine colours. For simplification, the definitions in this report align with that of IRENA.

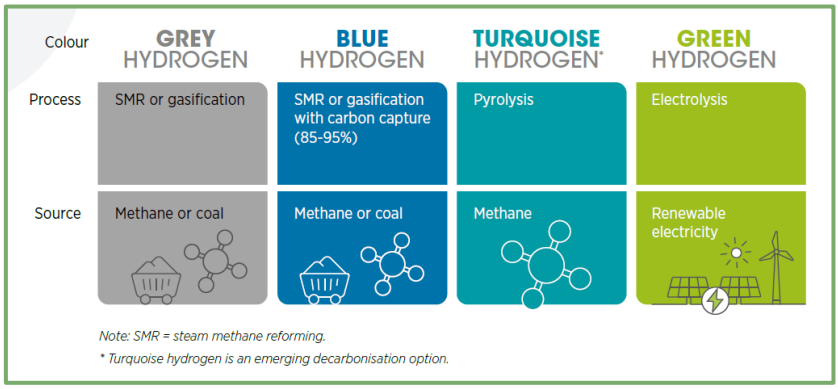


Figure 15: Hydrogen Colour Spectrum

Source: IRENA, 2021c

Grey Hydrogen: Is hydrogen produced through the Steam Methane Reforming (SMR) of natural gas or coal gasification. Coal gasification is the most carbon-intensive method of producing hydrogen, and brown/black hydrogen is often used to describe hydrogen produced through this process.

Blue Hydrogen: Is hydrogen produced through SMR of natural gas or coal gasification, but the carbon dioxide produced is captured and stored or processed for industrial use (carbon capture utilisation and storage). However, CCUS does not result in all the carbon dioxide being captured.

Turquoise Hydrogen: Is hydrogen extracted by using the thermal splitting of methane via methane pyrolysis. This is an emerging field that has not yet been proven on an industrial level.

Green Hydrogen: Is hydrogen produced via the electrolysis of water using renewable energy sources.

There is global recognition of the need to gradually move away from the colour terminology used to describe hydrogen to a more objective measure, as some scenarios may not fit succinctly under a particular colour description. For example, hydrogen production via water electrolysis using a combination of renewable energy and energy-efficient power from combined cycle machines. For this reason, the general approach being adopted globally is to move towards assessing the lifecycle product carbon footprint impact (PCF).

5.3 The Future of Green Hydrogen – Global Demand and Supply

Green Hydrogen is a critical enabler to decarbonise carbon-intensive industries as the world journeys to a net-zero future. Interest in green hydrogen has gained unprecedented momentum in recent years, which the COVID-19 pandemic has accelerated. As a result, an increased number of countries include a green hydrogen economy as a critical part of their strategy to reduce emissions and combat climate change. Green hydrogen demand is predicted to increase as more countries declare their hydrogen strategy.

According to IRENA, every year approximately 120 million tonnes of hydrogen is produced globally[16]. Grey hydrogen production (natural gas SMR and coal gasification) accounts for approximately 95% of this amount.

Moreover, of this quantity of hydrogen produced, 75% is used as feedstock for crude oil refining and ammonia and methanol production[17]. These are hard to abate sectors where it is difficult to reduce emissions through routes such as electrification significantly. In addition, fossil fuel is a finite resource. Thus, there is a need to find a more sustainable feedstock to ensure these sectors' viability and reduce the carbon footprint associated with these industries. Green hydrogen provides the opportunity to

[16] IRENA, *Green Hydrogen Supply: A Guide to Policy Making*, (Abu Dhabi: IRENA, 2021d) <https://irena.org/-/media/Files/IRENA/Agency/Publication/2021/May/IRENA_Green_Hydrogen_Supply_2021.pdf> [accessed March 2022].
[17] Ibid.

decarbonise these sectors by providing hydrogen produced through renewable energy with an overall low product carbon footprint.

Additionally, there is also growth potential to expand green hydrogen to new applications due to hydrogen's versatility as an energy carrier. ***Figure 16*** suggests potential applications of green hydrogen beyond existing industrial pathways.

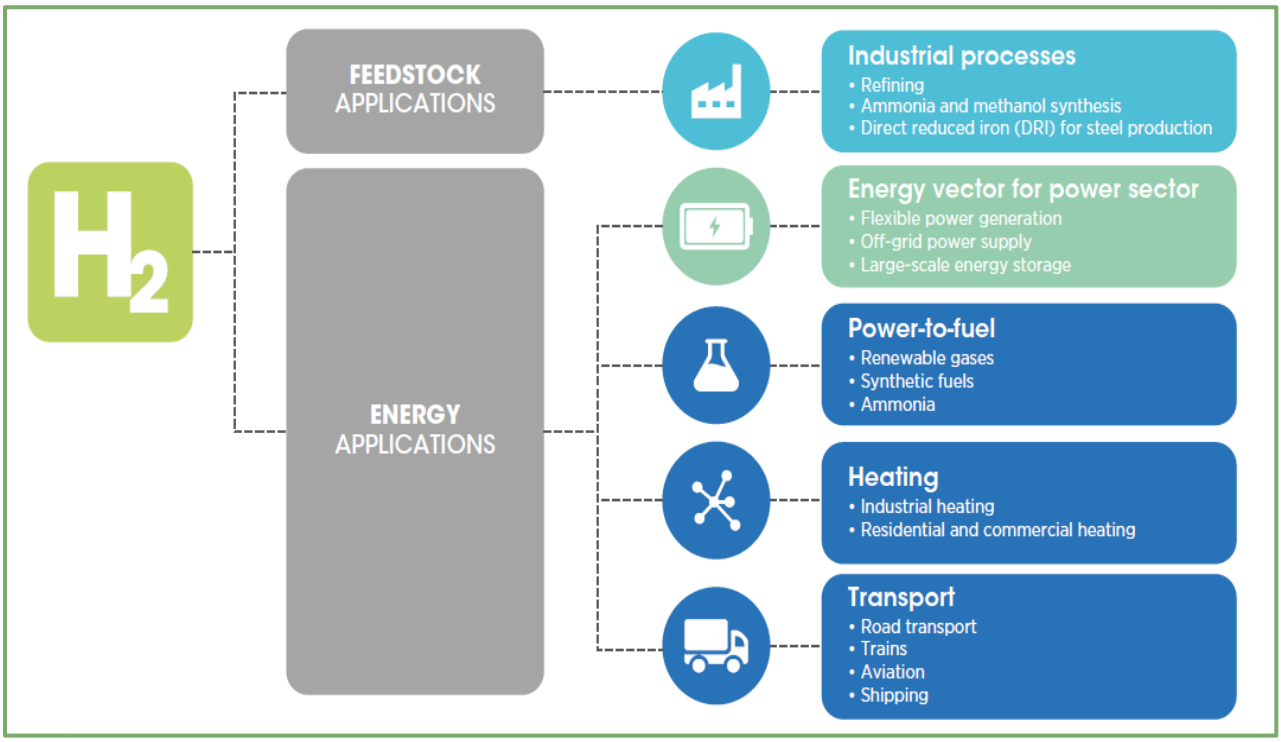


Figure 16: Green Hydrogen Potential Market Opportunities

Source: IRENA, 2021e

The current installed hydrogen electrolysis capacity globally is believed to be in the range of 300MW[18]. The green hydrogen production wave has gathered tremendous momentum in recent years, with an ever-increasing number of governments and private investors announcing large-scale hydrogen electrolyser projects in the megawatt and gigawatt range. This figure is expected to increase exponentially by 2030 to an estimated 90GW if all the announced and planned projects are factored[19][20].

Figure 17 following provides a projection of the hydrogen production demand and associated hydrogen electrolyser demand based on IEA's projection for both the Announced Pledges Scenario and Net Zero

[18] IEA, *Global Hydrogen Review revised version*, (Paris: IEA Publications, 2021a) <https://iea.blob.core.windows.net/assets/5bd46d7b-906a-4429-abda-e9c507a62341/GlobalHydrogenReview2021.pdf> [accessed March 2022].
[19] Ibid.
[20] Hydrogen Council, *Hydrogen Insights: A perspective on hydrogen investment, market development and cost competitiveness*, (Brussels: The Hydrogen Council, 2021) <https://hydrogencouncil.com/wp-content/uploads/2021/02/Hydrogen-Insights-2021.pdf> [accessed March 2022].

Emissions Scenario.[21] ***Figure 18*** provides a comparative view from varied references of the projected hydrogen demand by 2050 and the associated renewable electricity needed.

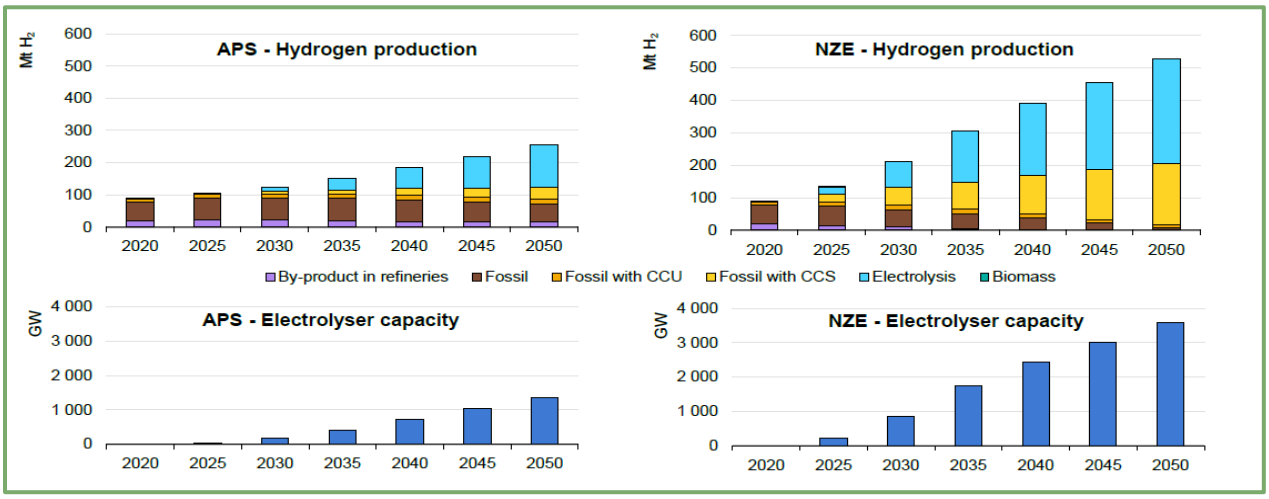


Figure 17: Green Hydrogen Production Demand and Associated Electrolyser Demand

Source: Adapted from IEA, 2021a

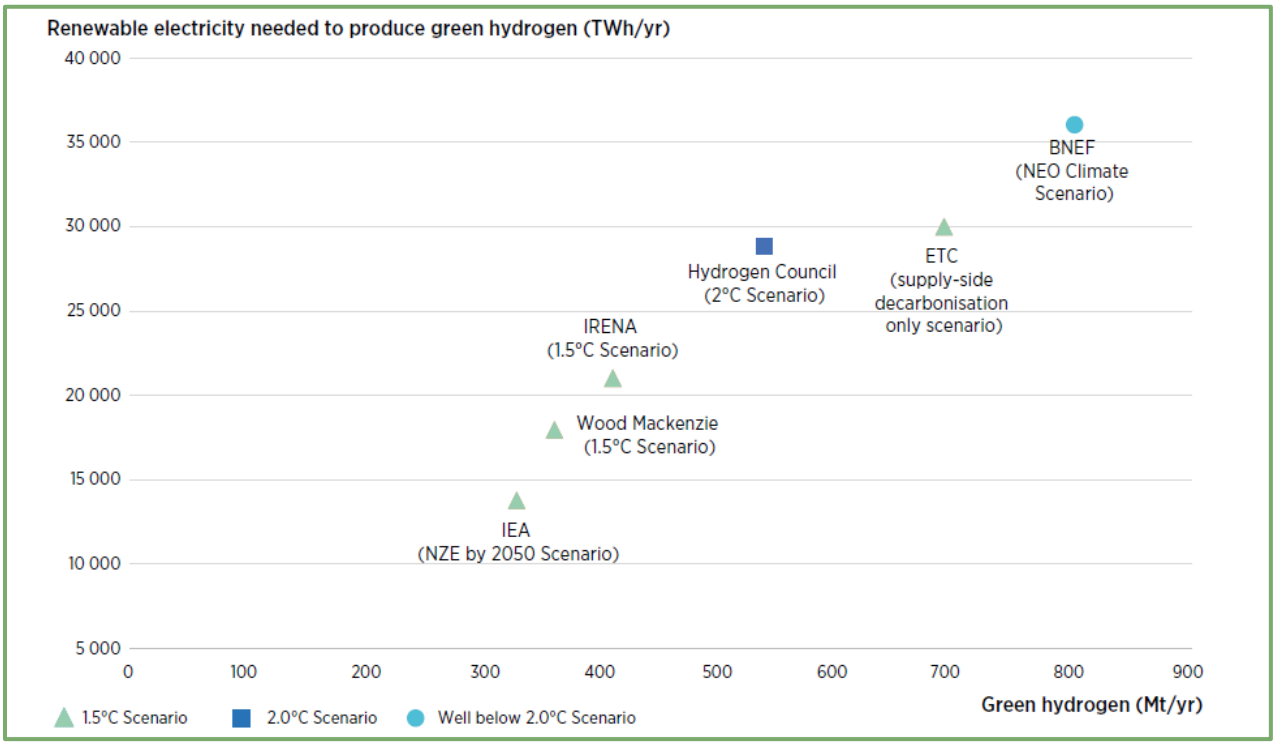


Figure 18: Global Hydrogen Demand by 2050 and Global Demand for Renewable Electricity

Source: IRENA, 2021e

[21] IEA, *Global Hydrogen Review revised version*, (Paris: IEA Publications, 2021a).

