Unlocking Geothermal Power

How the Eastern Caribbean could become a geothermal powerhouse

Christiaan Gischler
Nils Janson
Camila González
María Jimena Córdoba
Scarlett Santana

Energy Division
INE/ENE

TECHNICAL
NOTE Nº
IDB-TN-1256

June 2017

Unlocking Geothermal Power

How the Eastern Caribbean could become a geothermal powerhouse

Christiaan Gischler
Nils Janson
Camila González
María Jimena Córdoba
Scarlett Santana

June 2017

Inter-American Development Bank

Cataloging-in-Publication data provided by the
Inter-American Development Bank
Felipe Herrera Library

Unlocking geothermal power: how the Eastern Caribbean could become a geothermal powerhouse / Christiaan Gischler, Nils Janson, Camila González, Scarlett Santana, María Jimena Córdoba.
p. cm. — (IDB Technical Note ; 1256)
1. Geothermal resources-Caribbean Area. 2. Public-private sector cooperation-Caribbean Area. I. Gischler, Christiaan E. II. Janson, Nils. III. González, Camila. IV. Santana, Scarlett. V. Córdoba, María Jimena. VI. Inter-American Development Bank. Energy Division. VII. Series.
IDB-TN-1256

JEL code: Q40; Q43; Q48

Keywords: energy; renewable energy; sustainable; caribbean; eastern caribbean; geothermal; public-private partnership

http://www.iadb.org

ADFD	Abu Dhabi Fund for Development
AFD	French Development Agency
BRGM	French Geological and Mining Survey
°C	Degrees Celsius
CABEI	Central American Bank of Economic Integration
Capex	Capital expenditures
CARILEC	Caribbean Electric Utilities Services Corporation
CEL	Comisión Ejecutiva Hidroeléctrica del Río Lempa (El Salvador)
CFE	Comisión Federal de Electricidad (Mexico)
CFG	Compagnie Française pour le Développement de la Géothermie et des Energies Nouvelles
CNDC	Centro Nacional de Despacho de Carga (Nicaragua)
CNE	Consejo Nacional de Energía (El Salvador)
CSP	Concentrated solar power
DCF	Discounted cash flow
DOMLEC	Dominica Electricity Services Limited
EDF	Électricité de France
EIA	Environmental impact assessment
EIB	European Investment Bank
ENATREL	Empresa Nacional de Transmisión Eléctrica (Nicaragua)
ESA	Electricity Supply Act
GDC	Geothermal Development Company (Kenya)
GDP	Gross domestic product
GNP	Gross national product
GRDA	Geothermal Resources Development Account
GRENLEC	Grenada Electricity Services Limited
GW	Gigawatt
GWh	Gigawatt hour
HFO	Heavy fuel oil
ICE	Instituto Costarricense de Electricidad
IDB	Inter-American Development Bank
IPP	Independent power producer
IRENA	International Renewable Energy Agency
JICA	Japan International Cooperation Agency
kJ	Kilojoule
kV	Kilovolt
kWh	Kilowatt hour
LUCELEC	Saint Lucia Electricity Services
MW	Megawatt

NEVLEC	Nevis Electricity Company Limited
NIA	Nevis Island Administration
OECS	Organization of Eastern Caribbean States
OLADE	Organización Latinoamericana de Energía
PPA	Power purchase agreement
PPP	Public-private partnership
PURPA	Public Utilities Regulatory Policies Act (California)
PV	Present value
SIEPAC	Sistema de Interconexión Eléctrica de los Países de América Central
SKELEC	Saint Kitts Electricity Company
SPV	Special purpose vehicle
tCO_2	Tons of carbon dioxide
TWh	Terawatt hour
UNEC	United Network of the Eastern Caribbean
UNESCO	United Nations Educational, Scientific and Cultural Organization
US$	United States dollar
VINLEC	Saint Vincent Electricity Services Limited
West JEC	West Japan Engineering Consultants, Inc.

Table of contents

Tables

Figures

1 Introduction

This document presents strategy for developing geothermal potential through public-private partnerships (PPPs) in the Eastern Caribbean. The five countries of study are Dominica, Grenada, Saint Kitts and Nevis, Saint Lucia, and Saint Vincent and the Grenadines.

The objective of this study is to perform the required analyses to recommend a strategy for developing geothermal energy projects through PPPs in the Eastern Caribbean (the region), considering legal and financial issues. The analyses conducted for each country include the following:

- Assessing the policy and regulatory framework to propose necessary changes to enable geothermal development
- Assessing the status of geothermal development to build on the work that is already done
- Proposing the financial and legal structure of the geothermal projects
- Assessing the economic and financial viability of the geothermal projects

Based on these analyses, the authors propose a strategy for developing geothermal projects through PPPs and assess its expected benefits. Throughout this document, the authors are referred to as "we."

This document is divided into three parts. In Part A, we present the factors that enabled geothermal development in key geothermal markets, specifically Costa Rica, Nicaragua, El Salvador, the United States, Kenya, Iceland, and Guadeloupe. For each of these cases we present an overview of the electricity sector and the potential for developing geothermal resources, explain the most notable geothermal projects, and identify the key factors that enabled those projects to come about.

In Part B, we present the strategy to develop geothermal projects through PPPs in the five Eastern Caribbean countries with geothermal potential. We first present the barriers faced by governments in implementing geothermal projects and then present the proposed approach to address these barriers and deploy geothermal energy. Specifically, we explain how developing geothermal projects through PPPs and establishing a geothermal risk mitigation fund addresses the barriers to implementing geothermal projects. We also describe the major characteristics of the geothermal risk mitigation fund and an overview of the risks faced in implementing the PPP strategy. Finally, we present the economic and financial benefits that would result from implementing the geothermal projects. Part B is organized as follows:

- Barriers to Geothermal Development in the Eastern Caribbean States (Section 9.1)
- Proposed PPP Strategy for Geothermal Development (Section 9.2)
- Expected Economic and Financial Benefits of Implementing the Proposed Strategy (Section 9.3)

In Part C, we present the development of geothermal resources in the Eastern Caribbean countries. We start with an overview of geothermal development in the five countries of study, and then we present our analysis of each of the countries. For each country, we present the main characteristics of the electricity sector and the status of geothermal development. We then present our recommendations for the design of a PPP structure for the geothermal projects and the changes to the legal, institutional, and regulatory framework required to implement the proposed PPP structures. Finally, we assess the economic and financial viability of the geothermal projects.

Part A: Lessons Learned from International Experiences with Geothermal Development

In Part A, we present the main factors that enabled geothermal development in key geothermal markets. For each of these cases we present an overview of the electricity sector and the potential of the geothermal resources, explain the most notable geothermal projects, and identify the key factors that enabled geothermal development. We have structured Part A as follows:

- **Analysis of Geothermal Development for Each Country**—We analyze the experience of countries that have successfully developed their geothermal resources. We include countries in different regions of the world as well as Guadeloupe, because of the similarity of its electricity market's size and structure to that of the five islands in our study. We present our analysis by country in the following order: Costa Rica (Section 2), Nicaragua (Section 3), El Salvador (Section 4), United States of America (Section 5), Iceland (Section 6), Kenya (Section 7), and Guadeloupe (Section8). For each of the countries we include:

    - **An Overview of the Electricity Market** This section describes the electricity market, including information on the country's installed capacity, generation matrix, and demand. Reviewing each country's electricity sector allows us to understand the context in which the geothermal project was implemented, and the importance of geothermal generation in the country's electricity sector. The electricity sectors of the countries in our study vary significantly in terms of their size and the percentage of installed capacity that geothermal generation accounts for.

    - **A Review of the Geothermal Resource Potential**—This section presents the potential of the geothermal resources in terms of generation capacity. Based on this review, we can understand the size of the geothermal resource in the country and the potential for future development.

    - **An Assessment of Geothermal Projects**—This section presents an assessment of the geothermal projects that were implemented and future geothermal projects. Given the large size of most of the geothermal markets analyzed, we present examples of notable geothermal projects for all countries except for Guadeloupe. These examples provide insights into the varying approaches that can be adopted by countries in developing their geothermal resources. We focus on presenting the structure of the transaction used to develop the geothermal project, and describe the key actors involved and the project agreements signed.

    - **An Assessment of the Key Factors That Enabled Geothermal Development**—This section identifies the key factors that enabled the country to develop its geothermal resources. We find that for all countries, the public sector played an active role in enabling geothermal development.

2 Costa Rica

Costa Rica is located in the southern part of the Central American isthmus, between Nicaragua and Panama. Selected data for Costa Rica are provided in **Table 2.1**

Table 2.1 Selected Data for Costa Rica

Land Area (km^2)	Population (2015)	GDP US$ Billion (2014)	Installed Electric Power GW (2011)	Electricity Consumed GWh (2011)
51,060	4,814,144	70.97	2.944	8,792

Source: Central Intelligence Agency (US), https://www.cia.gov/library/publications/resources/the-world-factbook/geos/cs.html.

In the early 1970s, Costa Rica met its electricity needs using hydro and thermal energy sources (70 percent and 30 percent respectively).

The continuous rise in oil prices, especially during the 1973 crisis, motivated the authorities of the national utility company, the Costa Rican Institute of Electricity (Instituto Costarricense de Electricidad, or ICE), to study the possibility of using alternative energy sources for generating electricity, including geothermal energy[1].

Preliminary exploratory studies of the geothermal areas in the Cordillera Volcánica de Guanacaste (a volcanic chain in the northern region of Costa Rica) were performed in 1975. The first technical report (a set of prefeasibility studies) on the viability of exploiting geothermal resources for generating electricity in that area was completed in 1976[2]. The positive outcome of this work allowed ICE to apply for loans from the Inter-American Development Bank (IDB), in order to initiate the development of the Miravalles geothermal field.

In this section, we provide the following information about geothermal development in Costa Rica:

- Costa Rica and Its Electricity Sector (Section 2.1)
- Geothermal Resource Potential in Costa Rica (Section 2.2)
- Geothermal Projects in Costa Rica (Section 2.3)
- Future Geothermal Projects in Costa Rica (Section 2.4)

1. P. Moya, "Costa Rican Geothermal Energy Development 1994–2006" (workshop for Decision Makers on Geothermal Projects in Central America, organized by UNU-GTP and LaGeo, San Salvador, El Salvador, November 26–December 2, 2006).
2. Rogers Engineering Co., Inc. and GeothermEx, Inc., "Guanacaste Geothermal Project, Technical Prefeasibility Report" (prepared for Instituto Costarricense de Electricidad, 1976).

2.1 Costa Rica and Its Electricity Sector

Costa Rica has a Gross National Product (GNP) of US$45,105 million and a GNP per capita of US$9,596 (2012), which has increased an average of 4.9 percent during the last decade. Costa Rica has abundant natural renewable resources that could be used to produce energy (hydro, solar, wind, and geothermal power). In recent years, there have been important changes in the country's energy policies, as well as in the technologies. The government is planning to provide incentives to renewable energies for electricity generation. Comprehensive information on the electricity sector in Costa Rica is found in the document "The Electrical Sector in Costa Rica (Principal Characteristics)".[3] That information is summarized in the following paragraphs.

The main entities in the Costa Rican electrical sector are the Ministry of Environment and Energy (Ministerio de Ambiente y Energía, or MINAE) and ICE.

The prevalent governmental actor in the electricity sector is the ICE, who is in charge of drawing up the strategic national plans (medium and long term) for developing the electrical sector. One of its responsibilities is to guarantee the equilibrium between supply and demand of electricity.

The Expansion Plan for Electric Generation (2012–2024) was published in 2012; it presented a number of objectives for the following 12 years, including developing big hydro projects such as Reventazón, Diquís, Pacuare, and Savegre, and promoting the diversification of the generation sources. In addition, it noted that the Central American Electrical Interconnection System (SIEPAC, for its acronym in Spanish) is important in the electricity sector in the country. The Central American market would be developed very fast in the coming years, with the possibility of greater volumes of energy to be exchanged through SIEPAC.

Since 1990, Costa Rica has allowed power generation by private sector actors in a limited way. Law 7200 allows private generation to be up to 15 percent of the total generation of the National Electric System (Sistema Eléctrico Nacional, or SEN). With the current law, private generation could reach up to 30 percent of the total installed capacity, which represents about 883 MW (see Table 2.1).

Electricity distribution and commercialization in Costa Rica are done by eight public companies and there is no participation of private companies, besides ICE. Seven public companies carry out distribution and commercialization: Compañía Nacional de Fuerza y Luz, two municipal companies (Jasec and Esph), and four cooperatives.

3. U. Zúñiga, "El Sector Eléctrico en Costa Rica, Principales Características" (PDF document), www.nuca.ie.ufrj.br/gesel/pdf.V.SISEE/1.13.pdf.

2.2 Geothermal Resource Potential in Costa Rica

The current installed capacity in Costa Rica is 200 MW. **Table 2.2** presents the results of the first phase of reconnaissance studies carried out from 1987 to 1989.

Table 2.2 Identified Geothermal Areas in Costa Rica (1989)

Geothermal Zone (by volcano)	Single-Flash (est. MW)	Double-Flash (est. MW)
Miravalles	164	213
Rincón de la Vieja	137	177
Irazú/Turrialba	101	130
Tenorio	97	123
Platanar	97	122
Poas	90	116
Barva	85	109
Fortuna	61	77
Orosi/Cacao	33	41
Total	**865**	**1108**

Source: ICE, "Evaluación del Potencial Geotérmico de Costa Rica" (Instituto Costarricense de Electricidad, Internal Report, San José, November 1991), p. 70.

ICE was able to install 163 MW (single-flash) in Miravalles, very close to the original estimation of 164 MW in the reconnaissance study. There might be the possibility to increase the current capacity at Miravalles, but for the time being, ICE is trying to reach nominal capacity in all their plants.

The second priority to develop the geothermal resources in Costa Rica was the Rincón de la Vieja volcano. In this geothermal zone, ICE has already installed a binary plant that has a capacity of 35 MW in the Las Pailas geothermal field. Currently, ICE is developing a new geothermal project (Unit 2) that is intended to generate an additional 55 MW in the Las Pailas geothermal field, based on its prefeasibility study completed in 2012 by West Japan Engineering Consultants, Inc. (West JEC).

Besides the Las Pailas geothermal zone, ICE has identified another geothermal zone, Borinquen, in the area close to the Rincón de la Vieja volcano. There, ICE is planning to develop two more units to complete the geothermal development in the Rincón de la Vieja geothermal field. West JEC also finished the prefeasibility study for Units 1 and 2 in Borinquen in 2012.

2.3 Geothermal Projects in Costa Rica

Table 2.3 shows the current geothermal units in Costa Rica. Costa Rica currently has an installed capacity of 163 MW in Miravalles and 35 MW in Las Pailas, for a total of 198 MW of installed geothermal capacity.

ICE commissioned Unit 1 (55 MW) in March 1994, and continued the development of Unit 2 (another 55 MW) in the Miravalles geothermal field. ICE installed the first wellhead unit WHU-1 (5 MW), which entered into operation by the end of 1994.

Because some of the production wells were already drilled and the construction of Unit 2 was still underway, ICE and the Comisión Federal de Electricidad in Mexico (CFE) made an agreement to use wellhead units of CFE for generation in Miravalles. This agreement was in place while ICE built Unit 2. Once this unit was ready, the production wells used in WHU-2 and WHU-3 were dismantled and returned to CFE.

Table 2.3 Geothermal Plants in Costa Rica

Plant Name	Power (MW)	Owner	Start Year	Shut-Down
Miravalles				
Unit 1	55	ICE	3/1994	
WHU-1	5	ICE	11/1994	
WHU-2	5	CFE	9/1996	4/1999
WHU-3	5	CFE	2/1997	4/1998
Unit 2	55	ICE	8/1998	
Unit 3	29	ICE	3/2000	
Unit 5	19	ICE	1/2004	
Las Pailas				
Unit 1	35	ICE	7/2011	

While drilling the wells for Unit 2 in Miravalles, some extra wells were drilled to supply the corresponding steam to Unit 3, which began operations in March 2000. Unit 3 was a Build-Operate-Transfer project for 15 years; in March 2015, it became the property of ICE. Units 1, 2, and 3 are all single-flash units.

At the Miravalles geothermal field, ICE decided to install a binary plant in order to take advantage of some extra energy from the brine. By January 2004, the binary plant (Unit 5) was online, with a capacity of 19 MW.

At the Las Pailas geothermal field (Rincón de la Vieja volcano), ICE commissioned a binary plant (35 MW) in July of 2011, using its own financial resources as well as aid from the Central American Bank of Economic Integration (CABEI). Las Pailas Unit 1 belongs to CABEI, but after 12 years of monthly payments, ICE will get first opportunity to buy the geothermal unit.

FIGURE 2.1 Units 1 and 2 at Miravalles Geothermal Field

Source: Photo by Paul Moya Rojas.

FIGURE 2.2 Unit 1 at Las Pailas Geothermal Field

Source: Photo by Paul Moya Rojas.

2.4 Future Geothermal Projects in Costa Rica

The planned geothermal developments in Costa Rica are shown in **Table 2.4.**

Table 2.4 Future Geothermal Developments in Costa Rica

Plant Name	Power (MW)	Owner	Planned Start-Up
Las Pailas			
Unit 2	55	ICE	2019
Borinquen			
Unit 1	55	ICE	2023
Unit 2	55	ICE	2024

Source: ICE, "Evaluación del Potencial Geotérmico de Costa Rica" (Instituto Costarricense de Electricidad, Internal Report, San José, November 1991), p. 70.

ICE aims to continue the development in Pailas (Unit 2) and Borinquen (Units 1 and 2). Law 9254, published in August 2014, will support these developments. Japan International Cooperation Agency (JICA) and the European Investment Bank (EIB) will provide a loan to build these three units.

3 Nicaragua

Nicaragua is located in the central part of the Central American isthmus, bordered by Honduras to the north and Costa Rica to the south. Selected data for Nicaragua are provided in **Table 3.1.**

Table 3.1 Selected Data for Nicaragua

Land Area (km^2)	Population (2005)	GDP US$ Billion (2014)	Installed Electric Power GW (2011)	Electricity Consumed GWh (2011)
119,990	5,907,881	29.47	1.275	2,777

Source: Central Intelligence Agency (US), https://www.cia.gov/library/publications/resources/the-world-factbook/geos/nu.html.

Nicaragua has highly active geothermal resources, mainly due to the volcanic mountain chain that runs parallel to its Pacific coast. This chain is composed of 16 active volcanoes, lagoons, residual volcanic structures, volcanic calderas, and many areas with hydrothermal activity. They indicate the presence of magmatic bodies with high geothermal potential[4].

In this section, we provide the following information about geothermal development in Nicaragua:

- Nicaragua and Its Electricity Sector (Section 3.1)
- Geothermal Resource Potential in Nicaragua (Section 3.2)
- Geothermal Projects in Nicaragua (Section 3.3)
- Future Geothermal Projects in Nicaragua (Section 3.4)

4. M. González, "Estado Actual del Desarrollo de los Recursos Geotérmicos en Nicaragua" (Instituto Italo-Latino Americano [IILA], San Salvador, Pisa, San José, April 2009–May 2010).

3.1 Nicaragua and Its Electricity Sector

Comprehensive information on the electricity sector in Nicaragua is found in the government document The Electricity Market of Nicaragua *(El Mercado Eléctrico de Nicaragua).*[5] That information is summarized in the following paragraphs. The main entities of the electricity market in Nicaragua are listed in **Table 3.2.**

The electricity sector in Nicaragua is composed of a wholesale electricity market, where there are contracts in the regular electricity market, and the spot electricity market. Currently there are about 17 energy producers (companies) and 27 power plants that are part of the Interconnected National System (Sistema Interconectado Nacional, or SIN). The majority of these plants use fossil fuels, and some power plants produce renewable energy such as hydro, geothermal, and wind.

Transmission from the power plants to the distribution centers is done by a public company, Empresa Nacional de Transmisión Eléctrica (ENATREL), which is in charge of the operation and maintenance of the National Transmission System. This system has more than 2,500km in transmission lines and about 77 substations distributed around the country. In June 2000, ENATREL obtained the concession for 30 more years.

The National Center of Dispatch (Centro Nacional de Despacho de Carga, or CNDC), under ENATREL, is in charge of:

- The commercial administration of the national wholesale market from Nicaragua, including the spot market transactions in the regional electric market,
- The programming, dispatch, and supervision of the operation of the SIN and the international connections, and
- Authorizing producers and high-demand consumers according to applicable laws and regulations.

5.Government of Nicaragua, "El Mercado Eléctrico de Nicaragua," http://www.mem.gob.ni/media/file/ELECTRICIDAD/Descripcion%20General%20del%20MEN%20Enero2013.pdf.

Table 3.2 Entities in the Electricity Market in Nicaragua

Entities	Web Adress
Ministerio de Energía y Minas (MEM)	http://www.mem.gob.ni
Instituto Nicaragüense de Energía (INE)	http://www.ine.gob.ni
Centro Nacional de Despacho de Carga (CNDC)	http://www.cndc.org.ni
Comisión Regional de Interconexión Eléctrica (CRIE)	http://www.crie.org.gt
Empresa Propietaria de la Red (EPR), Línea SIEPAC Primer Sistema de Transmisión Regional	http://www.eprsiepac.com
Consejo de Electrificación de América Central (CEAC)	http://www.ceaconline.org
Consejo de Ministros de Energía de los Países del Sistema de Integración Centroamericana (SICA)	http://www.sica.int
Organización Latinoamericana de Energía (OLADE)	http://www.olade.org

Source: Government of Nicaragua, "El Mercado Eléctrico de Nicaragua," http://www.mem.gob.ni/media/file/ELECTRICIDAD/Descripcion%20General%20del%20MEN%20Enero2013.pdf.

Companies with distribution concessions on specific areas are in charge of distribution in Nicaragua. These companies are divided as follows:

- The companies with big concessions areas in the national territory:
  - DISNORTE (Distribuidora de Electricidad del Norte, S.A.)
  - DISSUR (Distribuidora de Electricidad del Sur, S.A.)
- Public companies that have a concession and their own generation, or purchase electricity under contract:
  - Purchase of energy in the national wholesale market
  - Purchase electricity for DISNORTE and/or DISSUR
  - Own generation and distribution of isolated systems
- Small private concessions:
  - Zelaya Luz, S.A.
  - Empresa Hidroeléctrica Bilampí Musún S.A. (HIBIMUSUN S.A.)
  - Empresa Hidroeléctrica Salto Mollejones Wapi S.A. (HISMOW S.A.)
  - Empresa Hidroeléctrica Río Bravo Puerto Viejo S.A.
  - Asociación de Luz Eléctrica La Pita Central (ASOLPIC)
  - Asociación Pro-Desarrollo del Servicio Eléctrico Bocay (APRODELBO)
  - Asociación de Trabajadores de Desarrollo Rural Benjamín Linder (ATDER_BL)

An international electricity market has been developed in order to solve occasional deficits in any of the Central American countries. To increase the capacity to transmit electricity in the Central American market, the SIEPAC was built.

3.2 Geothermal Resource Potential in Nicaragua

The current installed capacity in Nicaragua is 150 MW. Numerous geothermal areas have been identified in Nicaragua. The geothermal areas identified in an OLADE reconnaissance study in 1980, as well as in the Nicaraguan Master Plan in 2001, are shown in **Table 3.3**.

Table 3.3 Identified Geothermal Areas in Nicaragua

Geothermal Area	Est. Potential (MW)	Completed Study
El Hoyo–Monte–Galán	159	Prefeasibility
Managua–Chiltepe	111	Prefeasibility
Casita–San Cristóbal	225	Reconnaissance
Volcán Cosigüina	106	Reconnaissance
Volcán Telica–El Ñajo	78	Reconnaissance
Tipitapa	9	Reconnaissance
Caldera de Masaya	99	Reconnaissance
Caldera de Apoyo	153	Reconnaissance
Volcán Mombacho	111	Reconnaissance
Isla Ometepe	146	Reconnaissance

Source: M. González, "Estado Actual del Desarrollo de los Recursos Geotérmicos en Nicaragua" (Instituto Italo-Latino Americano [IILA], San Salvador, Pisa, San José, April 2009–May 2010).

Although reconnaissance studies have been conducted in each of these areas, prefeasibility and feasibility studies need to be completed in order to verify the real potential in these geothermal zones.

3.3 Geothermal Projects in Nicaragua

Table 3.4 shows the geothermal units installed in Nicaragua. The installed capacity is 78 MW (in Momotombo) and 72 MW (in San Jacinto–Tizate), for a total of 150 MW.

The first geothermal unit (35 MW, single-flash) in the Momotombo geothermal field was commissioned in 1983. Six years later in 1989, the second unit (35 MW, single-flash) came into operation. In late 2002, two binary units (4 MW each) were installed in the Momotombo geothermal field. The San Jacinto–Tizate geothermal field initially had two wellhead units installed (2005–2011) to prove the existence of a commercially exploitable geothermal reservoir, while two single-flash units of 36 MW were built. The first unit (36 MW) began operations in 2012, while the second came online a year later.

Table 3.4 Geothermal Plants in Operation in Nicaragua

Plant Name	Power (MW)	Concession Holder	Start Year
Momotombo			
Unit 1	35	Momotombo Power Company, until 2024	1983
Unit 2	35	Momotombo Power Company, until 2024	1989
Binary Unit 1	4	Momotombo Power Company, until 2024	2002
Binary Unit 2	4	Momotombo Power Company, until 2024	2002
San Jacinto–Tizate			
WHU-1	5	Polaris Energy Nicaragua, S.A. (PENSA) (Ram Power Corporation)	2005
WHU-2	5	Polaris Energy Nicaragua, S.A. (PENSA) (Ram Power Corporation)	2005
Unit 1	36	Polaris Energy Nicaragua, S.A. (PENSA) (Ram Power Corporation)	2012
Unit 2	36	Polaris Energy Nicaragua, S.A. (PENSA) (Ram Power Corporation)	2013

Source: M. González, "Estado Actual del Desarrollo de los Recursos Geotérmicos en Nicaragua" (Instituto Italo-Latino Americano [IILA], San Salvador, Pisa, San José, April 2009–May 2010).

The Government of Nicaragua decided some years ago to allow private companies to continue the development of the country's geothermal resources. This is evident in the geothermal concessions that the government has approved for two developed geothermal fields (Momotombo and San Jacinto–Tizate).

Currently, the company that has the concession in the Momotombo geothermal field is Momotombo Power. Before this company, Ormat Technologies held the concession for over five years.

The company that has the concession for the San Jacinto–Tizate geothermal field is Polaris Energy Nicaragua, S.A. (PENSA), a subsidiary of Ram Power Corporation.

FIGURE 3.1 San Jacinto–Tizate Geothermal Plant

3.4 Future Geothermal Projects in Nicaragua

Three more concessions have been awarded in other geothermal areas; they are summarized in **Table 3.5.**

Two commercial wells in El Hoyo–Monte Galán and one slim-hole in Managua–Chiltepe geothermal areas were drilled[6], but these wells did not identify the geothermal anomaly because permeability was not found. Geotérmica Nicaragüense (GEONICA) was a consortium formed by ENEL Italy (60 percent) and LaGeo El Salvador (40 percent). It was liquidated following the settlement of a dispute between ENEL and Comisión Ejecutiva Hidroeléctrica del Río Lempa (CEL). GEONICA renounced both concessions in 2011, and Managua–Chiltepe was subsequently awarded to Alba Geotermia, an ALBA Group company.

Table 3.5 New Geothermal Concessions in Nicaragua

Geothermal Area	Concession Holder	Est. Potential (MW)
El Hoyo–Monte–Galán	GEONICA	159
Managua–Chiltepe	GEONICA	111
Casita–San Cristóbal	Consorcio Cerro Colorado Power	125

Source: M. González, "Estado Actual del Desarrollo de los Recursos Geotérmicos en Nicaragua" (Instituto Italo-Latino Americano [IILA], San Salvador, Pisa, San José, April 2009–May 2010).

In Casita–San Cristóbal, Cerro Colorado Power drilled a slim-hole to a depth of 850m, and found the steam cap of a geothermal system. This confirmed the commercial-size potential for a single-flash development in the field.

Besides the development that has been taking place in the concession areas (such as the drilling of geothermal wells in both commercial and slim-hole formats), the Nicaraguan government has recently accepted a new geothermal study from the IDB/Nordic Development Fund (NDF) in Cosigüina and from JICA in the Caldera de Apoyo and Volcán Mombacho geothermal areas. These studies will provide a better understanding of the potential of those geothermal areas. The study on the Cosigüina volcano and the study on Caldera de Apoyo and Mombacho (financed by JICA) have already been completed.

6. M. González, "Estado Actual del Desarrollo de los Recursos Geotérmicos en Nicaragua" (Instituto Italo-Latino Americano [IILA], San Salvador, Pisa, San José, April 2009–May 2010).

4 El Salvador

El Salvador is centrally located in the Central American isthmus, bordering Guatemala and Honduras. Selected data for El Salvador are provided in **Table 4.1.**

Table 4.1 Selected Data for El Salvador

Land Area (km^2)	Population (2015)	GDP US$ Billion (2014)	Installed Electric Power GW (2011)	Electricity Consumed GWh (2011)
20,721	6,141,350	50.94	1.507	5,412

Source: Central Intelligence Agency (US), https://www.cia.gov/library/publications/resources/-the-world-factbook/geos/es.html.

The current installed capacity in El Salvador is 204 MW. Initially, geothermal development in El Salvador was done by a public institution, CEL, which sought soft loans for exploration work and later was able to install the majority of the units in Ahuachapán and Berlin geothermal fields. CEL carried out all the geothermal development until 1999. At that point in time, the government of El Salvador created LaGeo, a company with mixed ownership, to take charge of the developments.

In this section, we provide the following information about geothermal development in El Salvador:

- El Salvador and Its Electricity Sector (Section 4.1)
- Geothermal Resource Potential in El Salvador (Section 4.2)
- Geothermal Projects in El Salvador (Section 4.3)
- Future Geothermal Projects in El Salvador (Section 4.4)

4.1 El Salvador and Its Electricity Sector

Comprehensive information on the latest changes in the electricity sector in El Salvador is in a publication from the National Energy Council (Consejo Nacional de Energía, or CNE)[7]. That information is summarized in the following paragraphs.

In the mid-1990s, El Salvador initiated a process to reform the electric sector. The first step of the reform was to create the regulatory framework and institutions to approve the General Electricity Law and the Law for the Creation of the General Superintendence of Electricity and Telecommunications (SIGET, for its acronym in Spanish). The General Electricity Law (Decree No. 843) and its legislation were promulgated in 1996 and 1997 by the Direction of Electric Energy (Dirección de Energía Eléctrica, or DEE)—an entity that belongs to the Ministry of Economy (MINEC).

The next step in the reform of the electricity sector was to sell the government thermal plants and distribution companies, through CEL.

Together with the new legal framework, a tariff structure was established, noting that the electricity price should be set based on market principles. The price earned by the distribution companies took into account the offers of electricity prices in the wholesale market, the costs of service to the clients, and the charges for the use of the grid. The owners of the grid were responsible for grid maintenance, for operating efficiently, and for ensuring quality of service to final users in their geographical areas of operation.

In 1998, the Transmission Company of El Salvador (Empresa Transmisora de El Salvador, or ETESAL) and the Unit of Transactions (UT) were created. UT is responsible for operating and managing the electricity system.

Between 1999 and 2010, there were additional reforms in order to improve the electricity market and achieve better transparency as well as to open the market to long-term contracts. Between 2003 and 2008, the General Law and its regulation were amended. In addition, two laws were approved: the law that establishes the CNE as the rector entity of the sector, and the Law of Fiscal Incentives for Non-Conventional Renewable Energy. The Rules of the Operation of the Wholesale Market Based on Production Costs (Reglamento de Operación del Mercado Mayorista Basado en Costos de Producción, or ROBCP) were approved in 2009 and implemented in 2011, establishing a new scheme for the wholesale market.

7. Consejo Nacional de Energía, “Mercado Eléctrico,” http://www.cne.gob.sv/index.php?option=com_content&view=article&id=277&Itemid=119.

4.2 Geothermal Resource Potential in El Salvador

The current installed capacity in El Salvador is 204 MW. The main geothermal areas of high-enthalpy in El Salvador—that do not have power plants installed—are shown in **Table 4.2.** In all these areas some reconnaissance studies have been carried out, but more geothermal studies (prefeasibility and feasibility studies) are needed to verify if the estimated potentials are correct.

Table 4.2 Identified High-Enthalpy Geothermal Areas in El Salvador That Do Not Have Power Plants

Geothermal Zone	Est. Potential (MW)
Chinameca	76
San Vicente	117
Caluco	15
Coatepeque	70
Chambala	26
Chilanguera	11
Olomeca	11
Conchagua	13

Source: T. Campos, “The Geothermal Resources of El Salvador: Characteristics and Preliminary Assessment” (United Nations Workshop on the Development and Exploitation of Geothermal Energy in Developing Countries, Pisa, Italy, 1987).

4.3 Geothermal Projects in El Salvador

Table 4.3 shows geothermal plants installed in El Salvador. The current installed capacity is 95 MW in Ahuachapán and 109.4 MW in Berlin, for a total of 204.4 MW in El Salvador. At Ahuachapán, Units 1 and 2 are single-flash and Unit 3 is double-flash[8].

Table 4.3 Geothermal Plants in El Salvador

Plant Name	Power (MW)	Owner	Start Year	Shut-Down
Ahuachapán				
Unit 1	30	LaGeo	1975	
Unit 2	30	LaGeo	1976	
Unit 3	35	LaGeo	1981	
Berlín				
WHU-1	5	LaGeo	1992	1999
WHU-2	5	LaGeo	1993	1999
Unit 1	28	LaGeo	1999	
Unit 2	28	LaGeo	1999	
Unit 3	44.2	LaGeo	2007	
Unit 4	9.2	LaGeo	2007-08	

Source: T. Campos, "The Geothermal Resources of El Salvador: Characteristics and Preliminary Assessment" (United Nations Workshop on the Development and Exploitation of Geothermal Energy in Developing Countries, Pisa, Italy, 1987).

8. F. Montalvo and J. Guidos, "Estado Actual y Desarrollo de los Recursos Geotérmicos en Centroamérica" (Instituto Italo-Latino Americano [IILA], San Salvador, Pisa, San José, April 2009–May 2010).

FIGURE 4.1 **Ahuachapán Geothermal Units**

Source: LaGeo El Salvador, available at: www.lageo.com.sv

In the Berlin field, two back-pressure wellhead units were installed and generated electricity for some years while the field was being developed. Later, it was decided to change wellhead units to single-flash units and increase the production capacity of the field. The wellhead units were dismantled and two 28 MW units were activated in 1999 with another 44.2 MW unit activated in 2007. Also in 2007, a binary plant of 9.2 MW started production at Berlin.

FIGURE 4.2 **Berlin Geothermal Units**

Source: LaGeo El Salvador, available at: www.lageo.com.sv

4.4 Future Geothermal Projects in El Salvador

LaGeo already envisions improvements to power generation in each of the current fields in operation. In Ahuachapán, plans are to increase the capacity of Unit 3 by 5 MW and in Berlin to install a new unit of 28 MW and a binary plant of 5.7 MW.[9]

In the past, SIGET was the institution responsible for electricity regulation and in charge of awarding geothermal concessions within the country. However, the legislation changed in 2013, and currently the National Congress of El Salvador awards the concessions.

LaGeo Branch San Vicente 7 Inc. is the owner of two awarded geothermal concessions, San Vicente and Chinameca. Three exploratory wells were drilled in San Vicente during 2004 and 2007, with no significant results (temperatures between 150 and 250°C). Between 2012 and 2013, two more wells were drilled, and testing found that one of them had the capability to produce 7 MW. This result encouraged continuing drilling activity to install a unit of about 30 MW to 40 MW. On the other hand, in Chinameca, two exploratory wells were drilled during 2009 and 2010, one of which could produce 7 MW. Recently a new well was drilled, but even though the temperature found was around 240°C, the permeability was poor.[10]

5 United States

The United States is the country with the highest installed capacity for geothermal generation. The installed capacity was 3,442 MW in 2013, which only makes up a small percentage of total generation in the country. California hosts 2,703 MW of that installed capacity, which makes California's installed capacity higher than the installed capacity of the countries with the highest installed geothermal generation in the world: Philippines (1,904 MW), Indonesia (1,333 MW), and Mexico (1,005 MW).[11]

In California, the development of geothermal resources has been driven by California's high-quality geothermal resources, government policies, and state programs. In particular, the development of geothermal plants in California was driven by the Public Utilities Regulatory Policies Act (PURPA) and the Geothermal Resources Development Account (GRDA). PURPA, passed by the federal government in 1978, required utilities to purchase renewable power at avoided costs. It's estimated that this led to the development of 600 MW of geothermal capacity in California.[12] GRDA is a state-funded research and development program for geothermal in California and has funded at least four geothermal projects.[13]

In this section, we provide the following information about geothermal development in the United States, particularly in California:

- United States and Its Electricity Sector (Section 5.1)
- Geothermal Resource Potential in the United States (Section 5.2)
- Geothermal Projects in the United States (Section 5.3)
- Key Factors That Enabled Geothermal Development in the United States (Section 5.4)

9. J. Burgos, F. Montalvo, and H. Gutiérrez, "El Salvador Country Update" (Proceedings of the World Geothermal Congress 2015, Melbourne, Australia, April 19–25, 2015).

10. Ibid.

11. Geothermal Energy Association, "2014 Annual U.S. & Global Geothermal Power Production Report" (April 2014).

12. Elizabeth Doris, Claire Kreycik, and Katherine Young, "Policy Overview and Options for Maximizing the Role of Policy in Geothermal Electricity Development" (National Renewable Energy Laboratory, Technical Report NREL/TP-6A2-46653, September 2009), http://www1.eere.energy.gov/geothermal/pdfs/policy_overview.pdf.

13. Ibid.

5.1 United States and Its Electricity Sector

The United States is a large, high-income country located in North America. It had a population of approximately 319 million and a GDP per capita of US$53,143 in 2013.[14] In the United States, the summer peak demand was 768 GW in 2012 and the installed capacity was 1,501GW in 2011. The main sources of generation were natural gas (39 percent), coal (30 percent), nuclear (10 percent), and conventional hydro (8 percent).[15] Installed capacity for geothermal was 3,102 MW in 2011 or 0.3 percent of installed capacity.[16] In the United States, the states with the most geothermal generation and planned geothermal generation are California, Nevada, and Utah.

California is a state located on the West Coast of the United States. It had a population of 38.3 million in 2013 and is the state with the largest population in the United States.[17] In California, the GDP per capita was approximately US$46,029 in 2012.[18] In 2013, California had an installed capacity of 78,133 MW. The main sources of energy in California are natural gas (62 percent), large hydro (16 percent), and wind (8 percent). Installed capacity for geothermal generation is 2,703 MW or 3 percent of the installed capacity. In 2011, net peak demand in California was 60,310 MW.[19]

5.2 Geothermal Resource Potential in the United States

The United States has large amounts of undeveloped geothermal potential. A 2008 study by the U.S. Geological Survey estimates that the United States has a geothermal potential of:

- 3,675 MW (95 percent probability) to 16,457 MW (5 percent probability) in areas with systems that have been identified[20]
- 7,917 MW (95 percent probability) to 73,286 MW (5 percent probability) in areas that have undiscovered geothermal systems[21]

The states with the most promising geothermal potential were located on the West Coast. California has 25 known geothermal resources areas and a geothermal potential that is estimated to be between 3,644 MW and 4,732 MW.[22] California was the leader in planned capacity additions, developing resources, and the current nameplate capacity. This is because, on average, the geothermal resources in California are of high temperature, quality, and volume.[23]

14. World Bank, "World Development Indicators," accessed May 19, 2016, http://data.worldbank.org/indicator/SP.POP.TOTL; CIA, "The World Factbook: United States," accessed November 21, 2014, https://www.cia.gov/library/publications/the-world-factbook/geos/us.html. GDP per capita is in current US$.
15. U.S. Energy Information Administration, "Electricity Generating Capacity," accessed November 21, 2014, http://www.eia.gov/electricity/capacity/.
16. Geothermal Energy Association, "Annual U.S. Geothermal Power Production and Development Report: April 2011," accessed November 21, 2014, http://geo-energy.org/pdf/reports/April2011AnnualUSGeothermalPowerProductionandDevelopmentReport.pdf.
17. United States Census Bureau, "State & Country QuickFacts: California," accessed November 21, 2014, http://quickfacts.census.gov/qfd/states/06000.html.
18. Bureau of Economic Analysis, "Real per Capita Gross Domestic Product by State," accessed November 21, 2014, http://bea.gov/itable/iTable.cfm?ReqID=70&step=1#reqid=70&step=1&isuri=1. GDP per capita is in Chained 2005 Dollars.
19 The California Energy Commission, "Energy Almanac," accessed November 21, 2014, http://energyalmanac.ca.gov/electricity/electric_generation_capacity.html.
20. Identified systems are where the resource is currently generating electricity, where the resource is confirmed (there is a successful commercial flow test of a production well) or potential (there are reliable estimates of temperature and flow, but now successful wells have been drilled).
21. Geothermal Energy Association, "Geothermal Basics: Potential Use," accessed November 21, 2014, http://geo-energy.org/PotentialUse.aspx. This assessment was made by studying 13 states and by mapping potential via regression analysis.
22. California Energy Commission, "Geothermal Energy in California," accessed November 21, 2014, http://www.energy.ca.gov/geothermal/background.html; Benjamin Matek and Karl Gawell, "Report on the State of Geothermal Energy in California," February 2014, http://geo-energy.org/events/California%20Status%20Report%20February%202014%20Final.pdf.
23. Geothermal Energy Association, "2014 Annual U.S. & Global Geothermal Power Production Report" (April 2014).

5.3 Geothermal Projects in the United States

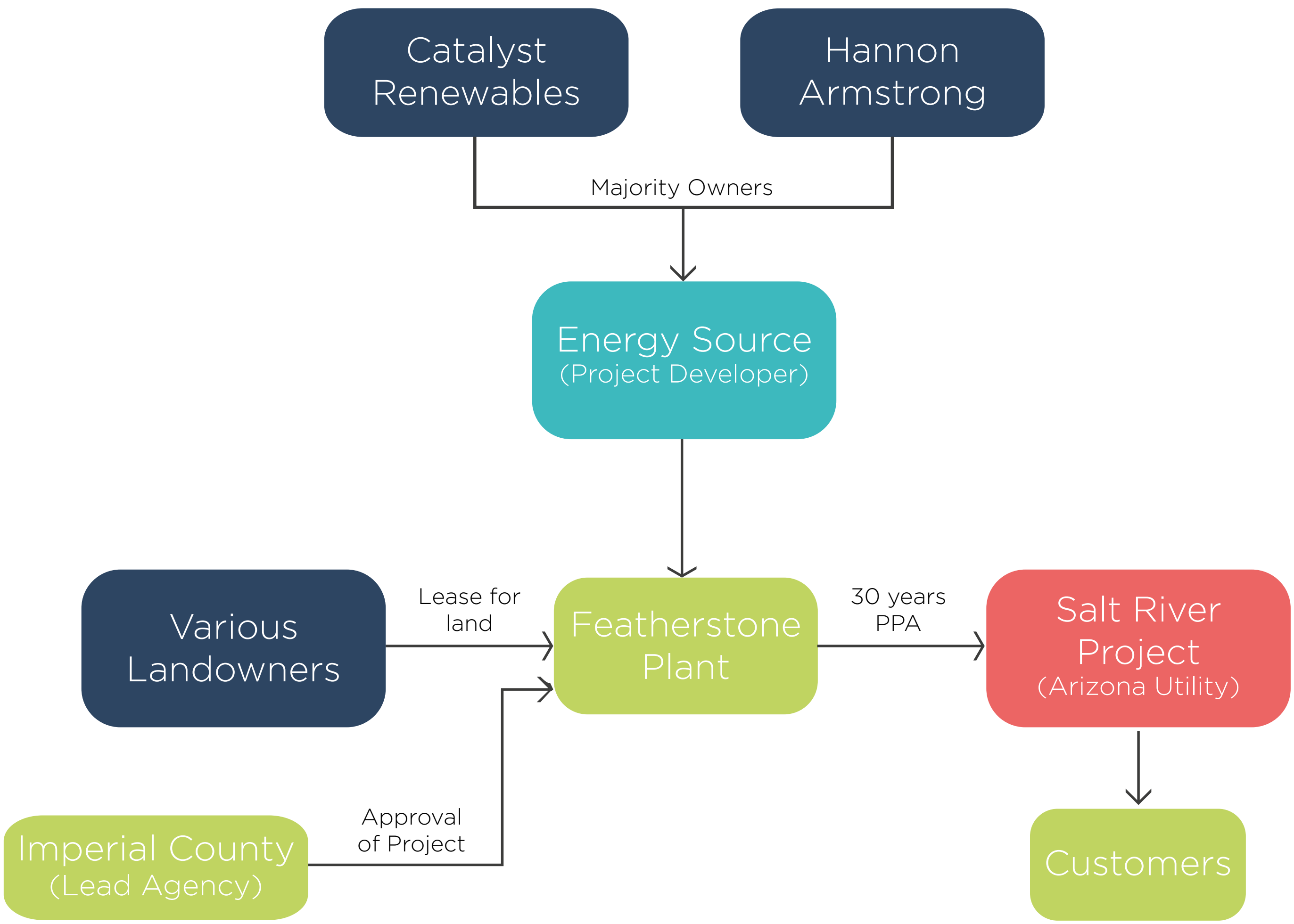
One of the most notable geothermal projects developed in the United States is the John L. Featherstone Plant located in California. This plant is notable because of how it was financed: 75 percent of the plant was financed with debt. The plant was named the Best Geothermal Project of 2012 by *Power Engineering and Renewable Energy World* magazine.[24] It also won the Environmental Stewardship Award from the Environmental and Energy Study Institute (EESI) and the Geothermal Energy Association (GEA).[25]

The Featherstone Plant is a 49 MW power plant located in Imperial Country, California. It generates electricity from the Salton Sea region, which is one of the largest and highest-temperature geothermal resources in North America.[26] The Salton Sea region is expected to have a geothermal potential of 1,400 MW.[27] It has geothermal fluid that is corrosive and contains a significant amount of minerals.[28] The Featherstone Plant produces electricity using three production wells, which are each 7,500ft deep, four injection wells, and geothermal reservoirs.[29] The plant has two of the largest production wells in the world.[30] The project was developed in 21 months, beginning construction in May 2010 and beginning operation in March 2012.[31] It was developed using well-established technology, including a 50 MW Fuji turbine and a crystalliser reactor clarifier process to remove solids from the brine.[32] **Figure 5.1** shows how the project was structured.

---

24. AECOM, "John L. Featherstone Plant Geothermal," accessed March 16, 2016, http://www.aecom.com/projects/john-l-featherstone-plant-geothermal-project/.
25. Power-technology.com, "John L Featherstone (Hudson Ranch I) Geothermal Power Plant, California, United States of America," accessed November 21, 2014, http://www.power-technology.com/projects/john-l-featherstone-hudson-geothermal-power-plant-california/.
26. AECOM, "John L. Featherstone Plant Geothermal," accessed March 16, 2016, http://www.aecom.com/projects/john-l-featherstone-plant-geothermal-project/.
27. Power-technology.com, "John L Featherstone (Hudson Ranch I) Geothermal Power Plant, California, United States of America," accessed November 21, 2014, http://www.power-technology.com/projects/john-l-featherstone-hudson-geothermal-power-plant-california/.
28. Leidos, "Geothermal Power Generating Facility," accessed November 20, 2014, https://www.leidos.com/project/geothermal-power-generating-facility-0.
29. Power-technology.com, "John L Featherstone (Hudson Ranch I) Geothermal Power Plant, California, United States of America," accessed November 21, 2014, http://www.power-technology.com/projects/john-l-featherstone-hudson-geothermal-power-plant-california/.
30. Leidos, "Geothermal Power Generating Facility," accessed November 20, 2014, https://www.leidos.com/project/geothermal-power-generating-facility-0.
31. AECOM, "John L. Featherstone Plant Geothermal," accessed March 16, 2016, http://www.aecom.com/projects/john-l-featherstone-plant-geothermal-project/; Travis Lowder, "Drilling for Dollars: Notable Developments in Geothermal Finance," *National Renewable Energy Laboratory–Renewable Energy Project Finance*, December 17, 2012, https://financere.nrel.gov/finance/content/drilling-dollars-notable-developments-geothermal-finance.
32. Power-technology.com, "John L Featherstone (Hudson Ranch I) Geothermal Power Plant, California, United States of America," accessed November 21, 2014, http://www.power-technology.com/projects/john-l-featherstone-hudson-geothermal-power-plant-california/.

FIGURE 5.1 Structure of the Featherstone Plant in California



Sources: Larry Grogan, "The Hudson Ranch I Geothermal Project," Geothermal Resources Council Bulletin 40, no. 3 (May/June 2011): 37–39, accessed November 21, 2014, http://www.hannonarmstrong.com/press/GRC_HRI_Article_-Jun2011.pdf; Blaydes & Associates and the California Energy Commission, "Geothermal Permitting Guide" (April 2007).

The Featherstone Plant was developed by EnergySource, whose majority shareholders are Catalyst Renewables and Hannon Armstrong.[33] In addition to EnergySource, there are several key bodies that have played a role in the successful development of the plant:

- **Salt River Project—**The Salt River Project is an Arizona utility that purchases electricity from the Featherstone Plant under a 30-year power purchase agreement (PPA).[34]
- **Various landowners—**The Featherstone Plant signed leases for land use with various landowners in the Salton Sea region, including the Hudson family.[35]
- **Imperial County—**Imperial County is the lead agency for the Featherstone Plant. The lead agency is the body that has the principal responsibility for approving the project. In California, the lead agency can vary based on the location and ownership of lands.[36]
- **Performance Mechanical Company—**The Performance Mechanical Company was the general contractor for the project. It provided construction management services, which also included completing site development, constructing a new county road, and earth work for the 60-acre site.[37]
- **Banks and other lenders—**75 percent of the cost of the Featherstone Plant was financed with debt. Banks and other lenders provided funding for exploration, for the construction of the plant, and for the operation of the plant. The role of the lenders and the different lenders involved are described in more detail below.
- **Companies who provided technical services and project monitoring—**Numerous companies were hired to provide technical services for the project and project monitoring. Among others, they include:
  - **Landmark Consultants** provided the geotechnical investigation, field, and laboratory testing services for the project.[38]
  - **Simbol Minerals** provided the mineral extraction services. Simbol Minerals is also providing the extraction services for Hudson Ranch II.[39]
  - **URS** (now part of AECOM) was hired to monitor the construction of the plant.[40]
  - **Leidos** provided due diligence and independent engineering services throughout the project's development, and is providing these services for the rest of the project's lifecycle.[41]

33.Travis Lowder, "Drilling for Dollars: Notable Developments in Geothermal Finance," *National Renewable Energy Laboratory–Renewable Energy Project Finance*, December 17, 2012, https://financere.nrel.gov/finance/content/drilling-dollars-notable-developments-geothermal-finance.

34. Power-technology.com, "John L Featherstone (Hudson Ranch I) Geothermal Power Plant, California, United States of America," accessed November 21, 2014, http://www.power-technology.com/projects/john-l-featherstone-hudson-geothermal-power-plant-california/.

35. Larry Grogan, "The Hudson Ranch I Geothermal Project," *Geothermal Resources Council Bulletin* 40, no. 3 (May/June 2011): 37–39, accessed November 21, 2014, http://www.hannonarmstrong.com/press/GRC_HRI_Article_Jun2011.pdf

36. Blaydes & Associates and the California Energy Commission, "Geothermal Permitting Guide," April 2007; Larry Grogan, "The Hudson Ranch I Geothermal Project," *Geothermal Resources Council Bulletin* 40, no. 3 (May/June 2011): 37–39, accessed November 21, 2014, http://www.hannonarmstrong.com/press/GRC_HRI_Article_Jun2011.pdf.

37. Power-technology.com, "John L Featherstone (Hudson Ranch I) Geothermal Power Plant, California, United States of America," accessed November 21, 2014, http://www.power-technology.com/projects/john-l-featherstone-hudson-geothermal-power-plant-california/.

38. Ibid.

39. Ibid.

40. AECOM, "John L. Featherstone Plant Geothermal," accessed March 16, 2016, http://www.aecom.com/projects/john-l-featherstone-plant-geothermal-project/.

41. Leidos, "Geothermal Power Generating Facility," accessed November 20, 2014, https://www.leidos.com/project/geothermal-power-generating-facility-0.

This US$400 million plant is particularly notable because of how it was financed. The project developers were able to use debt to finance 75 percent of the project costs, including the cost of exploratory drilling and construction costs.[42] The Featherstone Plant was the first utility-scale geothermal facility in the United States to secure debt for construction financing from commercial lenders since the 1980s.[43] Funding for exploratory drilling was provided by the Icelandic bank Glitnir (now Islandsbanki), which issued the Featherstone plant a US$15 million "resource verification" loan to conduct test-well drilling.[44] More than US$400 million for construction was raised from eight commercial banks, led by ING Capital, Société Générale, and WestLB. This funding was provided as a five-year loan, which EnergySource refinanced after the plant began operating with loans from Prudential, Sun Life, and TIAA-CREF.[45] In addition, the project received funding of US$10 million from the Fuji Electric Company and benefited from federal tax incentives from the American Recovery and Reinvestment Act.[46]

5.4 Key Factors That Enabled Geothermal Development in the United States

The development of geothermal plants in California was driven by government policy and the quality of California's geothermal resources. While geothermal development in the United States has slowed in recent years, the development of geothermal resources is expected to grow in upcoming years driven by state initiatives. The following factors have been key for the development of geothermal power plants in California:

- **Federal acts and regulations have directly led to geothermal development in California**—PURPA in 1978 required utilities to purchase renewable power at avoided costs. Between 1978 and 1989, it is estimated that PURPA led to almost 30 contracts for more than 600 MW of new capacity in California.[47]
- **The State of California directly supports geothermal development**—California is the only state with a state-funded research and development program for geothermal. In 1980, the California legislature established the Energy Commission's Geothermal Grant and Loan Program, also known as the GRDA. It provides funding to private and public entities for research, development, and the commercialization of geothermal projects. Since 1980, it has provided funding for over 174 geothermal research, development, and demonstration projects. It has funded at least four geothermal projects, as well as a number of direct-use projects.[48]
- **California has high-quality geothermal resources**—California has high-quality geothermal resources and a large geothermal potential. As mentioned earlier, California has 25 known geothermal resources areas and a geothermal potential estimated to be between 3,644 MW and 4,732 MW.[49] Even though other states, such as Nevada, have a more business-friendly environment and have developed more projects, the higher temperature, quality, and volume of California's geothermal resources allow developers to build much bigger plants.[50]

---

42. Travis Lowder, "Drilling for Dollars: Notable Developments in Geothermal Finance," *National Renewable Energy Laboratory–Renewable Energy Project Finance*, December 17, 2012, https://financere.nrel.gov/finance/content/drilling-dollars-notable-developments-geothermal-finance.

43. Travis Lowder, "Drilling for Dollars: Notable Developments in Geothermal Finance," *National Renewable Energy Laboratory–Renewable Energy Project Finance,* December 17, 2012, https://financere.nrel.gov/finance/content/drilling-dollars-notable-developments-geothermal-finance.

44. Ibid.

45. Leidos, "Geothermal Power Generating Facility," accessed November 20, 2014, https://www.leidos.com/project/geothermal-power-generating-facility-0.

46. EnerG, "Energy Source LLC Starts Construction of $400 million, 49MW Geothermal Project in California," accessed November 21, 2014, http://www.altenerg.com/xpress/2010/july/index.php-&content_id=308.htm; Power-technology.com, "John L Featherstone (Hudson Ranch I) Geothermal Power Plant, California, United States of America," accessed November 21, 2014, http://www.power-technology.com/projects/john-l-featherstone-hudson-geothermal-power-plant-california/.

47. Elizabeth Doris, Claire Kreycik, and Katherine Young, "Policy Overview and Options for Maximizing the Role of Policy in Geothermal Electricity Development" (National Renewable Energy Laboratory, Technical Report NREL/TP-6A2-46653, September 2009), http://www1.eere.energy.gov/geothermal/pdfs/policy_overview.pdf.

48. Ibid.

49. California Energy Commission, "Geothermal Energy in California," accessed November 21, 2014, http://www.energy.ca.gov/geothermal/background.html; Benjamin Matek and Karl Gawell, Report on the State of Geothermal Energy in California," February 2014, http://geo-energy.org/events/California%20Status%20Report%20February%202014%20Final.pdf.

50. Geothermal Energy Association, "2014 Annual U.S. & Global Geothermal Power Production Report" (April 2014).

6 Iceland

Iceland has successfully developed its geothermal resources and has an installed capacity of 665 MW for geothermal generation. One of the key drivers of geothermal development in Iceland was the government's active role in the development of geothermal resources. The government supported the development of geothermal resources in two ways. First, it reduced the resource risk faced by geothermal developers. Second, it has developed geothermal power plants. Many of the first plants developed in Iceland were built by government-owned agencies or companies.

We provide the following information about geothermal development in Iceland:

- Iceland and Its Electricity Sector (Section 6.1)
- Geothermal Resource Potential in Iceland (Section 6.2)
- Geothermal Projects in Iceland (Section 6.3)
- Key Factors That Enabled Geothermal Development in Iceland (Section 6.4)

6.1 Iceland and Its Electricity Sector

Iceland is a high-income country and a member of the Organisation for Economic Co-operation and Development (OECD) located in Western Europe. It had a population of 273,412 and a GDP per capita of US$47,610 in 2013.[51] In Iceland, 100 percent of the population has access to electricity.[52] It is the world's largest electricity producer per capita.[53]

Iceland has an installed capacity of 2,767 MW and almost all electricity is generated from renewable sources with 1,986 MW of hydro-electric generation (72 percent of installed capacity) and 665 MW of geothermal generation (24 percent of installed capacity). Iceland's remaining 4 percent of installed capacity includes wind power (2 MW) and generation from fossil fuels (114 MW).[54]

In 2013, Iceland generated approximately 18,116 GWh of electricity. Of this amount, 71 percent was generated from hydroelectric sources and 29 percent was generated from geothermal sources. Most of the electricity was used for industrial purposes. The largest users were the aluminum industry (68.4 percent) and the ferrosilicon industry (8.7 percent).[55] Residential consumption only made up 4.6 percent of electricity consumption. In 2013, the peak power fed into the grid was 2,236 MW.[56]

51. Statistics Iceland, "Population by origin and citizenship," accessed November 10, 2014, http://px.hagstofa.is/pxen/pxweb/en/Ibuar/Ibuar__mannfjoldi__1_yfirlit__yfirlit_mannfjolda/MAN00000.px; Statistics Iceland, "Gross domestic product," accessed November 10, 2014, http://www.statice.is/statistics/economy/national-accounts/gross-domestic-product/.
52. UNESCO, "Access to Electricity and Water for Domestic Use," accessed November 10, 2014, http://webworld.unesco.org/water/wwap/wwdr/indicators/pdf/H10_Access_to_electricity_and_water_for_domestic_use.pdf.
53. Askja Energy, "Energy Data," accessed November 10, 2014, http://askjaenergy.org/iceland-introduction/energy-data/.
54. Orkustofnun, "Energy Statistics in Iceland 2013," accessed November 10, 2014, http://os.is/gogn/os-onnur-rit/orkutolur_2013-enska.pdf.
55. Orkustofnun, "Generation of Electricity in Iceland," accessed November 10, 2014, http://www.nea.is/the-national-energy-authority/energy-statistics/generation-of-electricity/.
56. Landsnet, "Annual Report 2013," accessed March 16, 2016, http://www.landsnet.is/library/Skrar/Landsnet/Upplysingatorg/Skyrslur/arsskyrslur/Landsnet_Annual%20_Report_2013.pdf.

6.2 Geothermal Resource Potential in Iceland

In 2010, the National Energy Authority of Iceland estimated that an additional 4,300 MW of electricity can be generated from known high-temperature fields in Iceland. This would provide an additional 35 TWh of electricity per year.[57] This estimate was developed as an input to Iceland's Master Plan. The Master Plan examined 24 geothermal resources that are located near inhabited areas in the south, southwest, and northeast regions of Iceland.

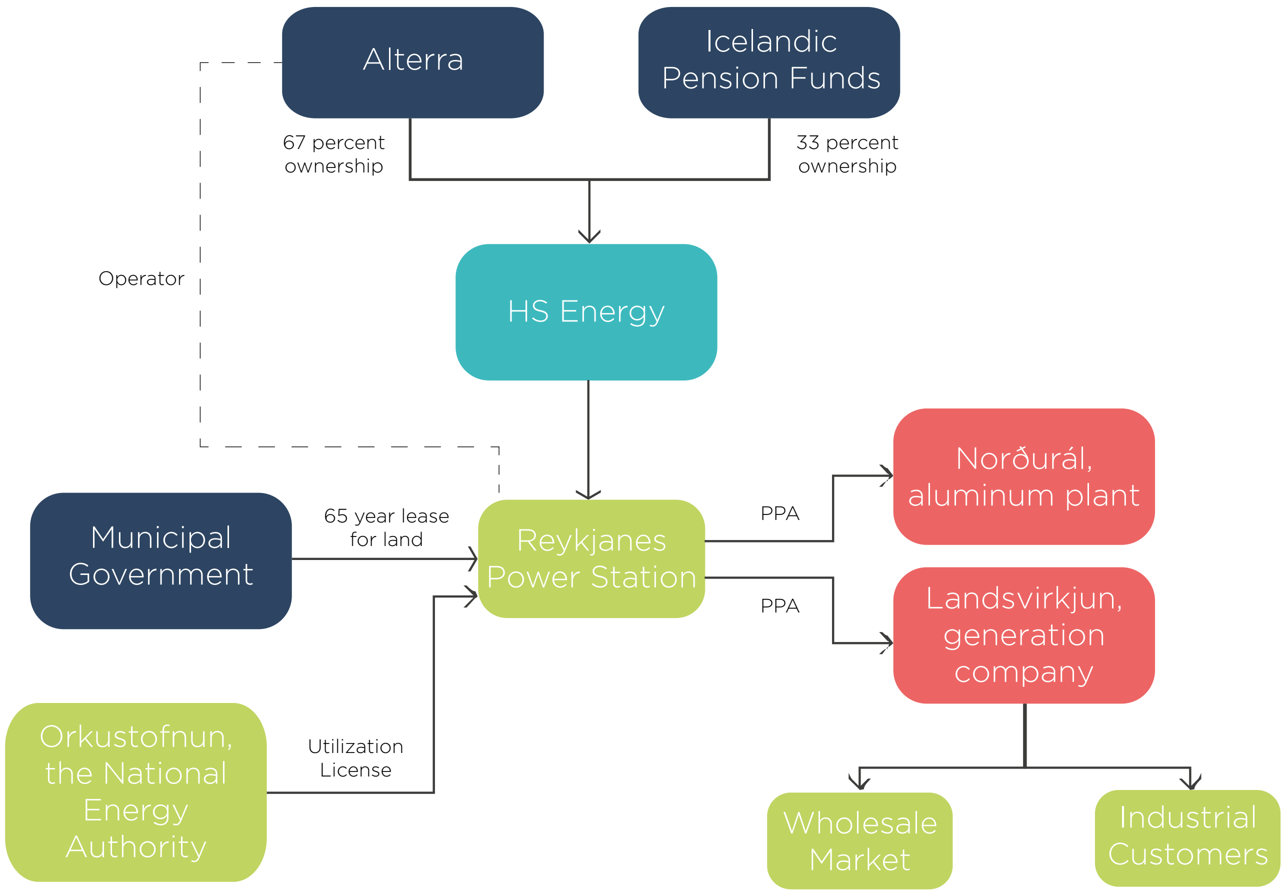
6.3 Geothermal Projects in Iceland

The Reykjanes Power Station illustrates Iceland's approach to developing geothermal power plants. It has three characteristics that are shared by many of the geothermal plants developed in Iceland. First, the plant was developed by a government-owned and municipal-owned company. The Reykjanes Power Station was originally developed by Sudurnes District Heating or HS Orka, a company founded to develop district heating from geothermal sources in Iceland. The company was owned by the government (40 percent) and seven municipalities in the area (60 percent). It was later purchased by Alterra Power Corporation.[58] Secondly, the plant was developed in an area whose geothermal resources were developed to provide district heating. In the Reykjanes geothermal field, drilling began in the 1950s, but power production drilling began in 1998.[59] This meant that the geothermal resource was known and well-explored prior to the development of the geothermal power generation plant. Lastly, the Reykjanes Power Station is being developed using a phased approach. The plant currently has an installed capacity of 100 MW, but an additional 50 MW and 30 MW are planned.

The Reykjanes Power Station is a 100 MW power plant located on the Reykjanes Peninsula.[60] This plant began operations in May 2006. It generates electricity using two Fuji Electric 50 MW double-flow condensing units and is connected to the transmission grid via a 220kV transmission line. When all of the phases of the plant are completed, it is expected to produce 180 MW of electricity. This additional capacity will be provided by a 50 MW double-flow condensing unit, and then a 30 MW low-pressure turbine.[61] The structure of the project is shown in **Figure 6.1.**

57. Orkustofnun, "Electricity Generation Capacity Is around 4300MW for High-Temperature Fields in Iceland," accessed November 10, 2014, http://www.nea.is/the-national-energy-authority/news/nr/90.
58. HS Orka HF, "Our Objective," accessed November 20, 2014, http://www.hsorka.is/english/HSCompanyInfo/HSCompanyHistory.aspx.
59. Alterra Power Corp., "Reykjanes: Geothermal Power Plant," accessed November 20, 2014, http://www.alterrapower.ca/files/assets/_pdf/Icleandic%20Assets/Reykjanes%20Power%20Plant%20-%20Iceland.pdf.
60. Ibid.
61. Ibid.

FIGURE 6.1 Structure of the Reykjanes Power Station



Sources: Alterra Power Corp., "Reykjanes: Geothermal Power Plant," accessed November 20, 2014, http://www.alterrapower.ca/files/assets/_pdf/Icleandic%20Assets/Reykjanes%20Power%20Plant%20-%20Iceland.pdf.; Alterra Power Corp., "Assets," accessed November 20, 2014, http://www.alterrapower.ca/properties/By-Country/Iceland/default.aspx.

The Reykjanes Power Station was developed by HS Orka, which is the third-largest electricity-generating firm in Iceland. At the time that the plant was developed, the company was owned by the government and municipalities. However, HS Energy was privatized in 2007.[62] Now it is owned by Alterra (67 percent) and Icelandic Pension Funds (33 percent). Alterra is also the operator of the Reykjanes Power Station.

There are three agreements that were needed to develop the Reykjanes Power Station: a lease for the land, a utilization license, and PPAs. In Iceland, the resources inside the land are owned by the landowner. However, the owner of the land does not have a guaranteed right to exploit these resources. As a result, Reykjanes Power Station had to obtain two agreements to be able to build the geothermal station. The first was a lease from the landowner (a municipal government), and the second was a utilization license from the National Energy Authority. In addition, the Reykjanes Power Station has signed two PPAs to sell the electricity produced. It has a PPA with Landsvirkjun, the National Power Company of Iceland, until 2019, and Norðurál, an aluminum-processing plant, through 2026. It plans to develop additional PPAs before expanding the plant's capacity.

62. Askja Energy, "The Energy Sector," accessed November 21, 2014, http://askjaenergy.org/iceland-introduction/iceland-energy-sector

6.4 Key Factors That Enabled Geothermal Development in Iceland

The success of geothermal development in Iceland can be attributed to the active role played by the government, which both absorbed the resource risk faced by geothermal developers and built plants. The government helped Iceland transition from a country that used geothermal resources for district heating to one that is a leader in developing geothermal power plants. Now that the geothermal power industry is well developed, the private sector has become more active and the government provides the sector with more limited support. The government's role and other factors key to the successful development of Iceland's resources are described in more detail below:

- **Iceland developed a public insurance scheme for geothermal risk**—Iceland developed a public insurance scheme, the National Energy Fund, for geothermal drilling. This fund would reimburse up to 80 percent of the cost of approved drillings that were unsuccessful and also provide grant support for exploratory activities. This fund played a key role in the early development of Iceland's geothermal development when the industry was less experienced and less information on the geothermal resources was available.[63]
- **The government played an active role in the development of geothermal resources**—The government has supported the development of geothermal resources and government-owned entities have also developed many of Iceland's geothermal resources. The government did so by establishing governmental agencies that have explored Iceland's geothermal resources and by subsidizing geothermal resource development. The State Electricity Authority was established to explore Iceland's geothermal resources and find ways that these resources could be used for profitable projects. It was replaced by the National Energy Authority and by the newly formed Iceland GeoSurvey, which carries out geothermal research. In addition, the government established the National Energy Fund, which subsidizes drilling.

  Another important way that the government supported geothermal development is that many of the early geothermal projects in Iceland were developed by government-owned agencies. The first geothermal power projects in Iceland were developed by regional district heating companies and national bodies.[64]
- **Iceland had experience developing geothermal resources for district heating before constructing geothermal power plants**—Iceland began its efforts to develop geothermal resources in 1907, but did not construct its first 3 MW plant until 1969. The areas where geothermal power plants were first built, such as the Reykjanes geothermal field, had geothermal resources that had already been explored and which provided district heating. As a result of developing geothermal resources to provide district heating, Iceland was able to build the capacity of its institutions and also gain important knowledge about its geothermal resources before building its first geothermal power plant.[65]

7 Kenya

Kenya is one of the largest and fastest-growing markets for geothermal development. The government has ambitious plans to expand the country's electricity generation from geothermal resources and plans to involve the private sector in their development. While earlier geothermal projects in Kenya relied heavily on support from multilateral development banks, the government now has the legal and regulatory framework, the experience, and the resources to attract the private sector with less support from multilaterals. One notable change is that the government is now assuming the exploration and early development risks for new geothermal developments and bringing in independent power producers (IPPs) at a later, less risky stage.

In this section, we provide the following information about geothermal development in Kenya:

- Kenya and Its Electricity Sector (Section 7.1)
- Geothermal Resource Potential in Kenya (Section 7.2)
- Geothermal Projects in Kenya (Section 7.3)
- Key Factors That Enabled Geothermal Development in Kenya (Section 7.4).

7.1 Kenya and Its Electricity Sector

The Republic of Kenya is located in the Great Lakes region of Eastern Africa. Kenya is a large middle-income country with a population of 41.8 million and a GDP per capita of US$994 in 2013.[66] In Kenya, an estimated 19.2 percent of the population had access to electricity in 2011.[67]

Kenya has an installed capacity of 1,765 MW and an effective capacity of 1,652 MW. Most of the installed capacity is owned by KenGen (70 percent), the state-owned generation company, and IPPs (22 percent). Most of Kenya's installed capacity is hydroelectric generation (46 percent), thermal generation (34 percent), and geothermal generation (14 percent). Electricity is also produced with solar, wind, and cogeneration, but these do not make up a significant percentage of Kenya's installed capacity.[68]

In 2013, electricity consumption was approximately 6,928 GWh; this figure grew an average of 6.3 percent per year between 2009 and 2013. Consumption was highest for commercial and industrial customers (51.8 percent) and domestic and small commercial customers (41.4 percent). Off-peak (0.5 percent), street lighting (0.2 percent), and rural electrification (6.2 percent) made up the remaining sales in 2013.[69] The peak demand for KenGen was 1,354 MW in its 2012–2013 financial year; this figure grew an average of 5.4 percent per year between KenGen's 2007–2008 and 2012–2013 financial years.

66. World Bank, "World Development Indicators," accessed May 19, 2016, http://data.worldbank.org/indicator/SP.POP.TOTL; Kenya National Bureau of Statistics, "Kenya Facts and Figures 2014," accessed May 19, 2016, http://www.knbs.or.ke/index.php?option=com_phocadownload&view=category&id=20&Itemid=1107. GDP per capita is in current US$.

67. World Bank, "World Development Indicators," accessed May 19, 2016, http://data.worldbank.org/indicator/EG.ELC.ACCS.ZS.

68. The Kenya Power and Lighting Company Limited, "Annual Report 2012/2013."

69. Kenya National Bureau of Statistics, "Kenya Facts and Figures 2014," accessed May 19, 2016, http://www.knbs.or.ke/index.php?option=com_phocadownload&view=category&id=20&Itemid=1107.

7.2 Geothermal Resource Potential in Kenya

The East-African Rift Valley is one of the largest and most promising geothermal resources in the world. The estimated geothermal potential in the Rift Valley in Kenya ranges from 7,000 MW to 10,000 MW.[70] There are 14 potential sites along the Rift Valley that have high temperatures. Kenya also has geothermal resources in the Homa Hills in Nyanza, Mwananyamala at the Coast, and Nyambene Ridges.[71] The Geothermal Development Company, the state-owned agency in charge of geothermal exploration and development, is focusing on developing steam resources in three primary resources areas: Menengai, Bogoria–Silali, and Suswa.

Kenya is planning to aggressively develop its geothermal resources. The draft energy policy set a target of developing at least 1,900 MW of geothermal generation by 2016 and 5,500 MW by 2030.[72] This will require an estimated capital investment of US$18 billion.[73]

7.3 Notable Geothermal Projects in Kenya

Kenya has an installed capacity of 209 MW and is planning to aggressively increase its geothermal generation in upcoming years.[74] As part of its plan to increase geothermal generation, the government is planning to partner with the private sector. In the past, most of the geothermal plants have been developed by KenGen, Kenya's state-owned generation company, with multilateral support. However, there are two notable exceptions that provide insight into how Kenya is planning to develop its geothermal resources going forward and that provide key lessons about how to successfully involve the private sector. The first is the Olkaria III geothermal power station; the second are the geothermal plants that the government is currently working to develop in the Menengai field.

70. Geothermal Energy Association, "2013 Geothermal Power: International Market Overview," September 2013, accessed May 19, 2016, http://geo-energy.org/events/2013%20International%20Report%20Final.pdf.

71. Geothermal Development Company, "Who We Are," accessed November 5, 2014, http://www.gdc.co.ke/index.php?option=com_content&view=article&id=139&Itemid=203.

72. Republic of Kenya: Ministry of Energy and Petroleum, "Draft National Energy Policy," February 24, 2014, accessed May 19, 2016, http://www.ketraco.co.ke/news/2014/Energy_policies.html.

73. Geothermal Energy Association, "2013 Geothermal Power: International Market Overview," September 2013, accessed May 19, 2016, http://geo-energy.org/events/2013%20International%20Report%20Final.pdf.

