POWER BELOW THE SURFACE

HARNESSING GEOTHERMAL ENERGY IN THE OECS

OECS GEOTHERMAL ENERGY:
CAPACITY BUILDING FOR UTILISATION, INVESTMENT AND LOCAL DEVELOPMENT

GEOBUILD
Advancing Geothermal Energy in the Caribbean

SCAN ME

ECS
Organisation of Eastern Caribbean States

Caribbean Development Bank

cif Caribbean Investment Facility

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Organisation of Eastern Caribbean States

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Advancing Geothermal Energy in the Caribbean

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FOREWORD

I am delighted to present this published booklet on geothermal energy development in the Organisation of Eastern Caribbean States (OECS). As we confront the challenges of climate change and energy security, geothermal energy development offers immense potential to transform both the energy landscape and our economic trajectory. It is indeed a revolution in the making.

By harnessing this clean, renewable and energy source, abundant in our region, we can reduce our dependence on imported fossil fuels, lower electricity costs for our citizens and businesses, and accelerate our transition to a low-carbon future. Geothermal energy provides a stable, round-the-clock power supply that complements other renewable sources like solar and wind. It also presents tantalising opportunities for developing new industries from direct uses.

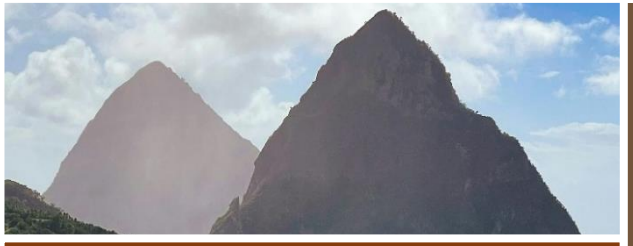
The OECS Geothermal Energy for Capacity Building for Utilisation, Investment and Local Development (GEOBUILD) Programme demonstrates how regional integration is driving sustainable development and energy independence across our islands. It also exemplifies our collective strength. By pooling our resources, expertise, and determination, we are advancing geothermal energy in the Eastern Caribbean more effectively than any single nation could achieve alone. From the advanced developments in Dominica to the promising prospects in Grenada, Saint Kitts and Nevis, Saint Lucia, and Saint Vincent and the Grenadines, each project contributes to an integrated vision of energy security for the Eastern Caribbean.

This regional approach allows us to share knowledge, mitigate risks, and maximise benefits across the five participating Member States. However, the journey to realise our geothermal potential will require collaboration between governments, the private sector, local communities and international partners. While challenges remain, the progress highlighted in this booklet demonstrates that geothermal energy in the OECS is no longer a pipe dream, but an emerging reality. Nonetheless, this booklet is a snapshot in time, not the final story of our efforts and it will be updated as developments warrant.

I invite you to learn more about geothermal energy and its promising future in our region. Together, we can build a more resilient, sustainable and prosperous Eastern Caribbean powered by the heat beneath our feet.

Dr. Didacus Jules
Director General, Organisation of Eastern Caribbean States

CONTENTS



INTRODUCING GEOTHERMAL ENERGY

What is geothermal energy? 06

Development Phases 07

Cleaner Energy? 08

A Cheaper Alternative? 10

Barriers to Development 13

Geothermal Plant Systems 15

OECS-GEOBUILD

Project Summary 16

Beneficiaries 18

Objectives 19

Development Status 20

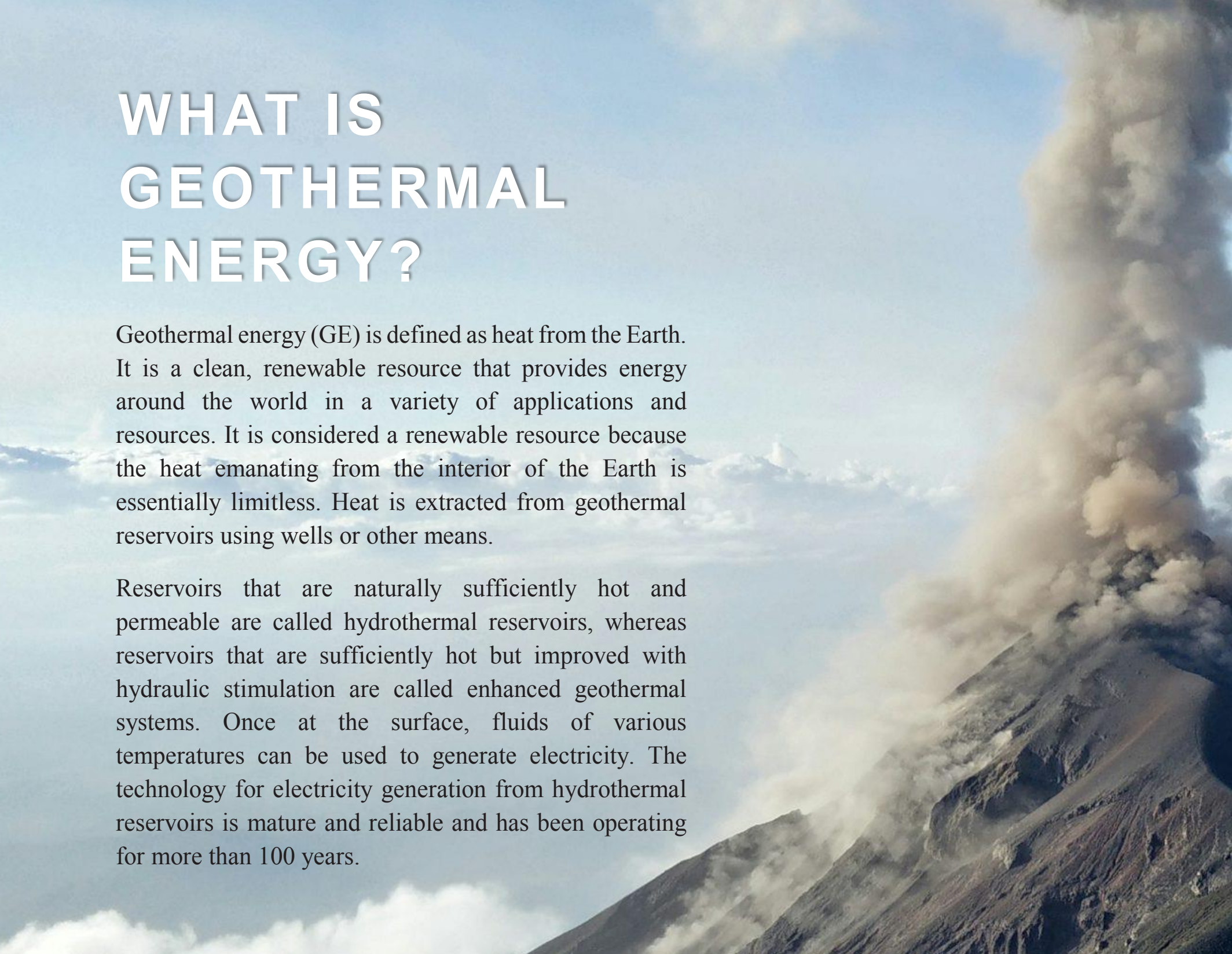
Five Beneficiary Countries 22

Summaries on Beneficiaries 3φ

Other Developments in the OECS 38

Project Sponsors 39

43 GLOSSARY



WHAT IS GEOTHERMAL ENERGY?

Geothermal energy (GE) is defined as heat from the Earth. It is a clean, renewable resource that provides energy around the world in a variety of applications and resources. It is considered a renewable resource because the heat emanating from the interior of the Earth is essentially limitless. Heat is extracted from geothermal reservoirs using wells or other means.

Reservoirs that are naturally sufficiently hot and permeable are called hydrothermal reservoirs, whereas reservoirs that are sufficiently hot but improved with hydraulic stimulation are called enhanced geothermal systems. Once at the surface, fluids of various temperatures can be used to generate electricity. The technology for electricity generation from hydrothermal reservoirs is mature and reliable and has been operating for more than 100 years.

DEVELOPMENT PHASES

A GE power project can be divided into a series of development phases before the actual operation and maintenance phase commences and post development phases after start-up.

Typical Stages

- Surface studies - to identify prospect for GE development.
- Exploration drilling - to prove there is a resource.
- Appraisal/Confirmation drilling - to prove the resource is sufficient (MW/well).
- Production Drilling - drill production wells & injection capacity.
- Power Plant Construction - deliver geothermal power plant, start-up and commissioning & connect to electricity grid.

Post development phases

- Operation and maintenance - operate geothermal power plant, make-up wells.
- Electricity distribution.
- Monitoring and optimization and Decommissioning.

CLEANER ENERGY?

Why geothermal energy is **cleaner**

DOMINICA GEOTHERMAL DEVELOPMENT COMPANY

The use of geothermal eliminates tons of greenhouse gases per year. Unlike fossil fuel power plants, no smoke is emitted from geothermal power plants, because no burning takes place; only steam is emitted from geothermal facilities. Emissions gases (nitrous oxide, hydrogen sulphide, sulphur dioxide, particulate matter, and carbon dioxide) are extremely low, especially when compared to fuel emissions from diesel power plants.

