Definition of Geothermal Energy

Geothermal energy refers to the thermal energy contained in the Earth as well as a set of processes enabling the extraction and industrial recovery of this internal heat. This energy is present everywhere underground in every climate.

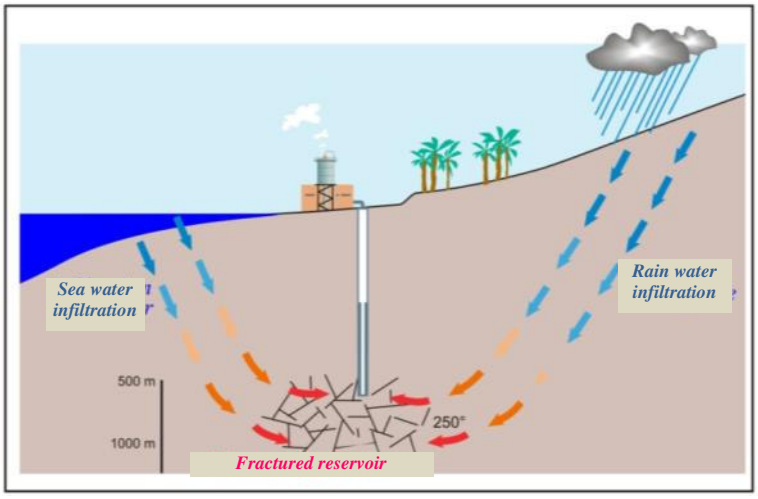


DIAGRAM OF THE WORKING OF GEOTHERMAL ENERGY

High enthalpy geothermal energy, which is used to produce electricity, is usually located more than 1,000 metres underground. In Dominica, the temperature of the reservoirs is estimated at 260 °C.

Thanks to the high temperatures, it is possible to produce electricity through cogeneration (combined production of electricity using steam turbines and of heat through condensate vapour recovery).

Objectives of geothermal energy

Clean energy to serve sustainable development

Geothermal energy produces little discharge. It is clean energy that does not contribute to climate deterioration and does not require transport or storage of polluting or hazardous substances. It is inexhaustible on a human scale.

Local energy

This energy is local. The required installations (production plants and pipelines) do not occupy a large area. Vapour plumes from the power plants are very visible from a distance. This energy does not depend on climatic conditions and is available 24 hours a day.

A contribution to the energy independence of the islands through electric power production

Geothermal energy is economical and innovative; it is one of the most cost-effective forms of renewable energy. It helps to achieve energy independence for electric power production. In volcanic islands such as Dominica, it can contribute to ensuring energy independence and eliminating the use of fossil fuels for electric power production. The Caribbean islands are now almost entirely dependent on fossil-based energy.

Geothermal energy can serve many purposes: hot water production for bathing, heating and cooling homes and buildings, air conditioning and agricultural and industrial uses.

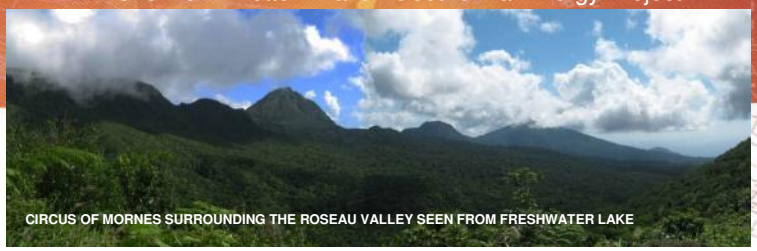
GEOTHERMAL POWER STATION IN WAIRAKEI, NEW ZEALAND

THE ELECTRIC POWER STATION IN BOUILLANTE, GUADELOUPE HAS BEEN IN OPERATION FOR 20 YEARS. IT PRODUCES 7% OF THE ISLAND'S ELECTRICITY NEEDS.