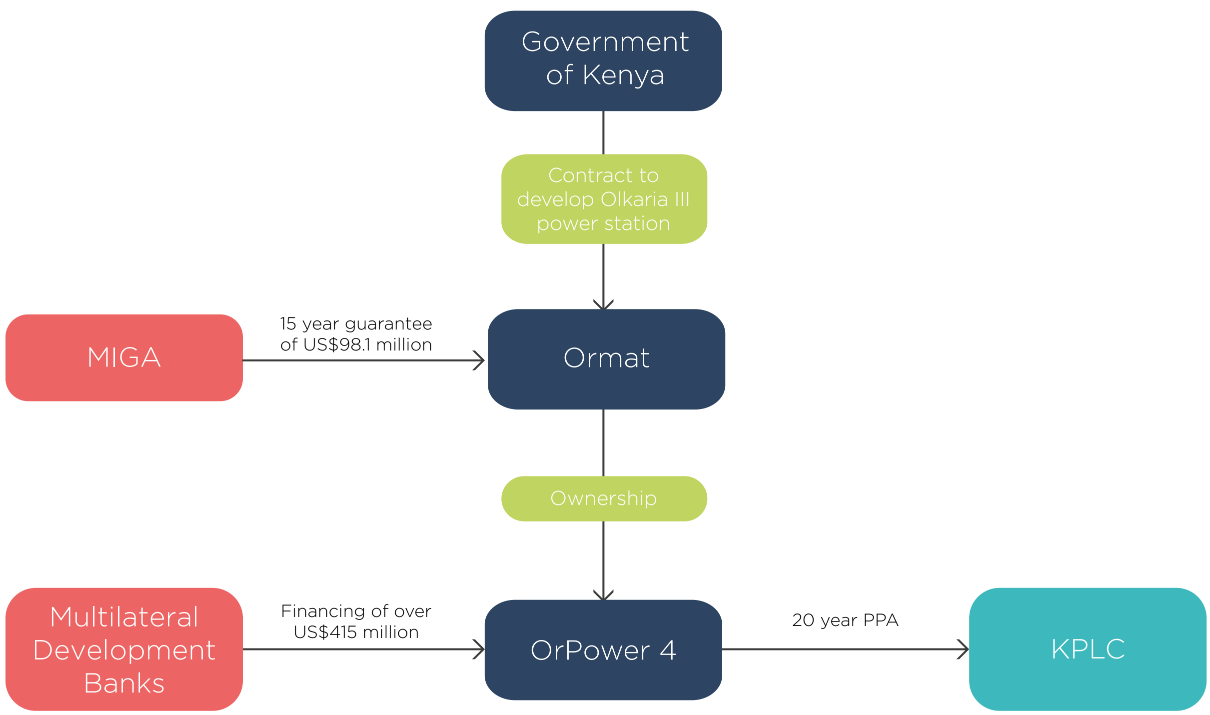
74. Geothermal Development Company, "Who We Are," accessed November 5, 2014, http://www.gdc.co.ke/index.php?option=com_content&view=article&id=139&Itemid=203.

Olkaria III

The Olkaria III geothermal power station is the first privately funded geothermal project in Africa.[75] Olkaria III is a 110 MW power station, and is owned and operated by OrPower4, a subsidiary of Ormat Technologies Inc.[76] This power station was developed on a Build-Own-Operate basis. Electricity is generated using binary/pentane technology, and all electricity generated by this plant is sold to Kenya Power and Lighting Company under a 20-year PPA.[77] The development and signing of the PPA was concluded in 1998 and amended in March 2011 to account for the increase in Olkaria III's installed capacity.[78] As part of this agreement, the Kenyan government received upfront fees of US$3 million, along with a royalty charge of US$2.5 to US$3 million per year.[79] The construction of this plant was paid for with a mixture of equity from OrPower4 and concessionary financing from multilateral development banks, which is described in more detail below.

There were two key ways that the government and multilateral development banks reduced the risks related to development of the Olkaria III geothermal power station. The first was that the power station was developed using a phased approach and the second was through the active involvement of multilateral development banks.

FIGURE 7.1 Structure of the Olkaria III Power Station



Sources: Ormat, "Olkaria III Geothermal Complex in Kenya Reaches 110MW with Commercial Operation of Plant 3," accessed November 6, 2014, http://www.ormat.com/news/latest-items/olkaria-iii-geothermal-complex-kenya-reaches-110-mw-commercial-operation-plant-3; Private Infrastructure Development Group, "Olkaria Geothermal Power Plant," accessed November 6, 2014, http://www.pidg.org/impact/case-studies/olkaria-geothermal-power-plant; Ormat, "Ormat Technologies Signs Long-Term Debt Financing for up to $310 Million for the Olkaria III Geothermal Power Complex in Kenya," accessed November 6, 2014, http://www.ormat.com/news/latest-items/ormat-technologies-signs-long-term-debt-financing-310-million-olkaria-iii-geotherm

75. Private Infrastructure Development Group, "Olkaria Geothermal Power Plant," accessed November 6, 2014, http://www.pidg.org/impact/case-studies/olkaria-geothermal-power-plant.
76. Geothermal Development Company, "Prequalification for Supply & Installation of Two (2) Geothermal Modular Power Plants Each of 30–35MW at Menengai Field Under Public Private Partnership on a Build Own Operate Basis," accessed November 6, 2014, http://www.gdc.co.ke/images/Tenders/tender_docs/076_PQ_For_Modular_Power_Plant.pdf.
77. Ormat, "Olkaria III Geothermal Complex in Kenya Reaches 110MW with Commercial Operation of Plant 3," accessed November 6, 2014, http://www.ormat.com/news/latest-items/olkaria-iii-geothermal-complex-kenya-reaches-110-mw-commercial-operation-plant-3.
78. World Bank, "Kenya Private Sector Power Generation Support Project," accessed November 6, 2014, http://www.worldbank.org/projects/P122671/partial-risk-guarantees-ipps-kenya?lang=en.
79. Private Infrastructure Development Group, "Olkaria Geothermal Power Plant," accessed November 6, 2014, http://www.pidg.org/impact/case-studies/olkaria-geothermal-power-plant.

The Olkaria III geothermal power station was built using a phased approach. There were two ways that its development was carried out using a phased approach. First, the Olkaria field was developed using a phased approach, and, second, the power station itself was built in three phases. As indicated by its name, the Olkaria III power station was the third power station build in the Olkaria field in the Rift Valley. Its nearby sister stations, Olkaria I and Olkaria II, were built and operating prior to the development of Olkaria III power station. This reduced the risk of developing the Olkaria III power station, because it provided additional information on the geothermal resource and also proved that the geothermal resource was commercially viable. Olkaria III power station was also developed with a phased approach. Originally, the project was to develop a power station with an installed capacity of 13 MW and then increase the installed capacity of the power station to 48 MW by 2009.[80] This expansion was carried out as planned, and then OrPower4 expanded the plant further to 110 MW in 2014. This phased approach reduced the risk faced by OrPower4 because OrPower4 was able to develop and study the geothermal resource, and work with the Government of Kenya before making additional investments.

The second notable aspect of the project is the active role that multilateral development banks had in all aspects of the project: the World Bank supervised the procurement of the project, and various multilateral development banks provided significant financial support for the project.[81] Multilateral development banks provided financial support through concessionary financing and through a guarantee. Donors provided significant financing for the first 48 MW of the power station and the expansion to 110 MW. The first 48 MW of the power station cost US$179.4 million. OrPower4 contributed US$59.7 million as a long-term commercial equity contribution, and the remaining balance was financed with long-term loans from various development finance institutions.[82] The expansion of the power station to 110 MW was financed by multilateral development banks. The Overseas Private Investment Corporation (OPIC) provided OrPower4 with a US$310 million debt facility for this expansion.[83] Another key way that multilateral development banks and donors provided support is through providing a guarantee for the project. The Multilateral Investment Guarantee Agency (MIGA) of the World Bank Group provided OrPower4 with a guarantee of up to US$98.1 million in 2008. This guarantee lasts for 15 years and covers the risks of war and civil disturbance, transfer restriction, and expropriation.[84] The guarantee from 2008 replaced a guarantee provided in 2002 for US$70 million, which only covered the first phase of the project.[85]

80. World Bank, "Kenya Private Sector Power Generation Support Project," accessed November 6, 2014, http://www.worldbank.org/projects/P122671/partial-risk-guarantees-ipps-kenya?lang=en.

81. Private Infrastructure Development Group, "Olkaria Geothermal Power Plant," accessed November 6, 2014, http://www.pidg.org/impact/case-studies/olkaria-geothermal-power-plant.

82. Private Infrastructure Development Group, "Olkaria Geothermal Power Plant," accessed November 6, 2014, http://www.pidg.org/impact/case-studies/olkaria-geothermal-power-plant; World Bank and UNDP: Climate Finance Options, "DEG/KfW Olkaria III Geothermal Power Station (Kenya)," accessed November 6, 2014, http://www.climatefinanceoptions.org/cfo/node/67 (no longer available). Financing for the project was arranged by Deutsche Investitions- und Entwicklungsgesellschaft mbH (DEG). DEG and KfW Entwicklungsbank (KfW) provided approximately 35 percent of the remaining balance. Other donors who provided long-term loans were Netherlands Development Finance Company (FMO), European Development Finance Institutions (EFP), Proparco, and The Emerging Africa Infrastructure Fund (EAIF).

83. Ormat, "Olkaria III Geothermal Complex in Kenya Reaches 110MW with Commercial Operation of Plant 3," accessed November 6, 2014; Ormat, "Ormat Technologies Signs Long-Term Debt Financing for up to $310 Million for the Olkaria III Geothermal Power Complex in Kenya," accessed November 6, 2014, http://www.ormat.com/news/latest-items/ormat-technologies-signs-long-term-debt-financing-310-million-olkaria-iii-geotherm. The OPIC loan had three tranches. The first two tranches provided US$265 million and a maturity of 18 years. This amount was to fund the expansion of the plant to 84MW. There was also a standby tranche of US$45 million if OrPower4 decided to increase the capacity beyond 84MW.

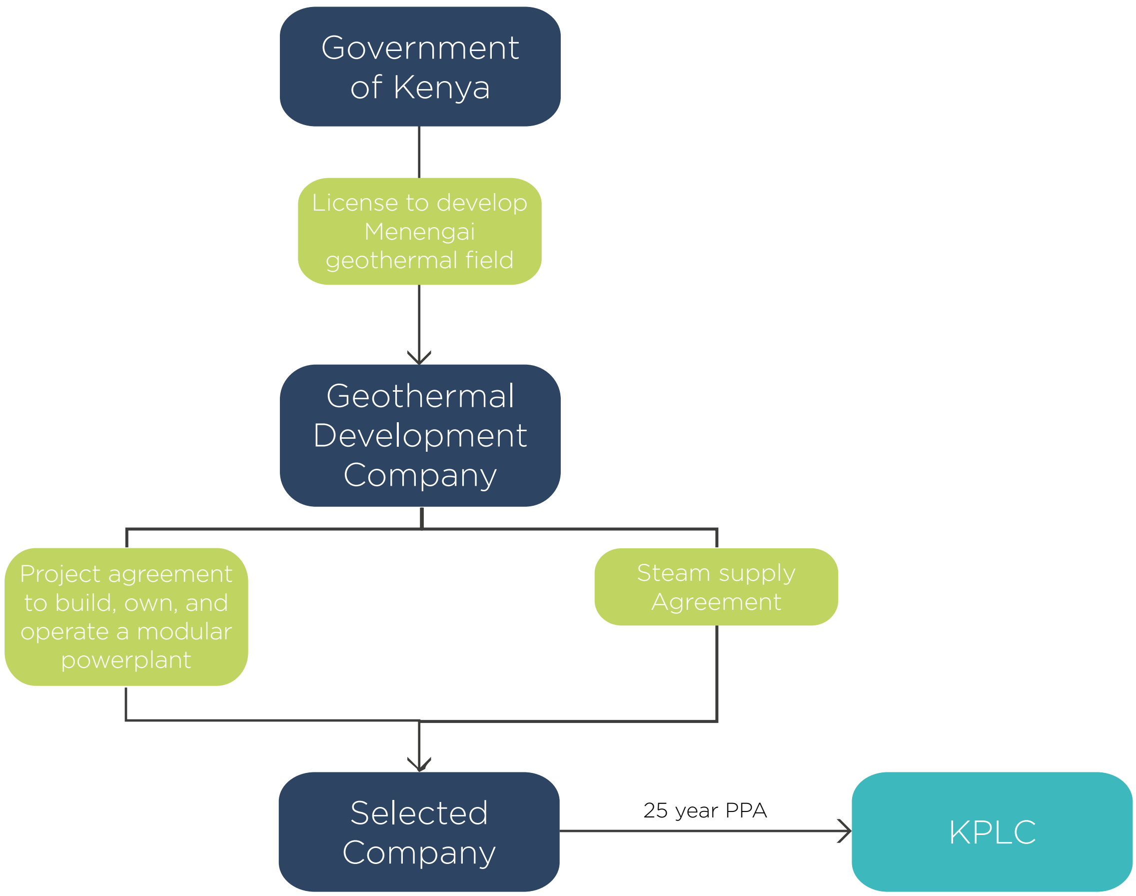
84. MIGA, "Project Brief: Fortifying Power Investments," accessed May 23, 2016, https://www.miga.org/Documents/power08.pdf.

85. MIGA, "MIGA Sees Solid Results in FY02," MIGA News 10, no. 2 (April–June 2002), accessed May 23, 2016, https://www.miga.org/Documents/vol10no2.pdf.

Menengai Field Development

The Geothermal Development Company (GDC) is in the process of procuring a project in the Menengai field that demonstrates Kenya's new model for geothermal development.

FIGURE 7.2 Proposed Structure of the Geothermal Development in the Menengai Field



Sources: Geothermal Development Company, "Prequalification for Supply & Installation of Two (2) Geothermal Modular Power Plants Each of 30–35MW at Menengai Field Under Public Private Partnership on a Build Own Operate Basis," accessed November 6, 2014, http://www.gdc.co.ke/images/Tenders/tender_docs/076_PQ_For_Modular_Power_Plant.pdf.

In Kenya's draft Energy Policy and Vision 2030, the government highlights its need to work with the private sector to develop geothermal resources and reach its targets for increasing Kenya's installed capacity. As part of this effort, in 2008 the government created the GDC, which is Kenya's state-owned agency responsible for geothermal exploration and development. This body absorbs exploration and early development risks by confirming the viability of potential geothermal resources through technical studies and exploratory drillings.

It then offers geothermal resources to potential power developers through competitive tendering.[86] The geothermal development in the Menengai field is being carried out under this model.

The development in the Menengai field differs significantly from previous geothermal projects completed in Kenya because this is the first development in the Menengai field and also because of the role of the GDC. The GDC is looking for two IPPs, which will each install a 30–35 MW modular power plant on a Build-Own-Operate basis. These plants will be developed on the Menengai geothermal field, which is licensed to the GDC, and will use steam from wells that have been drilled and confirmed by the GDC.

The IPPs will enter into a Project and Steam Supply Agreement with the GDC. The feed-in-tariff regime would govern the rates paid under the PPAs.[87] The IPPs will also finance and install the connection to Kenya Electricity Transmission Company (KETRACO)'s substation, and will enter into a PPA to sell the electricity to Kenya Power and Lighting Company Limited (Kenya Power). This project is expected to last for 25 years and to be followed by additional developments; the GDC plans to develop a 400 MW power station at the Menengai field. Companies submitted their information for prequalification in July 2014 and the GDC planned to commission the plants by the end of 2015.[88]

---

86. Magnus Gehringer and Victor Loksha, *Geothermal Handbook: Planning and Financing Power Generation* (Washington, DC: The International Bank for Reconstruction and Development, Technical Report 002/12, June 2012), accessed October 22, 2014, http://www.esmap.org/sites/esmap.org/files/DocumentLibrary/FINAL_Geothermal%20Handbook_TR002-12_Reduced.pdf.

87. The Ministry of Energy has issued the Feed-In-Tariffs Policy on Wind, Biomass, Small-Hydro, Geothermal, Biogas and Solar Resource Generated Electricity, which provides guidelines for PPAs and the feed-in tariff based on the size and type of generation. It was first issued in March 2008, and was revised in January 2010 and December 2012.

88. Geothermal Development Company, "Prequalification for Supply & Installation of Two (2) Geothermal Modular Power Plants Each of 30–35MW at Menengai Field Under Public Private Partnership on a Build Own Operate Basis," accessed November 6, 2014, http://www.gdc.co.ke/images/Tenders/tender_docs/076_PQ_For_Modular_Power_Plant.pdf.

7.4 Key Factors That Enabled Geothermal Development in Kenya

Kenya has been able to successfully develop 209 MW of geothermal generation and has successfully involved the private sector in the development of several of its power stations.[89] The success of Kenya's geothermal development can be attributed to the strong commitment from both the government and multilateral development banks. In particular, the following four factors were key for the successful development of Kenya's resources:

- **The government invests in geothermal development**—The Government of Kenya has expressed a strong commitment to the development of geothermal resources in its Vision 2030 and has played an active role in the development of geothermal resources. For Kenya's earlier geothermal projects, KenGen, the government-owned generation company, developed the geothermal power stations with concessionary funding. Now the government is using private sector participation to develop its geothermal resources, but is still assuming the exploration and early development risks through the GDC.
- **Kenya's legal framework for developing geothermal resources and IPPs is proven—** Kenya has experience developing IPPs and geothermal resources, which shows the legal framework to be proven and effective. Specifically, the legal framework establishes clear rules for governing the development of geothermal resources and governing IPPs. The Geothermal Resources Act of 1982 clearly lays out who owns the country's geothermal resources and establishes the process for granting license for exploring them. Kenya also has a well-established and tested framework that governs IPPs; Kenya has six IPPs that provide 22 percent of Kenya's installed capacity.[90] One key policy that facilitates the development of IPPs is the Feed-In-Tariffs Policy on Wind, Biomass, Small-Hydro, Geothermal, Biogas and Solar Resource Generated Electricity. This policy serves as the basis for the PPAs in Kenya, providing standard PPAs, guidelines for PPAs, and the value of the feed-in tariff based on the size and type of generation.
- **Kenya uses a phased approach for project development—**In Kenya, both geothermal fields and power stations have been developed using a phased approach. The best example of this approach is the Olkaria field, which has four power stations that were developed over the course of 25 years. The government is now working to add additional units on the existing power stations. The description of Olkaria III in Section 7.3 shows how Kenya used a phased approach for developing power stations.
- **Multilateral development banks have provided extensive support for geothermal development in Kenya—**Multilateral development banks have provided extensive support for the development of geothermal resources in Kenya. In addition to providing technical assistance and support in exploring resources during the early phases of Kenya's geothermal development, multilateral development banks have also provided financing for specific power stations.

89. Geothermal Development Company, "Who We Are," accessed November 5, 2014, http://www.gdc.co.ke/index.php?option=com_content&view=article&id=139&Itemid=203.

90. The Kenya Power and Lighting Company Limited, "Annual Report 2012/2013."

8 Guadeloupe

Guadeloupe has successfully developed its geothermal resources and has an installed capacity of 15 MW for geothermal generation. Guadeloupe is the only island in the Eastern Caribbean that has built a geothermal power plant. 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. Going forward, the government will continue to play a major role in the development of Guadeloupe's geothermal resources. In this section, we provide the following information about geothermal development in Guadeloupe:

- Guadeloupe and Its Electricity Sector (Section 8.1)
- Geothermal Resource Potential in Guadeloupe (Section 8.2)
- Geothermal Projects in Guadeloupe (Section 8.3)
- Key Factors That Enabled Geothermal Development in Guadeloupe (Section 8.4)

8.1 Guadeloupe and Its Electricity Sector

Guadeloupe, an overseas department of France, consists of a group of islands located in the Leeward Islands of the Lesser Antilles. In 2013, Guadeloupe had a population of 503,000[91] and a GDP of €9,454.6 million.[92] Électricité de France (EDF), the French publicly owned utility, supplies all of the electricity in Guadeloupe.[93]

In 2013, Guadeloupe had an installed capacity of 490 MW.[94] Most of this installed capacity is owned by EDF (around 70 percent), and IPPs own the remaining share (around 30 percent).[95] Most of Guadeloupe's installed capacity is thermal generation (82.5 percent). Electricity is also produced with solar (5.7 percent), geothermal (4.7 percent), wind (3.3 percent), and bagasse (2.7 percent). The government plans to expand electricity generation from renewable energy. It has established a goal of generating 50 percent of Guadeloupe's electricity from renewable energy by 2020, with geothermal and biomass accounting for much of this generation.[96]

Electricity consumption was 1,729 GWh in 2013,[97] and it grew by 15 percent between 2005 and 2012.[98] Consumption was highest for domestic and small business consumers (75 percent). Medium and large business, industries, and communities made up the remaining sales in 2012 (25 percent).[99] The peak demand for EDF was 254 MW in 2013.[100] Peak demand fell by 2 percent between 2010 and 2012, but did not change between 2012 and 2013.[101]

91. H. Liu, D. Masera, and L. Esser, eds., *World Small Hydropower Development Report 2013: Guadeloupe* (United Nations Industrial Development Organization and International Center on Small Hydro Power, 2013), accessed November 21, 2014, http://www.smallhydroworld.org/fileadmin/user_upload/pdf/Americas_Caribbean/WSHPDR_2013_Guadeloupe.pdf.
92. World Travel & Tourism Council, "Travel & Tourism Economic Impact 2014: Guadeloupe" (2014).
93. EDF Archipel Guadeloupe, "EDF Guadeloupe Presentation" (June 22, 2009).
94. H. Liu, D. Masera, and L. Esser, eds., *World Small Hydropower Development Report 2013: Guadeloupe* (United Nations Industrial Development Organization and International Center on Small Hydro Power, 2013), accessed November 21, 2014, http://www.smallhydroworld.org/fileadmin/user_upload/pdf/Americas_Caribbean/WSHPDR_2013_Guadeloupe.pdf.
95. EDF Archipel Guadeloupe, "EDF Guadeloupe Presentation" (June 22, 2009).
96. In 2013, renewable energy accounted for 17.5 percent of total installed capacity.
97. EDF, "Island Energy Systems: Provisional Balance Sheet Guadeloupe," July 2014, accessed July 21, 2014, http://translate.google.com/translate?hl=en&sl=fr&u=http://sei.edf.com/nos-engagements/bilans-previsionnels-offre-demande-47808.html&prev=search (no longer available).
98. Ibid.
99. Ibid.
100. Ibid.
101. Ibid.

8.2 Geothermal Resource Potential in Guadeloupe

Guadeloupe's geothermal resources are located in the Bouillante geothermal field, which is located on the western coast of Basse Terre. Guadeloupe has a confirmed geothermal resource of 30 MW[102] and an estimated geothermal potential of 3,500 MW.[103] There has been significant geothermal exploration of Guadeloupe's Bouillante geothermal field. The French Geological and Mining Survey (Bureau de Recherches Géologiques et Minières, or BRGM) began surface studies in the 1960s. From 1970 to 2001, seven exploration wells were drilled, which resulted in three production wells (BO-2, BO-5, and BO-6). Going forward, Géothermie Bouillante S.A., the publicly owned company responsible for developing the geothermal project, plans to drill two to three more exploratory wells in the northern part of Bouillante Bay. These wells will be drilled as part of the effort to develop a third geothermal power plant.[104]

8.3 Geothermal Projects in Guadeloupe

Guadeloupe has an installed capacity of 15 MW of geothermal generation consisting of a 4.7 MW plant, Bouillante 1, and a 10 MW plant, Bouillante 2. Géothermie Bouillante, the plant operator and project developer, is planning to increase Guadeloupe's geothermal generation capacity by building a third plant in the near future.[105]

The geothermal project in Guadeloupe has been developed in two phases, each with a different project structure. The first phase included private sector participation, whereas the second phase only included participation from government-owned companies. Even though the private sector is no longer involved in the development of Guadeloupe's geothermal resources, it played a key role in their development by providing the technical expertise needed to explore Guadeloupe's geothermal resources. In this section, we present the project structure for each of the project's phases.

---

102. EDF Archipel Guadeloupe, "EDF Guadeloupe Presentation" (June 22, 2009).

103. Erouscilla P. Joseph, "Geothermal Energy Potential in the Caribbean Region," March 2008, accessed November 21, 2014, http://sustainabledevelopment.un.org/content/documents/3339energy_joseph.pdf.

104. E. Bourdon, V. Bouchot, A. Gadalia, and B. Sanjuan, "Fieldtrip: Geology and Geothermal Activity of the Bouillante Volcanic Chain," March 25, 2011.

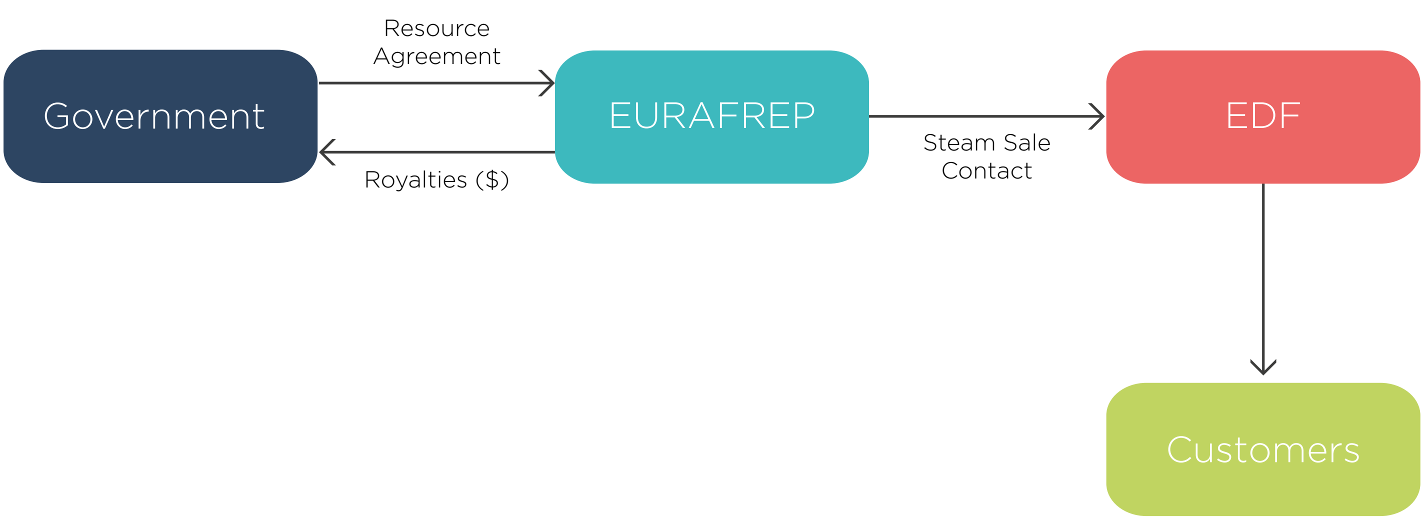
105. F. Demarcq, R. Vernier, and B. Sanjuan, "Situation and Perspectives of the Bouillante Geothermal Power Plant in Guadeloupe, French West Indies" (Deep Geothermal Days, Paris, April 2014), accessed November 20, 2014, https://hal-brgm.archives-ouvertes.fr/hal-00945589.

Phase 1: Bouillante I

The government developed Guadeloupe's first geothermal power plant under a structure that included private sector participation.
For the first geothermal plant, responsibilities for developing the geothermal generation plant were divided between EURAFREP, a private French oil company, and EDF, the government-owned utility. EURAFREP was responsible for the development and operation of the production well, and EDF was responsible for building and operating the geothermal plant. EDF hired a private company to build the plant under a turnkey contract.
This project structure allowed the government to access the private sector's technical expertise and financing for the exploration, drilling, and operation of the production wells, as well as for building the power plant. However, it did not allow Guadeloupe to successfully generate power from geothermal resources because EDF did not have the technical expertise that it needed to operate and maintain the power plant.

In the late 1960s, the government granted EURAFREP a resource concession that authorized it to explore and exploit the geothermal resource in the Bouillante geothermal field. In the first half of the 1970s, EURAFREP drilled four exploratory wells and one commercially viable production well.[106] EURAFREP then operated the production well and sold steam to EDF under a steam sale contract.[107] Once the production well was built, EDF was responsible for building and operating the generation plant. In 1987, it used a turnkey contract to hire Alstom, a private company, to build a 4.7 MW geothermal power plant.[108] EDF then operated the power plant from 1987 to 1993. During this time EDF faced technical difficulties operating the plant, which resulted in limited plant availability (average plant availability was 4,000 hours per year).[109] **Figure 8.1** shows the project structure of the first phase of the geothermal project in Guadeloupe.

FIGURE 8.1 Structure of the Bouillante I Geothermal Project



Sources: International Geothermal Association, IGA News: Newsletter of the International Geothermal Association, Quarterly 39 (January–March 2000).

106. International Geothermal Association, *IGA News: Newsletter of the International Geothermal Association,* Quarterly 39 (January-March 2000): 10–11.

107. Alstom, "Case Study: Geothermal Power, Bouillante 1: French West Indies" (2014), accessed November 20, 2014, http://www.alstom.com/Global/Power/Resources/Documents/Brochures/la-bouillante-geothermal-power-plant.pdf.

108. Ibid.

109. International Geothermal Association, *IGA News: Newsletter of the International Geothermal Association,* Quarterly 39 (January-March 2000): 10–11.

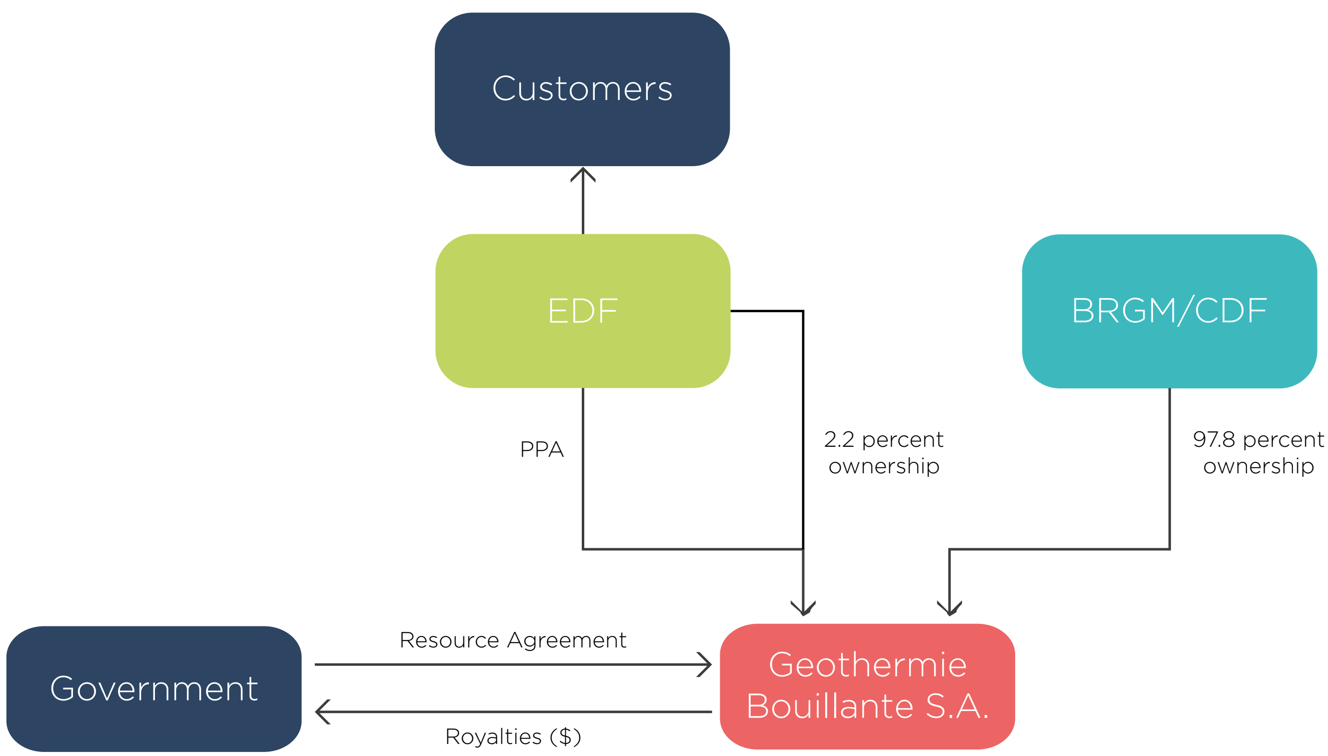
Phase 2: Bouillante II

The second phase of the development of Guadeloupe's geothermal was led by Géothermie Bouillante. This company had the technical expertise to successfully develop and operate a geothermal plant. As a result, the development of the second plant was successful.

Géothermie Bouillante is a French publicly owned company whose parent companies have extensive experience with geothermal development. It is a subsidiary of Compagnie Française pour le Développement de la Géothermie et des Energies Nouvelles (CFG) and EDF.[110] CFG is a French geothermal engineering company owned by BRGM, which is the leading public entity responsible for researching and implementing projects related to surface and subsurface resources risks.[111]

In 1993, Géothermie Bouillante bought EURAFREP's resource concession and EDF's power plant, and took ownership of Guadeloupe's geothermal project. Géothermie Bouillante also signed a PPA with EDF.[112] **Figure 8.2** presents the project structure for the second phase of Guadeloupe's geothermal project.

FIGURE 8.2 Structure of the Bouillante I Geothermal Project



Sources: International Geothermal Association, IGA News: Newsletter of the International Geothermal Association, Quarterly 39 (January–March 2000); BRGM, "Géothermie Bouillante," BRGM.eu, accessed November 21, 2014, http://www.brgm.eu/brgm/brgm-group/geothermie-bouillante.

110. International Geothermal Association, IGA *News: Newsletter of the International Geothermal Association*, Quarterly 39 (January–March 2000): 10–11.

111. BRGM, "CFG Services," *BRGM.eu*, accessed November 21, 2014, http://www.brgm.eu/brgm/brgm-group/cfg-services.

112. International Geothermal Association, *IGA News: Newsletter of the International Geothermal Association*, Quarterly 39 (January–March 2000): 10–11.

Géothermie Bouillante had the technical expertise required to improve the existing power plant's operations and successfully build new geothermal generation capacity. Géothermie Bouillante doubled the average yearly availability of the existing power plant by improving its automatic control system and steam gathering system and replacing its electromechanical equipment. In 2000, Géothermie Bouillante built a second power plant (10 MW) with three production wells, which was completed in 2003.[113] This second power plant has generated €60 million in savings to Guadeloupe customers in nine years.

Géothermie Bouillante's successful development of Guadeloupe's geothermal resources and operation of the power plants resulted in the government awarding it a new concession contract in 2009. This concession authorizes Géothermie Bouillante to carry out further exploratory drilling and production drilling and to build and operate additional geothermal power plants in the Bouillante geothermal field. Géothermie Bouillante plans to develop a third geothermal power plant in the near future.[114]

8.4 Key Factors That Enabled Geothermal Development in Guadeloupe

Guadeloupe has been able to successfully develop 15 MW of geothermal generation. The success of Guadeloupe's geothermal development can be attributed to the active role played by government-owned companies and, in particular, to the technical expertise of Géothermie Bouillante. In particular, the following three factors were key for the successful development of Guadeloupe's resources:

- **Technical expertise of Géothermie Bouillante—**Under the project structure of the first phase, EDF did not have the technical expertise required to operate and maintain the power plant successfully. Géothermie Bouillante had the technical expertise needed to improve the existing plant's operations and to build new generation capacity.
- **Guadeloupe used a phased approach for project development—**In Guadeloupe, the geothermal field has been developed using a phased approach. This phased approach allowed the government to apply lessons learned during the implementation of the project and to modify the project's structure.
- **The government invested in geothermal development—**The government has shown a strong commitment to the development of Guadeloupe's geothermal resource and has played an active role in its development. Although there was significant private participation during the exploration work carried out in the 1970s and production drilling and operation in the 1980s, publicly owned companies have played a key role in the development of Guadeloupe's geothermal resources. In addition, various government entities have provided financial support for geothermal development. These entities including the Guadeloupe regional government, the French Environment and Energy Management Agency (Agence de l'Environnement et de la Maîtrise de l'Energie, or ADEME), and the European Commission.[115]

113. International Geothermal Association, *IGA News: Newsletter of the International Geothermal Association*, Quarterly 39 (January–March 2000): 10–11.

114. F. Demarcq, R. Vernier, and B. Sanjuan, "Situation and Perspectives of the Bouillante Geothermal Power Plant in Guadeloupe, French West Indies" (Deep Geothermal Days, Paris, April 2014), accessed November 20, 2014, https://hal-brgm.archives-ouvertes.fr/hal-00945589.

115. International Geothermal Association, *IGA News: Newsletter of the International Geothermal Association,* Quarterly 39 (January–March 2000): 10–11.

Part B: PPP Strategy for Geothermal Development in the Eastern Caribbean

In Part B, we present our recommended strategy for developing geothermal resources through PPPs in the five Eastern Caribbean states. We first present the barriers to geothermal development in the countries in our study. Based on that, we then recommend a PPP strategy for developing geothermal resources in the region that addresses these barriers. Finally, we justify the proposed strategy by describing the estimated economic benefits that the region will gain from developing its geothermal resources. To reach our recommendations, we structured Part B as follows:

- **Barriers to Geothermal Development in the Eastern Caribbean States** (Section 9.1)—We provide an overview of the barriers faced by the countries in our study in developing their geothermal resources. We find that the countries in our study face high capital costs, high uncertainty, lack of access to credit at affordable rates, and lack of technical expertise in developing geothermal energy projects.
- **Proposed PPP Strategy for Geothermal Development** (Section 9.2)—Based on our findings in Sections 10–15, we recommend that the multilateral development banks and donors support the ongoing geothermal projects through PPPs and establish a fund to finance investments in geothermal energy in the Eastern Caribbean. In this section, we describe the recommended PPP structure and how PPPs can support the deployment of geothermal energy. We also present the financing needs of the projects in each country and describe how the Fund should be structured to support those financing needs and mitigate the risks identified in Section 9.1.
- **Expected Economic and Financial Benefits of Implementing the Proposed Strategy** (Section 9.3)—In this section, we justify our proposed strategy by presenting the economic benefits that the region will gain by developing its geothermal resource. First, we assess the aggregate net economic benefits that the region will gain if the proposed strategy is implemented. We then assess the competitiveness of the geothermal plants with other generation technologies by comparing their levelized costs. We also present the PPA rates that private investors need to earn to make the projects bankable and find that they are feasible to implement. Lastly, we estimate the reductions in customer tariffs and fossil fuel imports that will result from introducing geothermal generation.

9 Strategy for Geothermal Development

The five Eastern Caribbean countries of our study have significant geothermal potential that has not yet been developed. In this section, we present our proposed strategy to enable the development of geothermal power in the five countries. Based on our analysis in Sections 10–15, we recommend multilaterals establish a Fund to support projects that are already in progress in the five Eastern Caribbean countries through PPPs. The Fund will address the main barriers to geothermal development outlined in Section 9.1. The Fund would provide different types of funding that help mitigate the risks present in each stage of geothermal development. We explain the proposed strategy in detail in Section 9.2 and the expected economic and financial benefits of implementing the proposed strategy in Section 9.3.

9.1 Barriers to Geothermal Development in the Eastern Caribbean States

The five Eastern Caribbean countries in our study have enough potential for geothermal power to meet their baseload demand. With the use of geothermal energy, these countries could significantly lower their electricity prices, which are among the highest in the world, and reduce greenhouse gas emissions. The five countries in our study are at different stages of development for their geothermal resources; overall, the region has advanced slowly towards exploiting its geothermal potential.

The four largest barriers to geothermal development for electricity generation in the Eastern Caribbean are:

- High capital costs;
- High uncertainty, especially in the early stages of development;
- Lack of access to credit at affordable rates; and
- Lack of technical expertise in developing geothermal energy projects.

The first barrier is high capital costs. The investment required to develop a 10 MW geothermal plant is about US$87 million[116], which is difficult for governments in the Eastern Caribbean to finance without outside support. As a result, a combination of donor and private financing, as well as government funding, will be necessary to develop geothermal energy in the Eastern Caribbean.

The second barrier is high uncertainty, especially at early stages of development, and for private sector developers in particular. The possibility of investing about US$20 million[117] for surface exploration and exploratory drilling without any return typically means that private investors will not risk investing in these early stages. Government and donor support is often needed.

The third barrier is that Eastern Caribbean governments must pay a premium for commercial financing, as do private investors operating in these countries, due to high country risk. For example, most Eastern Caribbean countries are not rated by the top three international credit ratings agencies, while those that are, rate below investment grade.

The fourth barrier is that Eastern Caribbean governments do not have the technical expertise needed to develop geothermal energy projects. In addition, the size of the proposed geothermal projects in the Eastern Caribbean countries is small, which means that governments have trouble attracting large investors with vast technical expertise. Furthermore, the governments may not have the skill sets needed to evaluate proposals and successfully negotiate with potential project developers without outside support. For example, the Nevis Island Administration (NIA) originally partnered with West Indies Power, a geothermal developer with limited experience in developing geothermal energy projects. In 2013, the NIA had to cancel its contract with West Indies Power because of delays in beginning production drilling due to insufficient capital (see Section 14.3.2).

116. IDB, "Sustainable Energy Facility (SEF) for the Eastern Caribbean: Loan Proposal RG-L1071, RG-G1009, and RG-G1004" (2015), accessed December 2, 2015, http://www.iadb.org/en/projects/project-description-title,1303.html?id=RG-L1071; Magnus Gehringer and Victor Loksha, *Geothermal Handbook: Planning and Financing Power Generation* (Washington, DC: The International Bank for Reconstruction and Development, Technical Report 002/12, June 2012), accessed October 22, 2014, http://www.esmap.org/sites/esmap.org/files/DocumentLibrary/FINAL_Geothermal%20Handbook_TR002-12_Reduced.pdf.

117. IDB, "Sustainable Energy Facility (SEF) for the Eastern Caribbean: Loan Proposal RG-L1071, RG-G1009, and RG-G1004" (2015), accessed December 2, 2015, http://www.iadb.org/en/projects/project-description-title,1303.html?id=RG-L1071.

9.2 Proposed PPP Strategy for Geothermal Development

We recommend establishing a Fund to support the development of ongoing geothermal projects through PPPs to deploy geothermal energy in the five Eastern Caribbean states in our study. The strategy has two main components. First, we recommend implementing the geothermal project through PPPs. Second, we recommend the multilaterals establish a Fund as a vehicle to help finance the geothermal projects that are already in progress.

The PPP strategy addresses the barriers to geothermal development identified in Section 9.1 and enables projects that generate economic benefits for the five Eastern Caribbean countries in our study. Specifically, developing geothermal energy through PPPs allows governments to attain three major benefits:

- PPPs can help increase the funds available for geothermal projects by channeling private, public, and multilateral resources. It helps address two of the barriers discussed in Section 9.1: high capital costs and lack of access to credit at affordable rates. The combination of high capital costs of the geothermal projects and the limited fiscal space of governments means that the Eastern Caribbean countries lack sufficient funds to fund geothermal projects without other sources of financing.
- PPPs can help avoid project delays and help ensure that once the power plants are built they are efficiently managed. Studies have shown that the private sector is usually more efficient and effective at managing infrastructure construction and at service delivery.[118] In addition, the private sector has the necessary expertise to drill the wells and build and operate the plants, which is another of the barriers presented in Section 9.1.
- PPPs can also improve maintenance of infrastructure assets, which means that the forecasted generation and financial and economic returns of the geothermal projects are more likely to be realized. The PPP structure includes developing a special purpose vehicle (SPV) that would build, own, and operate the geothermal plants, which gives the SPVs incentive to ensure that the geothermal plants are adequately built and maintained.

The PPP strategy also contributes to developing geothermal projects that generate economic benefits for the Eastern Caribbean states. Electricity customers in the countries see high electricity tariffs and high volatility in their monthly bills.[119] The five countries have small, isolated electricity markets. That means that these countries lack the scale necessary to import cheaper fossil fuels for electricity generation, such as natural gas. As a result, they are dependent on costly imported liquid fossil fuels for electricity generation and electricity prices are high. High electricity prices hinder economic growth and high public sector energy bills drain public resources. Limited borrowing capacity, as implied by the countries' debt-to-GDP ratios averaging 86 percent, limits the governments' ability to invest in sustainable energy technologies and diversify the energy matrix. Therefore, the proposed PPP strategy will help attain these economic benefits (see Section 9.3):

- Reductions in generation costs and CO_2 emissions from electricity generation due to introducing geothermal generation that displaces diesel-based generation
- Reductions in electricity tariffs if savings in generation costs are passed on to end users
- Reductions in fuel oil imports due to introducing geothermal generation, which will have a positive impact on the national accounts of the Eastern Caribbean countries

In this section, we first explain in more detail our recommended strategy of implementing ongoing geothermal projects through PPPs. We first present the general recommended PPP structure (Section 9.2.1), followed by the specific recommended structures for each country (Section 9.2.2). Based on our review of the planned geothermal projects, we then estimate the total financing needs of each of the countries (Section 9.2.3), and present the characteristics of the Fund (Section 9.2.4). Finally, we present an overview of the risks prevalent in the geothermal projects and recommended actions to mitigate these risks (Section 9.2.5).

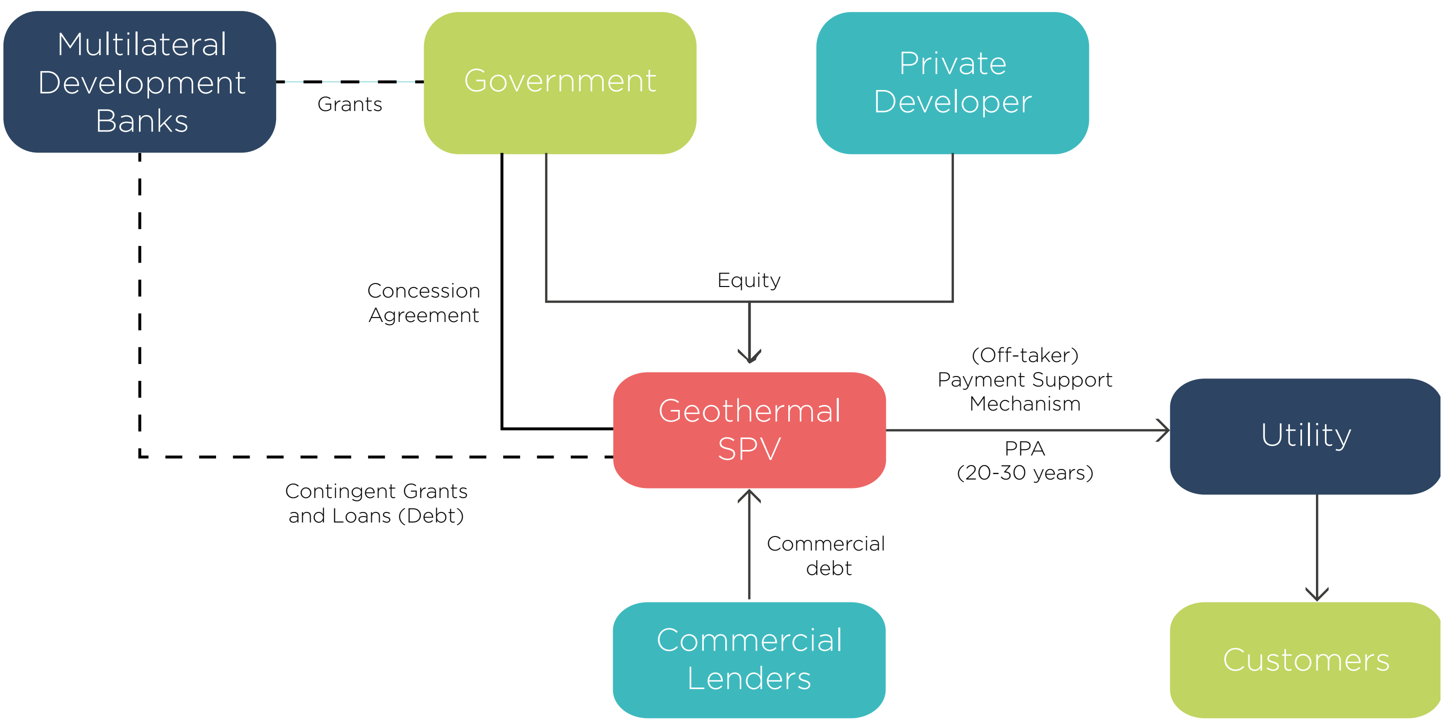
118. World Bank Institute, PPIAF, "Public Private Partnerships: Reference Guide," Version 1, February 2012.

119. In 2014, the average electricity tariff for the EC countries in this study was US$0.34/kWh. By comparison, in the United States of America (US), the average tariff was US$0.12/kWh. Source for US average tariff: U.S. Energy Information Administration, "Electric Power Monthly," August 26, 2015, accessed September 22, 2015, http://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_03. Source of average tariff of EC countries: CARILEC, *2014 Average Tariffs in EC Countries* (2015).

9.2.1 The recommended PPP structure

The recommended PPP structure would allow the governments to use private sector knowledge, resources, and financing, as well as multilateral funding, to develop geothermal resources. Under the recommended PPP structure **(Figure 9.1),** the government and a qualified private developer (or a consortium of private companies) would establish an SPV. The SPV would be granted a concession for developing the geothermal resource and building, operating, and maintaining the geothermal power plant. The SPV would sell all electricity generated by the geothermal power plant to the vertically integrated utility in the country under a PPA. The geothermal project would be financed through a mix of debt and equity. The owners of the SPV would provide equity capital. Debt would be provided by commercial banks and multilateral development banks (the Fund).

FIGURE 9.1 Recommended Project Structure for Geothermal Projects



The Fund would play a significant role in financing the projects and helping mitigate projects' risks. The Fund would provide different types of support, tailored to the stage of development of each geothermal project. Support would take the form of technical assistance, grants, contingent grants, and concessionary loans. Grants and contingent grants should be directed towards the riskier, earlier stages of geothermal development. Concessionary loans (debt) would be directed towards the production drilling and construction phases, which present reduced resource risks to investors (see more details in Section 9.2.4).

For some projects, lenders or equity investors might require an additional mechanism to enhance the quality of the cash flows of the geothermal projects. The enhancement mechanism could be a payment support mechanism that backs the utility's payments for the PPA. That support mechanism would reduce the risk of the project's revenues and, thus, make the project more bankable and appealing to investors. The payment support mechanism can be implemented in various ways. Some of the options include:

- Establishing a liquidity facility, such as a trust fund or escrow account. This involves setting up a single-purpose account that is managed by a third party. The utility would make periodic contributions to the bank account, and these funds would be exclusively used to pay the SPV in the event that the utility does not meet its payments under the PPA.
- Purchasing a third-party guarantee mechanism offered by a donor or financial institution. Examples of financial institutions that offer guarantees include the Multilateral Investment Guarantee Agency, which provides coverage for breach of contract.

9.2.2 The Fund should support the development of ongoing geothermal projects through PPPs

By supporting the geothermal projects that are already underway in the countries of our study, the Fund will build on the work that has already been done in each country. To identify the most appropriate PPP structure for each project, we answered the following five questions:

- Has a project structure been planned? Have any agreements been signed?
- Has the government contributed funds to the project?
- Who owns the electric utility? Is it fully state-owned, fully privately owned, or is it jointly owned by the government and private investors?
- Is the electric utility interested in developing the geothermal project?
- Has an SPV been established, and who owns it?

By answering these questions to determine the best PPP structure for each project, we ensured that:

- The PPP structures build on the existing work of the governments, donors, and private investors;
- The governments and private investors can recover their investments; and
- The PPP structures can be implemented in the existing market conditions.

The recommended PPP structure for each country is based on the principles of our general recommended PPP structure (presented in Section 9.2.1), but incorporates some of the specific characteristics of the projects that are already in place in each country. Exceptions to this include the projects in Saint Kitts and Nevis, Dominica, Saint Lucia, and Grenada. In Dominica, Saint Lucia, and Grenada, the governments have not yet announced a final project structure. For these countries, we recommend project structures similar to the one shown in Figure 9.1 with small differences (see below). In Saint Kitts and Nevis, the NIA has finalized the planned project structure for the first phase of its geothermal project to serve Nevis. However, we would recommend the government and NIA establish a jointly owned SPV with the private developer. This would allow the SPV to access concessionary funding from the multilateral development banks, reduce the cost of capital, and allow the government and NIA to be more invested in the project and ensure project benefits are also shared with end users. Since the NIA already signed some project agreements for the first phase of the project, the second phase (to serve Saint Kitts) could be structured as a continuation of the project that is already in place.

Below, we summarize our recommended PPP structure for each country. We also include a reference to the section of this report where we explain the recommended PPP structure in depth. Since total available funding provided by the multilateral development banks for the Fund would probably be less than the total financing needs, it is expected that only the more immediate stages of the geothermal projects would be able to access funding. That means that the Fund would likely not cover the second phases of the projects in Dominica and in Nevis (the phases for export). Those later stages of the projects could be financed by later phases of the Fund, after the first phase has been successfully implemented.

- **Saint Vincent and the Grenadines**—An SPV, jointly owned by the government and private partners, would develop a 10 MW to 15 MW geothermal project. The project has strong political support and the government plans to develop the project with Light and Power Holdings and Reykjavik. These companies began surface exploration in November 2013 and completed pre-investment studies by early to mid-2015. The parties finalized a detailed technical, project, and business plan that will serve as the foundation for the project agreements. The SPV would have a concession agreement to further explore the resource and design, build, own, operate, and finance the geothermal generation plant. The SPV would sell electricity to Saint Vincent Electricity Services Limited (VINLEC) under a PPA. Since VINLEC is state-owned, we recommend an additional support payment mechanism be included to back VINLEC's payments under the PPA. In Section 11.3, we present our recommendations for the PPP structure in further detail.
- **Dominica**—The geothermal project in Dominica has two phases, which have similar PPP structures. In both phases, the government and private partners would establish an SPV that they would jointly own. The private partners have not been selected, but the French Development Agency (Agence Française de Développement, or AFD) and World Bank have said they may fund Phase 1 of the project. The government would sign concession agreements with an SPV. The concession for the first phase would be to design, build, own, operate, and finance a 10 MW geothermal generation plant for

local consumption; the concession for the second phase will include all those activities in addition to carrying out production drilling. The second phase is for a 110 MW power plant to export electricity. The SPVs would sign a PPA with the utilities (off-takers). The PPA for the first phase will be signed with Dominica Electricity Services Limited (DOMLEC). The second phase will involve another PPA with EDF, the electric utility in Martinique and Guadeloupe, for exporting electricity to these two countries. In Sections 12.3 and 12.4, we provide our recommendations for the PPP structures of both phases in further detail.

- **Grenada**—An SPV, jointly owned by the government and private partners, would develop a 10 MW geothermal project. The recommended project structure would consist of three agreements: a resource agreement, a concession contract, and a PPA. The government would grant a resource agreement to a private developer to explore and use the geothermal resource. The government would then sign a concession agreement with the SPV to design, build, own, operate, and finance the power plant. Finally, the SPV would sign a PPA with Grenada Electricity Services Limited (GRENLEC), the off-taker. We recommend that the government maintain communications with GRENLEC as a potential partner in establishing the SPV. In Section 13.3, we provide our recommendations for the PPP structure in further detail.
- **Saint Kitts and Nevis**—The geothermal project in Saint Kitts and Nevis has two phases: building a power plant to serve Nevis (Phase 1), and building a power plant to serve Saint Kitts (Phase 2). We recommend that both phases be implemented as part of one phase/project. This approach would leverage the relationships and work carried out for Phase 1 and expedite the process for completing Phase 2. The NIA, the Government of Saint Kitts and Nevis, and the private developers would establish SPVs that they would jointly own. The government would probably not be involved in the SPV for the first phase of the project but would be for the second phase. The NIA would sign a concession agreement with the SPV. The concession agreement would be to carry out exploration drilling, production drilling, and designing, building, owning, operating, and financing the geothermal generation plant. The SPV would sign a PPA with Nevis Electricity Company Limited (NEVLEC) and Saint Kitts Electricity Company (SKELEC), the utilities that serve Nevis and Saint Kitts respectively. Since both NEVLEC and SKELEC have poor operational and financial performance and are state-owned, we recommend that a payment support mechanism be included in the project structure to back their payments to the SPVs. In Section 14.4, we provide our recommendations for the PPP structure in further detail.
- **Saint Lucia**—The government has identified a preferred developer and has an agreement with Ormat Technologies to carry out surface exploration and exploratory drilling. However, the government and its private partners have not yet defined the project structure that will be used to carry out the later stages of the project. We recommend that the PPP structure for the later stages include an SPV jointly owned by the government and a private geothermal developer. The PPP structure would consist of three agreements: an exploration concession, a concession agreement for field development, and a PPA. The government previously granted an exploration concession to the United Network of the Eastern Caribbean (UNEC) that would remain in place. The government would sign a concession agreement with the SPV to develop the resource (production drilling) and design, build, own, operate, and finance the power plant. The SPV would also sign a PPA with Saint Lucia Electricity Services (LUCELEC) under which it would sell the electricity generated. If Ormat does not carry out the field development stage, the project structure should allow Ormat to be compensated for any funds invested in the exploration phases. In Section 15.3, we provide our recommendations in detail.

9.2.3 The total financing needs: the estimated costs of the PPP geothermal projects

Table 9.1 presents the estimated costs for developing the proposed geothermal projects in each country in our study. The table shows that the estimated costs for developing geothermal projects vary significantly across countries.

The costs depend on the geothermal development stages that still need to be carried out and the size of the power plant. The smallest and largest costs are for the two phases of the geothermal project in Dominica.

Table 9.1 Estimated Financing Needs of Geothermal Projects by Stage

	Pre-Investment (Surface Exploration Studies)	Pre-Investment (First Two Slim-Hole Drillings)	Exploration (Test Drilling)	Field Development (Production Drilling and Power Plant)	Transmission and Distribution (T&D) and Access Roads	**Total**
Saint Vincent and the Grenadines (10 MW)	Completed	Will not be done	US$14M	US$66M	US$16.3M	**US$96.3M**
Dominica Phase 1 (10 MW)	Completed	Completed	Completed	US$52M	US$15M	**US$67M**
Dominica Phase 2 (110 MW)	Completed	Completed	Completed	US$531M		**US$531M**
Grenada (10 MW)	Completed	US$6M	US$14M	US$66M	US$16.3M	**US$102.3M**
Nevis (10 MW)	Completed	Completed	US$14M	US$66M	US$12.1M	**US$92.1M**
Saint Kitts (25 MW)	Completed	Completed	Completed	US$120M	US$16.3M	**US$136.3M**
Saint Lucia (20 MW)	Completed	US$6M	US$14M	US$132M	US$16.3M	**US$168.3M**
Subtotal without Dominica 2 and Saint Kitts	**US$0M**	**US$12M**	**US$56M**	**US$382M**	**US$76M**	**US$526M**
Total	**US$0M**	**US$12M**	**US$56M**	**US$1,033M**	**US$92.3M**	**US$1,1993M**

Source: Financial model that accompanies this report. Based on information from: IDB, "Sustainable Energy Facility (SEF) for the Eastern Caribbean: Loan Proposal RG-L1071, RG-G1009, and RG-G1004" (2015), accessed December 2, 2015, http://www.iadb.org/en/projects/project-description-title,1303.html?id=RG-L1071; Magnus Gehringer and Victor Loksha, Geothermal Handbook: Planning and Financing Power Generation (Washington, DC: The International Bank for Reconstruction and Development, Technical Report 002/12, June 2012), accessed October 22, 2014, http://www.esmap.org/sites/esmap.org/files/DocumentLibrary/FINAL_Geothermal%20Handbook_TR002-12_Reduced.pdf; Nexant, Caribbean Regional Electricity Generation, Interconnection, and Fuels Supply Strategy (March 2010), 1-38, accessed April 27, 2015, http://www.caricom.org/jsp/community_organs/energy_programme/electricity_gifs_strategy_final_report_summary.pdf.
Notes: The Field Development phase includes production drilling and the construction of the power plant. The costs of the Dominica Phase 2 and Saint Kitts projects include the costs of interconnection cables.

In the following sections, we describe how the Fund should be structured, and the type of support that it would provide both at a regional level and at a country level.

9.2.4 The types of support and the phases of the Fund

The Fund should provide different types of support and funding based on the current stage of geothermal development in each country. As such, the Fund allows multilateral development banks to tailor the support they provide to the specific needs of each country. By offering different types of funding and support, the Fund allows countries to address the four barriers discussed in Section 9.1. The Fund should be implemented in two or three phases. Phasing the fund allows the multilateral development banks to apply lessons learned and improve the execution of the Fund in the later phases. Since the size of funding needs is significant, phasing the Fund also allows multilaterals to phase their own mobilization of capital and help mobilize funding from additional sources.

We explain our recommendations in further detail below.

The Fund should be phased to finance the next stages of geothermal development

Phasing the Fund would allow the multilateral development banks and other financiers to mobilize the contributions they make in phases and apply lessons learned in the later phases. This phased approach reduces the risk that the multilateral development banks face in providing capital to the Fund and the projects.

The five countries in our study have made different levels of progress towards developing their geothermal resources. While some have advanced considerably towards developing their resources (such as Dominica and Nevis), others have not advanced beyond the pre-investment stage. The first phase of the Fund should be directed towards supporting the immediate next stages of the geothermal project in each country. We find the Fund may be able to support the early stages of geothermal development in Saint Vincent and the Grenadines, Grenada, and Saint Lucia, and the later stages of geothermal development and project development in Nevis and Dominica.

The Fund should provide different types of support and financing

The Fund should provide a combination of technical assistance, grants, contingent grants, and concessionary loans. Grants and contingent grants should be directed towards the riskier, earlier stages of geothermal development: surface exploration and exploratory drilling. Concessionary loans should be directed towards the production drilling and construction phases, which present reduced risks to investors.

These different types of funding would allow the countries to mitigate the risks they face in three ways:

- Grants and contingent grants support the early stages of geothermal development (surface exploration and exploratory drilling), which will reduce the investment risk when the resource is highly uncertain.
- Concessional loans support the later stages of geothermal development (production drilling and construction), when the risks faced by investors are lower because the resources have been proven. Concessional loans will give governments and private investors access to financing at a lower cost than they would have access to through commercial financing. In addition, concessional loans will support governments and private investors in financing the high capital costs of building a geothermal power plant.
- Technical assistance would support the geothermal projects throughout all stages. Among other potential uses, technical assistance would help governments in evaluating and negotiating with potential project developers. This support helps ensure that governments select private partners that have the necessary technical expertise to develop the geothermal project successfully. It also helps ensure that the terms agreed to between the government and private companies are beneficial to both the country and the private partner.

The type of funds allocated to each country would be based on the progress that each country has made in developing its geothermal resources, the financing needs, and the other available sources of funding. **Table 9.2** shows the types of funding that would be needed in each of the countries based on their current stage of geothermal development.

Table 9.2 Potential Types of Support for Each Country in the First Phase of Fund

Project	Development Stage	Potential Type of Support
Dominica Phase 1	Production well drilling completed	Concessional loan to build power plant
Grenada	Surface exploration needed to estimate resource ongoing	Grant and contingent grants to fund surface exploration
Nevis	Slim-hole drilling estimates good-quality resource	Grant and concessional loan to fund exploratory drilling and production drilling
Saint Lucia	Further surface exploration needed to confirm resource ongoing	Further surface exploration needed to confirm resource ongoing
Saint Vincent and the Grenadines	Surface exploration completed in 2015, will move directly to exploratory drilling without drilling slim-hole wells	Grant and concessional loans to finance exploratory drilling

All ongoing geothermal projects in the Eastern Caribbean would, in principle, be eligible for funding from the first phase of the Fund. However, since the total financing needs are likely higher than the available funding, the first phase of the Fund should channel funds to the more immediate stages of projects. Therefore, it is expected that the second phases of the projects in Dominica and Nevis (the phases for export) would not be financed by the first phase, but later phases of the Fund.

The Dominica (Phase 1) project would only need concessional loans. Dominica has made the most progress in exploring and developing its geothermal resources and has already confirmed its resource. As such, the risk faced by potential investors is lower and grant financing is not necessary. Nevis and Saint Vincent and the Grenadines have also advanced significantly, but both countries have yet to confirm the quality of their resource. As such, Nevis and Saint Vincent and the Grenadines would need a combination of grants and concessional loans to carry out exploratory drilling and subsequently production drilling. In contrast, Grenada and Saint Lucia have advanced more slowly towards developing their geothermal resource. We estimate that in the short to medium term they would need grants to complete their pre-investment and exploration stages.

We expect that equity and commercial debt will play a significant role in financing the projects in the subsequent phases of the Fund. This will be possible because the first phase of the Fund would mostly be directed to the earlier stages of geothermal development, when risks are higher. Therefore, the risks related to the uncertainty of the resource will be reduced in the second and third phases, making investing in the geothermal projects more attractive for investors and lenders.

9.2.5 The key risks of the strategy and the mitigation measures

The risks faced in implementing the strategy are directly related to the risks of the geothermal projects in the Eastern Caribbean.
The recommended geothermal projects face numerous risks. However, the type and severity of the risks varies across countries depending on the progress achieved to date in developing the geothermal resource. While countries that are in early phases of developing their geothermal resource face greater risks (predominantly resource risk), those countries that have completed exploratory drilling still face some risks that should be addressed (for example, construction risk).

Table 9.3 provides an overview of the types of risks prevalent in the geothermal projects in our study. The allocation of risks may vary from country to country, but the table reflects the recommended allocation principles.

Table 9.3 Risks Allocation and Mitigation for the Recommended PPP Structures

Risk	Party That the Risk Is Assigned To	Proposed Measure for Mitigating the Risk
Market, Demand, or Volume Risk	Utilities	The PPA between the SPV and the utility transfers the demand risk to the utility, who in turn can ensure the demand because it is the only utility operating in the country.
Resource Risk	SPV and the multilateral development banks	Selecting a project developer with the necessary technical expertise would be a key for reducing resource risk. Contingent grants for exploratory and production well drilling can help reduce costs and thus risks.
Construction Risk	SPV and, possibly, the construction company that builds the plant	The SPV can hire a company to build the plant and incorporate penalties if the plant is not completed on time or milestones are not achieved as contractually planned.
Technical Risk	SPV	The risk for the geothermal power plant is low because this is a proven technology. However, for projects that include exporting electricity, the risk is higher due to the use of interconnection cables. In those cases, detailed feasibility studies need to be carried out.
Operating Risk	SPV	Since the governments do not have the technical expertise to operate the geothermal power plant, the private partner should be qualified and bring the required expertise. The operating contract can be designed as a performance-based contract that rewards or penalizes the operator based on results.
Political and Social Risk	SPV and the government	The participation of the governments in the SPVs and multilateral development banks in the projects reduces the projects' political and social risk. Also, if the electricity prices are reduced through the use of geothermal energy, the public will likely support the project. In addition, the government and the SPV should carry out consultations with stakeholders to ensure their views and concerns are taken into account, from project design to implementation.
Environmental Risk	SPV and the government	This risk can be reduced by carrying out environmental impact assessments (EIA). The EIA will allow the governments and private partners to assess the risk of the geothermal project and propose an action plan to mitigate the risks identified.
Financing Risk	SPV and the government	The financial risk for the project is reduced with the PPA, and the payment support mechanism for the utility's payments under the PPA. Financing from development banks reduces the cost of capital, helps mitigate risks of the earlier stages of the projects, and reduces the likelihood that SPVs will not have access to financing.
Regulatory Risk	The government	The government is responsible for making any necessary changes to the legal and regulatory framework to enable the development of the project; for example, changes to the tariff to allow for cost recovery of geothermal generation. In addition, and because those changes take time, the parties to the project can draft clear rules governing the sustainable exploitation of the resource and the operation of the power plant in the project agreements (concession, PPA, and others).

Table 9.3 is meant to present an overall picture of the different types of risks prevalent in the geothermal projects in our study. However, the severity of risk and recommended mechanism to mitigate these risks will vary by geothermal project. For this reason, we do not include the impact of the risks. Instead, we include that information for each project in the country sections (Sections 11–15). For example, the resource risk for the geothermal project in Dominica is low because the resource is already confirmed. As such, we do not recommend specific measures to mitigate this risk for Dominica. However, the resource risk is high for all projects that have not completed exploratory drilling. On the other hand, the market, demand, and volume risk is common across all geothermal projects, and we propose measures to address this risk for all projects. Our recommendations to mitigate this risk include signing a PPA and using a payment support mechanism to back the utility's payments. This last recommendation is particularly relevant for utilities that have poor operational performance.

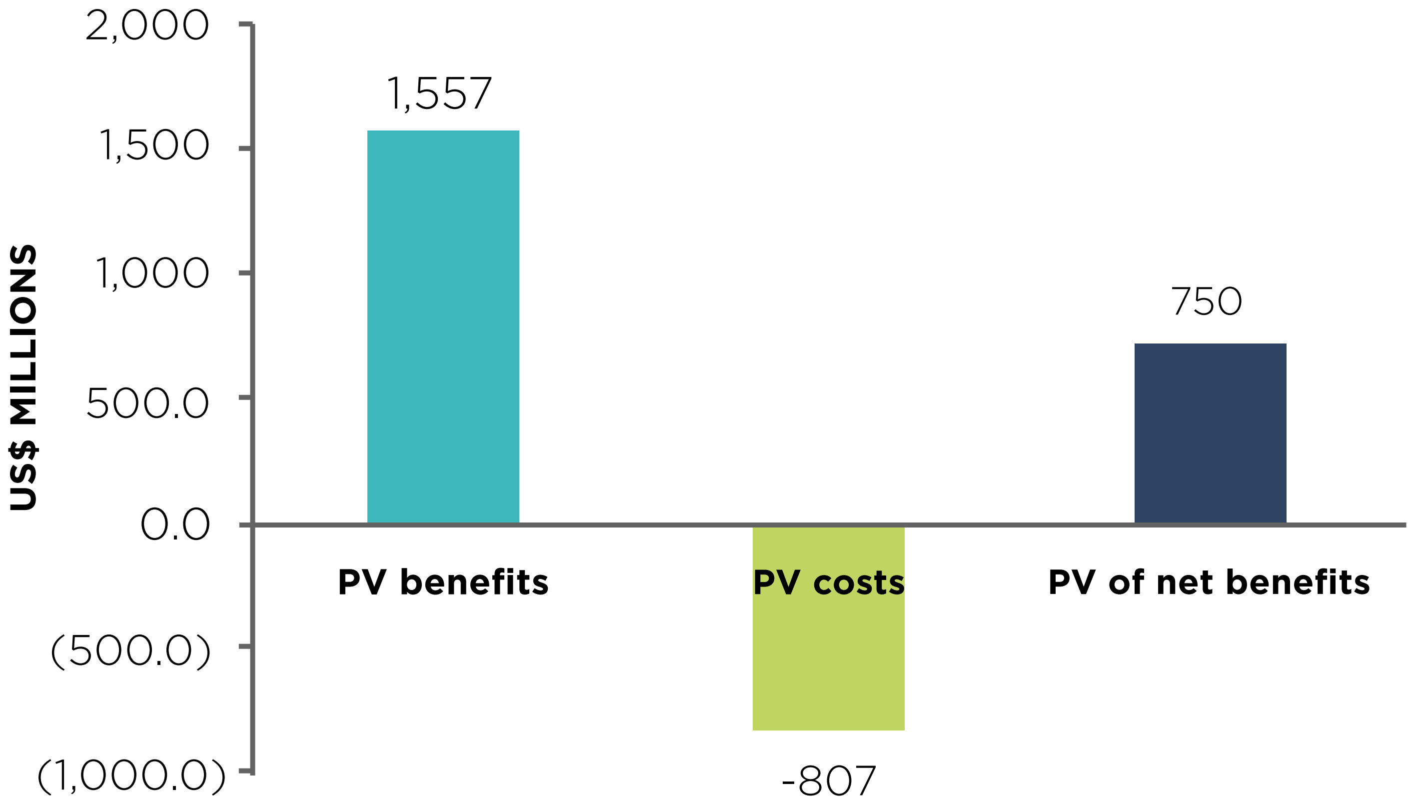
9.3 Expected Economic and Financial Benefits of Implementing the Proposed Strategy

We assess the economic and financial benefits of implementing the proposed strategy. We determine that implementing the proposed strategy results in aggregate net economic benefits to each country and the region (Section 9.3.1). We also assess the competitiveness of the geothermal generation with other technologies. We find that the levelized cost of geothermal generation is significantly lower than the current cost of generation in the beneficiary countries and is also lower than many of the alternative energy technologies in the Eastern Caribbean (Section 9.3.2). Then we estimate the PPA rates that allow the geothermal projects to cover their costs, service their debts, and provide equity investors with a 15 percent rate of return. We show that these PPA rates are feasible to implement because they are significantly below the current costs of service (Section 9.3.3). Lastly, we quantify the macroeconomic impact of developing geothermal in the region. We do so by estimating the reduction in the average tariff to customers and the reduction in fossil fuel imports in each country (Sections 9.3.4 and 9.3.5).

9.3.1 The geothermal projects generate net economic benefits to the countries and the region

Our assessment of the economic costs and benefits (cost-benefit analysis) of the geothermal projects shows that the projects are economically viable and increase social welfare. This means that the implementation of the Fund will allow the development of geothermal projects that generate net economic benefits for each of the countries and the region as a whole. In particular, the geothermal projects reduce the generation costs and the level of emissions in the region. The first phases of the geothermal projects (which exclude Dominica 2 and Saint Kitts) reduce the level of emissions in the region by 338,421 tCO_2 each year; including the second phases, the reductions reach 789,648 tCO_2 each year. Figure 9.2 shows that the present value (PV) of the net economic benefits of the seven projects in the five countries is US$750 million.

FIGURE 9.2 Net Economic Benefits of the Geothermal Projects in the Five Eastern Caribbean Countries



To arrive at this result, we carry out a cost-benefit analysis by estimating the economic costs and benefits of all the geothermal projects. We estimate the economic costs and benefits of the geothermal projects, for a period of 40 years, as follows:

- Our estimations of **economic costs** include the capital investments needed to complete the stages that are pending for the geothermal projects in each country. The stages that are pending depend on the status of each specific project (see Table 9.1 in Section 9.2.3 for an outline of the stages that are pending in each country). Since we do not have information on the amounts that have been invested in the past in the completed stages, we only include the capital expenditures (Capex) for the stages that are to be completed.
- Our estimations of **economic benefits** include the savings in generation costs and the benefits from reductions in CO_2 emissions. Generating electricity from geothermal resources costs less than generating electricity from fuel oil. Therefore, the countries will save in generation costs by replacing fuel oil generation with geothermal. In addition, geothermal generation produces less CO_2 emissions than fuel oil generation. Therefore, the countries will benefit from reductions in CO_2 emissions by replacing fuel oil generation with geothermal generation.

Appendix A shows in greater detail the methodology we followed for the cost-benefit analysis. See Sections 12.6.1, 13.5.1, 14.7.1, 14.8.1, and 15.5.1 for a detailed description of how we perform the cost-benefit analysis for each country.

Table 9.4 presents the economic costs and benefits of each of the seven projects and the net aggregated benefits for the region. Each of the geothermal projects has positive net economic benefits and therefore is economically viable. When aggregating the economic cost and benefits of the geothermal projects, we find that the aggregated net benefits are also positive. That means that the implementation of the Fund will allow the development of geothermal projects that generate net economic benefits for each of the countries and the region as a whole.