Geothermal power plants emit essentially no or very low levels of one of the most significant gases known to induce global warming: carbon dioxide. Experts generally agree that global warming poses significant environmental and health impacts, including flood risks, forest fires, increases in sea level, and loss of sea, plant, and animal life (biodiversity).

Geothermal power plants emit none or only a small fraction of the carbon dioxide (CO_2) emitted by traditional power plants on a per megawatt hour basis and can help reduce the overall release of CO_2 into the atmosphere and emit no nitrous oxide or methane.

There is no surface, air, or water pollution from the use of geothermal. Electricity generation from geothermal resources eliminates the mining, processing, and transporting required for electricity generation from fossil fuel resources that can impact the environment.

The noise level from a geothermal plant is less than that from a diesel plant. Noise from normal operation of power plants comes from cooling tower fans and is very low. A variety of noise muffling techniques and equipment are available for geothermal facilities. During drilling, temporary noise shields can be constructed around portions of drilling rigs. Noise controls can be used on standard construction equipment, impact tools can be shielded, and exhaust muffling equipment can be installed where appropriate.

A CHEAPER ALTERNATIVE?

Why geothermal energy is **cheaper.**

GE presents a valuable opportunity for Member States (MS) to improve their economic situation through increased income from royalty payments on GE production, taxes on income, and the export of energy to neighbouring islands or countries. By harnessing GE, MS can also produce "green hydrogen" for storage, ammonia, and various by-products, which will help them reduce high debts and allocate more resources for social, economic, and cultural development.

The stable and low-cost nature of GE can lead to the growth of new industries in MS, such as hotels, manufacturing, and information technology. It can also support direct applications like agro-processing, food drying, spas, fish production, and the cultivation of special plants. SMEs can also thrive with this resource.

In addition to energy, GE can produce valuable by-products, including minerals and agricultural goods. When used effectively, these by-products can bring in extra revenue for MS**.** According to the U.S. Department of Energy, GE requires less land than other energy sources, whether fossil fuel or renewable. Plus, since GE resources are tapped directly from the earth, there's no need for transportation. This makes GE plants more resilient to natural disasters like hurricanes.

Developing GE will create job opportunities, and the wages paid to workers will circulate back into the local economy. Tax incentives for developers can help lower costs, making GE even more affordable. Additionally, GE promotes knowledge sharing, capacity building, education, and research, as it is a new indigenous resource for the OECS.

GE electricity is cheaper to produce than any other energy source available to MS, allowing for lower electricity prices**.** This means residents can save more money and spend it within their communities**.**

By adopting GE, MS can significantly reduce their dependence on imported fuel for electricity generation. This shift cuts down on foreign oil imports, improving the countries' balance of payments and enhancing foreign reserves within the Eastern Caribbean Currency Union. As a result, this strengthens the Eastern Caribbean Dollar, giving MS greater control over their economic future and enhancing their energy security and independence.

Moreover, because GE does not rely on diesel fuel, there are no associated fuel costs or surcharges, which helps stabilize prices and reduce MS's reliance on unpredictable fossil fuel markets. This stability can also help control inflation. Although GE projects require significant initial investment, most production costs become predictable once the project is up and running. As a result, only a few factors can significantly change these costs, leading to greater economic stability for MS.

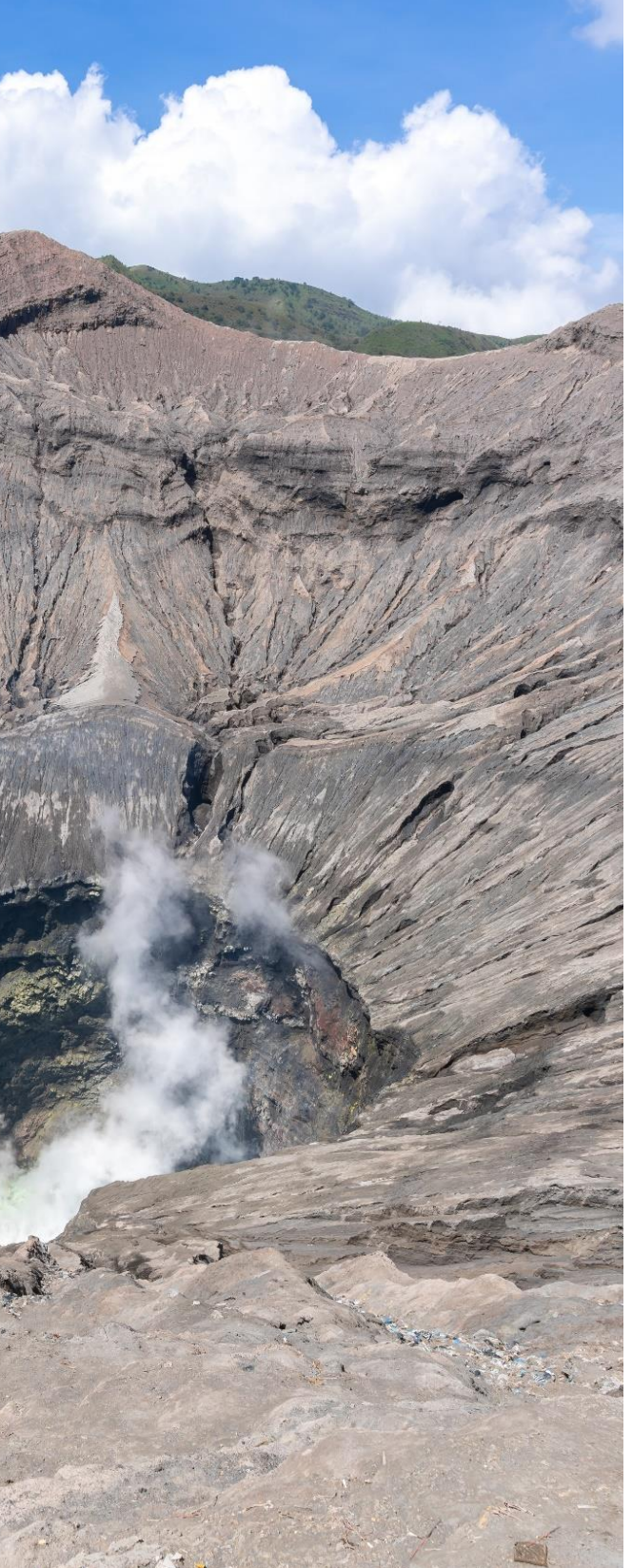
Countries that develop GE will benefit from a steady supply of electricity that isn't affected by fluctuations in global markets or outside factors. GE is reliable and renewable, with the earth's heat serving as a constant energy source that is essentially limitless. Rainwater and seawater continuously recharge underground thermal aquifers, ensuring a reliable energy supply. The geothermal heat that has been radiating from the earth's centre for billions of years is expected to continue for billions more.

FINANCIAL

Geothermal power plant development involves substantial capital requirements due to exploration drilling costs, for which it can be difficult to obtain bank loans. Since geothermal exploration is considered high risk, developers generally need to obtain some type of public financing. This risk is derived from the fact that capital is required before confirmation of resource presence or exploitability, and therefore before project profitability can be determined. Governments can reduce this risk and the cost of capital for private developers in a number of ways, like creating public companies that exploit geothermal resources and provide private companies (that install power plants and supply electricity to their customers) with the steam.

ENVIRONMENTAL & SOCIAL

While national regulations differ among countries, an environmental and social impact assessment of some type is almost always mandatory. Furthermore, apart from the assessment process, sufficient discussion with local groups may be needed before development can begin. These issues can delay or lead to the cancellation of the geothermal power project. However, if managed in a timely and efficient manner, they do not present an obstacle.



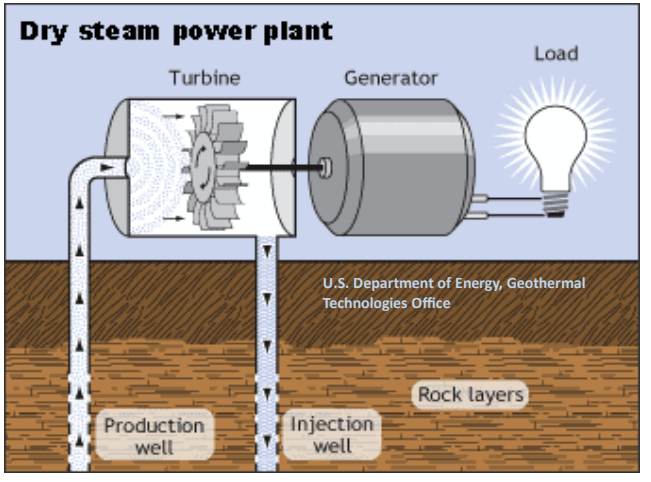
ADMINISTRATIVE

Administrative issues such as licensing, permitting and environmental assessments are technically not barriers. However, they need to be tackled carefully by project developers, as they might impact a geothermal project by causing unnecessary delays. On the other hand, governments should ensure that their regulations establish a transparent and straightforward process that will foster the deployment of new projects.