Energy Review of Dominica	
Number of inhabitants (2006 data)	72,514
Number of households	28,388
Average household consumption	1,188 kWh
Annual electric power consumption of all sectors	71,421 GWh
Annual growth of electricity demand	7.5% - 11% (DOMLEC 2008-2013)
Peak power requirements in 2010	15 MW
Power supplied by the project Installed capacity /producible potential of the project: 120 MW/ 731 GWh	10 - 20 MW (with diesel power stations off)
Coverage of electric power needs by the project in 2010	100%

THE BACON-MANIITO THERMAL ENERGY FIELD AND THE MAYON VOLCANO IN THE PHILIPPINES

Project location

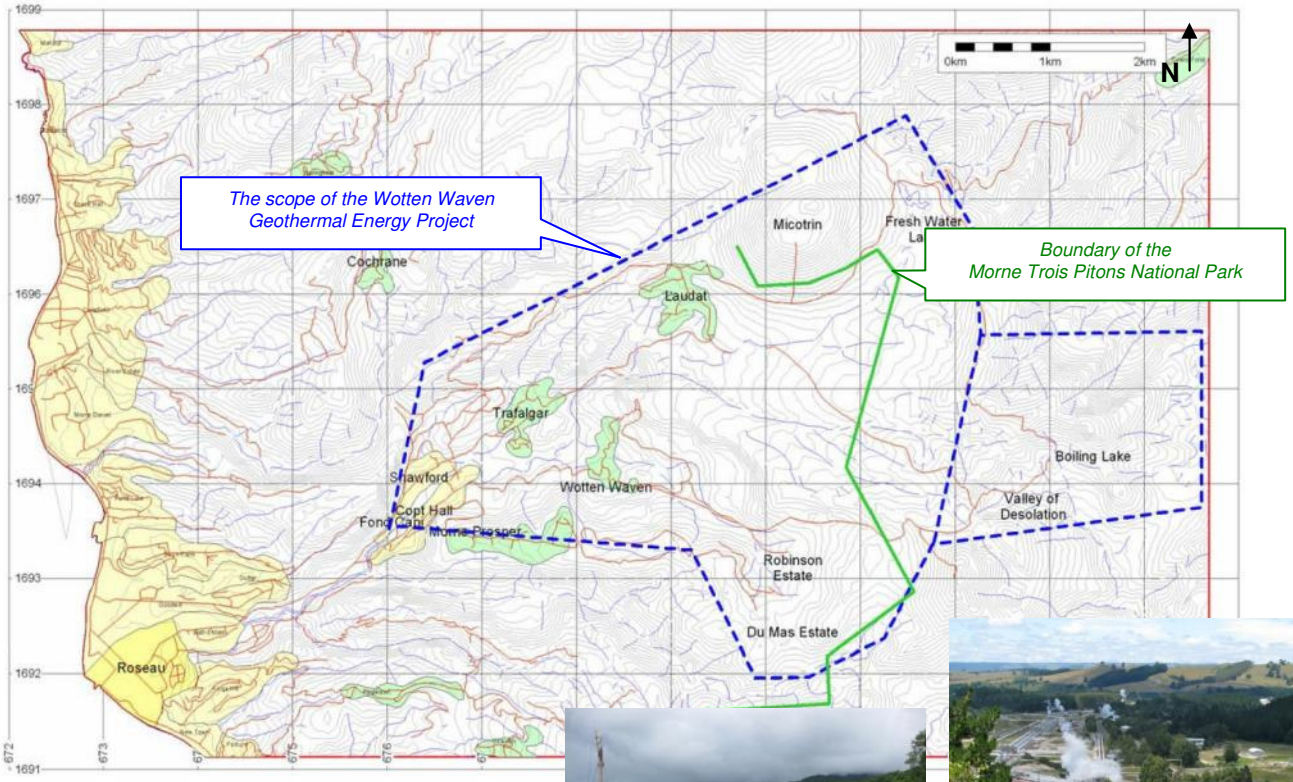

CIRCUS OF MORNES SURROUNDING THE ROSEAU VALLEY SEEN FROM FRESHWATER LAKE

The Wotten Waven geothermal energy project is located in the district of Roseau, in Dominica.

