Chapter 5 Project Activities in St. Kitts and Nevis

5.1 (Phase 1) Baseline Survey in St. Kitts and Nevis

This section presents the information confirmed in the baseline survey. In addition, some of the basic information that was followed up after the resumption of field activities and that formed the basis for the content of technology transfer is also included in this section.

5.1.1 Related organizations

The baseline survey included interviews and discussions with and site visits to the following agencies and sites.

- MPI (Ministry of Public Infrastructure, Post, Urban Development and Transport) * Main C/P
- SKELEC (St. Kitts Electricity Company Ltd.) * C/P
  - Needsmust Power Station
  - SKELEC PV Facility (500kW)
- NIA (Nevis Island Administration) * C/P
- NEVLEC (Nevis Electricity Company Ltd.) * C/P
  - Prospect Power Plant
- SCASPA (St. Christopher Air & Sea Ports Authority)
  - Robert L. Bradshaw Airport PV Facility
- NASPA (Nevis Air and Sea Ports Authority)
- NREI (Nevis Renewable Energy International)
  - Geothermal Potential Site
- WindWatt (Nevis) Ltd.
  - Windatt Wind Farm
- St. Kitts and Nevis Bureau of Standards
- St. Kitts Water Services Department
- Nevis Water Department

5.1.2 Survey Items

The survey was based on what should be identified in the baseline of this project. The items applicable to St. Kitts and Nevis are as follows.

(1) Power systems

- Basic Indicators on the electricity demand side
- Basic indicators on the electricity supply side
- Confirmation of status of transmission and distribution losses

(2) EE

- Confirmation of EE promotion status, policies, and plans
- Confirmation of human resources and organizational capacity for EE promotion

(3) Improvement of Existing Thermal Power Plant

- Confirmation of status on operation and maintenance of thermal power generation facilities

(4) RE

- Confirmation of the status of introduction, policies and plans, and implementation system and Capacity for RE/grid stabilization technologies
- Confirmation of human resources and organizational capacity for introduction of RE

5.1.3 Energy Policy and Electricity Development Plans

(1) Energy Policy

St. Kitts and Nevis developed a National Energy Policy in April 2011 with a vision to become the smallest green nation in the Western Hemisphere providing reliable, clean, affordable renewable energy to all citizens of the two islands.

It is a continuation of the 2011 version, which was reviewed and developed as the Revised National Energy Policy in July 2014 with EU funding support. In it, St. Kitts and Nevis states that it will be "an island nation with a sustainable energy sector" and its vision is to

- Reliable, renewable, clean, and affordable energy services are provided to all citizens.
- Energy efficiency and the substitution of fossil energy by renewable sources will be promoted in all sectors of the economy.
- 100 % of the electricity supplied in the country (by 2020) will be produced from renewable energy sources.

In addition, the following are the implementation policy measures to comply with this energy vision

- ➢ Diversification of energy security and energy matrix
- ➢ Institutional capacity strengthening
- ➢ Introduction of renewable energy sources
- ➢ Electricity sector strengthening
- ➢ Building a consistent legal framework
- ➢ Promote energy efficiency and conservation
- ➢ Energy use in the transport sector

Thus, the country's high electricity prices, rising transportation fuel prices, and global climate change awareness and concern have led to increased investment in RE technologies, as well as recognition of the need for energy efficiency and conservation, and the active and widespread adoption of RE. The policy is a framework to enable the country to transition from fossil fuel-based energy sources to RE sources such as wind, solar, geothermal, hydroelectric, and waste-to-energy.

With regard to energy efficiency and conservation, the policy does not state detailed measures, although it includes promotion in all sectors, including transportation and industry, and review of appropriate labeling, standards, and building codes.

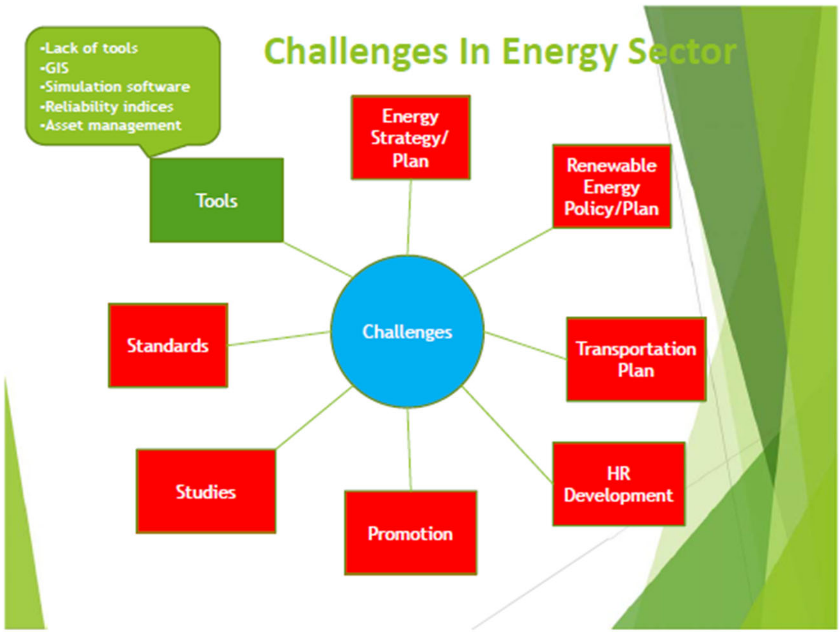
As noted above, the country had a goal of 100 % RE by 2020, which envisaged large wind, PV, and geothermal developments in Nevis. As of January 2023, the National Energy Policy has not been updated and is still on its way.

On the other hand, in October 2021, the country formally submitted its Nationally Determined Contribution (NDC) to the UNFCCC Secretariat, which sets a goal of a 61 % reduction in CO_2 emissions by 2030 relative to the base year of 2010. The NDC has also set a target of 61 % reduction in CO_2 emissions by 2030 relative to the 2010 baseline, subject to appropriate international climate finance, capacity building support, etc. for the following items

- Transition to 100 % RE in power generation
- Improving efficiency of electricity transmission and distribution
- Electrification of 2 % of total fleet
- Development of EV infrastructure

Note that for the NDC revision, St. Kitts and Nevis has been working with the NDC Partnership's Climate Action Enhancement Package (CAEP), the International Renewable Energy St. Kitts and Nevis was supported by IRENA and the EU Global Technical Assistance Facility in CAEP.

MPI has identified the energy sector challenges as the need for renewable energy policies, human resource development, standards, research, and tools. Regarding tools, there is a need for GIS, grid analysis, reliability indicators, and asset management systems. **Figure 5-1** shows the issues presented by MPI at the first JCC.



Source: MPI

Figure 5-1 Energy Sector Challenges by MPI

(2) RE Power Supply Development Plan

Table 5-1 lists the projects listed in the NDC that we expect to advance with international support.

Table 5-1 Power development plans listed in the NDC

Location	Type	Capacity	Remarks
Saint Kitts	PV	35.7 MW	Utility-Scale
Saint Kitts	Wind	6.6MW	
Saint Kitts	Geothermal	15 MW	
Nevis	Geothermal	10 MW	
-	PV	2 x 0.75 MW	to suppy two desalination plants

Source: Prepared by JET based on St. Kitts and Nevis NDC

On the other hand, during the baseline survey, power development plans were interviewed from the St. Kitts Electricity Company (SKELEC, The St. Kitts Electricity Company) and the Nevis Electricity Company Limited (NEVLEC, Nevis Electricity Company Limited). The existing and planned RE projects in St. Kitts and Nevis are listed in **Table 5-2**.

On St. Kitts, a 35 MW IPP Leclanche project is underway. The site has been finalized and groundbreaking ceremonies have been held, but plans are currently under review and construction is in preparation as of early 2023. In addition, a 5.7 MW Bellevue wind project is in the planning stages and a PPA with IPP is being prepared.

Table 5-2 RE Project in St. Kitts and Nevis

Location	Project and Location	Type	Gapacity	Year
St.Kitts	SCASPA	PV	0.7	2013
St.Kitts	SKELEC	PV	0.5	2015
Nevis	Windwatt	Wind	2.2	2011
St.Kitts	Leclanche	PV	35	2024?
St.Kitts	Bellevue	Wind	5.7	planned
Nevis	N3 Geothermal -Ph2	Geo	30	2025
Nevis	N3 Geothermal -Ph3	Geo	15	proposed
Nevis	N1 Geothermal -Ph4	Geo	15-30	proposed
Nevis	Off-shore wind -Ph4	Wind	50	proposed

Source: Prepared by JET based on information from SKELEC and NEVLEC.

Along with the planned line expansion on Nevis, NEVLEC has developed a geothermal development plan (**Table 5-3**): Phase-1 will add 66 kV to the existing 11 kV transmission line; Phase-2 will extend the 66 kV line and develop 30 MW of geothermal at the N3 site; and Phase-3 will develop another 15 MW of geothermal at the N3 site. In Phase-3, another 15 MW of geothermal power will be developed at the N3 site. In Phase-4, 50 MW of offshore wind power is planned along with the installation of 4-hour storage batteries. An additional 15 MW or 30 MW of geothermal power is planned for the N1 site.

Table 5-3 Development plan of grid and power supply by phase of NEVLEC

Phase	Nevis Geothermal and Grid Interconnection Plan (provisional)
Phase-1	Power Grid Reinforcement from 11 kV to 66 kV
Phase-2	Expand 66 kV, 30 MW Geothermal at N3, Connect into St. Kitts Power System
Phase-3	Hydrogen Based Project at Long Point, Install 15 MW Geothermal at N3
Phase-4	66 kV from Long Point to Camp, Offshore Wind at 50 MW, 4hr BESS, Additional Geothermal from 15 MW to 30 MW at N1, Expansion of Hydrogen Based Project

Source: Prepared by JET based on information from NEVLEC

5.1.4 Basic Indicators on the Electricity Demand Side

(1) Energy Consumption based on Energy Balance Table

Based on the energy balance of St. Kitts and Nevis (2016) published by the United Nations Statistics Division, energy consumption by sector and energy when final electricity consumption is evaluated on primary energy basis is shown in **Table 5-4**. Transportation sector has the largest share of energy consumption by sector (31 %), followed by commercial and public sector (26 %) and residential sector (22 %).

As for electricity, all of power generation comes from oil and non-industrial sector (commercial + residential) accounts for 70 % of electricity consumption.

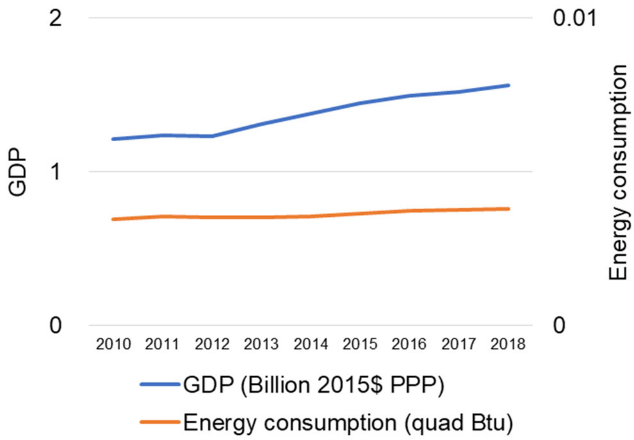
Table 5-4 Energy Consumption in St. Kitts and Nevis by Sector, by Energy, Primary Energy Basis, 2016, kTOE

	Industry	Other	Transportation	Total
Oil	1	3	25	29 (37 %)
Electricity (primary energy basis)	15	35	0	50 (63 %)
Total	16 (21 %)	38 (48 %)	25 (31 %)	79 (100 %)

Note: Primary energy conversion factor for electricity was assumed to be 30.0 %, energy efficiency at end use. Total losses including power plants in-house use, and transmission and distribution losses is approximately 20 % according to information provided by SKELEC.
Source: Prepared by JET using " St. Kitts and Nevis Energy Balance (United Nations Statistics Division)" and energy efficiency at end use mentioned above.

(2) Energy Consumption and Energy Intensity

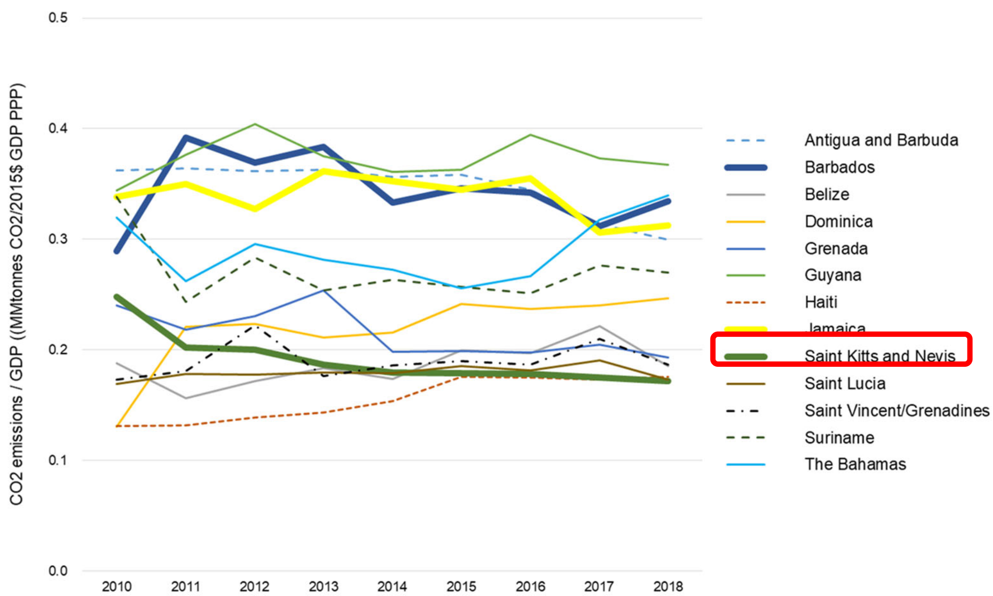
While the economy has been growing steadily during 2010-2018, the country's overall energy consumption has remained almost constant. (See **Figure 5-2**)



Source: JET based on U.S. Energy Information Administration data.

Figure 5-2 Trends of GDP and Energy Consumption (2010-2018)

Accordingly, the energy intensity trends for 2010-2018 also indicates a declining (= improving) trend as shown in **Figure 5-3**. St. Kitts and Nevis is the country with the lowest intensity among CARICOM member countries, that is, the country with the highest energy efficiency.



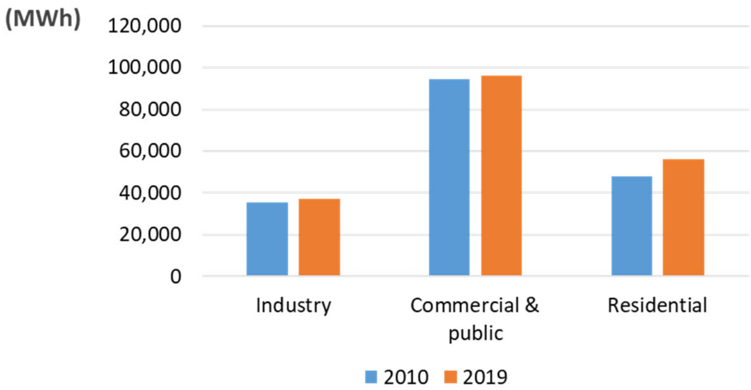
Source: JET based on U.S. Energy Information Administration data.

Figure 5-3 Energy Intensity Trends in CARICOM Member Countries (2010-2018)

(3) Electricity Consumption

The change in overall electricity consumption over the 10-year period from 2010 to 2019 is +6 %, and by sector: industrial: +4 %, commercial: +2 %, residential: +17 %. It has been observed that electricity consumption has increased in all sectors.

The **Figure 5-4** shows the change in electricity consumption by sector from 2010 to 2019.



Source: Prepared by JET based on " St. Kitts and Nevis Energy Balance (United Nations Statistics Division)".

Figure 5-4 Change in Electricity Consumption by Sector (2010-2019)

(4) Peak Demand and Daily Load Curves

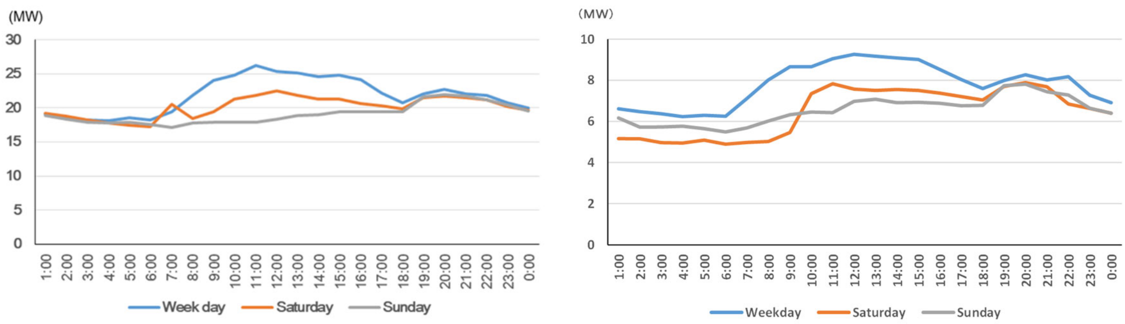
Figure 5-5 shows the peak demand and power daily load curves for St. Kitts and Nevis, respectively.

- St. Kitts island

  The current peak demand on St. Kitts Island is about 25 MW at 11AM. Although the demand decreases from the afternoon to the evening, the load curve shows that the lighting peak (18:00 to 20:00) occurs again.

- Nevis island

  The current peak demand on Nevis Island is about 10 MW at 12PM. Although the demand decreases from the afternoon to the evening, the load curve shows that the lighting peak (18:00 to 20:00) occurs again. Nevis Island is currently in a tight supply and demand situation for electricity.



Source: JET based on "ST. KITTS AND NEVIS RENEWABLE ENERGY POLICY (draft), MINISTRY OF PUBLIC INFRASTRUCTURE, POST, URBAN DEVELOPMENT AND TRANSPORT".

Figure 5-5 Electricity Daily Load Curves in St. Kitts and Nevis (left: St. Kitts Island, right: Nevis Island)

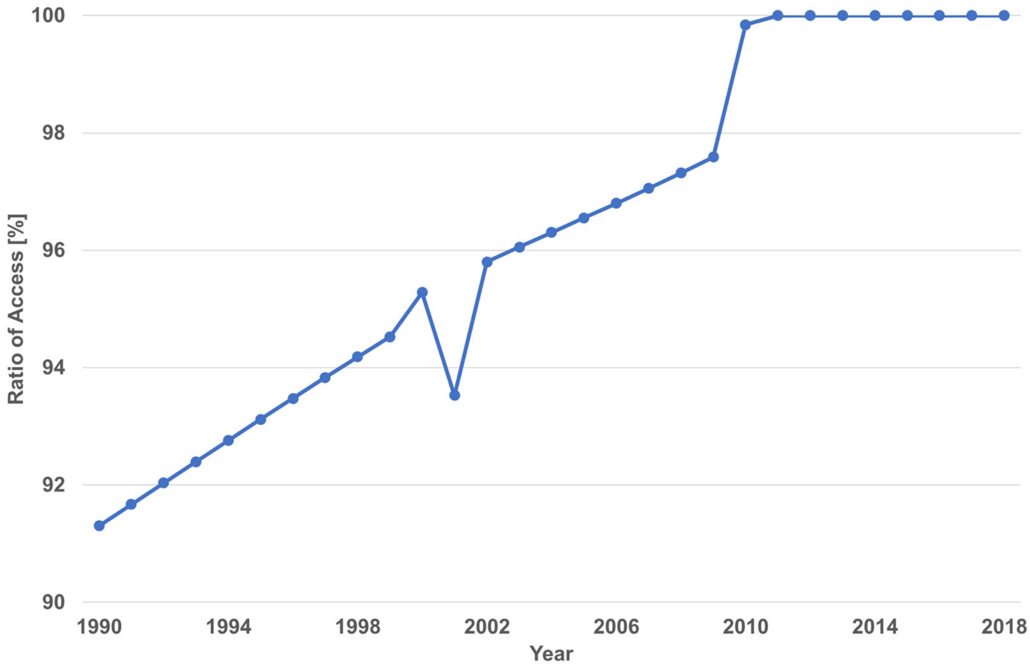
(5) Electricity Demand Forecast

No data on electricity demand forecasts have been published or studied as of January 2023; demand forecasts were studied in the revised 2014 version of the National Energy Policy, which projects that demand will exceed about 200 GWh by 2020 under the base scenario. On the other hand, electricity consumption has remained at about 200 GWh since 2011 and is not increasing.

5.1.5 Basic Indicators on the Power Supply Side

(1) Access to Electricity

Figure 5-6 shows the evolution of access to electricity (electrification rate), which has been steadily increasing since the 1990s, reaching 100 % in 2011.



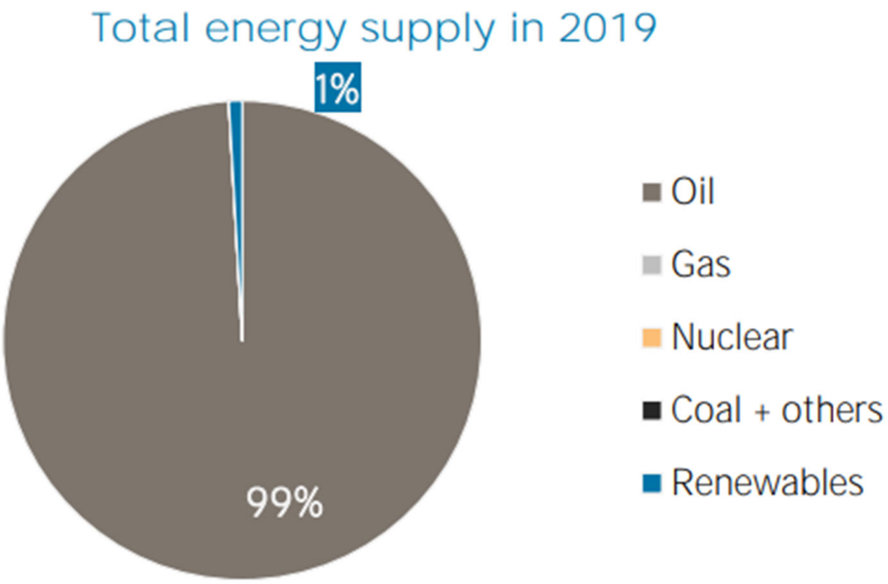
Source: Prepared by JET based on The World Bank - Access to electricity (% of population) – St. Kitts and Nevis

Figure 5-6 Access Rates in St. Kitts and Nevis

(2) Power supply configuration

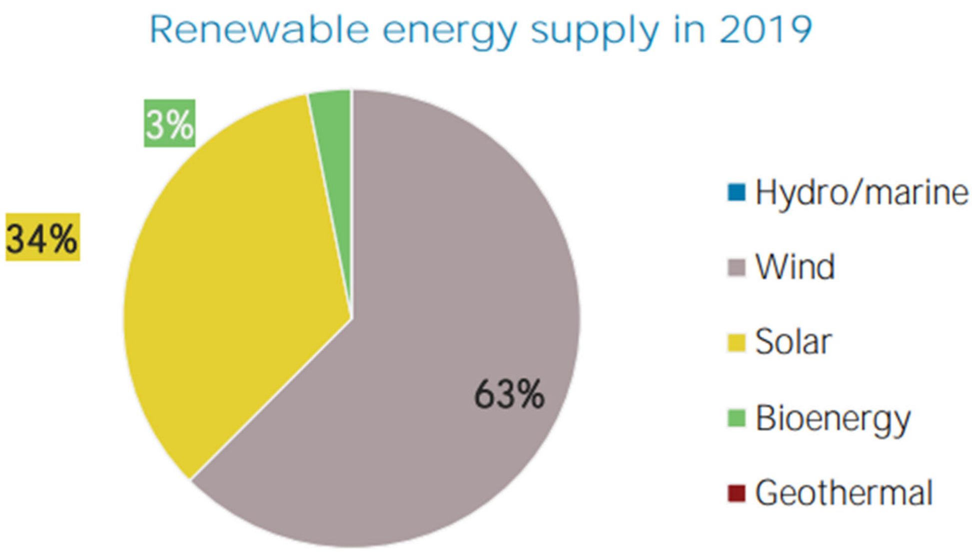
St. Kitts and Nevis consists of two islands, St. Kitts and Nevis. SKELEC and NEVLEC manage the island's power system and main power sources, respectively, for the St. Kitts and Nevis power companies.

The power composition by source and RE in 2019 are shown in **Figure 5-7** and **Figure 5-8**, respectively. wind power and solar power have been in operation since 2011 and 2013, respectively. Note that the power source composition of RE as of 2021 is 47 % solar and 53 % wind, with solar power growing.



Source: IRENA Energy Profile St. Kitts and Nevis

Figure 5-7 Power Source Composition of Non-Renewable and Renewable Energy Sources (St. Kitts and Nevis)



Source: IRENA Energy Profile St. Kitts and Nevis

Figure 5-8 Renewable Energy Power Source Composition (St. Kitts and Nevis)

(3) Power supply companies

SKELEC was established in 2011 by acquiring assets and operations from the government's electricity department (SKED, St. Kitts Electricity Department) and is the utility responsible for the generation, transmission, and distribution of electricity on St. Kitts Island. SKELEC has an installed capacity of 48.9 MW, consisting of 15 diesel generators at the Needsmust power plant. It is also working with the government of St. Kitts to build the Caribbean's largest solar power and energy storage system in 2020.

Table 5-5 lists SKELEC's thermal power generation facilities as of 2019.

Table 5-5 List of power generation facilities on St. Kitts Island (2019)

Plant	Unit	Type	Fuel	Manufacture	Installed Year	Rating Capacity (MW)	Minimum Load (MW)
Needsmust (St. Kitts)	G1	MSD	Diesel	MAN (Mirlees Blackstone)	1999	6.1	1.2
	G2	MSD	Diesel	MAN	2009	3.9	0.8
	G3	MSD	Diesel	MAN	2008	3.9	0.8
	G4	MSD	Diesel	MAN	2007	3.9	0.8
	Mobile set 1	MSD	Diesel	Caterpillar	2017	2.0	unknown
	Mobile set 2	MSD	Diesel	Caterpillar	2018	2.0	unknown
	Mobile set 3	MSD	Diesel	Caterpillar	2017	2.0	unknown
	Mobile set 4	MSD	Diesel	Caterpillar	2018	2.0	unknown
	Mobile set 5	MSD	Diesel	Caterpillar	2019	2.0	unknown
	Mobile set 6	MSD	Diesel	Caterpillar	2019	2.0	unknown
	G9	MSD	Diesel	MAN (Mirlees Blackstone)	1987	3.5	0.7
	G10	MSD	Diesel	MAN	2010	3.9	0.8
	G11	MSD	Diesel	MAN	2010	3.9	0.8
	G12	MSD	Diesel	MAN	2011	3.9	0.8
	G14	MSD	Diesel	MAN	2011	3.9	0.8

Source: Prepared by JET based on interviews

On the other hand, NEVLEC is responsible for the generation, transmission, and distribution of electricity on Nevis Island. NEVLEC is a wholly owned subsidiary of the Nevis Island government, established in 2000.NEVLEC consists of nine diesel generators with an installed capacity of 20.3 MW as of 2019.

Table 5-6 lists the generating facilities owned by NEVLEC as of 2019.

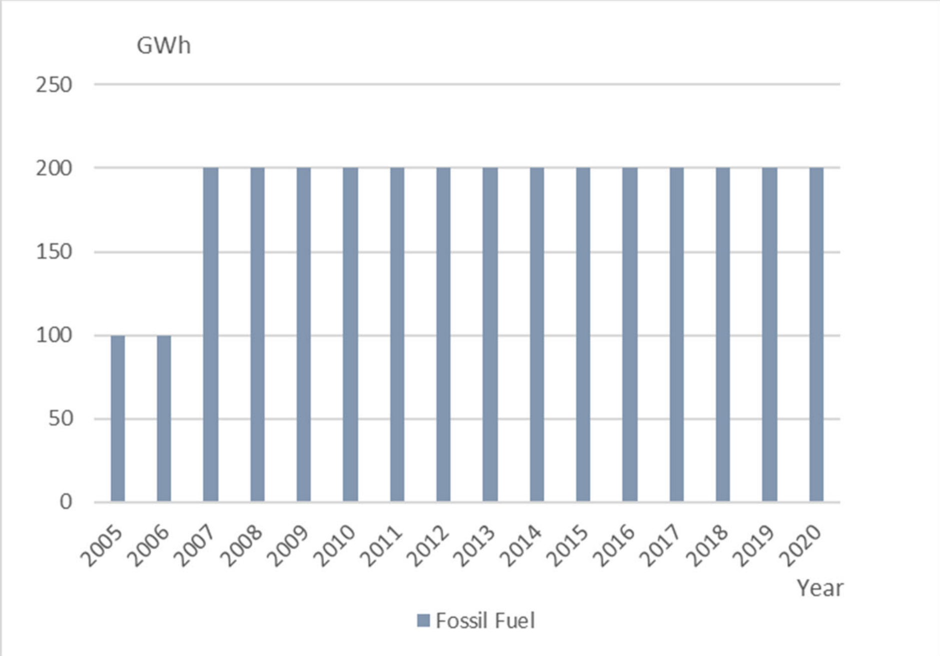
Table 5-6 List of power generation facilities in Nevis (2019)

Plant	Unit	Type	Fuel	Manufacture	Installed Year	Rating Capacity (MW)	Governor Type
Prospect (Nevis)	G3	MSD	Diesel	MAN (Mirlees Blackstone)	1985	0.9	Mechanical
	G4	MSD	Diesel	MAN (Mirlees Blackstone)	1990	2.0	Electrical
	G5	MSD	Diesel	MAN (Mirlees Blackstone)	1996	2.2	Electrical
	G6	MSD	Diesel	MAN (Mirlees Blackstone)	1996	2.2	Electrical
	G7	MSD	Diesel	Detroit Diesel	1997	2.5	Mechanical
	G8	MSD	Diesel	Wartila	2002	2.7	Electrical
	G9	MSD	Diesel	Cummins	2012	1.5	Electrical
	G10	MSD	Diesel	Detroit Diesel	2016	2.5	Mechanical
	G11	MSD	Diesel	Wartila	2017	3.8	Electrical

Source: Prepared by JET based on interviews

(4) Electric power supply status

Figure 5-9 shows the transition from 2005 to 2020 of the annual electricity production published by the EIA, which still relies on expensive imported diesel oil for power generation, although wind power has been operating slightly since around 2011.