Table 9.4 Economic Costs and Benefits of the Geothermal Projects (US$ Million)

Project	PV Benefits (US$)	PV Costs (US$)	PV of Net Benefits (US$)
Saint Vincent and the Grenadines	99	80	19
Dominica Phase 1	111	61	50
Grenada	101	79	22
Nevis	97	78	19
Saint Lucia	179	128	51
Subtotal (projects supported by Phase 1 of the Fund)	**587**	**426**	**161**
Dominica Phase 2	819	307	511
Saint Kitts	152	75	78
Subtotal (projects supported by later phases of the Fund)	**971**	**382**	**589**
Total	**1,557**	**807**	**750**

Dominica (Phase 1) and Saint Lucia have the highest net economic benefits of the projects that will be implemented with funding from Phase 1 of the Fund. There are two reasons for this. First, Dominica has invested significantly in exploration and only needs to carry out the field development stage to complete its geothermal project. As a result, this project faces lower economic costs. Saint Lucia has the highest net economic benefit because the power plant is the largest of the projects with funding in Phase 1. This means that the fixed costs for the pre-investment stages are offset by larger economic benefits driven by a larger generation capacity.

Saint Vincent, Nevis, and Grenada have lower net economic benefits, but they are still positive. This is because these countries must complete the exploratory stage and their plant sizes are relatively small. Dominica Phase 2 and Saint Kitts have the highest net economic benefits because they are larger plants. However, they will be developed at a later date, so will be supported by the later phases of the Fund.

9.3.2 The levelized cost of energy indicates that geothermal is competitive with many other types of generation

We have calculated the levelized costs of the geothermal projects to assess the competitiveness of the geothermal plants with other technologies. We found that the levelized cost of geothermal generation is significantly lower than the current cost of generation in the beneficiary countries and is also lower than many of the alternative energy technologies in the Eastern Caribbean. The average levelized cost of the geothermal generation projects proposed in the strategy is US$0.118 per kWh, ranging from US$0.081 per kWh in Dominica Phase 2 to US$0.147 per kWh in Grenada. In contrast, the levelized cost of heavy fuel oil is higher.

For example, the average levelized cost of heavy fuel oil estimated for 2023 for Bahamas, Barbados, and Bermuda is US$0.17.[120] These countries have electricity sectors of similar size and make-up to those in the countries included in our study and so can be used as a reference for heavy fuel oil (HFO) levelized costs in the region.

We present the levelized cost for each project, our methodology for calculating the levelized cost, and the levelized cost of geothermal generation compared to other technologies.

120. These figures are Castalia estimates based on the financial statements included in the utilities' 2014 annual reports and the U.S. Energy Information Administration's 2015 oil reference price estimations. EIA, "Annual Energy Outlook 2015 with projections to 2040," April 2015, accessed May 23, 2016, http://www.eia.gov/forecasts/aeo/pdf/0383(2015).pdf.

Levelized cost for each geothermal project

The average levelized cost of the proposed geothermal projects in the beneficiary countries is US$0.118 per kWh. The levelized cost for the projects ranges from US$0.081 per kWh in Dominica Phase 2 to US$0.147 per kWh in Grenada. Table 9.5 shows the levelized cost for each of the geothermal projects.

Table 9.5 Levelized Cost of Geothermal Projects in the Countries of Study

Project	Levelized Cost (US$ per kWh)
Dominica Phase 1	0.097
Dominica Phase 2	0.081
Nevis	0.138
Saint Kitts	0.091
Saint Vincent and the Grenadines	0.138
Grenada	0.147
Saint Lucia	0.132
Average	**0.118**

The best estimate of the levelized costs would include the amounts that have been invested in the past (in the stages that have been completed) and the return that investors will require on those amounts. However, we don't have complete or reliable information on those amounts, so to calculate the levelized cost in this report we only include the investments (capital expenditures) that are required going forward.

Methodology for calculating the levelized cost

We calculated the levelized cost for each of the geothermal projects using the financial model used to assess the financial feasibility of the geothermal projects. The levelized cost is the per-kWh cost (in real dollars) of building and operating a generating plant over an assumed financial life. Key inputs to calculating levelized cost include capital costs, fuel costs, fixed and variable operations and maintenance costs, and financing costs.[121] To calculate the levelized cost for geothermal technology, we found the total of the capital cost recovery factor per kWh, and the operations and maintenance cost per kWh. The capital expenditures recovery factor is the annualized capital costs divided by the annual output. We then added the operations and maintenance costs per kWh. Unlike many other technologies, the variable operations and maintenance costs and fuel costs of geothermal generation plants is close to zero.

121. U.S. Energy Information Administration, "Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2014," April 2014, accessed December 11, 2014, http://large.stanford.edu/courses/2014/ph240/suresh2/docs/electricity_generation.pdf.

The calculation of the levelized cost for each geothermal generation plant relied on four key assumptions about the operation of the plant, which are consistent with the assumptions used in the financial model. **Table 9.6** presents each of these assumptions.

Table 9.6 Assumptions for Calculating the Levelized Cost of Geothermal Projects

Variable	Assumption
Capacity factor	85 percent
Useful life	40 years
Cost of capital	10 percent
Operations and maintenance cost per kWh	■ US$0.01 for Dominica Phase 2 ■ US$0.02 for all others
Capex	■ Dominica 1 US$67 million ■ Dominica 2 US$531 million ■ Grenada US$82.3 million ■ Nevis US$78.1 million ■ Saint Kitts US$136.3 million ■ Saint Lucia US$168.3million ■ Saint Vincent US$96.3 million

Notes: The operations and maintenance cost per kWh is lower for Dominica Phase 2 because of the size of the geothermal generation plant. The Capex includes costs for T&D and access roads.

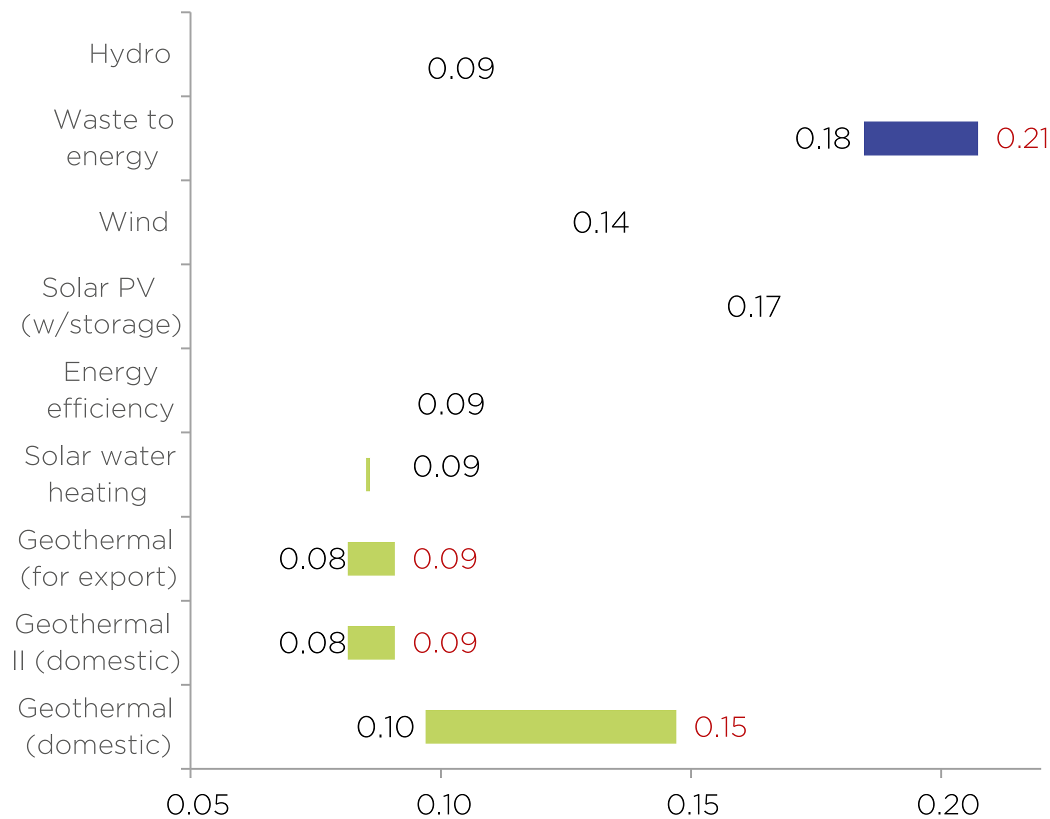
The differences in the levelized costs of geothermal generation are the result of differences in the:

- **Size of the geothermal generation plant**—The size of the geothermal plant affects the levelized cost in two ways. First, larger geothermal plants have higher total capital costs. However, larger plants generate more electricity, which can lead to a lower levelized cost. The impact of the size of the plant on the levelized cost will depend on which of these two effects has a larger impact.
- **Additional capital investment required to build the geothermal generation plant**—Projects that are in a later stage of development will require lower capital costs and, as a result, have lower levelized costs. It is important to note that the levelized costs that we calculated for each project only include the operations and maintenance costs, the financing costs, and the additional capital costs required to complete the geothermal investments. Since there were no estimates available for the investments already made for each of these projects, we were not able to include the previous investments in our analysis of levelized costs. Ideally, the levelized costs should include the full capital costs of the project so that technologies and projects can be more accurately compared. If additional information on previous and expected investments required is provided, we will refine this analysis in the next report.
- **Operations and maintenance costs**—The fixed operations and maintenance costs per kWh can change based on the size of the plant. We assumed that the operations and maintenance costs for Dominica Phase 2 is US$0.01 per kWh because of the size of the plant. This is lower than the fixed operations and maintenance costs that we assumed for the other plants, which was US$0.02 per kWh.

Competitiveness of geothermal energy versus other potential technologies

Figure 9.3 shows how the levelized cost of the geothermal projects proposed compares to the costs of other technologies. The competitiveness of geothermal generation with other technologies depends on the cost of each project and the size of the other generation technologies used. Depending on the project, geothermal generation can have a lower cost than on-shore wind, energy efficiency measures, hydro, and residential solar water heaters. For example, the average levelized cost of residential solar water heaters in the region is US$0.09, which is lower than the minimum levelized cost of geothermal of US$0.10 when only the first phases of the geothermal projects are considered.[122] However, when the second phases of geothermal projects are considered, the minimum levelized cost of geothermal at US$0.08 is the lowest of all the technologies presented in Figure 9.3. Geothermal generation is also always less expensive than solar CSP, small solar photovoltaic, and waste-to-energy. For example, the average levelized cost of waste-to-energy in the Organization of Eastern Caribbean States (OECS) countries is US$0.20, which is higher than the levelized cost of geothermal of all the countries in our study. However, the levelized cost of waste-to-energy ranges from a minimum of US$0.18 to a maximum of US$0.21.

FIGURE 9.3 Levelized Cost for Generation Technology (US$/kWh)



Source: IDB and Castalia, "Sustainable Energy in the Eastern Caribbean: Achieving an Unrealized Potential" (2015).

Note: "Geothermal (for export)" includes the 25 MW of Saint Kitts (the project will be located in Nevis for export to Saint Kitts), and the 100 MW of Dominica Phase 2 that would be directed to Guadeloupe and Martinique. "Geothermal II (domestic)" includes the 10 MW of Dominica Phase 2 that would be directed to Dominica, and "Geothermal domestic" includes these projects: Dominica Phase 1, Grenada, Saint Lucia, Saint Vincent and the Grenadines, and Nevis.

Other than large hydro, the introduction of the technologies with a lower levelized cost should have a limited impact on geothermal generation. The total generation available for each island from these technologies is relatively low and their introduction will displace diesel generation.

122. IDB and Castalia, "Sustainable Energy in the Eastern Caribbean: Achieving an Unrealized Potential" (2015).

9.3.3 PPA rates required to make the projects financially viable are feasible to implement

The PPA rates required to make the geothermal projects financially viable are feasible to implement, which improves the bankability of the geothermal projects. Our estimations show that the geothermal project allows the equity investors to earn a 15 percent real rate of return (base case) for PPA rates between US$0.09/kWh and US$0.19/kWh.[123] These PPA rates are the tariff at which the geothermal projects would need to sell each kWh of electricity to be able to cover their costs, service their debts, and provide equity investors with a 15 percent real return. As shown in Table 9.7, these PPA rates are feasible to implement because they are significantly lower than the costs of service from fuel oil generation currently in place.

Table 9.7 IRR to Equity Investors and PPA Rates for Geothermal Projects

US$/kWh	SVG	DOM	GRE	SKN Phase 1	SKN Phase 2	SL
PPA rate base case (15% return on equity)	0.16	Phase 1: 0.09 Phase 2: 0.12	0.19	0.14	0.15	0.17
Expected tariff with introduction of geothermal for base case	0.29	Phase 1: 0.24	0.34	0.23	0.23	0.30
Maximum PPA rate *(rate to still achieve a reduction in tariffs of 5–15%, reduction varies by country)*	0.18	Phase 1: 0.16 Phase 2: N/A	0.21	0.18	0.19	0.19
Current Tariff 2014	**0.35**	**0.37 (Phase 1)**	**0.37**	**0.32**	**0.32**	**0.32**

Sources: Cost of Service is based on annual reports from utilities (DOMLEC, 2014 Annual Report; GRENLEC, 2014 Annual Report; LUCELEC, 2013 Annual Report; VINLEC, 2013 Financial Statistics provided by the General Manager of VINLEC in December 2014) and CARILEC, 2014 Average Tariffs in EC Countries (2015). PPA rate and expected tariff with geothermal generation based on financial model that supports this report.

Notes: The IRR is Internal Rate of Return of the cash flows to equity investors. We assume a 15 percent real discount rate for equity cash flows. Dominica (DOM), Grenada (GRE), Saint Kitts and Nevis (SKN), Saint Lucia (SL), Saint Vincent and the Grenadines (SVG).

In fact, the expected tariffs with geothermal generation are below the current cost of service with fuel oil generation (see next section for the detailed estimation of expected tariffs). This result shows that the base PPA rates, which would allow the projects to cover all their costs and the equity investor to earn a 15 percent real rate of return, are feasible and therefore implementable.

Furthermore, there is some room (which varies by country) for slightly higher rates of return and PPA rates that would still result in reduced tariffs to end customers. The fact that the required PPA rates are feasible makes the geothermal projects more attractive for investors, therefore improving project bankability and the likelihood that their benefits will be realized.

9.3.4 The geothermal projects will reduce customers' tariffs

The development of geothermal projects will have a positive impact on the economies of the beneficiary countries. The main and most tangible benefits are the reduction in the average tariff to customers and also the reduction in the importation of fuel oil. We estimate that the implementation of the proposed projects will lead to an average tariff reduction of between US$0.02 per kWh to US$0.13 per kWh.[124] Below, we describe these impacts and how they were calculated.

The development of geothermal projects will have positive impact on the economies of the beneficiary countries. One of the most tangible benefits is the reduction in the average tariff to customers. The tariff will be lowered because the cost of generating electricity from geothermal generation is lower than the cost of generating electricity from fuel oil and diesel generation. If these savings are passed on to customers, the geothermal projects would lead to an average decrease in tariffs of about 20 percent.[125] That is a reduction from an average tariff of US$0.34[126] per kWh (2014) to an estimated average tariff of US$0.27 per kWh. Below we show how we calculated the expected tariffs.

For each country, the expected average tariff when geothermal generation is introduced is calculated as the weighted average of the current average tariff (2014) and the expected tariff with geothermal. More specifically, we carried out the following calculation:

$$\text{Expected tariff with geothermal} = \text{Current electricity tariff} * \text{Percentage of non-geothermal generation} + \text{Tariff for geothermal} * \text{Percentage of geothermal generation}$$

The weights are the contribution of geothermal and diesel (or HFO) generation to the total projected generation in each country when geothermal comes online.[127] The "tariff for geothermal" is the sum of two components: the estimated geothermal PPA rate, plus the portion of the current tariff—that is not generation cost—that will still be charged to customers, regardless of the generation source, when geothermal comes online. The estimated geothermal PPA rate is the rate at which the geothermal projects need to sell each kWh of electricity to be able to service their debts and provide equity investors with a 15 percent real return.[128] The portion of the current tariff that is added to the estimated PPA rate is an estimate of the costs not related to generation that are charged to customers via tariff regardless of the generation technology used. Such costs include an estimate of transmission and distribution costs, administrative and other non-generation operating expenses, and other costs.

The estimated PPA rate and tariffs are calculated using the financial model for geothermal projects that Castalia prepared for the IDB. We present the detailed financing analysis to arrive at the PPA rate for each country in sections 11.5.2, 12.6.2, 12.6.3, 13.5.2, 14.7.2, 14.8.2, and 15.5.2. **Table 9.8** shows the estimated tariff for each country.

124. Financial model that accompanies this report; Castalia, "Financial Model for Geothermal Projects in the Eastern Caribbean" (2015, developed for the IDB).

125. This is an estimate based on the current total generation, and the estimated generation from geothermal resources, and assumes that the cost reductions will be passed on to customers. The final reduction in tariff will depend on the Governments' or regulators' decision on how and what proportion of cost reductions are passed on to costumers.

126. CARILEC, 2014 *Average Tariffs in EC Countries* (2015); GRENLEC, 2014 Annual Report; VINLEC, 2013 Financial Statements. The average tariff is the cost of service calculated using the information from the 2014 and 2013 financial statements for the utilities that publish it, and the 2014 average tariffs published by CARILEC for utilities that do not publish financial statements.

127. Energy supply curve projected for the publication: IDB and Castalia, "Sustainable Energy in the Eastern Caribbean: Achieving an Unrealized Potential" (2015). The annual generation from geothermal projects is calculated with an 85 percent capacity factor.

128. Castalia, "Financial Model for Geothermal Projects in the Eastern Caribbean" (2015, developed for the IDB).

Table 9.8 Expected Tariff with Geothermal Generation for Each Country

	Current Electricity Tariff (US$/kWh)	Estimated PPA Rate (US$/kWh)	Tariff for Geothermal (US$/kWh)	Generation with Geothermal (%)	Expected Tariff with Geothermal Generation (US$/kWh)	Reduction in the Tariff Due to Geothermal (%)
Dominica Phase 1	0.37	0.09	0.18	68.6%	0.24	34.5%
Nevis	0.32	0.14	0.22	87.2%	0.23	27.6%
Saint Kitts	0.32	0.15	0.23	98.3%	0.23	28.2%
Grenada	0.37	0.19	0.29	30.6%	0.34	6.8%
Saint Vincent and the Grenadines	0.35	0.16	0.22	46.4%	0.29	18.2%
Saint Lucia	0.32	0.17	0.25	30.4%	0.30	6.3%
Average	**0.34**	**0.15**	**0.23**	**60.3%**	**0.27**	**20.3%**

Source: The generation mix comes from the generation forecast from the energy supply curve projected for the publication: IDB and Castalia, "Sustainable Energy in the Eastern Caribbean: Achieving an Unrealized Potential" (2015).
Notes: Reductions in tariffs take into account all decimals. We did not calculate the impact of the Dominica Phase 2 project on the tariff because this project would supply electricity to three countries: Dominica, Martinique, and Guadeloupe, and we do not have the information necessary to carry out this calculation. The expected generation from geothermal was calculated as the expected annual generation from geothermal when the plant is operating with an 85 percent capacity factor divided by the gross generation in 2014. The financial model allows for making this analysis using the total generation of later years.

9.3.5 The geothermal projects will improve national accounts

The development of geothermal projects will have a positive impact on the economies of the beneficiary countries. In addition to reductions in the average tariff to customers, another of the main, most tangible benefits is the reduction in the imports of fuel oil or diesel. Implementing the projects will lead to a reduction of fuel oil imports of an estimated value between US$8 million and US$21 million for each project and a total of US$51 million[129] for the first phases of the projects (five projects total). Below, we describe these impacts and how they are calculated.

Replacing fuel oil generation with geothermal generation will reduce the importation of fuel oil. This will benefit the countries' accounts by improving their current accounts and probably their foreign exchange reserves. The annual importation of fuel oil is expected to fall by an average of 144,401 barrels for each project. This would reduce the average fuel imports by US$8 million to US$17 million per project per year. For the Dominica Phase 2 and Saint Kitts projects, the reductions in fuel imports will be higher. The annual imports of fuel oil are expected to fall by an average of 335,216 barrels for each project when the project to serve Saint Kitts and the second phase of the Dominica project are also considered.

To calculate the reduction in fuel imports, we calculated the amount of electricity from fuel oil generation that would be replaced with electricity from geothermal generation. We then calculated the amount of fuel required to produce that amount of electricity being replaced to determine the reduction in fuel imported. Lastly, we used two prices for fuel oil to determine the value of the reduction in the importation of fuel. **Table 9.9** provides the expected reduction in fuel imports for each project.

129. U.S. Energy Information Administration, "Short-Term Energy Outlook," April 7, 2015, accessed April 27, 2015, http://www.eia.gov/forecasts/steo/report/. The value is based on an oil price of US$70 per barrel. This is the expected 2016 average West Texas Intermediate (WTI). The financial model that supports this report allows for running the analysis for different scenarios of oil price.

Table 9.9 Estimated Reduction in Fuel Imports by Country

	Plant Size (MW)	Reduction in Fuel Imports (Barrels)	Reduction in Fuel Imports @ US$70/barrel (US$ million)	Reduction in Fuel Imports @ US$97.9/barrel (US$ million)
Dominica Phase 1	10	120,334	8.4	11.8
Nevis	10	120,334	8.4	11.8
Grenada	10	120,334	8.4	11.8
Saint Vincent and the Grenadines	10	120,334	8.4	11.8
Saint Lucia	20	240,668	16.8	23.6
Subtotal (Projects supported by Phase 1 of Fund)	**60**	**722,004**	**50.4**	**70.8**
Saint Kitts	25	300,835	21.0	29.5
Dominica Phase 2*				
Dominica	10	120,334	8.4	11.8
Martinique	50	601,670	42.1	58.9
Guadeloupe	50	601,670	42.1	58.9
Total	**195**	**2,346,513**	**164.0**	**229.8**

* **For Dominica Phase 2,** the anticipated benefits are divided between Dominica, Martinique, and Guadeloupe, which are the proposed off-takers for this project. The portion of the expected benefit that we assigned to each was based on the planned installed capacity that would be dedicated to each country: Dominica 10 MW, Martinique 50 MW, and Guadeloupe 50 MW.

To carry out this analysis, we relied on two key assumptions:

- We assumed that the heat rate for electricity generation using fuel oil was 10,200 kJ/kWh. This is the value for an acceptable heat rate.[130]
- We assumed that the fuel price was US$70 per barrel and US$97.9 per barrel. This gives us a range of possible values for the value of the reduction in the importation of fuel oil in US dollars.[131]

130. It is the allowed heat rate established by the Jamaican regulator OUR for the electric utility JPS in their current regulatory period.

131. U.S. Energy Information Administration, "Short-Term Energy Outlook," April 7, 2015, accessed April 27, 2015, http://www.eia.gov/forecasts/steo/report/; U.S. Energy Information Administration, "Cushing, OK WTI Spot Price FOB," accessed April 27, 2015, http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=rwtc&f=m. US$70 is expected average West Texas Intermediate (WTI) price for 2016. US$97.9 is the average WTI crude oil price for 2013.

Part C: Development of Geothermal Resources in the Eastern Caribbean States

In Part C, we discuss the status of development of geothermal resources in the five Eastern Caribbean states in our study. Based on that, we then recommend the PPP structures to develop geothermal projects in each of the countries.
To reach our recommendations we structured Part C as follows:

- **Overview of Geothermal Development in the Eastern Caribbean States** (Section 10)—We provide an overview of the region's progress towards exploring and exploiting geothermal resources. We start by reviewing the electricity sectors and the legal and regulatory frameworks in the region, to understand the context in which the geothermal projects are being or will be implemented. We then present the region's progress towards exploiting its geothermal resources. We find that the five countries in our study have enough estimated potential for geothermal power to meet their baseload demand. Some of them have potential to export electricity to neighboring countries. The five countries are at different stages of development for their geothermal resources, but overall, the region has advanced slowly towards exploiting its geothermal potential.
- **Analysis of Geothermal Development and Recommendations for Each Country**—We present the analysis by country in this order: Saint Vincent and the Grenadines (Section 11), Dominica (Section 12), Grenada (Section 13), Saint Kitts and Nevis (Section 14), and Saint Lucia (Section 15). For each of the five countries in our study we provide:
    - **An overview of the electricity market**—This section contains a description of the electricity market with information on installed capacity, generation matrix, and demand. We then review the key laws, regulations, and policies governing the sector. We find that the frameworks of all five countries are simple. Each electricity sector is governed by one law, the Electricity Supply Act. The only exception to this is Saint Kitts and Nevis, where the electricity sectors on each island are governed by separate laws. Finally, we discuss the institutional structure of the sector, including its main actors, their responsibilities, and the relationships between them.
    - **The status of geothermal development**—In this section we discuss the potential of the geothermal resources (in terms of generation capacity) and the stage of development of the resource.
    We then present the status of the planned geothermal project. This includes the stage of development of the project, information on project size and costs, and the key actors involved.
    - **The recommended PPP structure**—Here we present the PPP structure we recommend for the geothermal project. That includes the key actors, the relationships among them, and key project agreements. When a proposed structure is already in place, we recommend additions or changes to it. We also identify the risks for the project and suggest how to best allocate and mitigate them. Lastly, we discuss a strategy for engaging key stakeholders to facilitate the implementation of the PPP geothermal project.
    - **Recommended changes to the legal, institutional, and regulatory framework**—Here we outline the major changes that must be made to the legal, institutional, and regulatory framework to allow for the implementation of the PPP geothermal project.
    - **Economic and financial analysis of the geothermal project**—In this last section, we assess the economic and financial viability of the geothermal projects. Specifically, we determine the net economic benefits to the countries and estimate the expected returns to the equity investor from the geothermal projects.

10 Overview of Geothermal Development in the Eastern Caribbean States

The five Eastern Caribbean countries in our study have enough estimated potential for geothermal power to meet their baseload demand. Some countries have enough potential to export electricity to neighboring countries. The Eastern Caribbean countries have the opportunity to lower their electricity prices, which are among the highest in the world, and reduce greenhouse gas emissions. The five countries in our study are at different stages of development for their geothermal resources, but overall, the region has advanced slowly towards exploiting its geothermal potential.

In the following sections, we provide an overview of the region's progress towards exploring and exploiting geothermal resources. We start by reviewing the electricity sectors and the legal and regulatory frameworks in the region, to understand the context in which the geothermal projects are being or will be implemented (see Section 10.1). We then present the region's progress towards exploiting its geothermal resources (see Section 10.2).

Other parts of this publication "Realizing Sustainable Energy in the Eastern Caribbean: Achieving an Unrealized Potential" contain a more in-depth description of the electricity sectors in the Eastern Caribbean and their potential for developing sustainable energy.

10.1 Overview of the Electricity Sectors in the Eastern Caribbean Countries

Electricity prices in the five countries in our study are among the highest in the world, and therefore reducing electricity prices is the main priority of the governments. Prices are high because the countries are small and have isolated electricity markets that depend on imported fuel oil for electricity generation. The cost of fuel is the largest operating expense for electricity utilities in the Eastern Caribbean, as electricity tariffs move together with oil prices. In many countries, electricity tariffs are indexed to fuel prices, or include a fuel surcharge that passes the cost of fuel directly to consumers. As a result, customers often see high fuel price volatility in their monthly bills.

The electricity systems

Table 10.1 presents an overview of the electricity systems in the five countries. Separate information is provided for Saint Kitts and Nevis because they are separate islands with separate service providers. The electricity systems in all five countries are small and tariffs are high. Installed capacity ranges from 13.9 MW to 86.2 MW, and peak demand from 9.3 MW to 59.7 MW. All countries produce at least 75 percent of their electricity using fuel oil. On average, fuel costs account for 65 percent of operating expenses for these countries.[132]

132. Based on DOMLEC, 2014 Annual Report, accessed May 23, 2016, http://www.domlec.dm/index.php/our-company/reports; GRENLEC, 2014 Annual Report, accessed May 23, 2016, http://grenlec.com/OurCompany/AnnualReport.aspx; LUCELEC, 2014 Annual Report, accessed May 23, 2016, https://www.lucelec.com/content/annual-reports; and VINLEC, 2013 Financial Statements, provided by Financial Manager of VINLEC during field visit conducted in December 2014.

Table 10.1	Overview of the Electricity Systems in the Eastern Caribbean Countries					
Island	Utility	Peak Demand (MW)	Installed Generation Capacity (MW)	Average Tariff (US$/kWh sold) (2014)	Average Fuel Cost (US$/kWh sold) (2014)	Percentage of Generation Capacity from Fuel Oil or Diesel
Dominica	DOMLEC	16.8	26.7	0.365	0.183	75%
Grenada	GRENLEC	29.2	48.6	0.370	0.205	99%
Saint Lucia	LUCELEC	59.7	86.2	0.322	0.178	100%
Saint Kitts	SKELEC	24.0	43.0	0.320		100%
Nevis	NEVLEC	10.4	13.4	0.320 (Estimated)		85%
Saint Vincent and the Grenadines	VINLEC	25.7	51.4	0.379 (2013) 0.352 (2014 Estimated)	0.20 (2013) 0.18 (2014 Estimated)	80%

Source: World Bank, "World Development Indicators"; for DOMLEC: CARILEC, 2014 Average Tariffs in EC Countries (2015); for GRENLEC: GRENLEC, Annual Report 2014, and CARILEC, 2014 Average Tariffs in EC Countries (2015); for LUCELEC 2014 Average Tariffs in EC Countries (2015); for VINLEC: Financial Statistics provided by the General Manager of VINLEC in December 2014; for SKELEC and NEVLEC: National Renewable Energy Laboratory, "Energy Snapshot: The Federation of Saint Christopher and Nevis," Energy Transition Initiative, Islands (March 2015, DOE/GO-102015-4581), accessed August 5, 2015, http://www.nrel.gov/docs/fy15osti/62706.pdf; Cartwright Farrell (NEVLEC), "Nevis Geothermal Project and Power Take-Off Presentation" (2012); CARILEC, 2014 Average Tariffs in EC Countries (2015); and SKELEC, "Request for Proposal: SKELEC's Renewable Energy Infusion Study" (2013).

The market structure

All countries except for Saint Kitts and Nevis have one vertically integrated electricity utility, responsible for generation, transmission, and distribution of electricity. In Saint Kitts and Nevis, there is a vertically integrated electricity utility that is responsible for generation, transmission, and distribution of electricity on each island.

There are no interconnections of the electricity grids between the countries. Although IPPs are allowed to generate electricity to sell to the utility, only one IPP operates in Nevis.[133] The majority of DOMLEC, GRENLEC, and LUCELEC are privately owned, while VINLEC, NEVLEC, and SKELEC are entirely state-owned (see **Table 10.2**).

Table 10.2	Market Structure of the Electricity Sector in the Eastern Caribbean				
Country	Utility	Jurisdiction	Government Ownership (%)	Role	IPPs Allowed?
Dominica	DOMLEC	All	21%	G, T, & D	Yes
Grenada	GRENLEC	All	21.6%	G, T, & D	Yes
Saint Vincent and the Grenadines	VINLEC	All	100%	G, T, & D	Yes
Saint Kitts and Nevis	NEVLEC	Nevis	100%	G, T, & D	Yes
Saint Kitts and Nevis	SKELEC	Saint Kitts	100%	G, T, & D	Yes
Saint Lucia	LUCELEC	All	45.4%	G, T, & D	Yes

Source: Note: G = generation, T = transmission, D = distribution.

133. Herbert Samuel, "A Review of the Status of the Interconnection of Distributed Renewables to the Grid in CARICOM Countries," October 2013, accessed November 17, 2014, http://www.credp.org/Data/CREDP-GIZ_Interconnection_Report_Final_Oct_2013.pdf.

The legal and regulatory framework

The legal and regulatory frameworks of all five countries are simple. The electricity sector in each country is governed by an Electricity Supply Act. The only exception to this is Saint Kitts and Nevis, where the electricity sectors on each island are governed by separate laws.[134] To simplify the discussion, we will refer to the legislation governing the electricity sectors of the countries in our study as ESAs.

The ESAs establish the structures of the electricity sectors and regulate the sector. The ESAs either grant licenses to the vertically integrated utility or create the legal framework necessary for the ministry responsible for energy to do so. The ESAs also establish the price-setting mechanism that is used to determine tariffs. The exception to this is Saint Kitts and Nevis, where tariffs are set by the governor general with approval from the National Assembly in Saint Kitts and by NEVLEC in Nevis. The ESAs of all the countries in our study allow for IPPs.[135] However, there is only one IPP in the countries studied. The IPP is located in Nevis, produces electricity from wind energy, and has 1.1 MW of generation capacity.[136]

Regulation of the electricity sectors varies between countries. Most countries in our study (Dominica, Grenada, and Saint Kitts and Nevis) have legislation that mandates creating an independent regulator for the electricity sector. Despite this, only Dominica has appointed a separate regulatory entity. Grenada and Saint Kitts and Nevis instead have assigned regulatory functions among different government agencies. In the other countries in our study (Saint Lucia and Saint Vincent and the Grenadines), regulation is established by statute in the ESAs and regulatory functions are spread among various government agencies.

How regulatory functions are distributed between different ministries also varies from country to country. In some countries, there is one ministry that is responsible for overseeing the electricity sector and for policymaking in the sector. An example of this is Grenada, where the Ministry of Finance, Planning, Economic Development, Trade, Energy and Cooperatives oversees GRENLEC and also develops policies for expanding renewable energy use. On the opposite end of the spectrum, the Ministry of Transport and Works in Saint Vincent and the Grenadines is the main body responsible for overseeing the electricity sector, but regulatory functions are spread across five other governmental bodies.

Most of the countries studied lack laws and regulations governing the exploration and exploitation of geothermal resources. Only Nevis has passed legislation that defines what a geothermal resource is and who owns it, and sets out the process for assigning rights to explore and exploit it. The rest of the countries are either working to prepare geothermal resource development bills or reviewing them for approval.

134. The Electricity Supply Act of 2011 governs the electricity sector of Saint Kitts and the Electricity Ordinance of 1998 governs the electricity sector of Nevis.

135. National Renewable Energy Laboratory and Organization of American States, "Energy Policy and Sector Analysis in the Caribbean 2010–2011," accessed October 31, 2014,http://www.ecpamericas.org/data/files/Initiatives/lccc_caribbean/LCCC_Report_Final_May2012.pdf.

136. Herbert Samuel, "A Review of the Status of the Interconnection of Distributed Renewables to the Grid in CARICOM Countries," October 2013, accessed November 17, 2014, http://www.credp.org/Data/CREDP-GIZ_Interconnection_Report_Final_Oct_2013.pdf.

10.2 Status of Geothermal Development in the Eastern Caribbean Countries

Geothermal has the potential to meet baseload demand for electricity of the five Eastern Caribbean countries in our study. These countries could significantly lower their electricity tariffs with the use of geothermal energy. The countries in our study are at different stages of geothermal development. We present the region's geothermal potential (Section 10.2.1) and the region's progress towards developing its geothermal resources (Section 10.2.2).

10.2.1 Geothermal potential in the Eastern Caribbean countries

The five countries in this study all have significant geothermal potential. Their estimated geothermal potential would meet domestic baseload demand. Some countries could generate enough electricity to be able to export electricity to neighboring countries via undersea connection cables. The countries are planning to build power plants that range from 10 MW to 30 MW and have sufficient estimated potential to run plants this size. However, not all countries have proven their resource. While Dominica has concluded production drilling and proven the quality and size of the resource, the rest of the countries have not.

Dominica has the largest estimated geothermal resources. Exploratory work confirmed 120 MW[137] of geothermal potential, which is enough to meet its baseload demand of about 10 MW[138] and export electricity to the neighboring countries of Martinique and Guadeloupe. In Nevis, the NIA has communicated that the island would have an estimated potential of at least 50–60 MW for local supply and export.[139] Other estimates suggest much higher potential based on slim-hole wells drilled in 2008.[140] The estimated potential is more than enough to meet the country's projected baseload demand in 2023 and export electricity.[141] By July 2015, Saint Vincent and the Grenadines had completed surface exploration studies that estimated 60 MW potential.[142] Neither of the other two countries (Grenada and Saint Lucia) have finished surface explorations. However, the surface exploratory work undertaken so far suggests that each country has enough geothermal potential to meet local demand.

If the countries studied are able to exploit their estimated geothermal potential to meet their baseload demand for electricity, they could significantly reduce their electricity tariffs. Geothermal power is clean and, because it is not intermittent, can be used to meet baseload demand. Geothermal power generation is cheaper and has less volatile prices than generation from fuel oil. The average estimated levelized cost for a 10–20 MW geothermal plant is between US$0.08 and US$0.15 per kWh[143]—much less than the average electricity tariffs in the Eastern Caribbean of US$0.34 per kWh in 2014.[144] The price of electricity generated from geothermal sources is also less volatile than electricity generated from fuel oil. There are no fuel costs for geothermal plants, and about 85 percent of the total cost is capital costs. In addition, a geothermal plant's operation and maintenance costs are small compared to the initial capital expenditures and do not vary significantly from year to year.[145]

---

137. Lucien Blackmoore, "Global Geothermal Development Plan Roundtable: Dominica Geothermal Resource Development Programme" (November 11, 2013, The Hague, Netherlands).

138. Based on 60 percent of peak demand.

139. Nevis Island Administration, "NIA, NEVLEC and NREI Sign Geothermal Power Purchase Agreement," November 26, 2015, accessed December 4, 2015, http://www.nia.gov.kn/index.php/news-4/news-articles-3/2538-nia-nevlec-and-nrei-sign-geothermal-power-purchase-agreement.

140. Jonathan Kelly and Anelda Maynard-Date, "Geothermal Explorations and Development in Nevis" (Central America Geothermal Workshop in Santa Tecla, El Salvador, October 30, 2009). Other estimates suggest 300–500 MW.

141. Nexant, Caribbean Regional Electricity Generation, Interconnection, and Fuels Supply Strategy (March 2010), 1-38, accessed April 27, 2015, http://www.caricom.org/jsp/community_organs/energy_programme/electricity_gifs_strategy_final_report_summary.pdf.

142. "Private Sector Briefed on St. Vincent's Geothermal Project," I-Witness News, July 30, 2015, accessed December 2, 2015, http://www.iwnsvg.com/2015/07/30/private-sector-briefed-on-st-vincents-geothermal-project/; "St. Vincent & the Grenadines Outline Progress on Geothermal Work," ThinkGeoEnergy, July 16, 2015, accessed December 2, 2015, http://www.thinkgeoenergy.com/st-vincent-the-grenadines-outline-progress-on-geothermal-work.

143. Financial model that accompanies this report, based on information from: Magnus Gehringer and Victor Loksha, Geothermal Handbook: Planning and Financing Power Generation (Washington, DC: The International Bank for Reconstruction and Development, Technical Report 002/12, June 2012), accessed October 22, 2014, http://www.esmap.org/sites/esmap.org/files/DocumentLibrary/FINAL_Geothermal%20Handbook_TR002-12_Reduced.pdf; IDB, "Sustainable Energy Facility (SEF) for the Eastern Caribbean: Loan Proposal RG-L1071, RG-G1009, and RG-G1004" (2015), accessed December 2, 2015, http://www.iadb.org/en/projects/project-description-title,1303.html?id=RG-L1071.

144. CARILEC, 2014 Average Tariffs in EC Countries (2015); GRENLEC, 2014 Annual Report; DOMLEC, 2014 Annual Report.

145. Based on annual operation and maintenance costs of US$125,000, total capital costs of US$48.5 million, and a 10 percent interest rate.

10.2.2 Progress in developing geothermal resources in the Eastern Caribbean

The development of geothermal resources in the five countries in our study is at different stages. None of the countries has developed a geothermal power plant yet. The two countries that have advanced the most towards exploiting their geothermal potential are Dominica and Saint Kitts and Nevis. The other three countries have not made as much progress in exploring and exploiting their geothermal resources, although Saint Vincent and Saint Lucia have secured a private partner to develop the resources.

Dominica and Saint Kitts and Nevis have the most developed geothermal resources. Dominica has advanced the furthest; it completed production well drilling for a plant to meet domestic demand in March 2014.[146] However, Dominica has been unable to finalize an agreement with a developer to construct a geothermal plant.

In Nevis, slim-hole drilling that was completed in 2008 estimates that Nevis has a resource large enough to meet national baseload demand.[147] Nevis has made progress in securing a partner to develop its resources. In September 2014, the NIA signed a concession agreement with a private developer to construct a geothermal power plant.[148] In November 2015 the private developer and NEVLEC signed a PPA and exploratory drilling is expected to begin in 2015 or early 2016.[149]

Saint Vincent completed surface exploration in 2015 that suggests a high-quality resource and has reached agreements with its private partners.[150] The pre-investment studies were carried out by Light and Power Holdings (majorly owned by Emera) and Reykjavik Geothermal. Negotiations to finalize the business plan presented by the private partners were carried out in August 2015.[151] Project developers expect to begin drilling in the second quarter of 2016.[152]

Saint Lucia and Grenada have not made as much progress in exploiting their geothermal resources. Grenada and Saint Lucia have not moved beyond surface exploration. In Grenada, pre-investment studies were completed in July 2015. They were funded by the New Zealand Aid Programme as a result of an agreement signed by the Foreign Affairs and Trade Minister Murray McCully in June 2014 to help Grenada and Saint Lucia develop their geothermal potential.[153] In July 2015, the government presented the results of the pre-investment studies to potential project developers to start developing a roadmap.[154] Similar works are being carried out in Saint Lucia. On this island, the government has carried out extensive exploratory work, but the results have not confirmed a commercially viable resource and more surface exploration is in progress. The government has partnered with Ormat for developing the geothermal resources, but specific agreements are still being discussed.[155]

146. Japan International Cooperation Agency and West Japan Engineering Consultants, Inc., "Study of Situation for Geothermal Energy Development" (April 2014).

147. Kerry McDonald, "Federation of Saint Kitts and Nevis: First Geothermal Powered Nation in the World" (West Indies Power, 2011), accessed September 26, 2013, http://ciemades.org/pdfs/conf11/may6/Nevis-Geothermal_K_MacDonald.pdf.

148. "Nevis Administration and NREI Sign Geothermal Concession Agreement," *ThinkGeoEnergy*, September 5, 2014, accessed October 29, 2014, http://www.thinkgeoenergy.com/nevis-administration-and-nrei-sign-geothermal-concession-agreement/.

149. "State Department Applauds Model Geothermal Power Purchase Agreement Signed in Nevis," *U.S. Department of State*, November 25, 2015, accessed December 2, 2015, http://www.state.gov/r/pa/prs/ps/2015/11/250002.htm.

150. "St. Vincent & the Grenadines Outline Progress on Geothermal Work," *ThinkGeoEnergy,* July 16, 2015, accessed December 2, 2015, http://www.thinkgeoenergy.com/st-vincent-the-grenadines-outline-progress-on-geothermal-work; Ellsworth Dacon, "St. Vincent's Geothermal Development Approach," *I-Witness News*, May 10, 2015, accessed September 16, 2015, http://www.iwnsvg.com/2015/05/10/st-vincents-geothermal-development-approach/.

151. Ellsworth Dacon, "Presentation: Geothermal Development in Saint Vincent and the Grenadines" (August 3, 2015, Malaysia), accessed December 3, 2015, http://www.irena.org/EventDocs/S5_Ellsworth_Dacon_St.Vincent_Malaysia_Presentation.pdf.

152. "St. Vincent Geothermal Project On Track to Start-Up in 2018," *Caribbean News Now*, July 22, 2015, accessed December 2, 2015, http://www.caribbeannewsnow.com/headline-St-Vincent-geothermal-project-on-track-to-start-up-in-2018-26989.html; Ellsworth Dacon, "Presentation: Geothermal Development in Saint Vincent and the Grenadines" (August 3, 2015, Malaysia), accessed December 3, 2015, http://www.irena.org/EventDocs/S5_Ellsworth_Dacon_St.Vincent_Malaysia_Presentation.pdf.

153. "NZ Firm Testing Caribbean Geothermal Resource," *New Zealand Energy News*, April 2015; "St. Lucia, New Zealand Sign Geothermal Support Partnership Agreement," *Caribbean News Now,* September 3, 2014, accessed May 23, 2016, http://caribbeannewsnow.com/topstory-St-Lucia,-New-Zealand-sign-geothermal-support-partnership-agreement-22625.html.

154. Government of Grenada, "Results of Geothermal Study to Be Presented," July 29, 2015, accessed December 2, 2015, http://www.gov.gd/egov/news/2015/jul15/29_07_15/item_1/results-geothermal-study-presented.html.

155. "St. Lucia Says Geothermal Exploration Will Begin in 2015," *Caribbean Journal,* December 18, 2014, accessed December 2, 2015, http://caribjournal.com/2014/12/18/st-lucia-says-geothermal-exploration-will-begin-in-2015/#.

Table 10.3 shows each country's progress towards exploring and exploiting geothermal power, and the estimated costs for developing the geothermal resource and geothermal power plants in the Eastern Caribbean. All of the projects are designed to meet domestic demand.

The project on Dominica could potentially have a second phase to export electricity via undersea interconnection cables to neighboring islands. The project in Nevis could also potentially have a second phase to export electricity to Saint Kitts and to other countries.

Table 10.3 Status of Geothermal Development in the Eastern Caribbean Countries

	Dominica	Nevis (Nevis and Saint Kitts)	Grenada	Saint Lucia	Saint Vincent
Estimated Resource Potencial	200–500 MW+[156]	50–60 MW+ [157]	30 MW+ [158]	75 MW+[159]	75 MW+ [160]
Confirmed Resource	120 MW [161]	Resource not confirmed	Resource not confirmed	Resource not confirmed	Resource not confirmed
Proposed Plant Size	Phase 1: 10 MW	Phase 1: 10 MW	10 MW	10 MW	10 MW
	Phase 2: 100–120 MW (Export)	Phase 2: 25 MW (Export to Saint Kitts)			
Development status	**Phase 1:** Production well drilling completed. **Phase 2:** Exploratory drilling confirmed resource.	**Phase 1:** Slim-hole drilling estimates good-quality resource. **Phase 2:** Slim-hole drilling estimates good-quality resource.	Surface exploration needed to estimate resource. Surface exploration ongoing.	Further surface exploration needed to confirm resource. Surface exploration ongoing.	Surface exploration completed in 2015. Drilling phase is expected to begin in early 2016.
Estimated Cost to Develop Geothermal Resources and Power Plant (US$)	US$52M	Phase 1: US$80M	US$86M	US$152.5M	US$50–80M
	US$300–531M	Phase 2: US$114–120M			
Planned Project Structure	Not yet defined	**Phase 1:** Concession contract for production drilling, power plant construction and operation. Concession was signed by a private consortium and the government. PPA with utility signed in November 2015. **Phase 2:** Not yet defined	Not yet defined	Preliminary agreement with private partner for surface exploration and exploration drilling. A project agreement for later stages is not yet defined.	Special purpose vehicle, owned by government and private company, for exploration, drilling, power plant construction and operation. Preliminary agreement for surface exploration signed.

Source:: Financial model that accompanies this report, based on information from: Magnus Gehringer and Victor Loksha, Geothermal Handbook: Planning and Financing Power Generation (Washington, DC: The International Bank for Reconstruction and Development, Technical Report 002/12, June 2012), accessed October 22, 2014, http://www.esmap.org/sites/esmap.org/files/DocumentLibrary/FINAL_Geothermal%20 Handbook_TR002-12_Reduced.pdf; IDB, "Sustainable Energy Facility (SEF) for the Eastern Caribbean: Loan Proposal RG-L1071, RG-G1009, and RG-G1004" (2015), accessed December 2, 2015, http://www.iadb.org/en/projects/project-description-title,1303.html?id=RG-L1071. Cost estimates (with exception of Dominica Phase 2) from West Japan Engineering Consultants, Inc., and based on production drilling and construction costs for a 10 MW power plant. Cost estimates for Dominica Phase 2 are from the West Japan Engineering Consultants, Inc. and include the construction costs of a 100–120 MW power plant and undersea interconnection. Cost estimates for interconnection cables between Saint Kitts and Nevis are adapted from: Nexant, Caribbean Regional Electricity Generation, Interconnection, and Fuels Supply Strategy (March 2010), 1-38, accessed April 27, 2015, http://www.caricom.org/jsp/community_organs/energy_programme/electricity_gifs_strategy_final_report_summary.pdf; Magnus Gehringer and Victor Loksha, Geothermal Handbook: Planning and Financing Power Generation (Washington, DC: The International Bank for Reconstruction and Development, Technical Report 002/12, June 2012), accessed October 22, 2014, http://www.esmap.org/sites/esmap.org/files/DocumentLibrary/FINAL_Geothermal%20Handbook_TR002-12_Reduced.pdf; West Japan Engineering Consultants, Inc., "Study on Current Status of Geothermal Development in the Eastern Caribbean Islands," March 2014.

156. World Bank, "Got Steam? Geothermal as an Opportunity for Growth in the Caribbean," Caribbean Knowledge Series, June 2013, accessed March 6, 2014, http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2013/06/21/000442464_2013062114270 3/Rendered/PDF/786080WP015.0G00Box377349B00PUBLIC0.pdf; AFD, "Geothermal Resource Development in Dominica: Exploratory drillings and complementary case studies," February 2008.
157. Nevis Island Administration, "NIA, NEVLEC and NREI Sign Geothermal Power Purchase Agreement," November 26, 2015, accessed December 4, 2015, http://www.nia.gov.kn/index.php/news-4/news-articles-3/2538-nia-nevlec-and-nrei-sign-geothermal-power-purchase-agreement.
158. World Bank, "Got Steam? Geothermal as an Opportunity for Growth in the Caribbean," Caribbean Knowledge Series, June 2013, accessed March 6, 2014, http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2013/06/21/000442464_20130621142703/Rendered/PDF/786080WP015.0G00Box377349B00PUBLIC0.pdf.
159. Ibid.
160. Ibid.
161. Lucien Blackmoore, "Global Geothermal Development Plan Roundtable: Dominica Geothermal Resource Development Programme" (November 11, 2013, The Hague, Netherlands).

An analysis of each country's progress towards exploiting its geothermal resources is included in the following sections:

- Saint Vincent and the Grenadines (Section 11.2)
- Dominica (Section 12.2)
- Grenada (Section 13.2)
- Saint Kitts and Nevis (Section 14.2)
- Saint Lucia (Section 15.2)

11 Saint Vincent and the Grenadines

The government in Saint Vincent and the Grenadines is actively pursuing the development of a 10–15 MW geothermal plant with the support of private partners. The geothermal resources on Saint Vincent have not been explored. However, Light and Power Holdings and Reykjavik Geothermal completed surface exploration in 2015.[162] The parties also completed negotiations and agreed on the business plan to develop the resource and power plant.[163] In addition, the Abu Dhabi Fund for Development (ADFD) and the International Renewable Energy Agency (IRENA) are providing the government with a US$15 million loan to support the development of its geothermal plant.[164]

We recommend the government implement the planned PPP structure for developing the geothermal project because it would allow for the successful development of Saint Vincent's geothermal resources.[165] Prior to signing the project agreements, the government would need to update the legal and regulatory framework to allow for the development of this project. Another option the government could pursue is to ensure that all regulatory aspects are covered in the contract that it signs with the private developer. The government has taken the first step in making changes to the legal framework. It submitted draft legislation to the cabinet, where the legal committee is carrying out the first round of revisions.

Multilateral development banks may be able to play an active role in supporting the planned project. Since the project is already being developed, the role of the multilaterals should be focused on providing funding for the project. Contingent grants could finance the earlier stages of the project and loans the more advanced stages of the project. For the project to be eligible to access multilateral funding, the project and/or the works and services would likely need to be procured competitively. The planned project and possible role for the multilateral institutions is described in more detail in the following sections:

- Overview of the Electricity Sector in Saint Vincent (Section 11.1)
- Status of Geothermal Development (Section 11.2)
- Recommended Financial and Legal PPP Structure (Section 11.3)
- Recommended Changes to the Legal, Institutional, and Regulatory Framework (Section 11.4).
- Economic and Financial Analysis of the Geothermal Project (Section 11.5)

162. "St. Vincent & the Grenadines Outline Progress on Geothermal Work," *ThinkGeoEnergy*, July 16, 2015, accessed December 2, 2015, http://www.thinkgeoenergy.com/st-vincent-the-grenadines-outline-progress-on-geothermal-work.

163. Ellsworth Dacon, "Presentation: Geothermal Development in Saint Vincent and the Grenadines" (August 3, 2015, Malaysia), accessed December 3, 2015, http://www.irena.org/EventDocs/S5_Ellsworth_Dacon_St.Vincent_Malaysia_Presentation.pdf.

164. "IRENA and ADFD Bring Renewable Power to 280,000 in Many Rural Communities," *IRENA.com*, January 18, 2015, accessed April 27, 2015, http://www.irena.org/News/Description.aspx?NType=A&mnu=cat&PriMenuID=16&CatID=84&News_ID=388.

165. Government of Saint Vincent and the Grenadines, "The La Soufriere Geothermal Project" (Costa Rica Study Tour: March 2014).

11.1 Overview of the Electricity Sector in Saint Vincent and the Grenadines

Saint Vincent Electric Services Ltd. (VINLEC), a vertically integrated state-owned electricity utility, has exclusive license to provide electricity in Saint Vincent and the Grenadines.[166] VINLEC is overseen by the Ministry of Transport, Works, Urban Development, and Local Government. The Electricity Supply Act of 1973 establishes the structure of and regulates the electricity sector. This legal framework lacks laws and regulations to govern the exploration and exploitation of geothermal resources. Despite a policy framework conducive to geothermal development, including developing utility-scale renewable energy projects, the government has not yet implemented the measures called for in the Energy Policy and Energy Action Plan.

11.1.1 The electricity market in Saint Vincent and the Grenadines

In Saint Vincent, VINLEC is the sole, vertically integrated provider of electricity services. VINLEC's total installed capacity was 51.4 MW in 2013, which is more than enough to meet peak demand of 25.7 MW. Installed capacity is spread over five islands, but most of the installed capacity is in Saint Vincent and there are no interconnections between islands. Residents on other islands can self-generate if they receive VINLEC's approval. In 2011, hydroelectric generation accounted for approximately 20 percent of total generation; the remaining 80 percent came from diesel plants.[167]

In 2013, peak demand in Saint Vincent was 25.7 MW.[168] Total demand increased rapidly from 2004 to 2007, but flattened and even decreased at points from 2007 to 2013 (see **Figure 11.1**). Demand grew by 2 percent per year over the full period. In 2013, 47 percent of demand was domestic, 45 percent was commercial, 5 percent was industrial, and 2 percent was other. Demand from the commercial sector grew the fastest from 2004 to 2013, increasing at a rate of 2.2 percent per year. Demand from the domestic segment grew at 2 percent per year during the same period.

11.1.2 Key laws, regulations, and policies governing the sector

The electricity sector in Saint Vincent is governed by the Electricity Supply Act, which establishes the sector's structure and the tariff-setting mechanism. The ESA grants VINLEC the exclusive right to supply electricity until 2033. The sector's development is also guided by the government energy sector policies, the Energy Policy and the Energy Action Plan. These policies outline the government's objectives and plan for reducing the cost of electricity and increasing renewable generation, but have not been implemented.

Policies in the energy sector

The Energy Policy and the Energy Action Plan present the government's vision of a more economical, more reliable, and less polluting energy sector. However, the government has not yet implemented the measures called for in the Energy Policy and Energy Action Plan.

The Energy Policy includes the following guiding principles for the energy sector:

- Providing clean, reliable, and affordable energy to consumers
- Reducing fossil fuel use through expansion of renewable energy and energy-efficiency technology
- Liberalizing the energy market and encouraging private sector participation in energy development and energy services
- Setting electricity tariffs that reflect the full cost of service, while providing minimal subsidies for energy services to the lowest-income households[169]

166. Saint Vincent is the largest and most populated island in the country, which also includes a chain of smaller islands referred to as the Grenadines. The Grenadines is made up of 31 islands, eight of which are inhabited.
167. VINLEC, 2011 Annual Report.
168. Information provided by Financial Manager of VINLEC during field visit conducted in December 2014.
169 "Sustainable Energy for SVG: The Government's National Energy Policy," March 2009, accessed March 21, 2015, http://www.gov.vc/images/stories/pdf_documents/svg%20nation%20energy%20policy_approved%20mar09.pdf.

The Energy Action Plan complements the Policy and defines specific targets for the period 2009 to 2030, including the following:

- Produce 30 percent of electricity from renewable resources (including hydroelectric power) by 2015 and 60 percent by 2020
- Reduce the projected increase in peak demand by 5 percent by 2015 and 10 percent by 2020
- Reduce projected electricity generation by 5 percent by 2015 and 15 percent by 2020
- Reduce electricity losses to 7 percent by 2015 and 5 percent by 2020

Additional measures that the Energy Action Plan calls for (there are 40 in total) include:

- Requiring the development of utility-scale renewable energy projects, either by VINLEC or IPPs
- Implementing a net-metering policy to increase the supply of power from distributed generation[170]

The government signaled the importance of geothermal development in the Saint Vincent and the Grenadines National Economic and Social Development Plan 2013–2025. In the plan, Objective 2 for energy is "to encourage exploration and increased utilization of renewable energy technologies" and one of the strategic interventions for this objective is to "explore the feasibility of geo-thermal energy."[171]

Laws and regulations governing the electricity sector

The Electricity Supply Act—which was passed in 1973 and amended in 1974, 1976, 1978, 1980, and 1987[172]—governs electricity supply in Saint Vincent and the Grenadines. It grants VINLEC an exclusive license for supplying electricity and gives it responsibility for issuing licenses to other parties that wish to generate, distribute, or transmit electricity in the country. This is an important provision because VINLEC does not operate on some of the smaller inhabited Grenadines. However, VINLEC has not established a procedure that IPPs can follow to obtain a license.

The ESA also establishes the tariff-setting mechanism. Either the prime minister or VINLEC can suggest a tariff adjustment at any time. If the parties disagree on a suggested tariff, they jointly appoint an arbitrator to determine the tariff. The ESA set the initial tariffs for VINLEC's services (which are no longer the tariffs used), but did not create a formula for adjusting tariffs over time.

In November 2012, the government prepared the Geothermal Bill with support from the Clinton Climate Initiative.[173] The legal framework governing the exploration and exploitation of geothermal resources is contained in the Geothermal Bill, approved by Parliament in August 2015.

170. Government of Saint Vincent and the Grenadines, "Energy Action Plan for Saint Vincent and the Grenadines: First Edition," January 2010, accessed July 29, 2015, http://www.gov.vc/images/stories/pdf_documents/svg%20-%20energy_action_plan_svg_first%20edition.pdf.

171. Government of Saint Vincent and the Grenadines, "National Economic and Social Development Plan 2013–2025," January 2013.

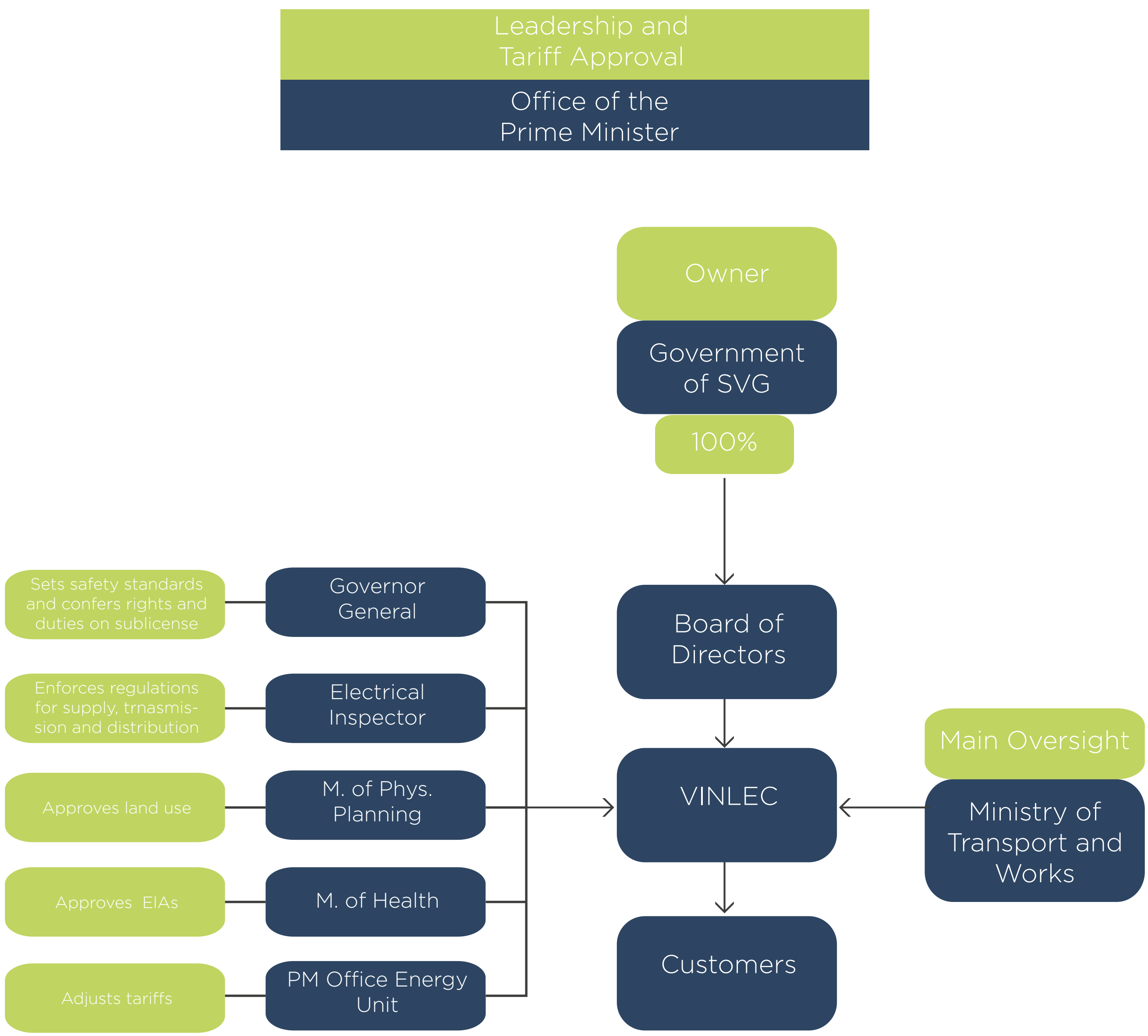
172. The Electricity Supply (Agreement) Act of 1984 ratifies a guarantee by the Government of Saint Vincent and the Grenadines on behalf of VINLEC, for a loan in the form of debentures, to the Commonwealth Development Corporation. This debenture is no longer outstanding and this act is therefore spent.

173. Japan International Cooperation Agency and West Japan Engineering Consultants, Inc., "Study of Situation for Geothermal Energy Development" (April 2014).

11.1.3 Institutional structure of the electricity sector

VINLEC, a vertically integrated state-owned electricity utility, holds an exclusive license to supply electricity in the country until 2033. The utility provides electricity to Saint Vincent and four of the islands of the Grenadines. There is no regulatory agency. VINLEC is overseen by the Ministry of Transport, Works, Urban Development, and Local Government. However, the Energy Unit in the prime minister's office is responsible for formulating and implementing the government's energy policies and coordinating activities related to renewable energy and energy efficiency initiatives.[174] **Figure 11.2** shows the relationships between key entities in Saint Vincent and the Grenadines' electricity sector.

FIGURE 11.2 Key Entities in Saint Vincent and the Grenadines' Electricity Sector



174. Government of Saint Vincent and the Grenadines: Ministry of National Security, Air & Sea Port Development, "About the Energy Unit," accessed March 20, 2016, http://www.security.gov.vc/security/index.php?option=com_content&view=article&id=87&Itemid=139.

Below we provide a more in-depth description of the major responsibilities in the electricity sector and the bodies responsible for carrying them out.

- **Policymaking**—The Energy Unit, created within the Office of the Prime Minister in 2008, is responsible for "assisting with the formulation and implementation of government's policies related to energy, and to coordinate specific activities related to government's renewable energy and energy efficiency initiatives."[175]

- **Regulation**—Regulatory functions are spread across government agencies. There is no independent regulator in the electricity sector.

    - The Ministry of Transport, Works, Urban Development, and Local Government oversees the electricity sector.[176]

    - The governor general is responsible for setting safety standards and can confer rights and duties on sub-licensees of VINLEC.[177]

    - The prime minister and VINLEC are responsible for adjusting tariffs.

    - The Physical Planning Unit within the Ministry of Housing, Informal Human Settlements, Lands, and Surveys and Physical Planning, is responsible for approving land-use plans in Saint Vincent and the Grenadines, including for the development of power projects.[178]

    - The government electrical inspector is responsible for enforcing regulations governing electricity supply, transmission, and distribution.[179]

    - The Ministry of Health and the Environment is responsible for managing the requirements and reviewing environmental impact assessments.[180]

- **Generation, Transmission, and Distribution**—VINLEC, a wholly state-owned enterprise, holds an exclusive license to supply power in Saint Vincent and the Grenadines until 2033.[181] The utility provides electricity service on Saint Vincent and four of the Grenadines. VINLEC is responsible for issuing licenses to other parties that wish to generate, distribute, or transmit electricity in the country. This is important because VINLEC does not operate on some of the smaller inhabited Grenadines.

175. Government of Saint Vincent and the Grenadines: Ministry of National Security, Air & Sea Port Development, "About the Energy Unit," accessed March 20, 2016, http://www.security.gov.vc/security/index.php?option=com_content&view=article&id=87&Itemid=139.

176. Government of Saint Vincent and the Grenadines: Ministry of Transport, Works, Urban Development & Local Government, "Ministry Objectives," accessed March 20, 2016, http://www.transport.gov.vc/transport/index.php?option=com_content&view=article&id=1&Itemid=20.

177. Government of Saint Vincent and the Grenadines, *The Electricity Supply* Act, 1973, Act No. 14 of 1973, May 30, 1973.

178. Government of Saint Vincent and the Grenadines: Ministry of Housing, Informal Human Settlements, Lands & Surveys and Physical Planning, "Physical Planning: Background," March 20, 2016, http://housing.gov.vc/housing/index.php?option=com_content&view=article&id=23&Itemid=4.

179. Government of Saint Vincent and the Grenadines, *The Electricity Supply* Act, 1973, Act No. 14 of 1973, May 30, 1973.

180. Reynold Murray, "Environmental Management Framework: Regional Disaster Vulnerability Reduction Project, St. Vincent and the Grenadines Component," January 2014, accessed May 20, 2016, http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/LCR/2016/03/29/090224b08424084b/3_0/Rendered/INDEX/St0OVincent0an0management0framework.txt.

181. Government of Saint Vincent and the Grenadines, *The Electricity Supply* Act, 1973, Act No. 14 of 1973, May 30, 1973.

11.2 Status of Geothermal Development

In Saint Vincent, the government is working with the private sector to explore its geothermal resources and to develop a 10–15 MW geothermal plant. There is strong political support for the project and the government plans to build this plant on a PPP basis with Light and Power Holdings and Reykjavik Geothermal. These companies began surface exploration in November 2013 and completed pre-investment studies by early to mid-2015.[182] The private developers and the government finalized a detailed technical, project, and business plan that will serve as the foundation for the project agreements.[183] Though the project's partners have only signed preliminary agreements for surface exploration, the government expects to start building the power plant by the end of 2016 and to begin operations in June 2018.[184]

11.2.1 Resource potential and development

Saint Vincent has an estimated potential to supply all baseload electricity demand on the island, and, through interconnections, the Grenadines and other neighboring islands.[185] The island has an estimated potential over 75 MW,[186] which could meet a large portion of VINLEC's projected demand of 94 MW in 2028.[187] Surface reconnaissance suggests that the resource is of high quality.[188] Geothermal power presents a clean and likely least-cost energy option. Initial surface exploration has found that both the eastern and western side of La Soufriere Volcano have the geothermal resources necessary for developing a geothermal power plant.[189] However, more detailed information on the size and quality of the resources is needed to prove the resource and accurately estimate the cost of developing geothermal power.

11.2.2 Planned project

The government plans to develop a 10–15 MW power plant on Saint Vincent on a PPP basis through the La Soufriere Geothermal Project.[190] The government plans to develop the geothermal plant through a special-purpose company that will be owned by the government and the private sector. The private sector companies are: Light and Power Holdings, which is based in Barbados, and Reykjavik Geothermal, a geothermal development company based in Iceland. Light and Power Holdings, 80.3 percent of which is owned by the North America–based energy company Emera,[191] will be the project's lead and will also lead the financing. Reykjavik Geothermal will be the project's technical lead. In addition to the equity contributions provided by the government, Light and Power Holdings, and Reykjavik Geothermal, the project will also be financed with debt. The government is seeking grants and concessionary

182. "St. Vincent & the Grenadines Outline Progress on Geothermal Work," *ThinkGeoEnergy,* July 16, 2015, accessed December 2, 2015, http://www.thinkgeoenergy.com/st-vincent-the-grenadines-outline-progress-on-geothermal-work.

183. Ellsworth Dacon, "Presentation: Geothermal Development in Saint Vincent and the Grenadines" (August 3, 2015, Malaysia), accessed December 3, 2015, http://www.irena.org/EventDocs/S5_Ellsworth_Dacon_St.Vincent_Malaysia_Presentation.pdf; "St. Vincent Geothermal Power Plant Could Be Operational by 2018," *Caribbean 360*, September 1, 2014, accessed November 10, 2014, http://www.caribbean360.com/news/st-vincent-geothermal-power-plant-could-be-operational-by-2018.

184. "St. Vincent Geothermal Project On Track to Start-Up in 2018," *Caribbean News Now*, July 22, 2015, accessed December 2, 2015, http://www.caribbeannewsnow.com/headline-St-Vincent-geothermal-project-on-track-to-start-up-in-2018-26989.html; "St. Vincent Geothermal Power Plant Could Be Operational by 2018," *Caribbean 360,* September 1, 2014, accessed November 10, 2014, http://www.caribbean360.com/news/st-vincent-geothermal-power-plant-could-be-operational-by-2018.

185. There is speculation that the companies are interested in developing Saint Vincent's geothermal resources because it could allow them to later expand geothermal generation and supply electricity to Light and Power Holdings' companies on other islands via undersea cables.

186. World Bank, "Got Steam? Geothermal as an Opportunity for Growth in the Caribbean," Caribbean Knowledge Series, June 2013, accessed March 6, 2014, http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2013/06/21/000442464_20130621142703/Rendered/PDF/786080WP015.0G00Box377349B00PUBLIC0.pdf.

187. This projection is based on the assumption that demand in Saint Vincent and the Grenadines grows an average of 6.9 percent per year.

188. Government of Saint Vincent and the Grenadines, "The La Soufriere Geothermal Project" (Costa Rica Study Tour: March 2014).

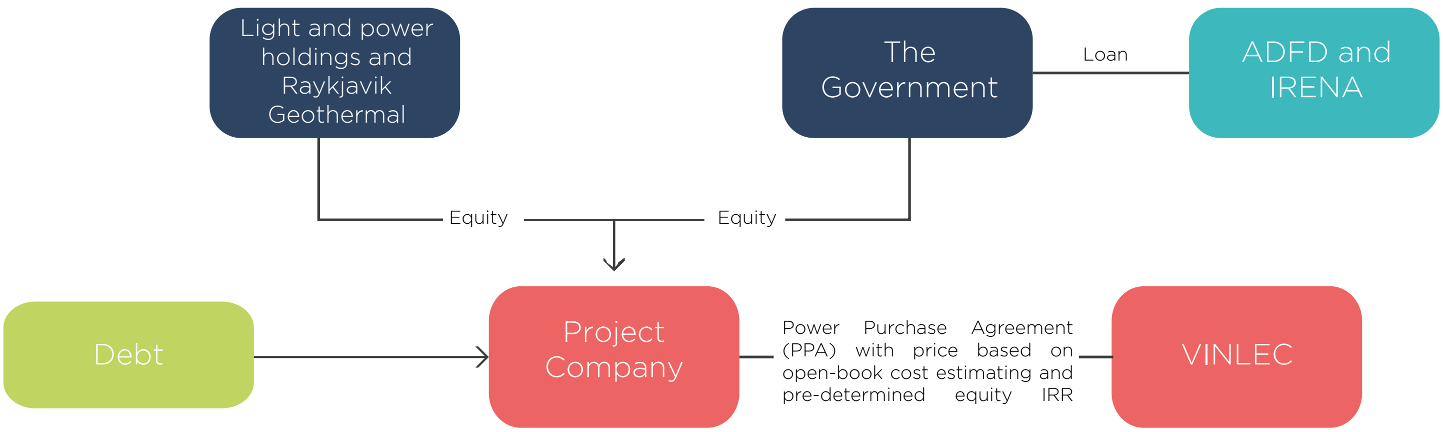
189. "Geothermal Power Plant to be Operational by June 2018," *The Gleaner*, September 2, 2014, accessed May 20, 2016, http://jamaica-gleaner.com/article/business/20140902/geothermal-power-plant-be-operational-june-2018.

190. Government of Saint Vincent and the Grenadines, "The La Soufriere Geothermal Project" (Costa Rica Study Tour: March 2014).

191. According to Emera's 2013 Annual Report, Emera's Caribbean utility operations includes ownership in Light and Power Holdings and its wholly owned subsidiary Barbados Light and Power Company, Grand Bahamas Power Company, DOMLEC, and LUCELEC. Emera acquired a controlling interest in Light and Power Holdings Limited on January 25, 2011.

debt financing from multilateral development banks.[192] In January 2015, the government was granted a US$15 million loan with a 2 percent interest rate[193] by the ADFD and IRENA for the development of the geothermal plant.[194] **Figure 11.3** shows the proposed structure of the project.

FIGURE 11.3 Planned Structure of the Geothermal Project



Sources: Government of Saint Vincent and the Grenadines, "The La Soufriere Geothermal Project" (Costa Rica Study Tour: March 2014).

To date, the government, Light and Power Holdings, and Reykjavik Geothermal have invested resources in establishing the baseline for the environmental impact analysis and carrying out surface exploration and pre-investment studies.

Cost estimates suggest that developing a 10 MW geothermal power plant in Saint Vincent could cost about US$80 million; this includes environmental impact assessments, exploration drilling, production drilling, and the construction of the power plant. [195]The construction of transmission lines and access roads would increase the total cost to about US$96 million. Initial estimates of the government and its partners state that the cost of carrying out production drilling and building the plant and grid interconnection are US$92 million for a 10–15 MW plant.[196] All electricity generated by the planned geothermal plant would be sold to VINLEC, the state-owned electricity utility, under a 20-to-30-year PPA.[197]

192. "St. Vincent Geothermal Power Plant Could Be Operational by 2018," *Caribbean 360*, September 1, 2014, accessed November 10, 2014, http://www.caribbean360.com/news/st-vincent-geothermal-power-plant-could-be-operational-by-2018. The Clinton Foundation is serving as an advisor to the government and has been working with the government under a Memorandum of Understanding (MOU) since 2012. The Clinton Foundation is helping the government with the negotiation of key agreements and commercial, financial, and legal terms.