The total area of the project is defined based on a potential geothermal reservoir area of 15 km^2, located in Roseau Valley. It forms the perimeter of the project study area. The geothermal reservoir corresponds to zones in which high temperature fluids are presumed to be located deep underground, which could be used for drilling sites and in power production.

The study area, corresponding to Roseau Valley, is bound by:

- Morne Louis and Morne Bruce;
- Morne Jack and Morne Micotrin;
- Boiling Lake;
- Watt Mountain and Morne John;
- Morne Prosper.



THE PERIMETER OF THE STUDY PROJECT: ROSEAU VALLEY


POWER STATION IN WAIRAKEI, NEW ZEALAND


DEVELOPMENT DRILLING PLATFORM AT BOUILLANTE IN GUADELOUPE

The four project phases

The project will require four phases:

- Phase 1: ***An exploration phase*** to determine the geothermal potential of the reservoir in the Roseau Valley. It is developed at exploratory drilling sites (9 sites have been selected in Roseau Valley with 9 enclosed platforms covering an area of 1,600 m² will be built)
- Phase 2: ***A development phase*** during which the various components of the installation will be set up (turbines, wells, pipes, 2-3 power stations), to use the geothermal source and produce energy. Some thirty hectares will be concerned by the project during the development phase. The 2-3 power stations will be linked to about fifteen drilling platforms by pipes.
- Phase 3: A phase of electric power production;
- Phase 4: A phase of site dismantling and restoration of impacted sites


PIPELINE IN BOUILLANTE


SEPARATOR IN BOUILLANTE

Characteristics and stakes of the project

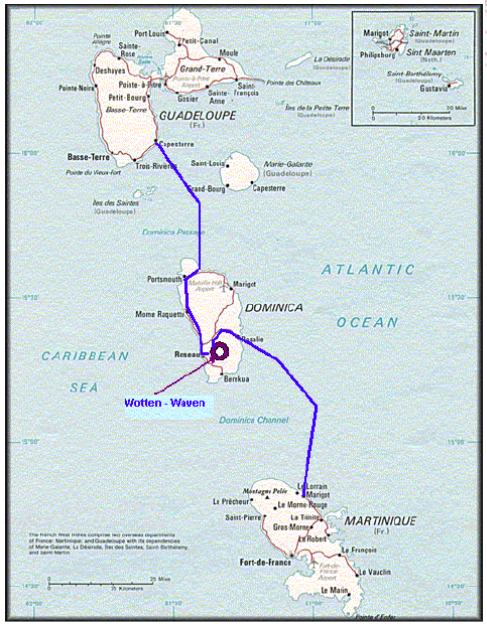
The Wotten Waven project would:

- **Provide basic electric power from a renewable source** with very low greenhouse gas emissions to cover all the needs of Dominica – about 15-20 MW – at a stable, competitive cost compared with current means of power production.
- **Export surplus electricity to Martinique and Guadeloupe**, of about 40 MW for each island to cover 20% of their respective consumption needs.

In the long run, this project could avoid the **600,000 tonnes of CO_2** into the atmosphere annually.

The estimated cost of the project, updated in December 2008, stands at 430-450 millions USD, i.e. **320-335 million EUR**.

The cost includes power stations, wells and related infrastructures but excludes connection by terrestrial and underwater high tension electric cable to the neighbouring islands (see map opposite) and the upgrading of the power grid in Dominica. These supplementary costs are now being evaluated.



CONNECTION OF THE PROJECT BY TERRESTRIAL AND UNDERWATER HIGH TENSION ELECTRIC CABLE TO THE NEIGHBOURING ISLANDS

The various steps in a geothermal energy project

Eleven steps, distributed over the main project phases, the exploration and development phases, are required to develop a geothermal energy project:

Exploration phase	• Project definition and recognition of the assessment, • In-depth exploration, • Pre-feasibility assessment, • Exploratory drilling and delimitation of the perimeter of the project, • Feasibility study (analysis of resources and estimation of potential development), • Project financing (Public-Private partnership), PPA (Power Purchase Act), • Project design documents, • Environmental Impact Assessment.
Development phase	• Production and reinjection of drilling in gradual phasing, • Building of power stations (plants) and transmission lines by phasing or gradually,/ • Commissioning of the project by phasing or gradually.