5.4 Regional Demand

The Latin America and Caribbean Region has a hydrogen demand of 4.1 million tonnes/year to satisfy the vibrant refining, chemical, and steel industries as of 2019.[22] Almost all of this demand is currently met through grey hydrogen production using carbon-intensive fossil fuels, primarily natural gas. With existing regional green hydrogen production through electrolysis accounting for only 0.2% of the hydrogen demand, there is a significant growth potential for green hydrogen production[23].

Accordingly, regional hydrogen demand is expected to increase by over 60% by 2030, although this value will be dominated by existing hydrogen uses rather than new applications[24]. It should be noted that this IEA projection does not include possible uses in the power sector, mining or buildings and does not include demand for hydrogen exports from the region. However, the LAC region could position itself to become a global exporter of green hydrogen to regions expected to have a high green hydrogen demand by 2030, including Europe and Asia regions.

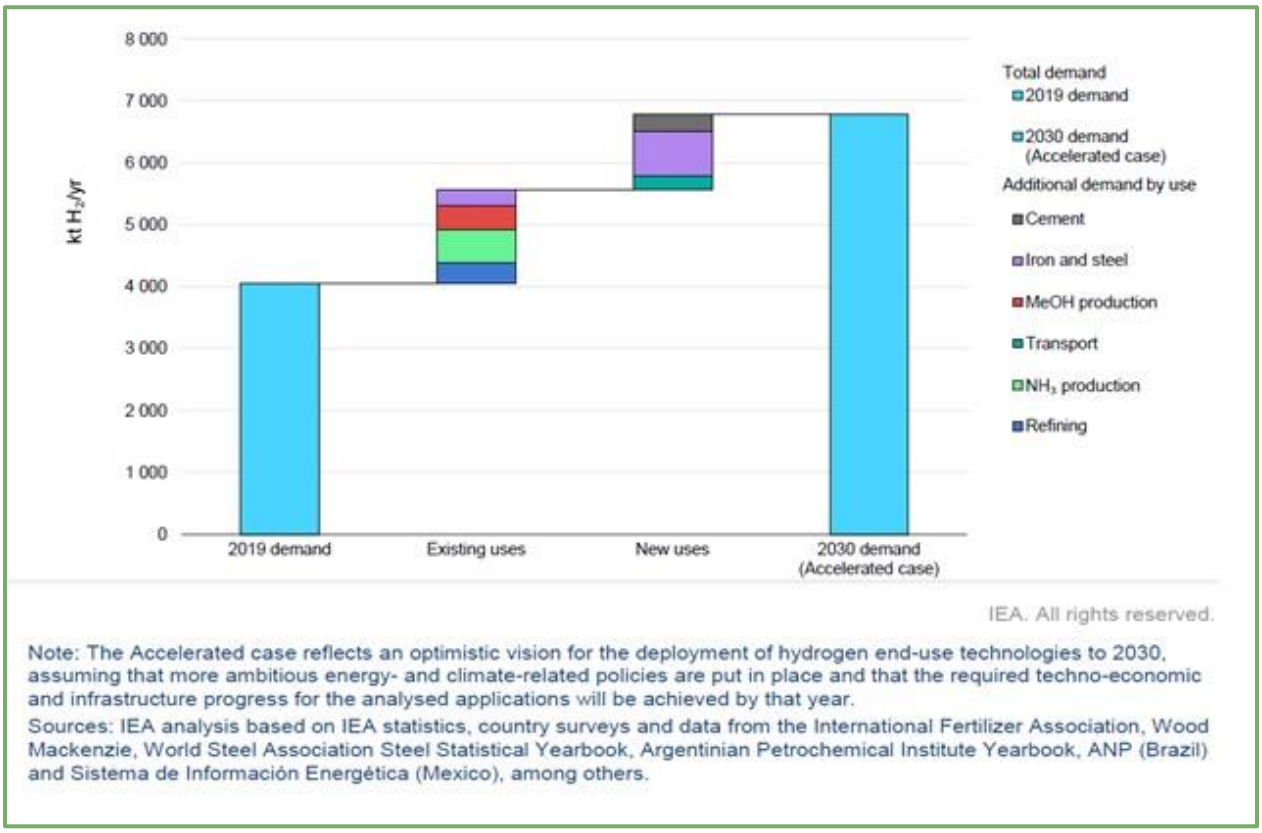


Figure 19: Change in Hydrogen Demand by Sector, Accelerated case, Latin America 2019-2030

Source: IEA, 2021b

[22] IEA, *Hydrogen in Latin America; From near-term opportunities to large-scale deployment*, (Paris: IEA Publications, 2021b) <https://iea.blob.core.windows.net/assets/65d4d887-c04d-4a1b-8d4c-2bec908a1737/IEA_HydrogeninLatinAmerica_Fullreport.pdf> [accessed March 2022].
[23] Ibid.
[24] IEA, *Global Hydrogen Review revised version*, (Paris: IEA Publications, 2021a).

5.5 Cost of Hydrogen Production

Currently, the levelized cost of green hydrogen at 4-6USD/kg is approximately 2-3 times the cost of grey hydrogen produced through unabated fossil fuels[25]. Green hydrogen cost would need to drop to below 2USD/kg to compete with grey and blue hydrogen. The two main contributors that limit the cost competitiveness of green hydrogen production are the availability and cost of renewable energy, and the cost of the electrolysers themselves.

Although water electrolysis is a mature technology, electrolysers are not available commercially at the scale required for green hydrogen production. There is a race to scale up globally, with several electrolyser suppliers increasing their manufacturing capability and ramping up their research to improve their standard module and balance of stack design to match the increasing global demand. Electrolyser suppliers are also investing in research to improve the performance of the electrolyser, which would, in turn, impact energy efficiency. In addition, due to increased investment in renewable energy production, there has been a reduction in the cost of renewable energy production within the last decade.

With the continued decreasing cost of renewable energy and electrolyser cost, technology innovation to increase performance and efficiency, and gleaned learnings from the large-scale deployment of electrolysers, overall green hydrogen production cost would continue to decline in the future. The general prediction is that the cost of green hydrogen production can begin to become competitive with grey hydrogen before 2030[26] (see ***Figure 20*** following).

[25] IRENA, *Making the Breakthrough – Green hydrogen policies and technology costs*, (Abu Dhabi: IRENA, 2021c) <https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Nov/IRENA_Green_Hydrogen_breakthrough_2021.pdf?la=en&hash=40FA5B8AD7AB1666EECBDE30EF458C45EE5A0AA6> [accessed March 2022].
[26] Ibid.

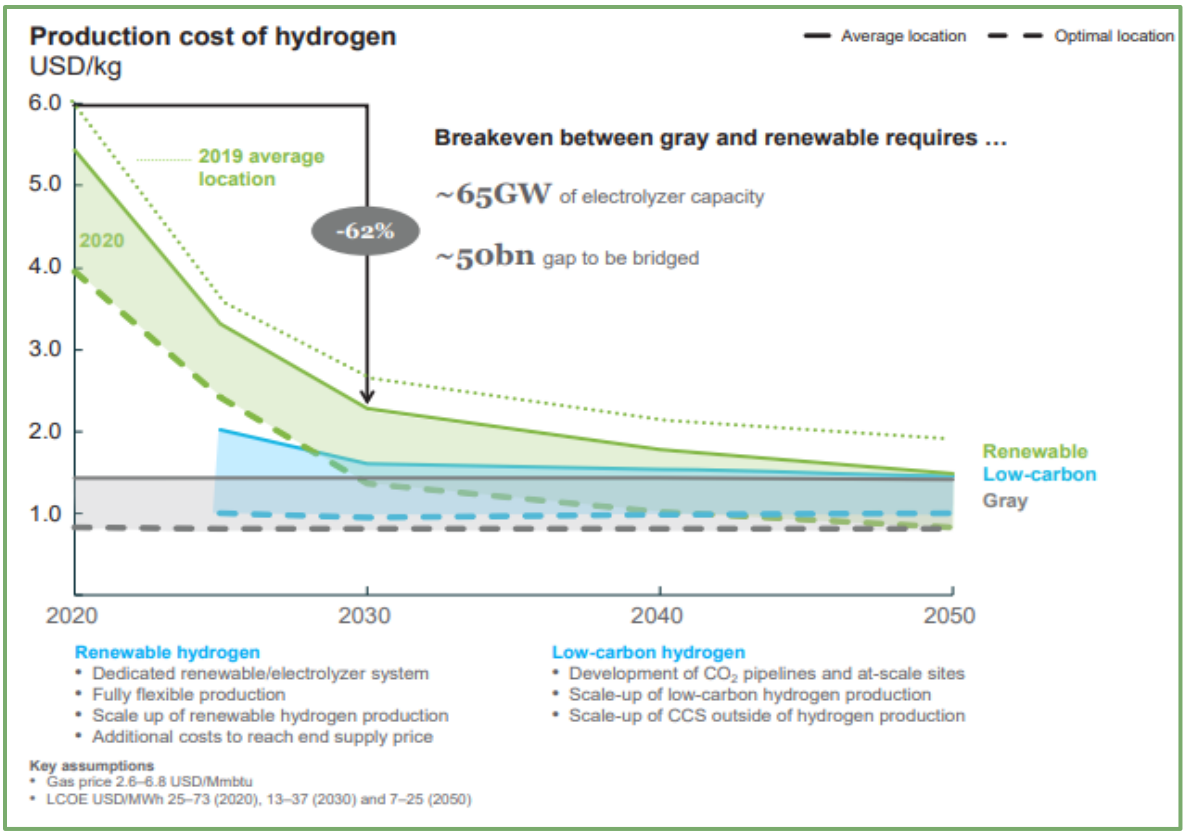


Figure 20: Hydrogen Production Cost by Production Pathway

Source: Hydrogen Council, 2021

There is a growing global consensus on introducing carbon pricing to account for carbon emissions associated with grey and blue hydrogen production. The belief is that carbon pricing is essential, and would be a catalyst to spur government and private entities into action towards achieving the ambitious Paris Agreement sustainability targets. In addition, introducing carbon pricing on grey hydrogen would also accelerate the cost competitiveness of green hydrogen compared to its carbon-intensive grey hydrogen counterpart.

5.5.1 Competitive Cost Policy Considerations

Given the need to ensure internationally competitive Levelized Cost of Hydrogen (LCOH) during these early stages of global green hydrogen development, Dominica should seek to scale up its green hydrogen value chain to unlock further cost reductions and secure a viable green hydrogen industry. Ensuring renewable power is developed at industrial scale, integrating power production and users of that power, and the balance of taxes and royalties to be applied for the duration of the concession should be seen as key to the greenfield industrial development. The Geothermal Resource Concession therefore should reflect such benefits, with measures to include wealth transfer to local entities through supportive investment structure, equity participation, local content rules for business and contractual technical services, and private sector led apprenticeships being negotiated into the agreement.

The Ministry of Planning, Economic Development, Climate Resilience Sustainable Development and Renewable Energy in collaboration with the GCF and other partners will play a key role in ensuring due consideration and risk mitigation measures are employed to keep costs competitive while maintaining maximum benefit to the people of Dominica.

5.6 Green Hydrogen Opportunities for Dominica

Already, there is a shortage of green hydrogen molecules to match the increasing global demand. Most certainly, this gap would continue to increase globally and regionally, as more governments and industries replace carbon-intensive hydrogen in existing industries with a green hydrogen source. This commitment to reduce carbon footprint, coupled with other drivers such as introducing carbon pricing, the falling cost of green hydrogen production, and hydrogen's versatility for use in new applications, would secure a vibrant, sustainable future green hydrogen market.

Dominica has high renewable energy production potential through geothermal, wind, and solar. It follows that Dominica has a transformative opportunity to become a green hydrogen producer by tapping into the renewable energy potential and exporting to countries with a high demand for green hydrogen. In essence, Dominica can serve as an industrial centre for renewable power generation, hydrogen production, and even further along the value chain into the ammonia and methanol production markets.

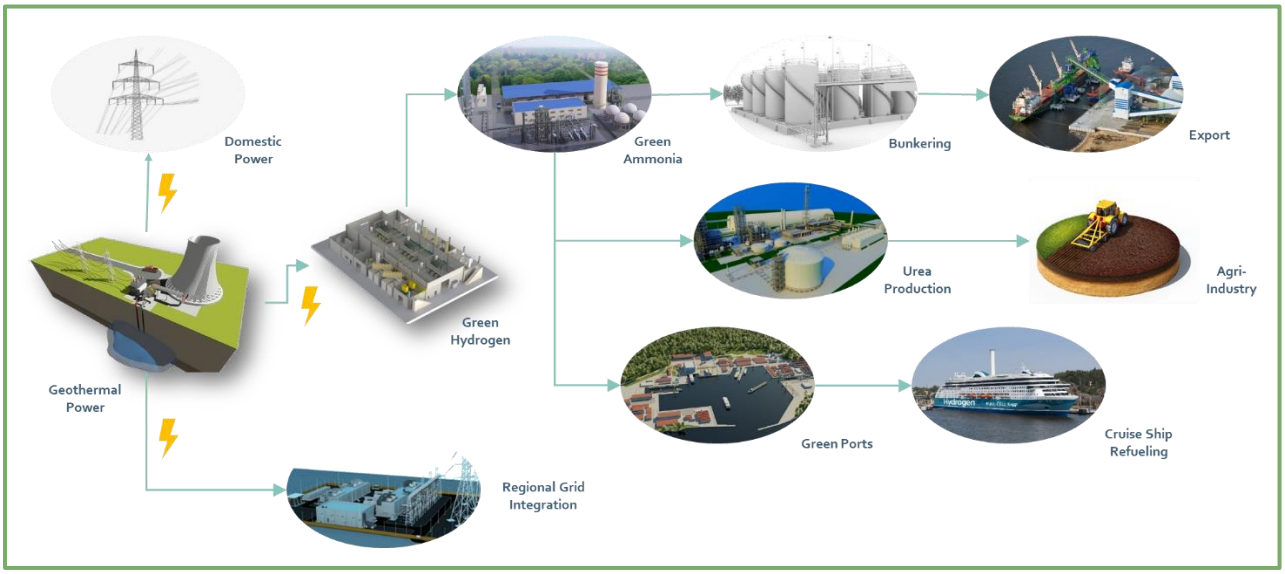


Figure 21: Potential Pathways for Geothermal and Green H_2 in Dominica

5.6.1 International Trade Opportunities

The challenge of long-distance transport of hydrogen must be overcome to facilitate uninterrupted international hydrogen trade. While transportation of pure hydrogen via pipeline is a mature technology, seaborne transportation of pure hydrogen is nascent and not yet proven as a cost-effective

option. Due to its low energy density by volume, hydrogen energy density must be increased to be transported via ship over long distances. Options include cryogenic hydrogen liquefication, liquid organic hydrogen carriers (LOHC), and conversion to hydrogen derivatives such as ammonia and methanol. However, there are energy losses associated with converting hydrogen to other energy vectors. Of the available options, conversion to ammonia is the most proven, mature, and cost-effective of the available options.