Source: Prepared by JET based on EIA Data

Figure 5-9 Annual Electricity Generated (2005-2020)

With respect to RE, the current RE generation capacity is 3 % and 1 % of the energy base. The existing RE generation capacity in St. Christopher and Nevis is summarized in **Table 5-7**

Table 5-7 Existing RE generation facility in St. Kitts and Nevis

Location/Project	Type	Capacity MW	Generation GWh estimated	Year	Tariff USc/kWh
S: SCASPA	PV	0.7	NA	2013	Self
S: SKELEC	PV	0.5	1	2015	Self
N: Windwatt	Wind	2.2	5.25	2011	NA

(S: St. Kitts, N: Nevis)

Source: Prepared by JET based on information from MPI, SKELEC, NIA, NEVLEC

However, the PV installed at SKELEC on St. Kitts has partially failed and is not operating at full output. In addition, the PV installed at The St. Christopher Air & Sea Ports Authority (SCASPA) airport, originally 1.3 MW, has reduced output due to panel damage.

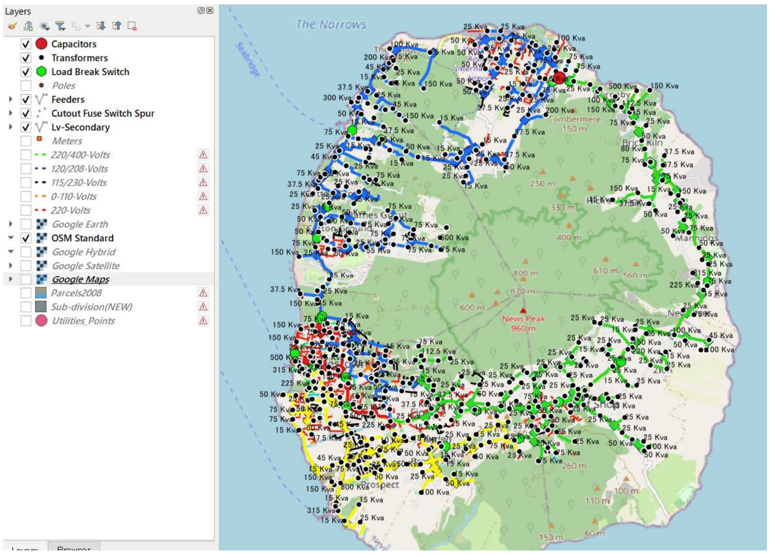
(5) Power Grid

The operators of the power transmission and distribution system in St. Kitts and Nevis differ from each other, with SKELEC operating on St. Kitts and NEVLEC operating on Nevis.

Both St. Kitts and Nevis are served by 11 kV power systems. Power system diagrams for both islands are shown in **Figure 5-10** and **Figure 5-11**, respectively.

Source: Prepared by JET based on SKELEC using Smallworld

Figure 5-10 Power Grid of St. Kitts Island (11 kV)



Source: NEVLEC

Figure 5-11 Power Grid of Nevis Island (11 kV)

5.1.6 Promotion of Energy Efficiency and Conservation (EE&C)

(1) EE&C Policy and Situation on EE&C Promotion

Major EE&C policies and the situation on EE&C promotion in St. Kitts and Nevis are shown in **Table 5-8**.

Table 5-8 Major EE&C Policies and Situation on EE&C Measures Promotion in St. Kitts and Nevis

Major policies/measures to promote EE&C	Contents
Energy policy, EE&C policy	▪ Although the National Energy Policy (NEP) 2011 has been formulated, it does not include a separate policy for EE. Also, there is no target value for EE. ▪ Nevis is currently experiencing a tight supply and demand situation for electricity and is interested in introducing various energy-saving technologies.
EE roadmap	▪ EE roadmap has not yet been established.
MEPS & Labeling (S&L)	▪ CARICOM Regional Organization for Standards and Quality (CROSQ) plans to establish a region-wide S&L program (in 2022). ▪ The CROSQ draft (2018) covers three products: household refrigerators, household air conditioners, and CFLs and LEDs. ▪ There is no movement toward MEPS development at the national level, but CROSQ is aware of the trend.
EE Building Code (EEBC)	▪ National EEBC formulated based on CREEBC 2018, already approved by the Prime Minister. ▪ The CREEBC is developed by experts from the International Code Council (ICC), ASHRAE, etc., in addition to C/Ps of this Project and national efficiency standards bureaus, etc., in each country. After publication, maintenance (every six months) is performed by CROSQ.
Certified Energy Manager (CEM)/ Energy Auditor (CEA) System	▪ CEM/CEA are issued by the Association of Energy Engineers (AEE, Georgia, USA), a non-profit organization and the only accreditation body in the region. Although there is no official certification system in each country, qualifications by AEE are recognized. ▪ The government encourages the acquisition of CEM/CEA.
Energy Audit	▪ Implemented in 2017- 2018 with CDB support. ▪ EA Results (St. Kitts): ➢ Government buildings: 8 ➢ Pumping stations: 13 houses ▪ EA Results (Nevis): ➢ Government buildings: 9 ▪ Pumping stations: 7 houses
ESCO	▪ Little interest in ESCO projects.
Pumping station	▪ St. Kitts ➢ Electricity costs are borne by the Ministry of Finance. ➢ Water is pumped from a submersible pump to a tank on high ground, and gravity provides water to the community. ▪ Nevis ➢ Installed inverters in intermediate pump facilities (2 locations). ➢ 40 % of the annual budget is paid for electricity. ➢ While the Nevis Water Department is highly interested in installing inverters at its pumping stations, the only data available for each pump is monthly power consumption (there is no time-specific power consumption or flow data).
Other	▪ EE shall include utilities in policy/regulatory coverage. ▪ Efficiency of electricity supply (figures below are approximate) ▪ SKELEC: ➢ In-house losses: 3.1 % ➢ Transmission and distribution losses: 17.4 % ➢ NEVLEC: Transmission and distribution loss: 14 % Note: The breakdown of technical and non-technical losses for both utilities is not available.

Source: JET

(2) Economic Feasibility Study of Inverter Room Air Conditioners (RACs)

Table 5-9 shows the results of the market survey of room air conditioners sold in St. Kitts and Nevis. Energy efficiency was indicated for both inverter and non-inverter models at rated operation, and all refrigerants were R410a.

Table 5-9 Room Air Conditioners Sold in St. Kitts and Nevis (2019 Survey)

Model	Price	Energy efficiency
Inverter RAC (18,000BTU=5.27kW)	US$ 814 Cost per unit capacity: 155 (US$/kW)	COP=3.06
Inverter RAC (12,000BTU=3.52kW)	US$ 740 Cost per unit capacity: 210 (US$/kW)	COP=3.24
Inverter RAC (12,000BTU=3.52kW)	US$ 629 Cost per unit capacity: 179 (US$/kW)	COP=3.06
Non-inverter RAC (18000BTU=5.27kW)	US$ 703 Cost per unit capacity: 133 (US$/kW)	COP=2.77
Non-inverter RAC (12,000BTU=3.52kW)	US$ 592 Cost per unit capacity: 168 (US$/kW)	COP=2.78

Source: JET

Results of economic feasibility trial calculation between inverter and non-inverter models based on the above market survey, the simple payback period for inverter models = 0.6-1.2 years, confirming that they have high economy in addition to energy savings. (See **Table 5-10**)

Table 5-10 Trial Calculation Results of Economic Comparison between Inverter and Non-inverter RACs in St. Kitts and Nevis

	5.27kW class	**3.52kW class**
Incremental Initial Cost	US$ 111	US$ 37 or 148
Annual Electricity Cost (Inverter RAC)	US$ 896 (5.27(kW)x2000(h)x0.26(US Cent/kWh)/3.06)	US$ 598 or 565 (3.52(kW)x2000(h)x0.26(US Cent/kWh)/3.06 or 3.24)
Annual Electricity Cost (Non-inverter RAC)	US$ 989 (5.27(kW)x2000(h)x0.26(US Cent/kWh)/2.77)	US$ 658 (3.52(kW)x2000(h)x0.26(US Cent/kWh)/2.78)
Annual Electricity Rate Benefit	US$ 94	US$ 60 or 93
Simple payback period	1.2 Years	0.6 or 1.6 Years

Note 1: Assumption: Full load equivalent operating hours = 2,000 hours (BSJ defines annual operating hours of room air conditioners as 2,000 hours.
Note 2: Electricity flat rate of residential customer = 0.26 (US Cent/kWh).
Note 3: For the efficiency of room air conditioners, an index (ISO standard is CSPF) with higher accuracy than the indices (COP, EER, etc.) for rated operation should be used as the energy-saving effects of inverters would be evaluated higher.
Source: JET

(3) Needs Survey for Various EE&C Technologies

As a result of a questionnaire survey (including interviews) on the priorities and needs for the various EE&C technologies in St. Kitts and Nevis to related organizations such as C/Ps and related donors, the top three technologies of interest were all related to inverter technology: optimized operation with inverter, inverter RAC, and VRF. On the other hand, there was little interest in improving the efficiency of refrigerators, which are the major electricity consuming appliance in household electricity consumption.

The results of this survey are shown in **Table 5-11**.

Table 5-11 Needs/Priority Survey Results regarding Introduction of Various EE&C Technologies in St. Kitts and Nevis

Priority	EE&C Technologies
1	Optimized operation with inverter
2	Inverter RAC
3	VRF
4	LED
5	BEMS
6	Smart meter
7	Amorphous transformer
8	Efficient motor (IE1 - IE3 level)
9	Heat recovery system (co-gen, heat recovery heat pump)
10	Efficient refrigerator
EV	St.Kitts: very high, Nevis: low

Source: JET

5.1.7 Operation and Maintenance of Thermal Power Generation Facilities

On St. Kitts, the EDC system has not yet been installed in the power system, and the frequency is controlled by a governor and manual control. There is no uniformity among manufacturers and controllers, and when an Energy Management System (EMS) is installed, it is necessary to harmonize control panels with multiple specifications. In addition, the diesel generators are operated with a minimum load of 60-70 % to prevent efficiency loss during partial load operation. Scheduled maintenance is performed by dispatching a person in charge from the main engine manufacturer to replace parts at the replacement time recommended by the main engine manufacturer.

The fuel for the thermal power generation equipment is all diesel oil imported from Venezuela, and the amount used is 29,000 Imperial Gal/day. A pipeline connects from the port to the fuel tanks. There are three fuel tanks with capacities of 6,000 bbl x 1, 3,000 bbl x 1, and 500 bbl x 1. The total capacity is equivalent to 12 days of consumption.

The monthly load factor and availability of the Needsmust power plant are shown in **Table 5-12** and **Table 5-13**; the average load factor from August 2017 to April 2019 is about 57 %, which is the international standard.

Table 5-12 Monthly load factor for Needsmust power plant [%]

	G1	G2	G3	G4	Mobile Cat 1	Mobile Cat 2	Mobile Cat3	Mobile Cat 4	G9	G10	G11	G12	G14
2017/8	63.2	76.5	79.1	74.2	-	0.0	0.0	-	69.9	79.0	81.3	81.5	80.0
2017/9	62.3	76.1	78.1	71.1	-	0.0	0.0	-	66.1	80.0	80.3	78.2	78.3
2017/10	63.8	76.3	77.9	73.9	-	0.0	0.0	-	0.0	79.6	82.2	81.4	81.0
2017/11	64.6	76.2	76.3	74.4	-	0.0	0.0	-	0.0	81.5	81.6	82.0	81.9
2017/12	63.0	76.9	72.6	74.7	-	28.5	35.9	-	0.0	79.7	80.3	81.4	79.0
2018/1	62.8	76.7	69.1	74.7	-	0.0	40.2	-	0.0	78.9	81.3	80.7	78.3
2018/2	60.8	76.2	72.9	73.4	-	0.0	48.7	-	0.0	77.0	80.4	79.2	76.3
2018/3	63.3	75.5	77.7	73.3	-	0.0	31.8	-	0.0	77.1	81.7	81.6	77.1
2018/4	61.5	72.4	76.9	80.8	70.7	75.0	75.0	72.6	0.0	0.0	80.9	80.2	55.5
2018/5	62.1	73.8	75.4	69.7	74.5	68.6	73.0	72.8	0.0	75.4	81.0	80.0	58.7
2018/6	61.5	74.2	75.2	67.2	0.0	65.0	65.0	79.8	0.0	79.0	82.0	80.7	80.3
2018/7	66.3	72.2	70.1	68.0	-	103.8	135.0	50.7	0.0	0.0	82.3	80.4	80.4
2018/8	65.5	73.0	64.2	69.0	0.0	0.0	71.8	72.4	0.0	0.0	82.6	82.3	0.0
2018/9	65.2	75.2	65.0	71.8	0.0	0.0	72.0	73.6	0.0	0.0	82.5	82.5	54.1
2018/10	64.6	71.9	69.0	69.8	69.9	69.4	71.3	69.8	67.8	81.1	81.9	81.9	83.3
2018/11	63.2	72.8	72.1	62.1	0.0	68.9	68.2	70.1	64.0	79.5	80.4	80.3	0.0
2018/12	63.2	72.7	72.8	5.0	0.0	70.7	71.8	44.1	64.5	0.0	78.9	80.5	0.0
2019/1	64.3	71.9	72.8	53.0	0.0	78.8	62.5	42.0	63.4	0.0	80.5	81.0	0.0
2019/2	62.7	72.1	71.6	42.9	0.0	67.1	69.3	55.3	64.4	0.0	80.0	79.9	0.0
2019/3	63.7	71.9	73.4	59.4	0.0	65.6	69.4	43.3	65.3	0.0	78.3	80.1	0.0
2019/4	62.1	67.8	71.9	63.2	0.0	61.8	66.6	35.2	63.5	0.0	79.1	80.0	0.0

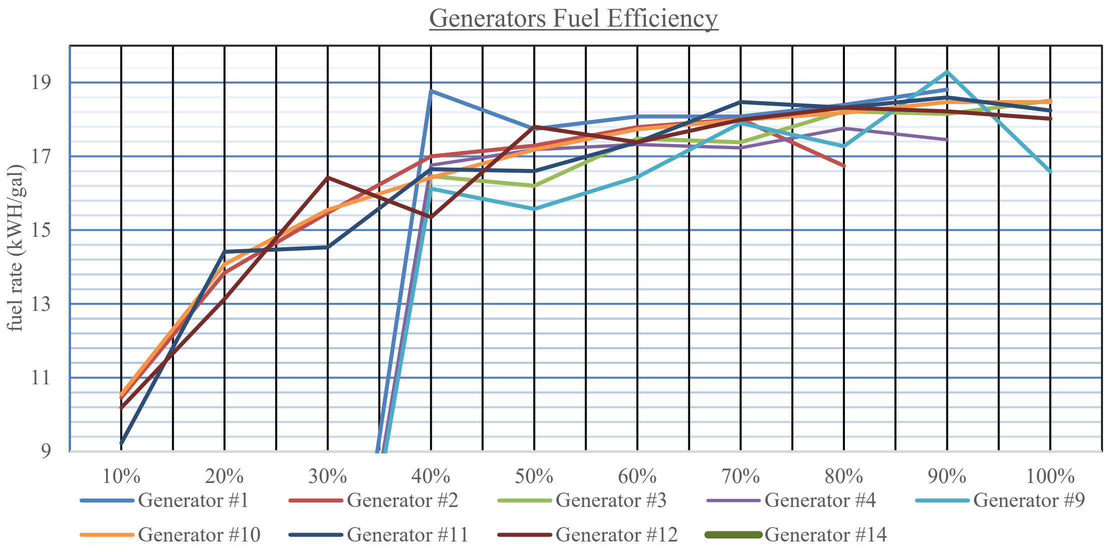
Source: Prepared by JET based on data provided by SKELEC

Table 5-13 Monthly availability of Needsmust power plant [%]

	G1	G2	G3	G4	Mobile Cat 1	Mobile Cat 2	Mobile Cat3	Mobile Cat 4	G9	G10	G11	G12	G14
2017/8	94.5	91.5	89.9	85.1	-	0.0	0.0	-	9.3	54.0	77.0	96.8	65.1
2017/9	84.3	71.9	86.9	80.7	-	0.0	0.0	-	2.5	61.0	86.9	78.1	36.4
2017/10	98.1	76.3	79.8	91.5	-	0.0	0.0	-	0.0	78.1	98.1	80.4	53.1
2017/11	91.8	84.4	52.1	95.3	-	0.0	0.0	-	0.0	98.6	88.3	91.5	59.3
2017/12	95.2	93.7	23.1	98.1	-	1.6	1.2	-	0.0	89.2	85.2	87.5	61.2
2018/1	98.5	92.2	26.2	93.4	-	0.0	1.2	-	0.0	78.8	79.6	85.2	71.5
2018/2	68.3	95.1	30.1	97.9	-	0.7	1.0	-	0.0	79.6	94.6	93.2	62.1
2018/3	97.8	90.7	79.2	95.0	-	7.0	7.9	-	0.0	11.0	100.0	96.1	55.6
2018/4	88.1	69.6	97.5	88.1	18.0	27.5	26.3	39.0	0.0	0.0	94.7	92.1	72.6
2018/5	90.1	65.9	99.6	90.1	22.5	20.6	17.1	26.9	0.0	27.7	100.0	94.1	57.1
2018/6	61.3	87.2	98.5	61.3	0.0	8.9	17.6	21.2	0.0	84.0	96.5	88.9	75.0
2018/7	94.4	82.8	99.2	94.4	0.0	19.9	14.1	46.0	0.0	0.0	92.6	65.7	7.1
2018/8	90.3	96.1	91.5	90.3	0.0	0.0	20.4	36.0	67.2	99.3	98.9	55.2	0.0
2018/9	96.0	98.6	4.2	96.0	0.0	0.0	24.0	48.8	67.4	96.8	96.5	98.9	3.1
2018/10	98.8	91.7	8.7	98.8	2.0	34.7	21.4	46.4	66.1	97.3	93.5	100.0	4.6
2018/11	94.0	83.2	93.9	94.0	0.0	12.6	5.0	15.9	57.5	88.3	93.3	91.9	0.0
2018/12	97.7	86.8	98.0	97.7	0.0	12.1	12.2	14.6	53.7	98.9	97.3	88.0	0.0
2019/1	62.1	94.2	98.9	62.1	0.0	19.6	4.8	19.0	57.5	86.4	100.0	99.1	0.0
2019/2	86.3	89.3	94.3	86.3	0.0	14.6	8.3	18.5	73.7	98.7	72.0	97.8	0.0
2019/3	97.8	88.3	99.3	97.8	0.0	24.5	9.5	27.8	67.5	95.3	28.8	94.0	0.0
2019/4	98.9	70.7	91.7	98.9	0.0	6.8	5.6	15.6	33.4	84.6	96.5	100.0	0.0

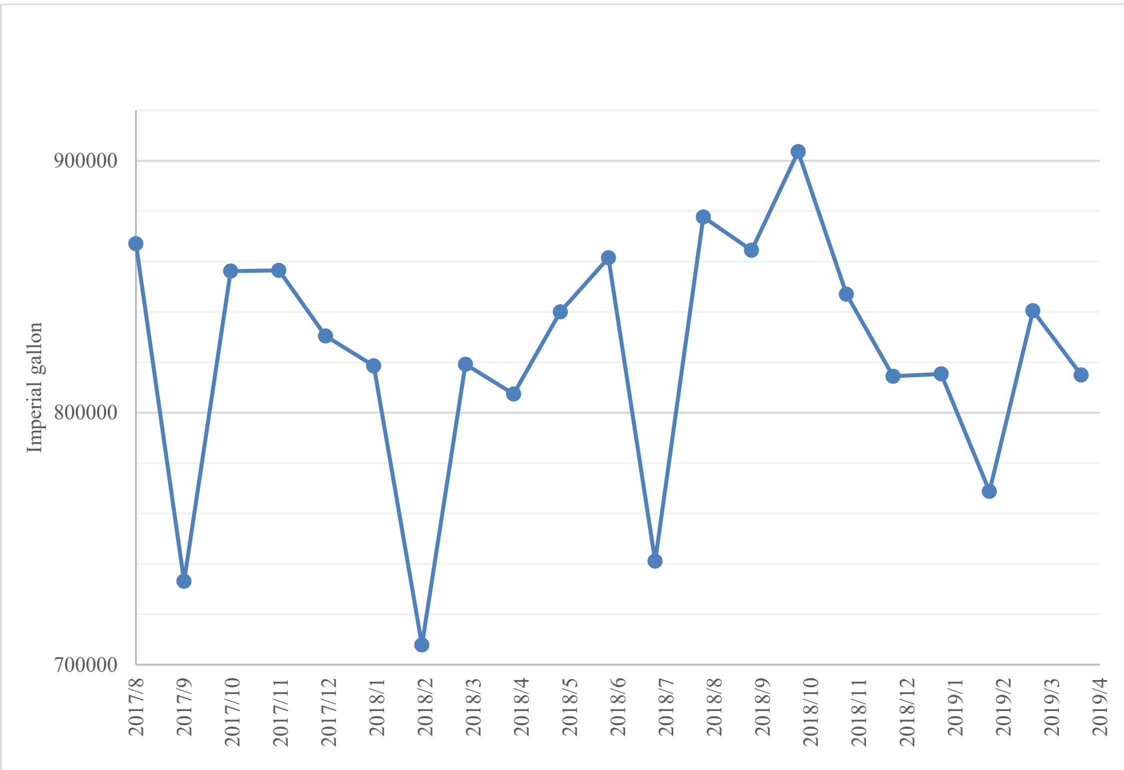
Source: Prepared by JET based on data provided by SKELEC

The load-fuel curves and monthly fuel usage of the power generation equipment installed at the Needsmust power plant are shown in **Figure 5-12** and **Figure 5-13**. As shown in the load-fuel curves, there is no significant decrease in efficiency at partial loads of 60-70 %, although there are some individual differences.



Source: SKELEC

Figure 5-12 Generator load-fuel curve (Needsmust power plant)



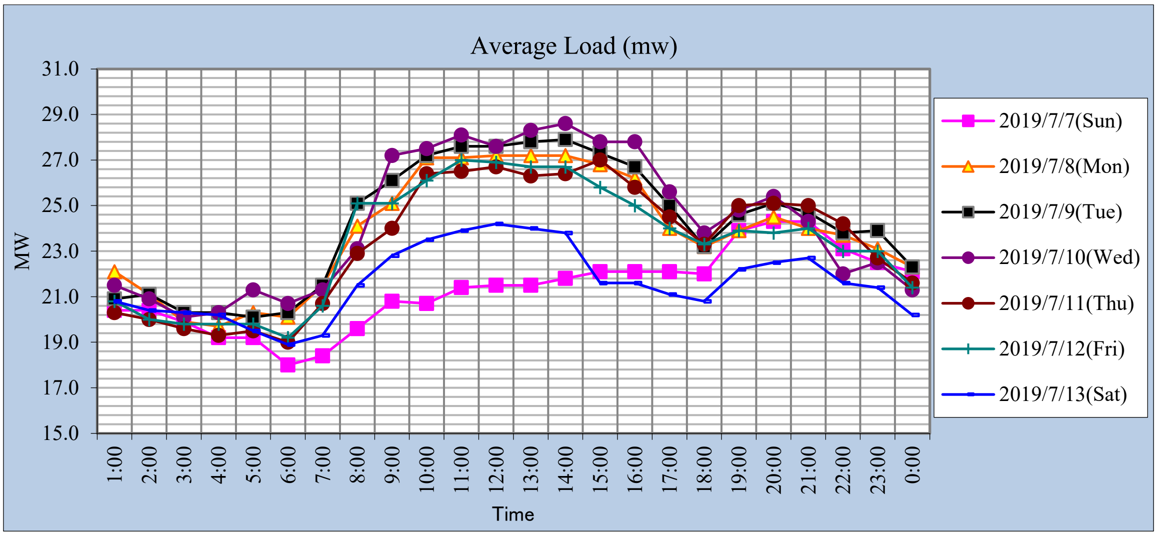
Source: Prepared by JET based on data provided by SKELEC

Figure 5-13 Monthly fuel consumption (Needsmust power plant)

Average hourly, daily, and monthly load and peak power on St. Kitts Island are shown in **Figure 5-14**, **Figure 5-15**, and **Figure 5-16**.

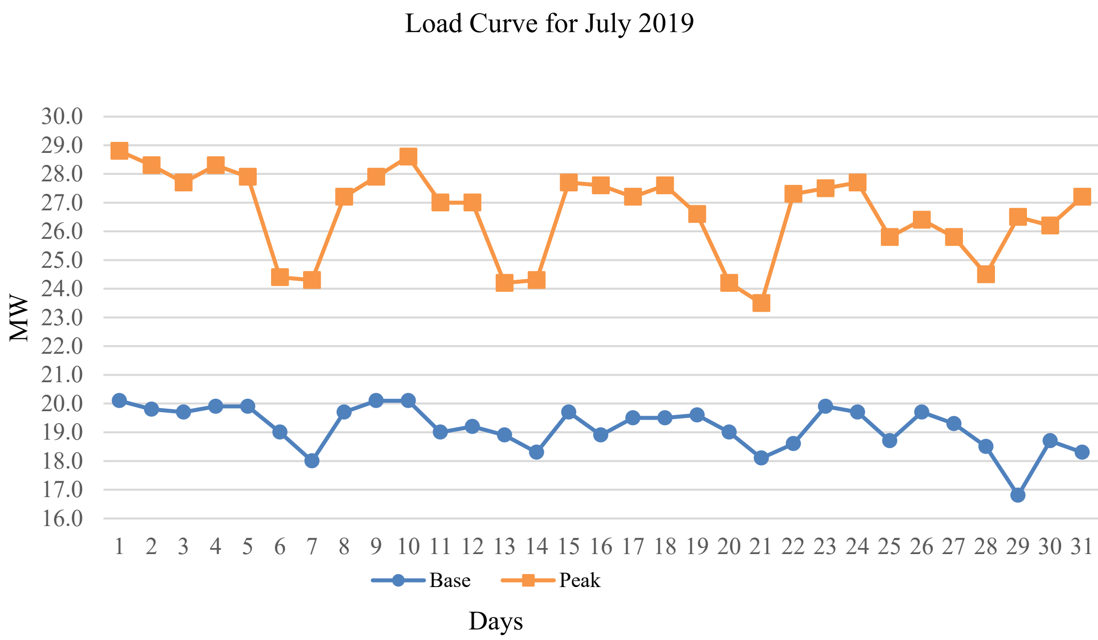
Fuel consumption fell in September 2017, February 2018, September 2018, and February 2019, but the amount of electricity generated also fell, suggesting that electricity demand was smaller due to climate and other factors.

From the hourly electricity load, we can expect a larger electricity load for business use, since the graph shape is characterized by air conditioning load from morning to evening and lighting load at night, and the load is larger on weekdays than on holidays (Saturday and Sunday).