The project schedule is presented below:

	2009	2010	2011	2012	2013	2014	2015	2016	2017
Start of exploratory drilling	•								
Start of development drilling		•							
Start of building of 1st product unit				•					
1st unit of 2x30 MW on line						•			
2nd unit of 2x30 MW on line									•
Estimated average power available for export						40 MW	40 MW	40 MW	100 MW

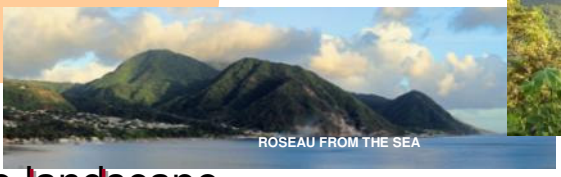
Expected benefits of the project

The Wotten Waven geothermal energy project proposes major benefits:

- Cover electricity needs of Dominica;
- Reduce and stabilise the cost of electricity;
- Bring new dynamism to the local economy;
- Create jobs during the introduction of the project (several hundred potential, skilled and unskilled jobs over a ten-year period);
- Create skilled jobs during well operation and maintenance (100-200 potential direct and indirect jobs);
- Generate revenue for the local economy through land rental and purchase;
- Provide local taxes for the national budget;
- Generate additional revenue for the national budget in proportion to the amount of electricity exported to Guadeloupe and Martinique;
- Guarantee part of the economic development of Dominica, especially in the Roseau-Wotten Waven region by creating several hundred direct and indirect jobs during the construction phases and operation of the power stations.
- In particular, the project will lower the cost of the kWh and significantly limit the need to import hydrocarbons.

The main shared benefits to be expected are:

- Preservation of the environment in the area (by producing energy that does not emit CO_2),
- Increased energy security for the partner islands,
- Creation of permanent, skilled jobs to ensure the reliability of the electric power delivery system (Dominica, Guadeloupe, Martinique);
- Stabilisation and reduction of the price of electricity in the islands of the Lower Antilles;
- An exemplary project to product geothermal energy-based power with its political and economic consequences in the Caribbean. (20% of needs covered by sustainable, renewable electricity in Guadeloupe and Martinique).



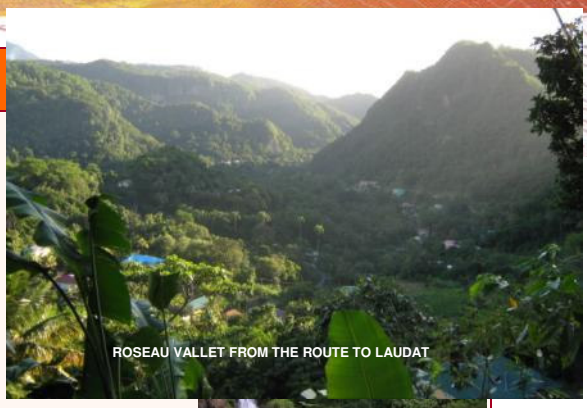
ROSEAU VALLEY

The stakes of the project for heritage, the environment, the landscape and the people of Dominica