International trade of shipborne pure hydrogen may not be realistically achieved in the near term. Dominica should then focus efforts on international trade of hydrogen derivatives and utilise already established trade markets and infrastructure. This option would attract international petrochemical producers to establish production facilities within Dominica at the source of renewable energy and hydrogen production.

GREEN HYDROGEN AND DOMINICA'S TRANSPORTATION SECTOR

The Government of Dominica has received readiness support from the GCF to identify and assess low-carbon transport options embarked on the development of a low-carbon transport roadmap for Dominica with a strong focus on options which can be implemented with a significant impact by 2030.

For the Commonwealth, the medium-term goal focus is zero GHG emissions from the transportation sector including both road and maritime transport.

Grutter Consulting, through the Government of Switzerland via the foundation KliK, is realising a comprehensive e-mobility proposal for Dominica linked with the sale of Internationally Transferred Mitigation Outcomes (ITMO) to the Swiss Government.

It is envisioned that this transportation study can be closely linked to renewable energy production via solar PV and geothermal for usage as electricity and/or hydrogen in transportation.

Grütter Consulting

5.6.2 Regional Trade Opportunities

Regional trade of pure hydrogen is more realistic, cost-effective and impactful within the LAC region. Some countries within the region have a high hydrogen demand but low renewable energy potential. Dominica can position itself to become a hydrogen hub and export pure hydrogen to hydrogen hungry countries to assist in decarbonising existing industries. Neighbouring countries like Trinidad and Tobago, with a vibrant petrochemical industry based on fossil fuels, can benefit from importing green hydrogen from Dominica. In addition, there is also an opportunity domestically and regionally for the deployment of hydrogen for fuel cell electric vehicles, e.g. trucks and buses. This must be supported by government policies and incentives, together with the installation of the required infrastructure, as the current capital cost is high compared with combustion engines and battery electric vehicles.

5.6.3 Green Fuelling Hub Opportunities

Dominica also has the opportunity to utilise green hydrogen to produce synthetic e-fuels not only for domestic and regional use but to become a green refuelling port for the shipping industry. Due to its

strategic location, central in the Caribbean, Dominica can act as a hub for the refuelling of cruise ships and other marine vessels.

Farther into the future, the use of green hydrogen and green ammonia as a fuel is a possibility once accompanied by the required technological advancements in the aviation and shipping industries. In recent times, research has been accelerated on the adoption of green ammonia as a marine fuel, and multiple projects are being progressed. In Japan, two consortiums – one comprising Japanese shipping company NYK Line and its partners Japan Engine Corporation, IHI Power Systems, and Nihon Shipyard, and another comprised of K Line, ITOCHU Corporation, NS United Kaiun Kaisha, Nihon Shipyard and Mitsui E&S Machinery are developing an ammonia-fueled ships[27]. In Europe Finland's Wärtsilä, as well as Germany's MAN Energy Solutions (in a collaboration with Korean shipbuilder Samsung Heavy Industries) are moving apace on the development of ammonia-fueled vessels.[28] and elsewhere. However, technological advancements are lagging in greening the aviation industry. Consequently, Dominica can position itself to play a prime role in the future as the aviation industry transitions towards a greener fuel.

5.6.4 Next Steps

Dominica has several key opportunities to become a major stakeholder in the green hydrogen market domestically, regionally and globally. The opportunities are not without challenges, and some are more readily achievable in the near term. Further investigation is required to confirm technical and economic viability and to prioritise timelines for deployment.

Dynamic collaboration between public and private sector entities is needed to fully exploit these green hydrogen opportunities and to ensure success. Firstly, the Dominican government would be responsible for formulating clear strategies and measures, mobilising grants and subsidies, coordinating regional and international collaboration, and implementing policies and regulations to support and drive the nation's green hydrogen economy development. It is essential that the government promptly implement the supporting regulatory framework not to hinder private sector investment.

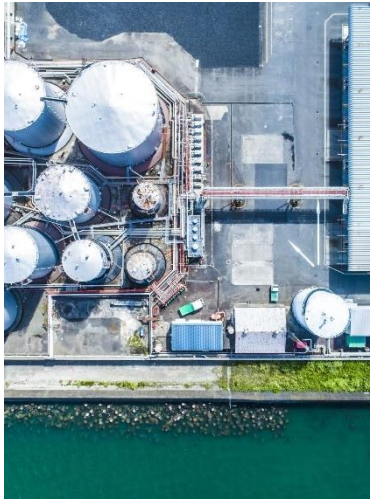
Likewise, the private sector is central to funding the hydrogen economy and would need to collaborate with the government, product developers, investors, and academia. The private sector would also be responsible for identifying the highest value hydrogen pathway unique to Dominica along the hydrogen value chain. The opportunities identified for green hydrogen and its derivatives would need to be championed by the private sector. This model is already adopted within the LAC region and **Appendix VI** provides a listing of a few of the significant transformative and visionary sustainable projects which are being led by private sector entities, with a focus on the NewGen Project.

[27] Offshore Energy, 'NYK: Project to commercialize ammonia-fueled ships set to begin', *Offshore Energy*, 2021 <https://www.offshore-energy.biz/nyk-project-to-commercialize-ammonia-fuelled-ships-set-to-begin/> [accessed March 2022].
[28] IEEE, 'Why the Shipping Industry Is Betting Big on Ammonia', *IEEE Spectrum*, 2021 <https://spectrum.ieee.org/why-the-shipping-industry-is-betting-big-on-ammonia> [accessed March 2022].

Now is the time for Dominica to mobilise and establish itself as a renewable energy and green hydrogen production centre to secure its stake in meeting the regional and international demand. Prolonged inaction would mean a missed opportunity for Dominica, as some other regions are very aggressive in their hydrogen strategy deployment.

06

Key Considerations for Green Industrial Development in Dominica



- Effective public and private sector engagement is key to achieving sustainability goals and can be achieved by having an understanding of the roles and responsibilities, having alignment on the strategy and working towards agreed mutual benefits.
- Financing efforts should be channelled towards accessing both public and private funds. The main barriers to funding are lack of project technical and economic definition, limited or unfavourable policies and framework, investment risks and the overall size of investment and high transaction costs.
- Overcoming the barriers to funding would involve a focus on four main overlapping areas; defining the business case, investor targeting, risk mitigation and timely and favourable implementation of government policies and framework.
- Business Facilitation is also integral to achieving desired outcomes, as it provides an orientation not only to the in-country requirements, but the expectations and realities in targeted markets.
- A strong legislative framework is also required to ensure structured and sustainable development. Dominica has already enacted several pieces of legislation which can be integrated into a comprehensive framework and enabling legal environment for green-based development.

06 Key Considerations for Green Industrial Development in Dominica

6.1 Enabling Public-Private Development

Governments worldwide have recognised the negative environmental, economic and social impacts of climate change. Many have responded to this challenge indicating their commitment to achieving climate goals and have declared ambitious NDCs. Similarly, some private sector corporations have also stepped up and announced their contributions. However, the sustainable goals would not be met if the private and public sectors operated in silos. Achieving these goals require alignment and effective collaboration.

This is especially true for Dominica as an upper middle income developing nation with unique challenges such as vulnerability to climate change, an economy that is highly dependent on the service sector, high business cost, inefficient trade process and a limited skilled labour market. With the private sector accounting for approximately 80% of the businesses, it is essential that the private sector partner with the government to accelerate the pathway to achieving climate goals and stimulate economic growth. Furthermore, Dominica should not limit public/private sector engagement to local entities, but this should be extended to leverage the LAC region's experience, learnings, and capabilities.

Figure 22: Public / Private Sector Roles and Responsibilities

Understanding roles and responsibilities, alignment on the sustainable energy strategy, and recognising the mutual benefits are all critical to enabling effective collaboration

between the public and private sectors. ***Figure 22*** compares the public and private sector roles in achieving sustainable goals. ***Figure 23*** shows the pathway to aligning public and private sectors on the sustainable energy strategy and the mutual benefits.

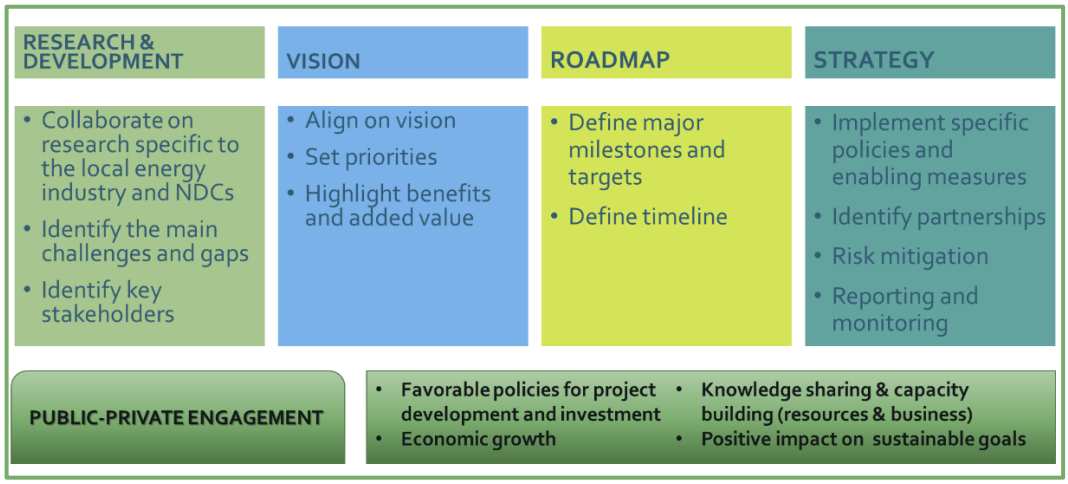


Figure 23: Public/Private Sector Mutual Benefits and Pathway to Engagement

Source: Modified from IRENA, 2021c, with input from UNEP 2019

6.2 Access to Finance

6.2.1 Investors and Financial Instruments

Based on IRENA's prediction, an excess of one hundred trillion dollars in investment is needed to finance the energy transition to allow countries to fulfil their NDCs and meet climate goals (see ***Figure 24***). This requires a shift in global investments towards sustainable projects and emerging and developing regions with high renewable energy potential. Dominica as a SIDS would need to compete with other regions, other developing countries and other sustainability projects to secure investment. Thankfully there are available programmes and financing options targeted explicitly for developing countries such as Dominica, whose high renewable energy potential is advantageous.

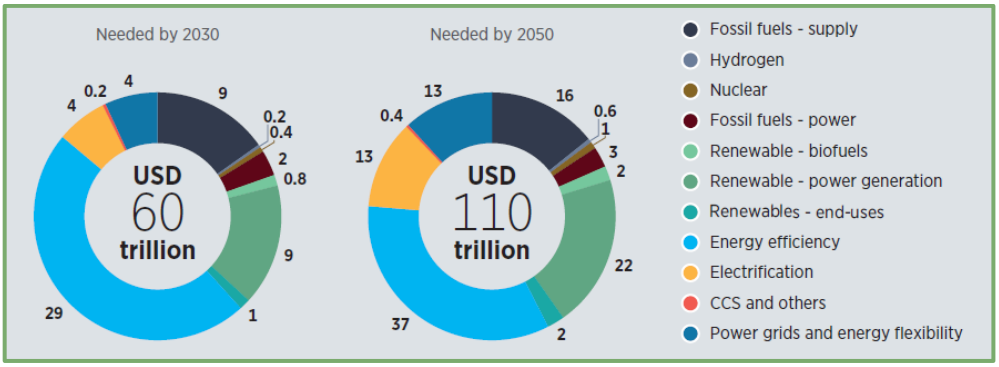


Figure 24: Cumulative energy-sector investment needed through 2030 and 2050 under IRENA's Transforming Energy Scenario

Source: IRENA, 2020a

Financing efforts should be channelled towards accessing both public and private finance. For the past decade, investment records for renewable energy projects have shown that the private sector provided the majority of funding (~85%)[29]. Nevertheless, public sector finance should still be pursued. It has a crucial role in closing the finance gap, financing the early project phases to develop the business case, reducing the risks and barriers, and leveraging private investment.

Investor options include Commercial Financial Institutions including Commercial and Investment Banks; Institutional Investors including Pension Funds, Private Equity Firms, Insurance Companies, Sovereign Wealth Funds, Endowments and Foundations; Corporate Actors, including Industry Bodies and Clean Energy Companies; Development Finance Institutions and Project Developers[30].