BARRIERS TO DEVELOPMENT

CAPACITY

For the OECS region to benefit from GE development, there is a need for increasing the capacity of Member States to develop their geothermal resources. This can be achieved by building internal expertise to manage the unique technical, regulatory, financial, environmental, and social issues associated with geothermal resource development and to instil best practices to address those emerging issues. Innovation, knowledge development and sharing, and research will be required over time to build capacity.

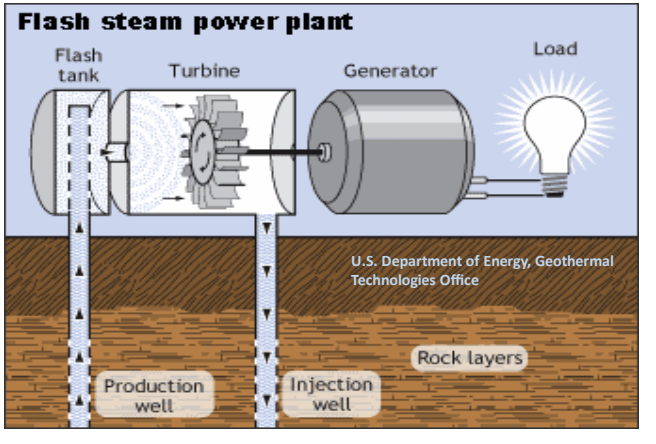


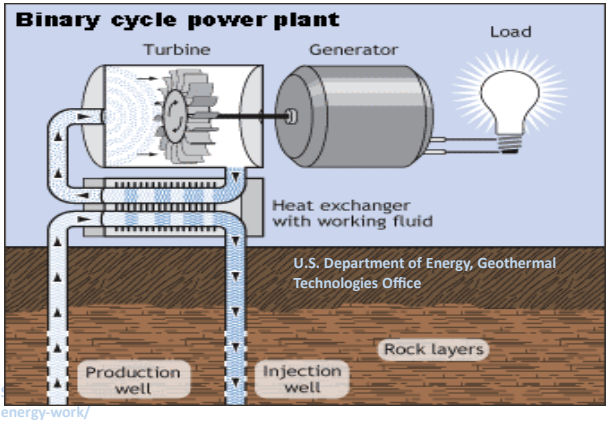
Direct Dry Steam Plants

This type of power plant uses steam to convert low-pressure, high-volume fluid from the steam field into electricity. They typically use condensing turbines, where the leftover water is either reused in a closed loop or evaporated in cooling towers. The steam must be at least 150°C and almost completely dry (99.995%) when it enters the turbine to avoid damage. These plants can generate between 8 MW and 140 MW of power. (S&P Global Platts, 2016).

Flash Plants

Flash power plants are the most common type of geothermal electricity plants in use today. They work similarly to dry steam plants, but they generate steam through a process called flashing. The steam is sent to turbines, and any leftover water is either reused or further processed at a lower pressure. These plants are most effective with well temperatures above 180°C because lowering the pressure decreases the fluid temperature. Most of the fluid and steam that isn't used is re-injected into the ground. Flash plants vary in size depending on whether they are single- (0.2-80 MW), double - (2-110 MW), or triple-flash (60-150 MW) plants (S&P Global Platts, 2016).

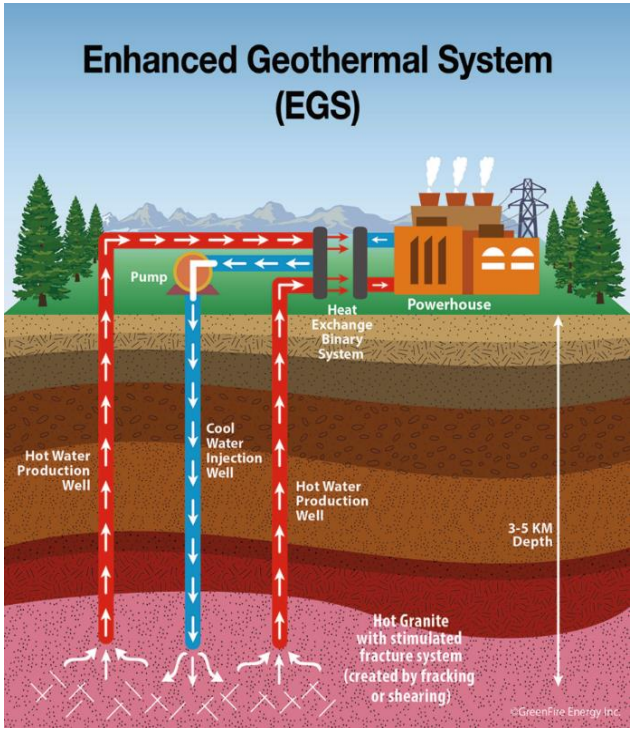




energy-work/

Binary Plants

These plants are typically used in low- to medium-temperature geothermal fields. They utilize the geothermal fluid to heat another fluid, like ammonia and water mixtures or hydrocarbons, through heat exchangers in a closed loop. This second fluid has boiling and condensation points that align better with the geothermal temperature. Binary plants usually operate with temperatures between 100°C and 170°C, but they can work with lower temperatures, although this reduces efficiency. The size of binary plants can vary from under 1 MW to 50 MW. (S&P Global Platts, 2016).



Enhanced Geothermal Plants

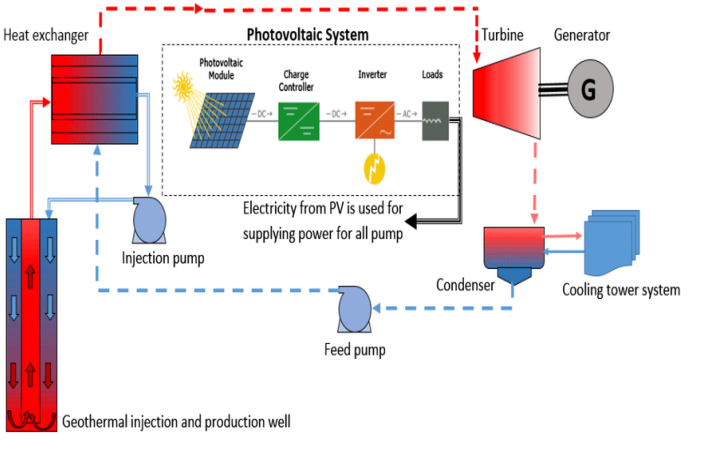
A lot of geothermal potential exists at greater depths that are not commonly drilled. Traditional hydrothermal methods rely on porous aquifers for hot water flow, but deeper rock is less porous, limiting this flow. To address this issue, research and demonstration projects are exploring new methods.

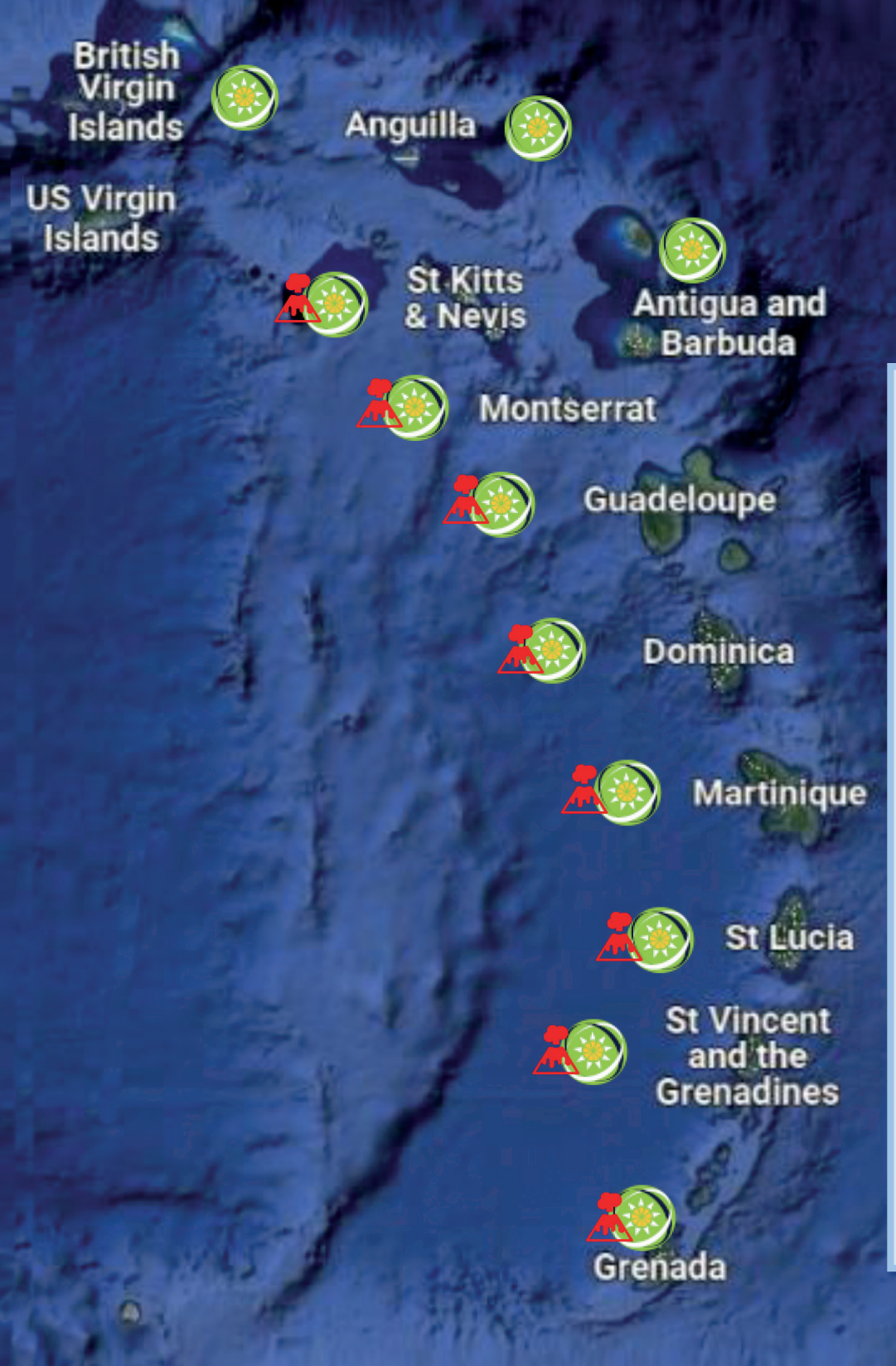
One approach involves creating artificial fractures to connect production and injection wells through hydraulic or chemical stimulation. This process uses high-pressure water mixed with a small amount of chemicals to create or reopen fractures in the deep rock. To keep these fractures open when the pressure drops, special materials called proppants are added. This method, known as enhanced geothermal system (EGS), uses binary plants to generate power from the hot brine. Since there's no natural water flow, all the brine must be re-injected to maintain pressure and stable production, which also helps eliminates air emissions during operation. Several pilot projects have been conducted in France and the United States.