Topography Geology/pedology	The altitude of the Roseau Valley varies from 150 m to 800 m. The hillsides are steep. The soil ranges from clay to allophanes and is sensitive to erosion. It can be crumbly.
Climatology	The area has a wet tropical climate. The study area receives between 150 and 250 inches of annual rainfall (3,810 millimetres and 6,350 millimetres). The rains can be violent.
Hydrology	The Roseau River is fed by two upstream rivers. The flow rate is torrential.
Protected areas	Morne Trois Pitons National Park is classified as a World Heritage Site by UNESCO, with its 17,000 hectares of national park and its circus of volcanoes. A potential Phase 1 drilling site is concerned by the protection of natural areas. The site is located near Freshwater Lake within the boundaries of Morne Trois Pitons National Park.
Flora and fauna	Rainforest covers the study area. An expertise was carried out on the flora in three zones. The zones are representative of the environments of Roseau Valley: **wetlands and degraded vegetation** (Zone 1: the Pachoute Estate, River Blanc), **mature but degraded forest** (Zone 2: Titou Gorge), **vegetation linked to fumaroles and degraded forests** (Zone 3: Dr. George C. Daniel near Wotten Waven). The milieu of Zone 2 is the most sensitive (mature forest cover and infrastructures). The milieu of Zone 1 is the least sensitive (seriously degraded wetlands and road).
Natural hazards	The area is subject to major seismic and hurricane risks (Cubic Code), a high risk of volcanic eruption and by low to medium risk of landslides. The specific risks of flooding, landslides, erosion, rainwater runoff and liquefaction must be determined by additional studies.
Landscapes	**Identity:** Roseau Valley is a “green fortress” dominated by a rainforest. It is preserved and peaceful, at a distance from the capital city of Roseau and from the coastline, and surrounded by a circus of majestic mornes. It has energy infrastructures (hydroelectric power stations, reservoirs). Tourist and energy activities and urban expansion testify to its development. **Visibility:** The valley is enclosed by mountains near the coast and is barely visible from the sea. The main landscapes of the valley and its plateaus are visible from the Northern Outer Route to Laudat. **Visitors:** Roseau Valley has eco-tourism facilities that are often linked to sulphur springs: hot springs in Wotten Waven, waterfalls, lakes including Freshwater Lake, the Rain Forest Aerial Tram, Titou Gorge near Laudat, outdoor activities, natural hot pools, etc. 590,000 people/year from cruise ships visit Roseau Valley.
Urban development	**8 urban communities** are found in Roseau Valley: Laudat, Morne Prosper, Wotten Waven, Trafalgar-Shawford, Fond Canie, Copt hall, Louisville, and Silver Lake. They represent about 2,000 inhabitants.

The stakes for the living environment are identified in the following chart:

Stakes	Description of stakes for the living environment
Social stakes	● Influence of traffic from the project on user travel, limit the disturbance and heavy traffic at rush hour ● Noise and sulphur odour from the wells and power stations will not affect the health of valley residents (the sulphur odour always exists), limit noise propagation by soundproofing the power stations ● Impacts on the landscape (presence of industrial buildings), limit visibility of these facilities from villages and tourist sites ● Integration of the population in a common project / a feeling of belonging to be developed instead of losing a territory ● Development of the local economy (numerous jobs during the construction and development phase)
Stakes related to tourism, cultural and historical heritage	● Change of the valley's identity towards geothermal energy production ● Renewable energy in relation to the land which will preserve the identity of Roseau Valley ● Creation of new infrastructures (teaching sites, museums related to geothermal energy), project promotion ● Modernisation of accommodation facilities ● Preserve strong eco-tourism development: preservation of rivers, tourist facilities of recycled wood ● Support for the development of channels dependent upon geothermal energy by supporting the local population (beauty products, spas, hot springs) ● There seems to be little cultural and historical heritage in Roseau Valley (awaiting data)
Accessibility	● Renovation of existing roads and construction of new routes ● Modification and improvement of the road network and valley accessibility
Landscape stakes	● Change in the valley's identity towards geothermal energy production ● Supporting new infrastructures in the landscape: architecture, location, boundary treatment ● More numerous industrial structures that are going to change the landscape of the valley, giving it a more marked industrial identity ● Integration of facilities in a major forest context ● Enhancement of the resources used: recycling of cleared timber (constructions, handicrafts)
Stakes for fauna and flora	● Limit the impacts on flora and fauna by identifying protected resources and applying suitable measures (change of location, compensation, etc.) ● Preserve identified protected species by building drilling sites in already degraded zones, avoid forest areas and proximity to waterways ● Integrate associations in this approach (initiatives)