Various financial instruments are available for public or private funding of renewable projects for developing countries. The applicable financial instrument should be selected based on evaluating a range of factors, including the project technology maturity, project developer capability, the local financial sector climate and the investor's risk/return profile. Financial instruments for SIDS include corporate loans, project finance loans, private equity funding, mezzanine finance, venture capital, project bonds and green bonds. Green bonds, introduced in 2007, has undergone a rapid transformation in the past five years, with its geographic reach expanding into the LAC region. Green bonds are fixed-income securities that aim to bridge the gap between investors and sustainable projects. IRENA's paper on Green Bonds provides more information on market trends and opportunities for green bonds[31]. In addition, a range of literature offers further information on financial instruments and mechanisms, including *Public Finance Mechanisms to Mobilise Investment in Climate Change Mitigation* which outlines public finance instruments[32]. *Financial Mechanism for Clean Energy in Small Island Developing States*[33] and *IRENA 2012- Financial Mechanism and Investment Frameworks for Renewables in Developing Countries*[34], focus on finance mechanisms for developing countries, including specific case studies including islands from LAC.

6.2.2 Main Barriers and Pathway for Attracting Investment

Projects require proper definition, which comes from the necessary due diligence required to holistically understand the business case i.e. from both the private and public sectors. Sound government policies and institutional frameworks, which consistently improve the ease of doing business and reduce

[29] IRENA, *Global Landscape of Renewable Energy Finance 2020*, (Abu Dhabi: IRENA, 2020a) <https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Nov/IRENA_CPI_Global_finance_2020.pdf> [accessed March 2022].
[30] Ibid.
[31] See IRENA, *Renewable Energy Finance: Green Bonds*, (Abu Dhabi: IRENA, 2020b) <https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Jan/IRENA_RE_finance_Green_bonds_2020.pdf> [accessed March 2022].
[32] See UNEP, *Public finance mechanisms to mobilise investment in climate change mitigation*, (Paris: UNEP, 2008) <https://wedocs.unep.org/20.500.11822/7973> [accessed March 2022].
[33] See IBRD, *Financial mechanisms for clean energy in small island developing states*, (Washington: Energy Sector Management Assistance Program, 2015) <http://documents1.worldbank.org/curated/en/615531467999077046/pdf/100835-ESMAP-P129321-PUBLIC-Box393246B.pdf> [accessed March 2022].
[34] See IRENA, *Financial Mechanisms and Investment Frameworks for Renewables in Developing Countries*, (Abu Dhabi: IRENA, 2013) <https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2013/IRENA-report---Financial-Mechanisms-for-Developing-Countries.pdf> [accessed March 2022].

unnecessary delays is key to investor facilitation. As a greenfield project, there are perceived risks, leading to more stringent qualifying requirements and borrowing terms to the investors. And developing projects at scale will not only increase the overall bankability of the investment portfolio for a number of actors to benefit, but also develop a more extensive pipeline of projects to attract investors.

Figure 25: Overcoming Barriers to Attracting Investments

Underpinning all of these areas is the current government's policy framework, which is seeking to attract and facilitate investment throughout the project lifecycle from the pre-Investment phase to the operational phase. The framework includes policies and a legislative framework to stimulate growth in the new energy sector and address challenges of conducting business. *Unlocking Renewable Energy Investment*[35] provides a comprehensive overview on overcoming the main barriers and unlocking investments (see ***Figures 25 and 26***), while ***Appendix VII*** provides a non-exhaustive listing of available programmes targeting large scale renewable projects in developing countries within the LAC region.

[35] IRENA, *Unlocking Renewable Energy Investment: The Role of Risk Mitigation and Structured Finance*, (Abu Dhabi: IRENA, 2016) <https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2016/IRENA_Risk_Mitigation_and_Structured_Finance_2016.pdf> [accessed March 2022].

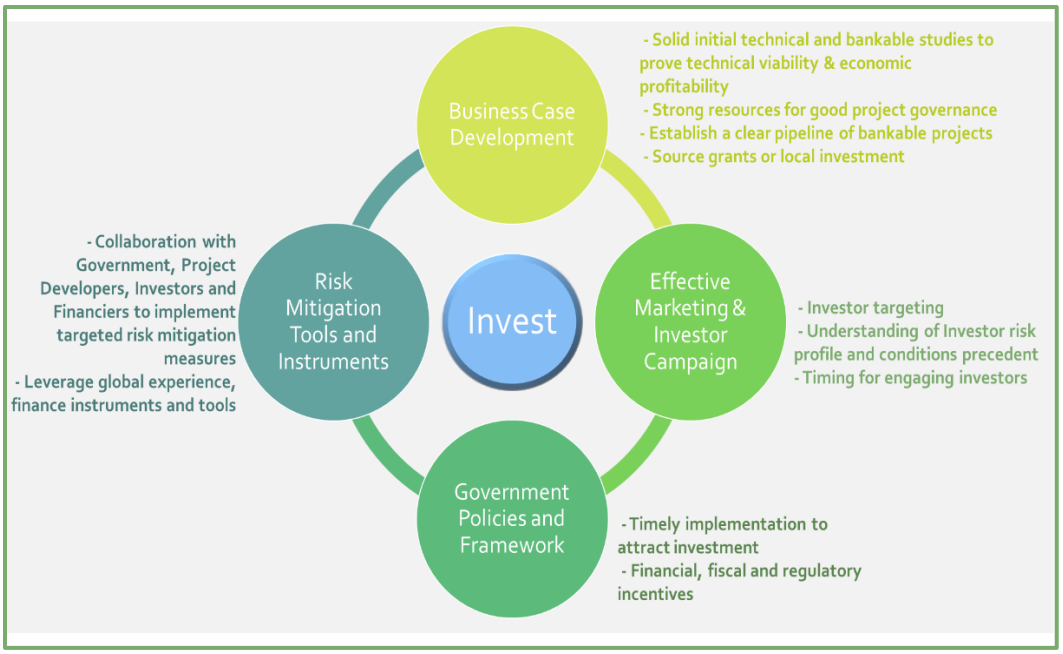


Figure 26: Pathway to Attracting Investments

6.3 Business Facilitation and Support

6.3.1 Green Marketing

The Commonwealth of Dominica, also known more popularly as the Nature Island of the Caribbean, has used and successfully capitalised on green marketing for decades, specifically in the area of Eco-Tourism. Green Marketing is known to be a holistic marketing concept that incorporates a broad range of activities which effects product modification in a manner that is less detrimental to the environment. Marketers leverage these classifications to:

- create a market niche for green products,
- impact and change the attitude and social consciousness and behavior of consumers, encouraging consumers to see green as added value and purchase green products,
- foster a consumer willingness to demand and spend more for environmentally friendly products,
- build sustainable consumer loyalty, and
- increase ecological value in green products and services and by so doing reinvigorate customers and the environment.

As it relates to the global trading of green hydrogen and its derivatives, Dominica can utilise green marketing strategies to access markets where there is a critical demand to decarbonise carbon-intensive industries, reduce emissions and combat climate change. Additionally, with the growing global consensus on the need to introduce carbon pricing on hydrogen and hydrogen derivatives produced

from carbon-intensive sources such as natural gas, the demand for green hydrogen and green hydrogen derivates is expected to continuously rise.

6.3.2 Trading

Export markets for green and sustainable food, products, services, energy and tourism, are expected to grow rapidly due to changing consumer preferences as the world becomes more environmentally aware.

Developing countries like Dominica, in particular, can benefit from such trade opportunities by increasing their exports in key economic sectors to respond to international demand for environmentally friendly goods and services. By transitioning to green hydrogen industrialisation, and laying a foundation for the production of eco-friendly sustainable agriculture, tourism, shipping and fuels, Dominica will be in a position to capture and realise the substantial gains these new opportunities provide.

6.3.3 Green Investing

Globally, the legislative and policy environment are fundamental for investments in the green economy and for sustainable development overall. Dominica is seeking to facilitate Green Investments aligned with its resiliency policies and environmentally friendly business practices, with conservation of its natural resources taking priority.

The Government remains focused on green initiatives with the planned introduction of green index funds, green bonds and support through environmental concessions and grants. The Dominica green economy will require advanced technical training, supportive supply chains and services in the high-tech area, access to finance and facilitation to favor investment in a relatively small economy.

There are growing opportunities in an economy such as Dominica for investments in green building infrastructure, low carbon transport, other renewable energy such as wind and solar, waste recycling and handling, high tech manufacturing, green urban agriculture and telecommunications. Investments in geothermal at scale will not only develop other sectors but also the expertise to develop new competitive export streams.

6.4 Incentives

International trade is a powerful driver of growth. It is imperative to direct that potential in ways that contribute rather than detract the progress towards a green economy. One way that international trade policy helps in the greening of economies is by providing incentives that include:

- liberalising trade in environmental goods and services (EGS) by lowering tariffs,
- offering non-tariff barriers to eco-friendly goods, and

- offering subsidies to locally manufactured eco-friendly goods to encourage the development of domestic competitive sectors to produce and export EGS.

As a new entrant into the green market, Dominica will have to maintain a close review on trends in targeted export markets, as well as in competing economies to ensure that technical regulations, regulatory regimes and restrictions are aligned to global standards and the island-specific expectations for sustainable development. Such focus should extend to institutional strengthening which create greater efficiencies in the public and private sectors, so that the maximum benefits can be extracted from the proposed investments. The proposed establishment of a Green Certification Institute as part of the GCF readiness proposal is one such initiative.

6.5 Subsidies to Fossil Fuels

Subsidies to fossil fuels are a formidable obstacle to the growth of renewable energy and the implementation of energy conservation and energy efficiency measures. Worldwide, governments and other stakeholders struggle to deal with the issue of subsidies to fossil fuels.

The absence of such support in Dominica should serve as a driver for accelerating the adoption of renewable energy on the island. Additionally, the removal of such facilities in other jurisdictions lowers the demand for fossil-fuel derived energy, and creates additional opportunities for Dominica to secure long-term markets for its green commodities, including power. This materially contributes to the reduction of energy-related carbon dioxide emissions on the island, and in its trading partner territories.

6.6 Legislative Framework

Maintaining green market share in the face of steadily increasing regulatory compliance by individual countries worldwide or individual buyers and sellers is stressful and challenging. Generally, individual countries have various organisations with legislation that:

- set up an infrastructure that will inform and assist exporters and provide accredited national or regional capacity to test and certify goods as compliant. Such an infrastructure may require working with foreign accreditation bodies, supporting technical training, and even building laboratories, and
- implement and enforce domestic standards that are not too far from those required internationally. Such domestic standards will build up private sector capacity and play an important role in helping firms adapt to any such new international standards.

The provision of policy, planning and compliance support for green industrialisation require the participation and interfacing of multiple state and non-public stakeholders, details of which are outlined at **Appendix VIII**. Often, the arrangements require considered attention prior to, and during implementation, since a recurring complaint is that the legislative requirements and the framework

available to comply makes it difficult to invest and do business. Dominica has already commenced a rationalisation of its legislative structure, and initiatives are being pursued under the GCF with a view to strengthening the existing framework and creating alignment with the intended green industrialisation thrust.

6.6.1 The Legislative Framework in Dominica

Dominica has created a one-stop shop – Invest Dominica Authority – that facilitates all of the developmental permits, certifications and licences required for development activity. The delivery of the relevant documents to developers is the purview of regulatory agencies with the required competencies, operating within the guidelines of overarching legislation, the key to be considered being:

6.6.1.1 Umbrella Legislation

In Dominica the Geothermal Resources Development Act No. 12 (2016) is the umbrella legislation that the government uses to bring together all the permits required to develop a geothermal project. This Act covers the required permits and/or licences for Development and Building, Electricity Supply, Environmental Health, and Noise Abatement.

6.6.1.2 Physical Planning Act

The Planning and Development Authority is responsible for planning and environmental controls in Dominica. As such for resource development, permission must be authorised and obtained in accordance with:

- Geothermal Resources Development Act No. 12 (2016), and
- Part IV, Section 4 of the Physical Planning Act 2002, **except** for the modifications of regulations under Act 12 (2016).

6.6.1.3 Electricity Act

In deriving electricity for resource development, the generation, transmission, distribution and supply must be obtained in accordance with:

- Geothermal Resources Development Act No. 12 (2016), and
- Part VI, section 30 of the Electricity Act 2006, **except** for the modifications of regulations under Act 12 (2016).

6.6.2 Other Legislative Requirements

6.6.2.1 Environmental Protection Act

This Act provides for the protection and improvement of the environment:

- the prevention and control of pollution and hazardous waste management
- the assessment of the impact of economic development on the environment, and
- the sustainable use of natural resources.

6.6.2.2 The Water and Sewerage Act

This Act facilitates the development of a National Water Policy that seeks to enable the establishment of a new legal, institutional, and regulatory framework regarding water resource management:

- water supply and connection,
- water regulations,
- wastewater and sewerage matters,
- drought orders and hydro-meteorological matters.

6.6.2.3 Waste Management Policy

A National Solid Waste Management Strategy is government policy that seeks to improve its waste management infrastructure (collection, transportation and disposal), promote waste to energy initiatives and prevent ruination of the natural setting. Likely impacts may extend, not only to the use of materials (e.g. the ban of Styrofoam and other non-compostable food and beverage container imports), but a reduction in the use of non-degradable packaging materials while simultaneously creating retail markets for biodegradable alternatives.