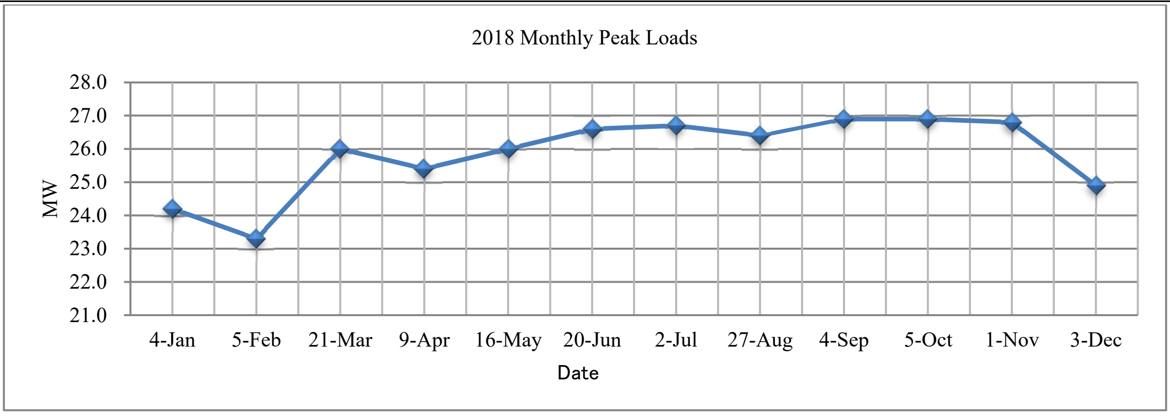
Source: SKELEC

Figure 5-14 Average hourly load on St. Kitts



Source: Prepared by JET based on data provided by SKELEC

Figure 5-15 Daily load curves for St. Kitts and Nevis



Source: SKELEC

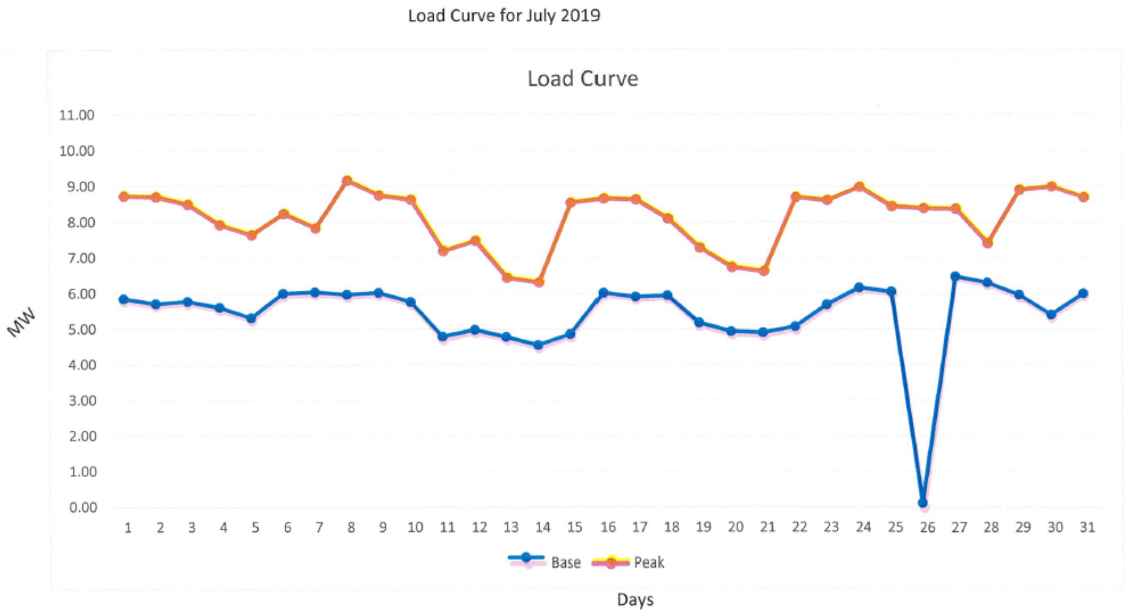
Figure 5-16 Monthly Peak Power on St. Kitts and Nevis

Although the EDC system has not yet been installed, it can be said that the system is operating efficiently as it is able to operate with a minimum load of 60-70 % in principle. In addition, except for G1 and G9, the diesel generators consist of equipment installed relatively recently, and in the short to medium term, there are no problems with supply capacity and the ability to adjust to the introduction of a certain degree of VRE.

On Nevis, the EDC system has not yet been installed in the power system, and the frequency is controlled by a governor and manual operation. A supervisor (SV) has been invited from the manufacturer to perform scheduled maintenance every 1,000 hours in accordance with the maintenance manual issued by the manufacturer. In addition, the generator is inspected every hour. In terms of training, in-house training is provided for newly hired employees. The company also sends employees to Miami, Finland, and England for training.

The fuel for the thermal power generation equipment is purchased from Delta, a fuel distributor.

The daily load curve for Nevis Island for July 2019 is shown in **Figure 5-17**. Similar to St. Kitts, load on holidays (Saturday and Sunday) tends to be smaller than on weekdays. Note that the reason for the zero-Base Load value on July 26 is thought to be that the data was not stored for some reason.



Source: NEVLEC

Figure 5-17 Daily load curves for Nevis

5.1.8 Introduction of RE

As indicated in **5.1.3(2)** , there are projects underway or planned for the introduction of RE. This section presents the status and potential of RE installations.

(1) Status of RE Introduction

The capacity of RE is 3 % of the total grid capacity base and 1 % at energy base. The existing RE generation facilities is shown in **Table 5-14**.

Table 5-14 Existing RE Generation Systems in St. Kitts and Nevis

Location/Project	Type	Capacity MW	Generation GWh estimated	Year	Tariff USc/kWh
S: SCASPA	PV	0.7	NA	2013	Self
S: SKELEC	PV	0.5	1	2015	Self
N: Windwatt	Wind	2.2	5.25	2011	NA

(S: St. Kitts, N: Nevis)
Source: Prepared by JET based on information for MPI, SKELEC, NIA, NEVLEC

Of the above, the PV system installed at the site of SKELEC in St. Kitts has partially damaged and is not operating at full output. The output of the PV system installed at the St. Christopher Air & Sea Ports Authority (SCASPA) airport was originally 1.3 MW, but panels were damaged and reduced output. The damage of the panels is due to the mounts of aluminum supporting structures. (The girders were made of aluminum, and thermal expansion caused stress on the panels, which were fixed with clamps, causing them to crack. The 0.5 MW PV from SKELEC has also been shut down due to an inverter burnout. The PV generation data is not available due to the expiration of the system's license. It is necessary to take measures such as strict scope and specification in selecting contractors when procuring equipment, and mandate maintenance and operational management after installation of equipment during defect liability period.

In addition, rooftop PV systems are installed, but the accurate number is not known. There is no FIT) and the PV is basically installed for private use. Excess reverse flow is supplied to SKELEC's grid at no cost.

In terms of wind power, a Windwatt installed with a rated output of 2.2 MW, consisting of eight 275 kW turbines per unit, in northern Nevis Island in 2010. However, due to blade damage, the plant can only operate at 1.5 MW. In addition, there is a need to curtail the output due to the impact of fluctuations on the grid, and the plant is currently operating with limitation of output 1.0 MW or less.

Photos of the SCASPA Airport PV system in St. Kitts and the wind turbine under repair at Windwatt in Nevis are shown in **Figure 5-18**.

Source: JET

Figure 5-18 SCASPA PV System in St. Kitts (left) and Windwatt Wind Turbine under Repair in Nevis

As for future RE plans for St. Kitts, a power purchase agreement (PPA) for large scale PV system has been signed by Leclanche and SKELEC of Switzerland. The project consists of 35.7 MW PV a 14.8 MW / 45.7 MWh BESS will be installed[9], which will be operated by shifting part of the PV generation during the daytime to nighttime. Of the generation output, 16 MW will be purchased by SKELEC. The maximum output that the grid will accept is 18 MW. Therefore, the excess energy will be charged to storage batteries during the day and discharged and at night. The system is planned to generate approximately 61.3 GWh with a 41,500 t-CO2 emission reduction.

The wind power on St. Kitts is planned to be 5.7 MW Belle Vue wind (reportedly 6.6 MW), and a PPA with North Star is in the pipeline[10].

Nevis has a few rooftops PV sites, but no centralized PV systems have been installed yet. There is a proposal for 5 MW from a private operator, but site has noy yet been identified. On the other hand, a solar desalination plant is planned with the support of the United Arab Emirates (UAE). Wind power has been proposed in Cades Bay and Deep Water Harbour.

Nevis has abundant geothermal potential. CDB and IDB is providing technical assistance and financing to NIA and NEVLEC under the Sustainable Energy Facility (SEF) Program. According to the CDB's procurement plan, the international competitive bidding for contractors will begin in

[9] https://www.leclanche.com/government-of-st-kitts-and-nevis-skelec-and-leclanche-commence-construction-of-caribbeans-largest-solar-generation-and-storage-system/

[10] https://www.sknis.gov.kn/2022/03/04/st-kitts-and-nevis-steadily-moving-towards-renewable-energy-reliance/

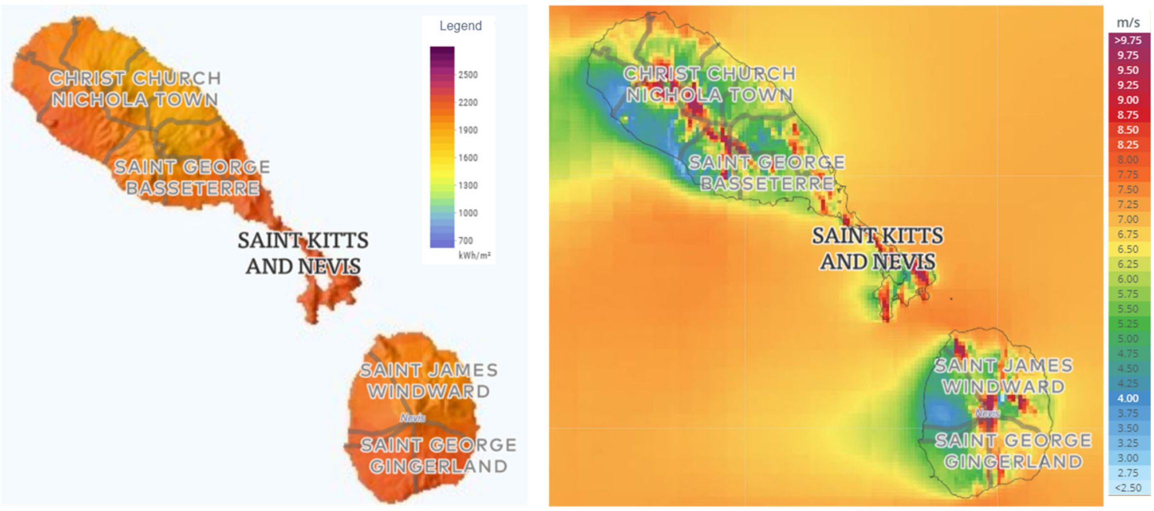
October 2022, and drilling of the first well after selection is scheduled to begin in June 2023[11]. Phase-1 of 10 MW geothermal development will include the drilling of five geothermal wells (one vertical and four horizontal wells) at vertical depths of approximately 4,500 to 5,000 ft. The maximum formation temperature is estimated to be 290°C. Once completed, the geothermal plant is expected to provide Nevis a stable 100 % RE supply.

(2) Potential of PV and Wind

The solar potential in St. Kitts and Nevis is generally high, ranging from 1,900 to 2,200 kWh/m^2/year (5.2 to 6.0 kWh/m^2/day). The St. Kitts has particularly strong solar radiation in the south, while the Nevis has almost no regional differences.

Wind potential is concentrated on the mountain tops and higher elevation areas of St. Kitts and Nevis. Some areas of the northern coast of St. Kitts and the southern peninsula also have high average wind speeds. As in other Caribbean countries such as Barbados, the wind comes from the east as a climatic feature, so wind speeds are low in the western part of the island, which is in the shadow of the mountains. It is the same in Nevis. Areas possible for development have limitation in terms of environmental and topographical aspects. Especially for wind power, it is not necessarily installed at sites with the best wind conditions.

The potential map of solar and wind in St. Kitts and Nevis is shown in **Figure 5-19**.



Source: ESMAP Global Solar Atlas, Global Wind Atlas

Figure 5-19 Solar and Wind Potential in St. Kitts and Nevis

(3) Geothermal potential

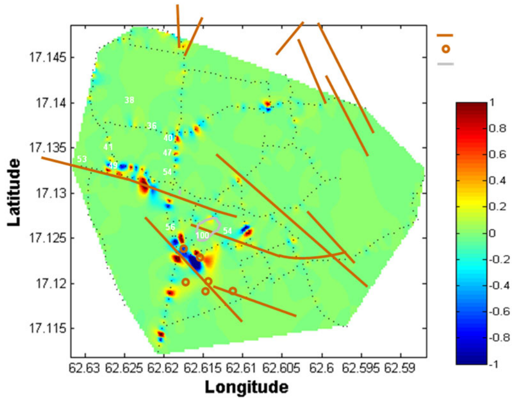
The Eastern Caribbean is a series of geologically young volcanic islands. The eastern Caribbean has developed complex plate tectonic activity, and many natural hydrothermal systems exist in the Caribbean Sea. The fumaroles, hot springs, dormant and active volcanoes, and other thermal phenomena found on the Caribbean islands are primarily related to the subduction of the North Atlantic tectonic plate beneath the Caribbean plate and the fact that the region is seismically active. Mt. Liamuiga in St. Kitts, and Nevis Peak in Nevis are the most active volcanic sites in the region, as are the Soufrière Hills in Montserrat, La Soufrière in Guadeloupe, the Soufrière Volcanic Centre

[11] https://www.caribank.org/work-with-us/procurement/procurement-notices/nevis-geothermal-energy-project

in St. Lucia, The Soufrière, Kick 'em Jenny (underwater) in Grenada, Ronde/Caille and Mt. St. Catherine[12].

In particular, Nevis Island has abundant potential for geothermal power, with a potential output of up to 300 MW reportedly[13]. At present, 10 MW of geothermal power is under development. Financing arrangement has slowed progress, and it is in the procurement stage as of the end of 2022. The goal of 100 % RE in Nevis depends on the installation of the geothermal power.

To assess geothermal potential, various data are necessary such as the depth and distribution of heat sources including magma and geothermal reservoirs that store hydrothermal fluids and steam, as well as the geological properties of rocks. Geophysical surveys recured for geothermal potential study includes gravity, magnetic, electromagnetic, and seismic surveys. The Eastern Caribbean Geothermal Energy Project has proposed geothermal exploration sites based on natural potential, Bouguer gravity anomalies, and active fault locations.



Source: GEOTHERMAL POTENTIAL OF ST. KITTS AND NEVIS ISLANDS, Geothermal Management Company, Inc. Eastern Caribbean Geothermal Energy Project ("Geo- Caraibes"; "G-C")

Figure 5-20 Gravity Anomaly and Active Fault in Nevis

St. Kitts Island also has geothermal potential, but detailed potential estimates and other studies have not yet been conducted. Exploratory drilling at Mt. Liamuiga is planned in the future.

(4) Biomass

The potential for biomass power generation in St. Kitts and Nevis is not high because the population is small (40,000 on St. Kitts and 10,000 on Nevis) and agricultural production such as sugarcane and rice are not large. Waste power generation is also considered unrealistic because it requires a certain population size.

On the other hand, a large amount of sargassum, which is a kind of hogweed, washes ashore on the beaches of St. Kitts and Nevis. The University of West Indies is researching the possibility of fermenting it with food waste to produce methane, which could be used for biogas power generation and fertilizer. However, the soft cellulosic nature of the sargassum has low methane production capacity, and the need for hydrothermal treatment for anaerobic fermentation means that practical

[12] A Review of Caribbean Geothermal Energy Resource Potential, The West Indian Journal of Engineering Vol.42, No.2, January 2020, pp.37-43

[13] Alexander Richter, ThinkGeoEnergy ltd. https://www.thinkgeoenergy.com/exploration-drilling-to-start-for-geothermal-project-on-nevis-caribbean/

application has not yet been achieved[14]. The need for anaerobic fermentation of sargassum has been discussed from the perspective of waste treatment rather than energy production.

It is conceivable that biodiesel could be introduced at the Needsmust and Prospect power plants on St. Kitts and Nevis, respectively, where diesel generators are currently in operation. On the other hand, biodiesel is more expensive than diesel and will increase the cost of electricity in the country, so there are no plans at this time.

Biomass is a challenge in the country, and the development of solar, wind, and geothermal energy is considered more promising.

(5) Grid Stability and Grid Analysis for RE Introduction

SKELEC conducted the Renewable Infusion Study in 2014 with hiring a consultant Leidos. This was a study for the addition of the then planned 4.4 MW of PV and 5.4 MW of wind to the then existing 9.2 MW diesel generator and 11 kV power system at that time. It noted about voltage flicker issues with the introduction of the 5.4 MW of wind. The grid analysis software used at this time was CYME for the power flow analysis and PSS/E for the transient stability calculations. The software for grid analysis had not been provided to MPI or SKELEC. It is not possible for MPI to independently verify the results of the grid analysis or to perform the analysis based on a new plan.

MPI and SKELEC wish to evaluate the impact of future large VRE on their own and requested JET to provide grid analysis software during the baseline study.

5.1.9 Status of transmission and distribution losses

SKELEC commissioned consultant Leidos to conduct the Renewable Infusion Study in 2014. This was a study for the addition of the then planned 4.4 MW of PV and 5.4 MW of wind to the then existing 9.2 MW diesel generator and 11 kV power system, noting voltage flicker issues with the introduction of the 5.4 MW of wind. The grid analysis software used at this time was CYME for the tidal flow analysis and PSS/E for the transient calculations. The software for grid analysis has not been provided to MPI, and MPI is not in a position to independently verify the results of the grid analysis or to perform the analysis based on a new plan.

MPI and SKELEC wish to assess the impact of future large-volume VRE on their own and have asked JET to provide phylogenetic analysis software in the baseline survey.

At the time of the May 2019 survey, the overall transmission and distribution losses were measured at 12 %. Of this, mechanical losses are estimated to be around 9 %. The remaining 3 % is Non-Technical Loss, which is thought to include meter accuracy errors, errors due to meter failures, and stolen power.

5.1.10 Human Resource and Organizational Capacity

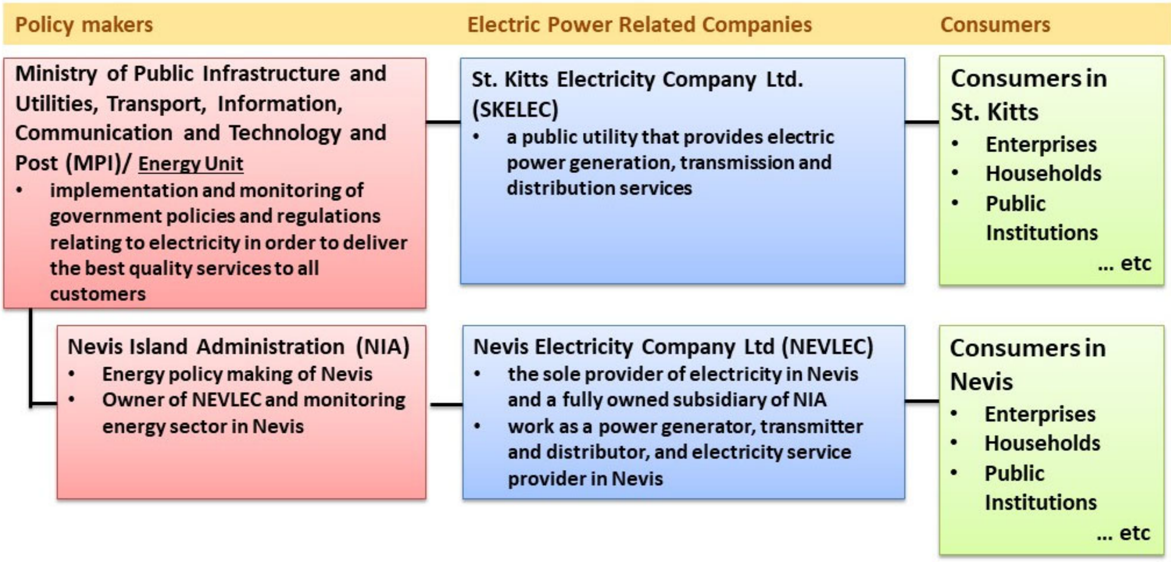
The following section analyzes C/Ps and other relevant organizations related to RE deployment and EE promotion in St. Kitts and Nevis, as well as the status of human resource development in these relevant organizations. A survey of human resources and organizational capacity was conducted

[14] Enhancing biogas production from Caribbean pelagic Sargassum utilizing hydrothermal pretreatment and anaerobic co-digestion with food waste, 2021 Jul;275:130035. doi: 10.1016/j.chemosphere.2021.130035. Epub 2021 Feb 20.

during the baseline survey until the second field trip in July 2019, and then updated with possible information during the subsequent activities.

(1) Energy Sector in St. Kitts and Nevis

The organizational chart of St. Kitts and Nevis' energy sector is shown in **Figure 5-21**. The details of each organization are summarized in the following sections.



Source: Prepared by JET

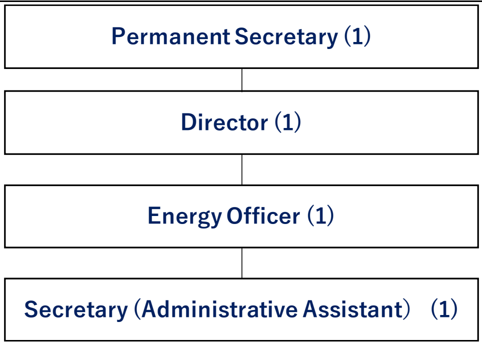
Figure 5-21 St. Kitts and Nevis Energy Sector Relationship Diagram (as of January 2023)

(2) MPI

MPI develops and implements energy policies, regulations, and monitoring and evaluation for quality energy supply in St. Kitts and Nevis. At baseline, the Energy Division of MPI had four staff members and the Energy Unit had three staff members. All staff members are employed as permanent. The Permanent Secretary assigns work to the Director and below, and activities are limited due to the small sized organization. MPI holds regular meetings to exchange information and conducts an annual personnel evaluation meeting with each staff member. There is little regular communication between MPI, SKELEC, and NIA.

Regarding human resource matters, when a vacancy occurs in a higher post, a person in a lower post can apply for it, and if he/she meets the requirements, he/she can be promoted. Occasionally, there are internal transfers from the Energy Division to the Water Service Department and secondments to other ministries. Each post has a fixed salary range, which is determined by qualifications, experience, and skills. There is no bonus. Regarding recruitment, MPI first considers internal personnel, and if none are available, public recruitment is conducted through newspapers, social media, and other means. There are no internal trainings and MPI use eternal trainings. There is no CEM or CEA certified personnel in MPI.

An organizational chart of the MPI Energy Unit is shown in **Figure 5-22**.



Source: Prepared by JET

Figure 5-22 Organization Chart of MPI Energy Unit (As of January 2023)

St. Kitts has a goal of 100 % RE by 2030. During the baseline survey, MPI asked JET to review the draft of the grid code that SKELEC had been working on. Regarding EE, MPI had opinion that ESCOs and energy audits were the responsibility of private companies and not within the scope of SKELEC's work. However, changes in power consumption due to EE will have an impact on future power development plans, so it is necessary to promote MPI's understanding.

(3) SKELEC

SKELEC is the electric utility that generates, transmits, and distributes electricity in St. Kitts. At the time of the baseline survey, SKELEC had 157 employees in four departments of Transmission & Distribution, Planning & Development, Finance & Administration, and Customer Service (CS). Each department has a manager and there are four mangers in SKELEC. The Needsmust thermal power plant that JET visited had 9 mechanics, 2 electrical engineers, and 13 operators. The CSs receive training by inviting outside instructors. For new hires, HR conducts an orientation, followed by guidance from each department head. Participation in external training is also possible, and employees also participate in CARILEC trainings.

In the baseline, some of the PV installed at SKELEC were not in operation due to malfunctions, and the need was pointed out to tighten the criteria for selecting suppliers when procuring equipment, and to ensure thorough maintenance and operational management after equipment is installed. SKELEC has conducted system stabilization studies through the RE Infusion Study to achieve 100 % RE.

(4) NIA

NIA is an organization under MPI that formulates the electricity policy for Nevis. NIA does not have MEPS system or CEM and CEA certificated employees. Energy audits have been conducted in Nevis twice in the past by donors (UNDP and CDB). Reports from donors are submitted to MPI and NIA does not have them. It was observed that there was a challenge on information sharing between MPI and NIA here. At the time of the baseline survey, NIA had installed 16 EVs, and there was a request for the dissemination of storage battery equipment from NIA.

(5) NEVLEC

NEVLEC is the operator of the electricity business in Nevis. At the time of the baseline survey, NEVLEC had 78 employees and four departments: Transmission & Distribution, Generation, Finance & Administration, and CS. NEVLEC has an in-house training program for new employees. On-the-job training is provided through external training programs, and management level employees attend external training programs. However, there is no human resource development plan. Monthly management and staff meetings are held. Personnel evaluations are conducted twice a year.

NEVLEC has approximately 7,500 customers, with Four Season Hotel being the largest customer (20-30 % of total demand) at the time of the baseline survey. NEVLEC has not prepared a long-term electricity supply and demand forecast. Smart meters have not been installed. System losses account for 14 % of the total, of which 9 % are technical losses and 5 % are non-technical losses. The supply and demand of electricity is in a tight situation, and NEVLEC was interested in the EE project.

A supervisor was invited from the manufacturer of the generators at Needmust Power Plant, and maintenance is being carried out systematically according to the maintenance manual issued by the manufacturer. However, unplanned maintenance also occurs, and there are operational issues such as delays in the arrival of parts and a lack of maintenance personnel etc. Power outages occur twice a month for about two hours each time, and the daily load factor is high at about 70 %.

(6) Other Related Organizations

- Water Services Department (WSD)

  WSD has a total staff of 85, with only one engineer and no CEM or CEA holders as of July 2019 due to a recent string of engineer retirements. In addition, human resource development is mainly through on-the-job training and participation in external workshops as needed. There was a need for human resource development in mechanical engineering, piping repair and design engineers etc.

- St. Kitts and Nevis Bureau of Standards (SKNBS)

  SKNBS revealed that they did not have any information on CEM or CEA.

(7) Support of Other Donors

JET interviewed each donor on site about the status of their support in St. Kitts and Nevis. **Table 5-15** summarizes the summary of the interviews.

Table 5-15 Overview: Support of Other Donors (As of July)

Project	Donors	Contents
Sustainable Energy for the Eastern Caribbean (SEEC)	CDB, EU, DFID	Co-finance project of USD 12mil. The loan (interest rate is 4.7-4.8 %, real interest rate less than 3 %) and TA are provided in parallel, from energy audit for SMEs and the government, formulation of EE implementation plans, and procurement and installation of EE equipment.
CDB Geo Smart Initiative	CDB, IDB, EU, DFID, GEF	PPP model for initial capital investment (concessional loan) and 5-donor co-financing in a package program of grants and loans under the Geo Smart Initiative.
Battery Energy Storage Systems (BESS) Study	CDB	A survey on storage battery systems, although details are not available.
Street Light Project	CDB	Research on the streetlight, although details are not available.
Grid Code	WB	Assistance in formulating SKELEC's Grid Code.
Energy Audit	UNDP	Details are unknown, but it is likely related to the Caribbean Energy Efficiency Lighting Project (CEELP), which ended in 2015.
Energy Audit	CDB	Details are unknown, but it appears to be part of Sustainable Energy for the Eastern Caribbean, which ended in 2018.

Note 1: DFID stands for the Department for International Development.
Note 2: GEF stands for Global Environment Facility.
Source: Prepared by JET

5.2 Issue Analysis and Technology Transfer Items to St. Kitts and Nevis

5.2.1 Organization of Technical Transfer Items

The following is a description of the technical items to be transferred to St. Kitts and Nevis under this project.

(1) Promotion of EE

- Review and recommendation of EE targets based on cost-effectiveness analysis for the introduction of equipment that can save energy.
- Review and make recommendations on facilities necessary to achieve EE targets.
- Review and recommendation of technologies necessary to achieve EE targets, including BEMS, etc.
- Review and recommendation policies and systems necessary to achieve EE goals.
- Formulation of human resource development plans necessary to achieve EE goals
- Implementation of on-the-job training, training in Japan, etc. in accordance with the human resource development plan for EE
- Verification and review of the effect of human resource development for EE
- Recommendations for realization of EE promotion projects
- Recommendations for formulating policies and systems recommended in the realization of EE goals

(2) Improvement of Existing Thermal Power Plant

- Review and recommendation of measures necessary to improve operational efficiency of thermal power generation facilities, etc.
- Review and recommendation of measures to improve maintenance of thermal power generation facilities and procurement of spare parts

(3) Introduction of RE

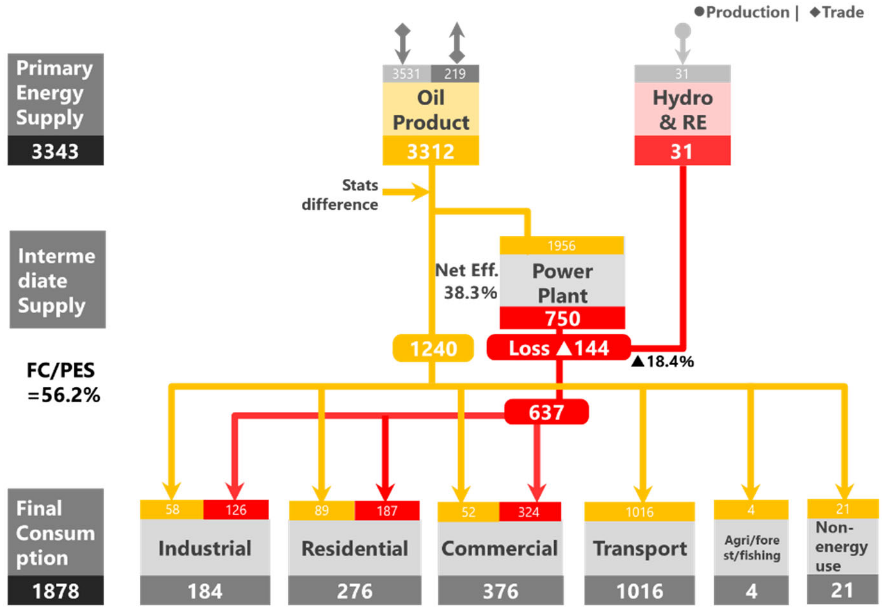
- Review and recommendation for policies and systems necessary to realize the goals for the introduction of RE
- Development of human resource development plans necessary to realize the goals for the introduction of RE
- Implementation of on-the-job training, training in Japan, etc. in accordance with the human resource development plan for RE
- Verification and review of the effectiveness of human resource development for RE
- Recommendations for the realization of projects to introduce RE
- Recommendations for the formulation of policies and systems proposed in the realization of RE introduction targets
- Renewable energy potential study
- Study of necessary costs of grid stabilization and study and recommendation of methods to promote RE
- Review and recommendation of facilities required to realize RE introduction targets
- Review and recommendation of technologies necessary to realize RE introduction targets

5.2.2 Latest Energy Balance Status of St. Kitts and Nevis in 2020

According to the latest St. Kitts and Nevis Energy Balance (2020, UNSD), almost all primary energy supply comes from imported petroleum products. The share of renewable energy supply is only 1 % in RE power generation.