GEOTHERMAL PLANT SYSTEMS

Combined-Cycle/Hybrid Plants

Some geothermal plants use a combined cycle, which combines a traditional method for generating electricity with a binary cycle, making better use of heat that would otherwise be wasted. This two-part system increases overall efficiency. Hybrid geothermal plants work similarly to regular geothermal plants but also incorporate another heat source, like one from a concentrating solar power plant. This extra heat raises the temperature of the geothermal fluid and boosts electricity production. Combined-cycle plants usually generate between a few MW and 10 MW of power.





PROJECT SUMMARY

There are currently eight, all with volcanic origin, out of the 11 MS actively pursuing GE projects:

1. The Commonwealth of Dominica
2. Grenada
3. Guadeloupe: one with an operating geothermal plant
4. Martinique
5. Montserrat
6. Saint Kitts and Nevis
7. Saint Lucia
8. Saint Vincent and the Grenadines

For these countries, it is considered by their respective governments that GE holds the greatest potential of the RE options available for transforming their energy matrices by directly displacing large proportions of the diesel fuel-based generation.

In addition to being renewable, GE as a source of energy for electricity production provides many advantages, by providing constant, dispatchable firm capacity (being not as variable as wind and solar) all year-round, except for scheduled maintenance outages. As a result, the respective governments have signalled harnessing GE as a priority RE option and have commenced the development of GE projects, beginning with exploration of this natural resource over the past several years.

The OECS-GEOBUILD Project aims to deliver capacity building for all stages of geothermal development and strongly supports policy development, planning, and effective geothermal reservoir management for sustainable geothermal development.

The four components of the Programme centre on capacity building for the people, institutions, and processes to successfully facilitate GE in the OECS. The programme components have been designed based on identified gaps, articulated needs of the OECS Member States, and from best practice and findings of published research literature in the field of GE.

1 - Capacity Building for Planning, Exploration and Project Management.

3 - Knowledge Management and Public Awareness

2 - Enhancing Policy, Legislative and Regulatory Environment

4 - Regional Coordination and Sharing for Geothermal Energy

Implemented in tandem, the components create a comprehensive package for transforming the landscape for increased uptake of GE.

GEOBUILD will provide governments with critical GE expert technical advice, supporting training of various persons in geoscience (and other technical areas), supporting GE project development, and providing public information and awareness in relation to GE development. This will be done through six regional level technical consultancies (the Technical Consultants) as follows:

1. GE Public Information and Communications (PIC)
2. GE Regional Capacity Advisor (RC)
3. GE Regional Legal and Transactional Advisory (LTA)
4. GE Regional Environmental and Social Advisory (ESA)
5. GE Regional Engineering and Technical Advisor (RETA)
6. GE Economic Advisor (EA)

GEOBUILD
Advancing Geothermal Energy in the Caribbean

BENEFICIARIES

This project will directly benefit five eligible OECS MS.

GEOBUILD

Advancing Geothermal Energy in the Caribbean

SAINT KITTS AND NEVIS

THE COMMONWEALTH OF DOMINICA

SAINT LUCIA

SAINT VINCENT AND THE GRENADINES

GRENADA

OBJECTIVES

Formulation of the most acceptable economic model and risk management solution for successful implementation of the project and minimization of possible risks.

Processes and frameworks that utilize and leverage existing and future skills and expertise for geothermal in the OECS.

Innovative and sustainable solutions to capacity needs and gaps with respect to GE in the participating OECS MS.

General back-stopping support in the form of legal and transactional advisory services, and advisory services for strengthening of the legal and regulatory framework for GE development.

Capacity building on key aspects of GE including resource exploration, project design and management, legal and transactional activities, economic and financial tools, and policy implementation.

Raising awareness among various publics at the national and regional levels on the use of geothermal resources in a safe and environmentally friendly manner.

The main objective of the Project is to provide specialized advisory support, analyses and capacity building for GE development based on critical needs to advance relevant project initiatives in beneficiary countries.

DEVELOPMENT STATUS

In the Caribbean, the greatest geothermal resource potential for electricity production is limited to the OECS. The following table summarises the status of geothermal developments in GeoSmart eligible countries, noting that St. Kitts and Nevis are looking at resources on both islands. The percentage indicates how far through the phase, the project has progressed. The dates for subsequent phases are indicative based on current understanding of the projects and stated goals of the project developer, which in some cases may be ambitious.

In all cases, the rate of progress has been determined by the status of the resource, the enabling environment in each country (legal/regulatory/permits), the ability to attract suitable developers, completion of contractual negotiations in a timely fashion, and access to the necessary funds/financing to complete each phase of works.

Status of Geothermal Developments in the OECS

(for first plant for domestic electricity demand)

	Dominica	Grenada	St. Kitts	Nevis	Saint Lucia**	St. Vincent
Market (Peak Demand Current*)	17 MWe	38 MWe	24 MWe	9 MWe*	62 MWe	21 MWe
Potential Project Scale	10 MWe	15 MWe	10-15 MWe	30-50 MWe	25-30 MWe	10-12 MWe
1. Surface reconnaissance	100%	100%	50%	100%	100%	100% (2012-2015)
2. Exploration drilling	100%	2026	***	50%	2025	2019-2020
3. Production drilling	100%	2030	***	2024	2028-2030	2019-2020
4. Power plant completion	2025	2030+	***	2025	2030+	***
5. Expected Operation	2025/2026	2030+	***	2026	2030+	***

**Values are rough estimates developed by CDB.*

*** World Bank is lead financier in Saint Lucia*

****Unknown.*

Source: CDB

The Energy Situation

THE COMMONWEALTH OF DOMINICA

DOMINICA

Population: ~73,000

Total Geographic Area: ~750 km^2

GDP: USD654.0 million in 2023

- Main Economic Sectors: Agriculture, Tourism

Photo: Nixon George, Quick Link Productions via Dominica GDC

Dominica has no proven reserves of conventional energy and is heavily dependent on imported petroleum products for electricity generation, transportation, cooking, and other energy requirements. Dominica has an energy mix with more than 96% petroleum base and ~4% hydropower.

The energy policy and regulatory framework in Dominica is characterised by the following policies, regulations, and institutions being in place:

(a) National Energy Policy
(b) Electricity Supply Act, No 6 of 2006
(c) Independent Regulatory Commission
(d) Draft Sustainable Energy Plan
(e) Geothermal Resources Development Act, No. 12 of 2016
(f) Draft Planning and Environmental Regulations
(g) Duty Waiver on Materials and Equipment for RE Development
(h) Liberalized Electricity Sector
(i) RE/Electricity Interconnection Policy and Procedure
(j) Assessment of GE resource
(k) Promotion of RE Technologies

Prior to the hurricanes of 2017, 67% of Dominica's electricity supply came from diesel generation, with the rest provided by hydropower. Electricity is supplied by the Dominica Electricity Services Ltd (DOMLEC) being the integrated utility. Although the framework allows for other players, DOMLEC is essentially the sole supplier of electricity to the nation.

DOMLEC is a majority privately-owned utility[1], with 52% of its shares being held by Dominica Power Holdings Ltd., a subsidiary of Light and Power Holdings Ltd. (LPH), a subsidiary of Emera Inc. of Canada.