6.6.2.4 National Hydrogen Strategy and Value Proposition

In order to advance a green hydrogen economy, it becomes imperative that a National Hydrogen Strategy for Dominica be developed to inter alia, (i) guide the overall macro frame, (ii) identify areas for possible legislative intervention, (iii) articulate a green hydrogen development model to deliver optimal benefits while balancing environmental and other concerns, and (iv) identify key bilateral, multilateral and regional partners. The MPECSRE has informed that a request for the development of such a strategy is under consideration by the Green Climate Fund and it is anticipated that approval will be received by the third quarter of 2022, for the possible completion and finalisation of the strategy by December 2022.

07

Development Pathway I – New Green Energy-based Industrial Opportunities for Dominica

- Dominica's national policies are aligned with key pillars, several of which place an emphasis on wealth generation for its citizens including economic diversification, sustainable and inclusive growth opportunities, increased employment and social development.
- Green energy-based industries present cross-sectional capacity building opportunities.
- Dominica's private sector will be the primary driver of new employment activity with significant markets created for both small business service industries and technical jobs.
- New technical vocational training facilities will have to be developed and existing tertiary level learning institutions in Dominica must be equipped to provide the educational foundation to citizens for participation in the development of green energy based industries.
- Commitment by the Government through public-private partnerships will generate the ability to build, attract and retain talent and human capital especially where the island may have been impacted by 'brain drain'.
- Key Performance Indicators (KPIs) will be taken into consideration, as part of designing the training system and monitoring and evaluation procedures.

07 Development Pathway I – New Green Energy-based Industrial Opportunities for Dominica

7.1 The Future Environment

Dominica's focus on its geothermal green growth development is vital in ensuring that its natural assets offer significant economic value to its citizens, its businesses and the State. Building capacity across all spheres will be essential in the transition towards a green hydrogen sustainable economy. Over the next decade, Dominica will experience the creation of thousands of new, quality job opportunities due to these new green industrial development initiatives, new resiliency policies and global environmental commitments. The public sector will also play a critical role in this structural economic reform to realise growth. Such focussed effort will entail:

- Commitment to Environmental, Social, and Governance (ESG) Policies with the Government as an investor seeking to apply high standards of non-financial metrics to identify sustainable growth opportunities, which include reducing environmental impact, improving participation of its citizenry in its economic development programme, and ensuring there are policies, laws and structures to support good governance and enforcement,
- Efficient use of natural resources and harnessing such resources for the highest sustainable value,
- Enhanced investor confidence with effective policies and commitment to the ease of doing business, and
- Development of new markets ensuring linkages with local, regional and international supply chains and demands for greener products.

Given the proposed expansion of geothermal energy utilisation and the focus on green development via GEIPs and the production of green hydrogen, seven (7) aligned sectors have been identified for development as seen following:

	SECTORS	DESCRIPTION
	Green Port and Ship Refueling Hubs	Investing in green ports will ensure environmentally sound and sustainable operations, including low emission renewable fuels for ocean going vessels like green ammonia/methanol, cargo-handling equipment, green power, and e-mobility as part of the business model.

	SECTORS	DESCRIPTION
	Sustainable Agriculture	Producing long-term agricultural crops and livestock while preserving the natural environment, reducing erosion, preserving water and using bio-fertiliser and pesticides such as those derived from carbon-free ammonia thus decarbonising the food value chain.
	Data Processing High-Tech Facilities	The largest purchaser of renewable energy today are high power consumption data centres. Geothermal power, as baseload renewable power can support the tech industry to improve its energy efficiency.
	Green Ammonia and Derivatives	Ammonia is used primarily for fertiliser with the future generation of “green” ammonia from green hydrogen as a carbon free clean fuel source can be used to generate electricity, refueling of ships, production of plastics, textiles, pharmaceuticals, pesticides, dyes and other chemicals.
	E-Methanol and Synthetic Renewable Fuels	Methanol is used to manufacture products such as plastics, paints, automotive parts, construction materials, and as a clean energy to fuel vehicles, buses, ships, fuel cells, and open flame equipment.
	Global Hub for Training	Dominica has the opportunity to develop a workforce with skills to develop low-carbon and climate resilient industries. Training can be developed in areas such as renewable energy, green infrastructure, sustainable transport, utilities management and waste management.
	Green Eco-Tourism	With proper policies in place across the tourism value chain, Dominica can promote green tourism as a sustainable product. Initiatives can include recycling programs, bio cleaning supplies, use of more sustainable materials instead of plastic, green transport options, water-conservation programs and maintenance of natural environments.

7.2 Local Private Sector Business Opportunities for Dominica

The local private sector is the primary driver of employment, growth and innovation. Its role is to support economic growth, workforce development and environmental sustainability. It is the role of Government to ensure there is favourable means to the ease of doing business, policies that incentivise investments and facilitate growth.

Dominica has an opportunity to develop an ecosystem for entrepreneurial action, promoting local business investments in technology, build capacity and export both products and services. As Dominica seeks to develop its energy asset, the private sector will be the primary agent of change with contributions to not only stimulate economic growth but also can help innovate and respond to market needs. Given the emphasis of developing an industrial framework for Dominica there are many new opportunities for generating new business, some of which are outlined below:

Figure 27: New Business Opportunities in Dominica

7.3 Training System and Skills Development

With significant investment in new green industrialised technology development and deployment in Dominica (anticipated to exceed over USD 1 Billion over the next decade), there will be significant markets created for both small business service industries and technical jobs. The Dominican private sector will be the primary driver of new employment activity, growth and innovation, playing a key role in supporting Government's thrust in economic growth, environmental sustainability, capacity building at the SME level, and workforce development at the employee level. Government policies can guide the development of new workforce development initiatives as means to attract investments, incentivise business, improve the ease of doing business and push a green-growth agenda.

Countries such as the US, Japan, Germany, Australia and Canada have identified green industries as their most significant employment generator over the next two decades, with green sustainable jobs leading to a more skilled employee, safer work environment, and higher compensation than jobs in similar sectors. This allows for gains in both employment and environmental improvement.

The ability to build, attract and retain talent and human capital especially where the island may have been impacted by 'brain drain', requires a commitment to develop strong support systems to enhance local training, resisting attempts to develop ad-hoc programmes with no linkages to the private sector, or the formal regional mechanisms for skills development. Accordingly, the training system should be designed for:

- A single point accountability for coordination for all Technical and Vocational Education and Training (TVET) programmes, with alignment to the regional CVQ System to harmonise training efforts,
- Development, implementation and maintenance of national training plans leading to a workforce that is competent and certified, and
- Integrating selected training programmes within industry, including apprenticeship programmes.

7.3.1 Key Performance Indicators

Key Performance Indicators to be considered, as part of the training system design include:

- Systems for buy-in from Stakeholders,
    - Establishment of subcommittees made up of SMEs and Large Businesses,
- Continuous assessment of workforce demands through annual Labour Market Surveys,
- Development of local and regional Occupational Standards,
- Development of a manpower databases,

    - TVET registry of programmes,
    - Database of Trained and Certified Assessors,
    - Database of Trained and Certified Trainers, and
    - List of Certified citizens from communities, enterprises and institutions,
- Institutional support to develop and use the Caribbean Vocational Qualifications (CVQs),
- Development of systems for Prior Learning Assessment and Recognition (PLAR),
    - Where an individual may be performing competently at something for a long period but has no official certification to recognise that competence, and
    - Where there is sufficient evidence that the applicant's prior performance and achievements can be verified against the occupational standards,
- Development of standards and guidance for employers to invest in Apprenticeship Schemes, including the utilisation of the Co-op approach as a structured educational strategy that combines institutional learning with relevant practical experience in the workplace, and
- The deployment of Quality Auditing systems across the training system.

7.4 Career Opportunities and Job Prospects

For the development of industrial sectors aligned with geothermal development, utilities such as power, telecommunications and water, and hydrogen and its derivatives, the following technical skillsets will be required:

- Geothermal Opportunities: Geothermal energy plants are high-heat installations requiring individuals with high tolerances for these environmental factors, and significant appreciation of safety. Skills in analysis of seismic maps, underground and above ground terrain are highly scientific, while aspects such as geothermal drilling projects require skillsets similar to those used in the oil and gas industry. Specific jobs include:
    - Scientists – Geologists to understand the makeup of geothermal sites and Chemists to determine the toxicity or value of the flow streams,
    - Professionals/Engineers – Civil, Design, Electrical, Environmental and Mechanical, Structural, Surveyors, Architects and Designers, HSE,
    - Artisans – Welders, Construction and Drilling Equipment Operators, Derrick Operators, Roustabouts, Mechanics, Pipe Fitters, Plumbers, Machinists, Electricians, Carpenters and Excavator Operators
- Green Hydrogen Production and Derivatives Opportunities: Electrolyser Plants are capital intensive and require scientists, engineers and operators with high levels of competencies

adaptable to the risks related to high-pressure equipment, safe handling of hydrogen and knowledge of parts, equipment and plant. These include:

- Research and Development – Lab Technicians, Chemists and Quality Specialists,
- Engineering and Manufacturing Jobs – Civil, Electrical, Mechanical, Chemical, HSE and Technicians, and
- Artisans – Welders, Construction, Equipment Operators, Mechanics, Pipe Fitters, Machinists, Electricians, Carpenters and Technical Skills Workers, Heavy Equipment Drivers.

7.5 Short-Term Requirements

Given Dominica's economic structure, there is an obvious local skills gap for the requirements of green hydrogen industrialisation. Addressing this requirement will require urgent focus. In the short-term, a local and regional approach can be adopted, capitalising on existing Caribbean Single Market and Economy (CSME) and OECS labour arrangements. However, consideration must be given to the fact that:

1. with the exception of Trinidad and Tobago and to some extent Jamaica, regional economies are not heavily oriented to industrial production,
2. there is a rapidly expanding demand for related competencies in markets such as Guyana and Suriname, and
3. other economies within the region are also pursuing transition strategies, and the adoption and integration of green technologies and approaches is still a relatively new and evolving sector in the Caribbean.

As such in the near-term, one strategy could facilitate the leveraging of bi-lateral agreements for the development of human capital, where Dominicans can be trained abroad (in the region and internationally) in aligned fields, with a contracted requirement for the provision of in-country service for a specified period following completion of the training. This approach, coupled with a carefully managed expatriate retention system which incorporates a documented mentorship and knowledge transfer provision can address immediate needs.

As a parallel intervention, the MPECSRE will pursue its proposal (in development) for GCF Readiness Support to establish a robust institutional framework aligned with the development of career clusters supportive of green industrial development. With an anticipated submission in 2023, the proposed support will establish a sustainable local system for the training, development, certification and re-certification of Dominicans, and position the island as a regional training centre, consistent with strategies for expanding and diversifying local economic opportunities and enhancing avenues for foreign exchange generation. ***Figures 28*** and ***29*** following provide details on related employment clusters and pathways.