As for the energy conversion sector, the overall net efficiency of thermal power plants is 38.3 %, which is within the standard level, but the transmission and distribution loss is as high as 18.4 %, which suggests that there is a considerable amount of non-technical losses in addition to energy losses in transmission and distribution cables, transformers, and other equipment.

An energy balance flow diagram for St. Kitts and Nevis based on the energy balance table is shown in **Figure 5-23**.

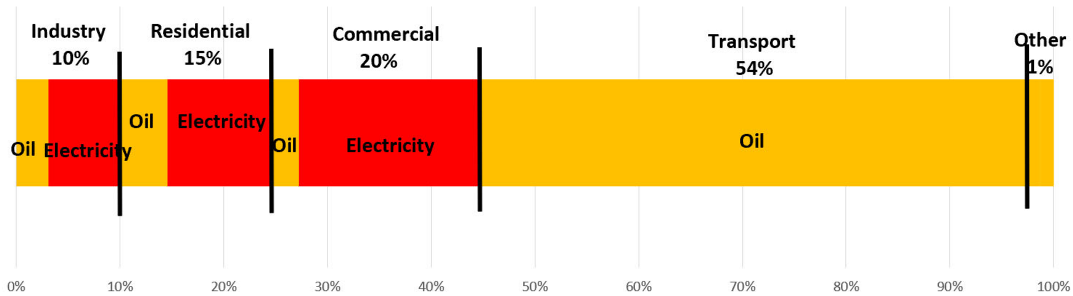


Source: Prepared by JET based on St. Kitts and Nevis Energy Balance Table (2020, UNSD)

Figure 5-23 Energy Balance Flow Diagram for St. Kitts and Nevis (2020, TJ)

Regarding the final consumption side, transportation sector accounts for 54 % of final energy consumption, followed by commercial (20 %), residential (15 %), and industrial (10 %) sectors.

With regard to electricity consumption, since the commercial and residential sectors account for 80 % of the total, energy efficiency and conservation measures in the non-industrial sector should be prioritized. (See **Figure 5-24**)



Source: Prepared by JET based on St. Kitts and Nevis Energy Balance Table (2020, UNSD)

Figure 5-24 St. Kitts and Nevis Final Energy Consumption Composition (by Sector, by Energy, 2020)

5.2.3 Technical Transfer Items

Based on the results of the baseline survey and the energy balance flow diagram, we organized and reviewed the technology transfer items, and the items in **Table 5-16** were selected as technology transfer items to Barbados.

Table 5-16 Technical Transfer Items to St. Kitts and Nevis

No	Technical Transfer Items	
1	**Promotion of EE**	
	1	EE Roadmap and Target Value Formulation [Recommendation]
	2	Equipment and Technology Necessary to Achieve EE Goals [Recommendation]
	3	Promotion of EE in Various Fields [Recommendation]
	4	Human Resource Development to Achieve EE Goals [Workshops]
	5	Policies and Systems Necessary to Realize EE Targets [Recommendation]
2	**Improvement of Operation and Maintenance Management of Thermal Power Generation Facilities [Recommendation]**	
3	**Introduction of RE**	
	1	Grid Analysis for Large VRE introduction [Recommendation]
	2	Strengthening the Power Grid between St. Kitts and Nevis [Recommendation]
	3	Improving Resilience through Asset Management [Recommendation/Seminar]
	4	Human Resource Development [Seminars]
	5	Policies and Systems to Realize the Introduction of RE [Recommendation/Seminars]
	6	Human Resource Development [Seminars]

Source: Prepared by JET

5.3 (Phase 2) Technical Transfer to St. Kitts and Nevis

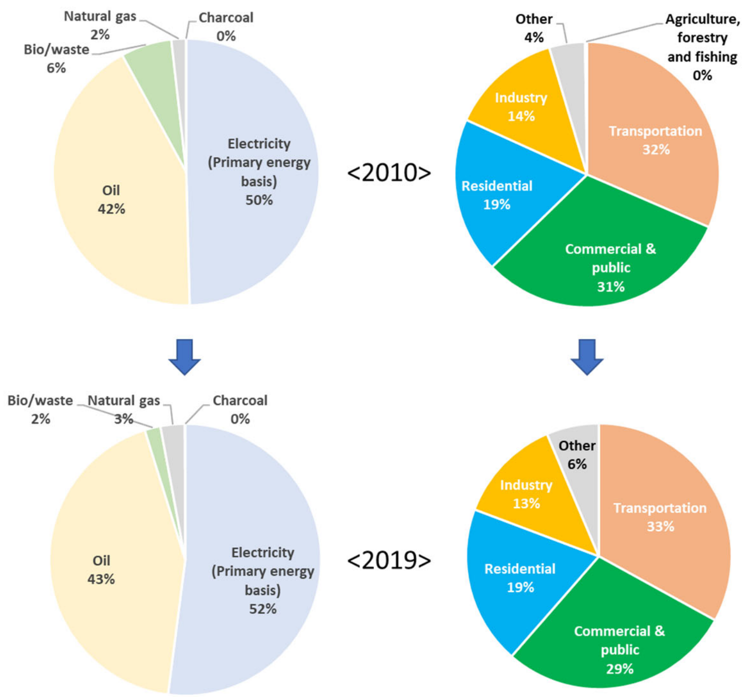
5.3.1 EE Roadmap and Target Value Formulation

(1) Preparation of EE Roadmap

In St. Kitts and Nevis, since there is no data on electricity demand by use, the EE roadmap was developed in consultation with the counterpart utilizing the "Consumer Guide Energy Efficiency" (BREA), a document provided by the Government of Barbados. Accordingly, as in Barbados, targeting the non-industrial sector, in which the main demands are for the three usages, air conditioning, refrigerator and lighting, the EE roadmap (including potential of electricity consumption reduction, energy saving rate, BAT for each application, etc.) was developed up to 2036 to achieve efficiency improvements in conjunction with the introduction of MEPS, and reported at the 1st and 2nd EE Workshops. In developing the roadmap, JET referred to the latest energy balance table (United Nations Statistics Division, 2019) available at the time of preparation for the EE Workshop.

■ Changes in energy consumption structure over time based on energy balance

A comparison of energy consumption ratio (primary energy basis) between 2010 and 2019 shows no significant changes in either consumption ratio by energy or by sector. **Figure 5-25** shows the energy consumption structure (by energy and sector) based on the energy balance table (UNSD) for 2010 and 2019.



Source: JET based on UNSD data

Figure 5-25 Changes in Energy Consumption Structure (primary energy basis) by Energy (left) and Sector (right) in 2010 (top) and 2019 (bottom)

Table 5-17 shows the energy consumption in St. Kitts and Nevis (by sector and energy, 2019).

Table 5-17 Energy Consumption in St. Kitts and Nevis by Sector, by Energy (primary energy basis), 2019, TJ

	Industry	Commercial & Public	Residential	Agriculture, forestry and fisheries	Transport-ation	total amount
Oil	62	54	94	4	1,086	**1,300 (38 %)**
Electricity (primary energy equivalent)	409	1,065	622	-	-	**2,095 (62 %)**
Total amount	**471 (14 %)**	**1,119 (33 %)**	**716 (21 %)**	**4 (0 %)**	**1,086 (32 %)**	**3,395 (100 %)**

Note 1: Calculated from the Energy Balance Table (United Nations Statistics Division) with electricity demand end efficiency = 32.5 %.
Source: JET based on energy balance table (UN Statistics Division).

- Key Assumptions
  - Medium-and-long term electricity demand forecast

    Using the latest energy balance table available at the time of preparation for the EE workshop (United Nations Statistics Division, 2019), JET calculated the average annual growth rate (AAGR) by sector from 2010 to 2019, made electricity consumption forecasts for each sector until 2036, and defined this assumption as the case where EE&C measures are not implemented (BAU, Business As Usual).

    Note: AAGR (commercial use) = 0.2 %, AAGR (residential use) = 1.7 %.

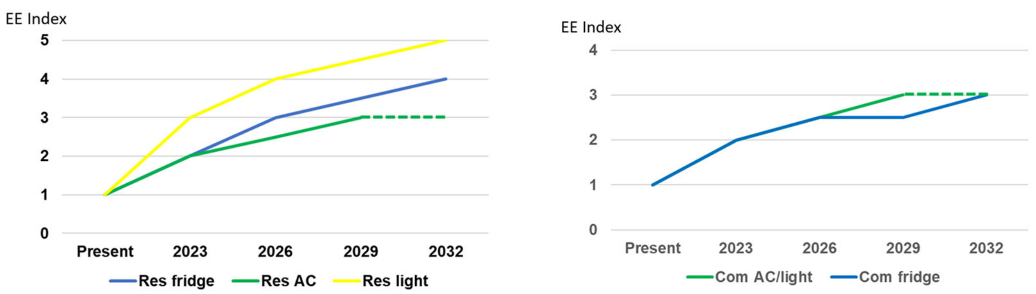
  - MEPS introduction/upgrade assumptions for major equipment

    As shown in **Table 5-18** and **Figure 5-26**, the same assumptions were made as in Barbados.

Table 5-18 Changes of MEPS assumed in the EE Roadmap (St. Kitts and Nevis)

	EE Index					
	Residential refrigerator	Residential RAC	Residential lighting	Commercial AC equipment	Commercial lighting	Commercial refrigerator
Present	1	1	1	1	1	1
2023	2	2	3	2	2	2
2026	3	2.5	4	2.5	2.5	2.5
2029	3.5	3	4.5	3	3	
2032	4		5			3

Source: JET



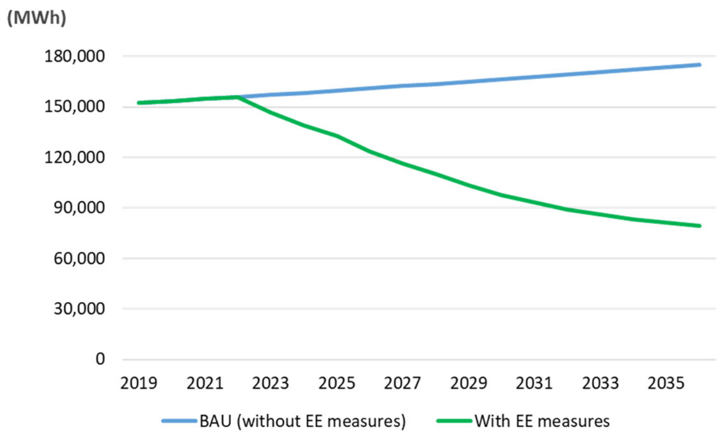
Source: JET

Figure 5-26 MEPS assumed in the EE Roadmap (left: residential use, right: commercial use)

- Study results of EE roadmap

- Electricity reduction in 2030 is about 69 GWh (energy saving rate of about 41 %, vs. BAU).
- The amount of electricity reduction in 2036 is about 96 GWh (energy saving rate of about 55 %, vs. BAU). The breakdown is 57 GWh for commercial sector and 39 GWh for residential sector.
- The ratio of energy saving contribution by equipment was 35 % for air conditioners, 32 % for refrigerators, and 33 % for lighting, which are almost equal.

Figure 5-27 shows the transition of electricity consumption up to 2036 in the EE roadmap (non-industrial sector) prepared.



Source: JET

Figure 5-27 Electricity Consumption Reduction Potential in St. Kitts and Nevis (Non-industrial Sector, up to 2036)

(2) Energy Audit (walk-through survey) Results

The results of a simple energy audit (walk-through survey) conducted in the Government of Barbados buildings were reported at the second EE Workshop (including proposals for EE&C measures for space cooling demand which is estimated to account for 50 % of office buildings, refrigerators, and lighting. (Refer to **4.3.1(2)**).

(3) Summary (including additional EE&C measures/efforts proposed)

While St. Kitts and Nevis does not set EE&C targets, the EE roadmap shown in **5.3.1(1)** was developed based on the assumption of early introduction of MEPS (the earlier it is introduced, the more energy-saving effects are accumulated) and periodic (and possible) increase of MEPS at a high pitch. As a result, electricity consumption in the non-industrial sector in 2030 was estimated to be approximately 98 GWh (reduction = 69 GWh, vs. BAU).

In addition to the introduction/upgrade of MEPS in the above three equipment, additional EE&C measures/efforts for further energy saving were considered, resulting in an energy saving rate of approximately 51 % (vs. BAU) and a national electricity consumption of approximately 100 GWh in 2030. **Table 5-19** shows additional EE&C measures to be prioritized and their energy-saving effects.

Table 5-19 Additional EE&C Measures/efforts and Expected Energy Saving Effects

Priority	Additional EE&C measures/efforts	Expected energy-saving effects
High	Thorough energy management practices (including BEMS installation)	10 GWh (10% reduction of commercial + industrial demand)
High	Introduction of MEPS into motors, OA equipment, home appliances, etc.	14 GWh (10% reduction for residential + commercial + industrial demand)
Medium	Mandatory introduction of building codes	10 GWh (10% reduction of residential + commercial demand)
low	Reinforcement of EE&C promotion and awareness raising activities	3 GWh or more (including higher cooling temperature settings, night purge, economy of energy efficient equipment, etc.)

Source: JET

5.3.2 Equipment and Technologies Necessary to Achieve EE Goals

Based on the description in **5.3.1(3)** , recommendations were made through EE workshops, etc., regarding the contents and results of studies related to energy consumption equipment and technologies necessary to realize EE&C goals. Specifically, the same contents as described in **4.3.1(2)** and **4.3.2** were used.

- Summary of key recommendations

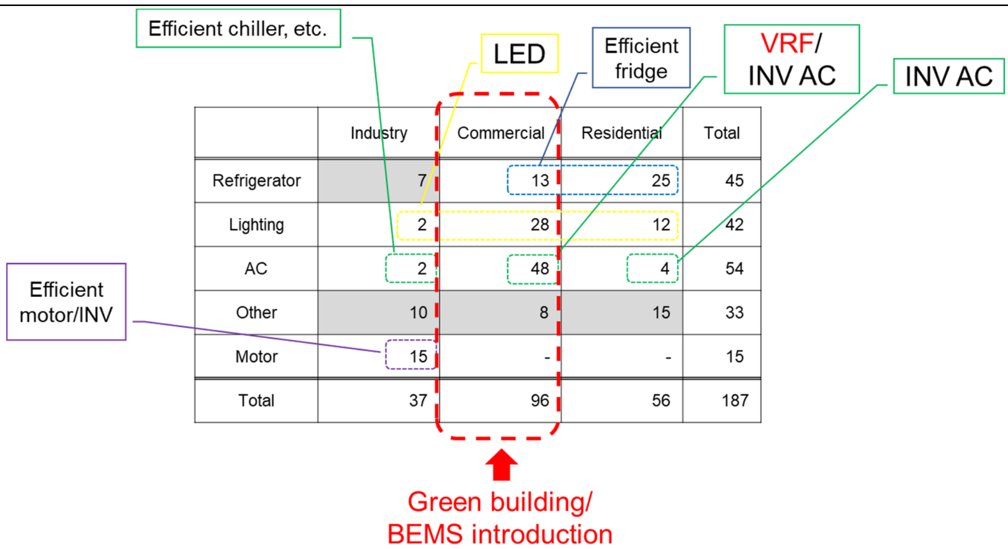
  When developing the EE roadmap that showed the changes in electricity consumption associated with the introduction of MEPS for three major equipment, a study from the equipment side was made while keeping BAT in mind. As a result, it has proved that there is an urgent need to improve the efficiency of air conditioners, refrigerators, and lighting fixtures, and a proposal for introducing / raising the MEPS at an early stage was made. Furthermore, the recommendation was made on the dissemination of BEMS (Building Energy Management System) which is necessary for effective implementation of energy management at each organization.

5.3.3 Recommendations for the Realization of EE&C Promotion Projects

As the power consumption structure in St. Kitts and Nevis by end-use is shown in **Figure 5-28**, the non-industrial sector accounting for about 81 %. Among these, the areas that are major power consumption areas but for which there is no specific policy prospects are commercial air-conditioning, commercial refrigerators, and industrial motors. For industrial motors, it is necessary to formulate MEPS for motors from now on, which will also apply to elevators, various pumps, etc. in the commercial sector.

On the other hand, although commercial air conditioning is one of the largest power consumption areas, early introduction of MEPS for central air conditioning is considered difficult (it is not even included in Japan's Top Runner program).

Therefore, JET recommends as a commercial green building project that VRF dissemination, implementation of energy management activities through BEMS utilization, and dissemination/sharing of project results (promotion of awareness raising activities) for EE&C/green building of commercial buildings be pursued. (See **Figure 5-28**)



	Industry	Commercial	Residential	Total
Refrigerator	7	13	25	45
Lighting	2	28	12	42
AC	2	48	4	54
Other	10	8	15	33
Motor	15	-	-	15
Total	37	96	56	187

Note: Gray shaded areas are where specific EE&C measures are not available.

Source: JET based on energy balance table (UNSD,2019)

Figure 5-28 Electricity Consumption (GWh) by Sector and Use in St. Kitts and Nevis and Green Building Proposal

The EE roadmap shows that the commercial sector has a large potential for reducing electricity consumption, and JET proposes the following specific implementation images for EE&C realization for commercial buildings and green building projects.

- Technologies to be introduced
  - High-efficiency air conditioning equipment (VRF, inverter RAC)

    Note: Depending on the location, the outdoor units of air-conditioning equipment will be covered with PV panels to shield the outdoor units from solar radiation (some people in Barbados have commented that this is effective as a measure against salt damage to the outdoor units).

  - High-efficiency refrigerators, high-efficiency lighting fixtures, BEMS
- Target buildings
  - Public office buildings (new building shall be avoided as the timing of construction is unclear)
- Goal

  For low-rise buildings, the goal is to achieve ZEB (in Japan, the results of a government technical committee indicated that ZEB is possible for buildings up to 4 stories or less).

5.3.4 Human Resource Development to Achieve EE Goals

The baseline survey was completed in July 2019, and a kick-off workshop was held in St. Kitts and Nevis during the fourth trip in October 2019 to discuss the training plan. the EE team conducted the fifth trip in February-March 2020 to discuss the energy conservation roadmap Ten participants (2 MPI, 1 NIA, and 7 SKELEC) attended.

JET was preparing for a full-scale training program thereafter, but the corona outbreak at the same time forced JET to suspend its human resource development activities in the region. JET then organized an online training program based on discussions with JICA. A summary of the first online training in EE for St. Kitts and Nevis is shown in **Table 5-20**.

The results of the monitoring of the training were positive. The second online training did not take place due to difficulties in scheduling with the local authorities.

Table 5-20 Overview of the first online training implementation (St. Kitts and Nevis)

Training Schedule	December 14, 2020, 10:00-12:00 (St. Kitts and Nevis time, co-located with RE, one hour of which is an EE lecture), Zoom
Participants	18 people (MPI 2, NIA 2, SKELEC 8, NEVLEC 6)
Programs	Impact of COVID-19 on electricity and energy demand and EE
Monitoring and Evaluation Results	4.2 (out of 5 points)

Source: Prepared by JET

After the resumption of travel, JETs discussed the content of the training with the St. Kitts and Nevis side on the sixth trip (September 2022) and decided to conduct two energy conservation training sessions with the content shown in **Table 5-21**.

Table 5-21 EE Training Summary (St. Kitts and Nevis, after resumption of travel)

Training Titles	Outline of Lectures
Energy Management and Energy Audits	- International standards for energy management and energy audits - Introduction of best practices in Japan
Data Logger and Software Demonstrations	- How to use the data loggers and software provided to St. Kitts and Nevis
EV and Battery Storage Market Trends	- EV classification and characteristics - EV market trends and storage battery market in the world - EV policies and infrastructure in each country - Analysis of EV manufacturers - Case studies of EV introduction in Japan and Barbados
Energy Consumption Analysis & EE Roadmap1	- Energy consumption analysis based on energy balance table - Energy efficiency and conservation (EEC) roadmap for the residential sector
EE Building Code1	- Overview of energy efficiency and conservation regulations in residential buildings
Energy Balance & EE Roadmap 2	- Energy efficiency and conservation (EEC) roadmap in commercial sector - Promising energy efficiency technologies in the non-industrial sector
Energy Efficiency Building Code 2	- Example of simplified calculation for residential buildings (Region-6) - Example of simplified calculation for residential buildings (Region-8) - Unique approaches for EEC in residential buildings (Okinawa)
Report on Energy Audit Results	- Energy audit and site survey (for MEB buildings)
Data logger Software Demonstration (follow-up)	- How to use the data logger software to be provided to St. Kitts and Nevis
Communication between organizations (common for RE and EE)	- Stakeholder analysis of each country's energy sector and review of baseline survey - Types of organizations and comparison - Importance of inter-organizational communication - Discussion on smooth communication between stakeholders

Source: Prepared by JET

The first EE training was conducted on November 14, 2022, in person and remotely as shown in **Table 5-22**. In addition to the above, presentations from participants and post-lecture discussions were held. The monitoring results of the training were generally positive. Participants requested that the second training session touch on power simulation and the size of storage batteries for EVs.

Table 5-22 Summary of 1st EE Training Implementation

Training Schedule	November 14, 2022, 10:00-14:30 (Barbados time) November 15, 2022, 10:00-14:30 (Barbados time) In person at Barbados Conference Room, online
Participants	12 people (MPI 3, NIA 1, SKELEC 5, NEVLEC 2, NWD 1)
Programs	(Day 1) 1. Energy management and energy audit 2. Data logger and software demonstration 3. Market trends of EVs and storage batteries (Day 2) 1. Examples of energy saving activities at pump stations (presentation by NWD) 2. Energy consumption analysis & EE roadmap 1 3. Discussion on energy saving activities at MPI (presentation by MPI) 4. EE Building Code 1 5. Discussion on energy management, energy audit and ESCO business
Monitoring and Evaluation Results	3.8 (out of 5 points)

Source: Prepared by JET

The second EE training was conducted face-to-face on January 16 and 24, 2023, as shown in **Table 5-23**. Monitoring of the training was positive. Participants requested that future trainings touch on energy quality and protection, energy demand, building code comparison (St. Kitts and Nevis vs. Japan), and leadership and organizational management in energy efficiency (including communication structure and reorganization).

Table 5-23 Summary of 2nd EE Training Implementation

Training Schedule	January 16, 2023, 10:00-15:00 (Barbados time) January 17, 2023, 10:00-15:00 (Barbados time)
Participants	11 people (MPI 2, NIA 2, SKELEC 4, NEVLEC 4)
Programs	(Day 1) 1. Energy Consumption Analysis & EEC Roadmap 2 2. EE Building Code 2 (Day 2) 1. Report on energy audit results 2. Demonstration of data logger software (follow-up) 3. Inter-organizational communication
Monitoring and Evaluation Results	4.4(5 点満点)

Source: Prepared by JET

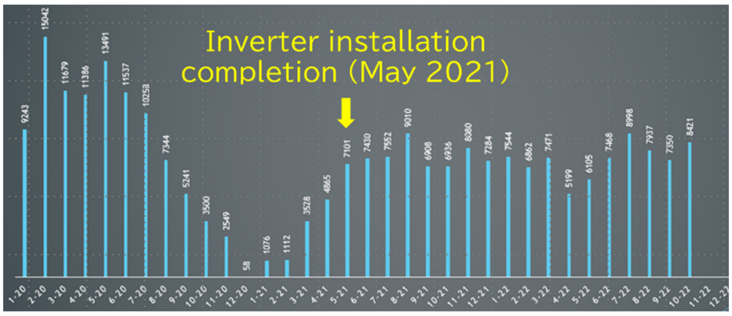
5.3.5 Policies and Systems Necessary to Realize EE Targets

Based on the understanding of the current situation (as of March 2023) and the recommendations for policies and systems necessary to promote EE&C made through this Project, JET recommends the following policies and systems necessary to promote EE&C after this Project and support for their formulation.

(1) Understanding of the Current Situation

Various EE&C initiatives and understanding of the current situation are as follows.

- National Energy Efficiency and Conservation Policy
  - Although EE&C promotion is included in the National Energy Policy and is positioned as one of the country's goals, EE&C plans/targets have not yet been established.
- MEPS/labeling program
  - There has been no specific movement toward establishing MEPS, but the Bureau of Standards is working with CROSQ to develop efficiency standards for air conditioners and refrigerators.
  - LED was provided free of charge to those who wish for promote LEDs.
- Energy management
  - Since the start of this Project, JET has continuously conducted on-site surveys and recommended the use of inverters for pumps and motors to the Nevis Water Department (NWD), and as of November 2022, approximately 40 % of pumps had been equipped with inverters, resulting in an energy saving effect of approximately 30 % (actual results). In addition, NWD plans to install inverters to all pumps by January 2023. NWD requested NIA's financial support for the project.
  - NWD will further promote voluntary EE&C activities/energy management activities as an organization and will also promote efficiency improvements in air conditioners and lighting. **Figure 5-29** shows the transition of power consumption before and after the installation of inverters.



Source: JET based on NWD material

Figure 5-29 Trends of Power Consumption at PADLOCK #1 Pump Station

- Building code
  - Adopted CREEBC (2018) as St. Kitts and Nevis (2022), with future plans to make building codes mandatory.

(2) National Energy Conservation and Efficiency Policy and MEPS/labeling Program

- Recommendations on policies and systems
  - Since St. Kitts and Nevis has not moved toward the development of a specific national energy efficiency and conservation plan, JET recommended individual policies, systems, and measures to promote EE&C.
  - During the presentation on the EE roadmap, it was suggested that the introduction of a MEPS/labeling program as early as possible is crucial for long-term EE&C points of view.

- Recommendations toward formulation of policies and systems
  - Although the EE&C promotion is included in the national energy policy and is positioned as one of the goals of the country, in light of the lack of movement to formulate a national EE&C plan and the personnel capacity, etc., it was judged appropriate to study and make recommendations regarding individual EE&C policies and systems, rather than to make specific recommendations regarding the formulation of the EE&C plan.
  - JET recommended that a data-based planning process is crucial when formulating EE&C policies. That is, it is important to refer to the energy balance and to evaluate electricity consumption by converting it to primary energy consumption.
  - In addition, it is also important to collect data on electricity consumption by use (not shown in the energy balance), and JET recommended the effective use of data loggers provided by this Project. (in particular, to measure electricity consumption by use at households under the current circumstances where households electricity consumption is growing, etc.)

  - After this Project, JET recommends support for electricity consumption surveys by use in the no-industrial sector which is undeveloped and data collection. (Priority: High)
  - After this Project, JET recommends support for EE&C policy study and planning, including the establishment of a MEPS/labeling program, which is one of the major EE&C policies. (Priority: High)

  Note 1: Japan's EE policy (energy saving targets from 2013 to 2030, and its progress, etc.) was introduced and explained at the 2nd EE Workshop. At the same time, the importance of introducing the MEPS/labeling program as early as possible, which has been proven to be effective among various EE&C policies (including the fact that the later the program is introduced, the less energy savings will be accumulated), was explained and proposed at the time of presenting the EE roadmap.

  Note 2: NIA commented that they would like to request JICA to provide expert support for EE&C policy formulation (including MEPS/labeling program) in the future (January 2023).

(3) Energy Management

- Recommendations on policies and systems
  - At the first EE workshop, the procedures and methods of energy management activities based on ISO 50001 were lectured, and best practices were introduced to explain the importance of promoting energy management activities with making recommendations. Specific details are described in the Barbados section **4.3.5(4)** .
- Recommendations toward formulation of policies and systems
  - The EE&C measures implemented by NWD with the utilization of inverter for pumps are the very essence of energy management activities implemented within the organization, and JET recommended that NWD seek ISO 50001 accreditation in the future.

- JET also proposed that it is important to share and disseminate information widely among public organizations and the private sector in the EE&C awareness activities, in order to horizontally disseminate this case as a successful example of EE&C activities.
  - After this Project, good examples of effective energy management will be summarized (e.g., best practices of Nevis Water Department and Japan) and common elements and factors that led to success will be analyzed and shared with stakeholders including the private sector. It is also important to establish benchmarks (e.g., energy consumption per floor area) by building use and present target values to energy consumers as well as those relating to buildings. As a model building for this purpose,0JET recommends support for implementation of green building project (including BEMS installation), as described in **5.3.3**. (Priority: High)

    Note: The engineer who played a central role in this energy management activity was invited to the 1st EE workshop (held in Barbados) to give a lecture.