193. LeAnnne Graves, "ADFD and IRENA Hand Out $57m in Loans for Renewable Energy Projects," *The National*, January 18, 2015, accessed April 27, 2015, http://www.thenational.ae/business/energy/adfd-and-irena-hand-out-57m-in-loans-for-renewable-energy-projects.

194 "IRENA and ADFD Bring Renewable Power to 280,000 in Many Rural Communities," *IRENA.com*, January 18, 2015, accessed April 27, 2015, http://www.irena.org/News/Description.aspx?NType=A&mnu=cat&PriMenuID=16&CatID=84&News_ID=388.

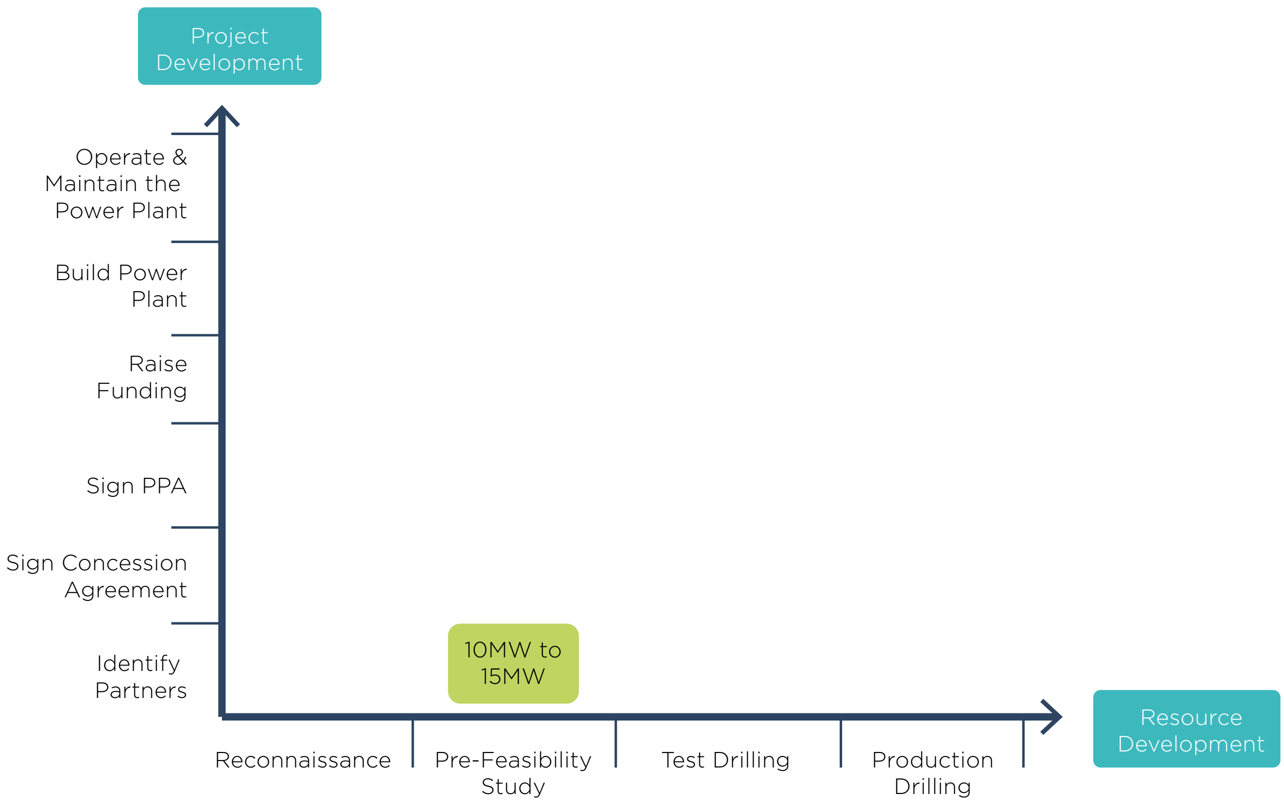
195. Financial model that accompanies this report, based on information from: Magnus Gehringer and Victor Loksha, *Geothermal Handbook: Planning and Financing Power Generation* (Washington, DC: The International Bank for Reconstruction and Development, Technical Report 002/12, June 2012), accessed October 22, 2014, http://www.esmap.org/sites/esmap.org/files/DocumentLibrary/FINAL_Geothermal%20Handbook_TR002-12_Reduced.pdf; IDB, "Sustainable Energy Facility (SEF) for the Eastern Caribbean: Loan Proposal RG-L1071, RG-G1009, and RG-G1004" (2015), accessed December 2, 2015, http://www.iadb.org/en/projects/project-description-title,1303.html?id=RG-L1071.

196. Ellsworth Dacon, "Presentation: Geothermal Development in Saint Vincent and the Grenadines" (August 3, 2015, Malaysia), accessed December 3, 2015, http://www.irena.org/EventDocs/S5_Ellsworth_Dacon_St.Vincent_Malaysia_Presentation.pdf.

197. Government of Saint Vincent and the Grenadines, "The La Soufriere Geothermal Project" (Costa Rica Study Tour: March 2014).

Figure 11.4 presents the status of the planned geothermal project. The government is still in the initial stages of exploring the resource and has reached preliminary agreements for developing the project. Nonetheless, the project is advancing quickly and the government expects the plant to begin operations by June 2018. Since agreeing on a commercial framework and signing a project Letter of Intent (LOI) in early 2013, the government and its project partners have completed a prefeasibility study, a geothermal resistivity study, and also the surface exploration.[198] In addition, they also carried out the baseline study for the environmental and social impact assessment and held several stakeholder consultations.[199]

FIGURE 11.4 Status of Planned Geothermal Project



The government and its project partners met in August 2015 to negotiate and finalize the business model of the project.[200] Light and Power Holdings and Reykjavik Geothermal, which have a Memorandum of Understanding (MOU) with the government, funded and carried out the surface exploration needed for the project.[201] While the exact terms in the agreement between Light and Power Holdings, Reykjavik Geothermal, and the government are confidential, the main items outlined in the agreement are that Light and Power Holdings and Reykjavik Geothermal are the only companies that have the right to negotiate with the government to develop the project, that the companies will pay for the exploratory costs, and a rate of return is established for the project. The agreement also defines what will happen if the resource is found feasible and not feasible. For example, the government does not have to move forward with the project if it is not expected to lead to a decrease in electricity prices.[202]

---

198. Government of Saint Vincent and the Grenadines, "The La Soufriere Geothermal Project" (Costa Rica Study Tour: March 2014); "St. Vincent & the Grenadines Outline Progress on Geothermal Work," *ThinkGeoEnergy*, July 16, 2015, accessed December 2, 2015, http://www.thinkgeoenergy.com/st-vincent-the-grenadines-outline-progress-on-geothermal-work.

199. Ellsworth Dacon, "St. Vincent's Geothermal Development Approach," *I-Witness News*, May 10, 2015, accessed September 16, 2015, http://www.iwnsvg.com/2015/05/10/st-vincents-geothermal-development-approach/.

200. Ellsworth Dacon, "Presentation: Geothermal Development in Saint Vincent and the Grenadines" (August 3, 2015, Malaysia), accessed December 3, 2015, http://www.irena.org/EventDocs/S5_Ellsworth_Dacon_St.Vincent_Malaysia_Presentation.pdf.

201. "St. Vincent Geothermal Power Plant Could Be Operational by 2018," *Caribbean 360*, September 1, 2014, accessed November 10, 2014, http://www.caribbean360.com/news/st-vincent-geothermal-power-plant-could-be-operational-by-2018.

202. Ellsworth Dacon, "St. Vincent's Geothermal Development Approach," *I-Witness News*, May 10, 2015, accessed September 16, 2015, http://www.iwnsvg.com/2015/05/10/st-vincents-geothermal-development-approach/.

The Government of New Zealand is providing technical support in reviewing the surface studies.[203] By July 2015, the government and its partners had completed the surface studies and the resulting detailed technical, project, and business plans.[204] In addition, the attorney general finalized the legislation needed for this project and it is under final review.[205]

The next steps for the project are to negotiate the public-private partnership agreements between the government, Light and Power Holdings, and Reykjavik Geothermal, and the PPA with VINLEC. The government started negotiations with Light and Power Holdings and Reykjavik Geothermal for the development of the project in July 2015.[206] The government and the companies are planning to competitively procure various stages of the project, including the design of the plant and also the drilling of the production wells.[207] Once an agreement has been signed, the project company will begin drilling.[208] The government, potentially in conjunction with its private partners, will also need to begin work on updating the grid, building transmission lines, and building access roads.

11.3 Recommended Financial and Legal PPP Structure

In Saint Vincent and the Grenadines, the government has identified a PPP structure that should allow it to successfully develop its geothermal resources. This PPP structure is proposed as part of La Soufriere Geothermal Project. We recommend the government implement this PPP structure. Under this project, a special purpose vehicle owned by the government and a consortium of private companies would develop Saint Vincent's geothermal resources and sell electricity generated to VINLEC under a PPA. This arrangement would allow the government to use the private sector's knowledge, resources, and financing to develop geothermal resources. While the project faces some risks because it is in its early stages, the largest risks can be mitigated with the support of multilateral development banks.

---

203. Bernard Hill, Project Director & Energy Manager at Hawkins Infrastructure, email message to Gianmarco Servetti, November 25, 2014.

204. "St. Vincent & the Grenadines Outline Progress on Geothermal Work," *ThinkGeoEnergy*, July 16, 2015, accessed December 2, 2015, http://www.thinkgeoenergy.com/st-vincent-the-grenadines-outline-progress-on-geothermal-work; Ellsworth Dacon, "Presentation: Geothermal Development in Saint Vincent and the Grenadines" (August 3, 2015, Malaysia), accessed December 3, 2015, http://www.irena.org/EventDocs/S5_Ellsworth_Dacon_St.Vincent_Malaysia_Presentation.pdf. The surface exploration phase was delayed by six months due to problems faced with the difficult terrain. The surface exploration phase originally included resistivity studies, with 34 magnetotelluric (MT) and transient electromagnetic (TEM) sounding sites. However, due to the terrain, an additional 10–20 TEM sounding stations were needed.

205. "St. Vincent Geothermal Power Plant Could Be Operational by 2018," *Caribbean 360*, September 1, 2014, accessed November 10, 2014, http://www.caribbean360.com/news/st-vincent-geothermal-power-plant-could-be-operational-by-2018.

206. Ellsworth Dacon, "Presentation: Geothermal Development in Saint Vincent and the Grenadines" (August 3, 2015, Malaysia), accessed December 3, 2015, http://www.irena.org/EventDocs/S5_Ellsworth_Dacon_St.Vincent_Malaysia_Presentation.pdf.

207. Ellsworth Dacon, "St. Vincent's Geothermal Development Approach," *I-Witness News*, May 10, 2015, accessed September 16, 2015, http://www.iwnsvg.com/2015/05/10/st-vincents-geothermal-development-approach/.

208. "St. Vincent Geothermal Project On Track to Start-Up in 2018," *Caribbean News Now*, July 22, 2015, accessed December 2, 2015, http://www.caribbeannewsnow.com/headline-St-Vincent-geothermal-project-on-track-to-start-up-in-2018-26989.html.

11.3.1 Structure of the PPP

The PPP structure proposed by the government in La Soufriere Geothermal Project would allow for the successful development of Saint Vincent's geothermal resources.[209] We recommend the government implement this PPP structure with two additions—including a payment support mechanism that backs VINLEC's payments under the PPA, and concessional funding from multilateral development banks. The proposed PPP structure, which has been discussed and is outlined in a LOI, is described in depth in Section 11.2.[210] Under this model, the geothermal resource in Saint Vincent would be developed by an SPV that is jointly owned by the government and its private partners. It would be financed through a mix of debt and equity contributions. The government has already been approved for a US$15 million loan to support this project.[211] The SPV would have a 20-to-30-year concession to design, build, own, operate, and finance the geothermal generation plant and would sell electricity to VINLEC under a 20-to-30-year PPA.

We recommend two additions to the PPP structure proposed by the government. First, we recommend that the government obtain additional concessionary funding. Multilateral development banks could provide contingent grants and concessional loans to the SPVs. The type of funding provided would differ based on the stage of the project's development. Grants and contingent grants would support the early stages of geothermal development—surface exploration (including environmental and social impact studies) and exploratory drilling. At these stages, the resource is highly uncertain. Contingent grants would be converted to concessional loans if the resource is confirmed and a power plant is built on the site, and repaid from revenues from electricity tariffs. The later stages of geothermal development—production drilling and power plant construction—would be supported by concessional loans. This funding would support the project during the stages with the highest risk, and will help reduce the overall cost of the project.

Secondly, since VINLEC is fully state-owned, it might be necessary to include a payment support mechanism that backs VINLEC's payments for the PPA. That support mechanism would reduce the risk of the project's revenues and, thus, make the project more bankable and appealing to investors. The payment support mechanism can be implemented in various ways. Some of the options include:

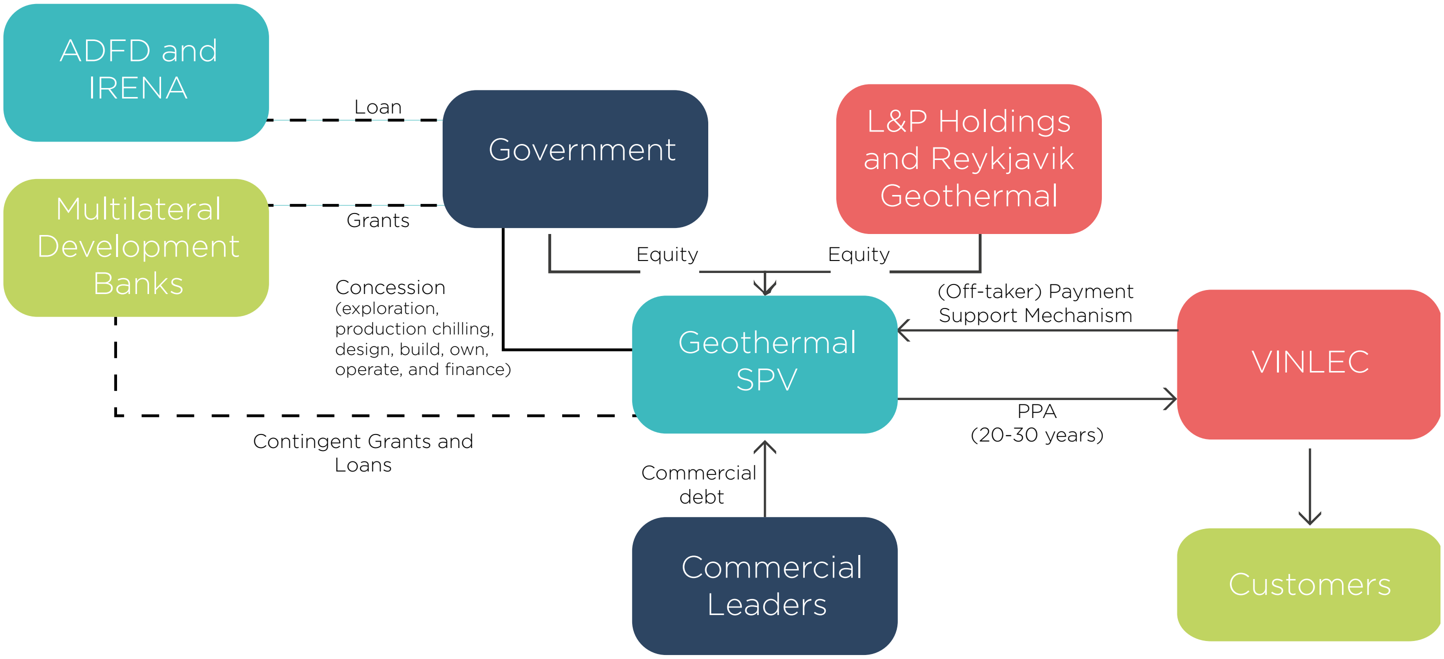
- Establishing a liquidity facility, such as a trust fund or escrow account, which would involve setting up a single purpose account that is managed by a third party. VINLEC would make periodic contributions to the bank account, and these funds would be exclusively used to pay the SPV in the event that VINLEC does not meet its payments under the PPA.
- A third-party guarantee mechanism offered by a donor or financial institution could also be used to back VINLEC's payments. Examples of financial institutions that offer guarantees include the Multilateral Investment Guarantee Agency, which provides coverage for breach of contract.

209. Government of Saint Vincent and the Grenadines, "The La Soufriere Geothermal Project" (Costa Rica Study Tour: March 2014).

210. Ibid.

211. "IRENA and ADFD Bring Renewable Power to 280,000 in Many Rural Communities," *IRENA.com,* January 18, 2015, accessed April 27, 2015, http://www.irena.org/News/Description.aspx?NType=A&mnu=cat&PriMenuID=16&CatID=84&News_ID=388; Kenton Chance, "Saint Vincent's Geothermal Project Gets US$15 Million Loan," *I-Witness News*, January 18, 2015, accessed September 15, 2015, http://www.iwnsvg.com/2015/01/18/st-vincents-geothermal-project-gets-us15-million-loan/.

FIGURE 11.5 Recommended PPP Structure for Saint Vincent and the Grenadines



Sources: The percentage ownership of the SPV comes from the following source: Ellsworth Dacon, "Presentation: Geothermal Development in Saint Vincent and the Grenadines" (August 3, 2015, Malaysia), accessed December 3, 2015, http://www.irena.org/EventDocs/S5_Ellsworth_Dacon_St.Vincent_Malaysia_Presentation.pdf

This model can be successful in Saint Vincent and the Grenadines for three main reasons. First, the proposed project developers have demonstrated commitment and have the expertise and resources. Light and Power Holdings knows the Caribbean energy market, and has partnered with Reykjavik Geothermal, who has solid technical expertise in identifying and developing geothermal resource; and the government can grant the right to develop the geothermal resource and owns the project's off-taker. The fast progress of the project and the investment by Light and Power Holdings and Reykjavik Geothermal also indicate that the proposed PPP should be successful.

Secondly, the project should be successful because it is likely a financeable project. The proposed project has the agreements needed to limit the risk faced by investors and lenders, which increase the likelihood of structuring a financeable project. In particular, the PPA and a payment support mechanism for VINLEC's payments under the PPA reduce the revenue risk for the SPV. VINLEC would ensure full cost recovery by passing on the PPA rate to its customers through the tariffs. The concession agreement and the PPA would then ensure that the SPV is able to repay its debts and allow the investors to receive the expected return.

Lastly, this project should be successful because of the potential size of geothermal resources on Saint Vincent. The geothermal resources on Saint Vincent are estimated to be large enough to power the planned 10–15 MW geothermal plant. The exploratory surveys provide potential investors with key information about the size and quality of the resource and with further confidence that Saint Vincent will be able to successfully develop a geothermal plant.

11.3.2 Key risks and mitigation measures

The proposed geothermal project has numerous risks because it is still in the early stages of geothermal exploration and no agreements have been signed. Table 11.1 provides an overview of all project risk.

Table 11.1 Allocation of Risks for the Proposed PPP Structure

Risk	Impact of Risk	Party That the Risk Is Assigned To	Proposed Measure for Mitigating the Risk
Market, Demand, or Volume RiskPotential	Medium	VINLEC and the government	A PPA and a payment support mechanism for VINLEC's payments under the PPA.
Resource Risk	Medium/High	SPV (government and private developers) and the multilateral development banks	The SPV's technical partner expertise helps mitigate this risk. Contingent grants for exploratory and production well drilling can help reduce costs.
Construction Risk	Medium	SPV and, possibly, the construction company that builds the plant	The SPV can hire a company to build the plant and incorporate penalties if the plant is not completed on time or milestones are not achieved as contractually planned.
Technical Risk	Low	SPV	None. The risk is low and this is a proven technology.
Operating Risk	Low	SPV	None. The risk is low.
Political and Social Risk	Low	SPV	The participation by the government in the SPV and multilateral development banks in the project reduces the project's political and social risk. Also, if electricity prices are reduced through the use of geothermal energy, the public will likely support the project.
Environmental Risk	Medium	SPV and the government	This risk can be reduced by carrying out an EIA. The EIA will allow the government to assess the risk of the geothermal project and propose an action plan to mitigate the risks identified.
Financing Risk	Medium	SPV and the government	The financial risk for the project is reduced with the PPA, the payment support mechanism for VINLEC's payments under the PPA, and potentially financing from development banks.
Regulatory Risk	Low	Government	The government is responsible for making any necessary changes to the legal and regulatory framework to enable the development of the project. Since those changes take time, the parties to the project can draft clear rules governing the sustainable exploitation of the resource and the operation of the power plant in the project agreements (concession, PPA, others).

We describe the largest risks for the project and the proposed mitigation measures below:

- **A commercially viable resource cannot be identified, or identifying and developing a production well is more expensive than expected (Resource Risk)**—The geothermal resource exploration in Saint Vincent is still in the early stages. While a prefeasibility study, a geothermal resistivity study, and surface exploration have been completed, no wells have been drilled. One of the risks for the project is that the project partners will not be able to identify and develop a commercially viable production well, or that the production well cannot be developed quickly and within the expected cost.
  To a large extent, this risk is mitigated through the participation of Reykjavik Geothermal in the surface exploration. Reykjavik Geothermal is an experienced developer that has been involved with the development of over 3,000 MW of geothermal projects in more than 30 countries. Reykjavik Geothermal's participation throughout the whole process ensures that the project receives excellent technical advice and that the cost estimates for developing the production well are accurate. Given that Reykjavik Geothermal is best placed to mitigate this risk, they should be asked to assume some of this risk.

- **Early stage risks discourage investment (Resource Risk)**—This risk can be mitigated through the support of the multilateral development banks. The multilateral development banks could help assume some of this risk through providing contingent grants. Under this arrangement, the multilateral development banks could offer to provide funding whose repayment would depend on the success of the drilling. For example, countries will have to repay the entire loan if the drilling is successful, but only a portion if the drilling is not. This reduces the resource risk faced by project developers.

- **The proposed project developers do not agree on the terms of the concession or other project documents (Market Risk)**—The government has negotiated project agreements with Reykjavik Geothermal and Light and Power Holdings and continues to do so.

- One of the key risks is that the government and the proposed project developers are unable to reach an agreement. Despite having a preliminary agreement on the maximum rate of return that the project developers can earn,[212] there are other aspects over which they may be unable to agree. For example, they may be unable to agree on the financial contributions that each partner must make or the allocation of risks among partners.

  To a large extent, this risk has been reduced through the initial commitments by the government and the proposed project developers. As mentioned earlier, the partners have reached preliminary agreements that will found the final agreements. Also, Reykjavik Geothermal and Light and Power Holdings are invested in the project; they funded some of the early exploration of geothermal resources on Saint Vincent.[213] The multilateral development banks can further reduce this risk by offering to provide concessionary financing and support for the geothermal exploration, which would reduce the risk for the project participants and would help make the project more attractive.

- **The project developers are not able to raise the financing needed for the project (Financing Risk)**—Another major risk for the project is that the project developers are not able to raise the financing needed for the project. The project developers would be unable to raise financing if investors or lenders did not believe that the project was financially viable. Specifically, they may be unwilling to invest if there are large, unmitigated risks, such as resource risks, or if the expected cash flows are highly uncertain or will not allow them to earn the required return on their investment.

  However, the participation of Light and Power Holdings and the government in the project will help reduce this risk. As mentioned, Light and Power Holdings' knowledge of the Caribbean energy sector and its financial position will help it make a compelling case to banks. In addition, multilateral development banks can help reduce this risk by offering concessionary financing for the project. Lastly, the proposed payment support mechanism for the PPA would also significantly reduce the project risk.

11.3.3 Strategy for engaging key stakeholders

The government has actively engaged stakeholders and kept them up to date on the development of the proposed geothermal project. The prime minister and the proposed project partners have worked to keep the public informed of the most recent project developments. In addition to carrying out preliminary stakeholder consultations, there have been numerous articles in the local and regional newspapers with detailed information about the proposed project and its progress to date. The prime minister is quoted in numerous articles, which shows his commitment and active engagement in the project. If his support for the project continues, this will help facilitate its development and ensure that key government bodies support the project.

In addition to its current efforts, the government should ensure that VINLEC is involved and updated on the project's progress. This is particularly important because VINLEC will purchase the electricity generated from the project. Even though VINLEC is a government-owned agency, it is important VINLEC is involved and kept informed of any new developments because the development of the plant will affect VINLEC's planning processes. VINLEC will also need to make sure that its contracts for purchasing diesel will allow it to transition to geothermal generation once the plant is online. To a large extent, this will require that VINLEC keep diesel suppliers up to date so that they can adjust imports accordingly.

Lastly, it is important for multilateral development banks to be involved and be kept informed of the project because of their key role in the project. They are providing technical assistance and will provide the concessionary funding, which will be key for the project's success. If the development banks are kept up to date, the funding could be made available more quickly.

11.4 Recommended Changes to the Legal, Institutional, and Regulatory Framework

The government has announced that it is reviewing the legislation required to implement the proposed geothermal project.[214] The government has not published this draft legislation, so we have not been able to review and evaluate the proposed legislation. However, at a minimum, the following major changes must be made to the legal, institutional, and regulatory framework to allow for the implementation of the project:

- **There should be a clear process for the geothermal power plant to obtain a license.** The Electricity Supply Act of 1973 gives VINLEC the sole right to generate electricity and provides it with the power to issue sublicenses. If the government wants to issue a license to the geothermal power plant directly, it must amend the ESA. Regardless of who grants the licenses, there must be a clear process in place to apply for and to obtain a license.
- **The tariffs should reflect the cost of producing electricity with geothermal generation.** The tariffs in Saint Vincent and the Grenadines are set by the prime minister and VINLEC, and pass on the cost of fuel to customers.[215] The prime minister and VINLEC must adjust the tariff to reflect the costs of producing electricity through geothermal generation. More specifically, they must ensure that the tariff allows VINLEC to recover the full cost of providing service at least-cost, regardless of the technology or fuel in use, and that the tariff reflects any reduced costs of electricity generation.
- **Saint Vincent should establish a clear framework governing geothermal resources.** Saint Vincent must have a legal framework that assigns ownership of geothermal resources, establishes a process for granting licenses to develop geothermal resources, and assigns responsibility for monitoring geothermal resources to a government body. One possible way to establish this framework is to approve the draft Geothermal Resources Exploration and Development Bill of 2012, which was developed with funding from the Caribbean Sustainable Energy Program. The Geothermal Bill is currently under review.[216]

214. "St. Vincent Geothermal Power Plant Could Be Operational by 2018," Caribbean 360, September 1, 2014, accessed November 10, 2014, http://www.caribbean360.com/news/st-vincent-geothermal-power-plant-could-be-operational-by-2018.

215. "Energy in St. Vincent and the Grenadines," The Vincentian, accessed November 12, 2014, http://thevincentian.com/energy-in-st-vincent-and-the-grenadines-p2747-107.htm.

216. "St. Vincent Geothermal Power Plant Could Be Operational by 2018," Caribbean 360, September 1, 2014, accessed November 10, 2014, http://www.caribbean360.com/news/st-vincent-geothermal-power-plant-could-be-operational-by-2018.

- **A regulator should be established.** We recommend establishing a regulator responsible for carrying out the regulatory functions described above. For example, the regulator would be responsible for approving VINLEC's tariffs based on the revised methodology established in the ESA. The regulator could also be responsible for monitoring the geothermal resource, although environmental regulation is not always within the jurisdiction of the regulator. Establishing a separate regulator responsible for these functions is one way to centralize these responsibilities. If the regulator has sufficient autonomy from other government agencies and has the resources to carry out its work, centralizing these functions will ensure that these functions are executed capably.

Drafting, reviewing, and approving the laws and regulations that would address these changes takes time to implement. The first draft of the Geothermal Bill was prepared in 2012 and by November 2015 had yet to be approved by Parliament (see Section 11.1.2).

Another way to address some of these changes is to establish regulation through contracts. For example, to ensure that tariffs for end customers reflect the (lower) costs of producing electricity through geothermal generation, the PPA that the SPV signs with VINLEC could establish the formula used to determine the tariffs VINLEC charges customers. Similarly, the agreements between the government and the private partners could include obligations that ensure the protection and sustainable development of the geothermal resource. For example, the agreement can mandate that an independent expert carry out periodic evaluations to monitor the environmental impact of the power plant. Since regulatory functions in Saint Vincent are spread across various government agencies, if a regulator is not established a committee could be formed to monitor the SPV's compliance with contractual obligations. Any dispute arising from failure to adhere to contract obligations could be handled by a regular court, an administrative court, or a special expert panel as applicable.

Establishing regulation through contracts would only serve as a short-term solution to prevent delays in project implementation. There are some regulatory functions that cannot be covered through regulatory contracts and for which regulations and laws will need to be established. For example, the government will still need to develop the process through which licenses to establish a geothermal plant are obtained.

11.5 Economic and Financial Analysis of the Geothermal Project

In this section, we assess whether the geothermal project in Saint Vincent and the Grenadines is economically and financially viable. We first perform a cost-benefit analysis to determine whether the geothermal project generates net economic benefits to the country. We then use the discounted cash flow method to evaluate whether the geothermal project is financially viable to investors. We conclude that the geothermal project is economically and financially viable. Therefore, we recommend the government and investors proceed with implementing it. We present our analysis and results as follows:

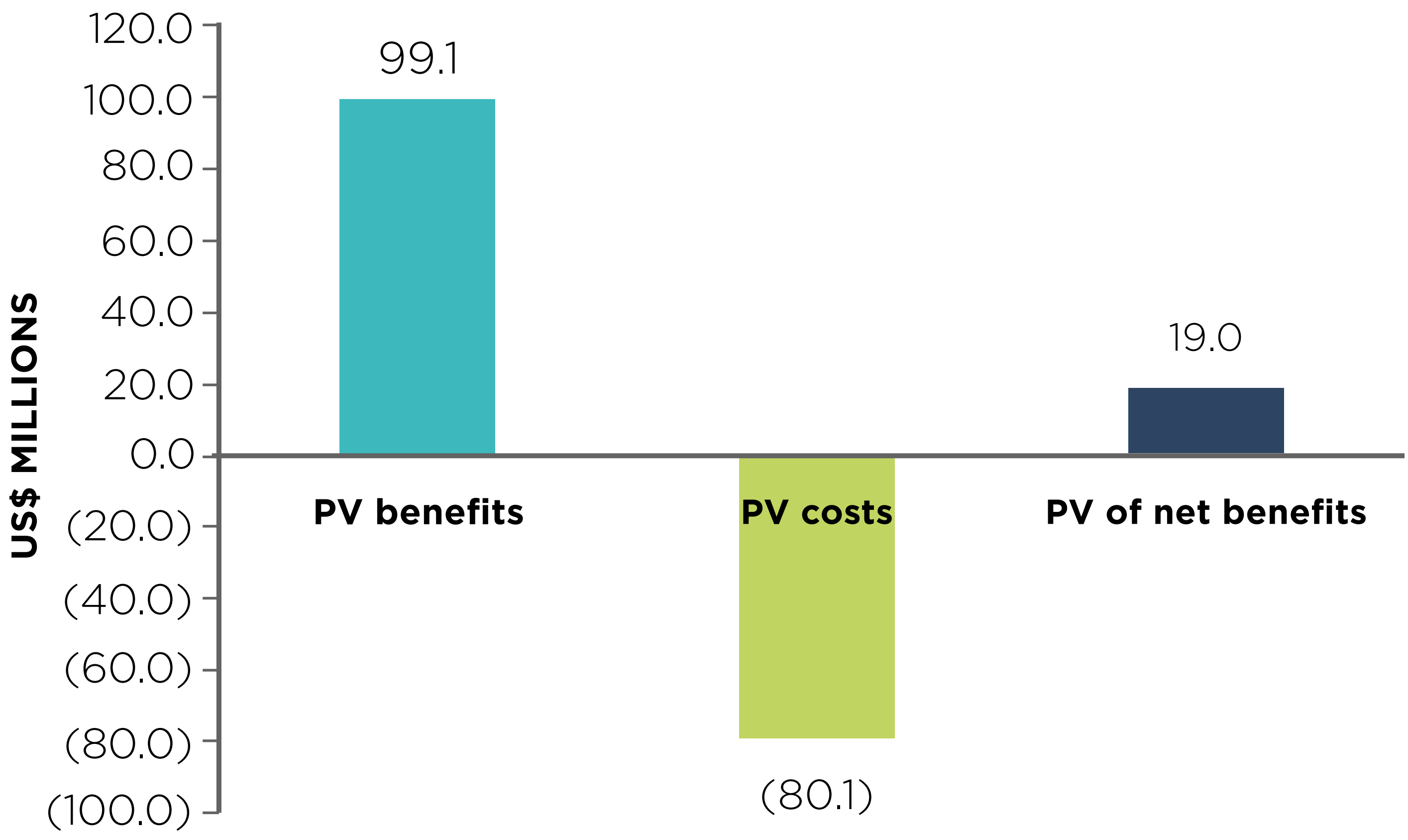
- Cost-benefit analysis (Section 11.5.1)
- Financial analysis (Section 11.5.2)

11.5.1 Cost-benefit analysis

We perform a cost-benefit analysis to determine whether the geothermal project is economically viable. We conclude that Saint Vincent and the Grenadines' geothermal project is economically viable and increases social welfare.

The present value of the project's net economic benefits is positive and equal to US$19 million (see Figure 11.6). Therefore, the government and donors should proceed with developing the project.

FIGURE 11.6 Present Value of Net Economic Benefits of the Saint Vincent and the Grenadines' Geothermal Project



To determine the economic viability of the geothermal project, we estimate its net economic benefits for a period of 40 years. Net economic benefits equal the economic benefits minus the economic costs of the project. Economic benefits include savings in generation costs (because generating electricity from geothermal resources can cost less than from fuel oil or diesel), and reductions in CO_2 emissions. Economic costs are the capital expenditures needed to complete all project stages. We then bring the economic benefits and costs to present value (PV) with a social discount rate of 12 percent (in real terms).[217] The geothermal project is economically viable if the PV of the project's net benefits is positive—if economic benefits outweigh economic costs. Further details about the assumptions and methodology we use are presented in Appendix A.

11.5.2 Financial analysis

We use the discounted cash flow (DCF) method to determine whether the geothermal project in Saint Vincent and the Grenadines is financially viable for equity investors. We conclude that the geothermal project allows the equity investors to earn a 15 percent real rate of return when the PPA rate is about US$0.16/kWh. This PPA rate is the tariff at which the geothermal projects would need to sell each kWh of electricity to be able to service their debts and provide equity investors with a 15 percent real return. This PPA rate is feasible to implement, because it is significantly lower than the current electricity tariff from fuel oil generation of US$0.35/kWh.[218] The final PPA rate will be determined through negotiations between the partners of the project.

217. IDB, "Guidelines for the Economic Analysis of IDB-Funded Projects," June 2012, http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=36995807.

218. CARILEC, 2014 *Average Tariffs in EC Countries* (2015).

Table 11.2	Financial Results of Geothermal Project	
NPV to Equity Investors (US$ million)	IRR to Equity Investors (Real)	PPA Rate S$/kWh)
0	15%	0.16
5.7	20%	0.18
10.8	25%	0.20

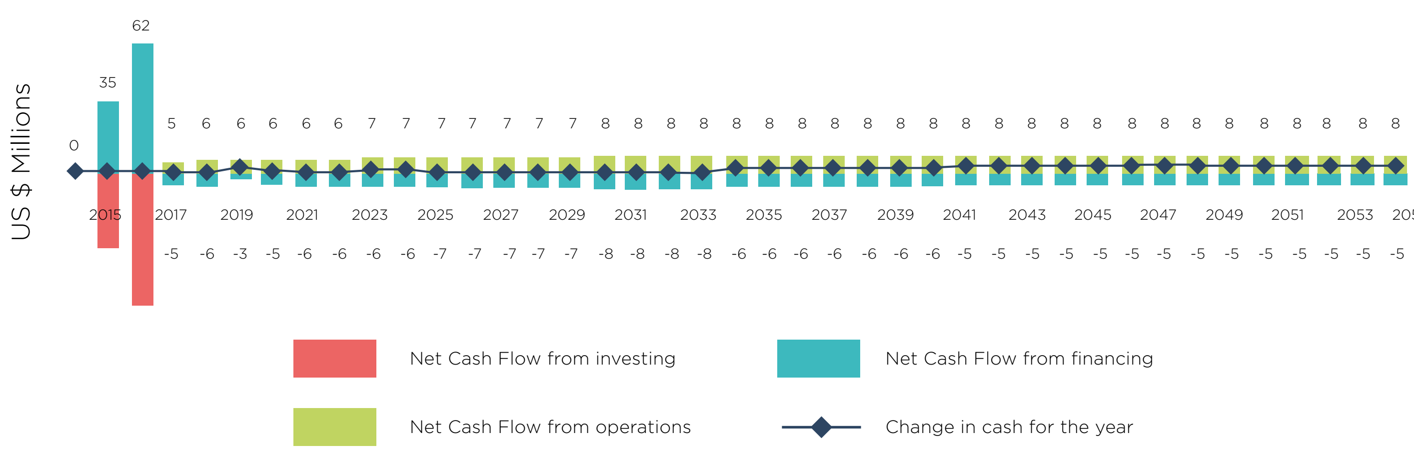
Notes: The IRR is Internal Rate of Return of the cash flows to equity investors. We assume a 15 percent real discount rate for equity cash flows.

In this section, we present the estimated cash flows from the geothermal project. The DCF methodology we use and our main assumptions are in Appendix B.

Cash flows from the geothermal project

In Figure 11.7, we present the projected cash flows of the geothermal project for a PPA rate of US$0.16/kWh. Cash flows from financing are positive from 2016 to 2017 and are directed towards financing the capital expenditures (investments). The highest capital expenditures occur from 2016 to 2017, when the power plant is under construction. When the power plant begins operations in 2018, the cash flows from operations become positive and are used for repaying debt.

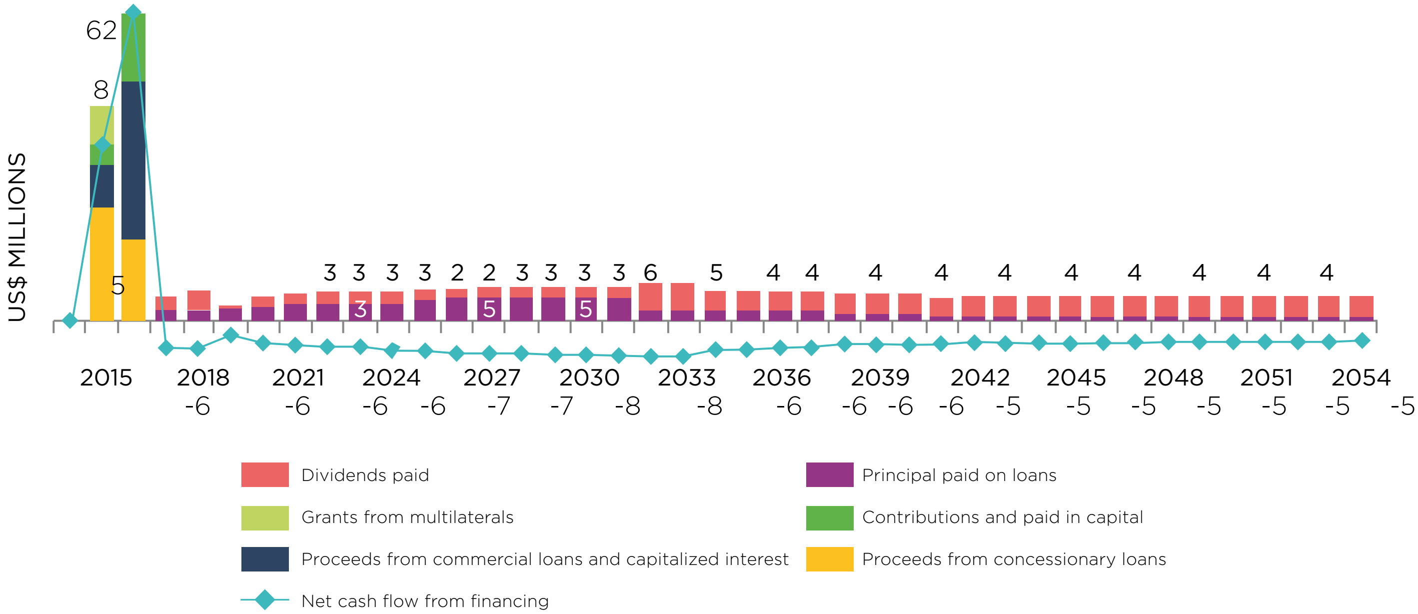
FIGURE 11.7 Cash Flows for the Saint Vincent Geothermal Project



Regarding financing (Figure 11.8), the majority of financing in 2016 comes from concessionary loans and grants provided by the Fund. This is due to the fact that concessionary financing is directed towards financing the riskier stages of geothermal development that occur in 2017—exploration. However, commercial loans are also used to finance a portion of the investments in production drilling and reinjection wells that occur in 2016.

In 2017, the majority of the financing is commercial debt and equity that is directed towards power plant construction. Once the power plant begins operations in 2018, the cash flows from operations are directed towards repaying the debt. The net cash flows from contributions and paid-in capital and dividends paid are the cash flows to the equity investor, which we discuss below.

FIGURE 11.8 Financing Cash Flows



The cash flows to the equity investors are presented in **Figure 11.9.** The cash flows to the equity investor are negative during 2015 to 2017, when the equity investors make their paid-in contributions to finance a portion of the capital expenditures. By 2018, the cash flows to the equity investors are positive because the cash flows from operations become large enough to pay for operating costs, cover working capital, and service debt. The remaining cash flows are the cash available to equity investors. As payout policy we assumed that dividends are equal to the minimum of the cash available to equity and retained earnings, subject to retained earnings not falling below zero. As further debt payments are made, the principal amount is further reduced and the cash flows to the equity investors increase.

FIGURE 11.9 Cash Flows to the Equity Investors

12 Dominica

The geothermal resources in Dominica are proven and the government has identified a two-phase approach for developing them. Of the countries in our study, Dominica has advanced the furthest in the exploration of its geothermal resources. It has carried out exploratory drilling and has developed an 11 MW production well. The government is now in the process of looking for private companies who are interested in developing the geothermal resources.

The government plans to develop its geothermal resources using a two-phase approach that uses private sector participation. In the first phase, it will develop a 10.5 MW geothermal power plant, which will provide electricity to meet domestic demand. In the second phase, it will develop a 100–120 MW geothermal power plant and interconnection cables for exporting electricity to Martinique and Guadeloupe. The government currently does not have any commercial agreements with a project developer to develop these plants.

The next steps are for the government to identify a suitable project developer who will construct the geothermal power plant for Phase 1 and carry out the feasibility study for Phase 2. In addition, the government should pass legislation that clearly defines the framework for governing geothermal resources. Also, the multilateral development banks could play an active role in this project by providing funding for Phase 1 and technical support, grants, contingent grants, and concessionary loans for Phase 2. For the project to be eligible to access multilateral funding, the project and/or the works and services would probably need to be procured competitively. The planned project and possible role for the multilateral development banks is described in more detail in the following sections:

- Overview of the Electricity Sector in Dominica (Section 12.1)
- Status of Geothermal Development (Section 12.2)
- Recommended Financial and Legal PPP Structure for Phase 1(Section 12.3)
- Recommended Financial and Legal PPP Structure for Phase 2 (Section 12.4)
- Recommended Changes to the Legal, Institutional, and Regulatory Framework (Section 12.5)
- Economic and Financial Analysis of the Geothermal Project (Section 12.6)

12.1 Overview of the Electricity Sector in Dominica

Dominica Electricity Services Ltd. (DOMLEC), a vertically integrated state-owned electricity utility, has an exclusive license to provide electricity in Dominica. The Electricity Supply Act of 2006 establishes the structure of the electricity sector and creates the sector regulator, the Independent Regulatory Commission (IRC). The IRC is overseen by the Ministry of Public Works, Energy, and Ports which is also responsible for developing policies for geothermal development.[219] The government has drafted, but not yet approved, the Draft National Energy Policy (2014), the Draft Sustainable Energy Plan (2014), and the Geothermal Resources Bill (2013). These documents describe the government's goals and actions for developing a more economical, more reliable, and less-polluting energy sector.

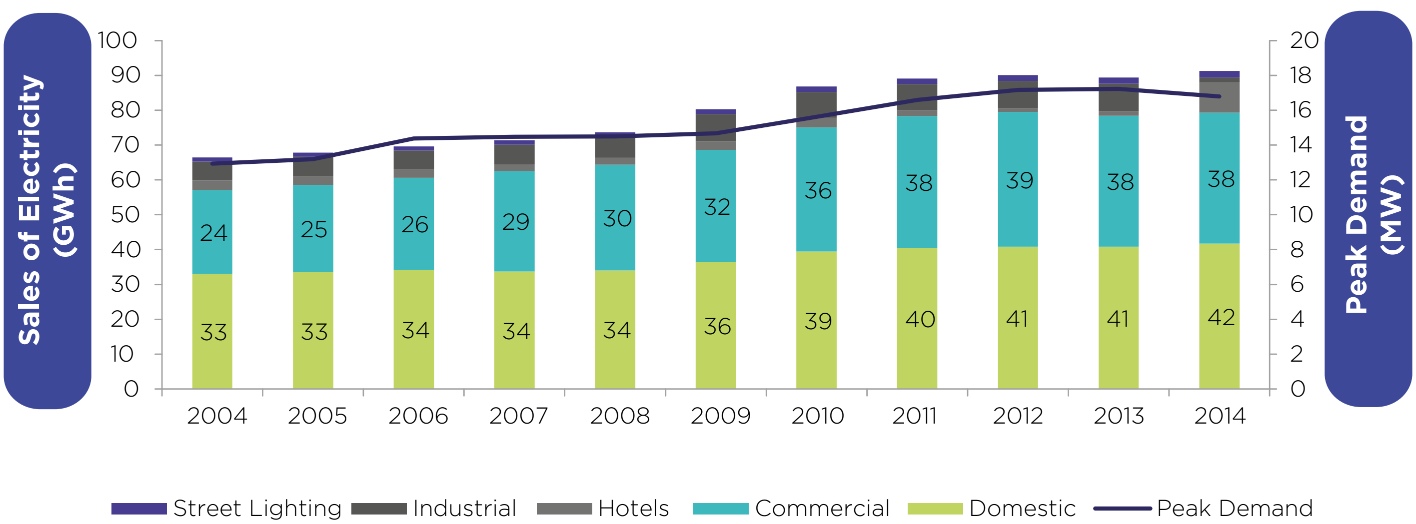
219. Government of Dominica: Ministry of Public Works, Energy, and Ports, accessed October 31, 2014, http://publicworks.gov.dm/.

12.1.1 The electricity market in Dominica

In 2014, DOMLEC's total installed capacity was 26.7 MW, which consisted of 20.1 MW of diesel generation and 6.6 MW of hydropower units (the effective hydropower capacity during the dry months is approximately 3.2 MW). DOMLEC operates two diesel power stations and three hydroelectric power stations. DOMLEC's installed capacity is well above peak demand, which was approximately 17 MW in 2014.[220]

The growth of DOMLEC's electricity sales and peak demand has slowed during the last four years, but there was a slight increase in both electricity sales and peak demand in 2014. This increase was driven by increased sales in the residential sector. In 2014, DOMLEC served 35,354 customers—including 3,954 domestic customers, 4,055 commercial customers, 39 hotels, and 42 industrial customers. In 2014, domestic customers had the highest total demand (46 percent of the electricity consumed) and commercial consumers had the second highest total demand (41 percent of the electricity consumed; see Figure 12.1. In 2014, electricity sales increased by 2 percent, twice as high as the average annual growth rate of 1 percent between 2003 and 2012.[221] Peak demand also increased by 1 percent in 2014; however, the growth rate for peak demand has decreased since 2009.

FIGURE 12.1 Electricity Demand by Sector and Peak Demand (2004–2014)



Source: Source: DOMLEC, Annual Reports 2004–2014.

12.1.2 Key laws, regulations, and policies governing the sector

The electricity sector in Dominica is governed by the Electricity Supply Act of 2006, which establishes the structure of the electricity sector and creates the sector's regulator. The ESA granted DOMLEC the exclusive right to supply electricity until December 2015. Discussions between IRC and DOMLEC since 2012 culminated in 2013 with IRC granting DOMLEC two new licenses; a Generation License gives DOMLEC the non-exclusive right to generate electricity, and a Transmission, Distribution, and Supply License gives DOMLEC the exclusive right to transmit, distribute, and supply electricity in Dominica. Both licenses are for 25 years and went into effect on January 1, 2014.

The government has drafted several other laws and policies that will guide the development of the sector once they are approved. These include the Geothermal Resources Development Bill (2013), the Draft National Energy Policy (2014), and the Draft Sustainable Energy Plan (2014). The Geothermal Resources Development Bill will establish the legal framework for exploring and developing geothermal resources. The Draft National Energy Policy (2014) and the Draft Sustainable Energy Plan (2014) will establish the government's objectives for the electricity sector and the actions that it would pursue to achieve these objectives.

220. DOMLEC, 2014 Annual Report.
221. Ibid.

Policies in the energy sector

The government's policies in the electricity sector aim to reduce energy prices, increase environmental sustainability, and reduce fossil fuel use. The Low-Carbon Climate-Resilient Strategy, adopted in 2012, sets out many of the government's objectives for the energy sector—it envisions a "low-carbon, climate-resilient" development strategy. Specifically, it identifies the objectives of developing renewable energy projects and promoting energy efficiency and energy conservation programs.[222]

The government has also drafted three other key documents for the energy sector: the Geothermal Resources Development Bill (2013), the Draft National Energy Policy (2014), and the Draft Sustainable Energy Plan (2014).[223] These documents have not been approved, but would establish the government's objective for the energy policy as to "pursue sustainable energy that is reliable, extends access to energy, and provides energy at the lowest possible cost"[224] and would identify the actions needed to achieve those goals.

The Geothermal Resources Development Bill (2013) was first developed in 2012 and has undergone a process of revisions since then. According to the prime minister, the Ministry of Energy and the attorney general's office have approved the Geothermal Bill. It is now undergoing a final revision to address stakeholder comments and will soon go to Parliament.[225] The Geothermal Bill "provides for the regulation of geothermal resources with the objective of ensuring the sustainable development of the resource, and ensuring its allocation to the uses that are most economically beneficial to Dominica."[226]
In particular, the Geothermal Bill:

- Establishes procedures for allocating geothermal resources in Dominica, including a "competitive track," under which the government tenders out a concession and awards it to the best bidder presenting the best option, and a "negotiated track" for cases where there is not sufficient information for competition to work;
- Creates a statutory board to advise the minister responsible for energy (who in turn advises the cabinet) on geothermal resource development; and
- Establishes an approach for securing approvals to develop geothermal projects.

222. Government of Dominica, "Low-Carbon Climate-Resilient Strategy 2012 to 2020" (2012), accessed October 30, 2014, https://unfccc.int/files/cooperation_support/nama/application/pdf/dominica_low_carbon_climate_resilient_strategy__(finale).pdf.

223. Lancelot McCaskey, "The Independent Regulatory Commission's Position on RE including Geothermal Energy Development in Dominica" (The Caribbean Renewable Energy Forum, March 2014).

224. Government of Dominica, "Draft National Energy Policy," April 15, 2014, accessed October 28, 2014, http://www.cipore.org/wp-content/uploads/downloads/2014/04/FINAL-NEP-Final-Draft-Commonwealth-of-Dominica-140415.pdf.

225. "Dominica seeks $50m loan for Geothermal Project from World Bank," ThinkGeoEnergy, May 19, 2015, accessed December 3, 2015, http://www.thinkgeoenergy.com/dominica-seeks-50m-loan-for-geothermal-project-from-world-bank/.

226. Government of Dominica, "Draft Geothermal Resources Development Bill," January 7, 2013, p. 2, accessed April 27, 2015, https://unfccc.int/files/cooperation_support/nama/application/pdf/geothermal-resources-development-bill-current-jan-30-2013.pdf.

Laws and regulations governing the electricity sector

The ESA is the most important document governing the regulatory framework of the electricity sector in Dominica. The ESA establishes the structure of the sector, including the procedure for licensing and monitoring utilities. The regulation and governance of the sector is further developed through decisions made by the IRC. These documents are further described below:

- The Electricity Supply Act—The ESA establishes the institutional framework of the electricity sector as well as the rights and duties of the different bodies in the electricity sector. The ESA creates the IRC, which is responsible for setting tariffs, licensing service providers, and setting service standards. In addition, it sets the process for granting electricity licenses. The ESA also specifies that renewable resources must be included in Dominica's electricity generation expansion plans.
- Decisions issued by the IRC—The IRC has issued several decisions that further develop the legal framework governing the sector. The most important decision issued by the IRC is the IRC's decision on Regulatory Policy and Procedure—Licensing Procedures. This decision sets out the license application process. Another important decision is the IRC's decision on the Tariff Regime for Dominica Electricity Services Ltd. 2009/004/D, which establishes the tariff-setting mechanism. The Tariff Regime sets a formula for determining tariffs that allows for DOMLEC to recover costs associated with generation from renewable energy and electricity purchased from IPPs.[227]

The legal framework governing the electricity sector lacks laws and regulations that govern the exploration and exploitation of geothermal resources. The government, in collaboration with the Organization of American States (OAS), prepared the Geothermal Resources Development Bill, which is intended to fill this gap. The Geothermal Bill has been revised several times; the most recent draft was completed in April 2013. It specifies that geothermal resources belong to the state, and sets out the process for receiving the government's approval for exploring and developing geothermal resources. The government expected Parliament to pass this version of the bill by the end of 2015.[228]

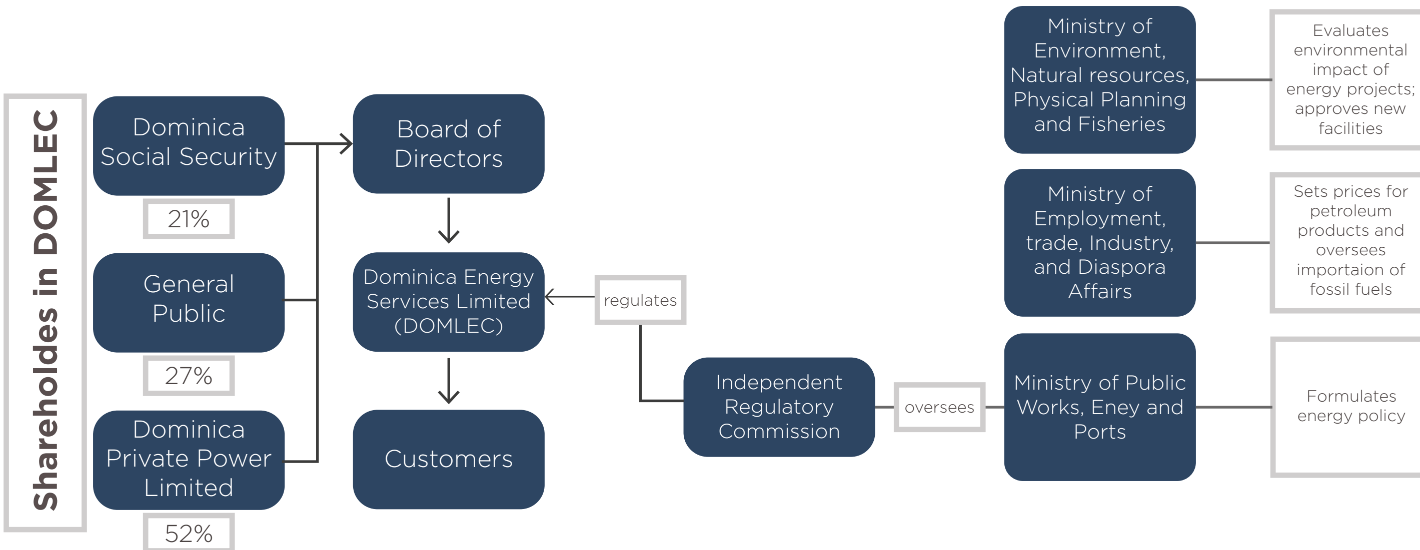
12.1.3 Institutional structure of the electricity sector

In Dominica, there are several entities that play a key role in the electricity sector. DOMLEC is the sole provider of electricity services. The Ministry of Public Works, Energy, and Ports sets the policies for the energy sector in Dominica. The IRC is the electricity sector's regulator. **Figure 12.2** presents the relationships between the key entities in Dominica's energy sector.

227. Independent Regulatory Commission, "Decision Document: Tariff Regime for Dominica Electricity Services Ltd.," (Document Ref: 2009/004/D, April 27, 2010), accessed November 12, 2014, http://www.ircdominica.org/files/downloads/2011/09/Descision_re_DOMLECs_Tariff_Regime.pdf.

228. "Geothermal Bill to go before Parliament soon," *Dominica News Online*, March 18, 2015, accessed March 20, 2015, http://dominicanewsonline.com/news/homepage/news/economy-development/geothermal-bill-to-go-before-parliament-soon/.

FIGURE 12.2 Institutional Structure of the Electricity Sector



Below we provide a more in-depth description of the major responsibilities in the electricity sector and the bodies responsible for carrying them out.

- **Policymaking**—There are three ministries responsible for making policy, planning, coordinating, and funding the energy sector.
  - The Ministry of Public Works, Energy, and Ports is the most important ministry in the sector. It is responsible for creating policies, overseeing the IRC, and coordinating the country's geothermal initiative. In particular, the Geothermal Project Management Unit is responsible for coordinating and managing the exploration and exploitation of geothermal resources at Wotten Waven.[229]
  - The Ministry of Environment, Natural Resources, Physical Planning, and Fisheries is responsible for environmental and natural resource management, including evaluating the environmental impact of energy projects and approving new facilities.
  - The Ministry of Employment, Trade, Industry, and Diaspora Affairs oversees the importation of fossil fuels and sets the price of petroleum products in Dominica.
- **Regulation**—The IRC is the economic regulator of the electricity sector. Its objectives are:
  - "To be an independent arbiter in all matters relating to the sale of electricity,
  - To establish rules and guidelines which will allow for consistency, predictability and transparency in the regulation of electricity supply in the nation,
  - To be a forum for customer appeals in their dealings with the service providers,
  - To protect the health and safety of all persons affected by the operators in the sector,
  - To support Government's policy on the supply of electricity for national development, and
  - To engage and work with other agencies to promote, protect and enhance a sustainable environment."[230]
- **Generation, Transmission, and Distribution—** DOMLEC is a vertically integrated and privately owned utility. It has a non-exclusive license to generate electricity and an exclusive license for transmission, distribution, and supply of electricity in Dominica. Although the IRC has the authority to grant licenses to IPPs, there are currently no IPPs operating in Dominica.

229. West Japan Engineering Consultants, Inc., "Study on Current Status of Geothermal Development in the Eastern Caribbean Islands," March 2014.
230. Independent Regulatory Commission, "About Us: Objectives and Functions," accessed November 3, 2014, http://www.ircdominica.org/about-us/objectives-functions/.

12.2 Status of Geothermal Development

Dominica has one of the best-explored and most promising geothermal resources in the Eastern Caribbean countries. The government has confirmed geothermal potential of 120 MW.[231] In March 2014, the government drilled its first commercial production well, which has a capacity of 11 MW.[232] The government's project to develop the country's geothermal resources includes two phases. The first phase is building a 10 MW power plant to supply electricity in Dominica. The second phase is building a larger power plant and interconnection cables to export electricity to Guadeloupe and Martinique.[233] The government's next step is to reach an agreement with developers to build and operate the first power plant.

12.1.2 Resource potential and development

The government has advanced considerably in developing Dominica's geothermal resources. It confirmed the geothermal resource potential of the Wotten Waven–Trafalgar–Laudat geothermal field ("the Wotten Waven field") through exploratory and production well drilling. Dominica has a total estimated geothermal potential of 200–500 MW,[234] has a confirmed geothermal potential of 120 MW,[235] and has drilled a commercial production well with generation capacity of 11 MW.[236] The 200–500 MW estimated potential is based on surface-level reconnaissance work and has not been proven through drilling. The government also completed an environmental impact study for production wells in 2013.[237]

To date, the country has spent about US$20 million exploring and developing geothermal sites.[238] Donors have financed most of these costs. The government confirmed the 120 MW resource by drilling three exploratory wells between December 2011 and June 2012.[239] These wells were drilled in the Wotten Waven field. The cost of exploratory drilling alone was US$11.7 million.[240] The government also received a US$2.6 million grant from the European Union Caribbean Investment Fund to develop geothermal resources in Dominica.[241]

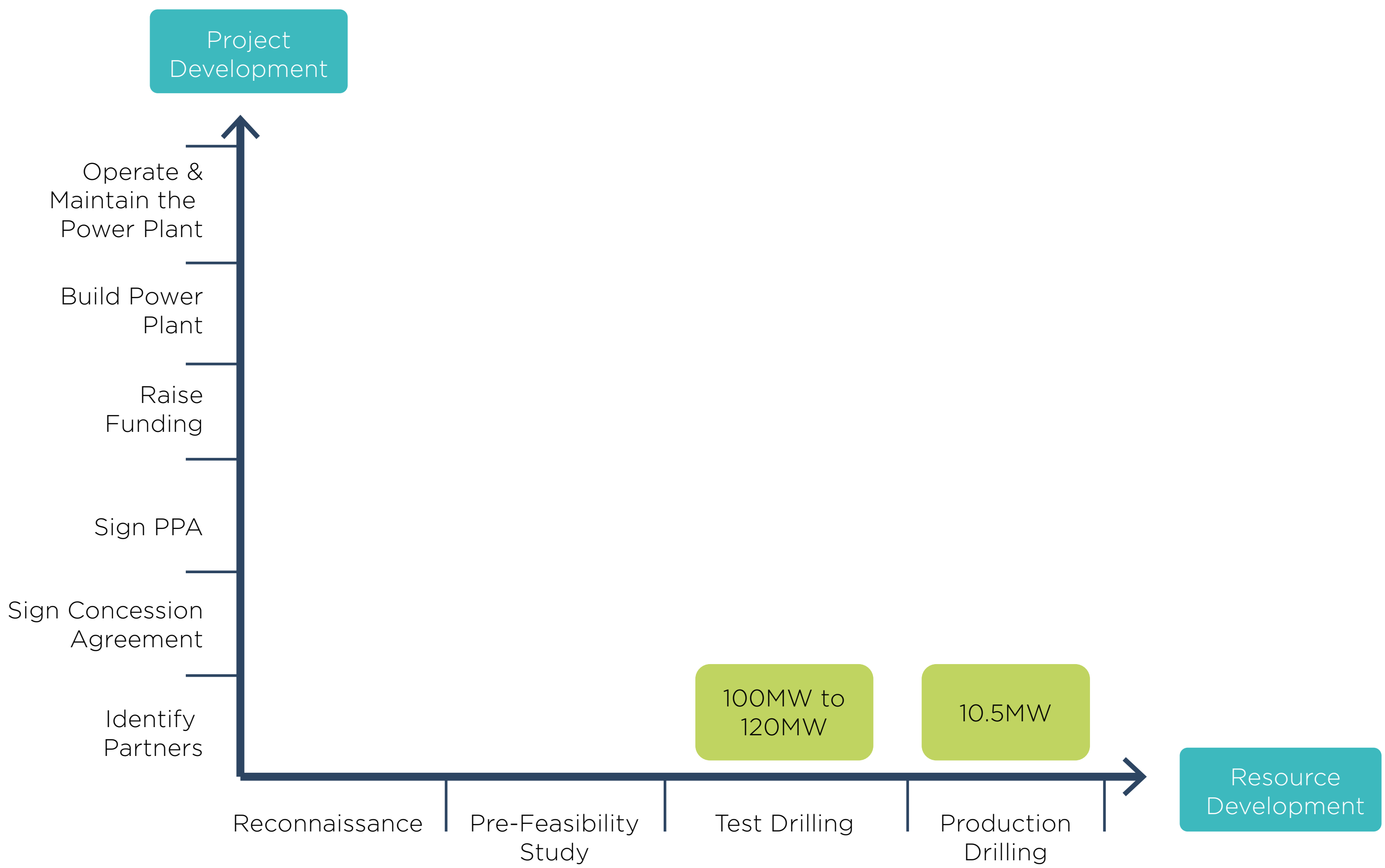
Furthermore, the government received a €6.5 million concessionary loan from the AFD to finance the drilling and testing of the commercial production well.[242] The government used this funding to drill a reinjection well during November–December 2013, and a commercial production well during January–March 2014.[243] Both these wells were drilled in the Wotten Waven field.

12.2.2 Planned project

The government has a clear two-phase plan to develop its geothermal resources. The first phase is building a 10.5 MW geothermal power plant to meet domestic demand.[244] The second phase is carrying out the production drilling and building a 100–120 MW geothermal power plant to export electricity to Martinique and Guadeloupe.

Figure 12.3 presents the status of Dominica's geothermal project. Despite significant progress in developing the resource, the government has not advanced in reaching an agreement to finance, build, and operate the power plants.

FIGURE 12.3 Status of Planned Geothermal Project



244. The government has indicated that the first phase of the project may reach a capacity of up to 20 MW. See the following source: Government of Dominica, "Geothermal: The Next Generation" (The Caribbean Renewable Energy Forum, March 2014).

Phase 1: 10.5 MW power plant to meet domestic demand

This generation plant would meet Dominica's current baseload demand of about 10 MW[245] (expected to grow to 16 MW by 2023).[246] Since the government has drilled an 11 MW commercial production well for this plant, the first phase of the project may only include the construction and operation of the power plant. The government initially expected the plant to be fully operational by 2016,[247] but no agreements have been signed with a developer yet.

The government has not determined how it will structure the transaction to finance, build, and operate the power plant. Its original plan was to develop the project in partnership with EDF. However, EDF withdrew from the project in 2013 due to low profitability of the investment.[248] The government recently identified a new private developer that could develop the power plant. In April 2014, a consortium of the French GDF Suez Group, CDC infrastructure, and NGE Group informed the government of its interest in developing the project.[249] In addition, AFD and World Bank have said they would fund a 15 MW plant.[250] The Clinton Climate Initiative is supporting the government in its negotiations with the consortium.[251]

There are no published cost estimates for building the power plant, and estimates vary significantly. Preliminary estimates indicate that carrying out the remaining production drilling and building a 10 MW power plant costs about US$52 million.[252] The construction of transmission lines and access roads would increase the total cost to about US$68 million. Another cost estimate, developed by the West Japan Engineering Consultants Inc., indicates that the cost of building a prototype 20 MW power plant is about US$40 million. Their cost estimate increases to US$58.22 million when costs of physical contingencies, consultant fees, and administrative expenses are included.[253] The government will almost certainly need outside financing to develop the 10 MW plant given the government's total estimated capital expenditure budget for FY 2014/15 of about US$170 million (already accounting for loans and grants).[254]

The government's next steps include finishing some of the preparatory work required for the project and completing the project agreements. This includes completing an environmental and social baseline study, and upgrading the transmission and distribution lines of the local grid. The government expected to complete the environmental and social baseline study in June 2015.[255] The government would need to finish upgrading the grid so that it is operational by the time the power plant is completed. The project agreements the government must develop include an agreement with a developer to build, finance, and operate the power plant. It would also facilitate the signing of a PPA with DOMLEC (which will be the project's off-taker).

---

245. World Bank, "Got Steam? Geothermal as an Opportunity for Growth in the Caribbean," Caribbean Knowledge Series, June 2013, accessed March 6, 2014, http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2013/06/21/000442464_20130621142703/Rendered/PDF/786080WP015.0G00Box377349B00PUBLIC0.pdf. Estimated as 60 percent of peak demand.

246. Based on recent growth trends.

247. Government of Dominica, "Geothermal: The Next Generation" (The Caribbean Renewable Energy Forum, March 2014).

248. "French Company, EDF, Reported to Have Withdrawn from Dominica's Geothermal Project," *Dominica News Online*, April 15, 2013, accesed November 4, 2014, http://dominicanewsonline.com/news/homepage/news/french-company-edf-could-withdraw-from-geothermal-project/.

249. "French Consortium Plans to Revive Large Project in Dominica," *ThinkGeoEnergy*, April 15, 2014, accessed December 3, 2014, http://www.thinkgeoenergy.com/french-consortium-plans-to-revive-large-project-in-dominica/.

250. "French AFD Prepared to Finance 15MW Project in Dominica," *ThinkGeoEnergy*, July 3, 2013, accessed December 3, 2015, http://www.thinkgeoenergy.com/french-afd-prepared-to-finance-15-mw-project-in-dominica/; "Work to Begin on Domestic Geothermal Plant This Fiscal Year," *Dominica News Online*, August 4, 2015, accessed December 3, 2015, http://dominicanewsonline.com/news/homepage/news/economy-development/work-to-begin-on-domestic-geothermal-plant-this-fiscal-year/.

251. Leslie Labruto, "Tripartite Partnership: Clinton Climate Initiative, Rocky Mountain Institute–Carbon War Room, and IRENA Lighthouses" (Presentation given in Martinique, June 24, 2015).

252. Financial model that accompanies this report, based on information from: IDB, "Sustainable Energy Facility (SEF) for the Eastern Caribbean: Loan Proposal RG-L1071, RG-G1009, and RG-G1004" (2015), accessed December 2, 2015, http://www.iadb.org/en/projects/project-description-title,1303.html?id=RG-L1071; Magnus Gehringer and Victor Loksha, *Geothermal Handbook: Planning and Financing Power Generation* (Washington, DC: The International Bank for Reconstruction and Development, Technical Report 002/12, June 2012), accessed October 22, 2014, http://www.esmap.org/sites/esmap.org/files/DocumentLibrary/FINAL_Geothermal%20Handbook_TR002-12_Reduced.pdf.

253. West Japan Engineering Consultants, Inc., "Study on Current Status of Geothermal Development in the Eastern Caribbean Islands: Field Trip Report and Study Tour in Costa Rica," March 2014.

254. Government of Dominica, "Budget Address for Fiscal Year 2014/15," July 23, 2014, accessed October 30, 2014, *http://finance.gov.dm/phocadownload/budget_addresses/budget_address_2014_2015.pdf.*

255. Government of Dominica, "Geothermal: The Next Generation" (The Caribbean Renewable Energy Forum, March 2014).

Phase 2: 100–120 MW power plant to export electricity to Martinique and Guadeloupe

The second phase of the project will be a second power plant of 100–120 MW to export electricity to Martinique and Guadeloupe. This phase of the project would include production drilling and the construction and operation of the power plant. The power plant would be completed in two stages (each of 50–60 MW) after Phase 1 of the project has been completed.

The electricity sectors in Guadeloupe and Martinique are large enough to likely absorb over 50 MW of geothermal capacity. Both countries have relatively high peak demand—about 284 MW in Guadeloupe and 281 MW in Martinique.[256] In addition, electricity produced from geothermal resources in Dominica is expected to be the least-cost source of generation for each of these systems (although this will largely depend on the cost of the undersea interconnection cables).

The government has not defined a structure for financing, building, and operating the power plant. However, the consortium led by GDF Group expressed interest in developing the larger power plant after it completes Phase 1 of the project.[257] Since EDF would be the off-taker for exported electricity, a PPA with EDF would be needed to successfully develop the project. The French government has stated that EDF intends to purchase geothermal power from Dominica.[258]

The estimated cost of this project varies significantly. In 2014, West Japan Engineering Consultants, Inc. estimated the cost of the entire project to be between US$300 million and US$531 million. This estimate includes the cost to develop the power plant and the cost of building interconnection cables to Martinique and Guadeloupe.[259] On the other hand, the Government of Dominica presented an estimated cost of the power plant alone of US$439 million.[260] Since the estimated cost of this project is about the size of Dominica's GDP, it would need support from donors and the private sector to finance this project.

The government's next steps include completing the feasibility studies for the project—both on the undersea interconnection cable and on the power plant itself. The government is planning to complete a feasibility study for building an undersea interconnection cable between Dominica, Guadeloupe, and Martinique.[261] The European Investment Bank has agreed to finance this feasibility study.[262] The feasibility study is expected to be completed in two to three years.[263]

256. Nexant, *Caribbean Regional Electricity Generation, Interconnection, and Fuels Supply Strategy* (March 2010), accessed April 27, 2015, http://www.caricom.org/jsp/community_organs/energy_programme/electricity_gifs_strategy_final_report_summary.pdf.

257. "French Consortium Plans to Revive Large Project in Dominica," *ThinkGeoEnergy,* April 15, 2014, accessed December 3, 2014, http://www.thinkgeoenergy.com/french-consortium-plans-to-revive-large-project-in-dominica/.

258. "French AFD Prepared to Finance 15MW Project in Dominica," *ThinkGeoEnergy*, July 3, 2013, accessed December 3, 2015, http://www.thinkgeoenergy.com/french-afd-prepared-to-finance-15-mw-project-in-dominica/.

259. Japan International Cooperation Agency and West Japan Engineering Consultants, Inc., "Study of Situation for Geothermal Energy Development" (April 2014).

260. Government of Dominica, "Geothermal: The Next Generation" (The Caribbean Renewable Energy Forum, March 2014).

261. Government of Dominica, "Geothermal: The Next Generation" (The Caribbean Renewable Energy Forum, March 2014).

262. Anelda Maynard-Date and Alexis George, "Geothermal Status, Progress and Challenges in the Eastern Caribbean Islands" (presented at Short Course V on Conceptual Modelling of Geothermal Systems, organized by UNU-GTP and LaGeo, in Santa Tecla, El Salvador, February 24–March 2, 2013), accessed October 31, 2014, http://www.os.is/gogn/unu-gtp-sc/UNU-GTP-SC-16-05.pdf.

263. Japan International Cooperation Agency and West Japan Engineering Consultants, Inc., "Study of Situation for Geothermal Energy Development" (April 2014).