The remaining stake is held by Dominica Social Security and the general public. DOMLEC's total installed generation capacity is approximately 26.7 MW (with 20.1 MW being diesel-powered) with peak demand about 17 MW (pre-hurricane level). The average retail price of electricity in Dominica ranged from USD0.40 to USD0.45 per kWh during 2016.

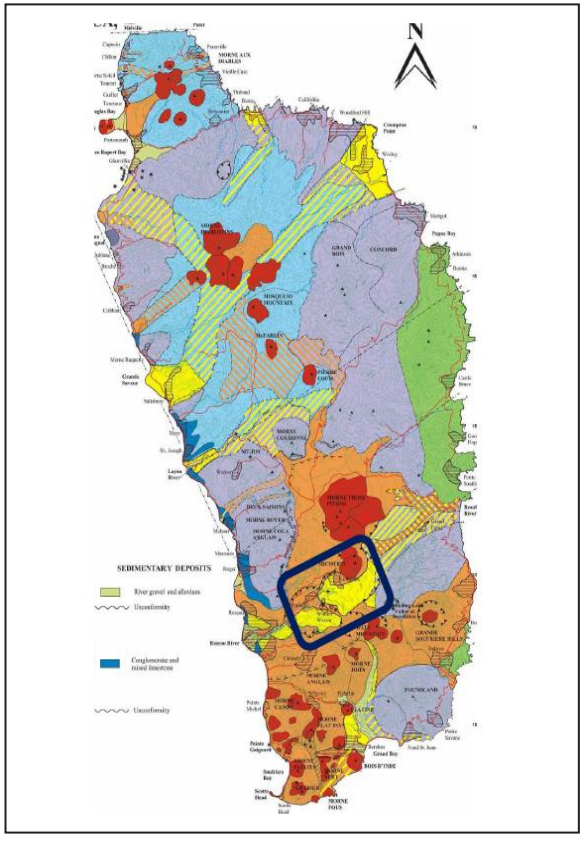
Dominica, rich in renewable energy resources, is developing a 10 MW power plant to harness its substantial geothermal potential, estimated to be the highest in the Caribbean. This and future projects could meet Dominica's entire foreseeable power demand and also generate a sizable surplus for export via submarine connections to neighbouring islands.

The geothermal power plant project is progressing steadily. Grading works for the plant and reinjection pipeline route began in July 2024, with foundation works to follow. The project timeline indicates that the Commercial Operation Date (COD) is scheduled for December 2025.

Alongside the power plant development, the transmission network is also taking shape. Kalpataru Projects International Ltd (KPIL) of India has been selected as the contractor for this crucial component. The contract between DGDC and KPIL was signed on September 3, 2024. The transmission network will comprise 33kV underground cables, 69kV overhead and underground cables, and substations that will connect the new geothermal plant with existing diesel and hydro power plants, ensuring efficient energy distribution across the island and potentially facilitating future energy exports.

This geothermal power plant, once operational, will play a crucial role in Dominica's energy landscape. It will contribute significantly to the country's renewable energy portfolio, potentially reducing reliance on less sustainable energy sources and positioning Dominica as a leader in geothermal energy production in the Caribbean region.

With support from several international development partners (including AFD, OAS, French Overseas Departments of Guadeloupe and Martinique, the Government of New Zealand, the UK FCDO, the UN/SIDS DOCK, and IRENA) and the World Bank, the GOCD has been pursuing a 10 MW GE Project.



Area of Exploration and Exploitation

CDB has had several discussions with all the parties and has been communicating with the lead entity arranging the financing on behalf of the private consortium.

The World Bank has provided funding support for the drilling of an additional production well, reinjection wells, and installation of transmission lines. In addition to World Bank loan resources, the project has also benefited from grant funding (from UK FCDO and SIDS DOCK) which the World Bank is administering on behalf of GOCD.

Some key info on the GE project:

(a) Plant Location: Laudat (lat. 15.3310/long. 61.3255)
(b) Projected Capacity: 10.0 MWe gross
(c) Reinjection Line – relocated based on new reinjection strategy
(d) Number of Production Wells: 1 (WW-P1) already drilled.
(e) Production Well Location: Laudat.
(f) Number of Reinjection Wells: 3

Completed:

(a) Conclusion of agreements for Joint Venture SPV project company
(b) Conclusion of Concession Agreement.
(c) Conclusion of PPA
(d) Design of Power Plant -Condensing (Flash) or Binary.
(e) Selection of EPC (power plant, drilling).
(f) Ordering of Power Plant
(g) Civil works

Geothermal Energy Project

2012-2013

Drilling operations occurred. The commercial viability of the geothermal resource has been well established.

2019

Further testing was done. The project has therefore been at the power plant design and construction stage for a while.

2020

The ESIA for the plant was updated and publicised in keeping with the requirements of the Bank and the GCF, for a "Category A" project.

2024

The project now targets 10 MW (for the domestic market). The private partners have expressed interest in securing funding from the CDB (through the GeoSmart Initiative). This funding may include GCF resources under the SEF Programme of GeoSmart. At this time, a concession agreement, project company joint venture/SPV agreement, and PPA were completed.

GRENADA

The Energy Situation

Grenada is overwhelmingly dependent on imported petroleum products to satisfy its growing energy demand. Additionally, the small and isolated nature of the electricity market in Grenada, like many of CDB's BMCs, inhibits the achievement of economies of scale in the production and distribution of electricity, resulting in higher unit cost. The average peak electric demand for Grenada is 29MW. In 2016, the average electricity tariff in Grenada peaked remains relatively high at USD0.26/kWh.

As a result, Grenada (like the majority of CDB's BMCs) is seeking to reduce its dependence on imported fossil fuel, improve national energy security, and improve its competitiveness through increasing the deployment of sustainable energy options, RE and energy efficiency. In this regard, the Government of Grenada (GOGR) has undertaken several steps over the past decade, including the approval of a National Energy Policy (since 2011), and the setting of ambitious EE and RE targets.

The Electricity Supply Act was revised in 2015, and a new regulatory framework is being established. A draft Geothermal Resource Development Bill has also been prepared to reflect GOGR's priority focus in this area. As part of the Paris Climate Change Accord 2015, the country has committed to a significant Nationally Determined Contribution for carbon emission reduction of 30% by 2025, with 2010 as the baseline year.

GRENADA

Grenada is a tri-island state, located 145 km north of Trinidad and Tobago and is the most southerly of the Windward Islands.

Population: ~106,000

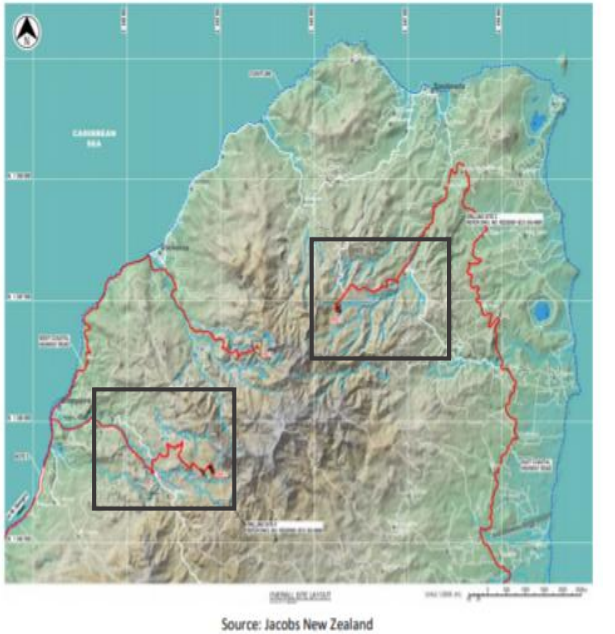
Total Geographic Area: ~340 km^2

- Grenada: 89% of total area (34 km long and 19 km wide)
- Carriacou: 10% of total area
- Petit Martinique: 1% of total area

GDP: USD1.32 billion (2023, WB)

- Main Economic Sector: Tourism

Grenada Geothermal Exploration Drilling Sites



Source: Jacobs New Zealand

Geothermal Energy Project

In line with its energy policy, GOGR is seeking to explore all viable RE options for electricity generation, including solar, wind, and GE. As a result, the GOGR has commenced exploration of its GE potential, with support from international development partners. Such support includes technical assistance provided by the Governments of New Zealand and Japan to complete a comprehensive geothermal pre-drilling surface exploration programme in 2015. New Zealand's assistance has been provided through the New Zealand Aid Programme administered by the Ministry of Foreign Affairs and Trade (NZMFAT) and the Government of Japan, through the Japanese International Cooperation Agency (JICA).

The comprehensive surface-based geothermal investigation programme was undertaken by Jacobs New Zealand Ltd and Nippon Koei, which constituted Phase 1 of the geothermal development programme. The results of Phase 1 indicated the presence of a high temperature (200 – 290 °C) geothermal source that would support a 15MWe single flash power plant, which would be a suitable size for Grenada's electricity market. The consequent recommendation was for an exploratory drilling campaign that would drill multiple wells to confirm the existence of and to characterize the geothermal resource and assess their suitability for power generation.