(4) Building Code

- Recommendations on policies and systems
  - Although St. Kitts and Nevis positioned the current CREEBC as a government-approved book, JET recommended that a simplified building code should be developed, given that St. Kitts and Nevis plans to make the building code mandatory in the future (1st and 2nd EE workshops). Specific details are described in the Barbados section **4.3.5(5)** .
- Recommendations toward formulation of policies and systems
  - CREEBC published in 2018 is a technical guidebook for building (commercial and residential new construction/existing renovation) designers and is a standard book for designers that specifies in detail motor efficiency, lighting, air conditioning, VRF, water piping insulation, surface insulation performance, window/sash insulation performance, and other specifications adopted in buildings. St. Kitts and Nevis is planning to make building codes mandatory in the future, and the EE workshop participants commented that they would like to learn more about Japanese building codes and use them as a reference for St. Kitts and Nevis.
  - JET proposed the development of a simplified building EE&C evaluation method that is practical and permeates a wide range of people and fostered a common understanding with this regard.
    - After this Project, JET proposes to support the development of an EE&C evaluation method for buildings targeting a wide range of people, similar to the simplified method for energy efficiency evaluation of buildings in Japan. (Priority: Medium)

(5) Awareness Raising Activities

- Recommendations toward formulation of policies and systems
  - The economy of inverter air conditioners has further increased since the baseline survey due to the recent surge in electricity prices. While appealing to the fact that various energy-saving equipment can provide more economic benefits than ever before, JET

recommended the effective EE&C promotion and awareness raising activities, focusing on voluntary EE&C actions by individuals/organizations.

- After this Project, JET recommends support for dissemination and awareness raising activities which widely appeal to end users the various benefits such as energy saving, decarbonization, and economic benefits that can be obtained by introducing high-efficiency air conditioning, refrigerators, and lighting equipment. (Priority: Low)

5.3.6 Improvement of Operation and Maintenance of Thermal Power Generation Facilities

(1) Improvement of operational efficiency

Diesel-fired power plants are operated at baseload with a minimum load of 60-70 % in principle to absorb the fluctuations of renewable energy. Fuel consumption is optimized, although it is controlled by governor control and manual operation. After reviewing the situation, JET confirmed with SKELEC and NEVLEC that there is no problem with the current direction.

(2) Maintenance Improvements

A 10 MW class geothermal power generation facility is planned to be installed on Nevis Island in the future, with a maximum peak capacity of 9 MW on Nevis Island in July 2019. At this stage, the Prospect power plant has a capacity of approximately 20 MW, so when the geothermal facility is installed, it should be operated as a backup in case the geothermal facility fails.

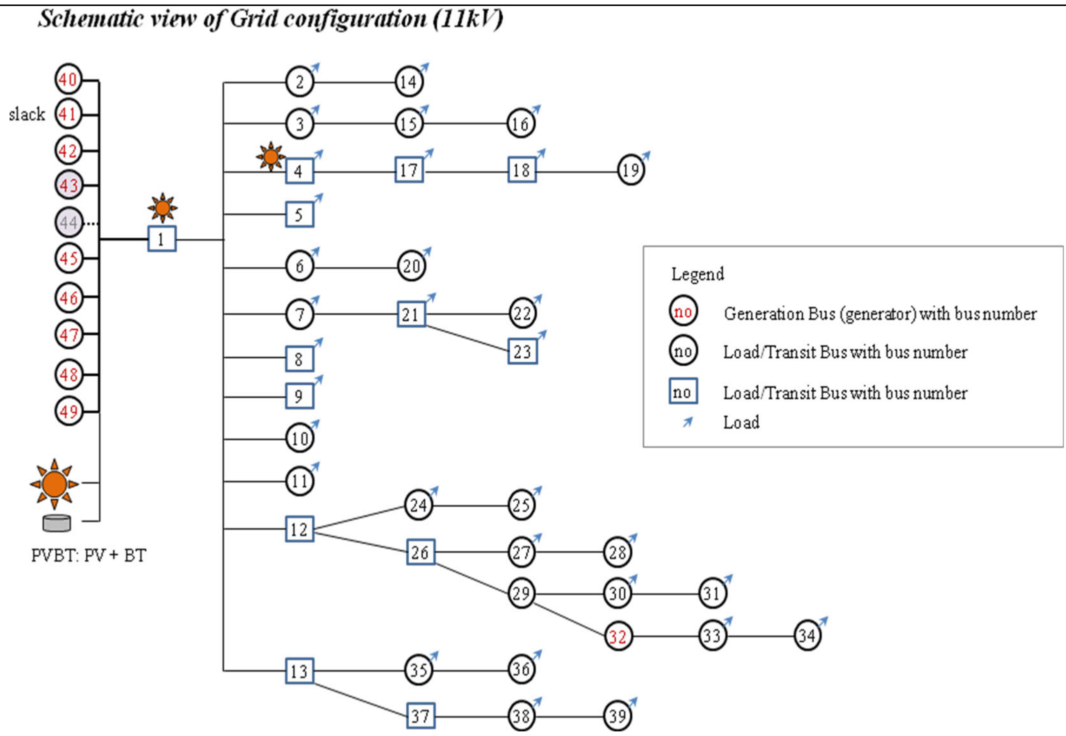
Since both islands are undergoing scheduled maintenance and spare parts management is thorough, operation as a backup facility should be feasible. As a result of our discussions, JET confirmed with SKELEC and NEVLEC that there is no problem with the current direction.

5.3.7 Introduction of Renewable Energy and Grid Stabilization

(1) Grid analysis for introduction of RE

In the future, the 35 MW PV and BESS 14.8 MW with 45.7 MWh capacity are planned for construction and will be operational in St. Kitts grid. The grid will have 16-18 MW of large VRE connection (above 16-18 MW will be charged to BESS). In addition, 5.7 MW of Bellevue wind power will be connected. A grid analysis was needed to take these projects into account.

Nevis Island has the potential for geothermal power that exceeds the maximum demand for electricity in Nevis. Once the geothermal power generation is started, 100 % RE is achievable with a stable power source in Nevis. NEVLEC also has requested JET, as well as St. Kitts Island, to conducted grid simulation for more efficient system operation. For this reason, the power flow analysis software "Microgrid Designer" was provided, demonstrated, and exercise was provided in Seminars for Grid Stability and Large RE. The model of the St. Kitts and Nevis grid conducted in the grid analysis is shown in **Figure 5-30**.



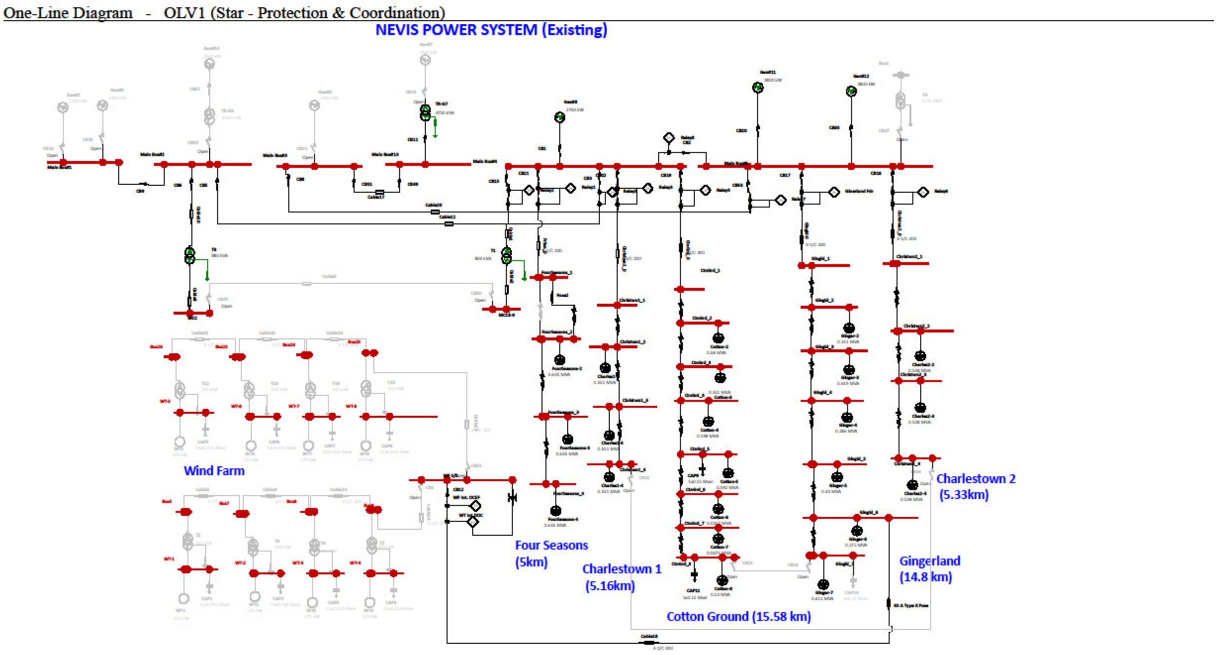
Source: Prepared by JET with information from SKELEC

Figure 5-30 Grid Model for Analysis for St. Kitts Island

Data such as line constants required for the input of the St. Kitts power system were obtained from the PSS/E model conducted by Leidos.

On the other hand, the Nevis power system shown in **Figure 5-31** was input in software ETAP based on NEVLEC GIS data. Line constants and other data were based on general database data in ETAP.

The results of the power flow analysis for St. Kitts are shown in figures below. The additional 35 MW PV of Laclanche at near Needmust power station and the 5.7 MW Bellevue wind resulted in higher node voltages and higher transmission line currents on the transmission lines to which the wind turbines are connected, but both voltage distributions were within rated value.

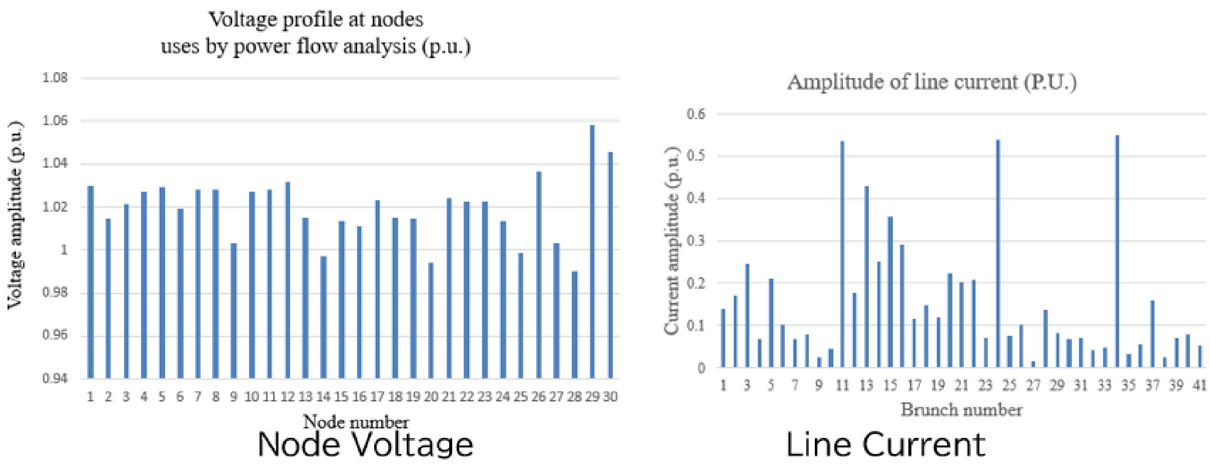


Source: Prepared by JET with information from NEVLEC

Figure 5-31 Single Line Diagram for Grid Analysis Model for Nevis Island (Prepared in ETAP)

The results of the grid analysis for St. Kitts are shown in **Figure 5-32** and **Figure 5-33**. The 35 MW PV at Laclanche and the 5.7 MW Bellevue wind addition resulted in higher node voltages and higher currents on the wires to which the wind turbines are connected, but both are within their rated values.

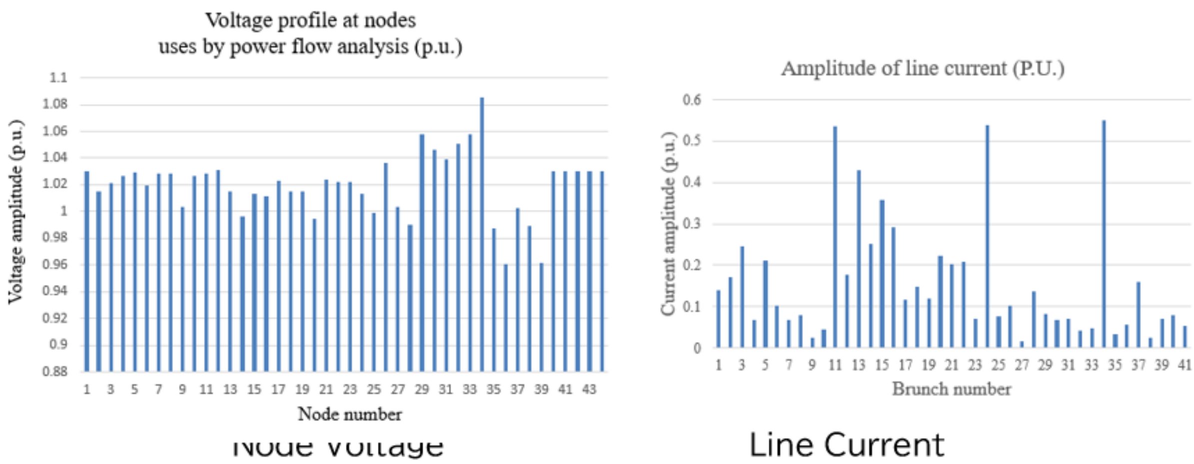
<The Grid in 2020 in St. Kitts> Power flow analysis results for the case that PV 1.2 MW is installed to 11 kV grid voltage with demand of 25 MW.



Source: Prepared by JET using Microgrid Designer

Figure 5-32 Result of Power Flow Analysis in St. Kitts in 2020 (Node Voltage and Line Current)

＜Additional RE System in St. Kitts＞ Power flow analysis results for an additional 35 MW of PV and 5.7 MW of wind in addition to 1.2 MW of existing PV, assuming grid voltage 11 kV and a demand of 25 MW on St. Kitts Island.

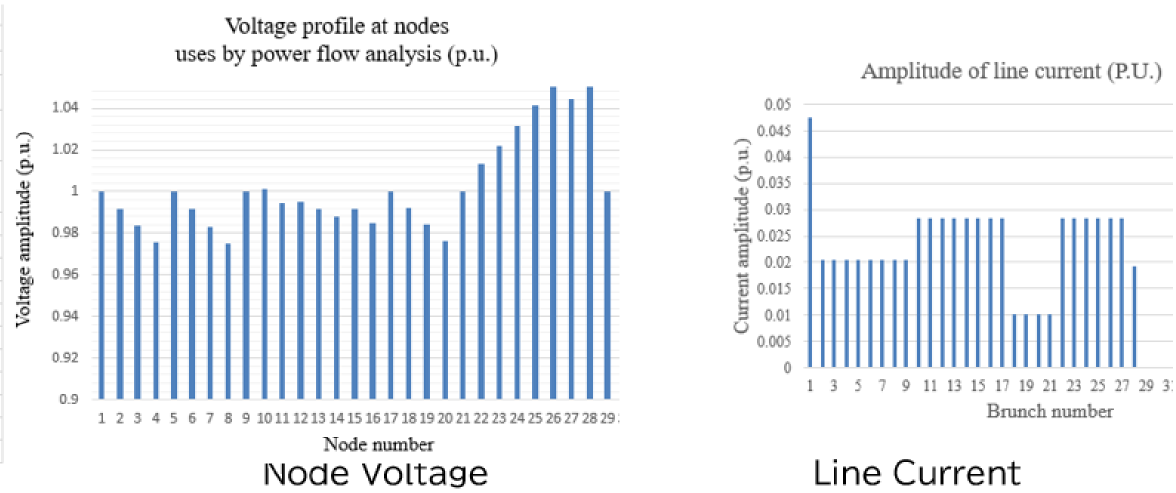


Source: Prepared by JET using Microgrid Designer

Figure 5-33 Result of Power Flow Analysis in St. Kitts in 2020 with Planned PV and Wind Projects (Node Voltage and Line Current)

Figure **5-34** shows the results of the grid analysis for Nevis Island. As a result of the 2.2 MW wind power, the node voltage of the line to which the wind turbines are connected was increased and the line current was increased, but both are within their rated values

＜Nevis Grid in 2022＞ The result of power flow analysis for Nevis 11 ｋV grid with existing thermal power and 2.2 MW wind



Source: Prepared by JET using Microgrid Designer

Figure 5-34 Result of Power Flow Analysis in Navis in 2022 (Node Voltage and Line Current)

Currently, both St. Kitts and Nevis have thermal power plants concentrated almost all in one location, and distribution lines are installed radiating out from them. This establishes a stable system that is less prone to system instability. However, when PV and wind power are installed in the suburbs, power flows through the distribution lines in a different direction from before may cause the voltage rise. The voltage increase is high near at the end of lines where the PV and wind power are connected, and the voltage at loads in the middle of the distribution lines is increased.

Therefore, it is necessary to install reactive power compensators to control the voltage by injecting reactive power. In both St. Kitts Island and Nevis Island, it is necessary to apply reactive power compensators such as STATCOM, SC, SCO.

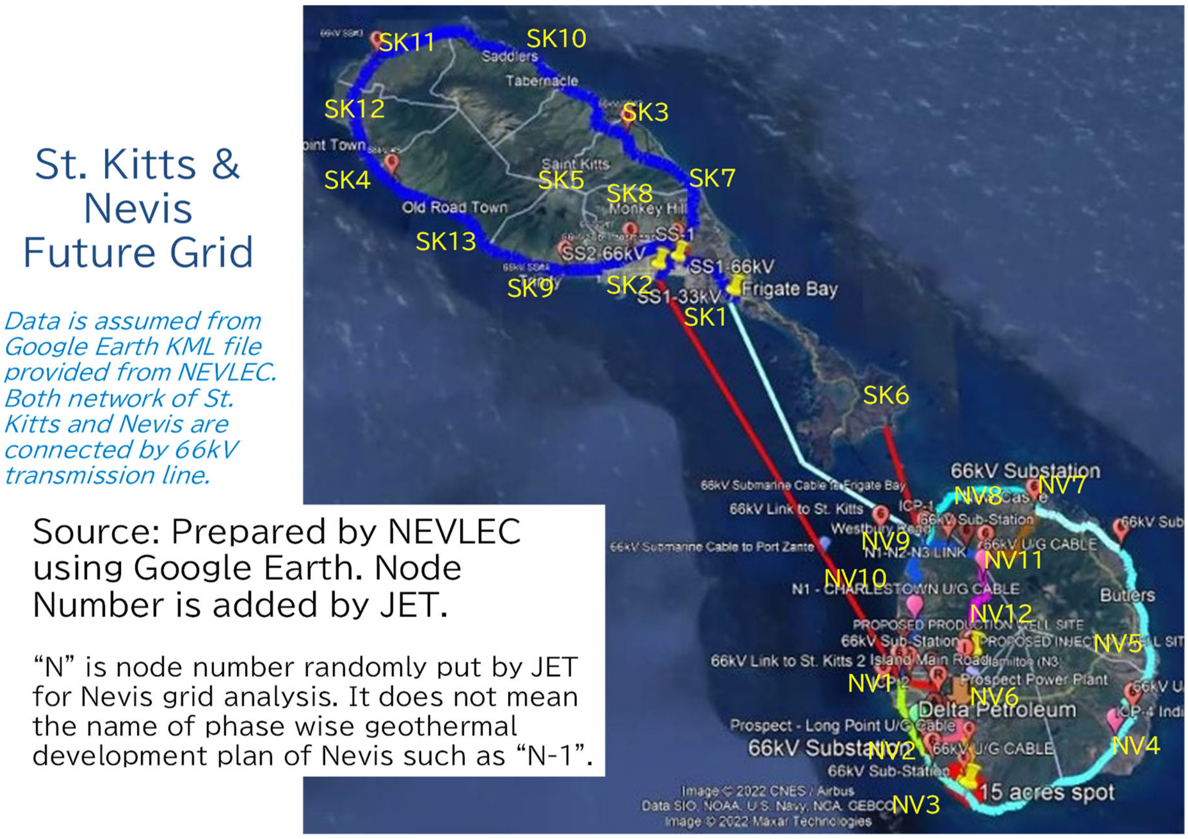
(2) Power grid between St. Kitts Island and Nevis Island

In St, Kitts, there is Needsmust Power Station and in Nevis has Prospect power plant, currently almost one main thermal power station in each Island. The Leclanche PV 35 MW site in St. Kitts is adjacent to the Needsmust power plant. Since all major power generation infrastructure is concentrated in one location, if this site is damaged, restoration will not be easy, which is a challenging situation in terms of resilience.

The 35 MW PV system in St. Kitts is expected to supply 25 % of the island's electricity. Another 5.7 MW of wind is planned at Bellevue, but the remainder will still need to be covered by thermal power.

On the other hand, NEVLEC has proposed a plan to interconnect Nevis with St. Kitts via a 11 kV interconnect line and 66 kV loop transmission line. Although the St. Kitts-Nevis interconnection is still under discussion and has not yet been officially included as a national plan, Dr. Joyelle Clarke, Minister of Environment and Climate Change, stated that "St. Kitts and Nevis must be considered as one space with respect to geothermal utilization, and cooperation between NEVLEC and SKELEC is possible".

The 11 kV and 66 kV interconnection plan proposed by NEVLEC is shown in **Figure 5-35**.



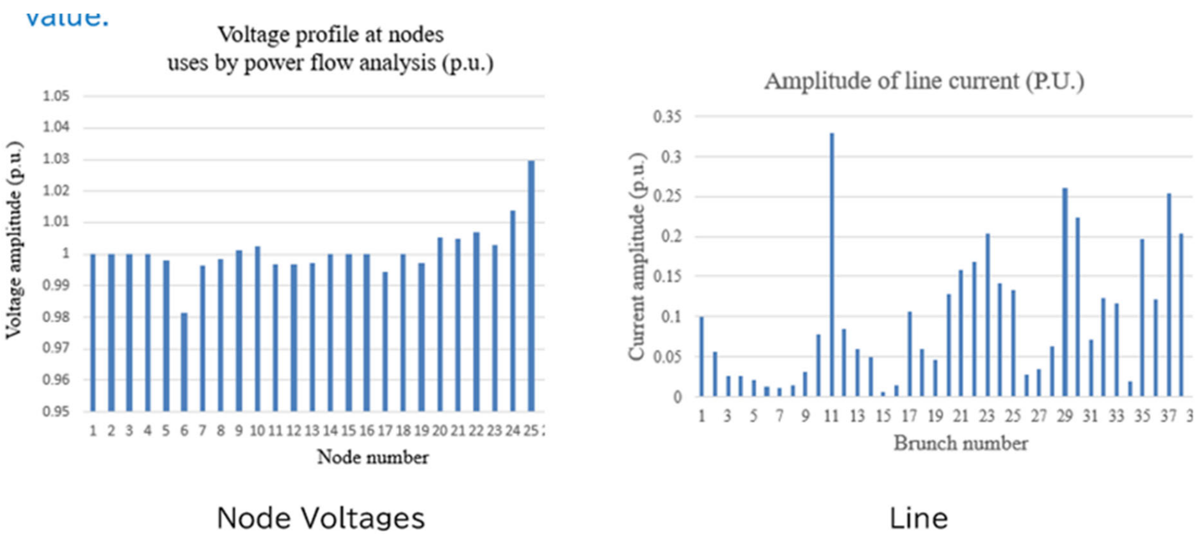
Source: Prepared by NEVLEC with Google Earth, and modified by JET

Figure 5-35 11kV and 66 kV Grid Interconnection Plan proposed by NEVLEC

First, an 11 kV submarine cable will be used to connect points for the shortest route at the two islands by extending the existing 11 kV system. Then, a new 66 kV line is proposed to be installed around the perimeter of each of St. Kitts and Nevis, and the two 66 kV lines will be connected by submarine cables to form a loop line. The grid analysis was conducted as an exercise with the above interconnection plan. The above figure shows the Google Earth layout used for the grid analysis of the 66 kV loop line.

The power flow analysis was conducted assuming a future system as shown in the figure above. The new 66 kV transmission line voltage surrounding St. Kitts Island and Nevis Island is assumed to be constructed, and a loop system is assumed to be established with the two islands interconnected submarine cables, together with 11 kV submarine interconnection.

The Figures below shows the results of the power flow analysis with assumption as follows: (i) a demand of 25 MW in St. Kitts Island and 10 MW in Nevis Island, (ii) 1.2 MW PV, 35 MW PV, and 5.7 MW wind, and 6 MW charging/discharging power of BESS in St. Kitts Island, (iii) 2.2 MW wind, 50 MW and 30 MW geothermal power, with assumption that 20 MW is consumed in future hydrogen plant. The results of the power flow analysis are shown in **Figure 5-36**.



Source: Prepared by JET using "Microgrid Designer"

Figure 5-36 Result of Power Flow Analysis for 66 kV Interconnection of St. Kitts Island and Nevis Island

The power flow analysis is based on 66 kV system. As the result, voltage was increased at 5-6 % at node 25 (NV12 in the figure of the former page), where 30 MW of geothermal generation is assumed to be connected. This is considered to be acceptable. The magnitude of transmission line current is within the normal range, provided that hydrogen plant with total load of 20 MW also installed at node14 and 15 (NV1 and NV2 in the figure of the former page). Line 11 had the higher line current. This line is between nodes SK1 and SK2 in the center of St. Kitts. It is within the normal operating range of high-power flow between the power plant and load.

St. Kitts and Nevis are currently considered independent microgrids, respectively. When the two islands are interconnected, they will become two interconnected autonomous microgrids, which will contribute to resilience enhancement. For example, if the one power plant of the island is damaged by a hurricane, the powerhouse in the other island could be a power source to restore the damaged island with minimal blackout periods.

However, if the power flows through the interconnection line is increased for demand in the two islands, it is highly possible to be instable due to long periodic fluctuation of grid, because the interconnection line is a long distance.

Unless stabilization measures are taken in the grid, the maximum transmission capacity of the interconnection line is generally designed to be the smaller capacity of the grid that is interconnected. In that case, transmission from Nevis to St. Kitts should be kept below about 10 MW, which is the grid capacity of Nevis.

However, the max load of St. Kitts is 25 MW. In evening and night and rainy days when PV does not generate, 10 MW transmission is not sufficient for St. Kitts. If St. Kitts aims for 100 % RE, more than 10 MW of transmission would be required from geothermal generation from Nevis. To increase the capacity available for transmission from Nevis to St. Kitts to reach 100 % RE for the two islands, the following measures need to be considered.

- To install control equipment such as reactive power compensators at both ends of the interconnection line. A detailed study is needed to determine how much more stable power transmission will be possible with the reactive power compensators.
- To operate one of the 66 kV loop interconnection lines as a dedicated transmission line for sending geothermal power from Nevis to St. Kitts.
- To interconnect between Nevis Island and the St. Kitts Island by DC, not AC. However, the investment cost would be more costly

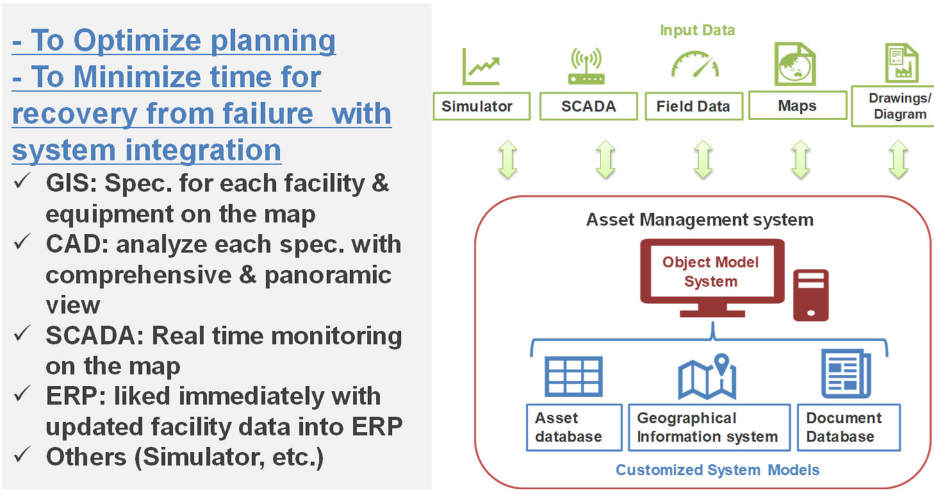
(3) Improve resilience through asset management

During the first JCC, the C/P expressed the need to strengthen resilience. This is due to concerns about natural disasters such as hurricanes, which have grown in size with recent climate change: the Bahamas and other Caribbean countries suffered from huge damage from Durian, a Category 5 hurricane in 2019. In response to this need, JET presented the network asset management system as one of the measures that helps enhancement of resilience, which can speed up restoration after a failure or disaster.