12.3 Recommended Financial and Legal PPP Structure for Phase 1

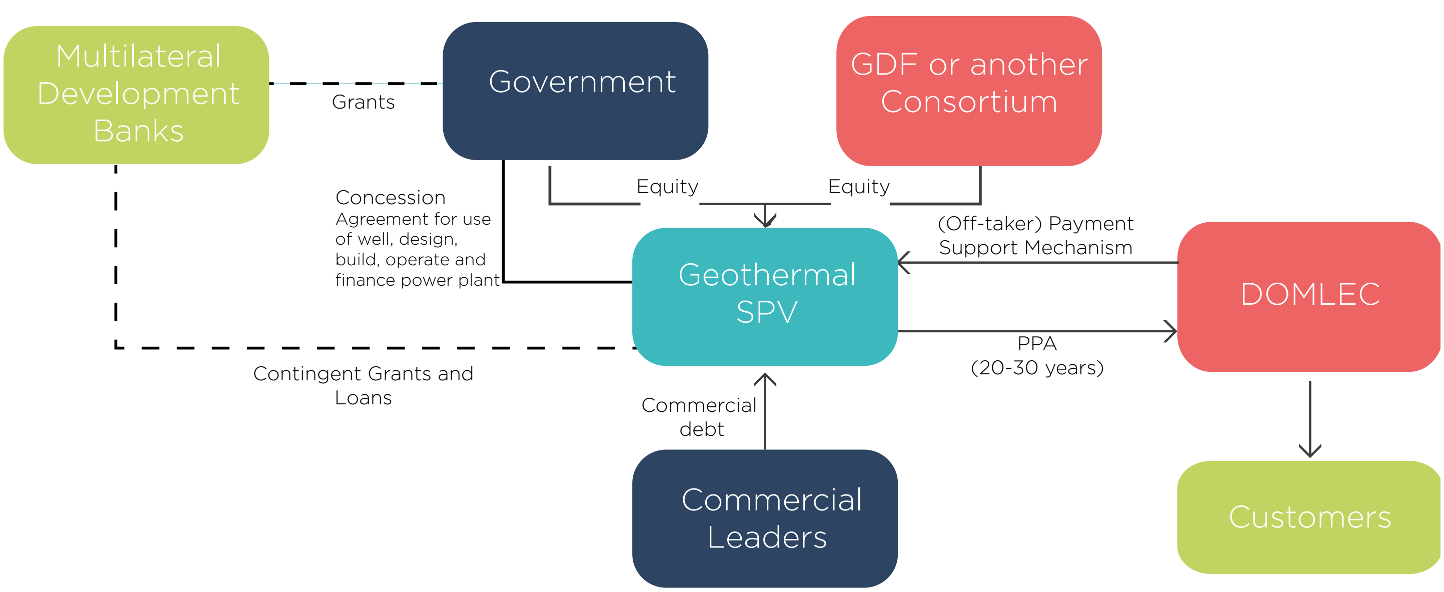
We recommend the Government of Dominica develop its geothermal resources using private sector participation. The government plans to develop Dominica's geothermal resources through a two-phase approach, which is described in depth in Section 12.2. Both phases should have similar structures. However, the proposed project for Phase 1 will be simpler with fewer off-takers. The government should develop the proposed geothermal power plant for Phase 1 with an experienced project developer. The power plant is a low-risk project because it is likely a financeable project and because the government has already developed an 11 MW production well. To develop the power plant, we recommend the government sign a concession agreement with a project developer and also help negotiate a PPA with DOMLEC.

12.3.1 Structure of the PPP

To develop a 10.5 MW geothermal power plant for Phase 1, the government of Dominica could sign a concession agreement with an SPV. The recommended PPP structure and the relationship between each of the major project participants for Phase 1 of Dominica's power plant are shown in **Figure 12.4.**

The SPV could be jointly owned by the government and its private partners. It would be financed through a mixture of debt and equity contributions. The two agreements that would form the foundation of this PPP are the concession agreement and the PPA with DOMLEC. The concession would be for about 20 to 30 years, which will be long enough for the SPV to repay its debts and for the government and the private developer to earn the required return on equity. The concession would be to use the production well as well as to design, build, and operate the geothermal power plant. The PPA with DOMLEC would cover the same period as the concession agreement.

FIGURE 12.4 Recommended PPP Structure for Dominica (Phase 1)



Some lenders may require additional mechanisms that enhance the quality of the cash flows of the project. In particular, it may be necessary to include a payment support mechanism that backs DOMLEC's payments under the PPA. That support mechanism would reduce the risk of the project's revenues and, thus, make the project more bankable. The mechanism could be implemented in various ways. Some of the options include establishing a liquidity facility (such as a trust fund or escrow account) or third-party guarantees (offered by donors or financial institutions); see the recommended structure in Section 9.2.1 for more details.

This PPP structure would involve participation from the following key actors and relationships:

- **Private developers (potentially GDF) and the SPV**—Private companies would develop the geothermal power plant by forming an SPV with the government. This SPV would have a concession from the government to use the production well and design, build, operate, and finance the geothermal power plant. The SPV would also have a PPA with DOMLEC for selling its electricity. The concession and the PPA should cover the same time period and last for 20–30 years—long enough for all debts to be repaid and for the project developers to earn the required return on equity. The planned project would be financed with both equity contributions from the owners of the SPV and with debt financing.
- **The government**—The government should develop the geothermal power plant by forming an SPV with the private developers. The government would also be responsible for providing the SPV with the right to use the 11 MW production well and signing a concession agreement with the SPV to build, operate, and finance the power plant.
- **DOMLEC—DOMLEC** would purchase the electricity produced by the geothermal power plant. DOMLEC should sign a PPA with the SPV, which should have a duration that matches the duration of the concession agreement.
- **The multilateral development banks**—The multilateral development banks would play a key role in this project by providing funding to the SPV. The funding may be used for drilling additional production wells or it may be used to provide debt financing for the project. This funding will reduce the cost of the project and make it more attractive to project developers. One of the key entities that will likely provide funding for the project is AFD, which has said that it would fund a 15 MW plant.[264]
- **Banks and other entities that provide debt financing**—Banks and other entities would provide commercial debt for the project. It is likely that they would be unwilling to loan money to the project until a concession agreement is in place and a PPA has been signed with DOMLEC.

The proposed project structure can be successful because the project developer will have few risks that can be mitigated. This is because there is a proven 11 MW production well in Dominica and the project will have a guaranteed revenue stream. The proven 11 MW production well in Dominica significantly reduces the resource risk faced by the developer.

In addition to having a lower resource risk than many of the other projects in the OECS, the project is likely financeable and may be very attractive to potential investors because of the second phase of the project. The project would likely be bankable because the concession agreement and the PPA would ensure that the project has the revenue required to pay its debts and also to provide investors with the return on equity that they require. Also, the finance risk is reduced because both the AFD and World Bank have separately indicated interest in providing funding for a 15 MW plant.[265]

264. "French AFD Prepared to Finance 15MW Project in Dominica," *ThinkGeoEnergy*, July 3, 2013, accessed December 3, 2015, http://www.thinkgeoenergy.com/french-afd-prepared-to-finance-15-mw-project-in-dominica/.

265. "Work to Begin on Domestic Geothermal Plant This Fiscal Year," *Dominica News Online,* August 4, 2015, accessed December 3, 2015, http://dominicanewsonline.com/news/homepage/news/economy-development/work-to-begin-on-domestic-geothermal-plant-this-fiscal-year/

12.3.2 Key risks and mitigation measures

This will be a low-risk project for the investors because of a proven geothermal resource, the proposed agreements, and promised financing. One of the largest risks for the development of a geothermal power plant is the resource risk. In this project the resource risk is very low because an 11 MW production well has already been drilled and proven. In addition, there is little financing risk because AFD has already indicated that it would fund a 15 MW plant, the World Bank has also indicated interest in funding,[266] and the proposed agreements would transfer the demand risk to DOMLEC. **Table 12.1** provides a more complete description of the project's risks.

Table 12.1 Allocation of Risks for the Proposed PPP Structure

Risk	Impact of Risk	Party That the Risk Is Assigned To	Proposed Measure for Mitigating the Risk
Market, Demand, or Volume RiskPotential	Low	DOMLEC	This risk would be mitigated by a PPA and DOMLEC's ability to make its payments under this PPA (because of its strong financial performance).
Resource Risk	Low	SPV	An 11 MW production well has already been drilled and tested. Even if the government plans to build a 15 MW plant, the resource risk is low because the resource has been proven.
Construction Risk	Medium	SPV and, possibly, the construction company that builds the plantt	The SPV can hire a company to build the plant and incorporate penalties if the plant is not completed on time or milestones are not achieved as contractually planned.
Technical Risk	Low	SPV	None. The risk is low and this is a proven technology.
Operating Risk	Low	SPV	None. The risk is low.
Political and Social Risk	Low	SPV	None. The risk is low. If the electricity prices are reduced through the use of geothermal energy, the public will likely support the project.
Environmental Risk	Medium	SPV	This risk can be reduced by carrying out an EIA. The EIA will allow the government to assess the risk of the geothermal project and propose an action plan to mitigate the risks identified.
Financing Risk	Low	SPV and banks, including AFD	The financial risk for the project is reduced through the PPA from DOMLEC and the concession agreement. In addition, AFD has already indicated that it would fund a 15 MW plant. Other development banks would potentially provide financing as well.
Regulatory Risk	Low	Government	The government is responsible for making any necessary changes to the legal and regulatory framework to enable the development of the project. Since those changes take time, the parties to the project can draft clear rules governing the sustainable exploitation of the resource and the operation of the power plant in the project agreements (concession, PPA, others).

266. "Work to Begin on Domestic Geothermal Plant This Fiscal Year," *Dominica News Online*, August 4, 2015, accessed December 3, 2015, http://dominicanewsonline.com/news/homepage/news/economy-development/work-to-begin-on-domestic-geothermal-plant-this-fiscal-year/.

We describe the largest risks for the project and their proposed mitigation measures below:

- **The government cannot find a suitable project developer or cannot agree on the terms of the concession or other project documents**—This is the biggest risk for the project. However, we believe that the government should be able to find a good project developer to partner with in developing the geothermal power plant given that this project is financeable and has low risk. The interest expressed by the consortium of the French GDF Suez Group, CDC infrastructure, and NGE Group indicates that finding a good project developer should not be a major risk.
- **The project developers are not able to raise the financing needed for the project (Financing Risk)**—Another major risk for the project is that the project developers are not able to raise the financing needed for the project. The project developers would be unable to raise financing if investors or lenders did not believe that the project was financially viable. Specifically, they may be unwilling to invest if there are large, unmitigated risks, such as resource risks, or if the expected cash flows are highly uncertain or will not allow them to earn the required return on their investment. However, the interest indicated by the World Bank and AFD in financing the project signals that this should not be a major risk.[267]

  In addition, the concession agreement and PPAs will mitigate this risk by ensuring that the SPV has access to the resource and a guaranteed revenue stream. In addition, the SPV may have access to concessionary financing for the project.

12.3.3 Strategy for engaging key stakeholders

One of the most important aspects of the Phase 1 project is that it is a pilot project for Phase 2 and would allow the government to develop the relationships needed to successfully implement Phase 2. As a result, the government's strategy should focus on building relationships and not just on putting in place the agreements for the 10.5 MW power plant. In addition to engaging the public, the government should actively engage the following stakeholders during the project's development and implementation:

- **Potential project developers**—The government should regularly consult potential project developers to ensure that they are aware of the opportunity to invest in Dominica, to identify and address any major concerns that project developers may have, to ensure that the project is sufficiently attractive to investors, and to assess the capacity and expertise of the developers. Consulting project developers before procuring a concession agreement or finalizing the project structure can allow the government to structure a good project and to get the most attractive offer. In addition, updating potential project developers throughout the development of the Phase 1 project could help them become interested in the Phase 2 project.
- **DOMLEC**—The government must consult and work with DOMLEC to develop a PPA that DOMLEC will sign. A PPA is essential for the success of any geothermal projects and, since DOMLEC is privately owned, the government cannot simply require DOMLEC to sign the PPA.
- **Multilateral development banks**—The government should work with multilateral development banks so that it receives financial assistance needed to develop this project and to establish the relationships needed to develop the Phase 2 project. Specifically, the government will need to work with AFD, which has promised to fund the project, and potentially with the other multilateral development banks.
- **Électricité de France (EDF)—The** government should keep EDF updated on Phase 1's progress because EDF will be the off-taker for the geothermal power plant developed in Phase 2. Keeping EDF updated on the progress of Phase 1 will mean that it will be ready for Phase 2 and know what to expect from the project.
- **The Independent Regulatory Commission**—The government should actively involve the IRC in the development of the geothermal power plant for Phase 1. This will ensure that the IRC has the knowledge necessary to understand how geothermal generation will impact DOMLEC and be able to account for it in its tariff decisions. In addition, it will allow the IRC to better assess DOMLEC's performance and expansion planning.

267. "Work to Begin on Domestic Geothermal Plant This Fiscal Year," Dominica News Online, August 4, 2015, accessed December 3, 2015, http://dominicanewsonline.com/news/homepage/news/economy-development/work-to-begin-on-domestic-geothermal-plant-this-fiscal-year/.

12.4 Recommended Financial and Legal PPP Structure for Phase 2

We recommend the government develop the proposed geothermal power plant and interconnection cables for Phase 2 in partnership with an experienced project developer. The recommended structure for developing and financing this plant would be very similar to that of the plant developed in Phase 1. The main differences in the proposed PPP structure are that the SPV will assume more resource risk and there will be a second PPA with EDF. To develop the geothermal plant, the government should sign a concession agreement with the project's developer and help negotiate a PPA with EDF. This concession agreement should give the project developer responsibility to design, build, own, operate, and finance the second geothermal plant and interconnection cables.

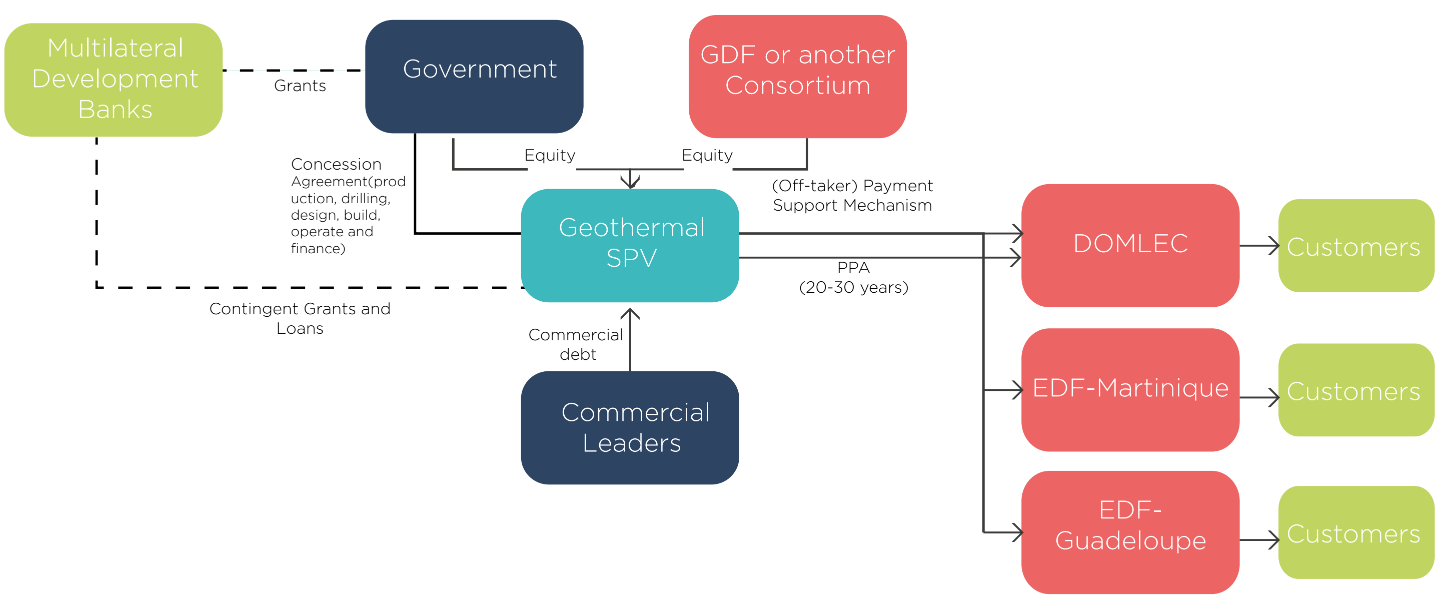
The government can opt to structure the two phases with one developer, either in one contract or two separate contracts. The developer would initially be responsible for Phase 1, and then both parties would have the option to continue with Phase 2 based on the results achieved in Phase 1.

12.4.1 Structure of the PPP

To develop a 100–120 MW geothermal power plant and interconnection cables for Phase 2, the Government of Dominica could sign a concession agreement with an SPV. The recommended PPP structure and the relationships between each of the major project participants for Phase 2 are shown in **Figure 12.5.**

There are key agreements that would form the foundation of this project: the concession agreement and the PPA with EDF. The concession would most likely be for about 20 or 30 years (the same period as the PPA), which would likely be long enough for the SPV to repay its debts and for the private developer to earn the return on equity needed. The concession would be to design, build, own, operate, and finance the geothermal power plant and interconnection cables. The responsibility for identifying and developing the geothermal resource, and also building and financing the plant and interconnection cables, would be assigned to the private developer because it will be best placed to mitigate any related risks.

FIGURE 12.5 Recommended PPP Structure for Dominica (Phase 2)



This PPP structure would involve participation from the following key actors:

- **Private developers and their SPV**—Private companies and the government would partner to establish an SPV and develop the geothermal power plant and interconnection cables. This SPV would have a concession from the government to carry out production drilling and design, build, own, operate, and finance the geothermal power plant and interconnection cables. The SPV would also sign a PPA with EDF for selling its electricity. The concession and the PPA should cover the same time period (about 20 to 30 years)—long enough for debts to be repaid and for the project developers to earn the return on equity required.

  The proposed SPV would be owned by the private developers and the government. The project would be financed with both equity contributions and with debt financing. It is likely that the SPV that develops the geothermal power plant for Phase 1 would also develop the geothermal power plant and interconnection cables for Phase 2. It is essential that the private companies involved in Phase 2 demonstrate experience building and operating interconnection cables. In addition, they must show that they can raise the amount of funding needed, which will be significantly larger than the funding required for Phase 1.

- **The government**—The Government of Dominica would also have equity ownership in the SPV. Another of its main responsibilities is to sign a concession agreement with the SPV.
- **EDF—EDF** will purchase the electricity produced by the geothermal power plant and supplied to Martinique and Guadeloupe. EDF will sign a PPA with the SPV, which will need to have a duration that matches the duration of the concession agreement.
- **DOMLEC**—If any of the electricity generated by the Phase 2 plant is sold to DOMLEC for the local markets, a PPA with DOMLEC would also be needed. In that case, if the same SPV is developing Phase 2 of this project, the PPA for Phase 2 may simply be an extension or amendment to the PPA from Phase 1.
- **Multilateral development banks**—The multilaterals could play a key role in this project by providing funding to the SPV, especially due to the size of the investment needs. The funding may be used for drilling production wells and to provide debt financing for the project. This funding would reduce the cost of the project and make it more attractive to project developers.
- **Banks and other entities that provide debt financing**—Banks and other entities will provide debt financing for the project. It is likely that they will be unwilling to loan money to the project until a concession agreement is in place and the PPAs have been signed with EDF and DOMLEC.

If Phase 1 is completed successfully, the likelihood of Phase 2 being completed successfully increases. The main reasons are the proven geothermal resource and because the project will likely be financeable. The geothermal resource in Dominica has been explored and confirmed. As a result, the project developer will have a reduced resource risk. In addition, the project is likely financeable and may be attractive to potential investors because of its size and because it is the second phase of the project. The project will likely be financeable because the concession agreement and the PPAs should ensure that the project has the revenue required to repay its debts and also to provide investors with the return on equity that they require. Also, the completion and successful operation of Phase 1 will show that the geothermal resource can be developed into a successful project.

An important consideration that the government should take into account as it begins implementing Phase 2 is that the project developer should have a proven track record with both geothermal development and interconnection cables. Given the role of the project developer in the proposed PPP structure and the large size of the project, the project developer should have both the technical expertise and financial resources necessary to ensure the success of the project. Also, to be able to access concessionary funding, the project and/or the works and services will likely need to be procured on a competitive basis.

12.4.2 Key risks and mitigation measures

The geothermal power plant and interconnection cables will be riskier than the geothermal power plant developed in Phase 1, despite the lessons learned and information provided by the development of the geothermal plant in Phase 1. Phase 2 will be riskier because no production wells for the plant have been drilled and, as a result, the resource risk for the plant is higher. In addition, the project will be more complicated because it will be larger, will include interconnection cables, and will have two off-takers. **Table 12.2** provides a more complete description of the project's risks.

Table 12.2 Allocation of Risks for the Proposed PPP Structure

Risk	Impact of Risk	Party That the Risk Is Assigned To	Proposed Measure for Mitigating the Risk
Market, Demand, or Volume RiskPotential	Low	DOMLEC, EDF	This risk will be mitigated by the PPA and DOMLEC's and EDF's ability to make payments under this PPA (because of their strong financial performances).
Resource Risk	Low	SPV and the government	The resource has been proven and the Phase 1 plant will provide useful information about the resource.
Construction Risk	Medium	SPV and, possibly, the construction company that builds the plant	The SPV can hire a company to build the plant and incorporate penalties if the plant is not completed on time or milestones are not achieved as contractually planned.
Technical Risk	Medium	SPV	This risk for the power plant is low because it is a proven technology. However, the risk for the interconnection cables is higher. This can be mitigated by finding a project developer with experience constructing and operating interconnection cables.
Operating Risk	Low	SPV	None. The risk is low.
Political and Social Risk	Low	SPV	None. The risk is low. If the electricity prices are reduced through the use of geothermal energy, the public will likely support the project.
Environmental Risk	Medium	SPV and the government	There is the risk that the interconnection cables will cause environmental damage. To mitigate this risk, it is important to have a project developer with experience constructing undersea interconnection cables. In addition, the government should carry out an EIA. The EIA will allow the government to assess the risk of the geothermal project and propose an action plan to mitigate the risks identified.
Financing Risk	Medium	SPV and banks	The financial risk for the project is reduced through the PPAs from DOMLEC and EDF, the concession agreement, and, potentially, financing from multilateral development banks.
Regulatory Risk	Low	Government	The government is responsible for making any necessary changes to the legal and regulatory framework to enable the development of the project. Since those changes take time, the parties to the project can draft clear rules governing the sustainable exploitation of the resource and the operation of the power plant in the project agreements (concession, PPA, others).

We describe several of the largest risks for the project and their proposed mitigation measures below:

- **The government cannot find a suitable project developer or cannot agree on the terms of the concession or other project documents (Market Risk)**—One of the key risks for Phase 2 of geothermal development in Dominica is that the government may not be able to find a project developer with the skills required, or that the government and the project developer do not agree on the terms of the concession. As mentioned earlier, the government should find a project developer with a proven track record in geothermal development, experience with undersea interconnection cables, and access to financial resources.

  To mitigate this risk, the government should take advantage of relationships with potential project developers that it established during Phase 1 and should receive support with the negotiation of project agreements from multilateral development banks. The government may also be able to use financing from multilateral development banks to reduce the project's risks and costs. This would allow it to develop a project that is attractive to bidders.

- **EDF and the SPV cannot agree on the terms for the PPA (Market Risk)**—If EDF and the SPV cannot agree on the terms for the PPA, the project will probably not be financeable. However, this risk is reduced because the French government has stated that EDF intends to purchase geothermal power from Dominica.[268]

- **The project developers are not able to raise the financing needed for the project (Financing Risk)**—Another major risk for the project is that the project developers are not able to raise the financing needed for the project. The project developers would be unable to raise financing if investors or lenders did not believe that the project was financially viable. Specifically, they may be unwilling to invest if there are large, unmitigated risks, such as resource risks, or if the expected cash flows are highly uncertain or will not allow them to earn the required return on their investment. However, the proposed concession agreement and PPAs will mitigate this risk by ensuring that the SPV has access to the resource and a guaranteed revenue stream. In addition, the SPV may have access to concessionary financing for the project. The multilateral development banks can help reduce this risk by offering concessionary financing for the project.

- **The interconnection cables cause environmental damage (Environmental Risk)**—There is the risk that the interconnection cables will cause environmental damage. To mitigate this risk, the government should get donor support to carry out an EIA. This will allow the government to identify and mitigate any potential impact. In addition, the government can ensure that the project developer has experience constructing undersea interconnection cables.

12.4.3 Strategy for engaging key stakeholders

The government's strategy for engaging stakeholders for Phase 2 of the project should be similar to its strategy for Phase 1 (see Section 12.3.3). The main difference may be that the government should update stakeholders over a longer period of time, and that the government should communicate the success and lessons learned from Phase 1. An additional difference is that stakeholder engagement during this phase will require more active consultation with EDF, and will also require consulting and engaging the public in Martinique and Guadeloupe.

---

268. "French AFD Prepared to Finance 15MW Project in Dominica," *ThinkGeoEnergy*, July 3, 2013, accessed December 3, 2015, http://www.thinkgeoenergy.com/french-afd-prepared-to-finance-15-mw-project-in-dominica/.

12.5 Recommended Changes to the Legal, Institutional, and Regulatory Framework

The legal, institutional, and regulatory framework in Dominica should be updated to prepare the island for the introduction of geothermal generation. Having an independent economic regulator makes Dominica's legal, institutional, and regulatory framework better placed to govern geothermal generation than that of other countries in the OECS. This will allow Dominica to make the necessary changes to the tariffs more easily. However, to prepare the legal, institutional, and regulatory framework for geothermal generation, the government should at least do the following:

- **The IRC should be trained on how to incorporate geothermal generation in the regulation.** The IRC's decision on the Tariff Regime for Dominica Electricity Services Ltd. 2009/004/D establishes the tariff-setting mechanism. It allows the IRC to set tariffs and will require that DOMLEC submit a detailed Rate Design Application in the upcoming years. The IRC should receive training on geothermal generation so it can assess the portion of DOMLEC's rate application dealing with its geothermal PPAs and make a better tariff decision. The IRC should set a tariff that allows DOMLEC to recover the full cost of service, regardless of the fuel or technology used for generation.
- **Dominica should establish a clear framework governing geothermal resources.** Dominica should have a legal framework that assigns ownership of geothermal resources, establishes a process for granting license to develop geothermal resources, and assigns responsibility for monitoring geothermal resources to a government body. One way to establish this framework is to approve the Geothermal Resources Development Bill (2013). This bill will establish the legal framework for exploring and developing geothermal resources.

Another way to address some of these changes is to establish regulation through contracts. For example, the agreements between the government and the private partners could include obligations that ensure the protection and sustainable development of the geothermal resource. The agreement could mandate that an independent expert carry out periodic evaluations to monitor the environmental impact of the power plant. The IRC can then monitor the SPV's compliance with contractual obligations.

Any dispute arising from failure to adhere to contract obligations could then be handled by a regular court, an administrative court, or a special expert panel as applicable.

Establishing regulation through contracts would only serve as a short-term solution to prevent delays in project implementation. There are some regulatory functions that cannot be covered through contracts and for which regulations and laws will need to be established. For example, the government will still need to develop the process through which licenses to establish a geothermal plant are obtained.

12.6 Economic and Financial Analysis of the Geothermal Project

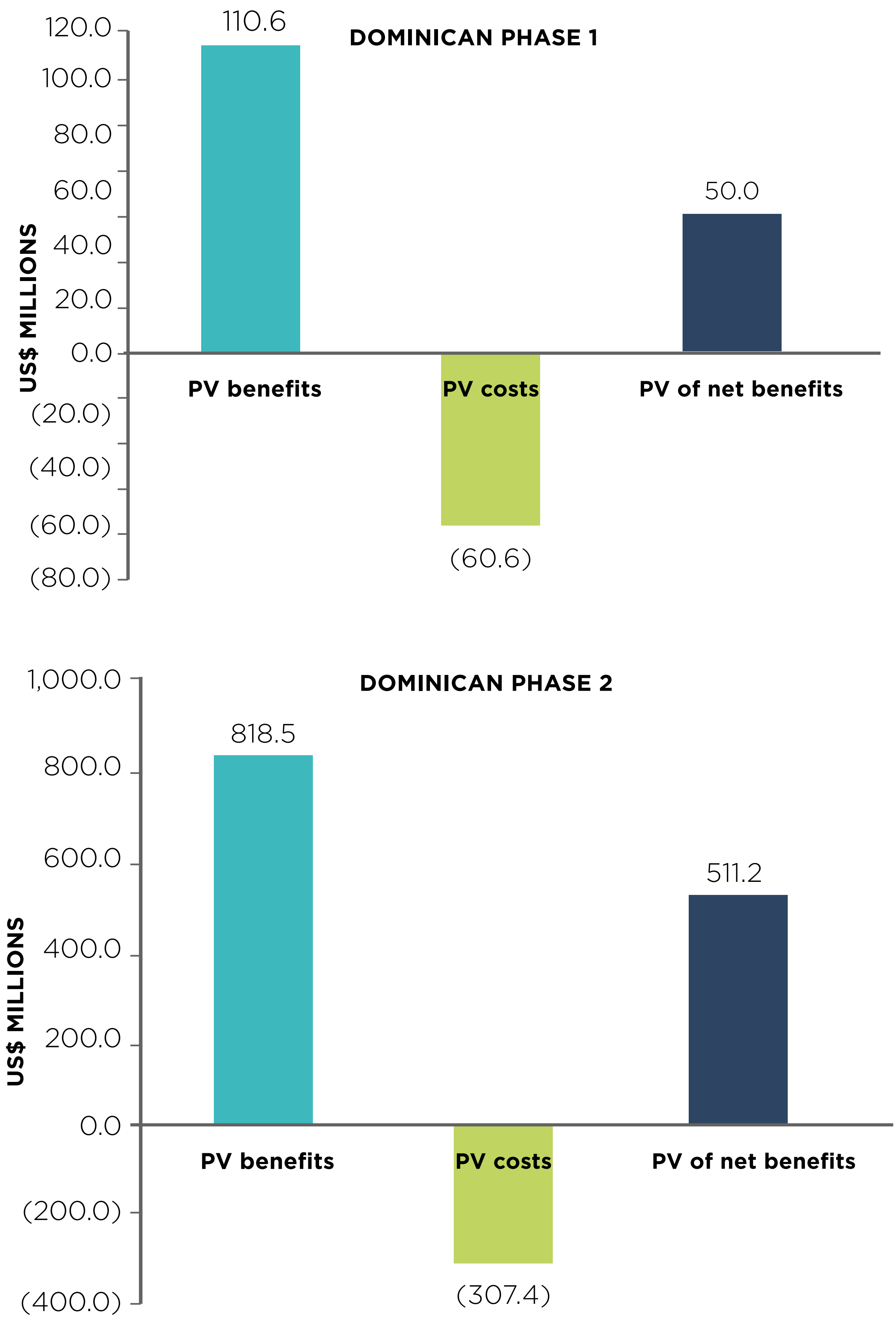
In this section, we assess whether the two phases of the geothermal project in Dominica are economically and financially viable. We first perform a cost-benefit analysis for each phase to determine whether it generates net economic benefits to the country. We then use the discounted cash flow method to evaluate whether each phase of the geothermal project is financially viable to investors. We conclude that both phases of the geothermal project are economically and financially viable. Therefore, we recommend that the government and investors proceed with developing both phases. We present our analysis and results as follows:

- Cost-benefit analysis (Section 12.6.1)
- Financial analysis (Sections 12.6.2 and 12.6.3)

12.6.1 Cost-benefit analysis

We perform a cost-benefit analysis to determine whether the two phases of the geothermal project are economically viable. We conclude that both phases of the geothermal project in Dominica are economically viable and increase social welfare. The present value of the net economic benefits of Phase 1 is positive and equal to US$50 million (see **Figure 12.6**). Similarly, the present value of the net economic benefits of Phase 2 is positive and equal to US$511 million. Therefore, the government and donors should proceed with developing both phases of the project.

FIGURE 12.6 Present Value of Net Economic Benefits of the Geothermal Project



To determine the economic viability of the geothermal project, we estimate its net economic benefits for a period of 40 years. Net economic benefits equal the economic benefits minus the economic costs of the project. Economic benefits include savings in generation costs (because generating electricity from geothermal resources can cost less than from fuel oil or diesel), and reductions in CO_2 emissions. Economic costs are the capital expenditures needed to complete all project stages. We then bring the economic benefits and costs to present value (PV) with a social discount rate of 12 percent (in real terms).[269] The geothermal project is economically viable if the PV of the project's net benefits is positive—economic benefits outweigh economic costs. Further details about the assumptions and methodology we use are presented in Appendix A.

12.6.2 Financial analysis Phase 1

We use the discounted cash flow (DCF) method to determine whether Phase 1 of the geothermal project in Dominica is financially viable for equity investors. We conclude that the geothermal project allows the equity investors to earn a 15 percent real rate of return when the PPA rate is about US$0.09/kWh. This PPA rate is the tariff at which the geothermal projects would need to sell each kWh of electricity to be able to service their debts and provide equity investors with a 15 percent real return. This PPA rate is feasible to implement, because it is significantly lower than the current electricity tariff from fuel oil generation of US$0.37/kWh.[270] The final PPA rate will be determined through negotiations between the partners of the project.

Table 12.3 Financial Results of Geothermal Project (Phase 1)

NPV to Equity Investors (US$ million)	IRR to Equity Investors (Real)	PPA Rate (US$/kWh)
0	15%	0.09
28	24%	0.10
5.6	33%	0.11

Notes: The IRR is Internal Rate of Return of the cash flows to equity investors. We assume a 15 percent real discount rate for equity cash flows.

In this section, we present the estimated cash flows from the geothermal project. The DCF methodology we use and our main assumptions are in Appendix B.

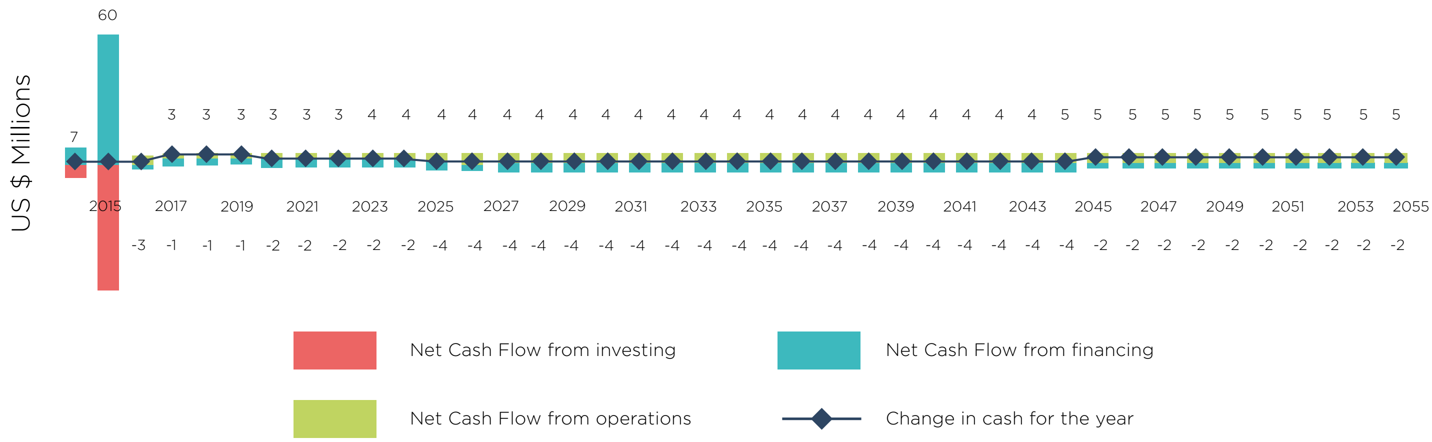
Cash flows from the geothermal project

In Figure 12.7, we present the projected cash flows of the geothermal project for a PPA rate of US$0.09/kWh. Cash flows from financing are positive from 2015 to 2016 and are directed towards financing the capital expenditures (investments) for building the power plant. When the power plant begins operations in 2017, the cash flows from operations become positive and are used for repaying debt and paying dividends out to equity investors.

269. IDB, "Guidelines for the Economic Analysis of IDB-Funded Projects," June 2012, http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=36995807.

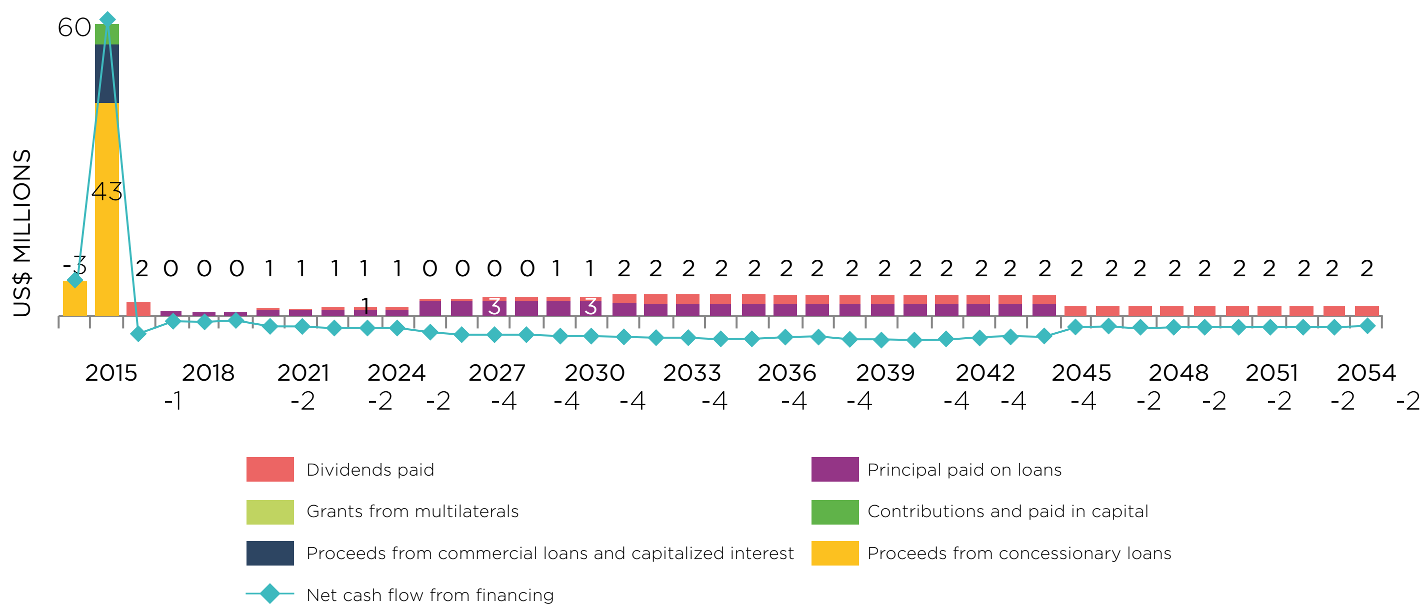
270. CARILEC, 2014 *Average Tariffs in EC Countries* (2015); DOMLEC, 2014 Annual Report.

FIGURE 12.7 Cash Flows of the Geothermal Project (Phase 1)



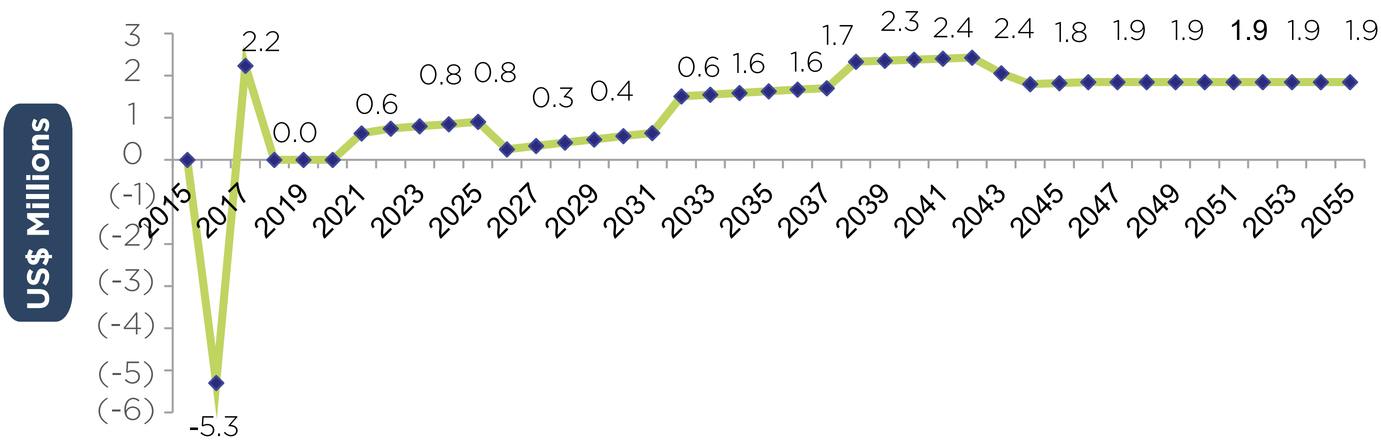
Regarding financing cash flows (shown in **Figure 12.8**), the majority of the financing in 2015–2016 comes from commercial debt and concessionary financing. In 2016, equity is included to finance a portion of the construction of the power plant. Once the power plant begins operations in 2017, the cash flows from operations are directed towards repaying the debt and paying out dividends. The net cash flows from contributions and paid-in capital and dividends paid are the cash flows to the equity investor, which we discuss below.

FIGURE 12.8 Financing Cash Flows of the Geothermal Project (Phase 1)



The cash flows to the equity investors are presented in **Figure 12.9.** The cash flows to the equity investor are negative in 2016, when the equity investors make their paid-in contributions to finance a portion of the capital expenditures. By 2017, the income from operations becomes large enough to pay for operating costs, cover working capital, and service debt. The remaining cash flows are the cash available to equity investors. As payout policy we assumed that dividends are equal to the minimum of the cash available to equity and retained earnings, subject to retained earnings not falling below zero. As further debt payments are made, the principal amount is further reduced and the cash flows to the equity investors increase.

FIGURE 12.9 Cash Flows to Equity Investors from the Geothermal Project (Phase 1)



12.6.3 Financial analysis Phase 2

We use the DCF method to determine whether Phase 2 of the geothermal project in Dominica is financially viable for equity investors. We conclude that the geothermal project allows the equity investors to earn a 15 percent real rate of return when the PPA rate is about US$0.12/kWh. This PPA rate is the tariff at which the geothermal projects would need to sell each kWh of electricity to be able to service their debts and provide equity investors with a 15 percent real return. This PPA rate is feasible to implement, because it is significantly lower than the average tariff of Dominica and most of the countries to which the electricity from this project would be sold.[271] The final PPA rate will be determined through negotiations between the partners of the project.

Table 12.4 Financial Results of Geothermal Project (Phase 2)

NPV to Equity Investors (US$ million)	IRR to Equity Investors (Real)	PPA Rate (US$/kWh)
0	15%	0.12
25.4	18%	0.14
52.3	20%	0.16

Notes: The IRR is Internal Rate of Return of the cash flows to equity investors. We assume a 15 percent real discount rate for equity cash flows.

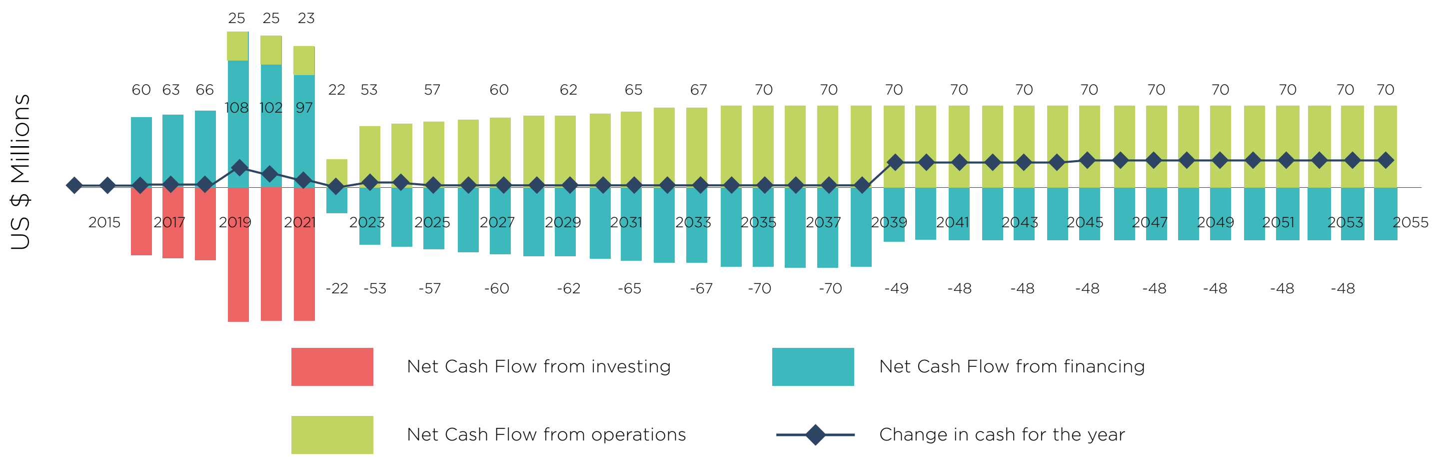
In this section, we present the estimated cash flows from the geothermal project. We explain the DCF methodology we use and our main assumptions in Appendix B.

271. The electricity generated by this project would be sold to Dominica, Guadeloupe, and Martinique. For the two latter countries, we use an average of the tariffs in Saint Vincent and the Grenadines (VINLEC, 2011 Annual Report), Grenada (GRENLEC, 2013 Annual Report), Saint Lucia (LUCELEC, 2013 Annual Report), and Dominica (DOMLEC, 2013 Annual Report). As an indication, the average tariff in the EC countries is about US$0.34/kWh.

Cash flows from the geothermal project

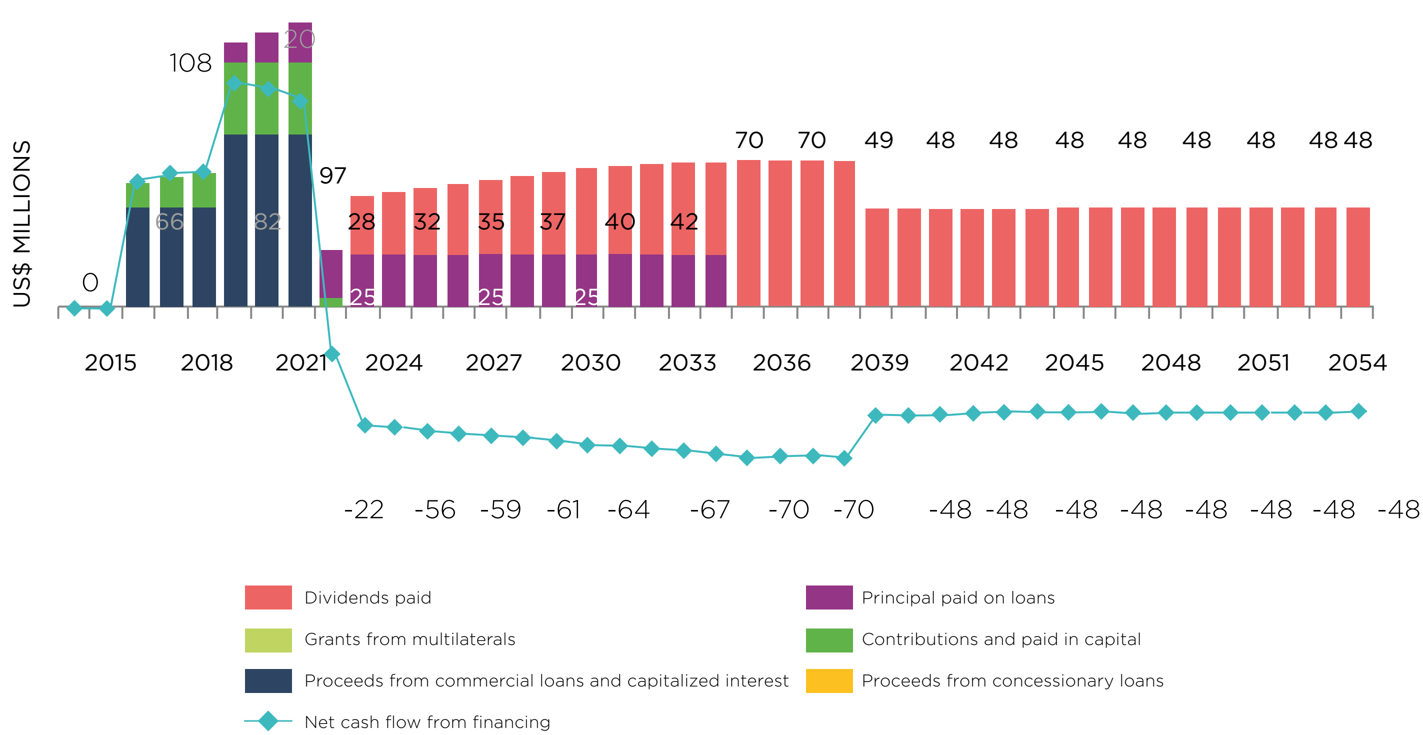
In **Figure 12.10**, we present the projected cash flows of the geothermal project for a PPA rate of US$0.12/kWh. Cash flows from financing are positive from 2017 to 2022 and are directed towards financing the capital expenditures (investments) for building the power plant. When the first 55 MW of the power plant come online in 2020, the cash flows from operations become positive and are used for financing a portion of the capital expenditures for the next 55 MW of generation capacity, repaying debt, and paying dividends out to equity investors. The other 55 MW of generation capacity come online in 2024. From this point on the cash flows from operations are used for repaying debt and paying dividends out to equity investors.

FIGURE 12.10 Cash Flows of the Geothermal Project (Phase 2)



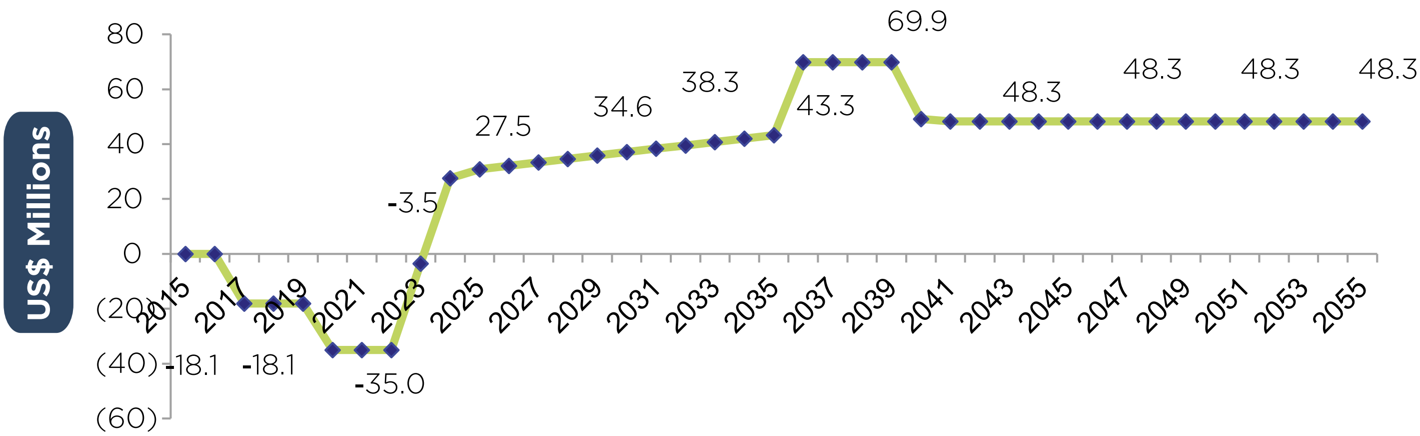
Regarding financing cash flows **(Figure 12.11)**, the majority of financing comes from commercial debt and equity, which is used to finance production drilling and the construction of the power plant and the undersea interconnection cable. The net cash flows from contributions and paid-in capital and dividends paid are the cash flows to the equity investor, which we discuss below.

FIGURE 12.11 Financing Cash Flows of the Geothermal Project (Phase 2)



The cash flows to the equity investor are presented in **Figure 12.12.** The cash flows to the equity investor are negative during 2017 to 2023, when the equity investors make their paid-in contributions to finance a portion of the capital expenditures. By 2024, when both units of the power plant (110 MW of generation capacity) come online, the income from operations becomes large enough to pay for operating costs, cover working capital, and service debt. The remaining cash flows are the cash available to equity investors. As payout policy we assumed that dividends are equal to the minimum of the cash available to equity and retained earnings, subject to retained earnings not falling below zero. As further debt payments are made, the principal amount is further reduced and the cash flows to the equity investors increase.

FIGURE 12.12 Cash Flows to Equity Investors of the Geothermal Project (Phase 2)



The geothermal resources in Grenada have not been studied extensively, but the government has recently restarted exploration works. Preliminary surface exploration studies suggest that Grenada's geothermal resource exceeds 30 MW, but it has yet to be confirmed.[272] The government and GRENLEC expressed interest in working together to explore the geothermal resource and develop a 10 MW geothermal plant. However, since 2013 progress in the project has slowed due to the change in government, the proposed changes to the ESA, and the lack of a geothermal framework. Recent actions from the government suggest that it might be relaunching the project. The government restarted exploration efforts without GRENLEC in 2014 with funds from the New Zealand Aid Programme. The government received and shared results of the 3G study with development banks in July 2015 to plan the way forward.[273] However, feasibility studies that provide information on the commercial viability of the project have not been carried out.

If the government decides to go ahead with the project, we recommend the government do so by signing a concession agreement with an SPV to explore and develop the resource and design, build, construct, own, operate, and finance a geothermal plant. Parliament would need to approve the Geothermal Resources Development Bill. Also, the government would need to finalize the Geothermal Resources Environmental and Planning Regulations and update the legal and regulatory framework to allow for the development of this project.

The multilateral development banks might be able to play an active role in supporting the planned project because the project is still in the early stages of development. Multilateral banks could provide grant funding and contingent grants for the early stages of the project and loans for the more advanced stages of the project. To avoid difficulties accessing funding from multilateral development banks, the project and/or the works and services would likely need to be competitively bid.[274] The planned project and possible role for the multilateral development banks is described in more detail in the following sections:

- Overview of the Electricity Sector in Grenada (Section 13.1)
- Status of Geothermal Development (Section 13.2)
- Recommended Financial and Legal PPP Structure (Section 13.3)
- Recommended Changes to the Legal, Institutional, and Regulatory Framework (Section 13.4).
- Economic and Financial Analysis of the Geothermal Project (Section 13.5)

272. World Bank, "Got Steam? Geothermal as an Opportunity for Growth in the Caribbean," Caribbean Knowledge Series, June 2013, accessed March 6, 2014, http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2013/06/21/000442464_20130621142703/Rendered/PDF/786080WP015.0G00Box377349B00PUBLIC0.pdf.

273. "Grenada Will Present Results of Study on Geothermal Potential," *ThinkGeoEnergy,* July 30, 2015, accessed December 3, 2015, http://www.thinkgeoenergy.com/grenada-will-present-results-of-study-on-geothermal-potential/.

273. The current legal and regulatory framework would not allow for a competitive bidding process because GRENLEC holds the right to issue sublicenses to IPPs. If the government is interested in performing a competitive bidding process for IPPs to explore and exploit the geothermal resource and build the power plant, the government would need to amend the Electricity Supply Act of 1994 or approve the Geothermal Bill with clear rules for third-party participation.

274. The current legal and regulatory framework would not allow for a competitive bidding process because GRENLEC holds the right to issue sublicenses to IPPs. If the government is interested in performing a competitive bidding process for IPPs to explore and exploit the geothermal resource and build the power plant, the government would need to amend the Electricity Supply Act of 1994 or approve the Geothermal Bill with clear rules for third-party participation.

13.1 Overview of the Electricity Sector in Grenada

Grenada Electricity Services Ltd. (GRENLEC), a private vertically integrated utility, has exclusive license to provide electricity services in the country. GRENLEC is overseen by the Ministry of Finance, Planning, Economic Development, Trade, Energy and Cooperatives, which monitors whether GRENLEC complies with the Electricity Supply Act of 1994. The ESA establishes the structure of and regulates the electricity sector. There is not a separate regulatory agency in place. The government has drafted, but not yet approved, the Geothermal Bill and the Geothermal Regulations.[275] These documents would establish the regulatory framework for developing Grenada's geothermal resources. Despite having a policy framework conducive to geothermal development, including a 20 percent target for domestic energy sources, the government has not yet implemented the measures called for in the National Energy Policy of 2011.

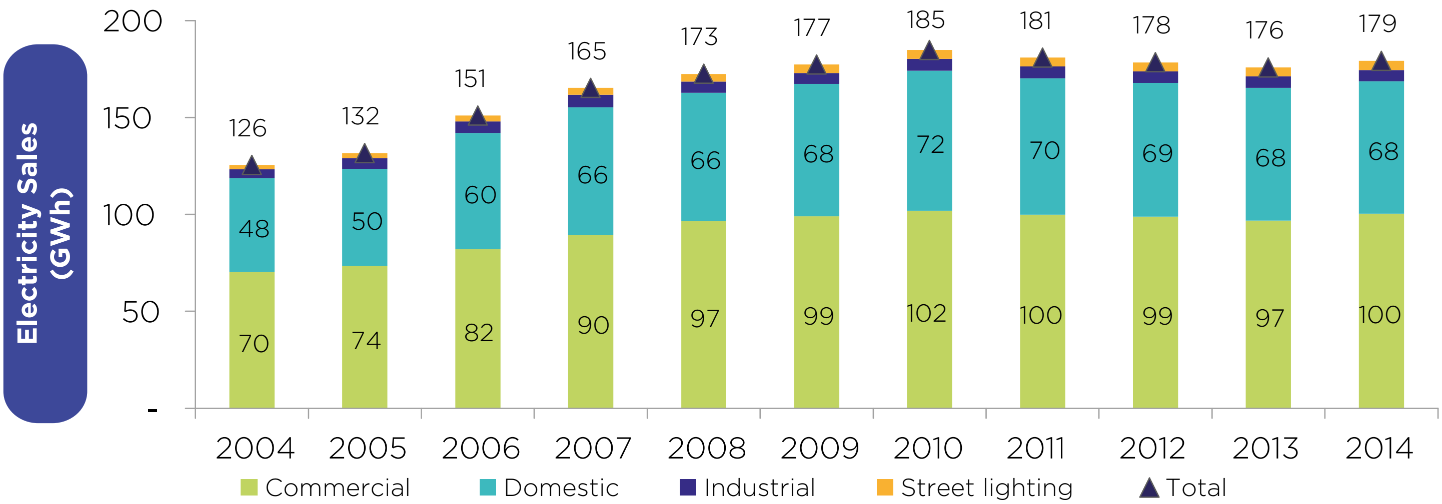
13.1.1 The electricity market in Grenada

In Grenada, GRENLEC is the sole, privately owned and vertically integrated provider of electricity services. GRENLEC's total installed capacity was 48.6 MW in 2014, which is more than enough to meet peak demand of 29 MW. All of GRENLEC's installed capacity runs on diesel.[276] Installed capacity is spread over the three islands, but most of it is in Grenada. Consumers can sell the electricity they generate from renewable sources to GRENLEC. However, these self-generators account for less than 400 kW of generated electricity and 1 percent of demand.[277]

In 2014, peak demand in Grenada was 29 MW. GRENLEC supplied electricity to 46,478 customers.[278] Total demand increased rapidly from 2005 to 2010, fell from 2011 to 2013, and rose slightly in 2014 (see **Figure 13.1**). The fall in demand was due to a stagnant economy and rising tariffs, which were driven by rising fuel costs. Demand grew by an average of 2 percent over the full period. In 2014, 56 percent of the demand was commercial, 38 percent was domestic, 3.2 percent was industrial, and 2.6 percent was street lighting.[279] Demand from the domestic segment grew the fastest during 2005 to 2010, increasing at an average rate of 7 percent per year. Demand from the commercial segment grew at an average of 6 percent per year during the same period.

275. Government of Grenada, "Geothermal Resources Environmental and Planning Regulations," December 21, 2011.
276. GRENLEC, 2014 Annual Report.
277. GRENLEC, "Customer Renewable Energy (RE) Interconnection Programme," accessed October 30, 2014, http://www.grenlec.com/YourEnergy/RenewableEnergy.aspx.
278. GRENLEC, 2014 Annual Report.
279. Ibid.

FIGURE 13.1 Electricity Demand by Sector (2004–2014)



Source: GRENLEC, Annual Reports 2004–2014.

13.1.2 Key laws, regulations, and policies governing the sector

The electricity sector in Grenada is governed by the Electricity Supply Act of 1994, which established the structure of the electricity sector and the mechanism for setting tariffs. The ESA grants GRENLEC the exclusive right to supply electricity until 2073. The Energy Policy outlines the government's objectives and plan for reforming the energy market to reduce electricity costs and increase renewable energy generation. However, the Energy Policy has not been implemented yet. Also, the government has yet to approve the Geothermal Resources Development Bill and the Geothermal Resources Environmental and Planning Regulations. They will establish the legal framework for exploring and developing geothermal resources.

Policies in the energy sector

The Energy Policy presents the government's objectives of reducing electricity prices and increasing energy security. The Energy Policy prioritizes developing renewable energy and reforming the national energy market to achieve its objectives. However, the government has not yet implemented the measures called for in the Energy Policy.

The Energy Policy delineates the following actions:

- Establishing a National Sustainable Energy Office (NSEO) to pursue the objectives of the Energy Policy;
- Creating a regulatory body for licensing, oversight, regulation, and rate setting for the electricity and transport sector;
- Formulating legislation and contracts consistent with a modern energy sector that would support the development of hydrocarbons and geothermal resources; and
- Setting the objective of renewable energy sources providing 20 percent of all domestic energy used for electricity and transport by 2020—specifically targeting geothermal, wind energy, and solar water heaters.[280]

To meet the renewable energy target, the Energy Policy calls for various measures, including: providing fiscal incentives for renewable energy; collecting and publishing data on energy production, energy consumption, and resource assessments; and developing local expertise for the installation and operation of renewable energy technologies. For the last measure, the Energy Policy states that the government will engage donors to join geothermal development programs that provide financing for technical assistance.

Laws and regulations governing the electricity sector

The Electricity Supply Act—which was passed in 1994 and amended in 1998, 2005, and 2013—governs electricity supply in Grenada. It grants GRENLEC an exclusive license to generate, transmit, distribute, and sell electricity until 2073 on all of the islands of Grenada. Any other party seeking to generate electricity in Grenada must do so with a

280. Government of Grenada, "The National Energy Policy of Grenada: A Low Carbon Development Strategy for Grenada, Carriacou and Petite Martinique," November 2011, http://www.gov.gd/egov/docs/other/GNEP_Final_Nov_23_2011.pdf.

sublicense granted by GRENLEC. The government would need to amend the ESA to implement its plans of reducing the term of GRENLEC's license to a 30-year period, and allowing for competitive bidding in the generation segment.[281]

The ESA establishes a clear tariff regime for GRENLEC. The ESA sets the tariff structure and establishes electricity rates that GRENLEC can charge its customers. The ESA also presents a methodology that GRENLEC must use to adjust its tariffs. The current tariff structure only allows GRENLEC to recover the cost of service when generating with diesel or heavy fuel oil. The ESA does not establish a mechanism for GRENLEC to recover the costs of generating electricity with other fossil fuels or renewable energy. Therefore, if geothermal generation were introduced in Grenada, the government would need to amend the tariff to allow for cost recovery.

One of the major challenges for geothermal development is the lack of legislation governing the development of geothermal resources. The government, in collaboration with the Organization of American States (OAS), prepared the Geothermal Resources Development Bill and the Geothermal Resources Environmental and Planning Regulations, which are intended to fill this gap.[282]

If the government passes the Geothermal Bill and the Geothermal Regulations,[283] they would establish the regulatory framework for exploring, exploiting, and protecting Grenada's geothermal resources. The Geothermal Bill defines what a geothermal resource is, who owns it, and establishes the process for granting rights to explore and exploit geothermal resources. The Geothermal Bill defines two procedures for granting rights on geothermal resources: a negotiated track and a competitive track. The negotiated track assigns a developer a right to explore and exploit the resource, and is used when a geothermal resource is not proven and until GRENLEC's monopoly license expires. The competitive track awards a concession to develop a geothermal resource through a competitive bidding process. The competitive track is used when a geothermal resource is proven.[284] The Geothermal Regulations also establish rules on how the EIAs must be carried out.

13.1.3 Institutional structure of the electricity sector

GRENLEC, a privately owned and vertically integrated utility, holds an exclusive license to supply electricity in Grenada until 2073. GRENLEC provides electricity to Grenada, Carriacou, and Petite Martinique. GRENLEC is overseen by the Ministry of Finance, Planning, Economic Development, Trade, Energy and Cooperatives ("the Ministry of Finance"), who is also responsible for setting policies for the energy sector. **Figure 13.2** presents the relationships between the key entities in Grenada's electricity sector.

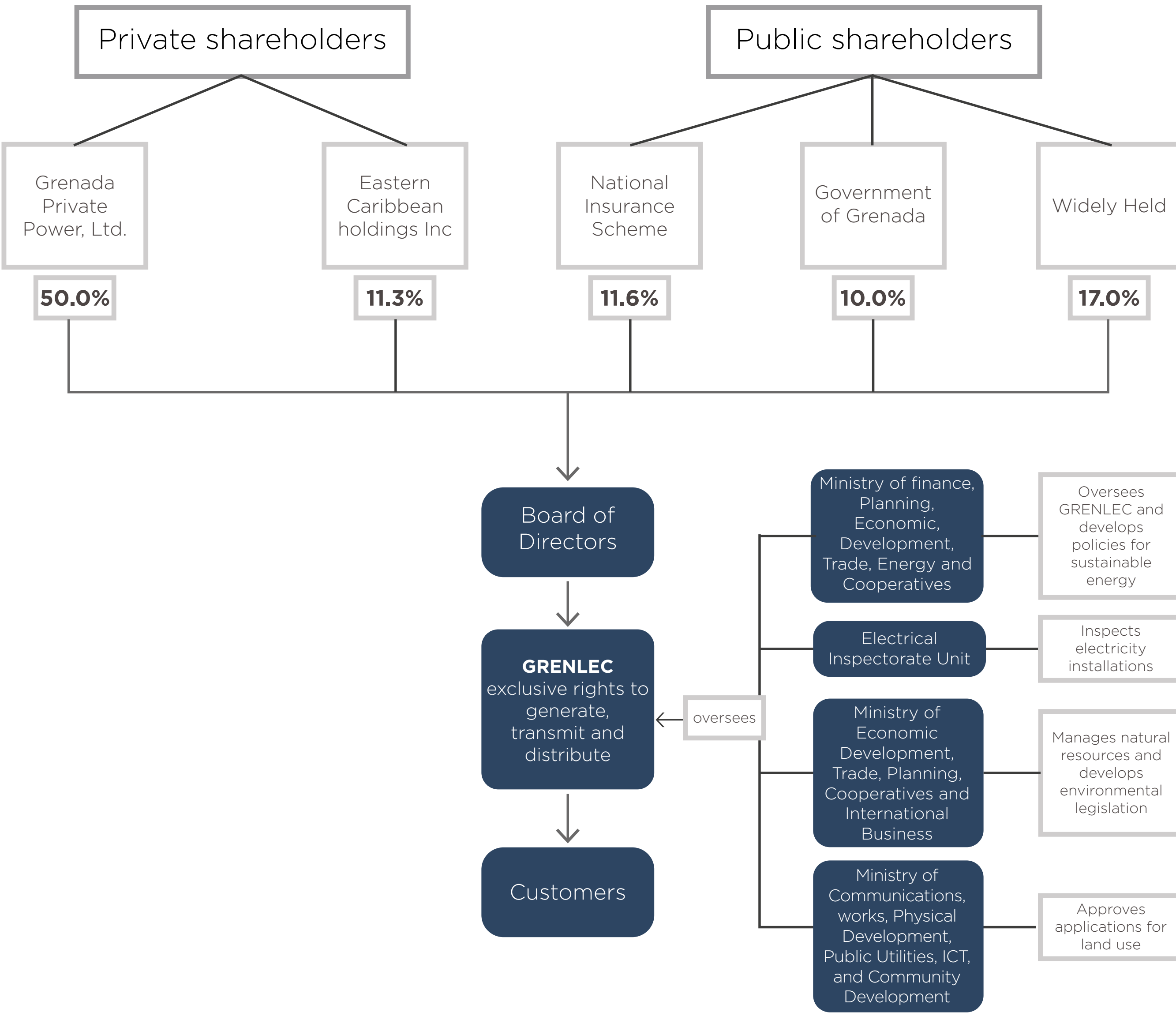
281. The Prime Minister, Hon. Keith C. Mitchell, identified these actions as part of his administration's plans for reducing electricity prices during his speech on November 7, 2013, at the event Launch of ECERA.

282. Government of Grenada, "2012 Budget Statement," March 9, 2012, accessed July 18, 2013, http://www.gov.gd/egov/docs/budget_speech/budget_statement_2012.pdf.

283. Government of Grenada, "Geothermal Resources Environmental and Planning Regulations," December 21, 2011.

284. Government of Grenada, "Geothermal Resources Development Bill of 2011," December 21, 2011.

FIGURE 13.2 Key Entities in the Grenada Electricity Sector



Source: Eastern Caribbean Securities Exchange, "Issuer Registration Statement," accessed June 6, 2014, http://www.ecseonline.com/issuer_profiles/documents/GESLRSStatement2014.pdf.

Below we provide a more in-depth description of the major responsibilities in the electricity sector and the bodies responsible for carrying them out.

- **Policymaking**—There are three ministries responsible for creating policies applicable to the energy sector. The Ministry of Finance is the most important ministry in the sector. There are two other ministries that are also responsible for creating policies applicable to the energy sector; however, they fulfill less influential roles compared to the Ministry of Finance.

- The Department of Energy and Sustainable Development of the Ministry of Finance oversees GRENLEC, determines future capacity expansion to meet electricity demand, and develops policies to promote sustainable energy. The Department of Energy and Sustainable Development's oversight and planning functions include:[285]

  * Requesting GRENLEC to extend its lines to areas not currently supplied with electricity, providing that the government, the Ministry, or the local authority pays for 50 percent of the expense

285. Government of Grenada, *Electricity Supply Act* 1994, Section 6 (11).

* Revoking GRENLEC's license at the end of 30 or 55 years, and approving sublicenses authorized by GRENLEC
    * Making regulations for consumer and public safety, and for quality of service and reasonable standards of performance by GRENLEC
    * Giving directions, after consulting with GRENLEC, to preserve the security of buildings or installations used for generation, transmission, or distribution of electricity
    * Making regulations to prescribe environmental standards to be observed by GRENLEC based upon the generally accepted standards applied to the operation of electricity utilities
  - The Ministry of Economic Development, Trade, Planning, Cooperatives & International Business is responsible for managing natural resources and enacting environmental legislation.[286]
  - The Physical Planning Unit within the Ministry of Communications, Works, Physical Development, Public Utilities, ICT, and Community Development is responsible for approving applications for developing land.[287]

- **Regulation**—Although the Public Utilities Commission Act 13 of 1994 (PUC Act) mandated the establishment of a Public Utilities Commission (PUC) to regulate the electricity sector, the PUC has not been appointed. The government intends to establish the Public Utilities Regulatory Commission (PURC) through the Public Utilities Regulatory Commission Act (PURC Act), which would replace the PUC and PUC Act, respectively. The PURC Act would assign the PURC with responsibilities to regulate the electricity sector, such as setting and regulating GRENLEC's rates and approving PPAs between GRENLEC and IPPs.[288] However, until the PURC is established there is no independent economic regulator in Grenada. Currently, regulatory functions are spread across the following ministries:
  - The Ministry of Finance oversees GRENLEC to ensure it complies with the ESA
  - The Electrical Inspectorate Unit of the Ministry of Public Works is responsible for checking and testing electric lines and plants to ensure the safe and reliable provision of electricity

- **Generation, Transmission, and Distribution**—GRENLEC, a privately owned company, holds an exclusive license to supply power in Grenada until 2073. The utility provides electricity service on Grenada, Carriacou, and Petite Martinique.

  GRENLEC is responsible for granting permits to customers to install distributed generators that use renewable resources and sell the excess electricity to the grid. GRENLEC is also responsible for granting sublicenses for third parties that wish to generate, transmit, or distribute; however, no sublicense has been granted to date.

13.2 Status of Geothermal Development

Grenada's geothermal resources have not been studied extensively. Preliminary surface exploration suggests that Grenada's geothermal resource exceeds 30 MW but it has yet to be confirmed.[289] The government and GRENLEC expressed interest in working together to explore the geothermal resource and develop a 10 MW geothermal plant. However, since 2013 progress in the project has slowed due in part to the change in government and the proposed changes to the ESA. Recent actions from the government suggest that it might be relaunching the project. The government restarted exploration works in 2014 with the support of the Government of New Zealand. The government received and presented the results of 3G studies in July 2015 to determine the way forward.[290]

13.2.1 Resource potential and development

The development of geothermal resources in Grenada has advanced slowly and has not progressed beyond preliminary surface exploration.[291] To a large extent, the change in the government after the 2013 election and the government's plans to amend the ESA caused the geothermal project to be put on hold. Nonetheless, the government recently restarted exploration works without GRENLEC with the support of the Government of New Zealand. These works are funded by the New Zealand Aid Programme as a result of an agreement signed in June 2014 to help Grenada and Saint Lucia develop their geothermal potential.[292] The government received the results of the study in June 2015.[293]

Surface exploration studies completed in 2015 suggest a high-temperature resource. However, further surface exploration is required to determine the size of the field and composition of the reservoir.[294] Preliminary studies suggest Grenada's potential to be at least 30 MW.[295] However, surface reconnaissance carried out by GRENLEC in 2009 suggests that the resource is of low enthalpy, meaning that it would be relatively expensive to develop.[296] Further exploration is needed to confirm the size and quality of the resources, and to determine whether developing geothermal energy in Grenada is commercially viable.

---

289. World Bank, "Got Steam? Geothermal as an Opportunity for Growth in the Caribbean," Caribbean Knowledge Series, June 2013, accessed March 6, 2014, http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2013/06/21/000442464_20130621142703/Rendered/PDF/786080WP015.0G00Box377349B00PUBLIC0.pdf.

290. 3G studies are surface exploration studies carried out before the test drilling phase to estimate the size and temperature of the geothermal resource.

291. To date, there have been four studies of Grenada's geothermal resources. In 1981, OLADE carried out a reconnaissance study that found that Mt. Saint Catherine would be the most feasible area for geothermal development. In 1982, Gerald To date, there have been four studies of Grenada's geothermal resources. In 1981, OLADE carried out a reconnaissance study that found that Mt. Saint Catherine would be the most feasible area for geothermal development. In 1982, Gerald Huttrer completed a study that evaluated the temperature and chemistry of specific sites. In 2008–2009, GRENLEC carried out a study, but it has not released the findings of its study to the government. In 2015, the government completed new surface exploration. GRENLEC, "Geothermal Energy in Grenada" (Costa Rica Study Tour: March 2014).

292. "NZ Firm Testing Caribbean Geothermal Resource," *New Zealand Energy News*, April 2015; "St. Lucia, New Zealand Sign Geothermal Support Partnership Agreement," *Caribbean News Now*, September 3, 2014, accessed May 23, 2016, http://caribbeannewsnow.com/topstory-St-Lucia,-New-Zealand-sign-geothermal-support-partnership-agreement-22625.html.