A Geothermal Development Roadmap has been prepared which outlines the major steps, timelines and budget required to realize a geothermal power in Grenada. The next major step is for exploration drilling to test the conceptual models of the geothermal system and verify the existence, temperature, permeability, and extent of the resource. The GOGR has established a GE project management unit in the ministry responsible for energy which has been overseeing the test drilling programme (drilling of slim hole exploration wells) and will be responsible for undertaking the necessary activities to support this stage.

The GOGR Geothermal Resources Development Roadmap (2015) presents the development strategy and approach. The Government has chosen to follow this development approach:

(a) A national entity drills exploration wells and confirms the existence and characteristics of the geothermal source.
(b) The entity undertakes competitive bidding for the development rights for the geothermal field.
(c) A private entity (preferably through a PPP) further elaborates the technical and economic feasibility of the development; negotiates a power purchasing agreement; develops the wellfield and finances, constructs and operates the power plant. The strategy envisages development of a nominal 15MWe (3 x 5MWe) geothermal power plant in the northern half of Grenada.

The project's exploration drilling plan proposes to drill two deviated, rotary slim hole exploration wells (one well at each site) to approximately 2165 m measured depth. The current schedule is for drilling to commence in 2026.

The Energy Situation

ST. KITTS AND NEVIS

Like many island states, St. Kitts and Nevis is highly reliant on imported fossil fuels to meet its energy needs. The Federation's two utilities are the St. Kitts Electricity Company Ltd. (SKELEC) and the Nevis Electricity Company Ltd. (NEVLEC). These two utilities are vertically integrated, state-owned enterprises that operate independently from each other, with responsibility for generation, transmission, distribution, and the sale of electricity to customers on their respective islands.

SKELEC has a total capacity of 43.75 MW and operates a 2 MW solar photovoltaic facility that was connected to the St. Kitts grid in 2015. These facilities service a peak demand of approximately 24 MW and a base load of approximately 14 MW. NEVLEC operates 17 MW of diesel generation capacity, and purchases energy from a 2.2 MW privately owned wind farm operating on Nevis. It serves a peak demand of approximately 8 MW and a base load of 5 MW.

The Federation Parliament approved the National Energy Policy (NEP) in 2011, and subsequently adopted amendments in 2014. The NEP and its amendments include acceleration of the Federation's goal of transitioning power generation resources away from imported fuels towards increased development of local RE resources. Government in 2015 also set a target of conversion of generation capacity from carbon-based fuel sources to 100% renewable sources by 2020.

ST. KITTS AND NEVIS

The twin-island state of the Federation of St. Christopher (St. Kitts) and Nevis is located west of Antigua and Barbuda, and Anguilla.

Population: ~54,000

- St. Kitts: ~42,000 (75% of population)
- Nevis: ~12,000 (25% of population)

Total Geographic Area: ~269 km^2

- St. Kitts: ~67% (two-thirds) of total area (176km^2)
- Nevis: ~33% of total area
- GDP: USD1.08 billion (2023, WB)
- Main Economic Sector: Tourism

Mount Liamuiga, St. Kitts

Geothermal Energy Project in St. Kitts

2015

The Government of St. Kitts and Nevis (GOSKN) entered into an MOU with a private developer to undertake surface exploration work to evaluate the opportunity for geothermal development on St. Kitts.

2016

The initial results from the surface exploration work were expected in Q1 2016 and a second MT campaign were planned for Q2 2016. Public statements by the Minister of Energy indicated that the developer envisaged undertaking a slim-hole exploration programme from Q4 2016, funded by the developer.

2017

The developer announced that 90% of the surface exploratory studies were completed in the Brimstone Hill area. This was reported to have included Geology, Geochemistry and Geophysics, as well as production of a conceptual model and assessment of the GE resource. The developer further reported that the conclusions of the preliminary assessment could support a GE project of over 20 MW. The next stage of the development was that of exploration drilling to confirm the resource. The developer and the GOSKN have, however, not concluded a concession agreement since this was proposed by the developer in 2016.

2021

At a meeting between CDB and GOSKN in 2021, the government reiterated that the objective of developing a GE project on the Island of St. Kitts remains a high priority. An Integrated Resource and Resilience Plan which was undertaken (with completion set by end of 2021) should have provided greater clarity on the plan going forward.

Geothermal Energy Project

in Nevis

The Nevis Island Geothermal Energy Project is a proposed 10 MW binary geothermal power plant. The project will be developed to meet the demand for electricity in Nevis. The project's development plan consists of drilling and installation of four full-size wells (two production wells and two injection wells), and the construction of a binary-cycle air-cooled generating plant. The plant would be located on two parcels of rural land, both of which are Hamilton Heritage Trust land.

This land has been leased to a private project company, by the Nevis Housing and Land Development Corporation, a statutory body of the Nevis Island Administration (NIA). The lease is pursuant to a 30-year concession agreement between the private company and NIA for the development of GE on the island of Nevis. Once in operation, the intended commercial arrangement includes a 25-year PPA between the private company and NEVLEC. NEVLEC is a fully owned subsidiary of NIA, and the sole supplier of electricity on the island of Nevis.

Drilling rig on site, Nevis
(Photo: Clean Power Nevis)

Status of Development of the Project

The project is in the Pre-Financial Closure stage. In this stage, the project's Business Case is under review, including the financial model, the ownership structure, the PPA, and financial and technical ability of both the private company and the utility to meet PPA terms. If the project moves forward, it will enter the development phases of development drilling and power plant construction.

In the first semester of 2019, the private company applied for funding from the CDB to support the drilling of geothermal wells included in the project's Development Plan.

The project has concluded the exploration studies and test drillings, which included geochemistry studies of warm springs and wells, magnetotelluric surveys, geological studies, and drilling and testing of four slim holes (N-1, N-2, N-3, and N-4).

In July 2019, CDB engaged a consultant to carry out a technical appraisal of the Development Plan. This appraisal concluded that drilling a full-size well on the same pad as two successful slim holes has minimal risk, and it is likely to produce enough steam for the planned 10MW project.

At that time, the private company engaged with NIA for a further negotiation of the concession agreement and the PPA with the utility, given that these have expired. It was reported that these negotiations were not successful and hence, the NIA has taken a different approach.

The Energy Situation

ST. VINCENT AND

St. Vincent and the Grenadines (SVG), like most other countries in the Caribbean region, is heavily dependent on imported petroleum products to meet its energy requirements. In the primary energy mix, petroleum products account for 96%, hydropower 3%, and other marginal energy sources account for the remaining 1%. Electricity production on the majority of the SVG islands is entirely diesel-based, except for the main island of St. Vincent where 80% of the electricity is produced by diesel generators and the remaining 20% by small hydropower plants.

ST. VINCENT AND THE GRENADINES

Population: ~110,000

- St. Vincent: ~100,000
- 7 smaller inhabited islands: ~10,000 (25% of population)

Total Geographic Area: ~390 km^2

- St. Vincent: ~ 342.7 km^2
- The Grenadines: ~ 47.2 km^2

GDP: USD1.07 billion in (2023, WB)

- Main Economic Sectors: Agriculture, Tourism

Map Showing Geothermal Project Location

2013

GOSVG, Reyjavik Geothermal (RG) and Light and Power Holdings made a comprehensive desk study with the focus on a geographic cross section between the Wallibou hot spring area and the summit of Mount Soufrière. The study utilised information from previous studies, along with other data sources and remote sensing techniques, to provide the most complete data set to date on the possible deep and hot geothermal resource under Mount Soufrière. It was concluded that the Soufrière volcanic systems show all the right ingredients to host a >200 °C geothermal reservoir at depth and this provided the impetus to pursue a surface exploration campaign. The results of this campaign form the basis to move forward with exploratory drilling as the next step in the geothermal development in St. Vincent.

Geothermal Energy Project

SVG is a set of volcanic islands with an active volcano, La Soufrière, in the north of the main island St. Vincent and, as such, it is expected to have excellent geothermal potential. Since 1991, several studies have been undertaken to examine the prospects for power generation from GE in St. Vincent. The St. Vincent Geothermal Project company (SVGCL) was formed between Reykjavik Geothermal (RG), Emera Caribbean and the Government of St. Vincent and the Grenadines (GOSVG). The private sector partners further committed equity for the drilling campaign, which seeks to drill three standard size wells and one reinjection well.

2016

In response to a funding request from SVGCL, CDB approved a package of grant and contingent grant resources under the GeoSmart Initiative for a drilling project to drill three full sized exploratory/production wells (with planned re-injection well not drilled), towards the establishment of a 10 MWe GE plant.

2019

After protracted negotiations around the terms of the PPA, relevant agreements were signed, and well development commenced in 2019. The result yielded temperatures in excess of the 200°C in two of the wells (the third well developed challenges). However, permeability of the wells was limited, and as a result, it was judged not economically feasible to advance the development of the power plant at that time. The project developers are now considering various technology options to overcome this barrier to advance the power project.