Assets are the elements that consist of the power system and asset management system includes information of all equipment for generation, transmission, substation, distribution, meters, switches, etc. The C/P requested a demonstration of the asset management system, which facilitates the management of the power system.

A conceptual diagram of the asset management system is shown in **Figure 5-37**. The asset management software (Smallworld) is a database containing geographic information for complex network infrastructure management and special GIS system that can processes a large amount of information at high speed. It manages even each piece of equipment in a facility, linking it with detailed data including drawings and specifications of each component of equipment.

The database can be linked with other systems in various ways such as SCADA, simulation, and Enterprise Resource Planning (ERP). Asset management system can be used as a platform of various systems. This will contribute to resilience enhancement by, for example, identifying the location of accidents and speeding up response time, and by linking with simulations to plan accident prevention by incorporating data on locations likely to have power outages and equipment prone to failures.

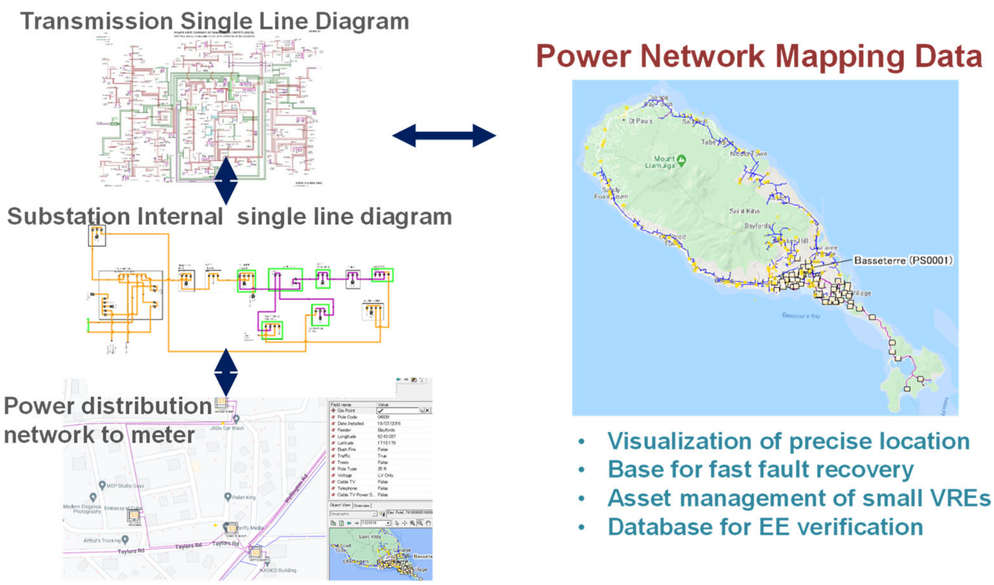


Source: Prepared by JET

Figure 5-37 Conceptual Figure of Asset Management System

In order to demonstrate the applicability of the asset management system, the work in Smallworld was subcontracted to conduct modeling, inputting GIS data, incorporating drawings and single line diagrams of distribution lines, and location data of poles, provided by St. Kitts.

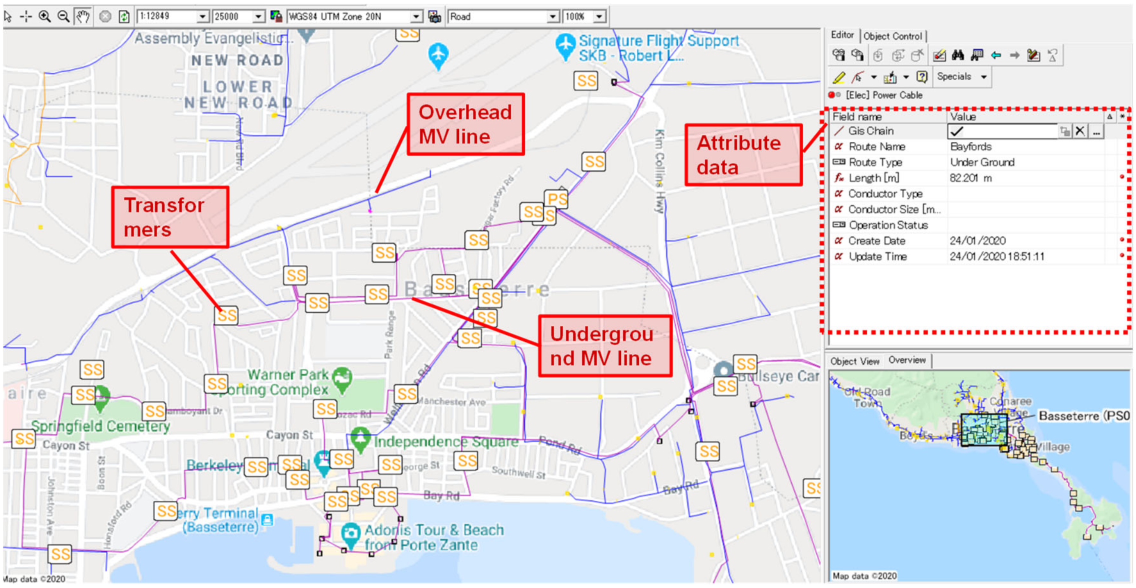
The asset management system prepared in this Project for St. Kitts is shown in **Figure 5-38**.



Source: Prepared by JET

Figure 5-38 Outline of Asset Management System in St. Kitts Island

In the St. Kitts Asset Management System, line and transformer information, pole locations, single line diagram, main specification of equipment, and substation internal configuration for each of the 11kV underground and overhead feeder lines were modeled and input using Smallworld. **Figure 5-39** shows an example of the screen.



Source: Prepared by JET using Smallworld, and Google Map as a base map

Figure 5-39 Location of 11 kV Feeders, Transformers, and Poles in St. Kitts Island in the Asset Management System

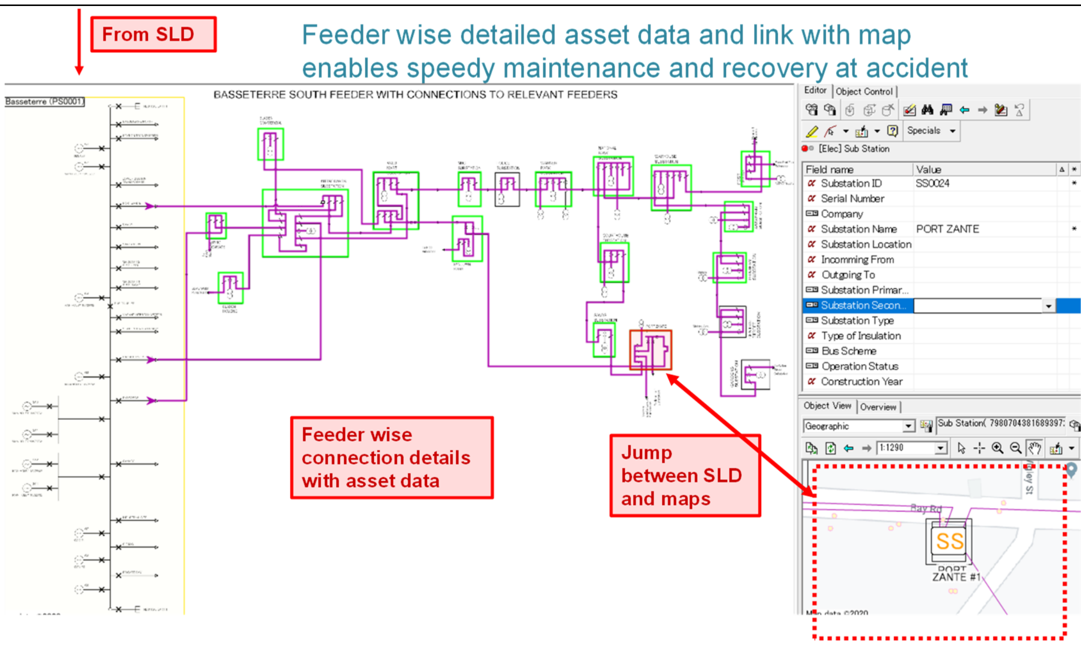
Geographic information of 11 kV feeders, poles, transformers, etc. can be displayed and used with Google Map and Google Earth with an add-on.

In addition, information on each equipment in a single line diagram is managed by each equipment and each wire as a unit in the asset database. (The single-line diagram shows the internal connections of substations and transformers and other components.) This facilitates the identification of the location of the cause of a power outage in the event of power cut due to an accident or other cause. Although SCADA is not currently installed in St. Kitts, when SCADA, which has instruments and communication systems for monitoring voltage, current, frequency, etc. at each location, is installed in the future, it will be possible to monitor and control the system in real time with geographical information.

The above asset management system was demonstrated during the seminar and was installed on the PCs of SKELEC's operations department staff, who practiced how to operate the system.

This demonstration system was provided only to SKELEC because it contains detailed information on SKELEC's power system and asset data. An example of the data is shown in **Figure 5-40**.

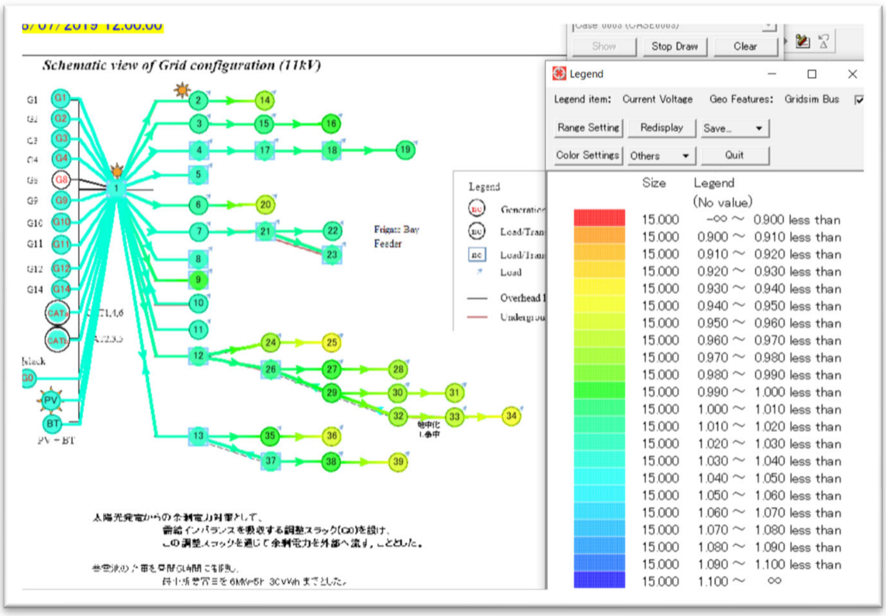
JET demonstrated the system in Seminars on Grid Stability and Large RE. The demonstration was also conducted remotely. Smallworld with the model installed was installed in a PC of SKELEC staff at a seminar in February 2023 so that SKELEC staff in St. Kitts could operate the demonstration system. If SKELEC wishes to continue to use the asset management system after the project is completed, it is expected that a license and maintenance agreement will be made with the Smallworld vendor (GE's agent), as well as regular software such as CAD and GIS.



Source: Prepared by JET

Figure 5-40 Example of Transformers and Equipment Configuration with Single Line Diagram in Asset Management System of St. Kitts

With a linkage of grid analysis software and asset management system, it is also possible to visually display the results of the grid analysis using the display function. **Figure 5-41** shows a visual diagram of the time and place where voltage drops are most likely to occur by color-coding the voltage change over time. The analysis result was obtained from Microgrid Designer. The figure shows that higher voltages are indicated in blue and lower voltages in yellow to red. It indicates that voltage drops are more likely to occur at the end of the Canyon feeder where Bellevue Wind is planned, especially in the evenings when demand is high.



Source: Prepared by JET using “Smallworld” and “Microgrid Designer”

Figure 5-41 Visualized Result of Power Flow Analysis in Asset Management System

Using an asset management demonstration system prepared with St. Kitts data, the application was also presented to Barbados and Jamaica at each seminar.

5.3.8 Human Resource Development for the Introduction of RE and Grid Stability

(1) Formulation of Training Plan

St. Kitts and Nevis has a policy goal of 100 % RE in the power sector. The path to the realization of the target is to develop and utilize the abundant geothermal potential of Nevis on two islands, and to develop PV and wind power, and to interconnect the two islands with enhancing their resilience The following are challenges regarding the realization of the RE goal.

- The country did not have grid analysis software to accommodate the planned increase in VRE, including 35 MW of PV, 5.4 MW of wind, and other possible RE. In response to modifications or changes in VRE plans, the grid analysis will be outsourced to consultants.
- There are plans of an 11 kV interconnection and a new 66 kV loop transmission line installation. The interconnection of the two islands is proposed by NEVLEC and has not yet officially included as national development plan by the MPI. It would need detailed assessment to conduct design, cost estimation, financial analysis, and grid simulation.
- Geothermal power in Nevis is the key to the goal of 100 % RE realization in St. Kits and Nevis. If geothermal power is realized, it will be possible to achieve the goal of RE with a power source. On the other hand, the price of geothermal power is estimated to be 16-17 USc/kW, which is high compared to the unit cost of VRE power generation. Investment was delayed, and financing has been a bottleneck.

Under the above situation, SKELEC and NEVLEC requested JET about technical transfer, including the provision of grid analysis software for operation, as well as verification and supervise, if it is outsourced, for the grid analysis in the future. There is a need to strengthen the capacity to update VRE plans in the future with update of grid plan, and to develop human resources to formulate grid plans. Therefore, it was agreed that the seminar would focus on grid planning and analysis based on the planned geothermal and VRE installations.

It was also agreed that “Microgrid Designer”, a grid analysis software used for educational purposes, would be provided. Microgrid Designer has some limitations, such as not including transient stability analysis, but it does not require an annual fee and can be used with Excel, making it easy to check grid capacity in response to increases in PV and wind power locally. Therefore, the parties agreed to introduce Microgrid Designer to the country and to transfer the technology.

Meanwhile, due to the travel restrictions related to the prevention of COVID-19 infection, JET has not been approved to travel St. Kitts and Nevis until the end of the Project. For this reason, it was decided to invite officials from MPI, NIA, SKELEC, and NEVLEC in St. Kitts and Nevis to Barbados and hold seminars in Barbados for items that require physical work, such as exercises.

Since Barbados has similar policy goal of 100 % RE, some of the seminars were conducted jointly with Barbados. In addition, for exercises dealing with the actual grid data of St. Kitts and Nevis, such as grid analysis exercises, exercises exclusively for St. Kitts and Nevis were conducted.

A summary of the technical seminars on Grid Stabilization and Large RE for St. Kitts and Nevis is presented in **Table 5-24**.

Table 5-24 Outline of Seminars on Grid Stability and Large RE in St. Kitts and Nevis

Title	Date	Objective	Contents
1st Seminar	3-5 Oct 2022	To confirm present situation and needs for seminar. To share basic technical knowledge for grid analysis with large RE	• RE target and challenges, revise of activity, general issues of grid with large RE penetration • Microgrid Concept for resilience Overview of Power system, per unit method, modeling, load flow analysis, introduction of method, software and tools
2nd Seminar	6 and 8 Dec 2022	To conduct and exercise grid modeling and analysis	Grid modeling, Microgrid, example, Load flow analysis and stability analysis, evaluation
3rd Seminar	18-19 Jan 2023	Review and exercise of grid analysis with scenario cases	Detailed system and countermeasures, protection, Exercise of tools for grid analysis with various RE scenarios

Source: Prepared by JET

After the baseline study, it JET hold a remote meeting to discuss with C/Ps to verify the updated status and needs, and it was decided to conduct a total of three Seminars on Grid Stability and Large RE to share challenges for grid stability with large amount of RE and to obtain knowledge for countermeasure.

The first seminar described the need for grid stabilization in response to increased VRE and with confirmation of updated RE plan in St. Kitts and _Nevis. The second seminar focused on the technical requirements for grid analysis and the fundamentals of power systems, as well as an introduction to grid analysis methods and tools. In addition, it was requested to conduct a study for hydrogen and ammonia utilizing surplus amount of geothermal energy. To reply to a request for a geothermal-based hydrogen plan, the general overview of hydrogen projection and cost comparison was presented. The third seminar focused on grid modeling examples and exercises including interconnection, and grid analysis for two islands, review of grid analysis exercises and analysis for each scenario case.

(2) Verification and Review of the Training Plan

For the verification of the training plan, the status of the two islands was reviewed, Q&A and feedback on the seminar content was obtained, and the detailed content and items for each seminar were discussed. The contents of the mass renewable energy and grid stabilization seminars conducted for St. Kitts and Nevis are shown in **Table 5-25**.

Lectures were mainly provided by online so that as much participants as possible could join. The days included exercises were held physically, with a hybrid online/offline method. The physical exercises were conducted in Barbados and participants were invited there, but if participants wished to join for the exercise remotely from St. Kitts and Nevis, they are also invited for online session, which is conducted simultaneously with physical exercise session. Since the issues related to large penetration of RE and grid stabilization are common to Barbados, some of the dates were conducted jointly with Barbados so that participants from both countries could exchange discussions. Participants from St. Kitts and Nevis were from MPI, NIA, SKELEC, and NEVLEC. The days for grid analysis exercises using SKELEC and NEVLEC grid data were for provided exclusively participants from St. Kitts and Nevis only.

Table 5-25 Agenda and Participants for the Seminars on Grid Stability and Large RE from St. Kitts and Nevis

Seminar	Agenda	Participant
1st Seminar 3, 4, and 5 Oct 2022	<Day-1 on-line only> Basics of Power System Engineering for Grid Stability 1. What is Power System?, Three-phase AC, Single line network description 2. Per Unit Method 3. Modeling of Power System Equipment: Transmission Line Transformer, Generator & Load 4. Active Power & Frequency: Frequency control, Area requirement 5. Reactive Power & Voltage: P-V Curve, Reactive power resource 6. Practice of Modeling of Grid	Day-1: 61 nos in total (joint with Barbados 2nd Seminar) MPI:3, SKEKEC:10, NEVLEC:3 NIA:1 Other :44
	<Day2 online/off-lin hybrid > Basics and Exercise for Load Flow Analysis 1. Overview of Load Flow Analysis: Purpose, Methods, Modeling of grid 2. Newton-Raphson Method: Theory, Characteristics 3. DC Flow Method: Theory, Simple method to solve load flow manually 4. Exercise of DC Flow Method 5. Practice on Microgrid/VPP Designer 6. Load Flow Analysis & Evaluation of sample Grid	Day-2: 44 nos (joint with Barbados 2nd seminar) MPI:3, SKEKEC:10, NEVLEC:3 NIA:1 Other :27
	<Day-3 on-line/off-line hybrid> Analysis of Grid Stability and LFC/ELD 1. Overview of Stability: Definition, Methods, Swing equation 2. Stability Model: Simplified grid model, Equivalent circuit of synchronous generator 3. Equal Area Criterion: Theory, Simple method to solve stability manually 4. Available Transmission Capacity & Spinning Reserve 5. Exercise of Equal Area Criterion 6. Practice on Microgrid/VPP Designer and LFC/ELD 7. Discussion for Interconnection, RE and Grid Stabilization in St. Kitts and Nevis	Day-3: 17 nos MPI:3, SKEKEC:10, NEVLEC:3 NIA:1
2nd Seminar 6 Dec (full day) and 8, Dec 2022 (Half day)	<Day-1 on-line > 0. Opening Remarks 1. Project Outline, Large RE, Feedback of 2nd seminar, Microgrid, Why Grid Stability is necessary 2. Grid Modeling 3. Basics of Power System Engineering 4. Load Flow Analysis and its Evaluation 5. Transient Stability Analysis and Evaluation of Stability 6. Discussion	Day 1:45 nos (Joint with Barbados) MPI:3, SKEKEC:12, NEVLEC:6 Other :24

Seminar	Agenda	Participant
	<Day-2 on-line> 1. Introduction and Schedule 2. Evaluation of Load Flow Analysis by Microgrid Designer, and Transient Stability Analysis 3. Example of LFC and ELD in Microgrid Designer 4. Hydrogen and Ammonia concept with Nevis Geothermal 5. Draft Program of Training in Japan 6. Consideration of Large VRE into Grid, Discussion	Day-2: 21nos MPI:3, SKEKEC:12, NEVLEC:6,
3rd Seminar 17-18, Jan 2023 (All full day)	<3rd Seminar: Day-1 on-line only> 1. Introduction for the Seminar, Review, and feedback 2. RE and Microgrid Planning 3. Development Status of Grid Forming Inverter and its Safety - Current Status, Blackout with GFM & Black Start using BESS 4. Battery & Hydrogen as an Electricity Storage, cost comparison 5. Special Protection System including Load Shedding, PV/WT Trip 6. Inter-connection, Simulation Cases for future grid of St. Kitts &Nevis 7. Harmonics and filtering 8. Measurement Function of Inverter, Grid Code 9. Sample of Other Countries Situations of Grid and RE 10. Demonstration of Asset Management System 11. Presentation from SKELEC and NEVLEC about current status and challenges	Day-2: 14 nos MPI:2, NIA:2, SKEKEC:4, NEVLEC:4, NWD: 2
	<3rd Seminar: Day-2 on-line/off-line hybrid > 1. Introduction of Microgrid Designer and Transient Analysis - Role of Tools for Power System Analysis, - Load Flow Analysis - Transient Stability Analysis for Operation and Control 2. Investment of MW and MWh of Energy Storage for VRE 3. Exercise on simple grid example and Microgrid - Load Flow Analysis, - Transient Stability Analysis 4. Exercise on Future Grid - Design and Operation Planning - Load Flow Analysis, - Transient Stability Analysis 5. Analysis Result and Countermeasure of Grid Stability 6. Discussion, policy recommendation, and Way Forward 7. Conclusion and Closing Remarks	Day-2: 14 nos MPI:2, NIA:2, SKEKEC:4, NEVLEC:4, NWD: 2

Source: Prepared by JET

The seminar materials used in each session are shown in **Appendix 5-1-1, 5-2-1, and 5-3-1**. The feedback obtained is attached in **Appendix 5-1-2, 5-2-2, and 5-3-2**, respectively.

In summary, the main feedbacks from the participants in the above three seminars are as follows.

- In discussions with NEVLEC prior to conducting the first seminar, participants requested for hydrogen and ammonia study using surplus electricity from geothermal development. In addition, there was a need for a comparison of hydrogen and storage batteries at the second seminar. Therefore, it was decided to include the results of the hydrogen preliminary study with geothermal power in the second seminar and the global trends and price trends of hydrogen and storage batteries were presented in the third seminar.
- As a result of the third (final) seminar, the importance of grid analysis for VRE, storage batteries for VRE fluctuations, and needs of GFM application in the future was understood. For future cooperation, conducting feasibility study of the geothermal hydrogen, the study for the impact on electricity prices, and the review of the plan for the installation of 34 MW of PV were also mentioned.
- Furthermore, although JET members were not allowed to travel to St. Kitts and Nevis for the second half of the project due to COVID-19, they expressed a wish for future RE and grid planning and policy update with field work in St. Kitts and Nevis and collecting local data, which has not been possible during the project,

Discussions on policy recommendations were also held, as shown in **Table 5-26**.

Table 5-26 Policy Discussion and Feedback on Seminars for St. Kits and Nevis

	Question from JET	Discussion
1	What is the most challenging for achieving 100 % RE?	・ Grid stability by storage and spinning reserves ・ Technology availability at appropriate cost, Cost of implementation. ・ The use of IPP result in an increase cost of energy to the consumers. ・ Control of grid voltages &frequencies ・ Who will bear the responsibility for grid stability
2	What is necessary for grid stability?	・ Batteries, grid forming inverters, SCO, demand response, microgrid integration, bi-directional relays, and control ・ Inverters that provide reactive power. ・ Wind and solar forecasting based on measurement of solar and wind ・ Include pumped storage, Hydrogen ・ SCO by utility. GFM can be part of the solution once it become commercially available. ・ to create multiple micro grids which can interconnect
3	How much sec/min/hrs of interruption per day or per year do you assume it is acceptable when 100 %RE is established?	・ The standards should be kept, 2 interruptions/yr, 1hr per year (Barbados) ・ 1 to 1.5 hours per year ・ better than 24 hours per year. ・ Interruptions should not exceed 1 week (168hrs) per year.
4	For achieving RE target 100 % with grid stability, who and how to cover the cost?	・ IPP producer should install stability measurement and should have the responsibility of minimizing the impact ・ Special selling rates should be given IPPs who invest in RE with control & stabilizing ・ It will be picked up by the consumers, as whoever pays it will need to pass it on to consumers. Incentive to minimize is necessary. ・ The feed in tariff rate has to be increased ・ Subsidy by government ・ The cost of grid stability will have to be shared between the utility, IPPs &customers.
5	Provide Additional suggestion for seminar	・ incentive/tariffs for other types of grid improvement beyond the storage ・ Weather prediction (LIDAR/satellite/etc; 15 min. ahead) required, along with microgrids,

Source: Prepared by JET based on Feedbacks for Seminars

Based on feedbacks above, the recommendation for realization of RE projects and achieving RE target were prepared.

5.3.9 Realization of RE Projects

(1) PV

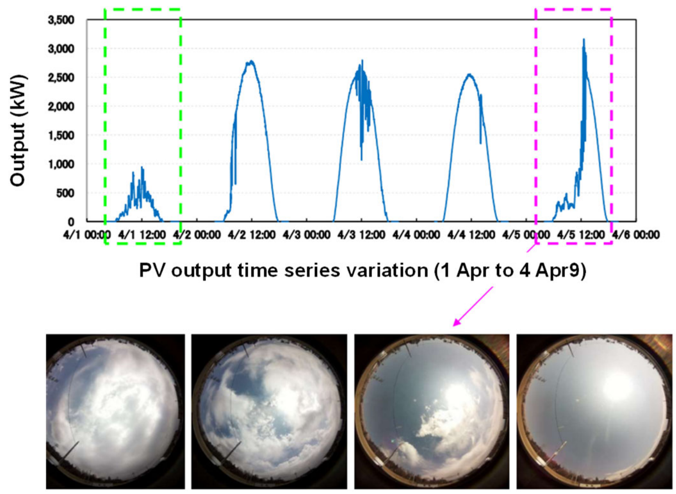
For the 35.7 MW Laclanche project in St. Kitts, the upper output limit of the power sent to the grid is 16-18 MW, and it is assumed that fluctuations will be absorbed by storage batteries. However, the storage battery output is reportedly 14.8 MW, and has limit, it is likely that the output fluctuation that is higher than battery output will affect the grid, depending on the weather, and that it will be necessary to supply spinning reserves of diesel generators to absorb the remaining fluctuations.

Referring to the good example of Jamaica, it is recommended to introduce a climate forecasting system capable of predicting PV output one hour in advance based on satellite data **Table 5-27** and/or a weather forecast using all-sky cameras capable of predicting output 15 minutes in advance as in **Figure 5-42**. Output forecasting enables optimal operation of the thermal power and minimize the idling time of spinning.

Table 5-27 Errors % of Intraday & Day-Ahead PV Power Forecast

Type	Data source	+1 hours ahead error(%)	+3 hours ahead error(%)	+24 hours ahead error(%)
Tropical/Subtropical, Humid (7 sites)	Solcast	(2.4% to 3.8%)	(3.2% to 5.6%)	(4.5% to 7.0%)
	Smart Persistence	(3.0% to 5.3%)	(3.7% to 6.9%)	(3.8% to 8.6%)
	GFS		(4.6% to 8.5%)	

Source: https://solcast.com/forecast-accuracy



Source: https://www.data.jma.go.jp/sat_info/himawari/kondan/kai3/shiryou3_2-2.pdf

Figure 5-42 Weather Prediction with All Sky Camera of Sky Perfect JSAT

(2) Wind

For wind power, JET also recommends that a weather forecasting system be installed in the same way as for PV. In addition, the 5.7 MW wind farm in Bellevue is considered to affect to the grid instability in the exercise, and grid stability with detailed load and local data should be conducted with transient stability analysis.

For the 50 MW offshore wind project in Nevis, JET assumed that a 66 kV transmission line and hydrogen and ammonia plants are to be constructed and assumed in grid analysis. After the site selection, it is recommended that power flow analysis and transient study analyses be conducted again according to the detailed demand patterns, and an operational plan, and constants of actual applied power lines.

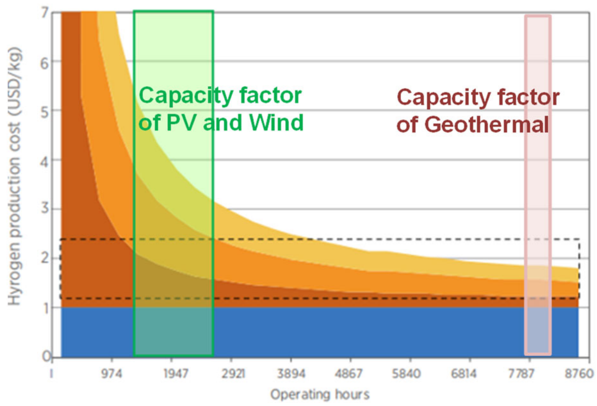
(3) Geothermal

The challenges for geothermal are financing and the high unit cost of electricity generation. The first phase of 10 MW is on the way of the procurement with the support of the Caribbean Development Bank. On the other hand, future expansion and further development will require additional initial investment. For interconnection with St. Kitts and hydrogen and ammonia production, an F/S level study for a financial plan to cover these needs is required.