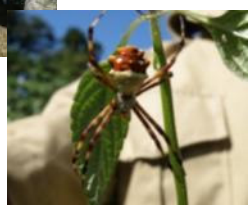
ROSEAU VALLET FROM THE ROUTE TO LAUDAT

TRAFALGAR FALLS

FRESHWATER LAKE

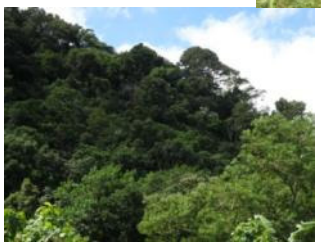
THE NORTHERN ROUTE TO LAUDAT

COMMON LIZARD OF DOMINICA, THE MOST COMMON IN WOTTEN WAVEN



FEMALE SPIDERE ARGIOPE ARGENTATA

THE WETLANDS OF LAYVYÈ BLAN
(PHOTO A.JAMES)



DR DANIEL RAINFOREST SITE
(PHOTO A.JAMES)

Significant impacts and measures for a site dedicated to geothermal energy

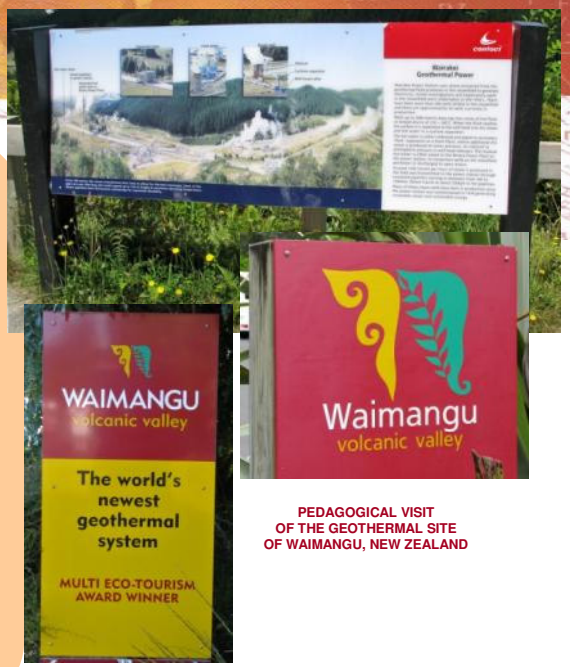
☹ Low negative impact ☹ Medium negative impact ☺ Positive impact

	Type of impact	Degree	Measures to limit impacts	Impact after measures
Phases 1 & 2	Soil pollution by geothermal fluids	☹	Reinject geothermal fluids	☺
	Surface water pollution by geothermal water	☹	Reinject geothermal fluids	☺
	Noise from the drilling site	☹	Choose sites at a distance from residential areas	☹
	Restoration of road network	☺	-	-
	Work performed by local companies	☺	-	-
	Disturbance of tourists	☹	Choose sites at a distance from tourist sites Technological tourism	☺
	Disturbance of fauna and increased mortality of species living on the ground	☹	Preliminary study of the fauna	☹
	Clearing of vegetation	☹	Preliminary study of the flora	☹
Phase 3	Remote visibility of the project sites	☺	-	-
	Intermediate visibility of the project sites	☹	Integration into the landscape	☹
	Discharge of cooling waters	☹	Closed circuit cooling system	☺
	Specific, limited discharge of geothermal fluids	☹	-	☹
	Reduction of polluting discharge into the atmosphere for power	☺	-	-
	Odour of rotten eggs due to H_2S	☹	Fans to facilitate the dilution of emissions coming out of the power station	☺
	Toxicity of H_2S	☹	Fans to facilitate dilution Set up detectors along the border of the power station	☺
	Noise disturbance to residents near the power stations	☹	Soundproof the installations	☹
	Nocturnal disturbance of fauna by installation lighting	☹	Redirect the lighting	☺
	Soil pollutions from hydrocarbons/ oils/lubricants	☹	Set up retention tanks	☺
	Creation of jobs for power station operation	☺	-	-
	Maintenance of installations by local companies	☺	-	-
	Technological tourism	☺	-	-
	Energy independence of Dominica	☺	-	-
	Export of electricity	☺	-	-
Phase 4	Noise from construction vehicles	☹	Use hydraulic or electric motors	☹
	Waste productions	☹	Eliminate waste through approved channels	☺
	Waste, mud on public roads	☹	Clean lorry wheels Surveillance of road cleanliness	☹
	Site restoration carried out by local companies	☺	-	-