2021

On April 9, La Soufrière erupted and between April 9 and 20, the University of West Indies Seismic Research Centre recorded at least 30 explosive events. As of May 9, the alert level for La Soufrière was decreased from Red (eruption ongoing) to Orange (eruption may occur with less than 24 hours' notice).[1]

SAINT LUCIA

The Energy Situation

Saint Lucia, like most eastern Caribbean countries, is characterized by a high dependence on imported fossil fuels to meet its energy demand. Saint Lucia has no known petroleum reserves and apart from limited usage of combustible renewables, all energy is imported, mainly from Trinidad.

Saint Lucia receives about 98% of its overall energy through imported oil products. All refined petroleum products are imported and subsequently stores at the Buckeye Partners (BPL) (formerly Hess Oil St. Lucia Company Limited) oil storage facility in the northern part of the island. BPL is the exclusive supplier of fuel to the island utility company, St. Lucia Electricity Services Limited (LUCELEC). LUCELEC is the sole supplier of electricity on the island. It has an available generation capacity of 88.4 MW, a maximum or peak demand of 61.88 MW and a customer base of 71,484. There is a total of 5.4 MW of renewable energy (solar), consisting of a 3MW solar farm and 2.4 MW of distributed generation. This accounts for about 2% of energy generation or 6% of capacity.

SAINT LUCIA

Saint Lucia is an island state in the Eastern Caribbean located to the south of Martinique and north of St. Vincent and the Grenadines.

Population: ~182,000

Total Geographic Area: ~616 km^2

GDP: USD2.52 billion (2023, WB)

- Main Economic Sectors: Agriculture, Construction, Tourism

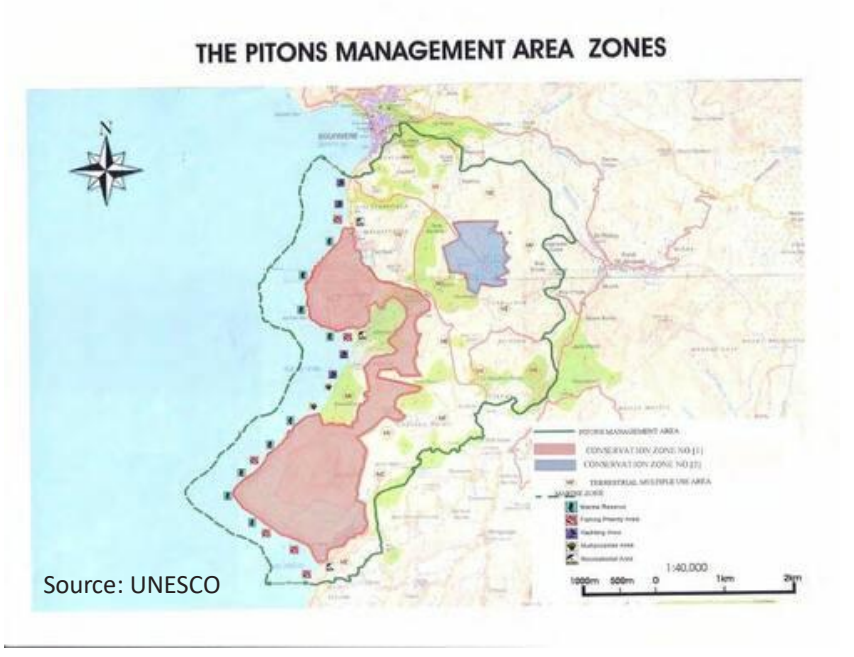
Geothermal Energy Project

The Government of Saint Lucia (GOSL) has secured funding through the WB to implement the Renewable Energy Sector Development Project (RESDP) at an estimated cost of USD21.8 million. The development objective of the RESDP is to inform the GOSL on the viability of its GE resource for electricity generation, to strengthen the enabling environment to scale-up clean energy investments with the private sector and decrease the country's dependence on imported fossil fuels. The project is being implemented by the Division of Energy and Public Utilities of the Department of Infrastructure, Ports and Transport.

The RESDP is being implemented between July 2022 and December 2026 and consists of two components:

Component 1

Exploration Drilling Programme comprises all activities related to geothermal exploration drilling to assess and estimate whether the resource is sufficient for development of a geothermal power plant.



Component 2

A Technical Assistance (TA) programme aimed at:

(i) increasing the GOSL's capacity to implement the project

(ii) strengthening Saint Lucia's regulatory framework for renewable energy integration and

(iii) supporting a reduction in the employment gender gap in the energy sector.

Under Component 2 (ii), the regulatory framework must be established to enable GE development near the boundary of the Pitons Management Area (PMA), a UNESCO World Heritage Site.

DOMINICA

Dominica is leading in the OECS in terms of its GE development programme. The GE resource has been proven and the government is currently pursuing the next phase of constructing a geothermal plant. The resource has been proven with drilling and completion of one (1) back-up production well in December 2022 (RV-12), and one reinjection well (RV-I2)-April 12, 2023. Flow testing took place in April 2023 and preliminary results show high production potential. Currently there is ongoing work on the transmission line network.

The Dominica Geothermal Development Company is the entity that is leading on the development of a 10MW GE plant in Dominica. A developer is currently constructing the power plant that is scheduled for completion in 2025.

ST. KITTS AND NEVIS

There is geothermal potential on both islands of St. Kitts and Nevis. The two islands are seeking to develop resources together. The current focus is on the island of Nevis where four slim holes have been drilled and it is advancing towards production drilling. The St. Kitts and Nevis Geothermal Project has secured funding of USD17 million from CDB. More funding will be required to drill more wells and later to construct a geothermal plant. An RFP was issued for the drilling programme and as of 2024, evaluation of bids is ongoing.

GRENADA

Following a request in 2014 from the GOGR, technical assistance was provided by the governments of New Zealand and Japan to investigate the potential for GE on mainland Grenada.

Results of preliminary surface-based investigations indicated the presence in the Mount St Catherine area of a high-enthalpy (200°C ~ 290°C) geothermal source, sufficient to support a 15 MWe geothermal power plant comprising 3 x 5 MWe units with ancillary plant and equipment. At present, Grenada's peak demand for electricity is ~ 33 MW.

Exploratory drilling at two sites is proposed. GoG undertakes a campaign to drill exploratory slim-hole wells at two sites, to depths up to 2,000m to confirm the presence and characteristics of a geothermal source. If drilling results are successful, a pre-feasibility study will rank the sites in order of feasibility and recommend a preferred site for further development. Subsequently via a robust tender process GoG awards a time-constrained concession for the development of the geothermal project at the preferred project site, to a qualified developer. Land acquisition is also being pursued and the ESIA was completed.

SAINT LUCIA

GE exploration is being undertaken by the Renewable Energy Sector Development Project (RESDP) 2022-2026, US$ 21.8 M. The aim is to inform on the viability of its geothermal resource for power generation and strengthen the enabling environment to scale-up clean energy investments with the private sector. New sites for drilling have been identified. The project team has signed an agreement with an Exploration Management Consultant in June 2023.

SAINT VINCENT AND THE GRENADINES

The plan for the GE development was for construction of power plant with the capacity of 10-15 MW. In 2019, three (3) production-sized exploration wells were drilled and produced temperatures in excess of 220°C but with limited permeability for electricity production, an in-depth analysis of the data is still needed. Alternative technologies are being sought for further geothermal development. SVG received recent support from the BRGM under the ETC for using innovative methods - the first post-volcanic geothermal survey was conducted but to date (October, 2024) results are still pending.

SUMMARIES ON BENEFICIARIES

GEOBUILD

Advancing Geothermal Energy in the Caribbean

OTHER DEVELOPMENTS IN OECS TERRITORIES

NOT UNDER GEOBUILD

GUADELOUPE

Guadeloupe is the only territory in the Caribbean with an existing operating geothermal power plant in Bouillante which was commissioned in 1986 and has a capacity of 15.5 MW. One of the key drivers of geothermal development in Guadeloupe was the government's active role in the development of geothermal resources. Although the private sector played an important role during the exploration phase in the 1970s and the production drilling and operation phase in the 1980s, the government played a key role in the development of both phases of Guadeloupe's geothermal development.

The current aim is to double its electricity production – to achieve a target of 20% geothermal share of electricity production by 2035. In April 2023, it was decided to have a new replacement well and production planned for 2025. There are additional plans for a third production unit – the development team is currently (as of October, 2024) addressing some operational and land challenges. There is the possibility of two other projects, but additional scientific investigations and financial resources are needed.

Bouillante Power Plant, Guadeloupe

MONTSERRAT

Significant exploratory work was undertaken in Montserrat. An RFP was issued for the period Nov 8, 2022 – June 14, 2023, for the economic development of Montserrat's existing geothermal wells on Build, Own, Operate and Transfer (BOOT) Basis. In addition, there has been the flow testing of two (2) geothermal wells - MON1 and MON2 in April 2023.

The Government of Montserrat and the Oxford Martin Programme are also collaborating on a study to assess the potential for GE and critical metals from volcanic geofluids. The research started in June 2024 and will run until October 2026, with its purpose being to explore whether extracting GE can be economically viable while also recovering critical metals. The study aims to develop sustainable extraction methods and evaluate impacts, with findings to be shared after its completion with Montserrat's government.