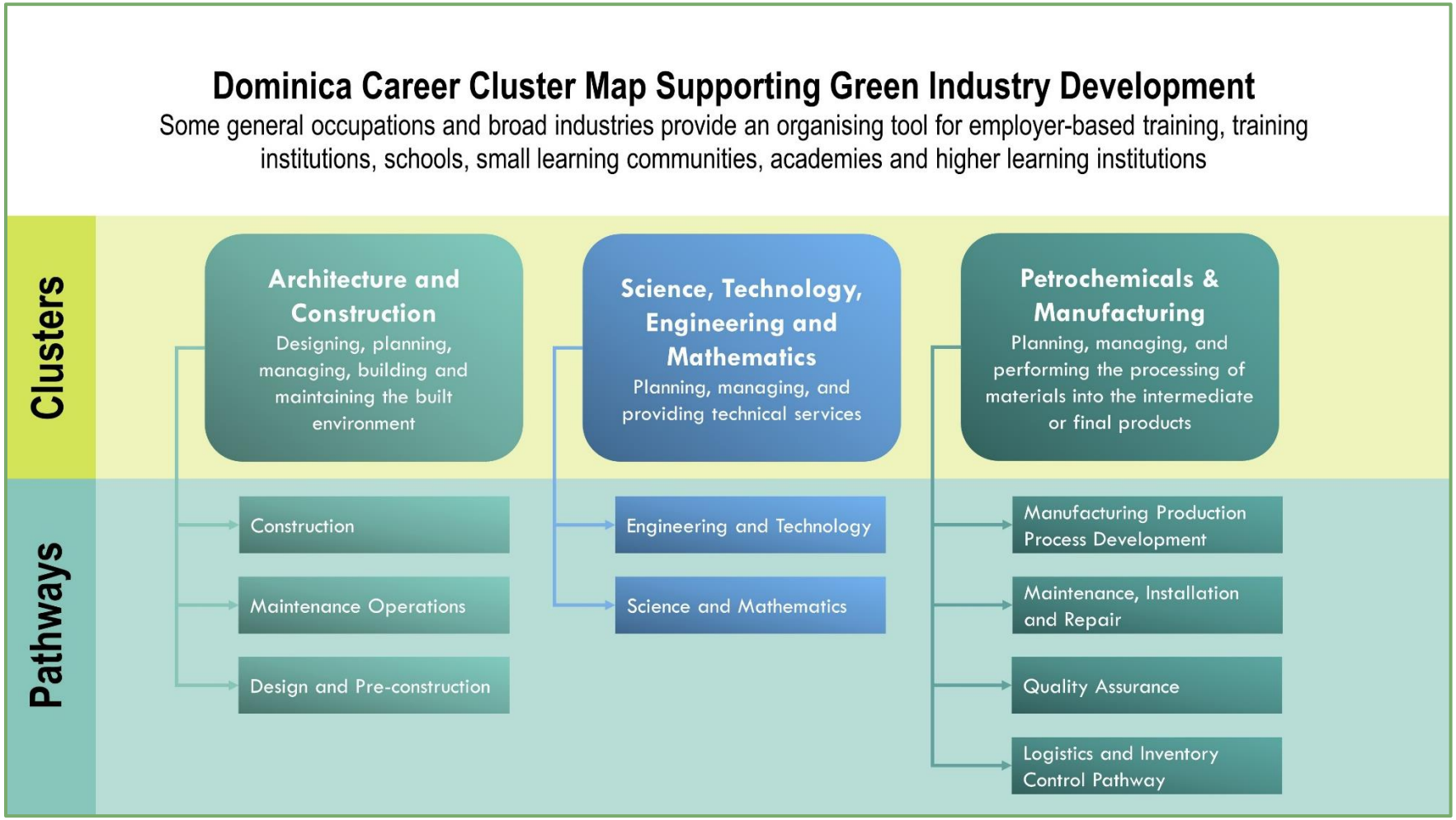


Figure 28: Energy Industry Career Cluster Map

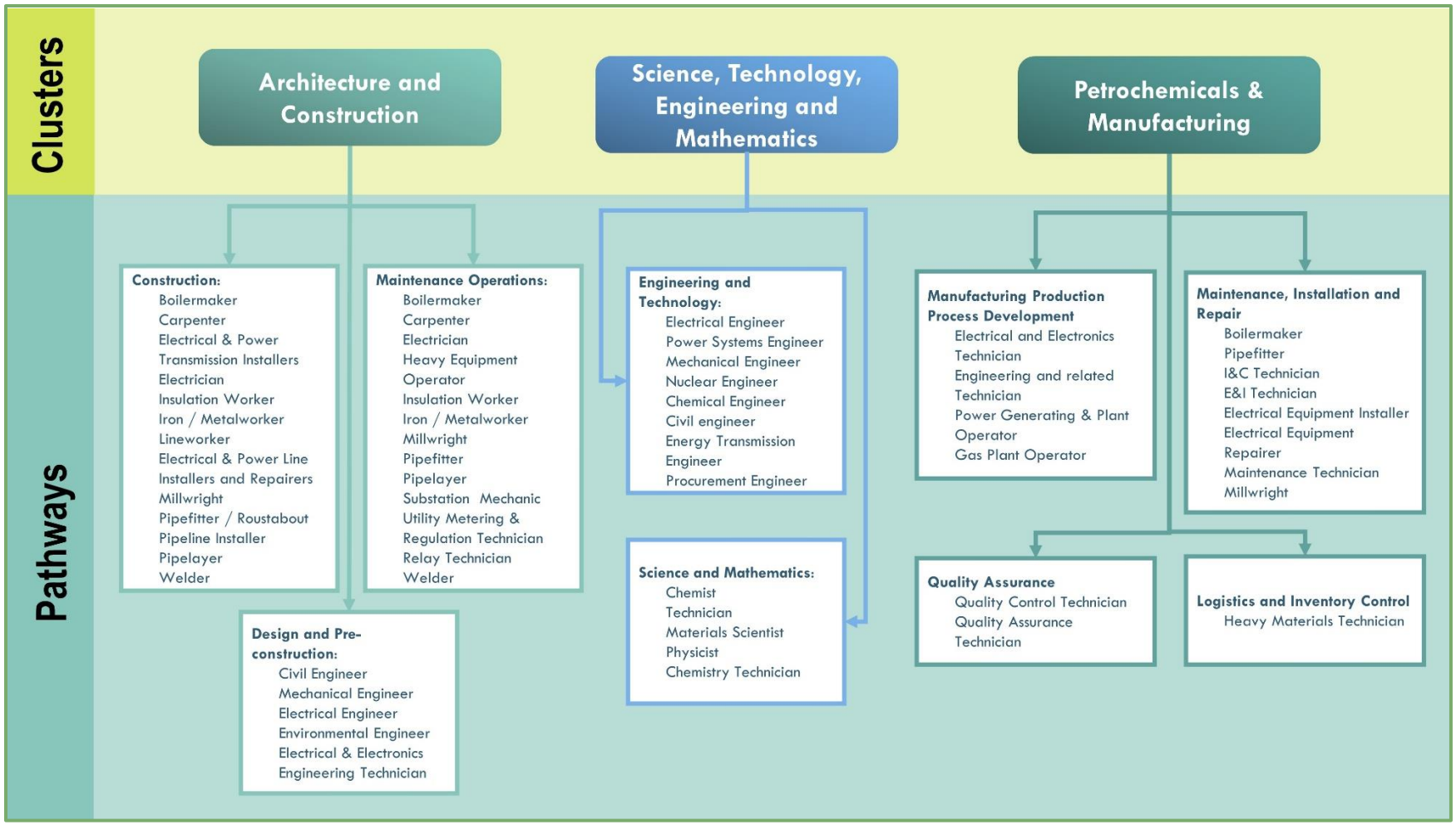
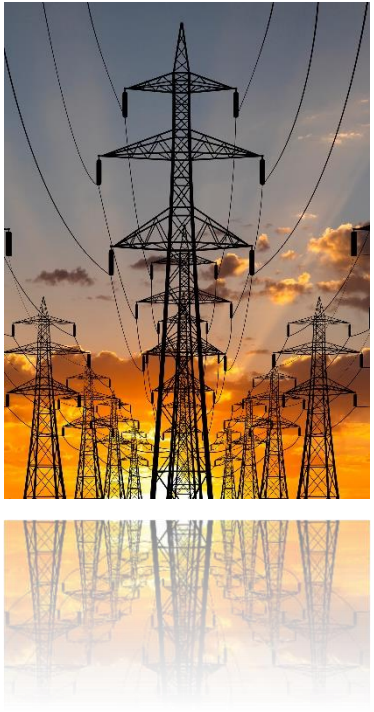


Figure 29: Energy Sector Job Opportunities

08

Development Pathway II – Dominica as a Catalyst for Regional Energy Integration and Industrial Development



- Efforts at regional integration, including matters related to the sustainable development of energy resources, have a long history in the Caribbean.
- The Caribbean Energy Policy provides a framework for securing and utilising energy resources in a sustainable manner, consistent with long-term development objectives.
- Dominica's development thrust aligns with regional and sub-regional energy frameworks, and its significant geothermal potential has the capability to support multiple development opportunities.
- The export of green electrons is an option to be considered in the context of the island's development focus, with several factors place Dominica in a position to assume a leadership role for realising Caribbean interconnection prospects.

08 Development Pathway II – Dominica as a Catalyst for Regional Energy Integration and Industrial Development

8.1 Vision

There is a long history of efforts to deepen Caribbean integration at multiple levels, extending back to the late 19th Century. Formal efforts toward what became known as the West Indies Federation commenced in 1947, and global trends suggest that as we progress through the 21st Century, questions of energy security and climate change will serve as a catalyst for integration among our SIDS.

The genesis of a regional focus on energy is articulated in Article 25 (f) of the 1973 Revised Treaty of Chaguaramas, which identified the need to "promote measures for the development of energy and natural resources on a sustainable basis"[36]. Commencing in 2003, the efforts at developing a Caribbean Energy Policy (CEP), which was formally agreed in 2013, highlighted the considerable risks associated with sub-optimal pricing and regulatory structures, and sectoral inefficiencies.

At the time, the vision was for a "Fundamental transformation of the energy sectors of the member States of the Community through the provision of secure and sustainable supplies of energy in a manner which minimises energy waste in all sectors, to ensure that all CARICOM citizens have access to modern, clean and reliable energy supplies at affordable and stable prices, and to facilitate the growth of internationally competitive Regional industries towards achieving sustainable development of the Community."[37]

Aligned objectives included, inter alia:

- accelerated deployment of renewable and clean sources of energy supplies towards increased energy supply diversification and affordability,
- sustained growth of intra-Community trade in energy,
- increased investment in production, transformation and distribution of viable energy resources,
- programmed expansion of electricity generation, transmission, distribution and trade,
- greater use of renewable energy for electricity generation as well as in the transportation, industrial and agricultural sectors, and
- strengthened research, development and innovation efforts in energy sector especially in areas of clean and renewable energy sources and technologies.

Further, the CEP advocated for a paradigm shift where territories – particularly those with renewable energy sources – can benefit from cross-border trade in electricity, and leverage opportunities for trade

[36] CARICOM, 'Revised Treaty of Chaguaramas', *ISSUU*, 2022, <https://issuu.com/caricomorg/docs/revised_treaty-text> [accessed March 2022].
[37] CARICOM, *CARICOM Energy Policy* (2013), <https://caricom.org/documents/10862-caricom_energy_policy.pdf> [accessed March 2022].

in energy services. Specifically, the geothermal potential of Nevis, Montserrat and Dominica were highlighted, with mechanisms to be developed for cross-border transmission utilising "submarine cable as the default mechanism."[38]

This Regional vision is mirrored with efforts at the sub-Regional level, with attempts to harmonise energy development being articulated by the Organisation of Eastern Caribbean States (OECS)[39]. Specifically, at the national level within Dominica, the vision for domestic expansion and wider regional integration has been outlined in several documents, including the 2012 Low-Carbon Climate Resilience Development Strategy, and the 2014 Draft National Energy Policy of the Commonwealth of Dominica, supported by a legislative framework including the Geothermal Resources Development Act, 2016, and the Climate Resilience Act (No. 16 of 2018) which establishes a coordinating framework for achieving resilience. This direction dovetails with the Dominica Climate Resilience and Recovery Plan 2020-2030, which is predicated on the significant renewable energy potential on the island.

8.2 The Basis for Dominica as a First-Mover

The vision for Dominica assuming a first-mover position for Caribbean energy integration is therefore based on several considerations:

- It stands out as having the highest geothermal potential in the OECS and CARICOM, and the greatest combined RE potential among the Windward islands,
- There is a Vision, and an alignment of that Vision with policies and a wholistic Resilience Model directed at achieving desired outcomes, anchored on communities and expanding to the economy and infrastructure, and
- The territory's relatively close geographic proximity to Guadeloupe and Martinique (45-50 km both ways), and the unmet demand for electricity in those islands make the potential trade in energy (as a proof of concept) quite viable.

Such is the potential, that a 2027 forecast projects that Dominica's power generation from installations accounting for 1.4% of the island's geothermal capacity, will satisfy approximately 70% of the country's power demand[40]. Levering the unutilised potential can allow Dominica to become a leader within the inter-island grid connection scheme and also across the Caribbean, contributing to the development of an estimated 25GW in potential renewable energy within the Region.

[38] CARICOM, 'Revised Treaty of Chaguaramas', *ISSUU*, 2022,
[39] OECS, 'About the OECS', *OECS*, 2020 <https://www.oecs.org/en/who-we-are/about-us> [accessed March 2022].
[40] Randy Kook Koon and others, 'A Review of Caribbean Geothermal Energy Resource Potential', *The West Indian Journal of Engineering*, 42,2 (2020), pp.37-43 <https://sta.uwi.edu/eng/wije/vol4202_jan2020/Documents/M04-RKoonKoonJan2020.pdf> [accessed March 2022]

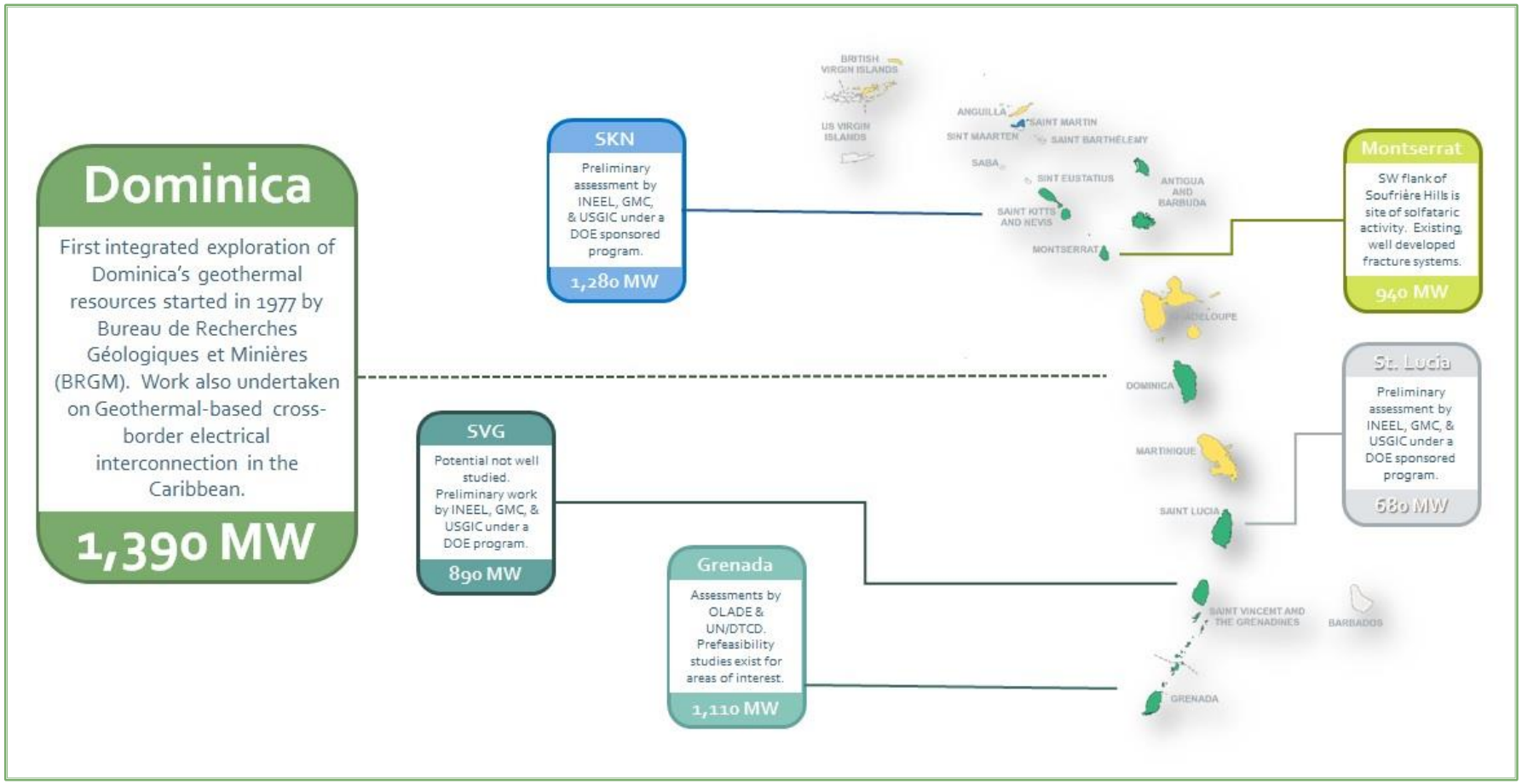


Figure 30: Geothermal Energy Potential in the OECS

Source: Developed from Koon Koon and others, 2020; Joseph, 2008; OECS, 2020

The realisation of these inter-island grid connections and for geothermal and other renewable energy installations throughout the islands have been hindered by shared challenges. A lack of energy diversification, uncertainty in energy prices (as most energy schemes are based on oil and gas industry prices) are among a few of the hindrances encountered throughout the Caribbean for the transition to renewables. However, the global efforts to mitigate the impacts of changing climatic patterns have spawned new urgencies, and spurred comprehensive changes in the energy sector. These changes create multiple opportunities for previously un- or under-utilised resources to be prioritised.