Alternative uses of geothermal energy

Geothermal energy is a basis for tourist activities. Setting up geothermal energy sites in the Roseau Valley offers Dominica an opportunity to generate:

- ***A strengthening of existing eco-tourism activities***: Roseau Valley has eco-tourism activities that represent the island's identity for tourists; the project will give the Roseau Valley a stronger industrial connotation, although hydropower activities already cut through the valley. However, geothermal energy supports the principles of sustainable development and enables the creation of sustainable tourist activities. Pedagogical visits will be organised along with tours so that local and foreign tourists can appropriate the project sites;
- ***Technological tourism***: tourist visits of the sites can be organised for this purpose; a welcome centre dedicated to geothermal energy will present the energy in an amusing way for young audiences (signs, information panels, visitor paths, etc);
- ***Leisure and wellness tourism***: geothermal activities are often associated with natural hot water pools and treatment activities (mud baths and skin treatments, rheumatism, etc). Products derived from geothermal energy could be developed (natural body care products, balneotherapy, etc).



PEDAGOGICAL VISIT
OF THE GEOTHERMAL SITE
OF WAIMANGU, NEW ZEALAND

VISITORS AT THE GEOTHERMAL SITE
IN ORAKEI KORAKO, NEW ZEALAND

Electric power production at the Wotten Waven project sites will allow Dominica to cover all of its needs and export part of its electricity to neighbouring islands. The Wotten Waven project will therefore contribute to the energy independence of Dominica.

This renewable energy-based energy independence will strengthen eco-tourism developed as a characteristic feature of Dominica.

The Wotten Waven geothermal energy product is an opportunity for Dominica to develop its knowledge about its territory, its regulation, its tourist industries, its economy and its regional policies:

- **Heritage/Archaeology**: Mapping of the cultural and historical heritage of the Roseau Valley;
- **Meteorological data:** Collecting meteorological data in a document or on a website to enable data comparison and regular updating; Indicators (measuring stations distributed over the territory) would enable better assessment of meteorological data, e.g. a detailed indication of winds;
- **Data on water**: Development of hydraulic studies on the rivers in the Roseau Valley (available flow rates, characteristics, valleys, etc); realisation of a regional scheme of fundamental directions for balanced water resource management on the scale of a catchment area. This document could be produced to develop a water policy and strong actions to preserve and develop the island's water resources;
- **Natural hazards**: Improved assessment of natural hazards including flooding, mudslides and erosion; introduction of effective instruments for locating these hazards;
- **Preservation of fauna and flora**: Development of studies of fauna and flora carried out by the Forestry and Wildlife Division;
- **Regulation of geothermal projects**: Regulation of geothermal projects modelled on the Quarry Code of Practice for quarry projects;
- **Energy policy**: Development of an ambitious energy policy focused on renewable energies (regional strategy plan to improve the institutional context and partnerships, the efforts to control and develop renewable energies);
- **Waste recovery**: Development of channels to recover waste;
- **Improvement of the road network**: Improvement of accessibility and traffic in the Roseau Valley (reinforcement, wider lanes, parking);
- **Updating CUBIC standards:** Improvement of anti-hurricane and anti-seismic standards;
- **Taking the value of landscapes into account**: Carrying out landscape studies to preserve and develop the living environment;
- **Development of tourist programmes**: museum, welcome centre, pedagogical visits, exhibitions, etc.;
- **Local economic development of spin-off products and services**: Support for the development of industries dependent on geothermal energy by providing support to the local population (beauty products, spas, hot spring, etc.).