293. Government of Grenada, Grenada Mission to the United Nations, "Brief on Geothermal Development in Grenada," July 29, 2015, accessed December 3, 2015, http://www.grenadamissiontotheun.org/#!Brief-on-Geothermal-Development-in-Grenada/tg6hr/55ce96520cf2ce5f89ab7e5c.

294. Ibid.

295. World Bank, "Got Steam? Geothermal as an Opportunity for Growth in the Caribbean," Caribbean Knowledge Series, June 2013, accessed March 6, 2014, http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2013/06/21/000442464_20130621142703/Rendered/PDF/786080WP015.0G00Box377349B00PUBLIC0.pdf.

296. GRENLEC, "Geothermal Energy in Grenada" (Costa Rica Study Tour: March 2014).

13.2.2 Planned project

Although the government has not made a final decision on how to develop its geothermal resources, various options for developing the project have been explored. One option involves GRENLEC as an active partner in the SPV for the geothermal project and the other option does not.

- **Project with GRENLEC**—Under this project structure, the government would issue a resource agreement that authorizes GRENLEC to explore and exploit the geothermal resource. GRENLEC would sign an agreement with an SPV that would build, operate, and transfer the power plant to GRENLEC when the contract expires. The SPV would be co-owned by GRENLEC and another private company. The SPV would sell electricity to GRENLEC under a PPA.[297]
- **Project without GRENLEC**—Under this project structure, the government would establish an SPV that would be owned by the government and the private sector. The project would have three main agreements: a resource agreement to authorize the exploitation of the geothermal resource, a concession agreement to design, build, operate, own, and finance the power plant, and a PPA between the SPV and GRENLEC. In addition to the equity contributions that would be provided by the government and the private developers, the project would also need to be financed with debt.

Previous governments had conversations with GRENLEC to determine how to develop the geothermal resources in Grenada. GRENLEC had proposed to develop a 10 MW geothermal power plant in the fourth quarter of 2015 and develop a further 40 MW of capacity in the long term.[298] The 10 MW plant would have served the country's baseload demand for electricity, but would not fully meet peak demand, which was 29.2 MW in 2013.[299] Developing the project would require investing in all phases of geothermal development—a prefeasibility study, exploratory drilling, production drilling, and plant construction and operation.[300] However, GRENLEC has stopped work on the project due to the uncertainty caused by the change in government and the proposed changes to the ESA.

Recent actions from the government suggest that it might be looking to relaunch the project under a new proposed project structure that would not include GRENLEC. In June 2014, the Government of New Zealand signed an agreement with the Government of Grenada to help develop its geothermal resources.[301] The government has restarted exploration works and the results of the study were presented in July 2015.

297. Japan International Cooperation Agency and West Japan Engineering Consultants, Inc., "Study of Situation for Geothermal Energy Development" (April 2014).
298. Japan International Cooperation Agency and West Japan Engineering Consultants, Inc., "Study of Situation for Geothermal Energy Development" (April 2014).
299. GRENLEC, 2013 Annual Report.
300. Japan International Cooperation Agency and West Japan Engineering Consultants, Inc., "Study of Situation for Geothermal Energy Development" (April 2014).
301. Bernard Hill, Project Director & Energy Manager at Hawkins Infrastructure, email message to author, November 25, 2014; "NZ Firm Testing Caribbean Geothermal Resource," *New Zealand Energy News*, April 2015; "St. Lucia, New Zealand Sign Geothermal Support Partnership Agreement," *Caribbean News Now,* September 3, 2014, accessed May 23, 2016, http://caribbeannewsnow.com/topstory-St-Lucia,-New-Zealand-sign-geothermal-support-partnership-agreement-22625.html.

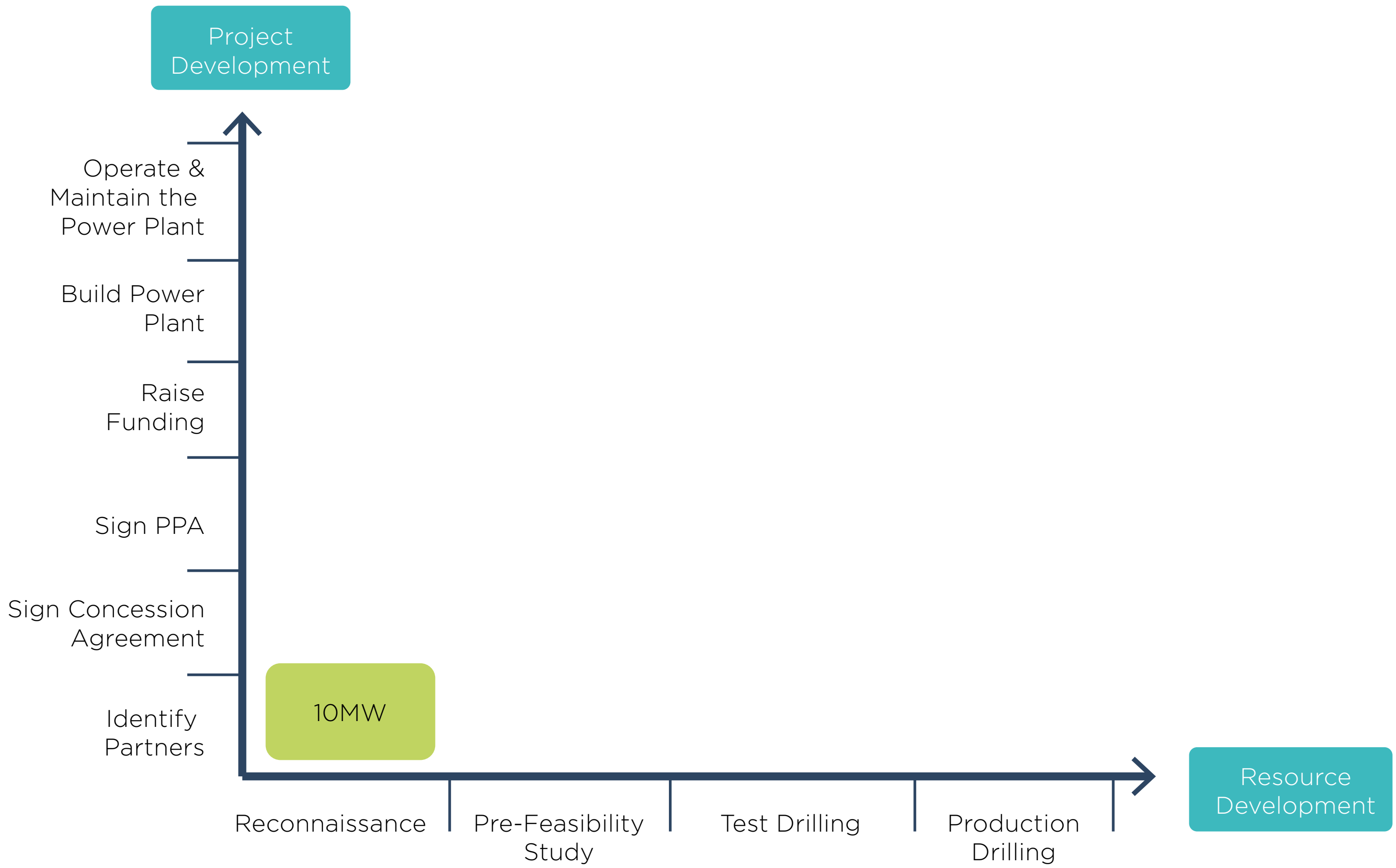
Neither GRENLEC nor the government has published cost estimates for developing a 10 MW geothermal plant. Cost estimates vary significantly, which reflects the uncertainty about the quality of Grenada's geothermal resource. Preliminary estimates suggest that a 10 MW geothermal power plant on Grenada could cost about US$87 million.[302] This estimate includes all stages, from surface exploration to production drilling and construction of the power plant. The cost of construction of the power plant is US$45 million. The construction of transmission lines and access roads would increase the total cost to about US$102 million. West Japan Engineering Consultants, Inc. estimated the cost of building a prototype 20 MW power plant to be US$40 million. Their cost estimate increases to US$125 million when costs for production drilling, physical contingency, and consultant fees and administrative expenses are included.[303] The government would need to determine the size and quality of the geothermal resource to accurately estimate the costs of the project.

302. Financial model that accompanies this report, based on information from: Magnus Gehringer and Victor Loksha, *Geothermal Handbook: Planning and Financing Power Generation* (Washington, DC: The International Bank for Reconstruction and Development, Technical Report 002/12, June 2012), accessed October 22, 2014, http://www.esmap.org/sites/esmap.org/files/DocumentLibrary/FINAL_Geothermal%20Handbook_TR002-12_Reduced.pdf; IDB, "Sustainable Energy Facility (SEF) for the Eastern Caribbean: Loan Proposal RG-L1071, RG-G1009, and RG-G1004" (2015), accessed December 2, 2015, http://www.iadb.org/en/projects/project-description-title,1303.html?id=RG-L1071.

303. West Japan Engineering Consultants, Inc., "Study on Current Status of Geothermal Development in the Eastern Caribbean Islands: Field Trip Report and Study Tour in Costa Rica," March 2014.

Figure 13.3 presents the status of the project. It shows that the project is still in the early stages of development. Despite the mutual interest by GRENLEC and the government in developing a geothermal power plant, the project's progress slowed in 2013 and 2014 and exploration work has just recently picked up. This is due to the government's plans to amend the ESA and the lack of a legal and regulatory framework for geothermal development. The project cannot move forward until the Geothermal Bill is approved.

FIGURE 13.3 Status of Planned Geothermal Project



The next step would be for the government to complete further surface exploration to determine the size of the field and quality of the resource.[304] Then, exploratory drilling can begin.

The government would also need to determine the project structure it will use to develop the resource and identify the private companies it will partner with.

304. Government of Grenada, Grenada Mission to the United Nations, "Brief on Geothermal Development in Grenada," July 29, 2015, accessed December 3, 2015, http://www.grenadamissiontotheun.org/#!Brief-on-Geothermal-Development-in-Grenada/tg6hr/55ce96520cf2ce5f89ab7e5c.

13.3 Recommended Financial and Legal PPP Structure

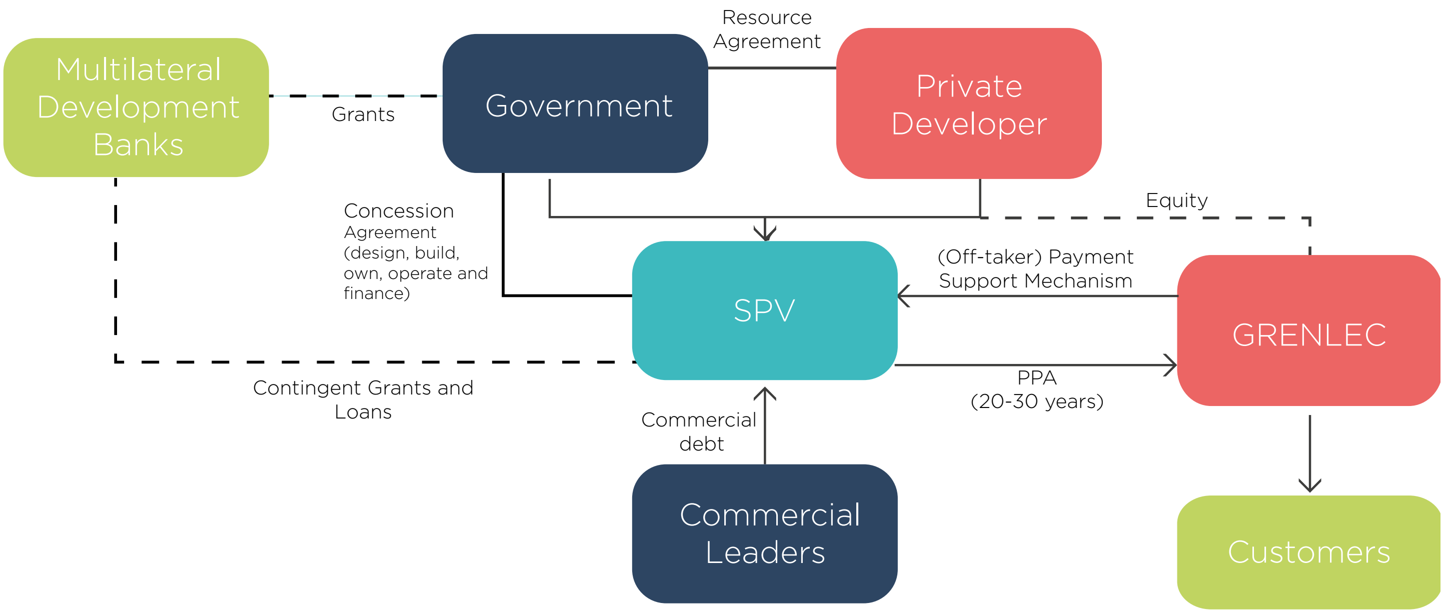
In Grenada, the government has explored two proposed PPP structures to develop Grenada's geothermal resources but no final decision has been reached. We recommend that the government goes ahead with the second PPP structure proposed, if commercially viable resources are found, and keeps the conversation open for GRENLEC's participation. Under this arrangement, the government would partner with a private developer to establish an SPV. The government would grant the SPV a resource agreement to explore and exploit Grenada's geothermal resource in an area. The government would also grant a concession contract where the SPV is responsible to build, own, operate, and finance the geothermal power plant.
This arrangement would allow the government to use the private sector's expertise, resources, and financing to develop its geothermal resources. While the project faces risks because it is in its early stages, the largest risks can be mitigated by partnering with a qualified geothermal developer and with support of the multilateral development banks.

13.3.1 Structure of the PPP

We recommend that the government go ahead with the PPP structure that it is currently considering, with one addition—funding from multilateral development banks—and keep the conversation open for GRENLEC's participation. The proposed PPP structure is discussed in detail in Section 13.2.2. Under that structure, the government would partner with another private company to develop an SPV. The government would grant a resource agreement to the SPV. The government would also grant a concession contract to the SPV to design, build, own, operate, and finance the geothermal power plant. The SPV would then sell electricity to GRENLEC through a PPA.

We recommend that the SPV obtain funding for the project from the multilateral development banks. The multilateral development banks would provide grants, contingent grants, and concessionary loans that would be provided directly to the SPV. The grants and contingent grants would support surface exploration and exploratory drilling. At the early stages of geothermal development, the resource is uncertain and so the resource risk is high. A contingent grant would reduce the resource risk because it would convert to a concessionary loan only if the resource is confirmed. The concessionary loan would be repaid from revenues from the electricity tariffs. The later stages of geothermal development—production drilling and power plant construction—could be supported by concessionary loans. **Figure 13.4** presents the proposed PPP structure with our recommendations.

FIGURE 13.4 Recommended PPP Structure for Grenada



Some lenders may require additional mechanisms that enhance the quality of the cash flows of the project. In particular, it may be necessary to include a payment support mechanism that backs GRENLEC's payments under the PPA. That support mechanism would reduce the risk of the project's revenues and, thus, make the project more bankable. The mechanism could be implemented in various ways. Some of the options include establishing a liquidity facility (such as a trust fund or escrow account) or third-party guarantees (offered by donors or financial institutions); see the recommended structure in Section 9.2.1 for more details.

Since GRENLEC and the government have discussed in the past the option that GRENLEC play an active role in the geothermal project, we recommend keeping this option open for consideration (indicated as a dotted line in the figure above). Regardless of whom the government chooses to partner with, GRENLEC will remain the off-taker and will fulfill an important role in the project.

It is too early to determine whether the proposed geothermal project in Grenada will be successful, because there is not enough information on the size and quality of the resource. However, the proposed PPP structure, with our recommended addition, would help mitigate the resource risk. That way the SPV will have more incentives and capacity to complete the surface studies, drill the test wells, and confirm the geothermal resource.

Once the geothermal resource has been confirmed, the proposed PPP structure would limit the risk to investors and lenders, making this a financeable project. Specifically, the resource agreement ensures that the SPV has the right to exploit the geothermal resource long enough to recover its investments. In addition, a PPP structure will allow the government to partner with an experienced geothermal developer that will provide the necessary technical expertise to develop the resource successfully.

13.3.2 Key risks and mitigation measures

Table 13.1 shows that the project's major risks are related to resource and project development.

The project has few major risks because the government has advanced in preparing the necessary legislation.

Table 13.1 Allocation of Risks for the Proposed PPP Structure

Risk	Impact of Risk	Party That the Risk Is Assigned To	Proposed Measure for Mitigating the Risk
Market, Demand, or Volume RiskPotential	Low	SPV	This risk will be mitigated by the PPA. The government should renew talks with GRENLEC to ensure it will agree to the PPA.
Resource Risk	High	SPV, the development banks, and the government	Grants and contingent grants for exploratory and production well drilling
Construction Risk	Medium	SPV and, possibly, the construction company that builds the plant	The SPV can hire a company to build the plant and incorporate penalties if the plant is not completed on time or milestones are not achieved as contractually planned.
Technical Risk	Medium	SPV	The government does not have the technical expertise to carry out the exploratory and production well drilling. However, the government can partner with a geothermal developer that can bring its expertise to the project.
Operating Risk	Medium	SPV	The government does not have the technical expertise to operate the geothermal power plant. However, the government can partner with a geothermal developer to operate the plant with penalties if standards of service are not maintained.
Political and Social Risk	Low	SPV	The government has expressed its plan to modify the ESA to reduce GRENLEC's license to 30 years. We recommend that the government renew talks with GRENLEC to ensure it will agree to the PPA. If GRENLEC's electricity costs are reduced through its purchase of geothermal energy, it will more likely support the project.
Environmental Risk	Medium	SPV and the government	This risk can be reduced by carrying out an EIA. The EIA will allow the government to assess the risk of the geothermal project and propose an action plan to mitigate the risks identified.
Financing Risk	Medium/High	SPV and the government	The financial risk for the project is reduced with the contingent grants for exploratory and production well drilling, the resource agreement, and the PPA.
Regulatory Risk	High	Government	The government has expressed its plan to modify the ESA to reduce GRENLEC's license to 30 years. Currently GRENLEC and the government are in discussions about the modifications to the ESA and no clear solution is foreseen in the short term. Since GRENLEC will play an important role in the project regardless of who owns the SPV, we recommend that the government continue its talks with GRENLEC regarding the PPA and the geothermal project itself. In addition, the government is responsible for making any necessary changes to the legal and regulatory framework to enable the development of the project. Since those changes take time, the parties to the project can draft clear rules governing the sustainable exploitation of the resource and the operation of the power plant in the project agreements (concession, PPA, others).

We describe the largest risks for the project and their proposed mitigation measures below:

- **A commercially viable well cannot be identified, or identifying and developing a production well is more expensive than expected (Resource Risk)**—The geothermal resource exploration has not advanced beyond surface exploration. 3G studies completed by the Government of New Zealand in 2015 suggest a large resource (4–8 square kilometers) with high temperatures (200–290°C).[305] However, further surface exploration is required to confirm the size and quality of the resource before exploratory drilling can begin. One of the major risks for the project is that the SPV is not able to develop a commercially viable well, or that the production well cannot be developed quickly and within expected cost.

  This risk can be reduced through the support of the multilateral development banks. The multilateral development banks could help mitigate this risk by providing contingent grants. Under this arrangement, the multilateral development banks could offer to provide funding whose repayment would depend on the success of the drilling. For example, the SPV will have to repay the entire loan if the drilling is successful, but only a portion if the drilling is not successful. This reduces the resource risk faced by the SPV.

- **The government cannot find a suitable project developer or cannot agree on the terms of the concession or other project documents (Market Risk)**—One of the key risks for the geothermal project in Grenada is that the government may not be able to find a project developer with the skills required, or that the government and the project developer do not agree on the terms of the concession. The government would need to find a project developer with a proven track record in geothermal development and access to financial resources.

  To mitigate this risk, we recommend the government take advantage of relationships with donors that have been supporting the surface exploration stage. The multilateral development banks could also support the government with the negotiation of a project agreement. The government may also be able to use financing from multilateral development banks to reduce the project's risks and costs. This would allow it to develop a project that is attractive to bidders.

13.3.3 Strategy for engaging key stakeholders

Since Grenada is still in the early stages of geothermal development, the government has not actively engaged with the public to keep them informed of the project's progress. Going forward, we recommend the government engage the public and ensure its support for the project. The easiest way to keep the public engaged is to hold public consultations, in which the government provides updates on the project's progress and expected benefits. In addition, the government can use the press to inform the public about its actions for developing the project, and thus show its commitment and active engagement in the project.

We also recommend the government ensure that conversations with GRENLEC are participative and continuous. Specifically, the government could inform GRENLEC about its progress on the project. Maintaining regular and open conversations with GRENLEC would ensure that GRENLEC agrees to fulfill its role as the off-taker of the project.

Lastly, it is important for multilateral development banks and other government entities to be kept informed of the project because of their key role in the project. Donors are currently providing technical assistance and the development banks will likely provide funding. These are factors for the success of the project. If the multilateral development banks and donors are kept up to date, the funding could be made available on a timely basis. In addition, we recommend the government ensure that other government entities are kept informed of the project's progress. Specifically, we recommend that the government actively engage with the Ministry of Economic Development, which will probably be responsible for monitoring the use of geothermal resources once the power plant begins operations.

305. Government of Grenada, Grenada Mission to the United Nations, "Brief on Geothermal Development in Grenada," July 29, 2015, accessed December 3, 2015, http://www.grenadamissiontotheun.org/#!Brief-on-Geothermal-Development-in-Grenada/tg6hr/55ce96520cf2ce5f89ab7e5c

13.4 Recommended Changes to the Legal, Institutional, and Regulatory Framework

The government has progressed significantly towards developing the legal, institutional, and regulatory framework needed to develop Grenada's geothermal resource. As mentioned in Section 13.1.2, the government prepared the Geothermal Bill and the Geothermal Regulations. Moving forward, we recommend the government carry out the following actions:

- **Reach an agreement with GRENLEC regarding the ESA and the structure of the sector.** The government is in the process of revising the ESA. The objective of the revision is to expand renewable energy by allowing competition in the generation segment and removing GRENLEC's monopoly. Until the government is able to reach an agreement with GRENLEC it will be difficult for GRENLEC and the SPV to agree on a PPA. Numerous development institutions have expressed their willingness to support discussions between the government and GRENLEC by providing independent facilitators.
- **Establish a framework governing geothermal resources.** We recommend that Grenada should have a legal framework that assigns ownership of geothermal resources, establishes a process for granting a license to develop geothermal resources, and assigns responsibility for monitoring geothermal resources to a government body. As mentioned above, the government has advanced significantly in this area, drafting the Geothermal Bill and the Geothermal Regulations with funding from the OAS. The government has also drafted the Public Utilities Regulatory Commission Bill, which assigns responsibility to the PURC for approving PPAs between GRENLEC and IPPs. If Parliament approves this legislation, it would establish the legal, institutional, and regulatory framework for exploring, exploiting, and protecting Grenada's geothermal resources.
- **Ensure tariffs reflect the cost of producing electricity with geothermal generation.** The tariffs in Grenada are set through a formula established in the ESA. The tariffs only allow GRENLEC to recover the cost of generating with diesel or heavy fuel oil. If the Public Utilities Regulatory Commission Bill is approved and the PURC is established, the PURC will be responsible for setting tariffs according to the rate-setting regulations that will be issued under the revised ESA. We recommend the government take actions to ensure that the formula, or other mechanism used to set tariffs, allows GRENLEC to recover the full cost of the service provided at least-cost, regardless of the technology or fuel in use, and also that it reflects any reductions in the costs of electricity generation. We recommend that the government and GRENLEC agree on the adjusted tariff formula before the resource agreement is signed.
- **Establish a regulator.** We recommend the government proceed with its plan of establishing the Public Utilities Regulatory Commission (PURC). The PURC would be responsible for some of the regulatory functions addressed above as well as other responsibilities. For example, the PURC would set and regulate GRENLEC's rates and approve PPAs between GRENLEC and IPPs. The regulator could also be responsible for monitoring the geothermal resource, although environmental regulation is not always within the jurisdiction of the economic regulator. Establishing a separate regulator responsible for these functions is one way to centralize these responsibilities. If the regulator has sufficient autonomy from other government agencies and has the resources to carry out its work, centralizing these functions will ensure these functions are executed capably.

Drafting, reviewing, and approving the laws and regulations that would address these changes takes time to implement. The Geothermal Bill and Geothermal Regulations were prepared in 2012 and by November 2015 had yet to be approved by Parliament (see Section 13.1.2).

Another way to address some of these changes is to establish regulation through contracts. For example, to ensure that tariffs for end customers reflect the (lower) costs of producing electricity through geothermal generation, the PPA that the SPV signs with GRENLEC could establish the formula used to determine the tariffs GRENLEC charges customers. Similarly, the agreements between the government and the private partners could include obligations that ensure the protection and sustainable development of the geothermal resource. For example, the agreement can mandate that an independent expert carry out periodic evaluations to monitor the environmental impact of the power plant. If the PURC is established, the PURC could monitor the SPV's compliance with contractual obligations. If the PURC is not established in the short term, a committee can be established for this purpose. Any dispute arising from failure to adhere to contract obligations could be handled by a regular court, an administrative court, or a special expert panel as applicable.

Establishing regulation through contracts would only serve as a short-term solution to prevent delays in project implementation. There are some regulatory functions that cannot be covered through contracts and for which regulations and laws will need to be established. For example, the government will still need to develop the process through which licenses to establish a geothermal plant are obtained.

13.5 Economic and Financial Analysis of the Geothermal Project

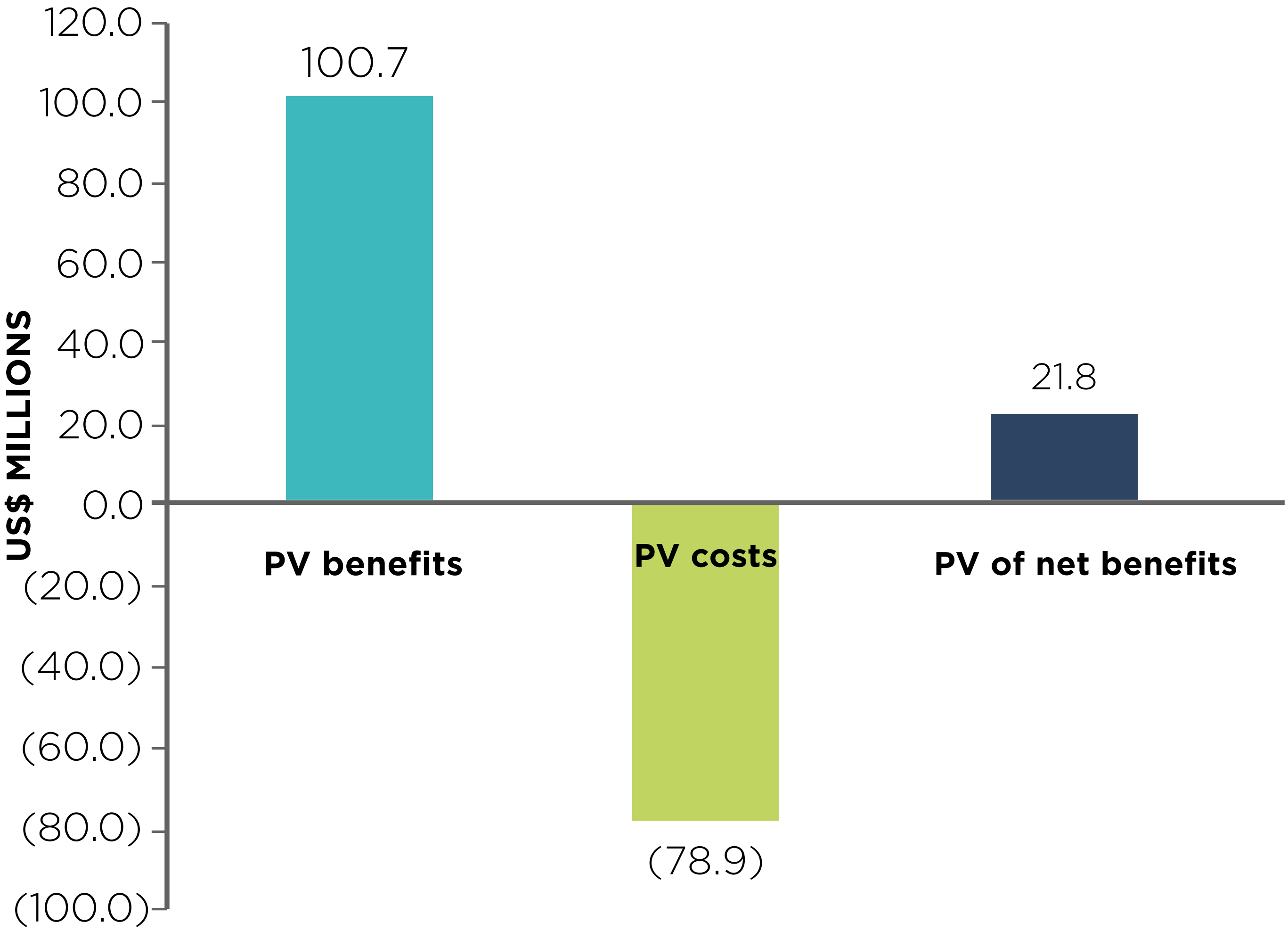
In this section, we assess whether the geothermal project in Grenada is economically and financially viable. We first perform a cost-benefit analysis to determine whether the geothermal project generates net economic benefits to the country. We then use the discounted cash flow method to evaluate whether the geothermal project is financially viable to investors. We conclude that the geothermal project is economically and financially viable. Therefore, we recommend the government and investors proceed with developing it. We present our analysis and results as follows:

- Cost-benefit analysis (Section 13.5.1)
- Financial analysis (Section 13.5.2)

13.5.1 Cost-benefit analysis

We perform a cost-benefit analysis to determine whether the geothermal project is economically viable. We conclude that Grenada's geothermal project is economically viable and increases social welfare. The present value of the project's net economic benefits is positive and equal to US$22 million **(Figure 13.5)**. Therefore, the government and donors should proceed with developing the project.

FIGURE 13.5 Present Value of Net Economic Benefits of Grenada's Geothermal Project



To determine the economic viability of the geothermal project, we estimate its net economic benefits for a period of 40 years. Net economic benefits equal the economic benefits minus the economic costs of the project. Economic benefits include savings in generation costs (because generating electricity from geothermal resources can cost less than from fuel oil or diesel), and reductions in CO_2 emissions. Economic costs are the capital expenditures needed to complete all project stages. We then bring the economic benefits and costs to present value (PV) with a social discount rate of 12 percent (in real terms). The geothermal project is economically viable if the PV of the project's net benefits is positive—economic benefits outweigh economic costs. Further details about the assumptions and methodology we use are presented in Appendix A.

306. IDB, "Guidelines for the Economic Analysis of IDB-Funded Projects," June 2012, http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=36995807.

13.5.2 Financial analysis

We use the discounted cash flow (DCF) method to determine whether the geothermal project in Grenada is financially viable for equity investors. We conclude that the geothermal project allows the equity investors to earn a 15 percent real rate of return when the PPA rate is about US$0.19/kWh. This PPA rate is the tariff at which the geothermal projects would need to sell each kWh of electricity to be able to service their debts and provide equity investors with a 15 percent real return. This PPA rate is feasible to implement, because it is significantly lower than the current electricity tariff from fuel oil generation of US$0.37/kWh.[307] The final PPA rate will be determined through negotiations between the partners of the project.

Table 13.2 Financial Results of Geothermal Project

NPV to Equity Investors (US$ millions)	IRR to Equity Investors (Real)	PPA Rate (US$/kWh)
0	15%	0.19
4.5	18%	0.21
9.1	21%	0.23

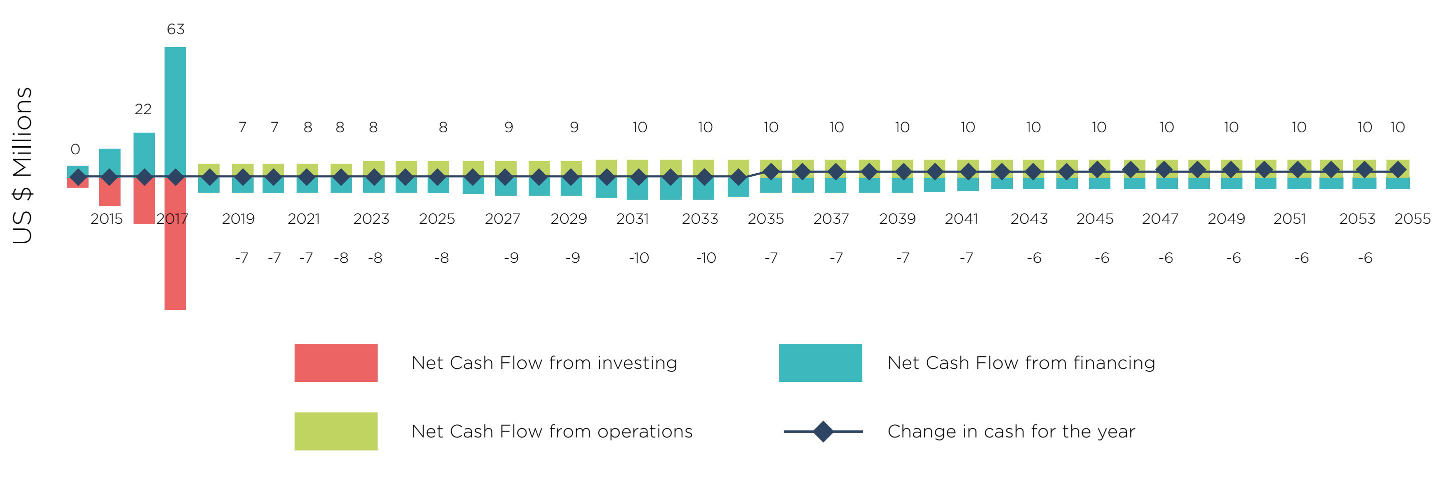
Notes: The IRR is Internal Rate of Return of the cash flows to equity investors. We assume a 15 percent real discount rate for equity cash flows.

In this section, we present the estimated cash flows from the geothermal project. The DCF methodology we use and our main assumptions are in Appendix B.

Cash flows from the geothermal project

In **Figure 13.6**, we present the projected cash flows of the geothermal project for an indicative PPA rate of US$0.19/kWh. Cash flows from financing are positive from 2015 to 2018 and are directed towards financing the capital expenditures (investments). The highest capital expenditures occur in 2018, when the wells are drilled and the power plant is under construction. When the power plant begins operations in 2019, the cash flows from operations become positive and are used for repaying debt.

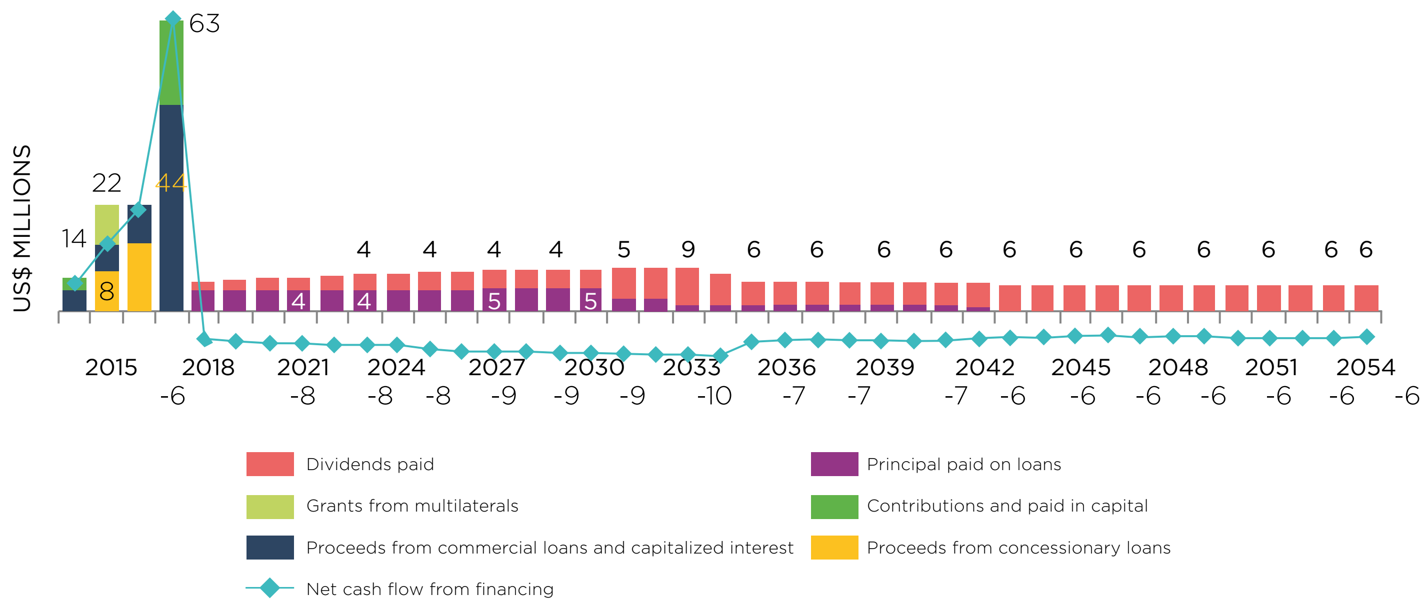
FIGURE 13.6 Cash Flows of the Geothermal Project



307. GRENLEC, 2014 Annual Report; CARILEC, 2014 *Average Tariffs in EC Countries* (2015).

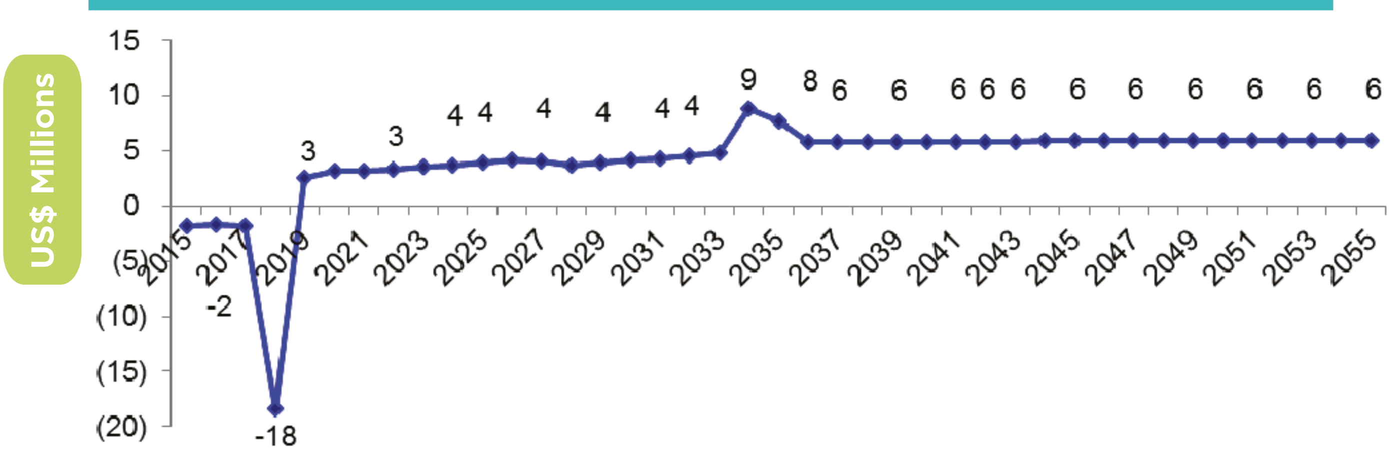
Financing cash flows in 2016 and 2017 are made up of concessionary loans and grants **(Figure 13.7)**. In 2018 commercial debt and equity contributions increase significantly and are used to finance power plant construction. Once the power plant begins operations in 2019, the cash flows from operations are directed towards repaying the debt and paying out dividends. The net cash flows from contributions and paid-in capital and dividends paid are the cash flows to the equity investor, which we discuss below.

FIGURE 13.7 Financing Cash Flows of the Geothermal Project



The cash flows to the equity investors are presented in **Figure 13.8** The cash flows to the equity investor are negative during 2015 to 2018, when the equity investors make their paid-in contributions to finance the capital expenditures. By 2019, the income from operations becomes large enough to pay for operating costs, cover working capital, and service debt. The remaining cash flows are the cash available to equity investors. As payout policy we assumed that dividends are equal to the minimum of the cash available to equity and retained earnings, subject to retained earnings not falling below zero. As further debt payments are made, the principal amount is further reduced and the cash flows to the equity investors increase.

FIGURE 13.8 Cash Flows to Equity Investors from the Geothermal Project



14 Saint Kitts and Nevis

The two islands of Saint Kitts and Nevis make up the Federation of Saint Christopher (often referred to by the abbreviated form, Saint Kitts) and Nevis, and are located in the Lesser Antilles of the Eastern Caribbean. In this section, "the Federation" will be used to refer to the country of Saint Kitts and Nevis, and the names of the islands will be used to refer to the islands as separate geographic and administrative entities. The islands of Saint Kitts and Nevis are separated by three kilometers at their nearest point. Nevis has a large degree of autonomy from the Government of Saint Kitts and Nevis; it has a separate premier, legislative body, and budget. The local government in Nevis is called the Nevis Island Administration (NIA).[308]

There is a two-phase plan for developing geothermal resources in Nevis. It includes developing a power plant to serve Nevis in a first phase, and another power plant in Nevis to serve Saint Kitts in a second phase. We present the two phases in this section. Phase 1 is also called the Nevis project, and Phase 2 is also called the Saint Kitts project.

Phase 1 of the project has advanced considerably. Test wells drilled in Nevis suggest the existence of a geothermal resource large enough to power the two planned plants. The NIA has signed two project agreements.[309] The NIA signed a concession agreement with a consortium of private companies for the development of a 10 MW power plant for Phase 1.[310] The concession was competitively procured. The NIA and the consortium also signed a 25-year PPA with NEVLEC.[311] Furthermore, the NIA has established the legal and regulatory framework necessary for developing the country's geothermal resources.

The government and the NIA could develop Phase 2 using the geothermal resource in Nevis, either with the same private partner as for Phase 1 or with another qualified partner. In Saint Kitts, geothermal development has not advanced beyond early surface exploration and results suggest a lower-quality resource than that found in Nevis. However, the government did complete an interconnection study that identified three potential routes to supply electricity from Nevis to Saint Kitts.

There are two sets of key actions that need to take place towards developing geothermal power in the Federation. On one side, the project developer for Phase 1 needs to carry out exploratory drilling. On the other, the government would need to carry out studies to determine the viability of building interconnection cables to transport electricity from Nevis to Saint Kitts for Phase 2. The government would also need to finalize any pending agreements for Phase 1 and reach agreements to implement Phase 2, either with the developer of Phase 1 or with another partner. The multilateral development banks can play an active role by providing funding for both phases.

The planned project and possible role for the multilateral development banks is described in more detail in the following sections:

- Overview of the Electricity Sector in Nevis (Section 14.1)
- Overview of the Electricity Sector in Saint Kitts (Section 14.2)
- Status of Geothermal Development (Section 14.3)
- Recommended Financial and Legal PPP Structure (Section 14.4)
- Recommended Changes to the Legal, Institutional, and Regulatory Framework in Nevis (Section 14.5)
- Recommended Changes to the Legal, Institutional, and Regulatory Framework in Saint Kitts (Section 14.6)
- Economic and Financial Analysis of the Geothermal Project in Nevis (Section 14.7)
- Economic and Financial Analysis of the Geothermal Project in Saint Kitts (Section 14.8)

308. Ernie Stapleton, "Renewable Energy Development on Nevis: Lessons Learned" (June 28, 2010), accessed November 12, 2014, http://www.credp.org/Data/CSEF2/Wednesday/pdf/Stapelton-Presentation_on_Renewable_Energy_Development_on_Nevis.pdf.

309. Nevis Island Administration, "NIA, NEVLEC and NREI Sign Geothermal Power Purchase Agreement," November 26, 2015, accessed December 4, 2015, http://www.nia.gov.kn/index.php/news-4/news-articles-3/2538-nia-nevlec-and-nrei-sign-geothermal-power-purchase-agreement.

310. "Nevis Island Administration (NIA) and Nevis Renewable Energy International, Inc. (NREI) Sign Geothermal Concession Agreement," *Nevis Pages*, September 3, 2014, accessed November 12, 2014, http://www.nevispages.com/nevis-island-administration-nia-and-nevis-renewable-energy-international-inc-nrei-sign-geothermal-concession-agreement/.

311. Nevis Island Administration, "NIA, NEVLEC and NREI Sign Geothermal Power Purchase Agreement," November 26, 2015, accessed December 4, 2015, http://www.nia.gov.kn/index.php/news-4/news-articles-3/2538-nia-nevlec-and-nrei-sign-geothermal-power-purchase-agreement.

14.1 Overview of the Electricity Sector in Nevis

The Nevis Electricity Company Ltd. (NEVLEC), a vertically integrated and state-owned electricity utility, has an exclusive license to provide electricity in Nevis. Nevis has coverage of 95 percent. In 2015, NEVLEC owned 13.4 MW of generation capacity and the island had a peak demand of 10.4 MW.[312]

The Electricity Ordinance of 1998 establishes the structure of the electricity sector in Nevis. There is no independent regulator. The Ministry of Housing, Public Works, Energy, and Public Utilities ("the Ministry of Housing") is responsible for oversight of public utilities at the national level, which includes overseeing NEVLEC.[313] The Ministry of Finance, Sustainable Development, and Human Resource Development ("the Ministry of Finance") is responsible for developing energy policies that apply to the Federation.[314] In 2011, the Government of Saint Kitts and Nevis drafted the Draft National Energy Policy and the Draft National Energy Action Plan. In 2014 these documents were revised with support of the European Union, but they have yet to be approved.

14.1.1 The electricity market in Nevis

In Nevis, NEVLEC is the sole, vertically integrated provider of electricity services. In 2015, NEVLEC's total installed capacity was 13.4 MW, which is more than enough to meet peak demand of 10.4 MW.[315] Diesel plants accounted for approximately 85 percent of total generation; the remaining 15 percent came from a wind farm.[316] In 2013, NEVLEC supplied electricity to 6,893 customers; 53 percent of demand was commercial, 35 percent was domestic, and 11 percent was from governmental offices.[317]

NEVLEC does not publish comprehensive information on its operating or financial performance. However, publicly available information suggests that NEVLEC performs inefficiently. NEVLEC's transmission and distribution losses exceed 20 percent in 2015 and tariffs are not at cost-recovery levels.[318]

312. National Renewable Energy Laboratory, "Energy Snapshot: The Federation of Saint Christopher and Nevis," *Energy Transition Initiative, Islands* (March 2015, DOE/GO-102015-4581), accessed August 5, 2015, http://www.nrel.gov/docs/fy15osti/62706.pdf.

313. Cedric Wilson, "Baseline Study of Energy Policies and Legislation in Selected Caribbean Countries" (2009).

314. Herbert Samuel, "A Review of the Status of the Interconnection of Distributed Renewables to the Grid in CARICOM Countries" (October 2013), accessed November 17, 2014, http://www.credp.org/Data/CREDP-GIZ_Interconnection_Report_Final_Oct_2013.pdf.

315. National Renewable Energy Laboratory, "Energy Snapshot: The Federation of Saint Christopher and Nevis," *Energy Transition Initiative, Islands* (March 2015, DOE/GO-102015-4581), accessed August 5, 2015, http://www.nrel.gov/docs/fy15osti/62706.pdf.

316. Cartwright Farrell (NEVLEC), "Nevis Geothermal Project and Power Take-Off Presentation" (2012).

317. NEVLEC General Manager, email message to Scarlett Santana, November 5, 2014.

318. National Renewable Energy Laboratory, "Energy Snapshot: The Federation of Saint Christopher and Nevis," *Energy Transition Initiative, Islands* (March 2015, DOE/GO-102015-4581), accessed August 5, 2015, http://www.nrel.gov/docs/fy15osti/62706.pdf; Cedric Wilson, "Baseline Study of Energy Policies and Legislation in Selected Caribbean Countries" (2009).

14.1.2 Key laws, regulations, and policies governing the sector

The electricity sector in Nevis is governed by the Electricity Ordinance of 1998. The Electricity Ordinance only applies to Nevis, not to Saint Kitts. The Electricity Ordinance grants NEVLEC an exclusive license to transmit, distribute, and supply electricity in Nevis. In addition, the government drafted, but has not approved, the Draft Energy Policy and the Draft Energy Action Plan. These documents were created at the federal level and apply to both Saint Kitts and Nevis. They outline the government's objectives and plan for increasing the supply of electricity from renewable generation and improving the efficiency of the electricity sectors in Saint Kitts and Nevis.

Policies in the energy sector

The government prepared the Draft Energy Policy and the Draft Energy Action plan for the Federation. These documents present the government's vision of more affordable, more reliable, and less-polluting energy sectors in Saint Kitts and Nevis. However, the government has not yet approved the Draft Energy Policy or the Draft Energy Action Plan.

The Draft Energy Policy includes the following objectives:

- Exploring alternative energy sources, particularly renewable energy, to decrease dependence on imported oil
- Interconnecting the electricity grids of Saint Kitts and Nevis, and interconnecting the Federation with other neighboring countries
- Improving the efficiency of power production, transmission, and distribution

The Draft Energy Action Plan complements the Draft Energy Policy and identifies the steps for achieving the objectives. However, the actions identified in the Draft Energy Action Plan of 2011 were vague and did not have timelines. In 2014, the European Union supported the government in revising the Draft Energy Policy and Draft Energy Action. These new versions of the documents have not been published nor approved.

Laws and regulations governing the electricity sector

The Electricity Ordinance governs the electricity sector in Nevis. It grants NEVLEC an exclusive license to transmit and distribute electricity.[319] NEVLEC's license does not have an expiration date.[320] The Electricity Ordinance does not establish a tariff-setting mechanism, but mandates that fair and reasonable rates be used. The Public Utilities Commission (PUC) was given the authority of setting and adjusting tariffs,[321] but because the PUC has not been appointed, NEVLEC sets its own tariffs.[322]

In addition, the Electricity Ordinance allows for private individuals or companies to generate electricity for their own consumption from wind and solar in Nevis.[323] The Electricity Ordinance also allows for IPPs to operate in the sector if they obtain a license from the Ministry of Housing. However, the legislation does not establish a process for obtaining a license.[324]

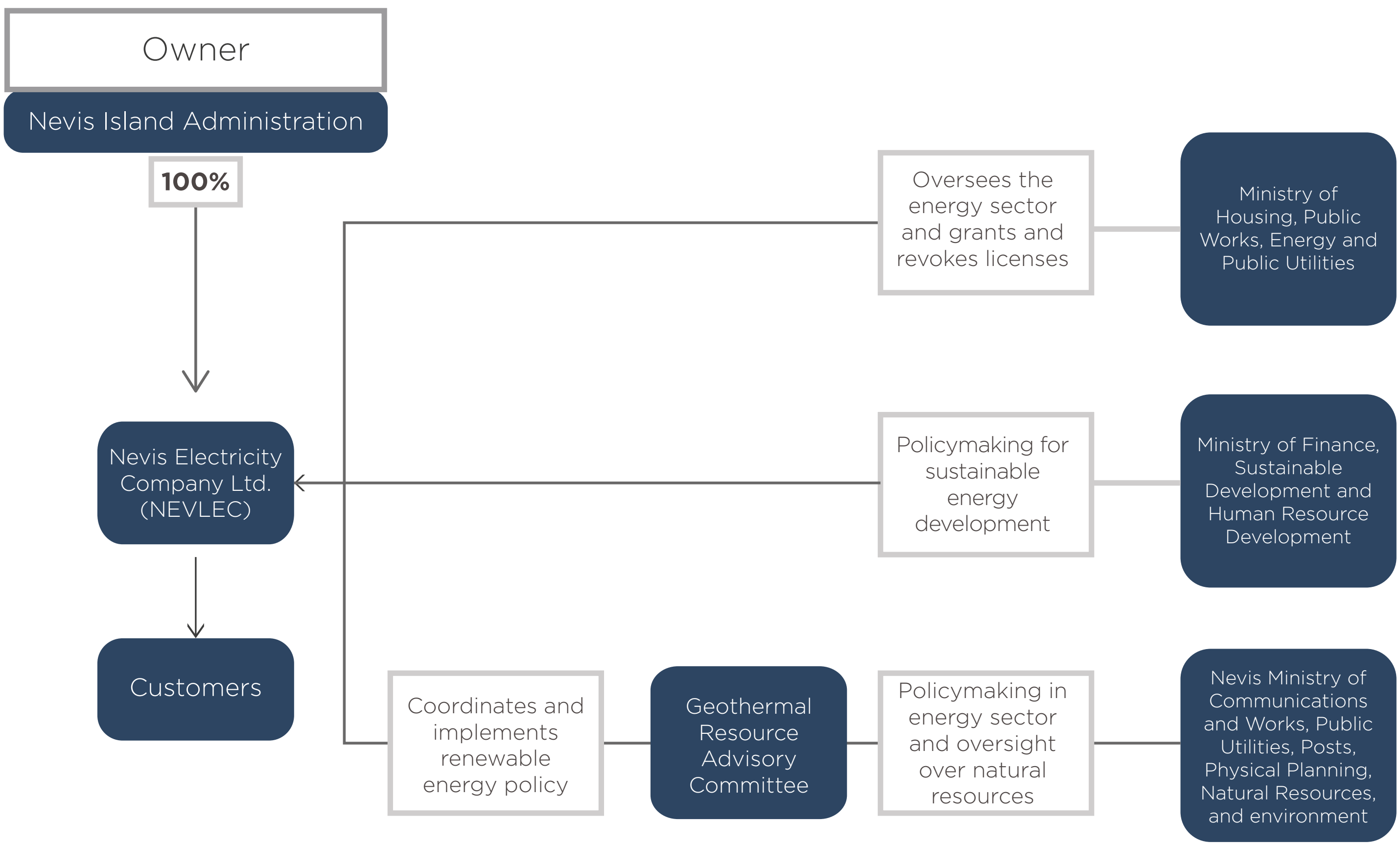
The legal and regulatory framework of the electricity sector is further developed by the Public Utilities Commission Act of 1992 ("the PUC Act") and the Geothermal Resources Development Ordinance of 2008. The government developed the PUC Act for the Federation. It mandates the establishment of the PUC to regulate the electricity sectors in Saint Kitts and Nevis; however, as mentioned previously, the PUC has not been appointed. The NIA developed the Geothermal Resources Development Ordinance of 2008 for the island of Nevis. The Geothermal

Ordinance defines what a geothermal resource is and establishes the legal framework for exploring and exploiting geothermal resources in Nevis.[325] The Geothermal Ordinance also establishes the Geothermal Resources Advisory Committee, which is led by the minister responsible for natural resources, to develop and implement renewable energy policies in Nevis.[326]

14.1.3 Institutional structure of the electricity sector

Nevis Electricity Company Ltd. (NEVLEC), a vertically integrated and state-owned electricity utility, is the sole provider of electricity in Nevis. NEVLEC is overseen by the Ministry of Housing. The Ministry of Finance is responsible for formulating energy policies for sustainable development at the national level.[327] **Figure 14.1** presents the relationships between the key entities in the Nevis electricity sector.

FIGURE 14.1 Key Entities in the Nevis Electricity Sector



325. "Landmark Geothermal Development Ordinance Passes in NIA," *WINN FM 98.9*, July 11, 2008, accessed November 5, 20134, http://stkittsweb.com/winnfm/winnfm/www.winnfm.com/news275a1.html?NewsID=2503.

326. National Renewable Energy Laboratory and Organization of American States, "Energy Policy and Sector Analysis in the Caribbean 2010–2011," accessed October 31, 2014, http://www.ecpamericas.org/data/files/Initiatives/lccc_caribbean/LCCC_Report_Final_May2012.pdf.

327. Herbert Samuel, "A Review of the Status of the Interconnection of Distributed Renewables to the Grid in CARICOM Countries" (October 2013), accessed November 17, 2014, http://www.credp.org/Data/CREDP-GIZ_Interconnection_Report_Final_Oct_2013.pdf.

Below we provide a more in-depth description of the bodies with major responsibilities in the electricity sector.

- **Policymaking**—There are two ministries responsible for developing policies in the energy sector.
  - The Ministry of Finance is responsible for developing sustainable energy policies.[328]
  - The Nevis Ministry of Communications and Works, Public Utilities, Posts, Physical Planning, Natural Resources, and Environment ("the Nevis Ministry of Natural Resources") is responsible for developing environmental policies and overseeing the use of natural resources.[329] The Geothermal Resource Advisory Committee, headed by the minister responsible for natural resources, coordinates and implements renewable energy policies related to geothermal resources.[330]
- **Regulation**—The PUC Act mandates that the PUC be established as an independent regulator. However, the PUC has not been appointed. Instead, the Ministry of Housing carries out some regulatory functions. The Ministry of Housing is responsible for overseeing NEVLEC and has the power at the national level to grant and revoke electricity licenses to generate, transmit, and distribute electricity.[331]
- **Generation, Transmission, and Distribution**—NEVLEC, a wholly state-owned enterprise, holds the exclusive license to transmit and distribute electricity. This license does not have an expiration date. IPPs can operate in Nevis, but they must sell their electricity to NEVLEC.[332] Currently one IPP operates in Nevis, which produces wind power.[333]

14.2 Overview of the Electricity Sector in Saint Kitts

The Saint Kitts Electricity Company Limited (SKELEC), a vertically integrated state-owned electricity utility, holds an exclusive license to provide electricity in Saint Kitts. Saint Kitts has coverage of 95 percent.[334] In 2015, SKELEC owned 43 MW of generation capacity, and had a peak demand of 24 MW.[335]

The Electricity Supply Act of 2011 establishes the structure of and regulates the electricity sector in Saint Kitts. There is no independent regulator. The Ministry of Housing is responsible for the oversight of public utilities at the national level. The Ministry of Finance is responsible for developing energy policies that apply to the Federation.[336] The government has drafted, but not approved, a Draft National Energy Policy and a Draft National Energy Action Plan. These documents outline the government's objectives of increasing the use of renewable energy and improving the efficiency of electric utilities in the Federation.

328. Ibid.

329. Nevis Island Administration, "Physical Planning: About," February 19, 2014, accessed October 31, 2014, http://www.nia.gov.kn/index.php/ministries/communications/physical-planning.

330. National Renewable Energy Laboratory and Organization of American States, "Energy Policy and Sector Analysis in the Caribbean 2010–2011," accessed October 31, 2014, http://www.ecpamericas.org/data/files/Initiatives/lccc_caribbean/LCCC_Report_Final_May2012.pdf.

331. Herbert Samuel, "A Review of the Status of the Interconnection of Distributed Renewables to the Grid in CARICOM Countries" (October 2013), accessed November 17, 2014, http://www.credp.org/Data/CREDP-GIZ_Interconnection_Report_Final_Oct_2013.pdf.

332. National Renewable Energy Laboratory and Organization of American States, "Energy Policy and Sector Analysis in the Caribbean 2010–2011," accessed October 31, 2014, http://www.ecpamericas.org/data/files/Initiatives/lccc_caribbean/LCCC_Report_Final_May2012.pdf.

333. Herbert Samuel, "A Review of the Status of the Interconnection of Distributed Renewables to the Grid in CARICOM Countries" (October 2013), accessed November 17, 2014, http://www.credp.org/Data/CREDP-GIZ_Interconnection_Report_Final_Oct_2013.pdf.

334. REEGLE, "Policy and Regulatory Overviews: Saint Kitts and Nevis (2012)," accessed November 5, 2014, http://www.reegle.info/policy-and-regulatory-overviews/KN.

335. National Renewable Energy Laboratory, *"Energy Snapshot: The Federation of Saint Christopher and Nevis,"* Energy Transition Initiative, Islands (March 2015, DOE/GO-102015-4581), accessed August 5, 2015, http://www.nrel.gov/docs/fy15osti/62706.pdf.

336. Herbert Samuel, "A Review of the Status of the Interconnection of Distributed Renewables to the Grid in CARICOM Countries" (October 2013), accessed November 17, 2014, http://www.credp.org/Data/CREDP-GIZ_Interconnection_Report_Final_Oct_2013.pdf.

14.2.1 The electricity market in Saint Kitts

In Saint Kitts, SKELEC is the sole, vertically integrated provider of electricity services. SKELEC's total installed capacity was 43 MW in 2015, which is more than enough to meet peak demand of 24 MW.[337] In 2013, diesel plants accounted for all of Saint Kitts' installed capacity.[338] SKELEC serves 16,000 residential customers and 1,800 commercial customers. In 2012, consumers on Saint Kitts purchased 123GWh of electricity.[339]

SKELEC does not publish information on its operating or financial performance. However, publicly available information suggests that SKELEC performs inefficiently. Transmission and distribution losses were 17 percent in 2015.[340] Residents complain of frequent blackouts[341] and SKELEC's system losses are estimated at 17 percent.[342] The World Bank's Enterprise Survey shows that firms experience an average of 4.2 electrical outages per month.[343] Because of the lack of publicly available information, SKELEC's accountability to the public for service quality and financial performance is limited.

14.2.2 Key laws, regulations, and policies governing the sector

The electricity sector in Saint Kitts is governed by the ESA. The ESA corporatized the Saint Kitts Electricity Department. It also laid the legal framework to grant SKELEC an exclusive license to transmit, distribute, and supply electricity in Saint Kitts for 25 years. In addition, the government drafted, but has not approved, the Draft Energy Policy and the Draft Energy Action Plan. These documents were created at the federal level and apply to both Saint Kitts and Nevis. The energy sector policies outline the government's objectives and plan for increasing the supply of electricity from renewable generation and improving the efficiency of the electricity sectors in Saint Kitts and Nevis.

Policies in the energy sector

The government prepared the Draft Energy Policy and the Draft Energy Action plan for the Federation in 2011. The government plans to update these documents to allow for distributed generation.[344] These documents present the government's vision of more affordable, more reliable, and less-polluting energy sectors in Saint Kitts and Nevis. However, the government has not yet approved the Draft Energy Policy or the Draft Energy Action Plan.

The revised version of the Draft Energy Policy has not been made publicly available. However, the 2011 version includes the following objectives:[345]

- Exploring alternative energy sources, particularly renewable energy, to decrease dependence on imported oil
- Interconnecting the electricity grids of Saint Kitts and Nevis, and interconnecting the Federation with other neighboring countries
- Improving the efficiency of power production, transmission, and distribution

---

337. National Renewable Energy Laboratory, *"Energy Snapshot: The Federation of Saint Christopher and Nevis,"* Energy Transition Initiative, Islands (March 2015, DOE/GO-102015-4581), accessed August 5, 2015, http://www.nrel.gov/docs/fy15osti/62706.pdf.

338. SKELEC, "Request for Proposal: SKELEC's Renewable Energy Infusion Study" (2013).

339. SKELEC, "Request for Proposal: SKELEC's Tariff Study" (2013).

340. National Renewable Energy Laboratory, *"Energy Snapshot: The Federation of Saint Christopher and Nevis,"* Energy Transition Initiative, Islands (March 2015, DOE/GO-102015-4581), accessed August 5, 2015, http://www.nrel.gov/docs/fy15osti/62706.pdf.

341. Jenise Ferlance, "SKELEC Explains Electricity Outages," *SKNVibes.com,* September 22, 2012, accessed September 25, 2013, http://www.sknvibes.com/news/newsdetails.cfm/63604.

342. Government of Saint Kitts and Nevis, "Draft National Energy Policy and Action Plan," 2010.

343. World Bank, "Enterprise Surveys: St. Kitts and Nevis (2010)," accessed July 21, 2013, http://www.enterprisesurveys.org/Data/ExploreEconomies/2010/st-kitts-and-nevis#infrastructure.

344. The Government of Saint Kitts and Nevis and the European Union, "11th EDF: National Indicative Programme 2014–2020," September 2, 2014, accessed December 4, 2015, https://ec.europa.eu/europeaid/sites/devco/files/nip-edf11-st-kitts-navis-2014-2020_en.pdf.

345. Government of Saint Kitts and Nevis, "National Energy Policy: St. Kitts and Nevis," April 25, 2011, accessed May 20, 2016, http://www.oas.org/en/sedi/dsd/Energy/Doc/NationalEnergyPolicyStKittsandNevis.pdf.

The Draft Energy Action Plan complements the Draft Energy Policy and defines steps for achieving these objectives.

Laws and regulations governing the electricity sector

The government developed the Electricity Supply Act of 2011 for the island of Saint Kitts. In 2014, the government, with support from the European Union, updated the ESA. However, the revised version has not been made publicly available nor is there evidence to suggest that it has been approved. Further revisions of the ESA may be necessary once geothermal power comes online.

The ESA governs and establishes the structure of the electricity sector in Saint Kitts. It does so by vesting all of the Saint Kitts Electricity Department's assets and liabilities to SKELEC. The ESA also laid the legal framework to allow the Ministry of Housing to grant SKELEC an exclusive license to transmit, distribute, and supply electricity in Saint Kitts for 25 years. In 2011, the government granted SKELEC its license. The ESA allows IPPs to operate in Saint Kitts by obtaining a license from the Ministry of Housing. However, the ESA does not establish the process that IPPs should follow to obtain a license.[346]

The ESA does not establish a tariff-setting mechanism, but instead, stipulates that the Public Utilities Commission (PUC) is responsible for reviewing and setting tariffs.[347] However, the PUC has yet to be appointed. The governor general is responsible for setting tariffs and can adjust the tariff at his discretion by issuing regulations. These regulations must be approved by National Assembly to come into effect.[348] The ESA does not establish a formula for calculating tariffs, does not set a minimum rate of return, and does not establish criteria that the National Assembly should use to evaluate proposed tariff adjustments.[349]

Another key law governing the electricity sector is the Public Utilities Commission Act of 1992 ("the PUC Act"). The government developed the PUC Act for the Federation. It mandates the establishment of the PUC to regulate the electricity sectors in Saint Kitts and Nevis. However, as mentioned previously, the PUC has not been appointed.

346. The Government of Saint Kitts and Nevis, "Saint Cristopher (Electricity Supply) Bill, 2011," accessed November 14, 2014, https://groups.google.com/forum/#!topic/sknfus/YceWobynQrk.

347. Ibid.

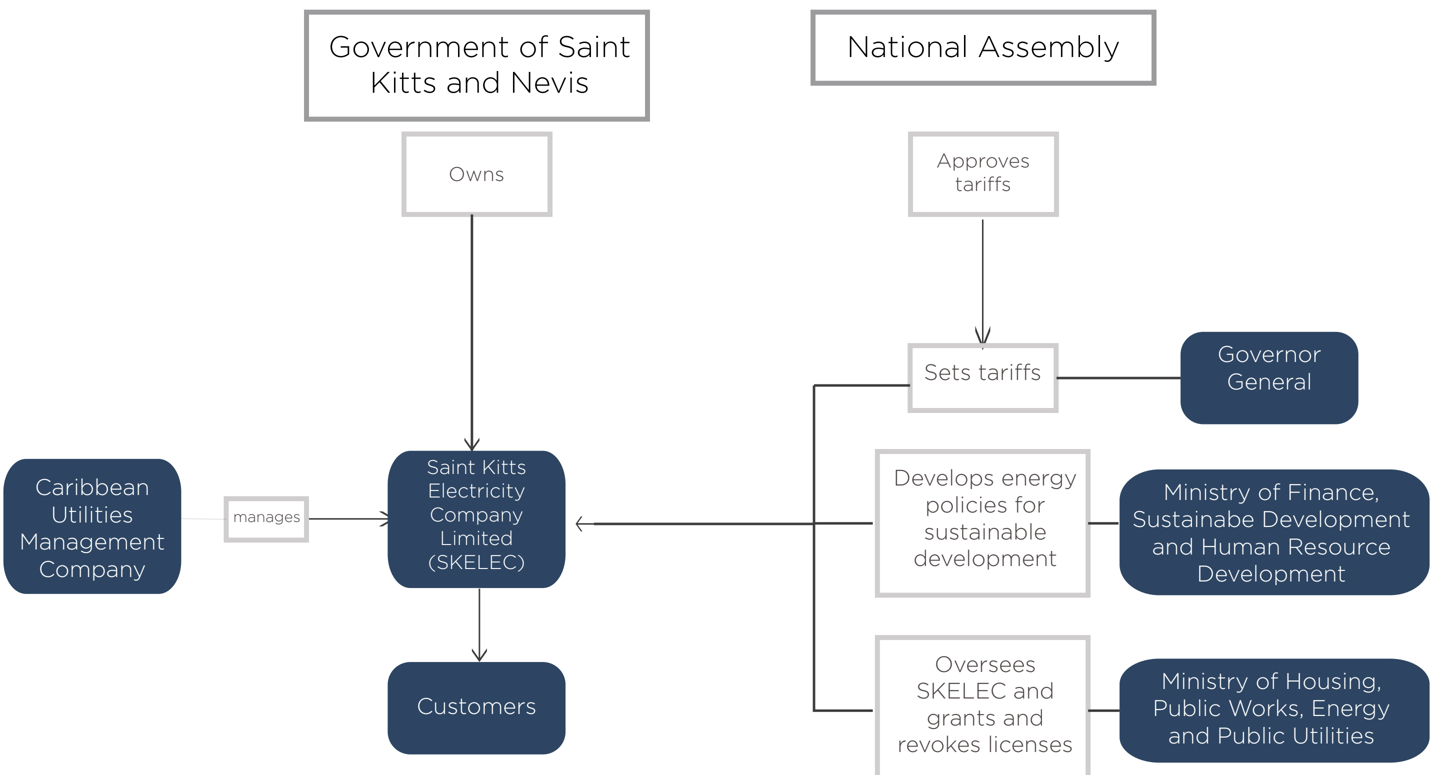
348. World Bank, "Project Appraisal Document… in Support of the First Phase of the Eastern Caribbean Energy Regulatory Authority Program," Report No: 51576-LAC, May 16, 2011, accessed November 17, 2014, http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2011/05/30/000356161_20110530015337/Rendered/PDF/515760PAD0P1010e0only0900BOX358362B.pdf.

349. The Government of Saint Kitts and Nevis, "Saint Cristopher (Electricity Supply) Bill, 2011," accessed November 14, 2014, https://groups.google.com/forum/#!topic/sknfus/YceWobynQrk.

14.2.3 Institutional structure of the electricity sector

SKELEC, a vertically integrated state-owned electricity utility, is the sole provider of electricity in Saint Kitts. SKELEC is overseen by the Ministry of Housing, Public Works, Energy, and Public Utilities ("the Ministry of Housing") of the Federation. The Ministry of Finance, Sustainable Development, and Human Resource Development ("the Ministry of Finance") is responsible for developing sustainable energy policies at a national level. **Figure 14.2** presents the relationships between the key entities in the Saint Kitts electricity sector.

FIGURE 14.2 Key Entities in the Saint Kitts Electricity Sector



Below we provide a more in-depth description of the major responsibilities in the electricity sector and the bodies responsible for carrying them out.

- **Policymaking**—The Ministry of Finance is responsible for developing energy policies to ensure the sustainable development of the Federation.[350]
- **Regulation**—The PUC Act mandates that the PUC be established as an independent regulator. The ESA further develops the responsibilities of the PUC. It stipulates that the PUC is responsible for reviewing and setting tariffs, and establishing and monitoring SKELEC's standards of service.[351] However, the PUC has not been appointed. Instead, regulatory functions are spread across the following government agencies:

350. Herbert Samuel, "A Review of the Status of the Interconnection of Distributed Renewables to the Grid in CARICOM Countries" (October 2013), accessed November 17, 2014, http://www.credp.org/Data/CREDP-GIZ_Interconnection_Report_Final_Oct_2013.pdf.

351. The Government of Saint Kitts and Nevis, "Saint Cristopher (Electricity Supply) Bill, 2011," accessed November 14, 2014, https://groups.google.com/forum/#!topic/sknfus/YceWobynQrk.

- The Ministry of Housing has the authority to grant and revoke licenses to generate, transmit, and distribute electricity. The Ministry of Housing is a ministry of the federal government, and is responsible for overseeing SKELEC and NEVLEC.
- The governor general of the Federation sets tariffs, subject to the approval of the National Assembly.[352]

- **Generation, Transmission, and Distribution**—SKELEC, a wholly state-owned enterprise, holds the exclusive license to transmit and distribute electricity in Saint Kitts for 25 years.[353] The Caribbean Utilities Management Company has a contract to manage SKELEC until 2014. The government has expressed its intention to take over SKELEC's management once the contract with the Caribbean Utilities Management Company expires.

14.3 Status of Geothermal Development

The Federation has made significant progress for Phase 1 of the project, but less so for Phase 2. Slim-hole wells were drilled in Nevis and conservative estimations suggest an estimated potential of upwards of 30 MW.[355] In Saint Kitts, geothermal development has not advanced beyond early surface exploration. Results suggest a lower-quality resource that would be expensive to develop.[356] Still, conservative estimates of Nevis's estimated geothermal potential suggest the resource is large enough to cover the Federation's projected demand of 31 MW in 2023. As such, the NIA is currently working to develop the geothermal resource in Nevis.

The NIA has signed the concession agreement and a PPA for Phase 1. The NIA would also need to finalize the lease to authorize access to the exploration lands. Exploratory drilling should begin soon and the NIA expects the plant to come online by the end of 2018.[357] The government and the NIA's next steps for Phase 2 include carrying out feasibility studies, finding a project developer, and completing the project agreements.

352. World Bank, "Project Appraisal Document… in Support of the First Phase of the Eastern Caribbean Energy Regulatory Authority Program," Report No: 51576-LAC, May 16, 2011, accessed November 17, 2014, http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2011/05/30/000356161_20110530015337/Rendered/PDF/515760PAD0P1010e0only0900BOX358362B.pdf.

353. The Government of Saint Kitts and Nevis, "Saint Cristopher (Electricity Supply) Bill, 2011," accessed November 14, 2014, https://groups.google.com/forum/#!topic/sknfus/YceWobynQrk.

354. Government of Saint Kitts and Nevis, "SKELEC Company Website," accessed October 31, 2014, http://www.skelec.kn/component/content/category/87-electricity-documents.html.

355. Nevis Island Administration, "NIA, NEVLEC and NREI Sign Geothermal Power Purchase Agreement," November 26, 2015, accessed December 4, 2015, http://www.nia.gov.kn/index.php/news-4/news-articles-3/2538-nia-nevlec-and-nrei-sign-geothermal-power-purchase-agreement.

356. Gerald Huttrer, "2010 Country Update for Eastern Caribbean Island Nations," April 2010.

357. Nevis Island Administration, "NIA, NEVLEC and NREI Sign Geothermal Power Purchase Agreement," November 26, 2015, accessed December 4, 2015, http://www.nia.gov.kn/index.php/news-4/news-articles-3/2538-nia-nevlec-and-nrei-sign-geothermal-power-purchase-agreement.