(4) Hydrogen

NEVLEC has requested JET to conduct a study to produce and export hydrogen and ammonia as a way to utilize the abundance of geothermal energy much more than demand in Nevis.

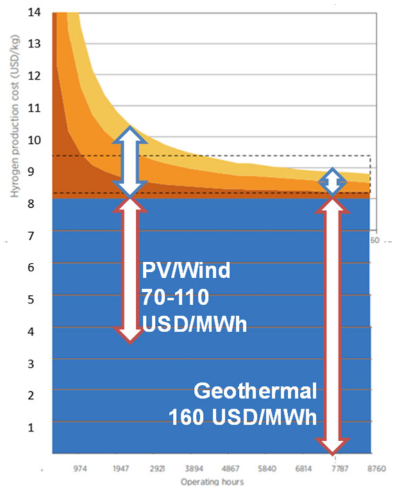
The cost is challenging when using geothermal energy as a power source to produce hydrogen by electrolyzing water. The cost of hydrogen produced by electrolysis of water using PV or wind power as green hydrogen can be compared with the cost of hydrogen produced by geothermal power. Although the cost of geothermal power generation is higher than that of PV and wind, geothermal is a stable power source and has the advantage of high-capacity factor for hydrogen electrolysis plants. The relationship between capacity factor (operation hours per year) and hydrogen plant costs is shown in the top figure of **Figure 5-43**.



RE Type	Capacity factor	Hour/yr	Electrolyser cost w/o electricity USD/kg*
PV	13-25%	1140-2190	2.8-4.5
Wind	20-30%	1752-2752	2.3-3.3
Geothermal	90-95%	7784-8322	0.8-0.9

*Electrolyser system cost (770USD/kW)

Source: IRENA Green Hydrogen Cost Reduction
Note: Efficiency at nominal capacity is 65% (with an LHV of 51.2 kWh/kg H2), the discount rate 8% and the stack lifetime 80 000 hours



Source: Prepared by JET using material of IRENA

Figure 5-43 Plant Cost (up) and Electricity Cost (bottom) for Hydrogen Production

The cost of hydrogen electrolysis is dominated by generation costs rather than plant costs. From the IRENA report in **Figure 5-43**, the cost of hydrogen production from PV and wind, of which cost is 7-11 USc/kWh, and hydrogen production cost will be about 7 USD/kg. In case of geothermal generation cost is 16 USc/kW, the hydrogen production cost will be about 9 USD/kg. Thus, it cannot say that geothermal hydrogen has a cost advantage than PV and wind, even geothermal has at higher capacity factor. This is a rough estimate; actual costs should be closely examined based on local conditions.

Since the demand for hydrogen within Nevis is very limited, it is necessary to consider the cost of transporting hydrogen to hydrogen consumption areas. There are several methods of transporting hydrogen, including hydrogen liquefaction, ammonization, and liquid hydrogen organic carrier (LHOC). LHOC is an efficient method of reducing transportation and storage costs, as transporting, and storing hydrogen in the form of MCH (Methylcyclohexane) is safer than transporting hydrogen gas at high pressure or liquid hydrogen at very low temperatures, and the volume can be compressed to about 1/500 of that of hydrogen gas.

As for ammonization, ammonia conversion from hydrogen is conducted by Haber-Bosch process to synthesize ammonia at high temperatures and pressures of 400-600°C and 20-100 MPa for transport as ammonia. OHC and ammonia conversion have the advantage in terms that it is possible to use existing liquid fuel tankers and facilities. However, energy is required for conversion to MCH, hydrogenation, and ammonia conversion. **Figure 5-44** shows an example of cost estimates from Nevis for each of these transport methods.

Cost of Hydrogen, LOHC, NH3 tanker

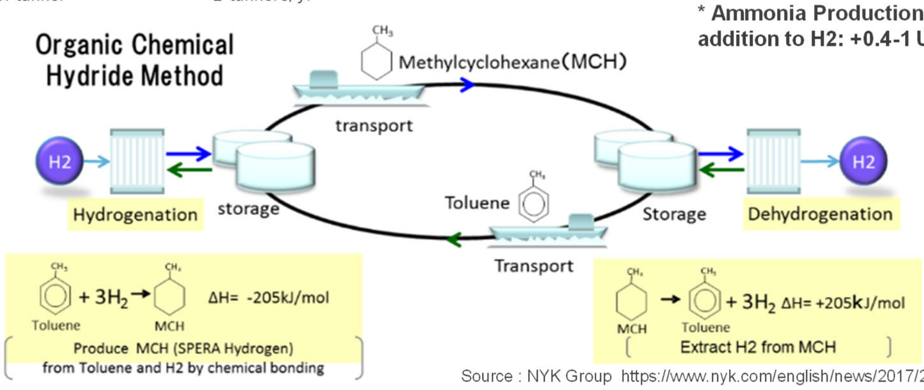
Geothermal capacity	10 MW
Operation hr	8000 hr/year
Power Production	80,000 MWh/year
Hydrogen efficiency	48.95 MWh/ton
Hydrogen production	1,634 ton/year
LOHC carriage	62 kgH2/t_LOHC
LOHC tanker	15,000 ton/year
H2 by LOHC tanker	930 tonH2/year
nos of tanker	2 tankers/yr

NH3/ LOHC Career cost (USD/kg)

Hydrogen market	km	LHOC/tanker	H2	NH3
Barbados	500	2	2.35	2
Jamaica	1,500	2.05	2.4	2.1
Miami	2,100	2.1	2.5	2.2
New York	3,900	2.2	2.6	2.25
Tokyo	18000	2.5	3.2	2.45

Source : Prepared by JET IEA Global Hydrogen Review

* **Ammonia Production cost in addition to H2: +0.4-1 USD/kg**



Source : NYK Group https://www.nyk.com/english/news/2017/20170727_01.html

Source: Prepared by JET based on IEA Global Hydrogen Review and NYK Group News (https://www.nyk.com/english/news/2017/20170727_01.html)

Figure 5-44 Example of Comparison of Transportation Cost by LOHC, H2, NH3

Above is very preliminary consideration. It is recommended that an F/S be conducted a detailed study of geothermal hydrogen in Nevis considering local condition and plant design.

5.3.10 Policy/ Legal System to Achieve Renewable Energy Installation Targets

The following are recommendations for the introduction and realization of RE targets in St. Kitts and Nevis

- It is recommended to develop geothermal power as a stable RE source as much as possible, and interconnect with St. Kitts to utilize geothermal power. In particular, in addition to the 10 MW to be developed on Nevis, a further 30 MW of geothermal power is desirable to be developed and connected to St. Kitts to supply stable geothermal power to both St. Kitts Island and Nevis Island.
- In order to increase resilience, it is also recommended that the 66 kV transmission line interconnection concept proposed by NEVLEC be realized with effective use of the

geothermal energy in Nevis. The concept is to connect the shortest section with the existing 11 kV first, and then build a loop line with 66 kV. Financing for this is critical, and an effective approach to funding sources, such as the Caribbean Development Bank, is needed.

- Applying the excess electricity generated by geothermal power in Nevis to hydrogen production is an important approach toward the coming hydrogen society. On the other hand, the cost of geothermal is high, and whether the advantage based on high-capacity factor cover the cost of inexpensive large VRE needs to be examined in detail in the F/S with local conditions. It is recommended that a study be conducted that includes the downstream of the geothermal hydrogen supply chain considering future market condition.

It would take more than several years to build the Nevis geothermal expansion and the 66 kV loop transmission line. On the other hand, VRE such as PV and wind have lower costs and shorter time to construction. During the transitional period, VRE is expected to increase, resulting in grid instability, including frequency and voltage fluctuation that have been challenging in Barbados, Jamaica, and other countries. The following policies are recommended until a stable supply of RE to the two islands by geothermal power is achieved.

Regarding policy recommendations, there are many items in common with Jamaica. The following items in common with Jamaica are shown in green text.

According to the increase of output of PV and wind, following considerations will be necessary.

(i) **Need of Spinning Reserve:** it is necessary to prepare stand-by thermal generation source (Spinning Reserve) that can instantaneously increase/decrease output to absorb fluctuation of VRE. Movement of cloud may fluctuate the output of PV more than 80 % within a minute. To cover the output fluctuation, high speed synchronous generator such as gas engine is necessary which has high ramp rate.

(ii) **Reactive Power Compensation:** AC electric power consists of Active Power and Reactive Power. Reactive power does not perform useful work, but it is necessary for the proper functioning of the electrical system. Reactive power is necessary to maintain voltage and grid stability. Both PV and wind systems are dependent on weather conditions, and their output power fluctuates due to changes in sunlight or wind speed. This variability can lead to voltage fluctuations and instability in the grid, which can cause problems such as equipment damage and power outages. Reactive power compensation can help to mitigate these issues by balancing the reactive power in the grid. Reactive power compensation devices, such as capacitors and SCO, will need to be installed in the PV or wind system to supply or absorb reactive power. These devices can help to stabilize the voltage in the grid and improve the power factor. Reactive power compensation is necessary along with installation of PV and wind systems to ensure the stability and reliability of the grid.

(iii) **Need of Synchronizing power**: Inverter connected power source such as PV and wind does not have synchronizing power. If PV and wind is increased in the grid, frequency will be disturbed when sufficient amount of synchronous generator as spinning reserve is not available. In case sufficient synchronous generator such as thermal power and hydropower is available in the grid, the problem will be avoided. However, in case the percentage of the inverter connected source is increased in the grid, the grid will face problems. When VRE is more than 30 %, especially, insufficient synchronizing power will be an issue. The inverter converts from DC to AC according to the frequency of the grid. Therefore, if the RoCoF of the grid is large, the frequency will change too fast, and the operation to restore the frequency will not be completed in time. If the frequency drops below the Nadir below the setting of the UFR, the UFR of the power plant will be opened and the power supply will be disconnected from the grid, causing the inverter-sourced power disconnected one after another. This further reduces the frequency. The UFR at the substation will then also shut down the load at the relevant feeder, resulting in a power cut in the area. Even if the VRE percentage increases, sufficient synchronizing power must be maintained.

In case inverter-connected VRE generates more than 1/3 of the grid capacity, insufficient inertia and synchronizing power will be a problem, and above issue may happen as illustrated in the figure below.

To avoid frequency fluctuations, the installation of storage batteries is effective. However, since storage batteries are also connected to the grid through an inverter, the problem of reduced synchronization power remains even if VRE and storage batteries are increased. The solution to this problem is GFM, which can determine the frequency using only VRE and storage batteries without the grid frequency, thereby maintaining synchronization power. The GFM is currently under development and demonstration and has been commercially introduced in Australia and other countries.

Until the geothermal development, which is stable power source different from VRE, progresses and the two islands are covered by the geothermal power, the above VRE measures are necessary, especially for St. Kitts.

The recommendations are mostly the same as in Barbados which also tartes 100 % RE and are shown in **Table 5-28**.

Table 5-28 Policy Recommendation for Introduction of large RE with Grid Stability in St. Kitts and Nevis

Item	Description
Interconnection	- St. Kitts and Nevis is recommended to be interconnected by AC or DC 66kV line to achieve stable 100% RE also for resilience. F/S is needed.
Hydrogen/Ammonia	- Hydrogen/Ammonia with geothermal need to be considered with geothermal cost reduction.
Investment to secure inertia and spinning reserve for grid	- Maintaining sufficient synchronous generator for spinning reserve - Introduction of Grid Forming Inverter (GFM) for VRE source - Weather projection system for optimum spinning reserve plan
Investment for voltage and reactive power	- Mandatory application of Inverter with reactive power compensation for and energy storage for Wind/Solar IPP
Sharing responsibility of grid stability among utility, IPP, consumers	- Utility: maintaining transmission and distribution line frequency and voltage stability, ancillary service - IPP of VRE: installation of reactive power compensation and energy storage - Consumer: demand response, ToU setting& EV charging, peak shifting
Option for storage (especially with inertia)	- In addition to BESS, consideration of V2G, hydrogen, (pumped storage), Compressed Air Energy Storage (CAES) and Gravity Storage based on cost analysis and future development
Data management	- Database management, update plans based on implementation status
Recycle/disposal	- Consideration for disposal and recycling of battery and PV panel
"Best-Mix" Energy	- Multiple alternative for RE and storage, not a single source (Solar/CSP/Wind/Biomass, BESS/Thermal/new storage, etc.)

Source: Prepared by JET

5.3.11 Training in Japan

The training in Japan was conducted as the final stage of technical transfer. The outline is reproduced as **Table 5-29**. Details are shown in **Appendix 3-6**.

Table 5-29 Outline of Training in Japan

Date & Time	Total of 14 days (Sunday, April 9, 2023 - Saturday, April 22, 2023)
Participants	Jamaica: 2 participants, Barbados: 4 participants, St. Kitts and Nevis: 3 participants
Location	JICA Tokyo, Tokyo, Ibaraki Pre., Fukushima Pre., Okinawa Pref.
Purpose	To promote the introduction of RE and EE in each country, the training will be provided to participants to acquire Japanese technologies and knowledge through lectures and site visits.

Source: Prepared by JET

The following is the summary of the areas and initiatives that the participants from St. Kitts and Nevis would like to receive support from JICA and the Japanese government in the future, based on the experience of training in Japan.

(1) EE

The participants from St. Kitts and Nevis identified the following as challenges/status regarding in promoting EE in their country.

- Application of the CREEBC is not mandatory.
- Formulation of a building code that includes EE and its inspection criteria (application for verification, on-site inspection)

- Lack of resources for data collection and management system related to EE

For promotion of EE, they stated that it is important (i) the introduction of high-efficiency air-conditioning equipment, (ii) ZEB technology and its introduction strategy, (iii) establishment of energy management system, (iv) EE regulations and enforcement, (v) introduction of high-efficiency home appliances, and (vi) energy audit.

The participants also explained the following needs and expectations for JICA and Japanese government.

- Capacity building for data collection
- Assistance in formulating EE policies
- Assistance in reviewing the formulation of various regulations related to EE
- Review of laws related to EE
- Promotion of EE (3E+S)
  * 3E+S: (i) Energy Security-Self Sufficient, (ii) Energy Efficiency-Energy Cost, (iii) Environment-Greenhouse Gas Emissions), (iv) Safety

(2) RE

The participants from St. Kitts and Nevis identified the following challenges for renewable energy deployment in their country.

- Absence of government policies, procedures, and regulations for strengthening and promoting RE installations and determination of power tariffs (outdated energy policy, transportation sector not taken into account, absence of grid code, FIT, and regulatory body, etc.)
- Import of substandard RE products
- Insufficient data collection and management systems related to the grid
- Subsidies for fuels
- Modernization of grid control including SCADA and AMI
- Adoption of storage batteries to enable grid stability and black start
- Aging and low efficiency of existing generators
- Capacity for contract negotiation with IPPs, project-management and engineering capacity
- Low cash flow of utilities against high GDP

In terms of the content of the training in Japan, the participants from St. Kitts and Nevis stated that they were particularly interested in (i) the standardization of technology, (ii) grid analysis for large RE penetration, (iii) hydrogen research, technology standardization, (iv) insurance and weather effects on offshore wind, (v) PV destruction due to typhoons, and (vi) RE observation systems.

The participants also explained that they have the following needs and expectations of JICA and Japanese government.

- Support for policies and regulations, incentives and penalty measures
- Planning for green hydrogen production, consideration of hydrogen transportation media
- Smart inverters (grid forming inverters)
- Update on RE Infusion Study (including FIT Impact Study)
- Grid Interconnection of St. Kitts Island and Nevis Island
- Resource Mapping
- BESS pilot project

Of the above, the grid interconnection of St. Kitts and Nevis was studied using a simplified model as an exercise, but a detailed technical study will be required in the future. It would be significant to support this and an updated version of the RE Infusion Study (power development plan including RE implementation) that includes policy and regulation aspects.

In addition, if pilot projects for GFM and BESS can be implemented, Japanese companies will be able to accumulate experience to enter the field and lead low-carbon development in island countries.

Chapter 6 Project Activities (Overall)

6.1 Joint Coordinating Committee (JCC)

6.1.1 1st JCC

Based on the results of the baseline survey conducted in Phase 1, the first JCC and kick-off workshop was held with relevant organizations in each country from October to November 2019 to report the results and confirm the policy for Phase 2 technology transfer activities.

(1) Jamaica

Table 6-1 provides the summary of the first JCC and kick-off workshop in Jamaica. Details of the first JCC in Jamaica is shown in **Appendix 6-1-1-1**.

Table 6-1 Overview of Jamaica 1st JCC and Kick-off Workshop

Date & Time	Wednesday, October 23, 2019, 9:00-12:30
Participants	Mr. Fitzloy Vidal (P/D), Mr. Horace Buckley (P/M), MSET, et al. PCJ, NESOL, JPS, BSJ, CMU, U-tech, UNDP, Wigton, JICA Jamaica, JET Total 23 participants
Location	Auditorium Hall at PCJ
Purpose	Baseline survey results, status report and confirmation. ▪ Confirmation of activity policy, evaluation method, challenge items and schedule for promoting EE (Energy Efficiency) and RE (Renewable Energy). ▪ Reviewed the revised Project Design Matrix (PDM) (Rev.1).
Discussion and Conclusion	The following changes regarding PDM were agreed upon. ▪ Technology transfer through demonstration on how to implement Network Asset Management and its effectiveness and set up indicators. ▪ The equipment to be provided was changed from instrumentation + system analysis software to only system analysis software. ▪ Organizing the names of Japanese expert positions. ▪ Creation of microgrid concept in some regions.
Photos	 

Source: Prepared by JET

(2) Barbados

Table 6-2 shows the summary of the first JCC and kick-off workshop in Barbados. Details of the first JCC in Barbados is shown in **Appendix 6-1-1-2**.

Table 6-2 Overview of Barbados 1st JCC and Kick-off Workshop

Date & Time	Monday, November 4, 2019, 14:30-15:30; MEWR Tuesday, November 5, 2019, 9:00-10:00; BL&P
Participants	Ms. Francine Blackman (P/D), Mr. Horace Archer(P/M) et al. MEWR, BL&P, JET, Ministry of Public Work Total 19 participants
Location	Conference Room at MEWR Conference Room at BL&P
Purpose	Baseline survey results, status report and confirmation. ▪ Confirmation of activity policy, evaluation method, challenge items and schedule for EE and RE promotion. ▪ Confirmation of the revised Project Design Matrix (PDM) (Rev.1).
Discussion and Conclusion	The following changes regarding PDM were agreed upon. ▪ Technology transfer through demonstration on how to implement Network Asset Management and its effectiveness and set up indicators. ▪ The equipment to be provided was changed from instrumentation + system analysis software to only system analysis software. ▪ Organizing the names of Japanese expert positions. ▪ Changed "F/S of RE potential sites" to creation of RE 100 % microgrid concept. ▪ Specify that case studies will be conducted by simulation in the microgrid concept.
Photos	 

Source: Prepared by JET

(3) St. Kitts and Nevis

Table 6-3 shows the summary of the first JCC and kick-off workshop in St. Kitts and Nevis. Details of the first JCC in St. Kitts and Nevis is shown in **Appendix 6-1-1-3**.

Table 6-3 Overview St. Kitts and Nevis 1st JCC and Kick-off Workshop

Date & Time	Tuesday, October 29, 2019, 9:00-13:00
Participants	Mr. Glenn Amory (P/D), Dr. Bertill Browne (P/M) and others MPI, NIA, SKELEC, NEVLEC, SKNIS (local media), JICA St. Lucia, JET Total 18 participants
Location	Conference Room at MPI
Purpose	Baseline survey results, status report and confirmation. ▪ Confirmation of EE and RE promotion activity policy, evaluation method, challenge items and schedule. ▪ Confirmation of the revised Project Design Matrix (PDM) (Rev.1)
Discussion and Conclusion	The following changes regarding PDM were agreed upon. ▪ Technology transfer through demonstration on how to implement Network Asset Management and its effectiveness and set up indicators. ▪ The equipment to be provided was changed from instrumentation + system analysis software to only system analysis software. ▪ Organizing the names of Japanese expert positions. ▪ Changed "Proposal on RE introduction" to "Conduct grid analysis to analyze issues of mass introduction of renewable energy".
Photos	 

Source: Prepared by JET

6.1.2 2nd JCC

The second JCC was held online with each country with the main purpose of reviewing the project and reaching an agreement with each partner country to extend the project period due to the impact of COVID-19. The dates of the meeting are shown in **Table 6-4** below. Details of the second JCC in Jamaica is shown in **Appendix 6-1-2-1**, in Barbados is shown in **Appendix 6-1-2-2**, in St. Kitts and Nevis is shown in **Appendix 6-1-2-3**.

Table 6-4 Overview of 2nd JCC

Country / Region	Date and Time
Jamaica	February 3, 2022, 8:30am- (Japan time 22:30-)
Barbados	November 22, 2021, 9:00am- (Japan time 22:00-)
St. Kitts and Nevis	November 25, 2021, 8:30am- (Japan time 21:30-)

Source: Prepared by JET

Both were agreed upon between the Japanese side and the C/P agencies. However, regarding the specific future schedule, the C/P agencies of each country expressed the condition that it would depend on the impact of COVID-19. Therefore, at the time of the second JCC, the possibility of resuming face-to-face technology transfer activities was not foreseeable.

6.1.3 3rd JCC

(1) Jamaica

Table 6-5 shows the summary of the third JCC in Jamaica. Details of the third JCC in Jamaica is shown in **Appendix 6-1-3-1**.

Table 6-5 Overview of Jamaica 3rd JCC

Date & Time	Thursday, March 30, 2023, 10:00-12:00
Participants	Dr. Olive Wilson Cross (P/D) and others MSET, JICA HQ, JICA Jamaica, JET Total 16 participants
Location	Online
Purpose	Report on the results of the project activities except for the training in Japan. ▪ Phase 2: Review of Detailed Activities in Technical Transfer ▪ Review of the revised Project Design Matrix (PDM) (Rev.7).
Discussion and Conclusion	The PDM was agreed except for the following items. The following two items were separately obtained from MSET after the JCC and reflected in the PDM. ▪ Progress on the Jamaican side regarding the Overall Goals indicators. ▪ Progress on the Jamaican side regarding the Overall Goals indicators.
Photos	(Omitted due to the online meeting)

Source: Prepared by JET

(2) Barbados

Table 6-6 shows the summary of the third JCC in Barbados. Details of the third JCC in Barbados is shown in **Appendix 6-1-3-2**.

Table 6-6 Overview of Barbados 3rd JCC

Date & Time	Monday, March 27, 2023, 10:00-12:00
Participants	Mrs. Debra Dowridge (Deputy Permanent Secretary) and others MEB, JICA HQ, JICA St. Lucia, JET, Total 18 participants
Location	Meeting Room at MEB
Purpose	Report on the results of the project activities except for the training in Japan. ▪ Phase 2: Review of Detailed Activities in Technical Transfer ▪ Review of the revised Project Design Matrix (PDM) (Rev.7).
Discussion and Conclusion	The PDM was agreed except for the following items. The following two items were separately obtained from the MEB after the JCC and reflected in the PDM. ▪ Progress of the Barbados side in relation to the Overall Goals indicators. ▪ Progress on the Barbados side for Project Purpose No.1 and 2 indicators.
Photos	 

Source: Prepared by JET

(3) St. Kitts and Nevis

Table 6-7 shows a summary of the third JCC in St. Kitts and Nevis. Details of the third JCC in St. Kitts and Nevis is shown in **Appendix 6-1-3-3**.

Table 6-7 Overview of St. Kitts and Nevis 3rd JCC

Date & Time	Tuesday, March 21, 2023, 9:30-11:30
Participants	Dr. Bertille Browne and others MPI, NIA, SKELEC, NEVLEC, NWD, JICA HQ, JICA St. Lucia, JET Total 19 participants
Location	Online
Purpose	Report on the results of the project activities except for the training in Japan. ▪ Phase 2: Review of Detailed Activities in Technical Transfer ▪ Review of the revised Project Design Matrix (PDM) (Rev.7).
Discussion and Conclusion	Each PDM indicator and the status of achievement were reviewed and agreed upon.
Photos	(Omitted due to the online meeting)

Source: Prepared by JET

6.2 Achievement of Project Goals and Overall Goals

Summaries of the PDM achieved through the project is provided below. Achievement was rated on a four-point scale: E=Excellent (Significantly Achieved), G=Good (Achieved), PA=Partially Achieved, and NA=Not Applicable (Cannot be evaluated). In addition, details of the final agreed PDMs for each country are shown in **Appendix 6-2-1-1**, **6-2-1-2**, and **6-2-1-3** for Jamaica; **Appendix 6-2-2-1**, **6-2-2-2**, and **6-2-2-3** for Barbados; and **Appendix 6-2-3-1**, **6-2-3-2**, and **6-2-3-3** for St. Kitts and Nevis.

6.2.1 Jamaica

(1) Project Purpose

Table 6-8 shows the progress in achieving the project goals and its achievement evaluation in Jamaica. The status of project achievement is also described below.

1) Number of RE facilities

IRP is currently under revision at MSET and is expected to be finalized during 2023. Therefore, the target value was supposed to be revised in line with the IRP but were not completed in time for the project period, so the original indicators remain unchanged.

The amount of hydro power remained unchanged from the baseline, while the amount of VRE was increased from 162 MW to 180 MW, bringing the total amount of RE generation to 209 MW in early 2023. Although progress has been made, the target value has not been reached, so the evaluation was rated PA (Partially Achieved).

2) Number of public buildings with EE program including BEMS

As shown in **Figure 3-30**, Jamaica's energy intensity has steadily progressed through 2021, and JET emphasized the importance of energy management activities, BEMS implementation, and data-driven initiatives to further promote energy conservation. These are in line with the energy efficiency and conservation sub-policy, and data loggers that can measure energy consumption were provided to help in this effort.

It was also confirmed through this project that the EE&C program is supported by IDB/JICA (CORE), CDB, EU, GIZ, and UNDP, and the target value is to promote EE&C programs for 44 public facilities over 4 years starting in 2019, while Jamaica reported that 60 EE&C programs have been implemented since 2015. Since there is no more detailed information available, it is unclear whether the target value has been met or not. So, the evaluation was rated NA (Not Applicable (Cannot be evaluated).

3) Number of trained staffs for introduction of RE

Throughout the seminar, necessary technical and regulatory matters such as GFM, spinning reserve, short circuit ratio, microgrid, transmission capacity, demand side management, etc. were discussed to share basic knowledge for grid analysis and explain the need for grid stability in the spread of VRE.

Seminar on Grid Stability and Large RE was conducted in three sessions, with 3, 6, and 6 participants from MSET, 4, 2, and 3 participants from OUR, and 25, 57, and 20 engineers from

JPS. Since the number of participants in each seminar was about the target value, it was assumed that the target was reached, and the evaluation was rated G (Achieved Good).

4) Number of trained staffs for promotion of EE

One demonstration, two domestic workshops (online), and one training in Japan were held to promote energy efficiency and conservation. A total of 19 people participated in the domestic workshops and 2 people participated in the training in Japan. While the number of participants for training in Japan was in line with the target value, the number of participants for domestic workshop was below the target value, and therefore, the evaluation was rated PA (Partially Achieved).

Table 6-8 Progress in achieving the project goals and evaluation in Jamaica

Description	Verifiable Indicator	Baseline Value	Target Value	Achievement	Evaluation
					4-step*
■ **Project Purpose** Human and institutional capacities are enhanced for the introduction of RE and promotion of EE	1. Number of RE facilities such as PV power station, wind generating facility, battery application, high-efficiency thermal power plant	1. Hydro 28.6 MW, VRE 162MW (total 191 MW) Rooftop 20MW BESS 20MW+ FH3MW	1.To be set according to IRP**	1. PV Total = 57MW; Wind Total = 101MW; Battery Total (plus Fly Wheel) = 24.5MW; Hydro Power Total = 28.6MW	PA
	2. Number of public buildings with EE program including BEMS: Building Energy Management System	2. BEMS 11(completed), 3 (planned)	2. EE program in total for 44 facilities in next 4 yrs	2. Number of public buildings which are implemented or introduced EE program is approximately 60 since 2015.***	NA
	3. Number of trained staffs for introduction of RE	3. Several Officers under MSET/PCJ took local trainings but no specialized staffs to RE	3. Domestic trainings: 20-30 personnel, Training in Japan: 1-4 personnel	3. In total, number of participants (accumulated total) was 117 personnel (MSET: 16) - 1st Seminar in Oct 2022 was 31 personnel (MSET: 4) - 2nd Seminar in Nov 2022 was 45 personnel (MSET: 6) - Final (3rd) Seminar in Feb 2023 was 39 personnel (MSET: 4) - 2 officers participated in the training in Japan. (MSET: 2)	G

Description	Verifiable Indicator	Baseline Value	Target Value	Achievement	Evaluation 4-step*
	4. Number of trained staffs for promotion of EE	4. 0 (External 3day Basic Energy Audit Training Course: Total No.150, Awareness building WS, seminars, etc.: Total No. 745)	4. Domestic trainings: 20-30 personnel, Training in Japan: 1-4 personnel	In total, number of participants (accumulated total) was 21 personnel (MSET: 8) - Demonstration on EE roadmap program etc. in Feb 2020 was 8 personnel - 1st Workshop in Feb 2023 was 3 personnel (MSET: 1) - Final (2nd) Workshop in Mar 2023 was 8 personnel (MSET: 5) - 2 officers participated in the training in Japan. (MSET: 2)	PA

Note 1: (*) means the following evaluation “4 step evaluation”: E=Excellent (Significantly Achieved), G=Good (Achieved), PA=Partially Achieved, NA=Not Applicable (Cannot be evaluated)

Note 2: (**) Due to the delay in the revision of the IRP, the target value was not reviewed because the revision was to be completed by the end of FY2023, after the completion of the project.