Dominica is exploring multiple pathways for green-related development using its geothermal potential. These opportunities can include from direct use (integrating into agricultural and processing industries) to power generation, where electricity is available to industries capable of producing green commodities along the hydrogen value chain (ammonia and methanol). Indeed, such prospects in the Portsmouth area has been the focus of this Country Assessment.

But, the possibility of trade in green electrons is also a possibility. For some time, consideration has been given to supplying Martinique and Guadeloupe. More importantly, an initial framework has been established under the Eastern Caribbean Geothermal Development Project (Geo-Caraïbes), with the support of several multi-national partners, and with the objective of catalysing multiple commercial geothermal projects and interisland electricity transmission [41]. Further afield, Trinidad and Tobago, with its significant and captive petrochemical industries seeking opportunities to decarbonise their outputs also emerges as a ready market for green electrons or green feedstock.

8.3 International References

Multiple relevant questions will no doubt be raised on the technical and economic feasibility of such a prospect in the Caribbean context. But models exist. The North Sea Link – a 720 kilometre cable – connects mainland Britain with Norway[42], and the Viking Link is a 765 kilometre connection being constructed between Britain and Denmark[43]. Even more ambitious projects are being contemplated. The 1,208 kilometre EuroAsia Interconnector is entering the construction phase [44] and the proposed 4,500 kilometre Australia-ASEAN Power Link is in the planning phase[45].

[41] OAS, 'Energy for Sustainable Development in the Caribbean', *Department of Sustainable Development*, 2008 <https://sdgs.un.org/sites/default/files/statements/3336energy_lambrides.pdf> [accessed March 2022].
[42] Tor Kjolberg, 'World's Longest Undersea Power Cable Linking Norway and UK', *The Daily Scandinavian*, 4 November 2021 <https://www.dailyscandinavian.com/worlds-longest-undersea-power-cable-linking-norway-and-uk/> [accessed March 2022].
[43] Jillian Ambrose, 'Work begins in Lincolnshire on world's longest subsea power cable', *The Guardian*, 13 July 2020 <https://www.theguardian.com/environment/2020/jul/13/work-begins-in-lincolnshire-on-worlds-longest-subsea-power-cable-viking-link> [accessed March 2022].
[44] EuroAsia Interconnector Limited, 'EuroAsia at a glance', *EuroAsia Interconnector*, 2021 <https://euroasia-interconnector.com/at-glance/> [accessed March 2022].
[45] Sonali Paul, 'Australia fast tracks approval process for $16 billion solar power export project', *Reuters*, 30 July, 2020 <https://www.reuters.com/article/us-australia-renewables-idUSKCN24V0S7> [accessed March 2022].

8.4 Next Steps

The scale of these projects reflects the importance being paid to securing renewable energy at the global level. This trend is unlikely to change given the realisation of impacts from the continued dependence on finite, fossil fuels. What is required is the vision and trigger for realising the Caribbean prospect. With its geothermal resource base and long-term, green-based development strategy, Dominica is at the forefront of this challenge and possibility.

09

Conclusion

09 Conclusion

The Government of Dominica has taken the lead in driving further developments towards exploring the country's renewable geothermal resources, and specifically in laying the foundation for green hydrogen industrialisation. In this regard, the following are of note:

1. Dominica has enacted a comprehensive legal framework, bringing several pieces of legislation into a single Act and providing approvals for development planning permission, certificates, licensees for power generation and distribution, environmental permission, noise abatement and other requirements.
2. Dominica has successfully completed the exploration of geothermal resources in the Roseau Valley, and the commissioning of a 10MW geothermal plant to be constructed by Ormat Technologies.
3. Dominica has made arrangements with a consortium of French Industrialists for the export of 100MW of geothermal power via undersea cable to the neighbouring French islands of Martinique and Guadeloupe.
4. Dominica is developing a broad spectrum of financial instruments to facilitate local, regional and international private sector partnerships in advancing a local and regional hydrogen economy.
5. Dominica is engaged in de-risking activities by undertaking geothermal reconnaissance, and providing (with financial partners) grant and concessional financing for geothermal exploration.
6. Dominica has received confirmation of financial support from the Investment Committee of the Green Climate Fund for its co-financing support for the development of a Green Eco-Industrial Park subject to the completion of a feasibility analysis.
7. Dominica is continuing its engagement with the GCF for additional capacity development support to include
    a. The development of a National Hydrogen Strategy and Value Proposition to be completed by the end of December 2022, and
    b. Readiness support to be received in 2023 for the establishment of institutional frameworks for the development of career clusters in support of green industrial development.

These comprehensive and investor friendly investment facilitation arrangements and preparation, lay a basis for the successful receipt of additional investor partners to rapidly develop its many geothermal reservoirs, which can be found in its six (6) geothermal zones.

These developments will not only lead to energy security for the Commonwealth of Dominica, but also support its climate resilience thrust towards becoming the first climate resilient nation, while sparking a

green energy industrial transition. Additionally, the proposed developments will also contribute to the achievement of many socio-economic benefits for the island namely:

- increased foreign direct investments,
- revenue generation from the exportation of green hydrogen and its derivatives,
- increased employment and higher-quality job opportunities becoming available to citizens, and
- improved training and human development capacity associated with the above.

Dominica will also be able to support its eco-centred tourism sector by offering green refuelling hub opportunities for the cruise ship and shipping industry. Ultimately, by increasing the country's ability to be self-sufficient there is a foreseen reduced timeline with regards to recovery after impactful events.

As a formative member of the Caribbean Community, and a signatory to the Paris Agreement, Dominica has a steady repertoire in advancing renewable energy utilisation and sustainable development initiatives that will bring both regional and global gains. The expansion of the nation's geothermal potential, especially in the north of the island, can allow for opportunities of regional green energy integration which can further advance industrial development within neighbouring Caribbean Islands driving the vision of a communal mitigation effort towards the global climate change crisis.

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Notes

Image Credits

Geothermal Plant	IADB
Boiling Lake	Dominica Hotel & Tourism Association
Map of Dominica	Worldometer
Map of Dominica	MapsOfWorld.com
Map of Dominica	FreeWorldMaps.net (Daniel Feher)
Creole Day Parade	Made in Dominica
Rousseau	CN Media LLC.
Bellevue Development Project	Dominica News Online
Eco-bulb	Sarunyufoto
Hydrogen Molecule	FiveTGroup
Banana Plantation	Government Information Service (Dominica)
E-methanol Production Facility	Liquid Wind
Tibay Villas	GEMS Holdings Limited
Boat on the River	Reef & Rainforest , Dive & Adventure Travel

Appendices

Government Policy	Objective
Draft National Energy Policy of the Commonwealth of Dominica (2014)	Seeks to achieve sustainable energy development that is reliable, provides the means for universal access to energy, and provides the opportunity for a significant reduction in energy cost. Government also intends to ensure the safe and efficient management of fossil fuels through measures such as rationalising storage facilities, promoting competition to ensure the lowest prices for petroleum products, and promoting quality standards and harmonisation within the region.
National Resilience Development Strategy 2030	Designed to bring hope to the people of Dominica by factoring more firmly climate and non-climate considerations in the development process, thereby increasing the probability of attaining key development objectives of economic growth, employment generation, poverty reduction, social protection and the overall improvement in the quality of life of all citizens. It presents the priorities that Government must pursue in the pursuit of sustainable economic growth while maintaining a prudent fiscal stance in the face of global realities, in particular climate change. Of highest priority is poverty reduction and progress towards achieving the sustainable development goal targets by 2030.
Climate Resilience and Recovery Plan	To support the vision of the Commonwealth of Dominica to become the world's first Climate Resilient nation under 3 pillars of resilience: (1) Climate Resilient Systems, (2) Prudent Disaster Risk Management Systems, and (3) Effective Disaster Response and Recovery

Additional Key Documents	Objective
Portsmouth Citizens Planning Commission	For the development of the Portsmouth Town aimed at improving the wealth, health and wellbeing of its residents.
Dominica Sustainable Land Management (SLM) Project (Project 1) Community Vulnerability Maps and Adaptation Plans (Project 2) Pilot Program for Climate Resilience (PPCR) *Currently at design stage*	Project 1: To develop capacities for sustainable land management in appropriate government, civil society institutions and user groups, and mainstream sustainable land management considerations into government planning and strategy development. Project 2 (draft): To expand the community vulnerability mapping and adaptation planning process to other vulnerable communities.
Invest Dominica Authority	Dominica is ideal for Dynamic Entrepreneurs and Green Innovators to seize opportunities.
Intended Nationally Determined Contribution (INDCs)	By 2030, total emission reductions per sector will be as follows: • Energy industries – 98.6% (principally from harnessing of geothermal resources), • Transport – 16.9%, • Manufacturing and construction – 8.8%, • Commercial/institutional, residential, agriculture, forestry, fishing – 8.1%, • Solid waste – 78.6%
Readiness Proposal with the Ministry of Planning and Economic Development for Commonwealth of Dominica for the GCF	The Economic Feasibility Analysis of a Geothermal-based Green Eco-Industrial Park in the Commonwealth of Dominica, and Geothermal Resources Mapping in the Northern geothermal zone in the region near the town of Portsmouth.

Key Indicators	Dominica (2017)	The Americas	World
Fixed-telephone sub. per 100 inhab.	*12.2*	23.9	13.0
Mobile-cellular sub. per 100 inhab.	*108.2*	111.8	103.6
Active mobile-broadband sub. per 100 inhab.	*39.2*	89.5	61.9
3G coverage (% of population)	*95.0*	93.9	87.9
LTE/WiMAX coverage (% of population)	*67.0*	84.3	76.3
Individuals using the Internet (%)	*69.6*	67.5	48.6
Households with a computer (%)	*56.8*	64.8	47.1
Households with Internet access (%)	*63.9*	68.3	54.7
International bandwidth per Internet user (kbit/s)	*79.7*	77.1	76.6
Fixed-broadband sub. per 100 inhab.	*21.6*	19.9	13.6
Fixed-broadband sub. by speed tiers, % distribution			
-256 kbit/s to 2 Mbit/s	-	6.6	4.2
-2 to 10 Mbit/s	*92.1*	23.1	13.2
-equal to or above 10 Mbit/s	*7.9*	70.3	82.6

Note: Data in italics are ITU estimates
Source: ITU, 2018

OPERATING STATISTICS

CAPACITY & DEMAND (kW)	2020	2019	2018	2017	2016
Generating Plant Installed Capacity					
- Hydro	**6,640**	6,640	6,640	6,640	6,640
- Diesel	**20,100**	20,100	20,100	20,100	20,100
Total	**26,740**	26,740	26,740	26,740	26,740
Firm* Capacity					
- Hydro (Dry Season)	**3,200**	3,200	3,200	3,200	3,200
- Diesel	**14,860**	14,860	14,860	14,860	14,860
Total	**18,060**	18,060	18,060	18,060	18,060
Peak Demand (kW)	**15,963**	15,680	12,920	18,010	17,766
Growth (%)	**1.8**	21.4	(28.3)	1.4	2.9
Load Factor = Average Demand/ Maximum Demand	**0.70**	0.68	0.58	0.54	0.72
ENERGY PRODUCED (kWh x 1000)					
Gross Generation					
- Hydro	**19,242**	20,152	24,180	27,152	36,367
- Diesel	**78,185**	73,029	41,224	58,495	75,422
Energy Purchased	**18**	13	7	90	114
Total	**97,445**	93,194	65,411	85,737	111,903
Growth (%)	**4.6**	42.5	(23.7)	(23.4)	4.5
Diesel Fuel Used in Generation					
Quantity (Imp.Gal)	**4,456,005**	4,184,277	2,372,105	3,299,289	4,217,167
Fuel Efficiency (kWh per Imp.Gal)	**17.5**	17.4	17.4	17.7	17.9

*Capacity available during normal operation in a very dry month, assuming the largest thermal unit breaks down while another is out for maintenance.