14.3.1 Resource potential and development

The geothermal resource has been further explored in Nevis than it has been in Saint Kitts. In Spring Hill, Nevis, West Indies Power drilled slim-hole wells during 2008 that suggest an estimated potential of 500 MW.[358] However, full-size wells have not been drilled to confirm the size of the resource, and more conservative estimations suggest an estimated potential of upwards of 50–60 MW.[359] West Indies Power invested approximately US$14 million to carry out surface exploration and drill slim-hole wells.[360] To date, the NIA has not invested any funds in the project.[361] Despite some evidence of geothermal potential on Saint Kitts, surface studies suggest that it is of lower quality than the resource in Nevis and therefore it would be more time consuming and expensive to develop.[362] However, the government plans to continue surface exploration in Saint Kitts with support from the Clinton Foundation.[363] This support is one part of a technical assistance program that also aims to expand other renewable energy technologies.

14.3.2 Planned project

The NIA has indicated interest in a two-phase plan to develop geothermal resources in Nevis.[364] Phase 1 would build a 9 MW geothermal power plant to meet demand in Nevis. Phase 2 would build a 40–50 MW geothermal power plant to export electricity to Saint Kitts (or neighboring islands). Figure 14.3 presents the status of Phase 1 and Phase 2 of the geothermal project. The NIA has advanced significantly in Phase 1, but has made less progress for Phase 2.

358. Jonathan Kelly and Anelda Maynard-Date, "Geothermal Explorations and Development in Nevis" (Central America Geothermal Workshop in Santa Tecla, El Salvador, October 30, 2009). The World Bank estimates the geothermal potential in Saint Kitts and Nevis to be around 25 MW.

359. Nevis Island Administration, "NIA, NEVLEC and NREI Sign Geothermal Power Purchase Agreement," November 26, 2015, accessed December 4, 2015, http://www.nia.gov.kn/index.php/news-4/news-articles-3/2538-nia-nevlec-and-nrei-sign-geothermal-power-purchase-agreement.

360. Nevis Island Administration, "Delays Over, Declares Nevis Geothermal Developer's CEO McDonald," November 17, 2010, accessed November 11, 2014, http://www.nia.gov.kn/index.php/news-4/news-articles-3/500-delays-over-declares-nevis-geothermal-developers-ceo-mcdonald.

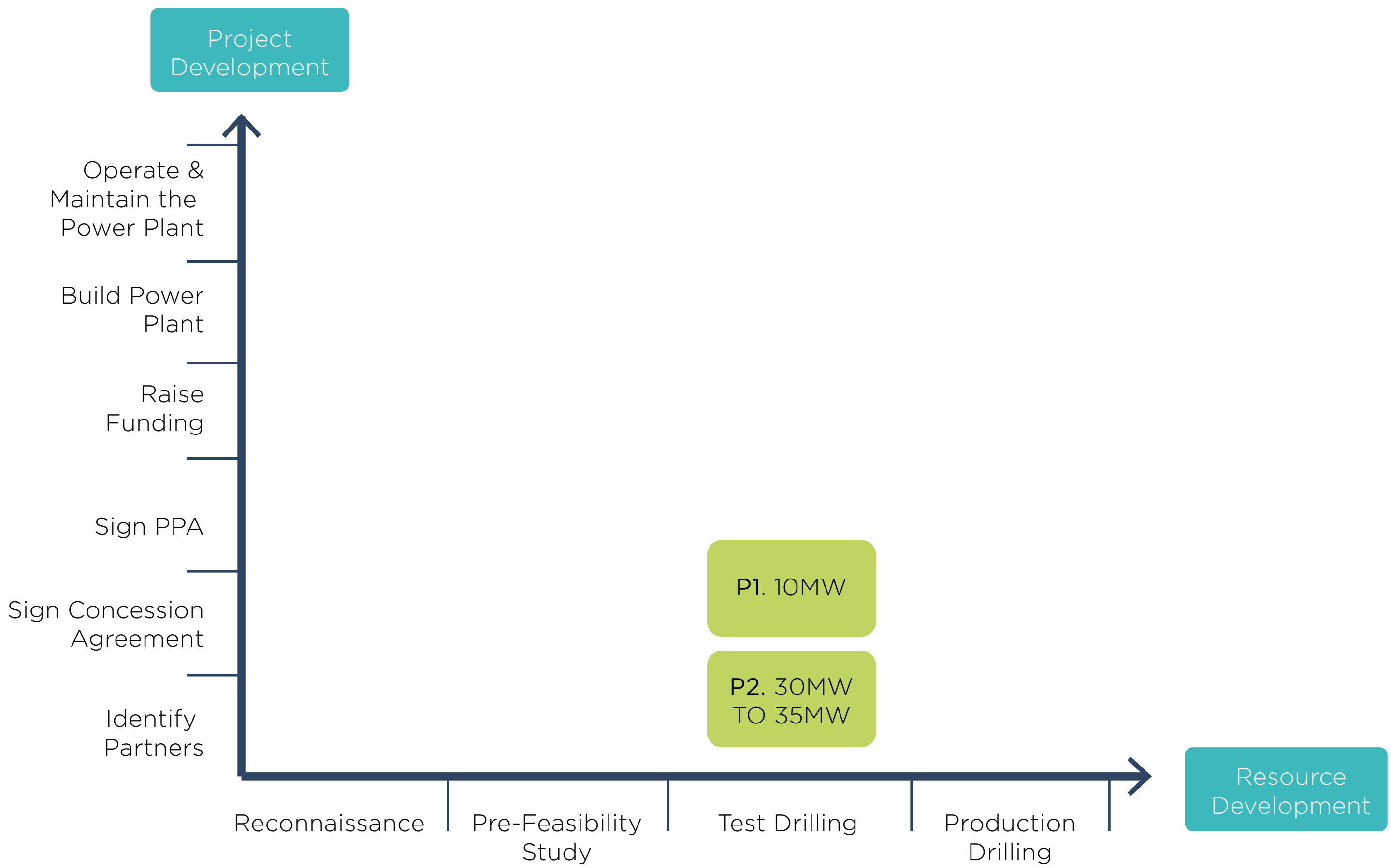
361. Government of Saint Kitts and Nevis, "Geothermal Development on Saint Kitts and Nevis" (Costa Rica Study Tour: March 2014).

362. Gerald Huttrer, "2010 Country Update for Eastern Caribbean Island Nations," April 2010.

363. "St Kitts Gets Help to Develop Alternative Forms of Energy," *Jamaica Observer*, April 23, 2014, accessed October 23, 2014, http://www.jamaicaobserver.com/News/St-Kitts-gets-help-to-develop-alternative-forms-of-energy_16505767.

364. Nevis Island Administration, "NIA, NEVLEC and NREI Sign Geothermal Power Purchase Agreement," November 26, 2015, accessed December 4, 2015, http://www.nia.gov.kn/index.php/news-4/news-articles-3/2538-nia-nevlec-and-nrei-sign-geothermal-power-purchase-agreement.

FIGURE 14.3 Status of Planned Geothermal Project



Phase 1: 10 MW power plant to meet demand in Nevis

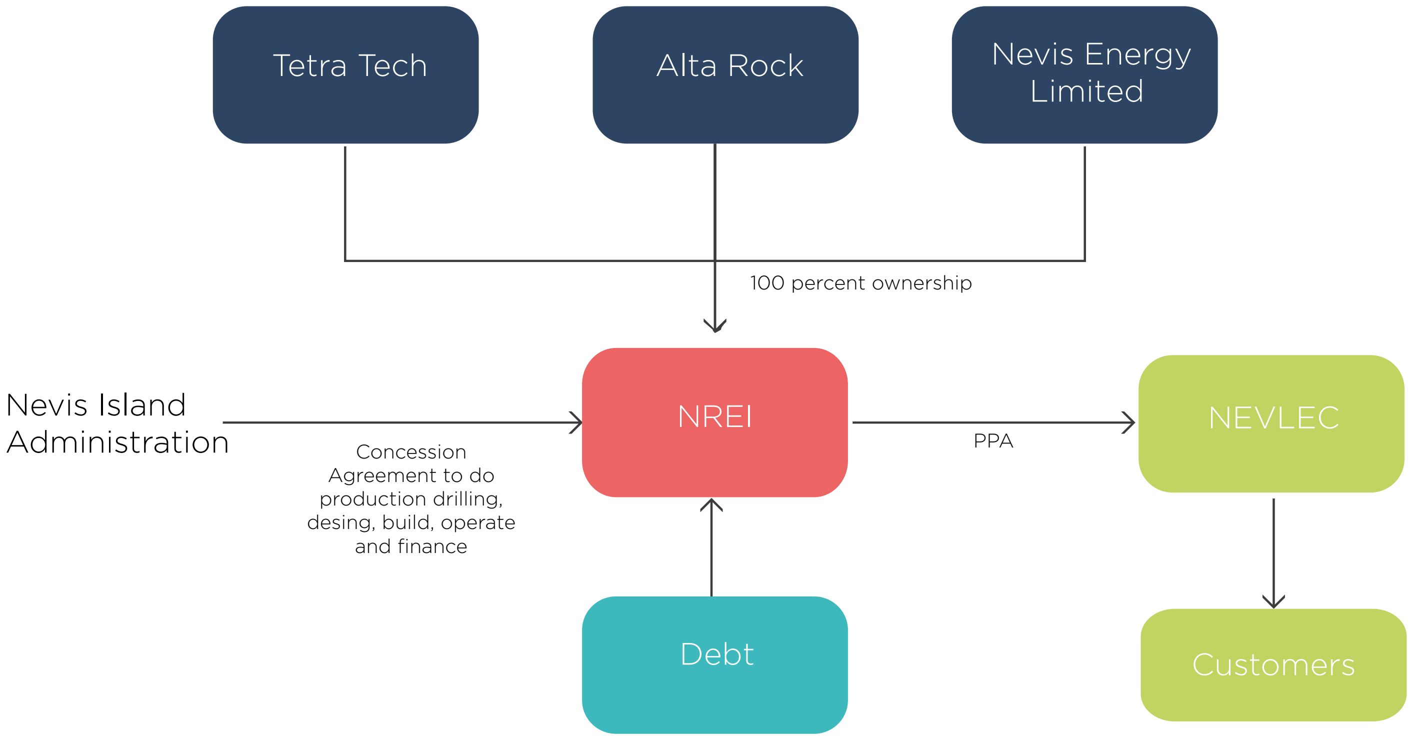
The NIA has made significant progress in Phase 1 of the project. In September 2014, the NIA signed a concession agreement with Nevis International for the exploration, production well drilling, and construction and operation of a 10 MW geothermal power plant.[365] In November 2015, NIA, NEVLEC, and Nevis International signed a 25-year PPA that will supply 9 MW of geothermal power.[366] This will nearly meet Nevis's peak demand of 10.4 MW.[367] **Figure 14.4** presents the structure of the planned project.

365. "Nevis Island Administration (NIA) and Nevis Renewable Energy International, Inc. (NREI) Sign Geothermal Concession Agreement," *Nevis Pages,* September 3, 2014, accessed November 12, 2014, http://www.nevispages.com/nevis-island-administration-nia-and-nevis-renewable-energy-international-inc-nrei-sign-geothermal-concession-agreement/.

366. Nevis Island Administration, "NIA, NEVLEC and NREI Sign Geothermal Power Purchase Agreement," November 26, 2015, accessed December 4, 2015, http://www.nia.gov.kn/index.php/news-4/news-articles-3/2538-nia-nevlec-and-nrei-sign-geothermal-power-purchase-agreement.

367. National Renewable Energy Laboratory, "Energy Snapshot: The Federation of Saint Christopher and Nevis," *Energy Transition Initiative, Islands* (March 2015, DOE/GO-102015-4581), accessed August 5, 2015, http://www.nrel.gov/docs/fy15osti/62706.pdf.

FIGURE 14.4 Planned Structure of the Geothermal Project



Sources: Nevis Pages. "Nevis Island Administration and Nevis Renewable Energy International, Inc. Sign Geothermal Concession Agreement." 3 September 2014. http://www.nevispages.com/nevis-island-administration-nia-and-nevis-renewable-energy-international-inc-nrei-sign-geothermal-concession-agreement/. (accessed on 12 November 2014); ThinkGeoenergy. "Nevis Choosing American Consortium for Geothermal Project." 21 November 2013. http://thinkgeoenergy.com/archives/17213 (accessed on 12 November 2014).

Two agreements have been signed to date: the concession agreement and a PPA. The concession agreement is to explore and exploit the geothermal resource and finance, build, and operate the power plant. Nevis International is a US consortium of private individuals and private firms established with support from the US State Department.[368] The private firms include two US-based firms (Tetra Tech and Alta Rock) and a Nevis-based firm (Nevis Energy Limited).[369] NEVLEC is the project off-taker and would purchase all the electricity generated by the project under the PPA contract.

Nevis International has not published its cost estimates for the project, and cost estimates from other sources vary. Preliminary estimates suggest that developing a 10 MW geothermal power plant in Nevis could cost about US$80 million.[370] These estimates include exploration and production drilling and power plant construction costs. The construction of transmission lines and access roads would increase the total cost to about US$96 million. On the other hand, West Japan Engineering Consultants, Inc. estimated the average cost of building a 20 MW power plant, not including production drilling, to be about US$40 million. Their cost estimate increases to approximately US$125 million when the costs for production drilling, physical contingencies, consultant fees, and administrative expenses are included.

368. "Nevis Not Giving Up on Geothermal," *ThinkGeoenergy,* May 22, 2015, accessed December 8, 2015, http://www.thinkgeoenergy.com/nevis-not-giving-up-on-geothermal/.

369. "Nevis Choosing American Consortium for Geothermal Project," *ThinkGeoEnergy*, November 21, 2013, accessed November 12, 2014, http://www.thinkgeoenergy.com/nevis-choosing-american-consortium-for-geothermal-project/.

370. Financial model that accompanies this report, based on information from: Magnus Gehringer and Victor Loksha, *Geothermal Handbook: Planning and Financing Power Generation* (Washington, DC: The International Bank for Reconstruction and Development, Technical Report 002/12, June 2012), accessed October 22, 2014, http://www.esmap.org/sites/esmap.org/files/DocumentLibrary/FINAL_Geothermal%20Handbook_TR002-12_Reduced.pdf; IDB, "Sustainable Energy Facility (SEF) for the Eastern Caribbean: Loan Proposal RG-L1071, RG-G1009, and RG-G1004" (2015), accessed December 2, 2015, http://www.iadb.org/en/projects/project-description-title,1303.html?id=RG-L1071.

Originally, the NIA partnered with West Indies Power, a private company based in the Netherlands Antilles, to develop the project. The two parties signed a geothermal exploration contract in 2006 to carry out exploratory drilling in Nevis.[371] In 2009, West Indies Power signed a PPA with NEVLEC. The project was to be financed by the Bank of Nova Scotia, with a US$30 million guarantee from the Export-Import Bank of the United States.[372] However, West Indies Power did not begin exploration and production drilling and construction in 2011, and did not follow the schedule agreed to with the NIA. The NIA cancelled its contract with West Indies Power because it alleged that West Indies Power did not have the financial resources to continue developing the project.[373] In 2013, West Indies Power disputed the decision by the NIA in court.[374] However, in 2014 the court ruled in favor of the NIA and disregarded West Indies Power's appeal.[375]

The next step is to finalize the lease to grant Nevis International access to the exploration lands. Exploratory drilling should begin soon and the NIA expects the plant to come online by the end of 2018.[376]

Phase 2: 30–35 MW power plant to meet demand in Saint Kitts

Phase 2 would build a second power plant in Nevis to provide electricity in Saint Kitts. The generation capacity of this plant would meet Saint Kitts' baseload demand of 24 MW.[377] The project will include production well drilling, construction of an undersea interconnection cable, and construction and operation of the power plant. Neither the government nor NIA has published an estimated completion date, nor defined a structure for financing, building, and operating the project. Nevis International, the project developer for Phase 1, has not yet expressed interest in developing the second power plant. Nonetheless, the government has previously stated that it expects construction to begin in 2017.[378] The government completed a study that identified three potential routes to supply electricity from Nevis to Saint Kitts.

Neither the government nor the NIA have published cost estimates for the project. Preliminary estimates suggest that developing a 35 MW power plant and building an undersea interconnection cable to supply electricity to Saint Kitts could cost between US$114 million and US$168 million.[379] These cost estimates include

371. Kerry McDonald, "Federation of Saint Kitts and Nevis: First Geothermal Powered Nation in the World" (West Indies Power, 2011), accessed September 26, 2013, http://ciemades.org/pdfs/conf11/may6/Nevis-Geothermal_K_MacDonald.pdf.

372. National Renewable Energy Laboratory and Organization of American States, "Energy Policy and Sector Analysis in the Caribbean 2010–2011," accessed October 31, 2014, http://www.ecpamericas.org/data/files/Initiatives/lccc_caribbean/LCCC_Report_Final_May2012.pdf.

373. Christiana Sciaudone, "Caribbean Geothermal Developer Sued by Nevis, Financial Partner," *Recharge News*, June 4, 2012, accessed November 11, 2014, http://www.rechargenews.com/news/geothermal/article1297639.ece.

374. "West Indies Power Nevis to Appeal Geothermal Contract Court Ruling," *Caribbean 360,* January 21, 2013, accessed October 31, 2014, http://www.caribbean360.com/index.php/news/st_kitts_nevis_news/656773.html#axzz2g0tuaMRA.

375. Merv-Ann Thompson, "ECCA Strikes Out West Indies Power Geothermal Appeal," *Saint Kitts & Nevis Observer,* July 1, 2014, accessed November 5, 2014, http://www.thestkittsnevisobserver.com/2014/06/27/ecca-strike-out.html.

376. Nevis Island Administration, "NIA, NEVLEC and NREI Sign Geothermal Power Purchase Agreement," November 26, 2015, accessed December 4, 2015, http://www.nia.gov.kn/index.php/news-4/news-articles-3/2538-nia-nevlec-and-nrei-sign-geothermal-power-purchase-agreement.

377. SKELEC, "Request for Proposal: SKELEC's Renewable Energy Infusion Study" (2013).

378. Government of Saint Kitts and Nevis, "Geothermal Development on Saint Kitts and Nevis" (Costa Rica Study Tour: March 2014).

379. IDB, "Sustainable Energy Facility (SEF) for the Eastern Caribbean: Loan Proposal RG-L1071, RG-G1009, and RG-G1004" (2015), accessed December 2, 2015, http://www.iadb.org/en/projects/project-description-title,1303.html?id=RG-L1071; Magnus Gehringer and Victor Loksha, *Geothermal Handbook: Planning and Financing Power Generation* (Washington, DC: The International Bank for Reconstruction and Development, Technical Report 002/12, June 2012), accessed October 22, 2014, http://www.esmap.org/sites/esmap.org/files/DocumentLibrary/FINAL_Geothermal%20Handbook_TR002-12_Reduced.pdf; Nexant, *Caribbean Regional Electricity Generation, Interconnection, and Fuels Supply Strategy* (March 2010), 1-38, accessed April 27, 2015, http://www.caricom.org/jsp/community_organs/energy_programme/electricity_gifs_strategy_final_report_summary.pdf; Magnus Gehringer and Victor Loksha, *Geothermal Handbook: Planning and Financing Power Generation* (Washington, DC: The International Bank for Reconstruction and Development, Technical Report 002/12, June 2012), accessed October 22, 2014, http://www.esmap.org/sites/esmap.org/files/DocumentLibrary/FINAL_Geothermal%20Handbook_TR002-12_Reduced.pdf; Nexant, *Caribbean Regional Electricity Generation, Interconnection, and Fuels Supply Strategy* (March 2010): 1–38, accessed April 27, 2015, http://www.caricom.org/jsp/community_organs/energy_programme/electricity_gifs_strategy_final_report_summary.pdf. Cost estimates based on information provided by JICA, the IDB, information from the Energy Sector Management Assistance Program (ESMAP), and Nexant. The cost for the interconnection cable is based on Nexant's findings, where it estimates that the interconnection between the islands of Nevis and Saint Kitts would cost about US$328 per kW of capacity. Assuming a capacity of 35 MW, this would put the total cost of the interconnection at about US$11.5 million.

the costs for production well drilling and building the power plant and interconnection cables. Since the estimated cost of this project is equal to about 80 percent of the 2014 budget of the Government of Saint Kitts and Nevis, the government and the NIA would need support from donors and the private sector to be able to finance this project.[380]

The NIA originally planned to develop the project as a second phase of the project with West Indies Power (to serve Nevis). In 2011, NEVLEC and SKELEC signed a Letter of Intent agreeing that a geothermal power plant in Nevis would provide electricity to Saint Kitts. The proposed project included US$100 million in debt funding from the Export-Import Bank and US$25 million in equity funding from West Indies Power.[381] However, this project was cancelled when NIA terminated its concession agreement with West Indies Power.

The government and the NIA's next steps include carrying out feasibility studies for the power plant, finding a project developer, and completing the project agreements. The project agreements include a concession agreement with a project developer to build, finance, and operate the power plant and undersea interconnection cable, and a PPA with SKELEC

14.4 Recommended Financial and Legal PPP Structure

The geothermal project in Nevis and Saint Kitts has two phases: one to provide electricity for Nevis, and another one to provide electricity to Saint Kitts and potentially other countries via undersea cables. The NIA has a structure and the agreements in place to implement the first phase of the project, as explained in the previous section. However, we would recommend that both phases be developed together. Ideally, Phase 2 would be developed as an expansion of the power plant developed for Phase 1, potentially by the same developer. This approach would leverage the relationships and work carried out for Phase 1 and expedite the process for completing Phase 2. However, to date, neither the NIA nor the government has indicated that they will proceed in this way.

14.4.1 Structure of the PPP

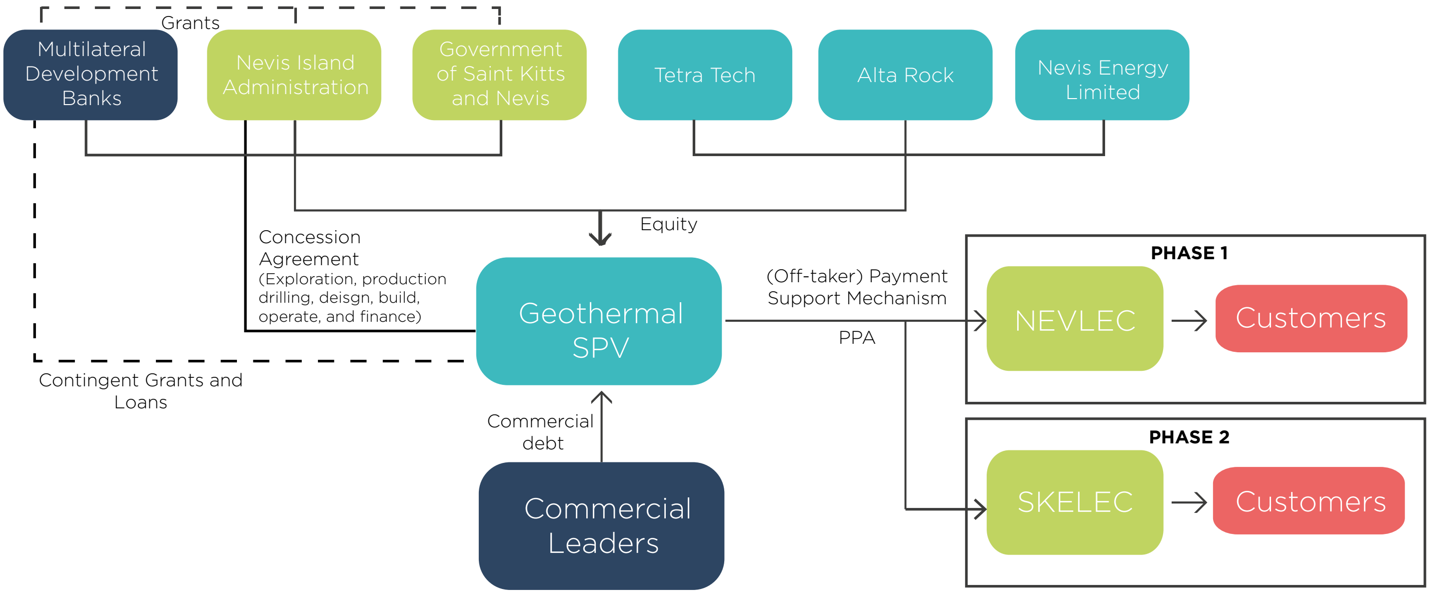
We recommend that the government and the NIA proceed with the implementation of the project in two phases, with three additions—the NIA should partner with Nevis International in establishing the geothermal SPV, include a payment support mechanism to back the off-taker's payments under the PPA, and develop Phase 2 as an expansion of the power plant for Phase 1. The project structure that is in place is described in detail in Section 14.3.2. The NIA signed a concession agreement with Nevis International to develop the geothermal resource (exploration) and to design, build, own, operate, and finance the geothermal generation plant. The project is expected to be financed through a mix of commercial debt and equity contributions. The SPV would then sell electricity to NEVLEC through a PPA. This project structure would allow the NIA to exploit its geothermal resources and access technical expertise and financing from the private sector.

380. The 2014 budget of the Government of Saint Kitts and Nevis was US$174 million. This information is based o the following source: "St. Kitts and Nevis 2014 Budget Address," *Caribbean Elections Today*, December 10, 2013, accessed November 12, 2014, http://www.caribbeanelections.com/blog/?p=3175.

381. Kerry McDonald, "Federation of Saint Kitts and Nevis: First Geothermal Powered Nation in the World" (West Indies Power, 2011), accessed September 26, 2013, http://ciemades.org/pdfs/conf11/may6/Nevis-Geothermal_K_MacDonald.pdf

Figure 14.5 presents our recommended PPP structure for both phases of the project. Phase 1 of the project will provide electricity to NEVLEC and Phase 2 of the project to SKELEC.

FIGURE 14.5 Recommended PPP Structure for Saint Kitts and Nevis



We recommend three additions to the project structure that is in place. First, we recommend that the NIA join Nevis International as a partner in developing the SPV. Under this project structure, the NIA would have two major responsibilities: it would have equity ownership in the SPV and it would grant a concession agreement that assigns the responsibility for exploration, production drilling, design, construction, operation, and finance of the geothermal power plant to the SPV. This partnership will allow the SPV to access funding from the multilateral banks. Multilateral development banks can provide funding in the form of grants, contingent grants, and concessionary loans that will be provided directly to the project.[382] This would reduce the project's cost of capital and that could be passed on to customers through reduced tariffs.

Second, we recommend that the government and the NIA develop both phases of the project as one. If this were the case, then the government and the NIA could partner with Nevis International to develop both phases of the geothermal project.

The main difference between the model that we recommend for Phase 2 and Phase 1 of the project is the off-taker. For Phase 1 of the project the off-taker is NELEC, the utility that serves Nevis, and for Phase 2 of the project the off-taker is SKELEC, the utility that serves Saint Kitts. Other than this difference, the major agreements in the project structure remain the same.

Third, since NEVLEC and SKELEC are fully state-owned and do not have strong financial performance, it might be necessary to include a payment support mechanism that backs SKELEC's and NEVLEC's payments under the PPAs. That mechanism would reduce the project's revenue risks and thus make the project more bankable and appealing to investors. The payment support mechanism can be implemented in various ways. Some of the options include:

382. The type of funding provided will differ based on the stage of the project's development. Grants and contingent grants will support the early stages of geothermal development—surface exploration (including environmental and social impact studies) and exploratory drilling. At these stages, the resource is highly uncertain. Contingent grants would be converted to concessionary loans if the resource is confirmed and a power plant is built on the site, and repaid from revenues from electricity tariffs. The later stages of geothermal development—production drilling and power plant construction—would be supported by concessionary loans. This funding will support the project during the stages with the highest risk, and will help reduce the overall cost of the project.

- Establishing a liquidity facility, such as a trust fund or escrow account, which involves setting up a single-purpose account that is managed by a third party. NEVLEC and SKELEC would make periodic contributions to the bank account, and these funds would be exclusively used to pay the SPV in the event that NEVLEC or SKELEC do not meet their payments under the PPA.
- A third-party guarantee mechanism offered by a financial institution could also be used to back SKELEC's and NEVLEC's payments. Examples of financial institutions that offer guarantees include the Multilateral Investment Guarantee Agency, which provides coverage for breach of contract.

We believe that this model could be successful because of two main reasons. First, the private partners have demonstrated commitment and have the expertise necessary to ensure that the project is successful. Tetra Tech and Alta Rock have the technical knowledge needed to carry out production well drilling and to design, build, and operate a geothermal power plant. Nevis Energy Limited understands the Caribbean energy market. The fast progress of the project also indicates that it should be successful.

Secondly, the project should be successful because it is likely a financeable project. The recommended project has the agreements needed to limit the risk faced by investors and lenders, which increases the likelihood of structuring a financeable project. In particular, the PPA and a payment support mechanism for off-taker payments under the PPAs reduce the revenue risk for the SPV. NEVLEC and SKELEC would ensure full cost recovery by passing on the PPA rate to their customers through the electricity tariffs. The concession agreement and the PPA would then ensure that the SPV is able to repay its debts and allows the investors to receive the expected return on equity.

14.4.2 Key risks and mitigation measures for Phase 1

Table 14.1 shows that the project has few major risks. The geothermal resource in Nevis is proven, so the major risks that the project faces are all related to production well drilling and project development.

Table 14.1 Allocation of Risks for the Proposed PPP Structure

Risk	Impact of Risk	Party That the Risk Is Assigned To	Proposed Measure for Mitigating the Risk
Market, Demand, or Volume RiskPotential	Medium	NEVLEC and SPV	A PPA and a payment support mechanism for NEVLEC's payments under the PPA
Resource Risk	Low	NIA and SPVt	Low. The risk is low because slim-hole drilling has been completed and the estimated resource potential is high.
Construction Risk	Medium	SPV and, possibly, the construction company that builds the plant	The SPV can hire a company to build the plant and incorporate penalties if the plant is not completed on time or milestones are not achieved as contractually planned.
Technical Risk	Low	SPV	None. The risk is low because this is a proven technology.
Operating Risk	Low	SPV	None. The risk is low because of the technical expertise of the project developer.
Political and Social Risk	Low	SPV	Including a payment support mechanism that backs NEVLEC's payments under the PPA, and the development banks' involvement, reduces the project's political and social risk. Also, if electricity prices are reduced through the use of geothermal energy, the public will likely support the project.
Environmental Risk	Medium	SPV and NIA	This risk can be reduced by carrying out an EIA. The EIA will allow NIA to assess the risk of the geothermal project and propose an action plan to mitigate the risks identified.
Financing Risk	Medium	SPV and NIA	The financing risk is reduced with the PPA, the payment support mechanism for NEVLEC's payments under the PPA, and potentially financing from development banks.
Regulatory Risk	Low	NIA	The risk is low because the rules governing the sustainable exploitation of the resource should already be established in the Geothermal Ordinance. If this is not the case, the NIA is responsible for making any necessary changes to the legal and regulatory framework to enable the development of the project. Since those changes take time, the parties to the project can draft clear rules governing the sustainable exploitation of the resource and the operation of the power plant in the project agreements (concession, PPA, others).

We describe each of the major risks and their proposed mitigation measures below:

- **The SPV is not able to secure funding for the project (Financing Risk)**—A major risk for the project is that the SPV is not able to raise the financing needed for the project. This would occur if financiers believe that the project is not bankable. However, this risk is unlikely. The project partners already signed a PPA, and having a PPA in place will reduce this risk since the project's revenues are known.[383] Including a payment support mechanism for NEVLEC's payments under the PPA would help mitigate this risk further. Including a payment support mechanism for NEVLEC's payments would ensure that the project receives the revenue stream to repay debts and investors. In addition, the multilateral development banks may provide concessionary financing for the project that can lower the cost of financing and make it more attractive to lenders. Finally, Tetra Tech's and Alta Rock's technical expertise will assure banks that the project can be developed successfully.

- **NEVLEC cannot meet the payments under the PPA (Financing Risk)**—Another risk for the project is that NEVLEC is not able to make the payments of the PPA rate to Nevis International. As discussed in Section 14.1.1, publicly available information suggests that NEVLEC operates inefficiently and is not able to recover its costs through tariffs. Including a payment support mechanism to back NEVLEC's payments under the PPA would reduce this risk.

383. Nevis Island Administration, "NIA, NEVLEC and NREI Sign Geothermal Power Purchase Agreement," November 26, 2015, accessed December 4, 2015, http://www.nia.gov.kn/index.php/news-4/news-articles-3/2538-nia-nevlec-and-nrei-sign-geothermal-power-purchase-agreement.

14.4.3 Key risks and mitigation measures for Phase 2

The proposed project has few major risks. The geothermal resource in Nevis is proven, so the major risks that the project faces are all related to production well drilling and project development. **Table 14.2** provides an overview of all project risks.

Table 14.2 Allocation of Risks for the Proposed PPP Structure

Risk	Impact of Risk	Party That the Risk Is Assigned To	Proposed Measure for Mitigating the Risk
Market, Demand, or Volume RiskPotential	Medium	SKELEC and the government	A PPA and a payment support mechanism for SKELEC's payments under the PPA
Resource Risk	Low	SPV and the government	Low. The risk is low because the project will be a brownfield development.
Construction Risk	Medium	SPV and, possibly, the construction company that builds the plant	The SPV can hire a company to build the plant and incorporate penalties if the plant is not completed on time or milestones are not achieved as contractually planned.
Technical Risk	Low	SPV	None. The risk is low because this is a proven technology.
Operating Risk	Low	SPV	It is too early to evaluate this risk because the project developer has not been identified. However, the SPV can have a technical partner with expertise in geothermal energy to mitigate this risk.
Political and Social Risk	Low	SPV	Including a payment support mechanism to back SKELEC's payments under the PPA, and the development banks' involvement, reduces the project's political and social risk. Also, if electricity prices are reduced through the use of geothermal energy, the public will likely support the project.
Environmental Risk	Medium	SPV and the government	This risk can be reduced by carrying out an EIA. The EIA will allow the government to assess the risk of the geothermal project and propose an action plan to mitigate the risks identified.
Financing Risk	Medium	SPV and the government	The financial risk the project developers face is reduced with the PPA, the concession agreement, and the payment support mechanism of SKELEC's payments under the PPA.
Regulatory Risk	Low	Government and NIA	Low. The risk is low because the rules governing the sustainable exploitation of the resource should already be established in the Geothermal Ordinance of Nevis. If this is not the case, the NIA and the government are responsible for making any necessary changes to the legal and regulatory framework to enable the development of the project. Since those changes take time, the parties to the project can draft clear rules governing the sustainable exploitation of the resource and the operation of the power plant in the project agreements (concession, PPA, others).

We describe each of the major risks and their proposed mitigation measures below.

- **The government and the NIA are not able to identify a project developer for the project (Market Risk)**—The government and the NIA have not yet identified the project developers for the project. This phase of the project requires a larger investment than the project to provide electricity in Nevis. As a result, investors could suffer bigger losses if the project was not successful. Despite carrying out a study to identify possible routes for the interconnection cables between Nevis and Saint Kitts, an in-depth feasibility study assessing the economic viability of building the interconnection cables to export electricity to Saint Kitts has not been developed. Until one is done, investors cannot assess the profitability of the power plant. Multilateral development banks could provide funding for this study.

  The risk of not finding a project developer will also be largely reduced if Phase 1 of the project (which will provide electricity to Nevis) reaches successful completion. This would make the Phase 2 project to serve Saint Kitts a brownfield development, and would provide good information on the geothermal resource. It will make the project to provide electricity in Saint Kitts more attractive to potential developers. The developer of Phase 1 could also become the developer of Phase 2.

- **SKELEC cannot meet the payments under the PPA (Financing Risk)**—Another risk for the project is that SKELEC is not able to make the payments of the PPA rate to the SPV. As discussed in Section 14.2.1, publicly available information suggests that SKELEC operates inefficiently and is not able to recover its costs through tariffs. The payment support mechanism included to back SKELEC's payments under the PPA will reduce this risk.

- **The SPV is not able to raise funding for the project (Financing Risk)**—A major risk for the project is that the SPV is not able to raise the financing needed for the project. This would occur if financiers believe that the project is not bankable. Having PPAs in place with the off-takers will reduce this risk since the project's revenues will be known. The payment support mechanism for SKELEC's payments under the PPA will help mitigate this risk further. Providing a payment support mechanism on SKELEC's payments will ensure that the project receives the revenue stream to repay debts and investors. In addition, the SPV will probably have access to concessionary financing that can lower the cost of financing the project and make it more attractive to lenders.

14.4.4 Strategy for engaging key stakeholders

We recommend the NIA and the government keep each other, the general public, and other key stakeholders updated on the project's progress to gain their trust and commitment. In addition to the general public, other key stakeholders that the NIA and the government could engage include other governmental bodies, NEVLEC, SKELEC, and development banks and donors.

The NIA has not actively engaged with the public in the past. It did not keep the public informed during the process to reach an agreement with the original project developer, West Indies Power, and there were public concerns regarding the lack of due diligence in the selection process.[384]
Also, the NIA has not communicated actively with the public during the selection of Nevis International. As a result, the public is concerned about the project despite the fact that the NIA selected Nevis International through a competitive tender process.[385] Had the NIA shared information about the process and engaged the public more actively, the public would likely express less concern.

However, the NIA has started informing the general public about the project's progress.[386] Going forward, we recommend the NIA continue engaging with the public to gain their support for the project. The easiest way to keep the public engaged is to hold public consultations in which the NIA provides updates on the project's progress and receives feedback. Public consultations will also allow the public to ask authorities about the process followed to reach project agreements and the expected impact in the electricity tariffs, which will help to gain the public's trust.

In addition to informing the public, we recommend the NIA and the government ensure that NEVLEC and SKELEC are involved and updated on the project's progress. This is particularly important because NEVLEC and SKELEC will serve as the project's off-takers. Even though NEVLEC and SKELEC are state-owned utilities, it is important that they are involved in the project developments because the geothermal power plant will affect their planning processes. NEVLEC and SKELEC will also need to make sure that their contracts for purchasing diesel will allow them to transition to geothermal generation once the plant is online. To a large extent, this will require that NEVLEC and SKELEC keep diesel suppliers up to date so that they can adjust imports accordingly.

We also recommend the NIA keep other governmental bodies involved and updated on the project's progress. Specifically, we recommend the NIA actively engage with the Nevis Ministry of Natural Resources, which will probably be the ministry responsible for monitoring the use of geothermal resources when the power plant begins operations.

Lastly, the NIA and the government should ensure that development banks are involved and updated on the project's progress. This is important because they will likely provide funding for the project, which will be key for the project's success. If the development banks are kept up to date, the funding could be made available more quickly.

---

384. Andre Huie, "Energy Minister Sees No Role for West Indies Power in Geothermal Development on Nevis," *Caribbean News Now,* September 17, 2014, accessed November 14, 2014, http://www.caribbeannewsnow.com/headline-Energy-minister-sees-no-role-for-West-Indies-Power-in-geothermal-development-on-Nevis-22817.html.

385. The Nevis Administration selected Nevis Renewable Energy International through a competitive bidding process where two other firms participated. The names of the other firms that participated in the bidding process have not been disclosed to the public. See sources: Emily Patrick, "NIA in Geothermal Talks with Unregistered Company," *St. Kitts & Nevis Observer,* December 6, 2013, accessed November 14, 2014, http://www.thestkittsnevisobserver.com/2013/12/06/geothermal-talk.html; "Successful Bidder Announced to Move Geothermal Development forward on Nevis," *Caribbean News Now,* November 22, 2013, accessed November 21, 2014, http://www.caribbeannewsnow.com/topstory-Successful-bidder-announced-to-move-geothermal-development-forward-on-Nevis--18763.html.

386. Nevis Island Administration, "NIA, NEVLEC and NREI Sign Geothermal Power Purchase Agreement," November 26, 2015, accessed December 4, 2015, http://www.nia.gov.kn/index.php/news-4/news-articles-3/2538-nia-nevlec-and-nrei-sign-geothermal-power-purchase-agreement.

14.5 Recommended Changes to the Legal, Institutional, and Regulatory Framework in Nevis

To implement the geothermal project successfully, there are two types of functions that the legal, institutional, and regulatory framework must allow. First, it must establish a clear process for exploring, exploiting, and protecting the geothermal resource. Second, it must ensure that electricity tariffs allow for the recovery of costs from geothermal generation.

The legal, institutional, and regulatory framework in Nevis has the laws and bodies that govern the development, exploitation, and protection of geothermal resources, and the sale of the electricity generated. The NIA has the Geothermal Ordinance of 2008, which establishes the legal and regulatory framework that governs the exploration and exploitation of geothermal resources in Nevis. Nevis also has the Electricity Ordinance of 1998, which governs the electricity sector in Nevis and the operation of IPPs. In addition, the Nevis Ministry of Natural Resources oversees the use of natural resources on the island.

Since the NIA has not published these laws, we have not been able to review and evaluate them in detail. However, we recommend that, at a minimum, the NIA ensure that these laws are consistent. In addition, the NIA should ensure that the legal, institutional, and regulatory framework:

- **Establishes a process for geothermal developers to obtain a license that is consistent across all relevant laws**. A clear process for developing geothermal resources reduces uncertainty, makes the project more attractive to investors, and facilitates raising financing. The NIA must therefore ensure there is a clear and established process in place that geothermal developers can follow to obtain a license. All relevant legislation should be consistent. In particular, the NIA should ensure that the process for obtaining an IPP license, included in the Geothermal Ordinance, is consistent with the Electricity Ordinance. In addition, the NIA should ensure that the Electricity Ordinance provides guidance to the IPPs on the purchase conditions and the process they must follow to sell electricity to NEVLEC.

- **Establishes regulations and assign responsibility for monitoring the geothermal resource to prevent overexploitation.** Nevis should have a regulatory body in charge of monitoring geothermal resources. This regulatory body would be responsible for setting the regulations and monitoring the use of the geothermal resource and ensuring that it is not overexploited. The NIA would need to ensure that the Geothermal Ordinance determines which body will have this responsibility.

- **Sets tariffs that reflect the cost of producing electricity with geothermal generation.** The tariffs in Nevis are set by NEVLEC (see Section 14.1.2).[387] The NIA should ensure that tariffs reflect the full costs of producing electricity with geothermal resources. More specifically, we recommend it ensure that the tariff allows NEVLEC to recover the cost of providing electricity at least-cost, regardless of the technology or fuel used, and that any potential reductions in the cost of electricity generation are passed on to customers.

- **Establishes a regulator**. Establishing a regulator responsible for carrying out the regulatory functions described above, among others, would make all rules and processes clearer and more transparent. For example, the regulator would be responsible for setting and regulating NEVLEC's tariffs. The regulator could also be responsible for monitoring the geothermal resource, although environmental regulation is not always within the jurisdiction of the regulator. Establishing a separate regulator responsible for these functions is one way to centralize these responsibilities. If the regulator has sufficient autonomy from other government agencies and has the resources to carry out its work, centralizing these functions will ensure that these functions are executed capably. To obtain savings in expenditures related to setting up the regulator and its administration, a sole regulator could be established with jurisdiction over the electricity sectors in both Saint Kitts and Nevis.

387. REEGLE, "Policy and Regulatory Overviews: Saint Kitts and Nevis (2012)," accessed November 5, 2014, http://www.reegle.info/policy-and-regulatory-overviews/KN.

It may be that some of these recommendations are not addressed by the Geothermal Ordinance and the Electricity Ordinance. If that were the case, another way to address some of these changes is to establish regulation through contracts. For example, to ensure that tariffs for end customers reflect the (lower) costs of producing electricity through geothermal generation, the PPA that the SPV signs with NEVLEC could establish the formula used to determine the tariffs NEVLEC charges customers. Similarly, the agreements between the NIA and the private partners could include obligations that ensure the protection and sustainable development of the geothermal resource. For example, the agreement can mandate that an independent expert carry out periodic evaluations to monitor the environmental impact of the power plant. Since regulatory functions in Nevis are spread across various government agencies, if a regulator is not established a committee could be formed to monitor the SPV's compliance with contractual obligations. Any dispute arising from failure to adhere to contract obligations could be handled by a regular court, an administrative court, or a special expert panel as applicable.

Establishing regulation through contracts would only serve as a short-term solution to prevent delays in project implementation. There are some regulatory functions that cannot be covered through contracts and for which regulations and laws will need to be established. For example, the government will still need to develop the process through which licenses to establish a geothermal plant are obtained.

14.6 Recommended Changes to the Legal, Institutional, and Regulatory Framework in Saint Kitts

To implement the project successfully, there are two main functions that the legal, institutional, and regulatory framework must be able to allow for. First, the legal, institutional, and regulatory framework should establish the process for developing and exploiting the geothermal resource. Second, the legal, institutional, and regulatory framework should allow for cost recovery for geothermal generation and establish the process for IPPs to sell electricity.

The NIA is responsible for implementing the changes for establishing the legal, institutional, and regulatory framework necessary for exploring and exploiting the geothermal resource. The NIA will need to implement these changes before the geothermal project to supply electricity in Nevis begins (see Section 14.4.3). This means that these changes should be in place when the geothermal project to supply electricity in Saint Kitts starts. In this section, we describe the key components that the Government of Saint Kitts and Nevis should ensure are present in the legal and regulatory framework:

- **Establish a clear process for IPPs to sell their electricity to SKELEC.** The Electricity Supply Act of 2011 governs the electricity sector in Saint Kitts. The government has not published the ESA, so we have not been able to review and evaluate it. However, a draft version of the Saint Cristopher Electricity Supply Bill of 2011 does not include the procedure that IPPs would follow for selling electricity to SKELEC.[388] The government must ensure that there is a clear procedure for IPPs to sell electricity to SKELEC.
- **The tariffs in Saint Kitts must reflect the cost of producing electricity with geothermal generation.** The tariffs in Saint Kitts are set by the governor general with approval from the National Assembly (see Section 14.2.3). The ESA does not include a formula for determining tariffs and mandates that the Public Utilities Commission (PUC) establish tariffs. Since the PUC has not been appointed, the tariffs are determined by the governor general. Regardless of who sets the tariffs, the tariffs must reflect the costs of producing electricity with geothermal resources. More specifically, the tariff must allow SKELEC to recover the cost of providing electricity at least-cost, regardless of the technology or fuel in use, and that any potential reductions in the costs of electricity generation are passed through to the customers in Saint Kitts.
- **A regulator should be established.** Or, regulation can be carried out through contracts, as described in the prior section.

388. The Government of Saint Kitts and Nevis, "Saint Cristopher (Electricity Supply) Bill, 2011," accessed November 14, 2014, https://groups.google.com/forum/#!topic/sknfus/YceWobynQrk.

14.7 Economic and Financial Analysis of the Geothermal Project in Nevis

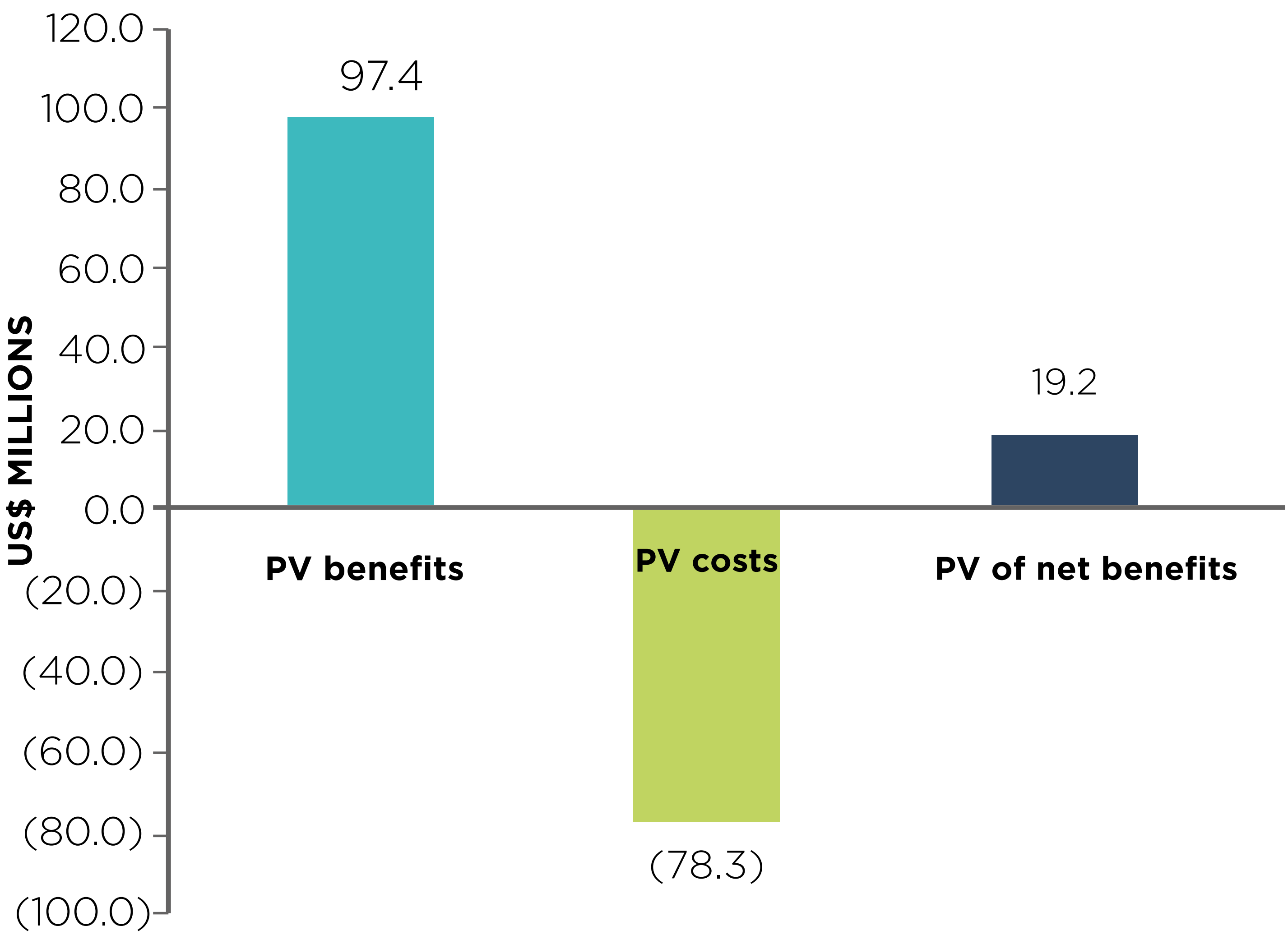
In this section, we assess whether the geothermal project to provide electricity in Nevis is economically and financially viable. We first perform a cost-benefit analysis to determine whether the geothermal project generates net economic benefits to the country. We then use the discounted cash flow method to evaluate whether the geothermal project is financially viable to investors. We conclude that the geothermal project is economically and financially viable. Therefore, we recommend the NIA and investors proceed with implementing it. We present our analysis and results as follows:

- Cost-benefit analysis (Section 14.7.1)
- Financial analysis (Section 14.7.2)

14.7.1 Cost-benefit analysis

We perform a cost-benefit analysis to determine whether the geothermal project is economically viable. We conclude that the Nevis geothermal project is economically viable and increases social welfare. The present value of the project's net economic benefits is positive and equal to US$19 million **(see Figure 14.6)**. Therefore, the NIA and the donors should proceed with developing the project.

FIGURE 14.6 Present Value of Net Economic Benefits of the Nevis Geothermal Project



To determine the economic viability of the geothermal project, we estimate its net economic benefits for a period of 40 years. Net economic benefits equal the economic benefits minus the economic costs of the project. Economic benefits include savings in generation costs (because generating electricity from geothermal resources can cost less than from fuel oil or diesel), and reductions in CO_2 emissions. Economic costs are the capital expenditures needed to complete all project stages. We then bring the economic benefits and costs to present value (PV) with a social discount rate of 12 percent (in real terms).[389] The geothermal project is economically viable if the PV of the project's net benefits is positive—economic benefits outweigh economic costs. Further details about the assumptions and methodology we use are presented in Appendix A.

14.7.2 Financial analysis

We use the discounted cash flow (DCF) method to determine whether Phase 1 of the geothermal project in Nevis is financially viable for equity investors. We conclude that the geothermal project allows the equity investors to earn a 15 percent real rate of return when the PPA rate is about US$0.14/kWh. This PPA rate is the tariff at which the geothermal projects would need to sell each kWh of electricity to be able to service their debts and provide equity investors with a 15 percent real return. This PPA rate is feasible to implement, because it is likely lower than the current electricity tariff from fuel oil generation.[390] The final PPA rate will arise from a negotiation between the partners to the project.

Table 14.3 Financial Results of Geothermal Project

NPV to Equity Investors (US$millions)	IRR to Equity Investors (Real)	PPA Rate (US$/kWh)
0	15%	0.14
6.0	23%	0.16
10.9	29%	0.18

Notes: The IRR is Internal Rate of Return of the cash flows to equity investors. We assume a 15 percent real discount rate for equity cash flows.

In this section, we present the estimated cash flows from the geothermal project. The DCF methodology we use and our main assumptions are in Appendix B.

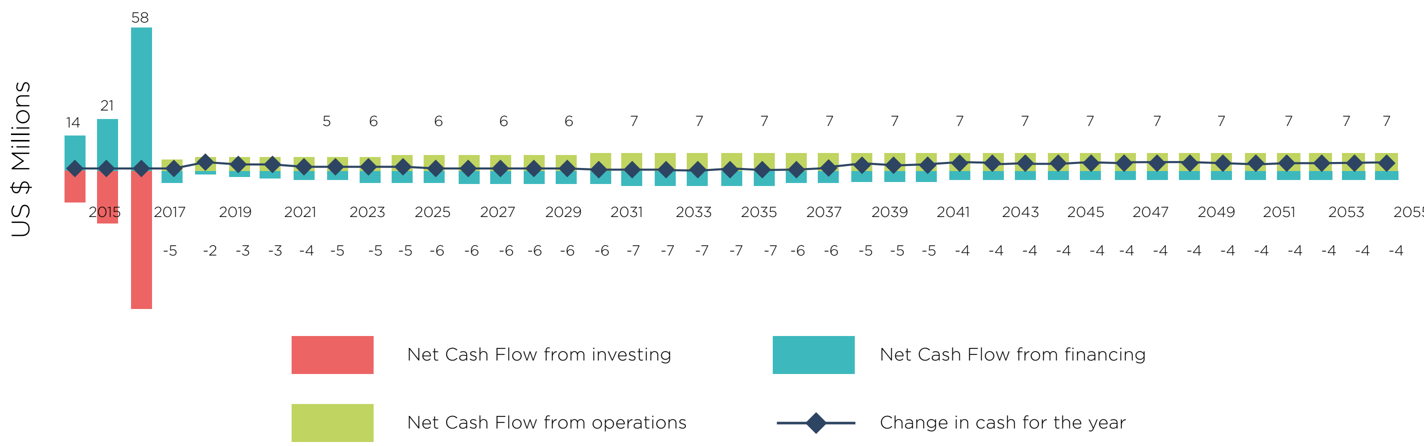
389. IDB, "Guidelines for the Economic Analysis of IDB-Funded Projects," June 2012, http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=36995807.

390. NEVLEC does not publish its financial statements, so we don't have information on the value of the tariff. As an indication, the average of tariffs in the EC countries is about US$0.34/kWh. Source for average tariff: CARILEC, *2014 Average Tariffs in EC Countries (2015).*

Cash flows from the geothermal project

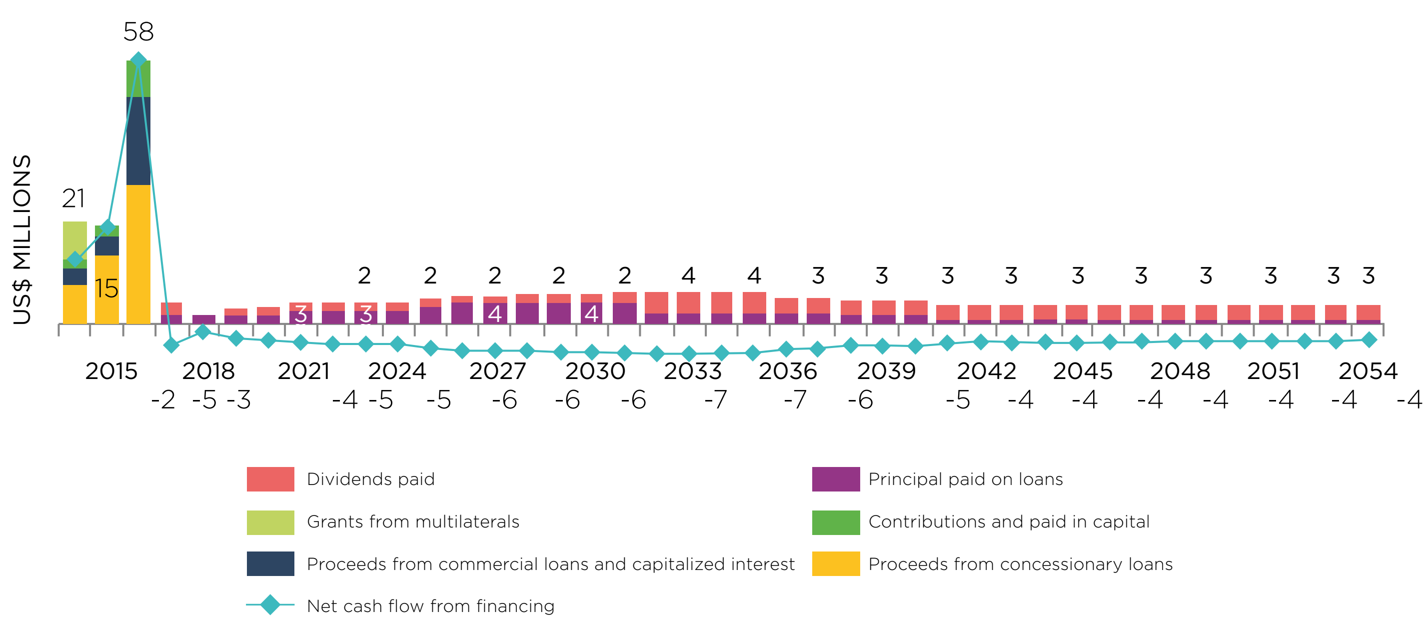
In **Figure 14.7,** we present the projected cash flows of the geothermal project for a PPA rate of US$0.14/kWh. Cash flows from financing are positive from 2015 to 2017 and are directed towards financing the capital expenditures (investments) for building the power plant. When the power plant begins operations in 2018, the cash flows from operations become positive and are used for repaying debt.

FIGURE 14.7 Cash Flows of the Geothermal Project



The majority of financing in 2015 and 2016 comes from concessionary loans and grants **(Figure 14.8)** This is due to the fact that concessionary financing is directed towards financing the riskier stages of geothermal development that occur at the beginning of the project. In 2017, commercial debt and equity increases significantly and are used to finance a portion of the production drilling and power plant construction. Once the power plant begins operations in 2018, the cash flows from operations are directed towards repaying the debt. The net cash flows from contributions and paid-in capital and dividends paid are the cash flows to the equity investor, which we discuss below.

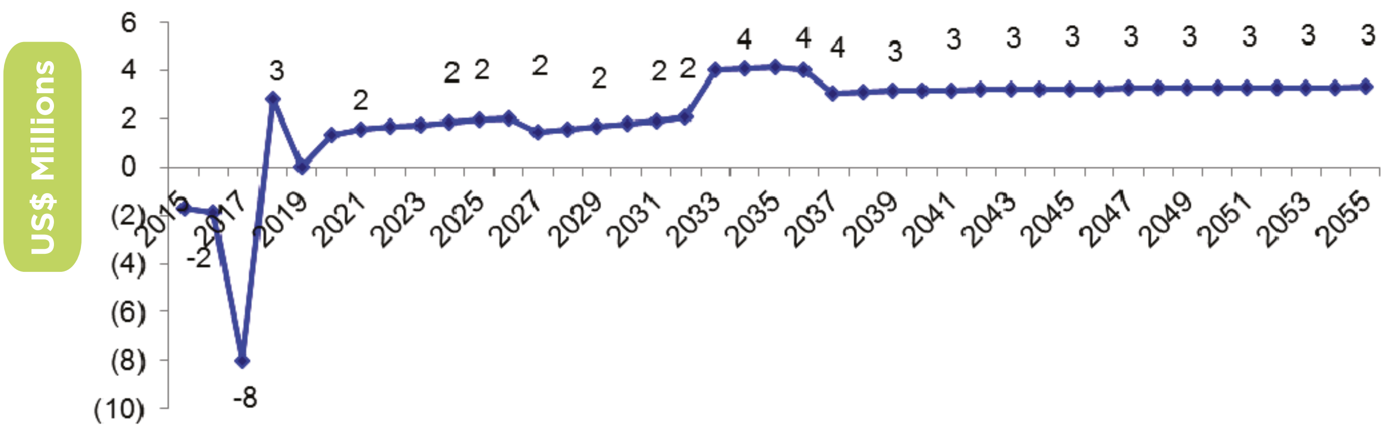
FIGURE 14.8 Financing Cash Flows of the Geothermal Project



The cash flows to the equity investors are presented in **Figure 14.9.** The cash flows to the equity investor are negative during 2015 to 2017, when the equity investors make their paid-in contributions to finance a portion of the capital expenditures. By 2018, the income from operations becomes large enough to pay for operating costs, cover working capital, and service debt.

The remaining cash flows are the cash available to equity investors. As payout policy we assumed that dividends are equal to the minimum of the cash available to equity and retained earnings, subject to retained earnings not falling below zero. As further debt payments are made, the principal amount is further reduced and the cash flows to the equity investors increase.

FIGURE 14.9 Cash Flows to Equity Investors from the Geothermal Project



14.8 Economic and Financial Analysis of the Geothermal Project in Saint Kitts

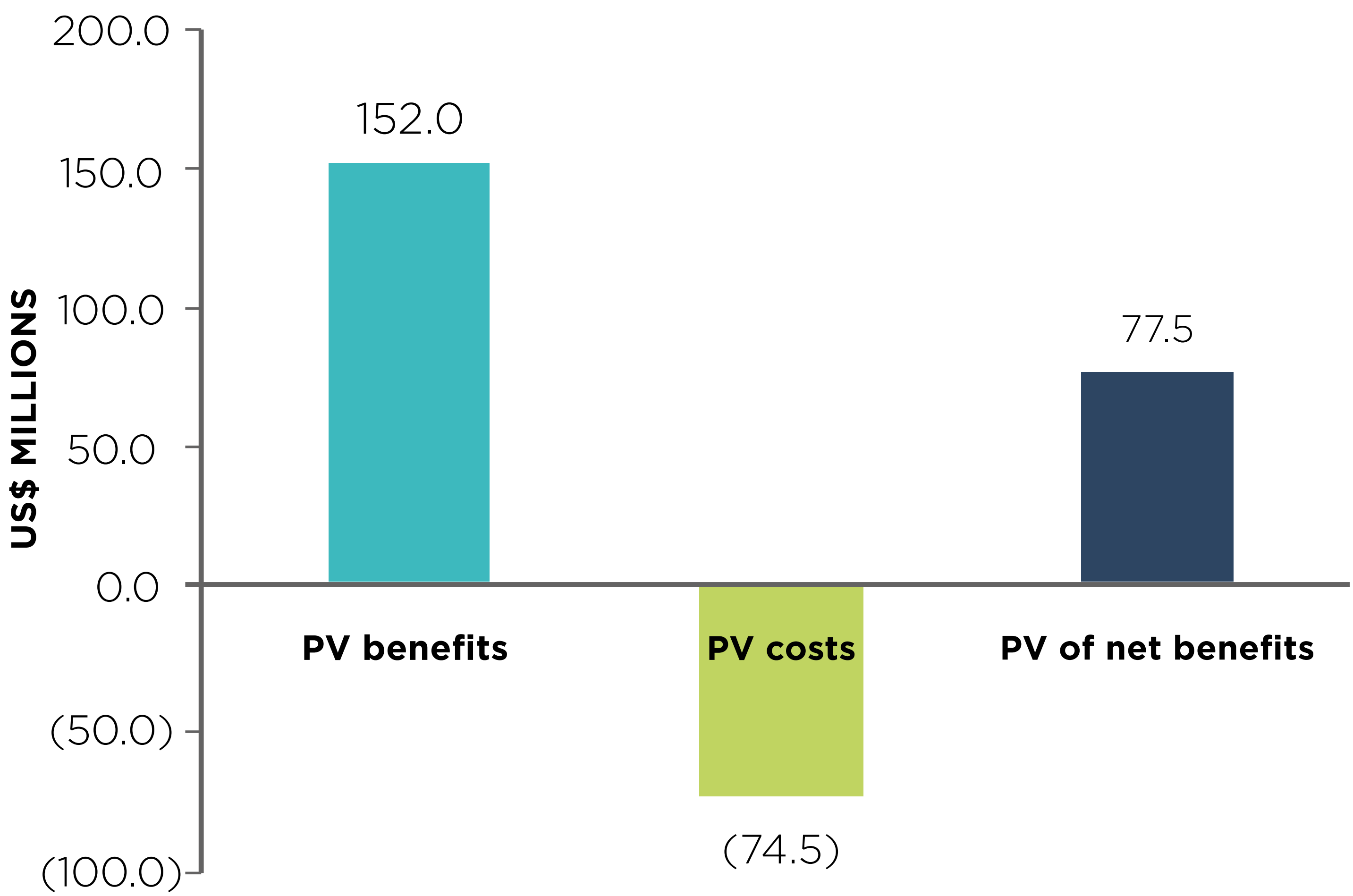
In this section, we assess whether the geothermal project to provide electricity in Saint Kitts is economically and financially viable. We first perform a cost-benefit analysis to determine whether the geothermal project generates net economic benefits to the country. We then use the discounted cash flow method to evaluate whether the geothermal project is financially viable to investors. We conclude that the geothermal project is economically and financially viable. Therefore, we recommend the Government of Saint Kitts and Nevis and investors proceed with implementing it. We present our analysis and results as follows:

- Cost-benefit analysis (Section 14.8.1)
- Financial analysis (Section 14.8.2)

14.8.1 Cost-benefit analysis

We perform a cost-benefit analysis to determine whether the geothermal project is economically viable. We conclude that the geothermal project is economically viable and increases social welfare. The present value of the project's net economic benefits is positive and equal to US$77.5 million (see **Figure 14.10**). Therefore, the government and donors should proceed with developing the project.

FIGURE 14.10 Present Value of Net Economic Benefits of the Saint Kitts Geothermal Project



To determine the economic viability of the geothermal project, we estimate its net economic benefits for a period of 40 years. Net economic benefits equal the economic benefits minus the economic costs of the project. Economic benefits include savings in generation costs (because generating electricity from geothermal resources can cost less than from fuel oil or diesel), and reductions in CO_2 emissions. Economic costs are the capital expenditures needed to complete all project stages. We then bring the economic benefits and costs to present value (PV) with a social discount rate of 12 percent (in real terms).[391] The geothermal project is economically viable if the PV of the project's net benefits is positive—economic benefits outweigh economic costs. Further details about the assumptions and methodology we use are presented in Appendix A.

391 IDB, "Guidelines for the Economic Analysis of IDB-Funded Projects," June 2012, http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=36995807.

14.8.2 Financial analysis

We use the discounted cash flow (DCF) method to determine whether Phase 2 of the geothermal project in Saint Kitts is financially viable for equity investors. We conclude that the geothermal project allows the equity investors to earn a 15 percent real rate of return when the PPA rate is about US$0.15/kWh. This PPA rate is the tariff at which the geothermal projects would need to sell each kWh of electricity to be able to service their debts and provide equity investors with a 15 percent real return. This PPA rate is feasible to implement, because it is likely lower than the current electricity tariff from fuel oil generation.[392] The final PPA rate will be determined through negotiations between the partners to the project.

Table 14.4 Financial Results of Geothermal Project

NPV to Equity Investors (US$millions)	IRR to Equity Investors (Real)	PPA Rate (US$/kWh)
0	15%	0.15
7.1	19%	0.17
13.2	22%	0.19

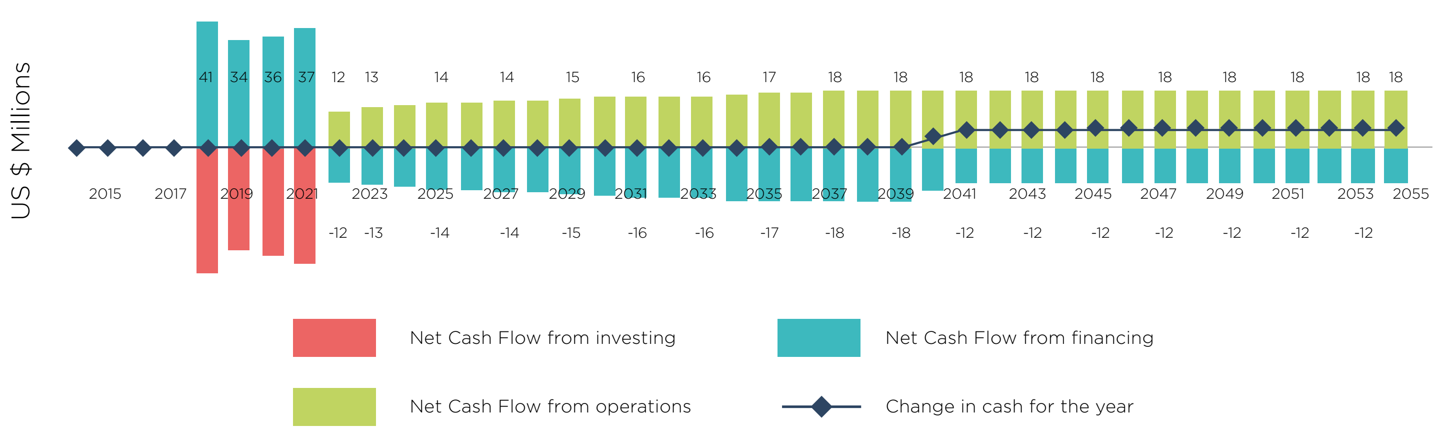
Notes: The IRR is Internal Rate of Return of the cash flows to equity investors. We assume a 15 percent real discount rate for equity cash flows.

In this section, we present the estimated cash flows from the geothermal project. The DCF methodology we use and our main assumptions are in : Methodology and Assumptions for Financial Analysis.

Cash flows from the geothermal project

In Figure 14.54, we present the projected cash flows of the geothermal project for a PPA rate of US$0.15/kWh. The figure shows that cash flows from financing are positive from 2019 to 2022 and are directed towards financing the capital expenditures (investments)—drilling the production wells and building the power plant and undersea interconnection cables. When the power plant begins operations in 2023, the cash flows from operations become positive and are used for repaying debt and paying dividends out to equity investors.

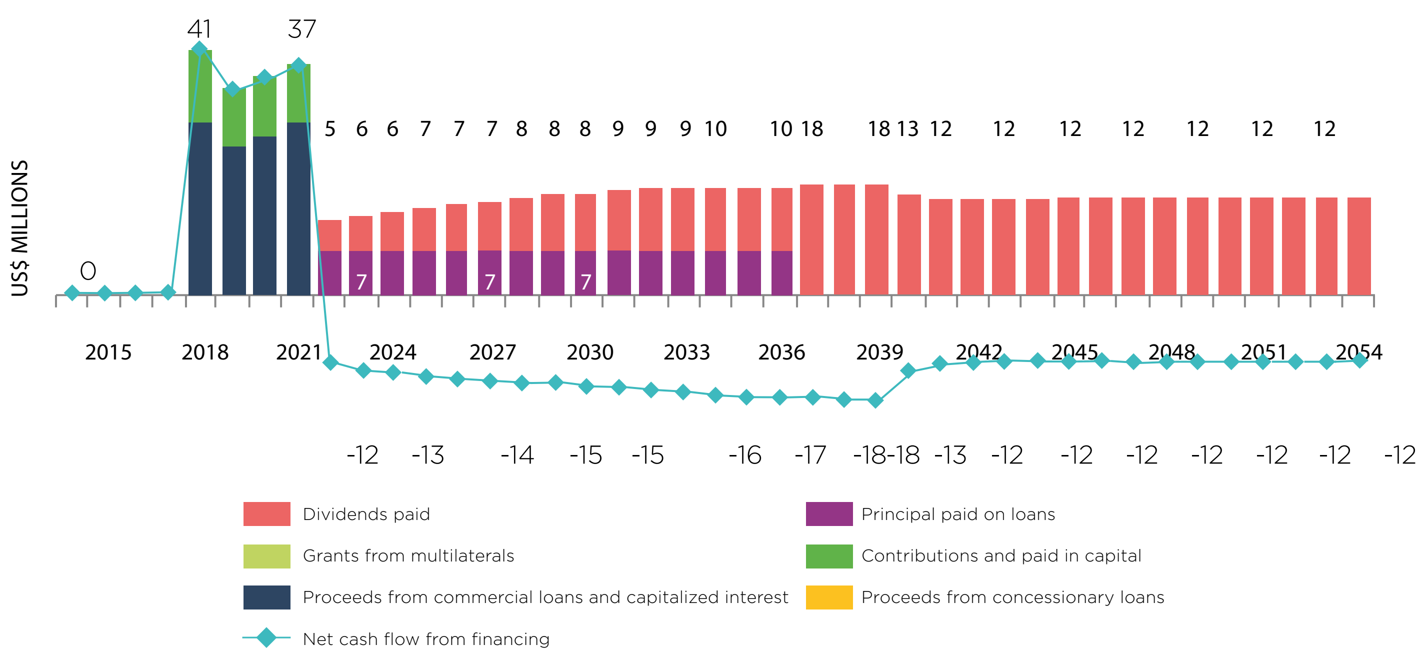
FIGURE 14.11 Cash Flows of the Geothermal Project



392. NEVLEC does not publish its financial statements, so we don't have information on the value of the tariff. As an indication, the average of tariffs in the EC countries is about US$0.34/kWh. Source for average tariff: CARILEC, *2014 Average Tariffs in EC Countries (2015).*

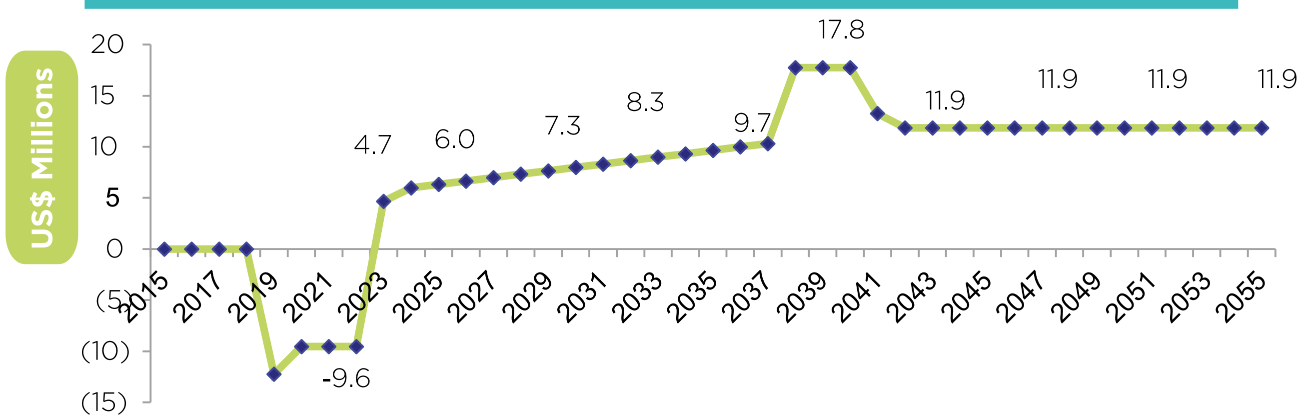
Cash flows from financing come from commercial debt and equity (see Figure 14.55). These cash flows are directed towards production drilling and the construction of the power plant and the undersea interconnection cable. This is feasible because the geothermal project to serve Saint Kitts has reached the field development stage, which is less risky and can attract private investment. It may be possible that concessionary financing is also offered to the second part of the Nevis project. Once the power plant begins operations in 2023, the cash flows from operations are directed towards repaying the debt. The net cash flows from contributions and paid-in capital and dividends paid are the cash flows to the equity investor, which we discuss below.