Note 3: (***) It is certain that energy efficiency efforts have been implemented for 60 facilities since 2015, but since no more detailed data was available, it is not known if these efforts have been implemented for 44 facilities in the four years of this indicator (2019 and beyond).

Source: Prepared by JET

(2) Overall Goals

Table 6-9 shows the progress in achieving the overall goals and future challenges to achieve the goals in Jamaica. At present, these have not achieved the target indicators for both items, and JET believe that the following challenges need to be addressed in order to achieve these targets.

1) Promotion of EE

"National Energy Conservation and Efficiency Policy (draft)" is mentioned as EE&C policy, but this policy needs to be updated as necessary. A possible opportunity to update the policy is when individual measures and initiatives for EE&C promotion, such as the introduction of a labeling system, are formulated.

In addition, as mentioned above, the improvement of efficiency of not only commercial but also home appliances and their widespread use are important items that contribute greatly to the promotion of EE. To this end, it is also important to raise the energy efficiency awareness of the entire population, the purchasers, and it is important to inform the public each time the policy is revised.

2) Introduction of RE

In accordance with the increase of VRE, investments that contribute to grid stabilization, such as reactive power compensators for fluctuation control, GFM, and introduction of BESS will be necessary. To this end, it is necessary to revise IRP, including demand management, introduction of EVs, optimization of transmission and generation, energy conversion, measures for large-scale VRE and revision of transmission capacity, and formulation and establishment of policies and institutions with resilience enhancement.

Table 6-9 Progress in achieving the overall goals and future challenges to achieve the goals in Jamaica

Description	Verifiable Indicator	Target Value	Achievement
■ **Overall Goals** Energy security is ensured through introduction of RE and promotion of EE	1. Energy self-dependency 2. Imported fossil fuel reduction	1. 50 % (50 %RE by 2030) 2. To 80 % (20 % by RE in energy base)	1. As of March 2023, RE generation accounts for 12.4 % of total generation. 2. As of March 2023, imported amount of fossil fuel is 87.6 % in energy base.

Source: Prepared by JET

6.2.2 Barbados

(1) Project Purpose

Table 6-10 shows the progress in achieving the project goals and its achievement evaluation in Barbados. For the second indicator, the original target value shown in Chapter 1 was "-". The target value was revised as shown in the table below in accordance with the actual progress and expected realization. The status of project achievement is also described below.

1) Number of RE facilities

Rooftop PV installations are accelerating, nearly tripling from 25 MW in 2019 to 73.5 MW by early 2023. In addition, 1 MW of utility-scale wind power was installed. Meanwhile, a 10 MW wind power was originally planned to be installed within the project period, but this has not yet been realized as the capacity was increased to 50 MW and postponed. Large-scale PV and wind power generation on a utility scale by IPPs, including offshore wind, are planned in the future.

While rooftop PV has significantly exceeded the target, the introduction of storage batteries has not progressed as expected, resulting in a rating PA (Partially Achieved).

2) Number of public buildings with EE program including BEMS

Confirmed that optimized BEMS have been installed in two government facilities as targeted. In order to meet energy consumption reduction targets, not limited to public facilities, the committee confirmed that the following initiatives have been implemented or planned in Barbados in recent years.

i) Banning the importation of inefficient lighting fixtures

ii) Pilot operation of a labeling system for dealers and importers beginning in 2023

iii) Preparation of an Energy Management Guidebook by the end of 2023

iv) Utilization of testing facilities within CARICOM (agreements are currently being developed with countries with testing facilities)

v) Consideration of banning the sale of inefficient air conditioning equipment

MEB, which recognizes the need to visualize its efforts, highly evaluated this proposal, explaining that not only the introduction of BEMS but also data-driven efforts such as energy management activities are important for promoting of EE. As a contribution to this effort, data loggers capable of measuring energy consumption were provided.

The EE&C program was confirmed to have received support from IDB, GIZ, and KEPCO (Korea Electric Power Corporation) through this project, and the evaluation was rated G (Good, achieved) since energy efficiency and conservation were confirmed to have been achieved in two buildings as per the target values.

3) Number of trained staffs for introduction of RE

Throughout the seminar, discussions were held on these issues, including legal approaches for further introduction of VRE, grid analysis, grid planning review, and resilience enhancement, and the need for grid stability was explained.

This domestic seminar on Grid Stability and Large RE was conducted in five sessions, and the number of participants was equivalent to or far exceeded the target value in some sessions. Therefore, the evaluation was rated "E" (Excellent/Significantly Achieved).

4) Number of trained staffs for promotion of EE

One demonstration, one remote training, two domestic workshops, and one training in Japan were held to promote EE. A total of 38 people participated in these activities, and the average number of participants was almost equal to the target value, so the evaluation was rated G (Good, achieved).

Table 6-10 Progress in achieving the project goals and evaluation in Barbados

Description	Verifiable Indicator	Baseline Value	Target Value	Achievement	Evaluation
					4-step*
■ **Project Purpose** Human and institutional capacities are enhanced for the introduction of RE and promotion of EE	1. Number of RE facilities such as PV power station, wind generating facility, battery application, high-efficiency thermal power plant	1. PV 10MW + 12MW rooftop BESS 5MW/20MWh	1. PV 10 MW (BLPC) + 25 MW (Other) + Wind 10 MW	1. As of January 1, 2023 there was 10 MW Utility owned PV, 73.5 MW of Distributed PV, 1MW of wind energy and 5MW (21MWh) utility battery energy storage connected to the grid.	PA

Description	Verifiable Indicator	Baseline Value	Target Value	Achievement	Evaluation 4-step*
	2. Number of public buildings with EE program including Building Energy Management System (BEMS)	2. Needs of MEB is very high to promote EE of public buildings.	2. 2 (Two) Government facilities.	2. An optimized BEMS was deployed in 2 Government facilities. The goal being to provide a comprehensive understanding of the energy consumption of their physical plant and provide for the optimal control of energy supply and demand. The goal is to reduce the energy consumption in these buildings by as much at 50 %. It features: 265 kW PV, 400 kWh LiFePo4 battery storage, lighting control equipment,Smart metering equipment, Power conditioning equipment. Other EE interventions such as retrofit of more efficient air conditioning and lighting is planned to be rolled out throughout Government with a target of reducing energy consumption by 40 % against the 2030 business as usual case.	G

Description	Verifiable Indicator	Baseline Value	Target Value	Achievement	Evaluation 4-step*
	3. Number of trained staffs for introduction of RE	3. 0	3. 6 personnel (MEB:3, BLPC:3) and others	3. In total, number of participants (accumulated total) was 39 personnel (MEB: 27, BLPC: 12) - Remote training in Dec 2020 was 4 personnel (MEB: 4) - 1st Seminar in Jul 2022 was 4 personnel (MEB: 2, BLPC: 2) - 2nd Seminar in Oct 2022 was 33 personnel (MEB: 12, BLPC: 3) - 3rd Seminar in Dec 2022 was 19 personnel (MEB: 4, BLPC: 4) - Final (4th) Seminar in Jan 2023 was 13 personnel (MEB: 3, BLPC: 2) - Training in Japan in Apr 2023 was 3 personnel (MEB: 2, BLPC:1)	G
	4. Number of trained staffs for promotion of EE	4. 0	4. 7 personnel	4. In total, number of participants (accumulated total) was 38 personnel - Demonstration on EE roadmap program etc. in Feb 2020 was 15 personnel - Remote training in Dec 2020 was 4 personnel - 1st Workshop in Nov 2022 was 5 personnel - Final (2nd) Workshop in Jan 2023 was 11 personnel - Training in Japan in Apr 2023 was 3 personnel	E

Note: (*) means the following evaluation "4 step evaluation": E=Excellent (Significantly Achieved), G=Good (Achieved), PA=Partially Achieved, NA=Not Applicable (Cannot be evaluated)
Source: Prepared by JET

(2) Overall Goals

Table 6-11 shows the progress in achieving the overall goals and future challenges to achieve the goals in Barbados. At present, these have not achieved the target indicators for both items, and JET believe that the following challenges need to be addressed in order to achieve these targets.

1) Promotion of EE

As for EE, while "National Energy Policy, 2019-2030" covers EE&C field, comprehensive EE&C master plan shall be developed and published with the intention of awareness raising for all. It shall include sector-wise (commercial, residential, industrial and transport) EE&C policies as well as cross-sectorial ones (e.g., labelling program).

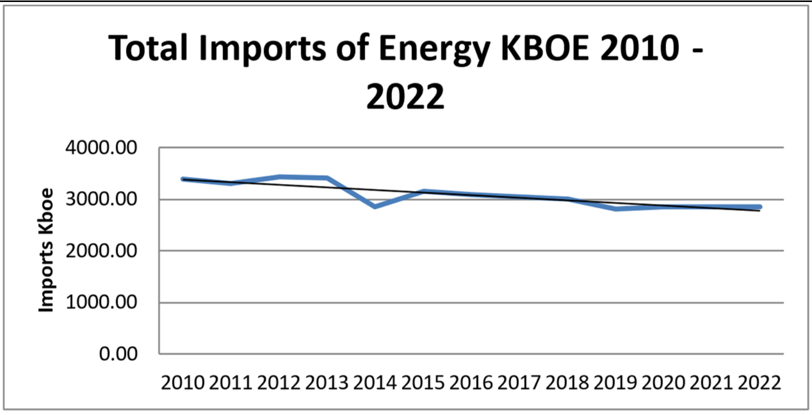
2) Introduction of RE

Since there is little potential for stable RE (hydro and geothermal), most of energy need to be provided from VRE of PV and wind. Future application of GFM with sufficient amount of energy storage will be necessary for 100% electricity in Barbados. The policy implementation for mandate BESS, EV, demand side management, sharing responsibility among utility, IPP, and consumers for grid stability is necessary with rapid VRE expansion. IRRP should be revised every two years with reviewing transmission capacity and revise of grid plans, with consideration of enhancement of resilience.

Table 6-11 Progress in achieving the overall goals and future challenges to achieve the goals in Barbados

Description	Verifiable Indicator	Target Value	Achievement
■ **Overall Goals** Energy security is ensured through introduction of RE and promotion of EE	1. Energy self-dependency 2. Imported fossil fuel reduction	1. 100 % (100 %RE by 2030) 2. 0 % by 2030	1. Renewable energy now makes up 3 % of Barbados overall energy mix (12 % of electricity production). 2. The importation of fossil fuel has decreased by 14.7 % since the 2010 baseline. Through the use of renewable energy and improvements in energy efficiency in the energy sector there has been a steady decrease of about 1.2 % per year. (See **Figure 6-1**)

Source: Prepared by JET



Source: Prepared by MEB

Figure 6-1 Total Imports of Energy from 2010 to 2022 (KBOE) in Barbados

6.2.3 St. Kitts and Nevis

(1) Project Purpose

Table 6-12 shows the progress in achieving the project goals and its achievement evaluation in St. Kitts and Nevis. The status of project achievement is also described below.

1) Number of RE facilities

Groundbreaking of 35 MW large-scale PV facility was conducted and is still in the design phase. In addition, as of March 2023, 10 MW geothermal power generation facility is in the procurement phase.

The evaluation was rated PA (Partially Achieved) because the project has not yet been completed but is in the process of being installed.

2) Number of public buildings with EE program including BEMS

The importance of data-driven initiatives such as energy management activities as well as the introduction of BEMS was explained, of which the Nevis Water Authority has voluntarily implemented energy management activities with the support of the St. Kitts and Nevis government since March 2020, when local activities were suspended. They have succeeded in reducing the power consumption of pumps by 30%. In addition, the data loggers were provided to St. Kitts and Nevis.

It was also confirmed through this project that EE&C program was supported by CDB, IDB, EU, DFID, and GEF. On the other hand, one hospital was identified as a public facility where EE&C efforts were made. It is unclear whether the hospital's EE&C efforts were influenced by this project or not, and the specific details and scale of the efforts are not known. Furthermore, due to the shortened project period, the project was not able to meet the target of "1 Proposal by JET will be prepared for the BEMS introduction" and although St. Kitts and Nevis voluntarily promoted EE, it is not possible to evaluate the project in accordance with the target value. The evaluation was rated NA (Not Applicable (Cannot be evaluated)) because the reasons are above.

3) Number of trained staffs for introduction of RE

Through the seminar, including grid analysis methods, technical and legal measures to achieve 100% RE were discussed, and the need for grid interconnection between the two islands, and the necessity of grid stabilization were also explained.

This domestic seminar on Grid Stability and Large RE was conducted in four sessions, and the number of participants was equivalent to or far exceeded the target value in some sessions. Therefore, the evaluation was rated "E" (Excellent/Significantly Achieved).

4) Number of trained staffs for promotion of EE

One demonstration, one remote training, two domestic workshops, and one training in Japan were held to promote EE. A total of 62 people participated in these activities, far exceeding the target, and the evaluation was rated "E" (Excellent/Significantly Achieved).

Table 6-12 Progress in achieving the project goals and evaluation in St. Kitts and Nevis

Description	Verifiable Indicator	Baseline Value	Target Value	Achievement	Evaluation 4-step*
■ **Project Purpose** Human and institutional capacities are enhanced for the introduction of RE and promotion of EE	1. Number of RE facilities such as PV power station, wind generating facility, battery application, high-efficiency thermal power plant	1. PV 1.2MW (St. Kitts), Wind 2MW(Nevis)	1.PV 35MW by 2020, Wind 5MW, BESS 44.2MWh (St. Kitts), Geothermal power 9MW (Nevis)	1. 10MW geothermal is in procurement process.	PA
	2. Number of public buildings with EE program including BEMS: Building Energy Management System	2. Needs of MPI is very high to promote EE of public buildings. (Current: 0)	2. 1 Proposal by JET will be prepared for the BEMS introduction	2. One. The Alexandra Hospital was upgraded to be more energy efficient.	NA
	3. Number of trained staffs for introduction of RE	3. 0 staff on this Project (Numbers of trainings by international agencies provided)	3. 10 personnel	3. In total, number of participants (accumulated total) was 66 personnel - Remote training in Dec 2020 was 18 personnel - 1st Seminar in Oct 2022 was 11 personnel - 2nd Seminar in Dec 2022 was 19 personnel - Final (3rd) Seminar in Jan 2023 was 14 personnel - Training in Japan in Apr 2023 was 4 personnel	E

Description	Verifiable Indicator	Baseline Value	Target Value	Achievement	Evaluation
					4-step*
	4. Number of trained staffs for promotion of EE	4. 0 staff on this Project (Numbers of trainings by international agencies provided)	4. 10 personnel	4. In total, number of participants (accumulated total) was 62 personnel - Demonstration on EE roadmap program etc. in Feb 2020 was 10 personnel - Remote training in Dec 2020 was 18 personnel - 1st Workshop in Nov 2022 was 16 personnel - Final (2nd) Workshop in Jan 2023 was 14 personnel - Training in Japan in Apr 2023 was 4 personnel	E

Note 1: (*) means the following evaluation "4 step evaluation": E=Excellent (Significantly Achieved), G=Good (Achieved), PA=Partially Achieved, NA=Not Applicable (Cannot be evaluated)

Note 2: (**) EE efforts were addressed in the renewal of the hospital, but the background and specifics of the renewal efforts were unclear. Therefore, it is unclear whether this is due to the impact of this project. Furthermore, the impact of this renewal on the promotion of EE in St. Kitts and Nevis is also unknown.

Source: Prepared by JET

(2) Overall Goals

Table 6-13 shows the progress in achieving the overall goals and future challenges to achieve the goals in St. Kitts and Nevis. At present, these have not achieved the target indicators for both items, and JET believe that the following challenges need to be addressed in order to achieve these targets.

1) Promotion of EE

As for EE, while "National Energy Policy, 2011" covers EE&C field, comprehensive EE&C master plan with target shall be developed and published with the intention of awareness raising for all. It shall include sector-wise (commercial, residential, industrial and transport) EE&C policies as well as cross-sectorial ones (e.g., labelling program).

2) Introduction of RE

100% RE for power in Nevis Island will be achieved by 10MW geothermal. In addition to 10 MW ongoing geothermal in Nevis, financing and implementation for geothermal, realization of 66 kV grid interconnection between St. Kitts and Nevis islands and utilization of geothermal also in St. Kitts is the key to achieve 100% RE. Otherwise, the future application of grid forming inverter with sufficient amount of energy storage will be necessary for 100% RE in St. Kitts Island. To reduce fossil fuel other than electricity, EV promotion is necessary.

Table 6-13 Progress in achieving the overall goals and future challenges to achieve the goals in St. Kitts and Nevis

Description	Verifiable Indicator	Target Value	Achievement
■ **Overall Goals** Energy security is ensured through introduction of RE and promotion of EE	1. Energy self-dependency 2. Imported fossil fuel reduction	1. 100 % (100%RE in power generation by 2030) 2. 2 % of total fuel import	1. Approximately 2 percent 2. Unchanged (*)

Note: Regarding (*), detailed figures were difficult to obtain, so this notation was used. Based on the World Statics Pocket Book 2020 Edition issued by UNSD, the imported fossil fuel was oil only and it was 3,774 TJ.
Source: Prepared by JET

6.3 Public Relations Activities

As part of public relations activities to promote understanding of our activities, we introduced our activities in conjunction with the kick-off workshop through the media in various countries. In addition, as a result of discussions with CCREEE, it was decided to include a presentation of the results of this project in CCREEE's RE/EE seminars and other events.

6.3.1 Interview in Barbados

The Embassy of Japan in Barbados, the JICA Saint Lucia office, and JET were interviewed by the local media (The Advocate), and the interview was featured in the general press. The article is shown in **Figure 6-2**.

Established October 1895
The Barbados Advocate
Business MONDAY
See Inside
Monday November 11, 2019
$1

Japan offers support

Asian island nation committed to helping with RE and EE

AS the Mia Mottley Administration seeks to make Barbados a 100 per cent fossil fuel economy by 2030, it is getting assistance from a world leader in renewable energy, Japan.

Last week, a three-member expert team from the Japan International Cooperation Agency (JICA) was in Barbados for meetings with the Government of Barbados and stakeholders in the renewable energy (RE) and electricity industry, concerning a three-year project, which is intended to provide technical assistance in the RE field, promote RE use and improve energy efficiency (EE) in the Caribbean. The ultimate goals, these JICA officials say, is to facilitate renewable energy becoming the primary source of power for the participating countries and the use of battery storage which is important for the grid's stability.

In an interview with The Barbados Advocate at the Embassy of Japan, Ambassador Extraordinary and Plenipotentiary, Teruhiko Shinada said while Barbados has set itself an ambitious goal, he does not believe it is impossible to achieve. He made the comments while indicating that there is "enormous room for Japan to assist Barbados towards that goal" and his country is willing, ready and able to give of its expertise to help make it a reality.

"The important point of this project is capacity building, and it is really important for local experts to have direct contact with our experts and eventually go to Japan to learn first-hand.

SUPPORT on Page 3

FALLEN SOLDIERS REMEMBERED

OVERCAST skies and an extended flood warning did not prevent scores of Barbadians from attending the Remembrance Day ceremony and parade held in National Heroes Square yesterday.

All members of armed and unarmed units were in position by 7:55 a.m. for the arrival of Governor-General of Barbados, Her Excellency Dame Sandra Mason with an escort from mounted troops. The Governor General of Barbados wore a steel grey dress and was adorned with a poppy brooch and her Governor General's medal.

Prior to her arrival, there were the arrivals of Prime Minister of Barbados, Mia Amor Mottley and Chief Justice of Barbados, Sir Marston Gibson.

With the arrival of the Governor General of Barbados who was escorted to her seat, the national Anthem of Barbados was played by the Royal Barbados Police Force Band, there was the firing of the canon, the two-minute observation of silence and the lowering of flags by the Ceno[illegible] half staff at 7:59 a[illegible] this time, the w[illegible] improved with grey turning blue and the crowd of locals and visitors along the boardwalk and Chamberlain bridge increasing in numbers.

SOLDIERS on Page 4

Deacons Primary students looking at the wreaths which were laid at the Cenotaph yesterday during the Remembrance Day celebrations.

Ambassador: Project still in progress

SUPPORT from Front Page

This project is still in the beginning phase and we have two and half years to go, in the capacity of Japanese Ambassador I would like to express my hope that the cooperation will develop the sector and the project will contribute to the policy realisation of Barbados," he said.

Adding to his comments, Masaaki Ebina, Subleader of the Project to Promote Energy Efficiency in Caribbean Countries, explained that apart from Barbados, the US$3 million project is being carried out in two other Caribbean countries – Jamaica and St. Kitts and Nevis, and it is hoped in the future to extend it to the rest of CARICOM. He made the point while explaining that Caribbean countries are heavily dependent on imported fossil fuels for energy, and there is a need to improve the EE and energy security of the countries. With that in mind, he said at the conclusion of the project, they are expecting to have facilitated the enhancement of the human and institutional capacities for RE introduction and EE promotion in the participating countries.

Mr. Ebina said that over a six months period, starting in April, the JICA Expert Team conducted a baseline survey to determine the situation in the three countries so far as renewable energy and energy efficiency is concerned. During that survey which was done between April and September of this year, he said they met with government officials and representatives of the power companies. He added that since the conclusion of the survey, the Joint Coordinating Committee held meetings to come up with an agreement on what type of knowledge is to be transferred. With that out of the way, he said the actually transfer of knowledge gets underway over the next two and a half years.

"During this technical transfer we are formulating two local training sessions, one is in the middle of next year, another local training session will be held in 2021, and after the two local training sessions we invite the key persons to Japan for three weeks for training. Japan has lots of experiences with renewable energy introduction and energy efficiency promotion. Some of the cases were a success, some of the cases failed and we show people what was the failure case, what was the success case and then participants will learn best practices," he stated.

In addition to facilitating capacity building in respect of the promotion of RE and improvement of EE in the Caribbean, the Japan sponsored project is also seeking to address capacity building as it relates to resiliency of power infrastructure. (JRT)

...ank committed to Barbados

...and a great group of clients that have been with us for many years," he said.

"We look at every market and look at its potential and look to see how we can operate safely within our risks parameters and if we can earn a return for our shareholders; and it's very clear to us after our analysis that Barbados continues to be a very strong market for us and we are looking forward to growing here for many years to come.

"Our very public commitment to Barbados is to see 2020 as a year of growth, we are very confident that that is going to happen, and we are very aggressively competing for all the good business in the market place, both retail, mortgages, credit card, small business is important to us, and big corporate commercial business that we do, so we are committed to the market and committed to growth in the market place."

King added that they were also committed to providing a good customer experience, and as such were working on improving their end-to-end processes so that mortgages, which used to take 20-30 days to get funded, can now be done in ten days, and in the future, hopefully five days, as they sought to continue to take out redundancies through using technology and digital more frequently.

He noted that in the years to come, you will see Scotiabank becoming more competitive in the market place as they were committed to "winning in Barbados and beyond."

Source: Advocate (Nov 11, 2019)

Figure 6-2 Introductory article by a local newspaper in Barbados (Advocate)

6.3.2 Interview in St. Kitts and Nevis

The first JCC was covered by the local media (St. Kitts Observer newspaper) and an overview of the project was posted on the Internet. **Figure 6-3**.

THE JAPAN INTERNATIONAL COOPERATION AGENCY PROMOTES ENERGY EFFICIENCY IN ST. KITTS AND NEVIS

- By Editor in Featured, In The News

Basseterre, St. Kitts, December 3, 2019 (SKNIS): The Japan International Cooperation Agency (JICA) was recently promoting energy efficiency within the Federation of St. Kitts and Nevis, through a project that ran from the month of October to November.

This project forms part of JICA's goal to give practical assistance to the Caribbean's energy sector in finding alternative renewable energy resources. This project also conforms to the Government of St. Kitts and Nevis' objective, which is to attain sustainable development.

In the opening ceremony for the Joint Coordinating Committee for Technical Cooperation to Promote Energy Efficiency in Caribbean Countries held earlier in October, Permanent Secretary in the Ministry of Public Infrastructure, Glenn Amory, said that St. Kitts and Nevis "suffers from the high importation bill of fossil fuels."

Mr. Amory continued by highlighting that for St. Kitts and Nevis to move forward, the Federation must "tap into renewable energy resources to increase efficiency and productivity."

According to the Director of the Energy Unit, Bertill Browne, this project is designed to "confirm the current situation and result of the baseline for energy efficiency and renewable energy." He also highlighted that it will "share the outputs, activities, means of verification, challenges and schedule for the project to promote renewable energy and energy efficiency."

Source: SKNIS website

Figure 6-3 St. Kitts and Nevis local newspaper (SKNIS) website introductory article

6.3.3 CariMET

The Caribbean Marine Energy Technology (CariMET) Forum was held during the trip for the purpose of hosting the first JCC. A summary of the forum is as follows.

- Date & Time:
  Tuesday, November 6, 2019, 9:00-17:00; Wednesday, November 7, 2019, 9:00-17:00
- Venue:
  Grenada Raddison
- Number of participants and main participants:
  CARICOM, CCREEE, SIDS DOCK, GIZ, Government of Grenada, MEWR of Barbados and about 70 others

During the forum, a meeting was held with CCREEE officials, who agreed to include a presentation of the results of this project in future CCREEE RE/EE seminars and other events.

6.3.4 Brochure

Two brochures were prepared as part of the public relations activities. Details are shown in **Appendix 6-3-1** and **6-3-2**. In addition, the following requests were received from C/Ps, and were prepared accordingly.

- Soft copy rather than hard copy is better
- A brochure pertaining to the promotion of EE for children would be good

6.4 Procurement of Equipment

The following equipment was procured through this project.

6.4.1 Data Logger

(1) Reasons for selection of equipment to be provided

As a result of the baseline survey, C/P wanted to provide power loggers among the items listed in Article 7(7) of the initial special specification and the Initial PDM for the following reasons.

Reason 1: The project countries (Jamaica, St. Kitts and Nevis, and Barbados) do not possess the power loggers and other items listed in Article 7(7) of the special specification. The project team was requested to provide these loggers because they were in possession of a small number of older models that were inconvenient to carry.

Reason 2: As a result of obtaining quotations, it was confirmed that the procurement of power loggers was appropriate in terms of functionality, budgetary constraints, and comparative advantage of Japanese technology.

For these reasons, the Power Logger was selected as the equipment to be provided.

(2) Specifications of equipment to be provided

Based on the results of the baseline survey, the following specifications were set for the equipment to be provided

■ Deliverables

➢ For St. Kitts and Nevis (200V-class model)

・Power Logger main unit (English version, 200V-class model)	2 pcs
・Sensor (CT)	2 sets
・Storage media	2 pcs
・Carrying case	2 pcs
・Viewer software	2 licenses

➢ For Barbados (200V non-compliant model)

・Power Logger main unit (English version, 100V-class model)	2 pcs
・Sensor (CT)	2 sets
・Storage media	2 pcs
・Carrying case	2 pcs
・Viewer software	2 licenses
・Line separators	2 pcs

➢ For Jamaica (200V non-compliant model)

・Power Logger main unit (English version, 100V-class model)	2 pcs
・Sensor (CT)	2 sets
・Storage media	2 pcs
・Carrying case	2 pcs
・Viewer software	2 licenses
・Line separators	2 pcs

(3) Implementation of equipment provision

After demonstrating how to use the loggers and the viewer software to the six institutions to which JET provided the equipment, JET provided the equipment as follows.

➢ Provision to St. Kitts and Nevis

・MPI	1 set (Jan. 2023)
・NIA	1 set (Jan. 2023)

➢ Provision to Barbados

・MEB	1 set (Sep. 2022)
・BNSI	1 set (Nov. 2022)

➢ Provision to Jamaica

・BSJ	1 set (Nov. 2022)
・MSET	1 set (Mar. 2023)

6.4.2 Grid Stabilization Analysis Simulation Software

Based on the content to be transferred and the results of the baseline study, as described above, the grid stabilization analysis simulation software "Microgrid Designer" was procured from EETRI and provided to Barbados and St. Kitts and Nevis for two licenses each. The recipients of the licenses are as follows. The software manual is shown in **Appendix 6-4**.

- Barbados
  MEB: 2 Licenses
- St. Kitts and Nevis
  MPI: 1 License, NIA: 1 License

6.4.3 Asset Management Software (Smallworld)

Based on the contents to be transferred and the results of the baseline survey, the grant was made to the St. Kitts side of St. Kitts and Nevis. The grantee is listed below. The details of the asset management software are as described in **5.3.7(3)** above.

- St. Kitts and Nevis
  MPI/SKELEC: 2 License

6.5 Subcontract

A power flow simulation for St. Kitts and Nevis was subcontracted to EETRI. A report summarizing the results of the analysis is presented in **Appendix 6-5**.