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Source: Extract from DOMLEC, 2021

Table 4: Potential environmental impacts of geothermal energy and mitigations

Activity	Low-Temp Systems	High-Temp Systems		Mitigation
		Vapour dominated	Liquid dominated	
Drilling Operations				
Destruction of forest and erosion	*	**	**	Minimise the potential for erosion in road construction. Road construction route to protect wildlife. Employ directional drilling. Noise abatement equipment & techniques. Site restoration and reforestation. Community consultation & communication. Minimise and recycle drilling fluid. Proper waste disposal.
Noise	**	**	**	
Bright Lights	*	*	*	
Contamination of ground-water by drilling fluid	*	**	**	
Mass Withdrawal				
Degradation of thermal features	*	**	***	Maintain reservoir pressure. Repair damaged wells immediately.
Ground subsidence	*	**	***	
Depletion of ground-water	O	*	**	
Hydrothermal eruptions	O	*	**	
Ground temperature changes	O	*	**	
Waste liquid disposal				
Effects on living organism				Re-injection of all liquid waste deep into the ground. Reduce the temperature of liquid waste by employing cooling methods or capturing heat for power generation. Ensure all structures in the field are earthquake resistant. Investigate water treatment & effluent removal systems.
Surface disposal	*	*	***	
Reinjection	O	O	O	
Effects on waterways				
Surface disposal	*	*	**	
Reinjection	O	O	O	
Contamination of ground-water	*	*	*	
Induced seismicity	O	**	**	
Waste gas disposal				
Effects on living organisms	O	*	**	Plant technology and design to minimise gas discharges. Re-injection of all liquid waste. Implement gas monitoring systems.
Microclimatic effects	O	*	*	
O No Effect	* Little effect	** Moderate effect		*** High effect

Source: Developed from T Hunt, 2000

The following are examples of some of the significant transformative and visionary sustainable green hydrogen projects within the LAC region being led by private sector entities:

Chile's Haru Oni Project

Led by HIF, this project aims to use renewable energy from the wind in Magallanes for green hydrogen production through electrolysis. The project will also capture CO_2 and use a synthesis process to combine the CO_2 and Hydrogen to produce eFuels, including carbon-neutral gasoline and carbon-neutral LPG. The first phase is expected to be operational by 2022[46].

Brazil's Base One Project

Led by Enegix and announced in 2021, the project aims to deploy around 3.4 GW of electrolysis capacity powered by renewable energy at Ceará, north-eastern Brazil for export[47].

French Guiana CEOG Project

Led by HDF, this project aims to combine a photovoltaic solar farm, a high-power electrolyser (16 MW), a hydrogen storage unit and high-power fuel cells, to produce electricity. The project is due to be commissioned in 2024[48].

Trinidad NewGen Project

Led by Kenesjay Green Limited, the project aims to supply low-carbon hydrogen produced through electrolysis of water, utilising power from a solar facility and combined cycle power plants as a greener feedstock to an existing ammonia facility. The project is in the pre-FEED phase with a projected start-up in 2026[49].

[46] Siemens Energy, 'Haru Oni: A new age of discovery', *Siemens Energy*, 2022 <https://www.siemens-energy.com/global/en/news/magazine/2021/haru-oni.html > [accessed March 2022].
[47] GlobeNewswire Inc., 'Enegix Energy to build US$5.4 billion green hydrogen facility in Brazil' *GlobeNewswire, Inc*., 2021 <https://www.globenewswire.com/en/search/organization/Enegix%2520Energy> [accessed March 2022].
[48] CEOG, 'The CEOG Project', *CEOG Project*, 2018, <https://www.ceog.fr/theproject > [accessed March 2022].
[49] NewGen, 'About Us', *NewGe*n, 2020 <https://newgenenergyltd.com/about-us/> [accessed March 2022].

The NewGen Project

The NewGen Project, which has already advanced engineering studies for a Hydrogen Production Facility, can feature as a reference project by Dominica, thereby reducing some of the unknowns and highlighting the risks and opportunities in implementing a green hydrogen production plant in the LAC region.

Private entity Kenesjay Green Limited with over 20+ years of energy sector project development experience locally and internationally, is pioneering the project. As a first-mover in the global hydrogen energy transition, the NewGen Project is leading the imperative to switch to a hydrogen economy within Trinidad and Tobago. In addition, the project has progressed through Concept and Bankable Feasibility Studies and is about to enter the Front-End Engineering Phase. Furthermore, the project has engaged with the primary key global electrolyser suppliers and has attracted international investors. ***Figure 31*** provides a case study of the NewGen Project, and ***Figure 32*** illustrates a typical Hydrogen Production Facility based on the NewGen Project base case.

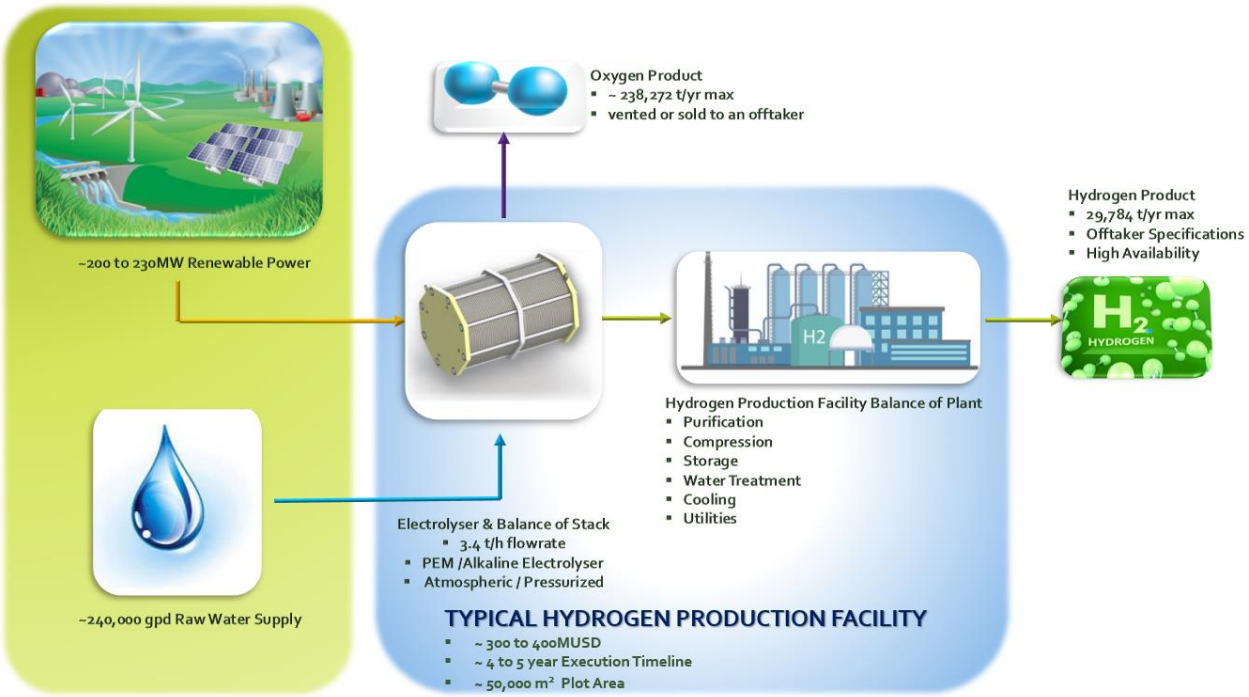

Figure 31: Typical Hydrogen Production Facility – The NewGen Project Base Case

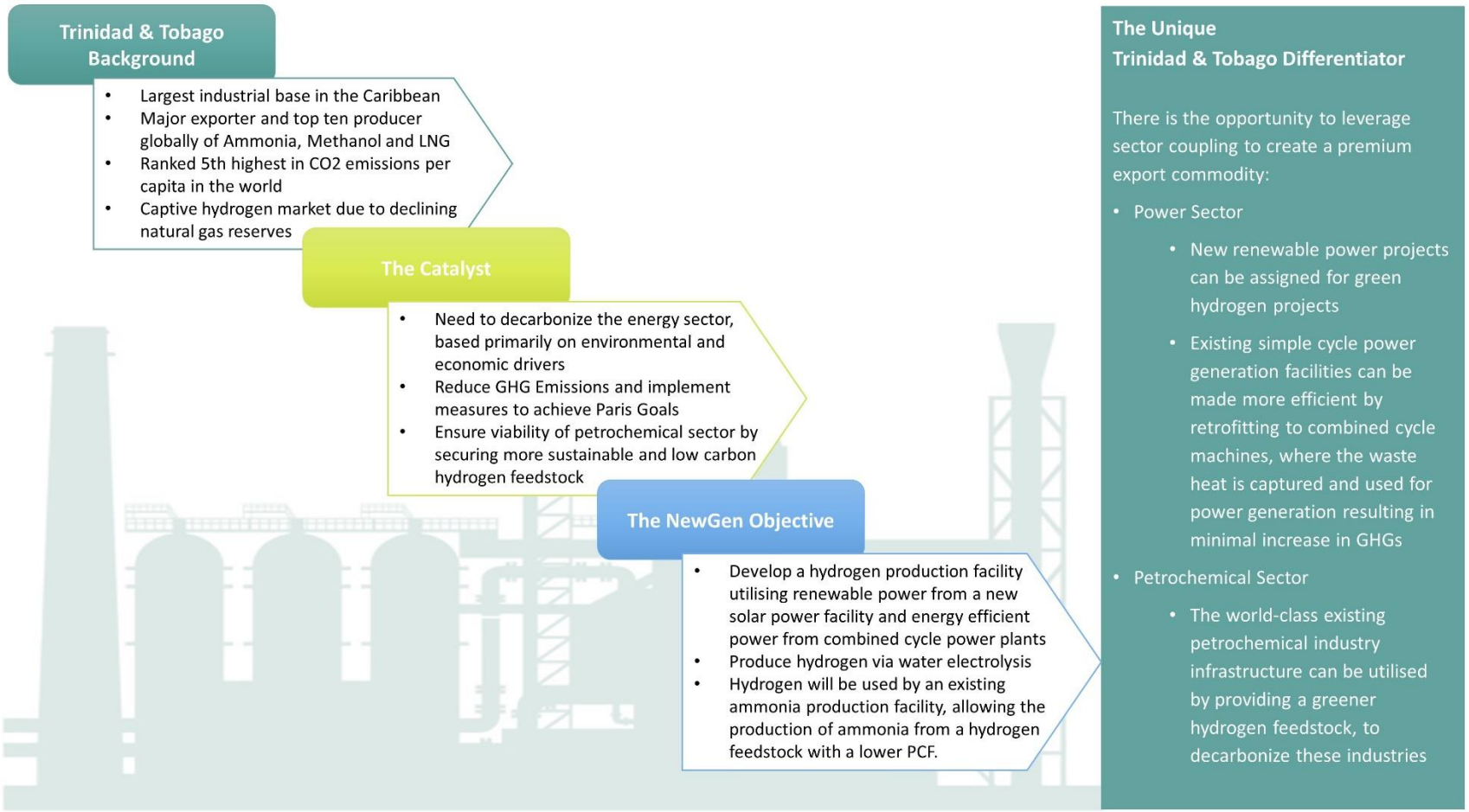

Figure 32: The NewGen Project Case Study

Table 5: Non-exhaustive listing of available programmes targeting large scale renewable projects in developing countries within the LAC region

Program	Definition	Technical Assistance	Financial Advice	Financial Investment
CCFAH	Commonwealth Climate Finance Access Hub	√	√	
CCREE PPF	Caribbean Center for Renewable Energy and Energy Efficiency Project Preparation Facility	√	√	√
CDB	Caribbean Development Bank		√	√
CIF	Climate Investment Fund	√	√	√
CPI	Climate Policy Initiative		√	
EDFI Electrifi	European Development Finance Institution Electrifi			√
ESMAP	Energy Sector Management Assistance Program	√	√	
GCF	Green Climate Fund	√	√	√
GEEREF	Global Energy Efficiency and Renewable Energy Fund		√	√
GEF	Global Environment Facility		√	√
GET. Invest	Global Energy Transformation Invest		√	
GFL	Green Finance Latin America and Caribbean		√	
IDB Invest	InterAmerican Development Bank Invest		√	√
IRENA CIP	International Renewable Energy Agency Climate Investment Platform	√	√	
IRENA ETAF	International Renewable Energy Agency Energy Transition Accelerator Financing	√	√	√
PFAN	Private Financing Advisory Network	√	√	
SEF	Sustainable Energy Facility	√		√
TAPSEC	Technical Assistance Program for Sustainable Energy in the Caribbean	√		
UNDP	United Nations Development Programme		√	

- Developers and investors, private or governmental
    - adhere to the terms and conditions of government policies
    - practice resource efficiency
    - mainly concerned with investment and economic return from land conversion into green industrialisation
- Government decision makers
    - enabling industry creation in industrial parks
    - responsible for setting environment and industrial standards
    - provide policy and investment incentives
    - monitor for compliance to government legislation
- Tenants
    - present and future occupiers that form an industrial symbiosis
- Environmental managers
    - assist with environmental planning of the parks
    - provide environmental services to tenants
    - monitor for compliance to environment norms
- Local communities
    - the public who is directly and indirectly affected by the industrial park
- International financing community
    - international financial institutions
    - bilateral and multilateral aid agencies
- Activists
    - bring pressure and awareness that may influence the government decision makers and the private sector regarding issues of concern, in particular those of the environs
- Innovators
    - a key lesson learnt from countries is that innovation is simultaneously required in business relations between companies, and resource flows.

Kenesjay Green Limited is an indigenous energy revolution company, with over 130 years' cumulative energy sector leadership experience spanning project development, engineering management, business development, plant operations, power, energy, and renewables.

KGL specialises in decarbonising and green project development that create first-mover advantages, including:

- Energy Efficiency and Renewable Energy
- Greening of Existing Industries
- Leveraging the New Hydrogen Economy
- Carbon Reduction
- Transportation Transition

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