PROJECT SPONSORS

THE CARIBBEAN DEVELOPMENT

The CDB is a development institution that supports Caribbean countries, known as Member Countries (MCs), in financing social and economic programmes and projects. Established by an agreement signed on October 18, 1969, in Kingston, Jamaica, the bank officially began operations on January 26, 1970. Its permanent headquarters is in Wildey, St. Michael, Barbados. The Barbados headquarters serves all regional borrowing member countries with staff recruited from these nations. On September 21, 2018, CDB opened its first Country Office outside of Barbados in Haiti.

CDB's membership consists of 28 countries: 19 regional borrowing members, 4 regional non-borrowing members (Brazil, Colombia, Mexico, and Venezuela), and 5 non-regional non-borrowing members (Canada, China, Germany, Italy, and the United Kingdom).

As part of its strategy to promote renewable energy (RE) in its BMCs, the CDB is developing tools to address various barriers to RE investments. GE has the potential to transform energy systems in the Eastern Caribbean by stabilizing electricity prices and reducing reliance on fossil fuels. However, challenges such as high upfront costs and complicated project structures hinder its development. To tackle these issues, it is essential to provide targeted technical assistance and financing, along with strong support for governments that play a key role in these efforts.

In response to these challenges, the CDB launched the GeoSmart Initiative. GeoSmart is the umbrella term used to capture all the Bank's efforts to support GE development. The initiative aims to mobilize resources from international agencies and other partners to accelerate viable GE projects in targeted countries by reducing developer risk during the early stages of development. The CDB plans to offer technical assistance, grants, contingent grants, and loans to geothermal projects at critical points in their life cycles, specifically in Dominica, Grenada, St. Kitts and Nevis, and St. Vincent and the Grenadines. It is important to note that the CDB is the lead financier for GE projects in Dominica, Grenada, St. Kitts and Nevis, and St. Vincent and the Grenadines, while the World Bank is leading efforts in Saint Lucia.

These interventions are expected to lower overall development costs and create competitive electricity tariffs, leading to stabilized or reduced electricity prices for consumers. Additionally, this initiative aims to cut CO_2 emissions from the electricity sector and decrease dependence on fossil fuel imports.

GeoSmart Resources

To date, the GeoSmart Initiative includes two main funding programmes: the Inter-American Development Bank's SEF for the Eastern Caribbean and the European Union Caribbean Investment Facility (EU-CIF) Geothermal Risk Mitigation Programme.

Under the SEF Programme, the Caribbean Development Bank (CDB) and the IDB have signed agreements for approximately USD128 million in grants, contingent grants, and concessional loans. This funding includes:

- USD20 million loan from the IDB
- USD3 million grant from the Global Environmental Facility (GEF)
- USD19.05 million contingent recoverable grant from the Clean Technology Fund
- USD60 million loan, USD16 million contingent recoverable grant, and USD4 million grant from the GCF
- USD5.6 million grant from the Government of Italy

Additionally, an agreement has been signed under the EU-CIF for EUR12 million for investment and technical assistance grants. The CDB has also administered GBP4 million under the GeoSmart Initiative.

To support the countries in developing their GE projects, the Bank helps with project preparation, builds individual and institutional capacities, and conducts various studies.

Approach

The CDB promotes a PPP approach to developing GE in member countries. In this model, the government takes the lead in managing risks associated with the resource, and then selects a reputable private partner with technical expertise and financial strength to help advance the project.

The project would be financed through a joint venture between the government and the chosen GE developer, who would hold the majority stake and take on most of the risk. Any grant funding provided to the government through GeoSmart would count as part of the government's equity in the joint venture. It's beneficial to secure as much upfront grant support as possible during the early, riskier phases of the project, as this can delay the need for the private partner to invest equity, which is typically the most expensive type of funding.

For debt financing, it's advisable to maximize the use of concessional loans, which can lower the overall project cost and result in better pricing in the PPAs. GeoSmart requires that any concessional funding benefits are passed on to end-users through the PPA pricing. To ensure this, the GE project developer must clearly present a financial model that shows the project's costs with and without the concessional financing, highlighting how it impacts the overall financial situation.

Established in 2012, the CIF is a regional programme of the European Union that aims to support economic development, regional integration, poverty reduction, and environmental protection. It achieves these goals by mobilizing resources for key economic infrastructure projects and supporting the private sector.

CIF acts as a catalyst to attract funding for development projects by combining EU grants with financial resources from European and regional institutions, governments, and the private sector. Currently, CIF funds projects in essential sectors for achieving the Sustainable Development Goals (SDGs), including renewable energy, water and wastewater management, sustainable transportation, environmental protection, information and communication technology, health, education, and support for SMEs.

CIF has three main interconnected objectives:

- Improving social access and quality of infrastructure in the Caribbean countries.
- Increasing environmental protection, supporting climate change adaptation and mitigation and prevention and mitigation of natural disasters.
- Promoting equitable and sustainable socio-economic development through improvements to social service infrastructure and support to SMEs.

This programme allows the European Union to participate in projects that go beyond conventional development cooperation instruments, addressing the unique needs of countries in the region that require innovative approaches and tailored support for investment.

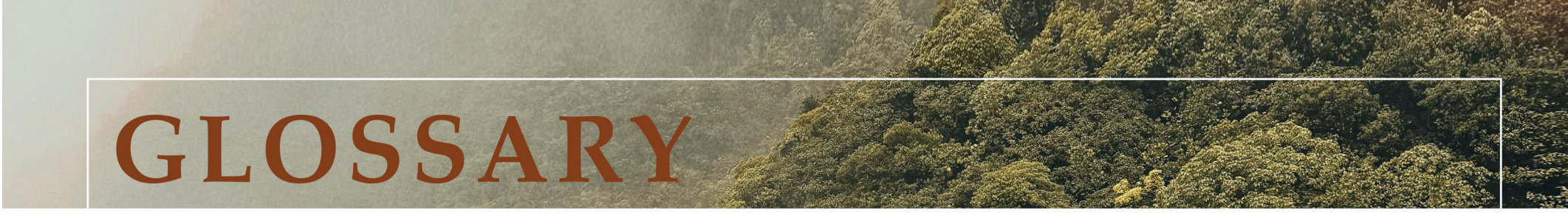
Inter-American Development Bank

The Inter-American Development Bank (IDB) is dedicated to improving lives in Latin America and the Caribbean. By providing financial and technical support, the IDB helps countries reduce poverty and inequality, enhance health and education, and develop infrastructure—all while aiming for sustainable and climate-friendly development. Established in 1959, the IDB is now the leading source of development financing in the region, offering loans, grants, and technical assistance, along with conducting extensive research.

The IDB focuses on achieving measurable results with a strong commitment to integrity, transparency, and accountability. Its development priorities include social inclusion and equality, productivity and innovation, and regional economic integration. Additionally, the IDB addresses important issues such as gender equality, climate change, environmental sustainability, and strengthening institutional capacity and the rule of law in its initiatives across Latin America and the Caribbean.

PROJECT FINANCING

The total estimated cost of the Technical Assistance (TA) Project is USD 3,131,253. The Caribbean Development Bank (CDB) will cover 89% of the project costs, amounting to USD 2,801,253, which will be used for hiring consultants, compensating Project Management Unit (PMU) staff, and hosting workshops. The OECS will provide counterpart funding for office accommodation, equipment, and administrative support for the PMU staff. CDB's contribution will come from a grant allocated from its Special Fund Resources (SFR), sourced from the European Union-Caribbean Investment Facility Geothermal Resource Mechanism (EU-CIF GRM) and the Inter-American Development Bank's Sustainable Energy Facility & the Green Climate Fund (IDB/SEF/GCF). These funds are drawn from existing resources and programmes.



GLOSSARY

AFD	French Development Agency
CDB	Caribbean Development Bank
CDB's BMCs	Caribbean Development Bank's Borrowing Member Countries
ESIA	Environment and Social Impact Assessment
EU	European Union
GCF	Green Climate Fund
GDP	Gross Domestic Product
GE	Geothermal Energy
IRENA	International Renewable Energy Agency
MOU	Memorandum of Understanding
MS	member states
MW	megawatt: 1,000,000 watts
OAS	Organization of American States
OECS	Organisation of Eastern Caribbean States
OECS GEOBUILD	OECS Geothermal Energy: Capacity Building for Utilisation, Investment and Local Development
PPA	Power Purchase Agreement
PPP	Public/Private Partnership
RE	Renewable Energy
RFP	Request for Proposal
RG	Reykjavik Geothermal
SDGs	Sustainable Development Goals
SEF	Sustainable Energy Facility
SME	small and medium-sized businesses
SPV	special purpose vehicle
UKFCDO	United Kingdom Foreign, Commonwealth and Development Office
UN/SIDS DOCK	United Nations/Small Island Developing States Dock
UNESCO	United Nations Educational, Scientific and Cultural Organization
WB	World Bank