FIGURE 14.12 Cash Flows from Financing



The cash flows to the equity investors are presented in **Figure 14.13.** The cash flows to the equity investor are negative during 2019 to 2022, when the equity investors make their paid-in contributions to finance a portion of the capital expenditures. By 2023, the income from operations becomes large enough to pay for operating costs, cover working capital, and service debt. The remaining cash flows are the cash available to equity investors. As payout policy we assumed that dividends are equal to the minimum of the cash available to equity and retained earnings, subject to retained earnings not falling below zero. As further debt payments are made, the principal amount is further reduced and the cash flows to the equity investors increase.

FIGURE 14.13 Cash Flows to Equity Investors from the Geothermal Project



15 Saint Lucia

The Government of Saint Lucia is still in the early stages of geothermal development. Previous extensive exploration works in Sulphur Springs and commercial agreements with project developers have had limited success.

In 2014, the government restarted its efforts to explore and develop geothermal energy in the country. It received US$2.8 million in grants from the World Bank and the New Zealand government to support these efforts.[393] Surface exploration began in early 2015. The government has an agreement with Ormat to carry out surface exploration in Soufriere. Yet, the government and Ormat have not finalized agreements to carry out the later stages of the project nor have they determined the project structure they may use.

If the government decides to go ahead with developing the power plant, we recommend the government do so by signing a concession agreement with an SPV to develop the resource and design, build, construct, own, operate, and finance a geothermal plant. The SPV should be owned by a qualified project developer. Also, the government would also need to amend the legal and regulatory framework to allow the proposed project to be implemented.

Multilateral development banks may be able to play an active role providing funding for a geothermal power plant in Saint Lucia. If the government decides to build a plant in Sulphur Springs, the multilaterals could support the procurement of the concession and provide contingent grants, grants, and loans for the project. If the resource in Sulphur Springs is not commercially viable, the best role for the multilaterals may be to help fund investments in the exploration of new areas. The planned project and possible role for the multilateral development banks is described in more detail in the following sections:

- Overview of the Electricity Sector in Saint Lucia (Section 15.1)
- Status of Geothermal Development (Section 15.2)
- Recommended Financial and Legal PPP Structure (Section 15.3)
- Recommended Changes to the Legal, Institutional, and Regulatory Framework (Section 15.4)
- Economic and Financial Analysis of the Geothermal Project (Section 15.5)

15.1 Overview of the Electricity Sector in Saint Lucia

Saint Lucia Electricity Services, Ltd. (LUCELEC), a privately owned and vertically integrated utility, is the sole provider of electricity in Saint Lucia. Saint Lucia has near universal coverage; over 96 percent of the population has access to electricity. LUCELEC provides service to 65,842 customers. At the end of 2013, LUCELEC's installed capacity was 86.2 MW and all electricity in Saint Lucia was generated with diesel generators, with the exception of 100 kW of solar generation. In 2013, peak demand was 59.7 MW, which means that LUCELEC's reserve margin—calculated as the difference between installed capacity and peak demand divided by total peak demand—was 44 percent.[394]

The Electricity Supply Act of 1994 establishes the structure of and regulates the electricity sector. There is no independent regulator and, instead, LUCELEC is overseen by various government agencies. The Cabinet of Saint Lucia and the Ministry for Public Service, Sustainable Development, Energy, Science, and Technology are responsible for developing policies for the energy sector and for energy sector planning. In June 2010, the Cabinet of Saint Lucia approved the National Energy Policy, which presents the government's plan to reform the energy sector and to lower the cost and price volatility of electricity.

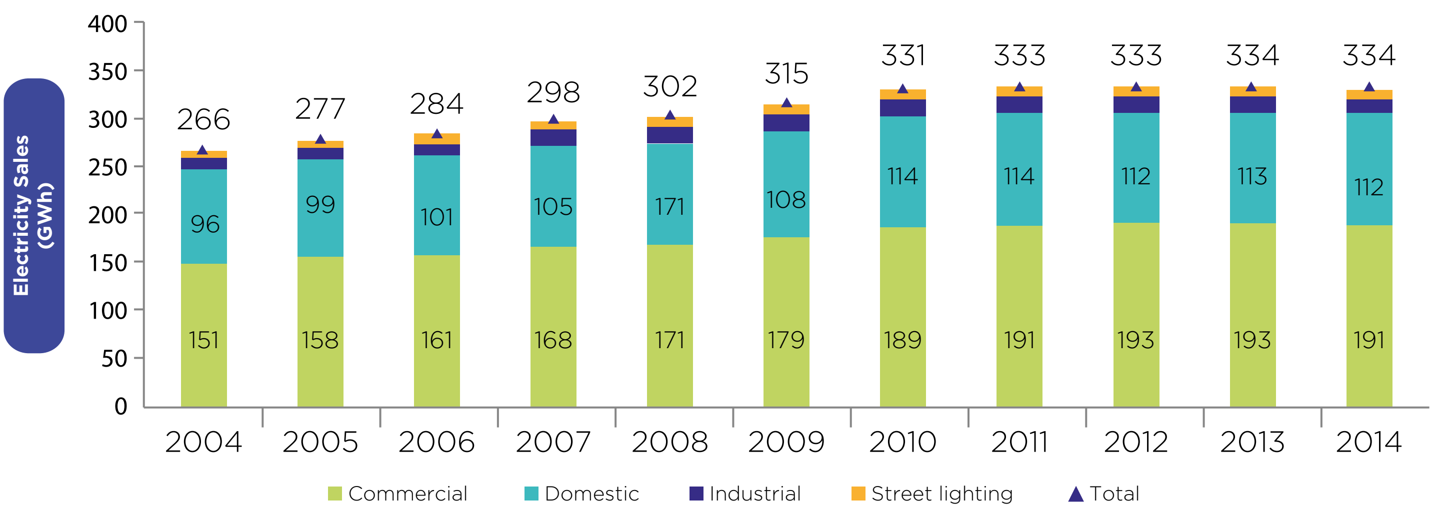
393. "St. Lucia Receives $2.8 mn for Geothermal Project," *Fox News Latino*, December 16, 2014, accessed January 5, 2015, http://latino.foxnews.com/latino/news/2014/12/16/st-lucia-receives-28-mn-for-geothermal-project/.

394. LUCELEC, 2014 Annual Report.

15.1.1 The electricity market in Saint Lucia

LUCELEC is one of the top-performing electricity utilities in the Caribbean and is the sole provider of electricity in Saint Lucia. It holds an exclusive license to generate, transmit, distribute, and sell electricity in Saint Lucia until 2045. Saint Lucia has almost universal coverage; LUCELEC provides electricity to 96 percent of households. Almost all electricity sold is generated using diesel generation—solar generation only makes up 100 kW of Saint Lucia's installed capacity. At the end of 2014, LUCELEC reported an installed diesel capacity of 86.2 MW and a peak demand of 57.2 MW.[395] LUCELEC's reserve margin—calculated as the difference between installed capacity and peak demand divided by total peak demand—was 51 percent in 2014.

FIGURE 15.1 Demand for Electricity in Saint Lucia by Sector, 2004–2014



Source: LUCELEC, Annual Reports 2004–2014.

In Saint Lucia, electricity demand has remained flat during the last five years. Total demand grew steadily from 2004 to 2010, but has remained at about 333.5 GWh per year since then. In December 2014, LUCELEC had 67,100 customers, consisting of 59,790 residential customers, 7,193 commercial customers, 98 industrial customers, and 19 street lighting customers. In 2014, the commercial sector consumed more than half of electricity (57 percent), followed by the residential sector (33 percent), the industrial sector (5 percent), and street lighting (3 percent).[396]

15.1.2 Key laws, regulations, and policies governing the sector

The electricity sector in Saint Lucia is governed by the Electricity Supply Act of 1994, which establishes the sector's structure and the tariff-setting mechanism. The ESA grants LUCELEC the exclusive right to supply electricity until 2045—a period of 80 years. In addition to the ESA, the sector's development is guided by the government's National Energy Policy (2010). The National Energy Policy establishes the government's plans to reform the energy sector and expand the supply of renewable energy to lower the cost and the price volatility of energy.

395. LUCELEC, 2014 Annual Report.

396. Ibid.

Policies in the energy sector

In June 2010, the Cabinet of Saint Lucia approved the National Energy Policy, which aims to use market forces to lower the cost of electricity by exploiting renewable energies and reducing Saint Lucia's dependence on imported oil. The policy also aims to achieve higher energy security and "minimize negative environmental effects from the energy sector."[397] The policy proposes the following reforms:

- **Updating renewable energy targets**—The policy establishes new renewable energy targets to 5 percent of the electricity generated in 2013, 15 percent in 2015, and 30 percent in 2020.
- **Opening the sector and encouraging private participation**—The policy establishes a plan for opening the sector. Under the plan, the government will allow the entry of IPPs. However, the government would need to amend the ESA to do so because the ESA gives LUCELEC exclusive license for electricity generation.
- **Establishing an independent regulatory commission for the electricity sector**—The policy proposes establishing a commission to regulate the electricity sector. The commission would be responsible for designing the tariff structure, setting tariff levels, monitoring standards on quality of service, and advising on issuing of licenses to IPPs. It would also establish and monitor the tendering processes for IPPs, and act as an arbitrator for disputes in the sector.
- **Reforming the tariff design**—The policy proposes reforming the tariff design. The new electricity tariff would be designed to be cost-reflective, include an indexation of fuel cost fluctuations, an adjustment for inflation, and an incentive factor for productivity improvements. The new tariff would also take into account the long-run marginal cost of supply for each customer category, the voltage level, and the costs for supplying electricity to consumers at different times of the day. In addition, cross-subsidies would be minimized, and the government would not be entitled to any special discounts.[398] In addition to the policy's proposal to establish an independent regulatory commission, Saint Lucia has been actively working towards establishing the Eastern Caribbean Energy Regulatory Authority (ECERA). If ECERA is implemented, it would serve as an advisor to national regulators.

In its 2014 Budget Statement, the government reaffirmed its commitment to expanding the use of renewable energy in Saint Lucia. Specifically, the government presented its plan for reforming the electricity sector and increasing the use of renewable energy. The 2014 Budget Statement includes the following objectives:

- Reforming the energy sector to reduce Saint Lucia's reliance on fossil fuels for generating electricity and reducing the cost of electricity to consumers
- Unbundling the generation segment and allowing IPPs to enter the renewable energy sector
- Producing 35 percent of total electricity generated from renewable sources by 2020[399]

Laws and regulations governing the electricity sector

The most important law in Saint Lucia's electricity sector is the ESA of 1994, which was amended in 1996, 2001, and 2006. The ESA is currently under review. The government's objective in revising the ESA is to create a legal framework that facilitates the participation of independent power producers and expands renewable energy. The government expects to have the Draft Electricity Supply Bill ready by September 2015.[400]

The ESA lays out the structure of the sector and sets out the tariff-setting mechanism. It grants LUCELEC the exclusive right for the generation, transmission, and distribution of electricity until 2045. However, one clause of the ESA allows the government to buy out this exclusive right in 2020 (after 55 years) if it provides two years' notice.[401]

397. Government of Saint Lucia, Ministry of Physical Development and the Environment, "Saint Lucia National Energy Policy," Article B-6, January 2010, accessed October 31, 2014, http://www.credp.org/Data/STL_NEP_Jan2010.pdf.

398. Ibid.

399. Government of Saint Lucia, Ministry of Finance, Economic Affairs, and Planning, "2014 Budget Statement," pp. 40–41.

400. Anthony Sammie, "Energy Sector Legislation," *Government of Saint Lucia Website*, August 4, 2015, accessed August 4, 2015, http://www.govt.lc/news/energy-sector-legislation.

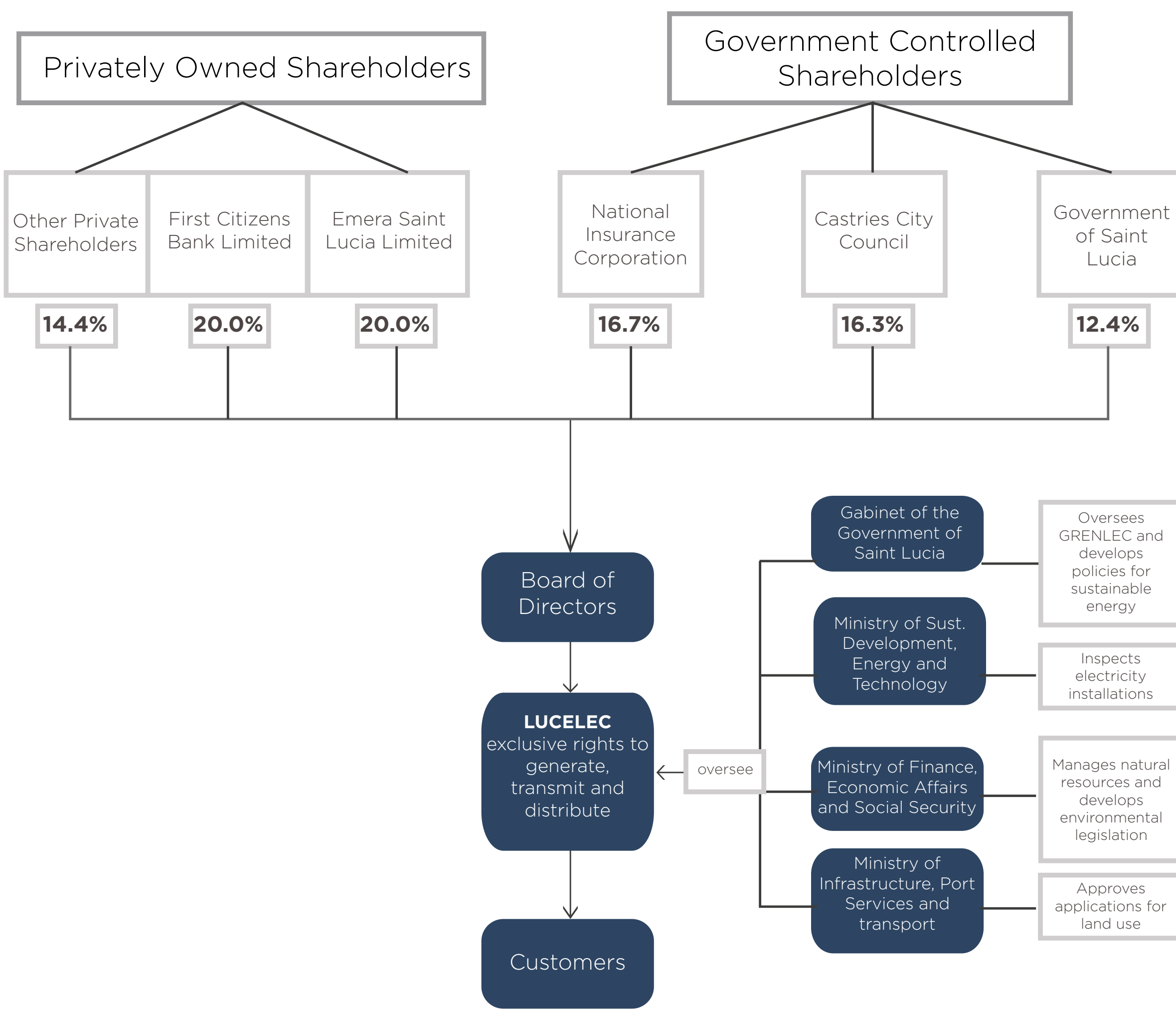
401. Government of Saint Lucia, "Electricity Supply Act," Chapter 9.02, Revised Edition of 2008, Part II, Sections 4–5. Chapter 9.02 of 2008 is a revised edition of the ESA, and contains a consolidation of the ESA of 1994 and its four amendments.

The ESA and its amendments establish the formula used to determine the tariffs that LUCELEC charges its customers.[402] The goal of the tariff formula is to cover the reasonable cost of providing the service while allowing a fair return on the capital invested in the business. The tariff is defined as the sum of two components: a basic energy rate and a fuel surcharge. The energy tariff is designed to allow LUCELEC to recover the cost of generating with diesel fuel. It does not have an explicit component that would allow LUCELEC to recover costs associated with generation from renewable energy or other thermal generation.[403] If geothermal generation were introduced in Saint Lucia, the government would need to modify the tariff formula to allow for cost recovery with other types of generation technologies.

15.1.3 Institutional structure of the electricity sector

LUCELEC, the vertically integrated utility, is responsible for providing electricity and has the exclusive right for the generation, transmission, and distribution of electricity. The Cabinet of Saint Lucia and the Ministry of Sustainable Development, Energy, Science, and Technology are responsible for developing policies for the electricity sector and for electricity sector planning. The electricity sector is overseen by various government agencies that are responsible for monitoring LUCELEC to ensure it complies with the regulations established in the ESA. **Figure 15.2** presents the relationships between the key entities in Saint Lucia's electricity sector.

FIGURE 15.2 Structure of the Electricity Sector in Saint Lucia



402. Government of Saint Lucia, "Electricity Supply Act," Chapter 9.02, Revised Edition of 2008, Part IV, Section 28.

403. In the ESA, Chapter 9.02 Revised Edition of 2008, Schedule 2 and Schedule 3 determine that the fuel to be used in the calculations is diesel fuel.

404. Micah George, "P.M. Calls on LUCELEC for Concessions," *The Voice*, accessed June 29, 2012, http://www.thevoiceslu.com/local_news/2008/july/10_07_08/PM_Calls_on_LUCELEC_for_Concessions.htm.

405. Judith Ephraim, "Geothermal Development in Saint Lucia" (Costa Rica Study Tour: March 2014).

Below we provide a more in-depth description of the major responsibilities in the electricity sector and the bodies responsible for carrying them out.

- **Policymaking**—The following two government agencies are responsible for policymaking in Saint Lucia:
  - **The Ministry of Sustainable Development, Energy, Science, and Technology** is responsible for monitoring the energy sector, carrying out energy planning, and developing energy policy. It recently appointed a person that will be responsible for coordinating any PPP initiatives in the energy sector. When the National Utilities Regulatory Commission is created (see "Regulation" below), the Ministry of Sustainable Development will also advise and provide strategic direction to the National Utilities Regulatory Commission. [406]
  - **The Cabinet of the Government of Saint Lucia** also plays an active role in the development of the sector. It prepared the National Energy Policy, which lays out the planned reform of the energy sector, and establishes new renewable energy targets.
- **Regulation**—There is no regulatory body in Saint Lucia. In the government's 2014 Budget Statement, the prime minister announced the government's intention to create the National Utilities Regulatory Commission, a multi-sector regulator for energy and water.[407] Until the commission is established, the electricity sector will continue to be regulated by statute. The ESA establishes how the tariff should be adjusted and provides some basic service standards that LUCELEC must meet. The government's role is limited to ensuring that LUCELEC complies with the law. The following government agencies are responsible for monitoring LUCELEC:
  - **The Cabinet of the Government of Saint Lucia** approves any sublicenses granted by LUCELEC to generate, transmit, distribute, or sell electricity. The Cabinet also has the power to revoke LUCELEC's license after the first 55 years (with a 24-month notice). [408]
  - The chief electrical engineer of the **Ministry of Infrastructure, Port Services, and Transport** is in charge of carrying out electrical inspections at commercial and domestic sites to ensure public safety.[409]
  - **The Ministry of Finance, Economic Affairs, Planning, and Social Security** is responsible for ensuring that LUCELEC follows the tariff determination guidelines established in the ESA.[410]
- **Generation, Transmission, and Distribution**—LUCELEC is a privately owned and vertically integrated utility with the exclusive license to generate, transmit, distribute, and sell electricity in Saint Lucia until 2045. In addition, LUCELEC is responsible for granting permits to customers to install distributed generators that use renewable resources and to sell the excess electricity to the grid. LUCELEC is also responsible for granting sublicenses for third parties that wish to generate, transmit, or distribute; however, no sublicense has been granted to date.

15.2 Status of Geothermal Development

The Government of Saint Lucia is in the early stages of geothermal development despite extensive exploration of its geothermal resources. The government has reached an agreement with Ormat to carry out surface exploration.[411] However, the government and Ormat have not yet finalized an agreement on how the later stages of the project will be developed because the quality of the resource in the area explored is unclear.

In 2014, the government restarted efforts to explore its geothermal resources. The government received US$2.8 million in grants from the World Bank and the New Zealand government.[412] The government and Ormat began surface exploration in 2015. One of the biggest challenges for geothermal development in Saint Lucia is that the island's most promising geothermal site is in a UNESCO (United Nations Educational, Scientific and Cultural Organization) World Heritage Site.

15.2.1 Resource potential and development

Saint Lucia's has an estimated geothermal potential of 75 MW.[413] If developed, this geothermal resource could potentially meet all baseload demand for electricity in Saint Lucia, which is about 35 MW.[414] However, this potential has not yet been proven through exploratory drilling.

The geothermal resources in the Sulphur Springs area of Saint Lucia have been explored extensively, but the quality of the resource in this area is unclear. Most of the exploration of the Sulphur Springs area was carried out during the 1970s and 1980s. During this time period, seven exploratory boreholes and two deep exploratory boreholes were drilled. The seven exploratory boreholes revealed that the geothermal resource in Sulphur Springs would be challenging to develop due to its low pH (around 2.8) and a high percentage of non-condensable gases. Neither of the two deep exploratory boreholes drilled was found to be suitable for commercial production. The first well had high temperatures, but was not permeable and was not productive. The second well provided superheated steam, but it was highly acidic and gas-rich. Thus, it was also deemed unsuitable for commercial production.[415]

Consultants have provided the government with different opinions on whether the Sulphur Springs area has commercially viable geothermal resources. The Compagnie Française pour le Développement de la Géothermie et des Energies Nouvelles (CFG) reviewed previous studies on the area and concluded that the Sulphur Springs–Terre Blanche zone is not suitable for commercial exploitation and thus should not be considered for further drilling. CFG identified new areas that should be explored for further survey. A 2014 report from the Japan International Cooperation Agency and West Japan Engineering Consultants, Inc. supports this conclusion. It states that the Sulphur Springs–Terre Blanche zone could be developed, but it would require specialized equipment and would be expensive. As a result, the report recommends exploring and developing new areas.[416] In contrast, the 2002 Morgan reinterpretation of the 1970s resistivity study confirmed the geothermal resources and found that the deep exploratory wells "just missed [the] reservoir."[417] The government is continuing to study this resource to determine what to do next. In 2014, the World Bank agreed to provide a US$2 million grant, which includes further assessing the Qualibou region by carrying out additional studies and reviewing previous studies.[418]

---

411. "St. Lucia Says Geothermal Exploration Will Begin in 2015," *Caribbean Journal,* December 18, 2014, accessed December 2, 2015, http://caribjournal.com/2014/12/18/st-lucia-says-geothermal-exploration-will-begin-in-2015/#.

412. "St. Lucia Receives $2.8 mn for Geothermal Project," *Fox News Latino*, December 16, 2014, accessed January 5, 2015, http://latino.foxnews.com/latino/news/2014/12/16/st-lucia-receives-28-mn-for-geothermal-project/.

413. World Bank, "Got Steam? Geothermal as an Opportunity for Growth in the Caribbean," Caribbean Knowledge Series, June 2013, accessed March 6, 2014, http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2013/06/21/000442464_20130621142703/Rendered/PDF/786080WP015.0G00Box377349B00PUBLIC0.pdf.

414. Judith Ephraim, "Geothermal Development in Saint Lucia" (Costa Rica Study Tour: March 2014).

415. This exploratory drilling was carried out by Merz and McLellan Co. in association with the Seismic Research Unit of the University of West Indies in Trinidad. This work was funded by the United Kingdom Overseas Administration (UKODA).

416. West Japan Engineering Consultants, Inc., "Study on Current Status of Geothermal Development in the Eastern Caribbean Islands," March 2014.

417. Judith Ephraim, "Geothermal Development in Saint Lucia" (Costa Rica Study Tour: March 2014).

418. "Tender: Geothermal Project Preparations in Saint Lucia, Caribbean," *ThinkGeoEnergy,* August 29, 2014, accessed November 6, 2014, http://www.thinkgeoenergy.com/tender-geothermal-project-preparations-in-saint-lucia-caribbean/.

Regardless, one of the biggest challenges for geothermal development in Saint Lucia is that the Sulphur Springs area is within a UNESCO World Heritage Site. There are limits to development that can be carried out within a World Heritage Site, and the World Heritage Committee advises "that power generation not be developed in the Sulphur Springs."[419] Developing a geothermal plant in Sulphur Springs could put the status of Saint Lucia's World Heritage Site in jeopardy.

In 2010, the government carried out its most recent effort to develop its geothermal resources. It signed a 30-year concession contract to develop the geothermal resource with UNEC, a subsidiary of Qualibou Energy Inc. A condition of maintaining the concession rights was that drilling must occur within 18 months of the concession signing date in 2010.[420] Since UNEC did not complete the drilling required, the government allowed Ormat to conduct exploration of the resource. Ormat would have to pay royalties to UNEC for using the exploration rights. In 2015, Ormat started surface exploration, carrying out 3G studies and slim-hole drilling.

15.2.2 Planned project

In 2014, the government restarted its efforts to explore and develop geothermal energy in the country and in 2015 began surface exploration.[421] The government and Ormat have an agreement in place to carry out the exploratory stage and have made significant progress to agree on a maximum PPA rate with LUCELEC.[422]The parties have not signed any agreements for the later stages of geothermal development (production drilling and power plant construction).

If exploratory drilling confirms the geothermal resource, the government would need to design and agree on a project structure for a 20–30 MW plant, reach an agreement with a project developer, and finalize guarantees on the PPA. LUCELEC has expressed its willingness to reach an agreement on the PPA.[423] **Figure 15.3** shows the government's progress in developing the project.

---

419. Judith Ephraim, "Geothermal Development in Saint Lucia" (Costa Rica Study Tour: March 2014).

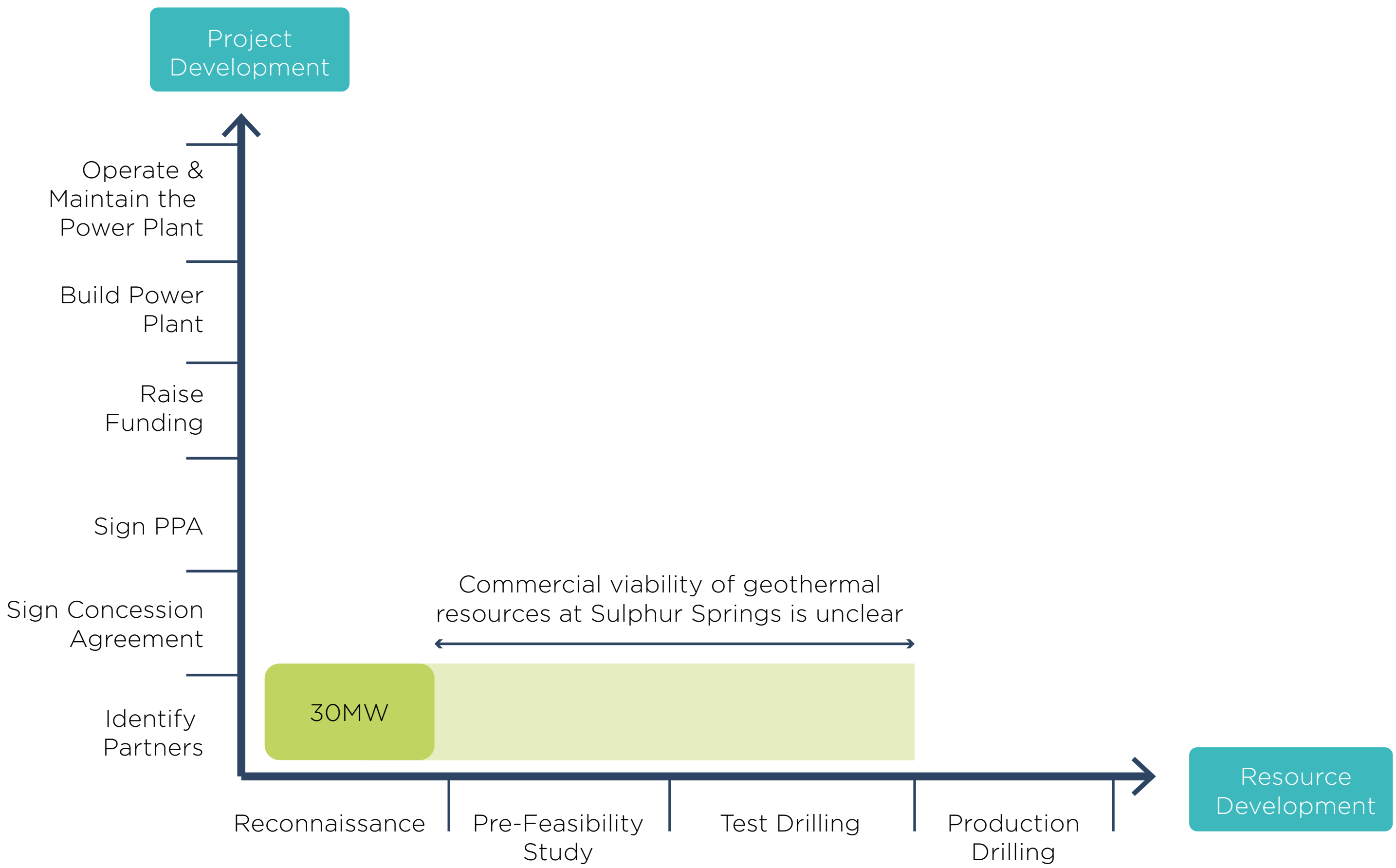
420. David McFadden, "Saint Lucia: Geothermal Energy Planned for Volcanic Caribbean Island," *The Huffington Post*, July 26, 2010, accessed May 22, 2013, http://www.huffingtonpost.com/2010/07/27/st-lucia-geothermal-energ_n_660401.html (no longer available).

421. "St. Lucia Receives $2.8 mn for Geothermal Project," Fox News Latino, December 16, 2014, accessed January 5, 2015, http://latino.foxnews.com/latino/news/2014/12/16/st-lucia-receives-28-mn-for-geothermal-project/; "St Lucia Installs Test Tower for Potential Wind Farm," *Caribbean 360,* April 17, 2015, accessed December 4, 2015, http://www.caribbean360.com/business/st-lucia-installs-test-tower-for-potential-wind-farm.

422. "St. Lucia Says Geothermal Exploration Will Begin in 2015," *Caribbean Journal,* December 18, 2014, accessed December 2, 2015, http://caribjournal.com/2014/12/18/st-lucia-says-geothermal-exploration-will-begin-in-2015/#.

423. LUCELEC, "LUCELEC Welcomes GOSL's Efforts to Evaluate Geothermal Resource," February 13, 2014, accessed December 4, 2015, https://www.lucelec.com/content/lucelec-welcomes-gosls-efforts-evaluate-geothermal-resource.

FIGURE 15.3 Status of Planned Geothermal Project



The government has not disclosed the proposed project structure for geothermal development nor any estimates for the cost of developing a power plant. Preliminary estimates suggest that the cost of developing a 20 MW project would be about US$152 million.[424] Those estimates include preliminary studies, exploration, production wells, and the construction of the plant. The construction of transmission lines and access roads would increase the total cost to about US$168 million.[425] Other estimates show the cost of developing a geothermal resource and building a 20 MW geothermal power plant would be approximately US$125 million.[426] Since the government had an overall deficit of US$208.88 million in FY 2013/14, the government will almost certainly need outside financing to develop the power plant.[427]

---

424. IDB, "Sustainable Energy Facility (SEF) for the Eastern Caribbean: Loan Proposal RG-L1071, RG-G1009, and RG-G1004" (2015), accessed December 2, 2015, http://www.iadb.org/en/projects/project-description-title,1303.html?id=RG-L1071.

425. Assumptions based on building 5km of access roads, 10 miles of T&D lines, and no substations with assumed costs of US$2.1 million per km of access road and US$960,000 per mile of transmission line. Cost estimations for construction of transmission lines and access roads based on the following sources: Western Electricity Coordinating Council, "Capital Costs for Transmission and Substations," February 2014, accessed June 22, 2015, https://www.wecc.biz/Reliability/2014_TEPPC_Transmission_CapCost_Report_B+V.pdf; World Bank, "ROCKS: Road Cost Knowledge System," 2002, accessed June 22, 2015, http://www.worldbank.org/transport/roads/rd_tools/rocks_main.htm.

426. West Japan Engineering Consultants, Inc., "Study on Current Status of Geothermal Development in the Eastern Caribbean Islands: Field Trip Report and Study Tour in Costa Rica," March 2014. This estimate includes the costs of developing the steam field, physical contingency, and consultant fees and administrative expenses.

427. Government of Saint Lucia, Ministry of Finance, Economic Affairs, and Planning, "2014 Budget Statement."

The government will receive help from numerous sources to determine what to do next. This support will help the government determine the quality of the geothermal resource, complete surface exploration, and negotiate with the developers that have expressed interest. In December 2014, the government received US$2.8 million in grants from the World Bank and the New Zealand government for its geothermal project.[428] This funding is being used to assess the resource at the Qualibou region by carrying out additional studies and reviewing previous studies, and also to provide transaction and regulatory support.[429]

In addition, the Government of New Zealand and the Clinton Climate Initiative have agreed to provide Saint Lucia with technical support for geothermal development, including training.[430] Also, the Department for International Development of the United Kingdom (DFID) has expressed interest in providing funding to drill 1–2 exploration wells.[431]

15.3 Recommended Financial and Legal PPP Structure

We recommend the government develop the power plant by establishing a jointly owned SPV with a qualified private developer. The government would sign a concession contract through which it will assign the responsibility for carrying out production drilling and building, operating, and financing a geothermal plant. The government would also need to support the negotiation of a PPA between the SPV and LUCELEC. This arrangement will allow the government to take advantage of the private sector's knowledge, resources, and financing to develop geothermal resources. The government may need to take an active role to mitigate some of the risks that the project faces. Specifically, the government may have to help mitigate the project's resource risk and the risks due to the fact that the most promising geothermal resource is located in a UNESCO World Heritage Site

15.3.1 Structure of the PPP

To develop a geothermal plant, we recommend the Government of Saint Lucia establish an SPV that is jointly owned by a private developer and the government. Under this structure, there would be three main agreements. The exploration concession previously granted to UNEC would remain, but the SPV would be transferred the responsibility for developing the resource. The government would sign a concession contract with the SPV to carry out production drilling and to design, build, own, operate, and finance the geothermal power plant. The SPV would sign a PPA with LUCELEC. The concession and the PPA will be for a period of about 20 to 30 years, which will likely be long enough for the SPV to repay its debts and the private developer and government to earn the required return on equity. The recommended PPP structure is shown in **Figure 15.4.**

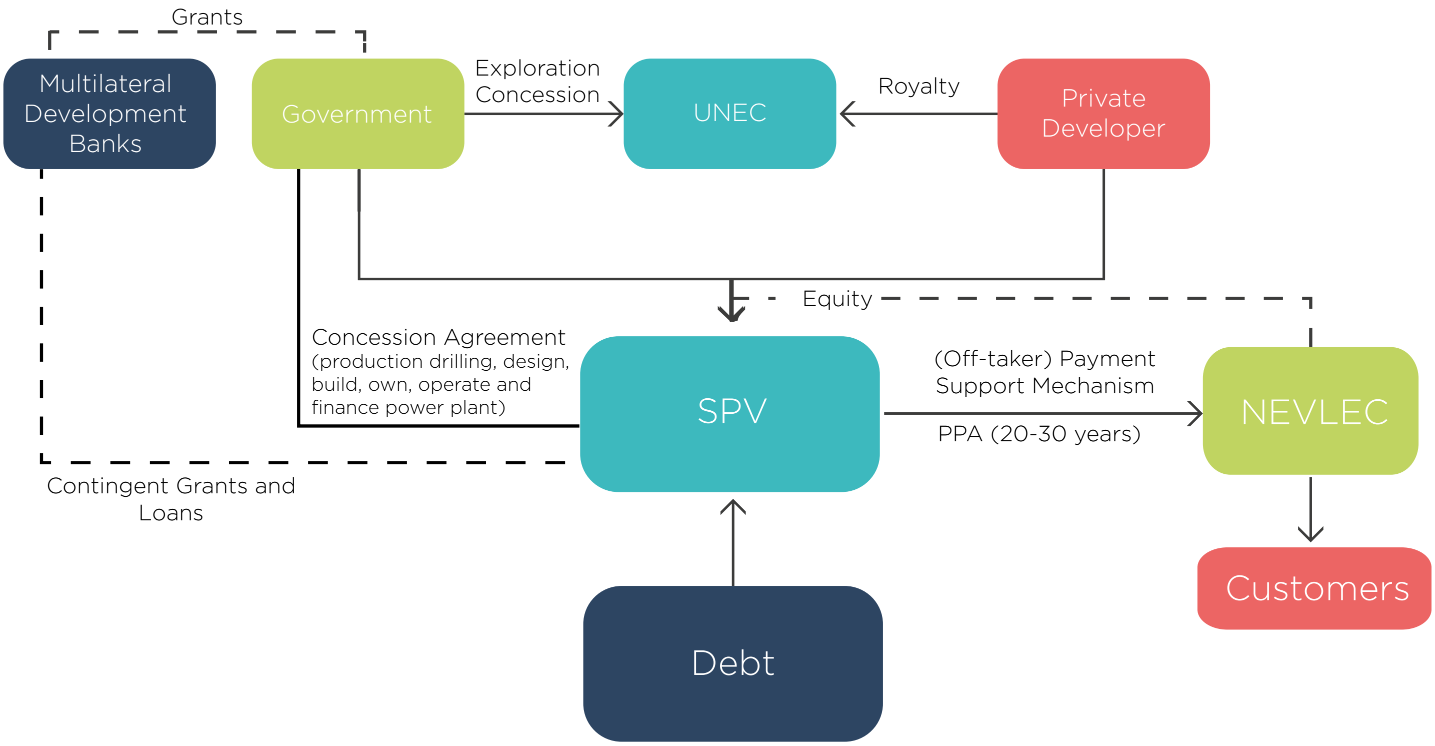
428. "St. Lucia Receives $2.8 mn for Geothermal Project," *Fox News Latino*, December 16, 2014, accessed January 5, 2015, http://latino.foxnews.com/latino/news/2014/12/16/st-lucia-receives-28-mn-for-geothermal-project/.

429. "Tender: Geothermal Project Preparations in Saint Lucia, Caribbean," *ThinkGeoEnergy*, August 29, 2014, accessed November 6, 2014, http://www.thinkgeoenergy.com/tender-geothermal-project-preparations-in-saint-lucia-caribbean/.

430. Caribbean Media Corporation, "St. Lucia and New Zealand Sign Geothermal Energy Contract," *DaVibes*, September 3, 2014, accessed October 29, 2014, http://www.dominicavibes.dm/news-141870/.

431. Bernard Hill, Project Director & Energy Manager at Hawkins Infrastructure, email message to author, November 25, 2014.

FIGURE 15.4 Recommended PPP Structure for Saint Lucia



Some lenders may require additional mechanisms that enhance the quality of the cash flows of the project. In particular, it may be necessary to include a payment support mechanism that backs LUCELEC's payments under the PPA. That support mechanism would reduce the risk of the project's revenues and, thus, make the project more bankable. The mechanism could be implemented in various ways. Some of the options include establishing a liquidity facility (such as a trust fund or escrow account) or third-party guarantees (offered by donors or financial institutions); see the recommended structure in Section 9.2.1 for more details.

The recommended structure includes a dotted line between LUCELEC and the SPV to indicate that LUCELEC could potentially participate in the SPV as a private partner, in addition to the private developer. LUCELEC has indicated it is open to discuss its more active participation in the project.

This PPP structure would involve participation from the following key actors:

- **Private developers (potentially Ormat) and the SPV**—Private companies and the government would establish the SPV to develop the resource and the geothermal power plant. This SPV would have a concession from the Government of Saint Lucia to develop the resource and design, build, own, operate, and finance the geothermal power plant. The SPV would also have a PPA with LUCELEC for selling its electricity. The concession and the PPA should cover the same time period. They would last for about 20 to 30 years—long enough for all debts to be repaid and for the project developers to earn the return on equity required. The proposed SPV would be owned by the private developers and the government. The planned project would be financed with both equity contributions from the owners of the SPV and with debt financing.

  A partner with specialized technical expertise is necessary for the successful development of a geothermal plant because of the uncertainty of Saint Lucia's geothermal resource. The private developer can also provide and raise the financing needed for developing the power plant.

- **The government**—The main responsibilities of the Government of Saint Lucia are to sign a concession agreement with the SPV, establish the SPV with its private partner, and, potentially, to continue investing in exploration efforts. The role of the government may change depending on whether the geothermal resource in Sulphur Springs is found commercially viable. If the geothermal resources in Sulphur Springs are commercially viable, the government would be a partner to the project. If the geothermal resource in Sulphur Springs is not found commercially viable, it may make sense for the government to provide funding, or find donors to provide funding, for surface exploration and exploratory drilling in other areas. This is because the project at a new area will be riskier and may not be attractive to investors.
- **LUCELEC—**LUCELEC would purchase the electricity produced by the geothermal power plant. LUCELEC would sign a PPA with the SPV, which would need to have a duration that matches the duration of the concession agreement. LUCELEC may also partner with the government and the private developers in establishing the SPV.
- **Multilateral development banks**—These banks would play a key role in this project by providing funding for the development of the geothermal project. The funding may be used for exploratory studies and drilling in Sulphur Springs or it may be used to provide loans for the power plant. If the resources in Sulphur Springs are not commercially viable, the funding could be used to explore new areas. This funding would reduce the cost of the project and make it more attractive to project developers.
- **Banks and other entities that provide debt financing**—Banks and other entities would provide commercial debt financing for the project. It is likely that they would be unwilling to loan money to the project until the exploratory drilling of a commercially viable resource is completed, a concession agreement is in place, and a PPA has been signed with LUCELEC.

The proposed project structure can be successful because, if the resource is proven, the project is likely financeable. The proposed concession agreement and PPA would ensure that the project has the necessary revenue, that project debt can be paid, and that investors receive their expected return on equity. The government's experience finding a partner and developing the necessary agreement for the previous project shows that projects in Saint Lucia can attract investors. However, given the unique circumstances in Saint Lucia, this project faces several large risks, which are described in Section 15.3.2.

There are also two considerations that we recommend the government note as it begins implementing this project. First, the project developer should have a proven track record. Given the role of the project developer in the proposed PPP structure, the project developer must have both the technical expertise and financial resources necessary to ensure the success of the project. The second consideration is that the government competitively bid the SPV and/or the works and services. Otherwise, the projects may face difficulty accessing concessionary financing from multilateral banks.

15.3.2 Key risks and mitigation measures

The proposed geothermal project has several major risks because it is still in the early stages of geothermal exploration and no project agreements have been signed. **Table 15.1** provides an overview of all project risks.

Table 15.1 Allocation of Risks for the Proposed PPP Structure

Risk	Impact of Risk	Party That the Risk Is Assigned To	Proposed Measure for Mitigating the Risk
Market, Demand, or Volume RiskPotential	Low/Medium	LUCELEC	This risk would be mitigated by a PPA and LUCELEC's ability to make its payments under this PPA (because of its strong financial performance).
Resource Risk	High	SPV, the multilateral development banks, and the government	Selecting a project developer with the necessary technical expertise would be a key for reducing resource risk. Funding from multilateral development banks could help reduce the costs of exploratory drilling.
Construction Risk	Medium	SPV and, possibly, the construction company that builds the plant	The SPV can hire a company to build the plant and incorporate penalties if the plant is not completed on time or milestones are not achieved as contractually planned.
Technical Risk	Low	SPV	None. The risk is low and this is a proven technology.
Operating Risk	Low	SPV	None. The risk is low.
Political and Social Risk	Medium/High	SPV	The Sulphur Springs area is in a UNESCO World Heritage Site. The government has been advised not to develop a plant in this area. To do so, the government will need to use more expensive drilling techniques or explore new areas.
Environmental Risk	Low	SPV and the government	This risk can be reduced by carrying out an EIA. The EIA would allow the government to assess the risk of the geothermal project and propose an action plan to mitigate the risks identified.
Financing Risk	Medium/High	SPV and the government	The financial risk for the project is reduced through the PPA from LUCELEC, the concession agreement, and, potentially, financing from development banks. Also, if electricity prices are reduced through the use of geothermal energy, the public will likely support the project.
Regulatory Risk	Low/Medium	Government	The government is responsible for making any necessary changes to the legal and regulatory framework to enable the development of the project. Since those changes take time, the parties to the project can draft clear rules governing the sustainable exploitation of the resource and the operation of the power plant in the project agreements (concession, PPA, others).

We describe the largest risks for the project and their proposed mitigation measures in more detail below.

- **A commercially viable resource cannot be identified; or identifying and developing a production well is more expensive than expected (Resource Risk)**—The largest risk for geothermal development in Saint Lucia is the resource risk. The geothermal resources explored in Sulphur Springs may not be suitable for commercial development or may be expensive to develop.

  To mitigate this risk, the government is receiving technical assistance from multilateral development banks to review the studies on the Sulphur Springs area. In addition, we recommend the government seek a project developer with a proven record of developing geothermal resources and who has experience developing geothermal resources in challenging areas.

  Another important way to mitigate this risk is through the financial support of multilateral development banks. If the geothermal resource in Sulphur Springs must be explored further, the multilateral development banks could help reduce the risk through providing contingent grants. Under this arrangement, the multilateral development banks would provide debt funding for the project, whose repayment would depend on the success of the drilling. This means that the project will have to repay the entire loan if the drilling is successful, but only a portion or none if the drilling is not. This reduces the resource risk faced by project developers.

- **The government may face opposition if it decides to develop the geothermal resources that are located in the UNESCO World Heritage Site (Political and Social Risk)**—Sulphur Springs is located within a UNESCO World Heritage Site and the government has been advised not to develop a power plant within the site. If the government decides to proceed with developing a geothermal plant in this area, it may face opposition from the international community and bodies involved in the tourism sector in Saint Lucia.

  The best way to mitigate this risk is to develop geothermal resources outside of the UNESCO World Heritage Site. However, if the government decides to develop a geothermal plant in the Sulphur Springs area, we recommend it take several steps to mitigate this risk. It could find a project developer that has experience in using drilling techniques that would avoid compromising the protected area. It could also begin to actively engage with the tourism industry and UNESCO to help them understand the planned development and how the UNESCO World Heritage Site will be protected.

- **The government cannot find a suitable project developer or cannot agree on the terms of the concession or other project documents (Market Risk)**—One of the key risks for geothermal development in Saint Lucia is that the government may not be able to find a project developer with the skills required, or that the government and the project developer will not agree on the terms of the concession. As mentioned earlier, we recommend the government find a project developer with a proven track record in geothermal development, experience developing challenging areas, and access to financial resources. While the government states that it has received a proposal from an interested developer, the proposed terms are unknown.

  To mitigate this risk, the government is receiving support with the negotiation of project agreements from multilateral development banks. The government may also be able to use financing from multilateral development banks to further explore its geothermal resources and reduce the project's costs. This would allow it to develop a project that is more attractive to potential bidders.

15.3.3 Strategy for engaging key stakeholders

Given the risks of the geothermal project and the early stage of its development, we recommend that the government actively consult stakeholders. Stakeholder inputs are needed to help the government develop a financeable and politically and socially acceptable project.

We recommend the government engage several other stakeholders to ensure that the project is socially and politically acceptable. This would require that the government actively engage the public, UNESCO, and the tourism industry. This is because the government would need to ensure that the development of a geothermal plant does not cause Saint Lucia to lose its UNESCO World Heritage Site or hurt the tourism industry. Regardless of where the government decides to build the geothermal plant, consulting these stakeholders will help reduce the chance that this will happen.

Also, to ensure that the project is financeable, we recommend the government consult with:

- **Potential project developers (potentially Ormat)**—The government could regularly consult potential project developers to ensure that they are aware of the opportunity to invest in Saint Lucia, to identify and address any major concerns that project developers may have, and to ensure that the project is sufficiently attractive to investors. The government would also assess the capacity and expertise of the project developers, potentially Ormat, to carry out a project like that planned in Saint Lucia. Consulting project developers before procuring a concession agreement or finalizing the project structure can allow the government to structure a good project and to get the most attractive offer.
- **LUCELEC**—We recommend the government consult and work with LUCELEC to develop a PPA. A PPA is essential for the success of the geothermal project. Since LUCELEC is privately owned, the government cannot simply require LUCELEC to sign the PPA. The government could help the SPV negotiate with LUCELEC to develop a PPA that LUCELEC is interested in signing. In particular, this PPA should provide LUCELEC with a way to recover the PPA rate it will pay to the SPV and the costs of stranded assets. One negotiating tool for the government is that the ESA allows the government to buy LUCELEC's exclusive right for generation, transmission, and distribution in 2020 (after 55 years) if it provides two years' notice.[432]
- **Multilateral development banks**—We recommend the government work with multilateral development banks so that it receives technical and financial assistance. Specifically, the government would need help to determine whether it can develop Sulphur Springs. If it will develop Sulphur Springs, multilateral development banks can provide concessionary financing. If not, the government may need financial support to explore other areas for geothermal development. In either case, multilateral development banks would be able to provide resources more quickly if they are kept abreast of the project's developments.

432. Government of Saint Lucia, "Electricity Supply Act," Chapter 9.02, Revised Edition of 2008, Part II, Sections 4–5.

15.4 Recommended Changes to the Legal, Institutional, and Regulatory Framework

The government will need to make significant changes to the legal, institutional, and regulatory framework to allow for geothermal development and to implement the National Energy Policy. Some of the changes may be difficult to implement because LUCELEC is privately owned and has an exclusive license to generate, transmit, distribute, and sell electricity. As a result, issuing a license to a geothermal developer would require the support of LUCELEC or would require that the government amend the ESA.

At a minimum, we recommend the following changes to the legal, institutional, and regulatory framework to allow for the successful implementation of the geothermal project:

- **Establish a process for the geothermal power plant to obtain a license.** As mentioned above, the ESA of 1994 provides LUCELEC an exclusive right to generate electricity and provides it with the power to issue sublicenses. If the government wants to issue a license to the geothermal power plant directly, it would need to amend the ESA. Otherwise, it would need to obtain support from LUCELEC, which may want to be compensated for allowing another entity to generate electricity. Regardless of who grants the licenses, there would need to be a process in place to apply for and to obtain a license.
- **Ensure tariffs reflect the cost of producing electricity with geothermal generation.** The tariffs in Saint Lucia are set through a formula established in the ESA. The tariffs only allow LUCELEC to recover the cost of generating with diesel. The government would need to review and amend this formula to ensure that the tariff allows LUCELEC to recover the full cost of providing service at least-cost, regardless of the technology or fuel in use, and also that it reflects any reductions in the costs of electricity generation. The government and LUCELEC would need to agree on the adjusted tariff formula before project agreements are signed.
- **Establish a clear framework governing geothermal resources.** Saint Lucia would need a legal framework that assigns ownership of geothermal resources, establishes a process for granting licenses to develop geothermal resources, and assigns responsibility for monitoring geothermal resources to a government body. One possible way to establish this framework is to approve the draft Geothermal Resources Development Bill of 2011, which was developed with funding from the Caribbean Sustainable Energy Program.
- **Establish a regulator.** We recommend the government proceed with its plan of establishing the National Utilities Regulatory Commission. The commission would be responsible for some of the regulatory functions addressed above as well as other responsibilities. For example, the commission would set and regulate LUCELEC's rates. As such, the commission would be responsible for ensuring that LUCELEC is able to recover its cost of service with geothermal generation. The commission could also be responsible for monitoring the geothermal resource, although environmental regulation is not always within the jurisdiction of the economic regulator. Establishing a regulator responsible for these functions is one way to centralize these responsibilities. If the commission has sufficient autonomy from other government agencies and has the resources to carry out its work, centralizing these functions will ensure these functions are executed capably.

Drafting, reviewing, and approving the laws and regulations that would address these changes takes time to implement. The first draft of the Geothermal Bill was prepared in 2011 and by November 2015 had yet to be approved (see Section 15.1.2).

Another way to address some of these changes is to establish regulation through contracts. For example, to ensure that tariffs for end customers reflect the (lower) costs of producing electricity through geothermal generation, the PPA that the SPV signs with LUCELEC could establish the formula used to determine the tariffs LUCELEC charges customers. Similarly, the agreements between the government and the private partners could include obligations that ensure the protection and sustainable development of the geothermal resource. For example, the agreement can mandate that an independent expert carry out periodic evaluations to monitor the environmental impact of the power plant. Since regulatory functions in Saint Lucia are spread across various government agencies, if a regulator is not established a committee could be formed to monitor the SPV's compliance with contractual obligations. Any dispute arising from failure to adhere to contract obligations could be handled by a regular court, an administrative court, or a special expert panel as applicable.

Establishing regulation through contracts would only serve as a short-term solution to prevent delays in project implementation. There are some regulatory functions that cannot be covered through contracts and for which regulations and laws will need to be established. For example, the government will still need to develop the process through which licenses to establish a geothermal plant are obtained.

15.5 Economic and Financial Analysis of the Geothermal Project

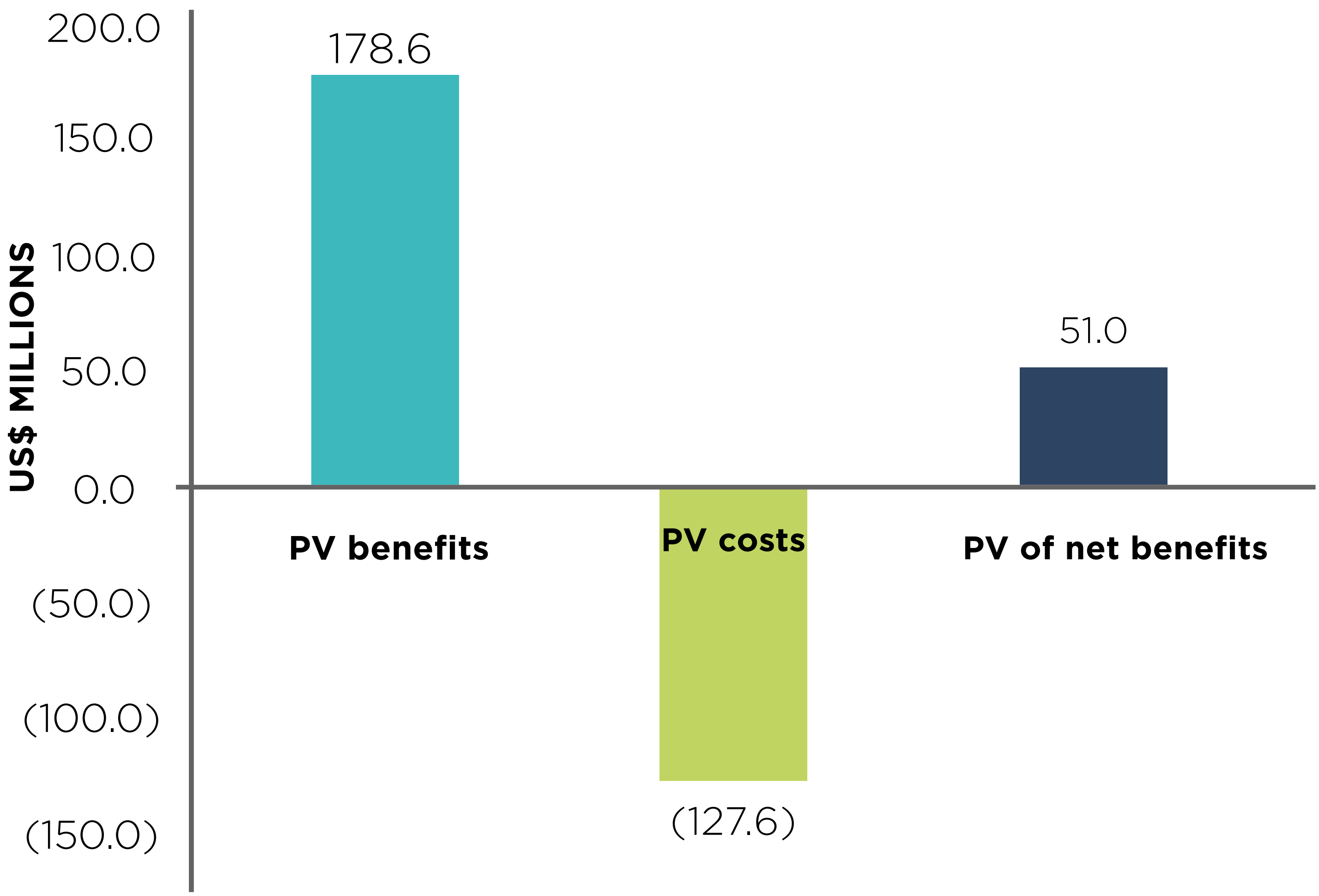
In this section, we assess whether the geothermal project in Saint Lucia is economically and financially viable. We first perform a cost-benefit analysis to determine whether the geothermal project generates net economic benefits to the country. We then use the discounted cash flow method to evaluate whether the geothermal project is financially viable to investors. We conclude that the geothermal project is economically and financially viable. Therefore, we recommend the government and investors proceed with implementing it. We present our analysis and results as follows:

- Cost-benefit analysis (Section 15.5.1)
- Financial analysis (Section 15.5.2)

15.5.1 Cost-benefit analysis

We perform a cost-benefit analysis to determine whether the geothermal project is economically viable. We conclude that Saint Lucia's geothermal project is economically viable and increases social welfare. The present value of the project's net economic benefits is positive and equal to US$51 million **(Figure 15.5)**. Therefore, the government and donors should proceed with developing the project.

FIGURE 15.5 Present Value of Net Economic Benefits of Saint Lucia's Geothermal Project



To determine the economic viability of the geothermal project, we estimate its net economic benefits for a period of 40 years. Net economic benefits equal the economic benefits minus the economic costs of the project. Economic benefits include savings in generation costs (because generating electricity from geothermal resources can cost less than from fuel oil or diesel), and reductions in CO_2 emissions. Economic costs are the capital expenditures needed to complete all project stages. We then bring the economic benefits and costs to present value (PV) with a social discount rate of 12 percent (in real terms).[433] The geothermal project is economically viable if the PV of the project's net benefits is positive—economic benefits outweigh economic costs. Further details about the assumptions and methodology we use are presented in Appendix A.

15.5.2 Financial analysis

We use the discounted cash flow (DCF) method to determine whether the geothermal project in Saint Lucia is financially viable for equity investors. We conclude that the geothermal project allows the equity investors to earn a 15 percent real rate of return when the PPA rate is about US$0.17/kWh. This PPA rate is the tariff at which the geothermal projects would need to sell each kWh of electricity to be able to service their debts and provide equity investors with a 15 percent real return. This PPA rate is feasible to implement, because it is significantly lower than the current electricity tariff from fuel oil generation of US$0.32/kWh.[434] The final PPA rate will be determined through negotiations between the partners of the project.

Table 15.2 Financial Results of Geothermal Project

NPV to Equity Investors (US$ millions)	IRR to Equity Investors (Real)	PPA Rate (US$/kWh)
0	15%	0.17
7.2	18%	0.19
16.2	21%	0.21

Notes: The IRR is Internal Rate of Return of the cash flows to equity investors. We assume a 15 percent real discount rate for equity cash flows.

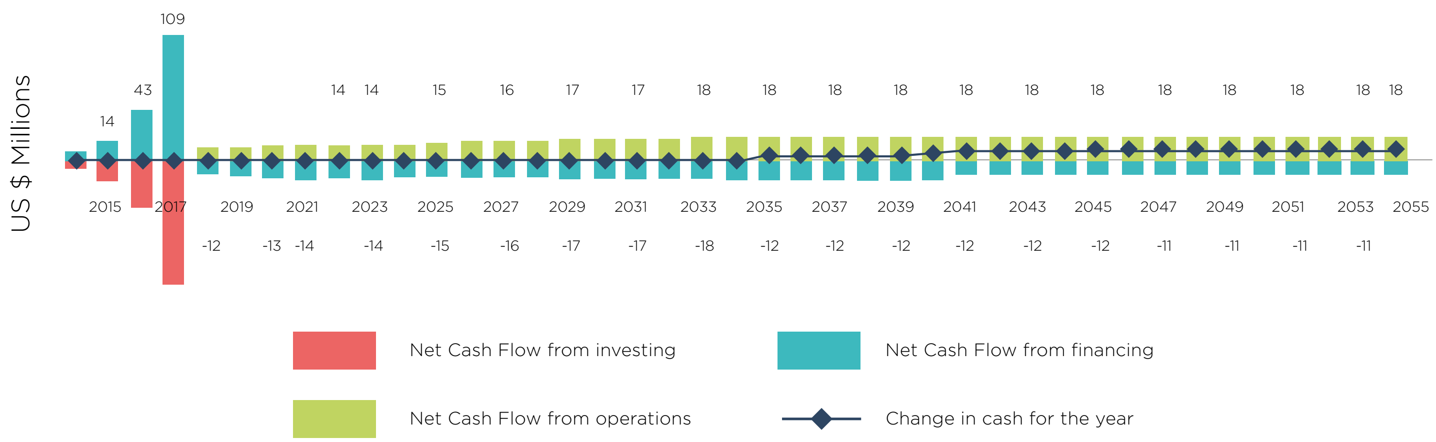
In this section, we present the estimated cash flows from the geothermal project. The DCF methodology we use and our main assumptions are in Appendix B.

Cash flows from the geothermal project

In **Figure 15.6**, we present the projected cash flows of the geothermal project for a PPA rate of US$0.17/kWh. Cash flows from financing are positive from 2015 to 2018 and are directed towards financing the capital expenditures (investments). The highest capital expenditures occur in 2018, when the power plant is under construction. When the power plant begins operations in 2019, the cash flows from operations become positive and are used for repaying debt and paying dividends out to equity investors.

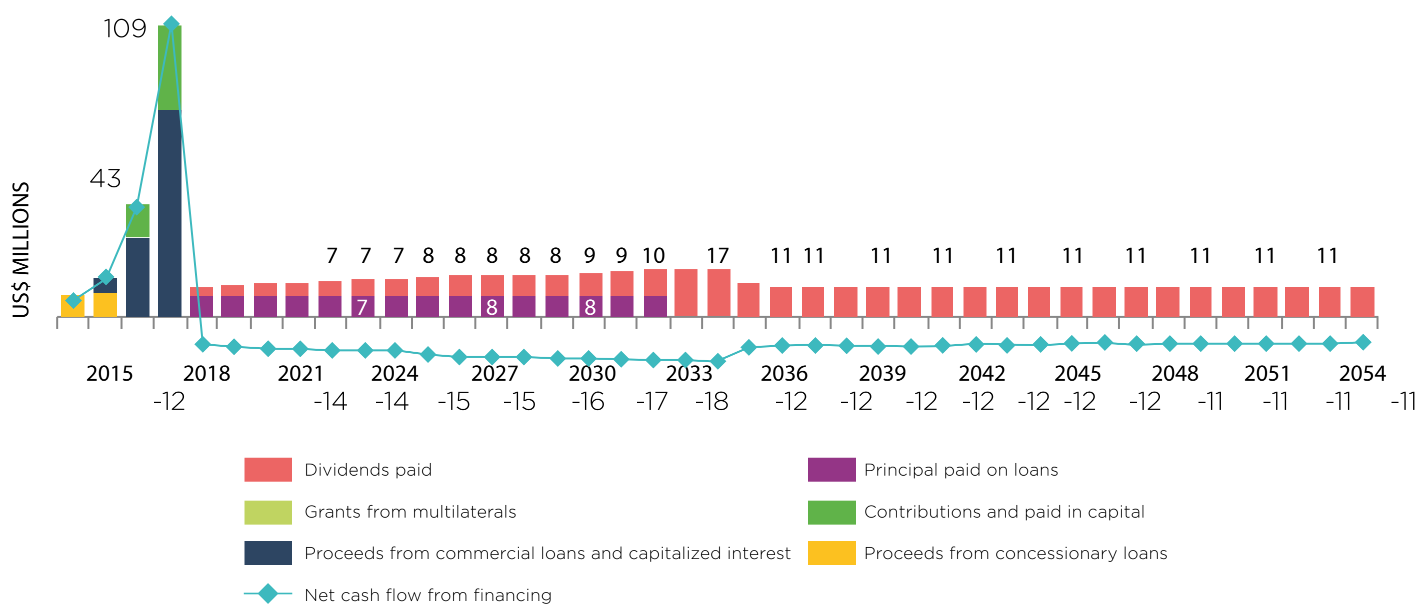
433. IDB, "Guidelines for the Economic Analysis of IDB-Funded Projects," June 2012, http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=36995807.

FIGURE 15.6 Cash Flows of the Geothermal Project



The majority of cash flows from financing from 2015 to 2016 come from concessionary loans and grants from multilateral development banks **(Figure 15.7)**. Concessionary financing is directed towards financing the riskier stages of geothermal development that occur at the beginning of the project—pre-investment and exploration. In 2017 and 2018, commercial debt and equity are included to finance the production drilling and power plant construction. Once the power plant begins operations in 2019, the cash flows from operations are directed towards repaying the debt and paying out dividends. The net cash flows from contributions and paid-in capital and dividends paid are the cash flows to the equity investor, which we discuss below.

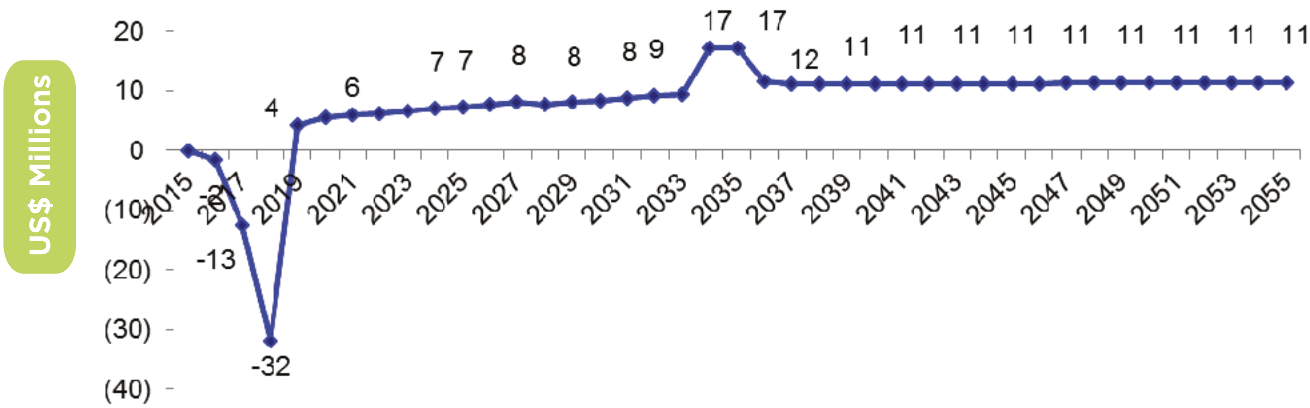
FIGURE 15.7 Financing Cash Flows of the Geothermal Project



The cash flows to the equity investors are presented in **Figure 15.8**. The cash flows to the equity investor are negative during 2016 to 2018, when the equity investors make their paid-in contributions to finance a portion of the capital expenditures. By 2019, the income from operations becomes large enough to pay for operating costs, cover working capital, and service debt.

The remaining cash flows are the cash available to equity investors. As payout policy we assumed that dividends are equal to the minimum of the cash available to equity and retained earnings, subject to retained earnings not falling below zero. As further debt payments are made, the principal amount is further reduced and the cash flows to the equity investors increase.

FIGURE 15.8 Cash Flows to Equity Investors from the Geothermal Project



Appendix A: Cost-Benefit Analysis Methodology and Assumptions

The objective of the cost-benefit analysis methodology is to determine whether a project is economically viable by estimating the geothermal project's net benefits. To do so, the present value (PV) of the project's net benefits is calculated. If the PV of the net benefits is positive, we conclude that the project is economically viable and increases social welfare.

Table A.1 shows our main assumptions for the cost-benefit analysis of the geothermal projects.

Table A.1 Assumptions for Cost-Benefit Analysis

Variable	SVG	DOM Phase 1	DOM Phase 2	GRE	NEV	SK	SL
Plant size (MW)	10	10	110	10	10	25	20
Plant availability (%)	85						
Capex (US million)	96.3	67	531	102.3	92.1	136	168.3
Operating cost of electricity from geothermal generation (US$/kWh) [435]	0.02	0.02	0.01	0.02	0.02	0.02	0.02
Social cost of one ton of CO_2 emissions (US$/t$CO_2$)[436]	10						
Tons of CO_2 emissions per MWh of electricity produced from fuel oil (No. 2) (tCO_2/MWh) [437]	0.76						
Average avoided cost of fuel oil generation (US$/kWh) [438]	0.25	0.26	0.26	0.28	0.25	0.25	0.25

To calculate the net benefits of the projects, we subtract the PV of the project's costs from the PV of the project's benefits. We use a social discount rate of 12 percent (in real terms), which is the rate that the IDB recommends be used in all IDB projects.[439]

We estimate the economic benefits and costs of the geothermal projects as follows:

Economic costs:

- **Capital Expenditures (Capex)**—These are the capital investments needed to complete the project stages that are pending for each specific project. As such, the costs included vary by project. For example, for the projects in Saint Vincent and the Grenadines, Grenada, Saint Kitts, Nevis, and Saint Lucia, we include the costs for completing the exploration stage (test drilling) and the field development stage (production drilling and power plant construction) and building the transmission and distribution grid and access roads. For Phase 1 of the project in Dominica, we only include the power plant construction costs and building the transmission and distribution grid and access roads, whereas for Phase 2 we also include costs for production drilling and for building the undersea interconnection cables.

Economic benefits:

- **Savings in generation costs**—Generating electricity from geothermal resources can potentially cost less than generating electricity from fuel oil. Therefore, the country will save in generation costs by replacing fuel oil generation with geothermal generation. We estimate the savings to the country as the difference between the Total Avoided Cost (TAC) of fuel oil generation and the Total Operating Costs (TOC) of geothermal generation. We use the following formulas to make this calculation:

$$TAC\ (US\$) = \text{Avoided Cost of Fuel Oil Generation}\ \frac{(US\$)}{(kWh)} \times \text{Generation from Geothermal}\ (kWh)$$

$$\text{Avoided Cost of Fuel Oil Generation}\ \frac{(US\$)}{(kWh)} = \frac{\text{Total Fuel Cost}\ (US\$)}{\text{Total Energy Sold}\ (kWh)}$$

$$TOC\ (US\$) = \text{Operating Costs from Geothermal}\ \frac{(US\$)}{(kWh)} \times \text{Generation from Geothermal}\ (kWh)$$

- **Reduction in CO_2 emissions**—Generating electricity from geothermal resources produces less CO_2 emissions than generating electricity with fuel oil. We calculate the economic benefit of the reduction in CO_2 emissions as the product of the expected reduction in CO_2 emissions and the social cost of CO_2 emissions. The expected reduction in CO_2 emissions is the product of the CO_2 emissions per unit of electricity produced from fuel oil and the units of electricity produced from geothermal generation.

Appendix B: Methodology and Assumptions for Financial Analysis

We use the DCF methodology to determine whether the geothermal project is financially viable to equity investors. To do so, we estimate the returns that equity investors would earn for investing in the project. That is, we estimate the value of the geothermal project to equity investors based on the cash flows that they receive from the operations of the geothermal power plant.

Table A.2 presents the main assumptions we use for forecasting the cash flows of the project. These are indicative assumptions based on our knowledge of and experience in project finance and geothermal projects, as well as information on the projects of study that is publicly available to date. Nevertheless, the final terms of the debt, equity, and project variables will be finalized and agreed to by the parties to the project. After the table, we describe the DCF methodology in further detail. The results of the financial analysis for each country are presented in Part C of this document.

Table A.2 Assumptions for Financial Analysis

Variable	SVG	DOM Phase 1	DOM Phase 2	GRE	SKN Phase 2	SKN Phase 1	SL
Real discount rate (%)	15						
Operations and Maintenance (O&M) (US$/kWh)	0.02	0.02	0.01	0.02	0.02	0.02	0.02
Corporate tax rate applicable in the country (%)	32	30	30	30	33	33	30
Accounts receivable as a percentage of annual revenue (%)	5						
Accounts payable as a percentage of annual O&M costs (%)	10						
Capex (US$ million)	96.3	67	531	102	136	92	168
Capex funded by grants and concessionary loans (US$ million)	39.6	50	0	23	0	53.5	15
Percentage funded by commercial debt (%)[440]	70						
Percentage funded by equity (%)[441]	30						
Concessionary loan grace period (years)[442]	5 to 10						
Concessionary loan maturity period (years)[443]	22 to 40						
Interest rate of concessionary loans (years)[444]	1.5 to 3.5						
Commercial loan grace period	Repayments begin with operations and interests are capitalized.						
Commercial loan maturity period (years)	15	15	12	15	15	15	15
Commercial loan interest rate (%)	7						
All-in cost of total debt (%)	3.41	2.55	6.97	4.44	7	2.93	5.76

440. This is the financing structure for the investments that are not funded by grants and concessionary loans (the Geothermal Risk Mitigation Fund).
441. This is the financing structure for the investments that are not funded by grants and concessionary loans from multilateral development banks.
442. These assumptions are based on terms of similar loans offered by the donors of the SEF.
443. These assumptions are based on terms of similar loans offered by the donors of the SEF.
444. These assumptions are based on terms of similar loans offered by the donors of the SEF.

The cash flows to equity investors are the cash flows that are left after all debt service payments are made. Specifically, we calculate the cash flows to equity investors as the dividends paid out to investors minus the equity invested in each period. Dividends are calculated as the minimum between the cash available to equity investors and the retained earnings, subject to retained earnings not being lower than zero. The cash flows available to equity investors are equal to the operating cash flows, minus cash flows for investments and for debt financing. We then bring the cash flows to equity to present value.

If the net present value (NPV) of the cash flows to equity investors is zero or positive, we can conclude that the project is financially viable to them. In other words, the geothermal project is financially viable to equity investors if the Internal Rate of Return (IRR) of the equity cash flows equals or exceeds the cost of equity.