Regulatory Guidelines on the Interconnection of Customer-Owned Renewable Energy Facilities to the Grid

Support for a Renewable Energy Transition in OECS Countries

December 2022

ABOUT THE GLOBAL GREEN GROWTH INSTITUTE

The Global Green Growth Institute was founded to support and promote a model of economic growth known as "green growth", which targets key aspects of economic performance such as poverty reduction, job creation, social inclusion, and environmental sustainability.

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Acronyms and Abbreviations

APUA	Antigua Public Utilities
DER	Distributed energy resources
DG	Distributed generation
DOMLEC	Dominica Electricity Services Limited
GGGI	Global Green Growth Institute
GHG	Greenhouse gas
IRC	Independent Regulatory Commission
kW	kilowatt
kWh	kilowatt-hour
kWp	kilowatt-peak
LUCELEC	St. Lucia Electricity Services Limited
NDC	Nationally Determined Contributions
NREL	National Renewable Energy Laboratory
NURC	National Utilities Regulatory Commission
OECS	Organisation of Eastern Caribbean States
PURC	Public Utilities Regulatory Commission
PV	Photovoltaic
SEF	Sustainable Energy Framework
UNFCCC	United Nations Framework Convention on Climate Change
VINLEC	St. Vincent Electricity Services Limited

Executive Summary

The electricity sector across OECS territories is commonly characterized by high electricity rates, heavy reliance on imported fossil fuels, and vulnerability to natural disasters and other threats. Being cognizant of these issues, OECS territories have published national energy policies and set NDC targets which include goals for increased utilization of renewable energy in electricity generation. Some of the main reasons for this include, inter alia, diversification of energy sources; enhancing resilience in the electricity sector to natural disasters, global fuel price increase, among other threats; greater utilization of indigenous resources in electricity generation; reducing GHG emissions; access to electricity; and electricity affordability.

Distributed generation is expected to play a key role in OECS territories meeting their renewable energy goals, and can deliver several benefits which include, among other things, the following:

- Deferred investments in generation, transmission or distribution facilities that would otherwise be recovered through electricity rates.
- Improvements in power quality and reliability.
- Reductions in land-use effects.
- Broad participation in meeting renewable energy goals.

To facilitate increased use of renewable energy distributed generation, appropriate and clear frameworks have to be in place so that interested individuals or entities wishing to gain approval for and to interconnect renewable energy DG systems to the public grid, are clear on the procedures and requirements to do so. Based on information gathered by GGGI, some OECS territories already have frameworks in place, however some territories do not have existing frameworks or have inadequate frameworks in place.

In that regard, and to help spur increased integration of renewable energy in electricity systems across the OECS region, GGGI has developed a set of guidelines, as presented in this document, to provide guidance to regional electricity sector decision makers in developing or improving their own frameworks for integration of renewable energy distributed generation power generation facilities in electricity networks across the OECS region.

Guidelines presented in this document are of a general nature and are only intended to provide guidance in developing or improving country-specific frameworks, in consideration of the legal and regulatory framework existing in each country. GGGI understands that some OECS territories may require targeted assistance in developing or improving their own renewable energy distributed generation frameworks, and as part of its project titled "Support for a Renewable Energy Transition in OECS Countries" has already embarked on providing such assistance. It is expected that GGGI's interventions will assist territories in achieving their renewable energy targets.

1 Introduction

1.1 Purpose

As part of its project titled "Support for a Renewable Energy Transition in OECS Countries", the Global Green Growth Institute (GGGI) committed to supporting the Sustainable Energy Framework (SEF) developed by the Organisation of Eastern Caribbean States (OECS) Commission, as well as the goals of the Eastern Caribbean Solar Challenge. As part of this support, GGGI conducted a series of consultation meetings with energy sector stakeholders from OECS Member States discussing GGGI's planned support of the SEF and soliciting information regarding development of regulatory frameworks to facilitate increased utilization of renewable energy (RE) in power generation.

Following the consultation meetings referenced above, GGGI developed a Framework and Workplan describing the series of activities GGGI intends to undertake in support of the SEF. These include, inter-alia, the development of regulatory guidelines to aid electricity sector decision makers in the Eastern Caribbean in developing their own frameworks for integration of renewable energy into electricity networks across the region. This document represents the first of these guidelines and is aimed at informing electricity sector stakeholders regarding major considerations and best practices when developing regulatory frameworks for interconnection to the grid of customer-owned renewable energy facilities.

1.2 Background

As indicated above, GGGI developed a Framework and Workplan describing activities it intends to undertake in support of the OECS's SEF. These activities, intended for completion during the first phase of the project, which is intended to conclude in February 2023, includes the development of regulatory guidelines on the topics indicated in Table 1 below, with Topic A being the subject of this document.

Table 1: Description of Regulatory Guidelines to be Developed by GGGI

DESCRIPTION OF REGULATORY GUIDELINES TO BE DEVELOPED BY GGGI	
Topic #	**Description**
A.	Interconnection of customer-owned renewable energy facilities to the grid.
B.	Procurement of utility-scale renewable energy facilities.

Based on information gathered by GGGI, as presented in the referenced Framework and Workplan, OECS territories are heavily dependent on fossil fuels for generation of electricity, with most territories having close to 90% or greater of their installed generation capacity being fossil fuel based. One notable exception is Dominica, with approximately 25% of the installed capacity attributable to hydroelectric facilities. Other renewable energy technologies found to be currently utilized in the OECS region for electricity generation include solar PV systems and wind turbine generators. Nevertheless, it is clear that OECS territories are generally heavily reliant on fossil fuels for electricity generation. However, at the same time, a number of territories have set aggressive renewable energy targets, of as much as 100% renewable energy in electricity generation by 2030, according to their respective energy policies or Nationally Determined Contributions. Attempting to achieve these targets will require overcoming several challenges including deficiencies in the necessary legal and regulatory frameworks needed to facilitate interconnection of utility scale and distributed renewable energy facilities.

In the referenced Framework and Workplan, GGGI presented summary information on the size, configuration and governance of the respective electricity systems of several OECS territories. In the process of summarizing and presenting this information, details on any existing frameworks for interconnection of customer owned renewable energy facilities in the respective OECS territories were also examined. This revealed that the OECS territories listed below already have frameworks in place to facilitate interconnection of customer owned renewable energy facilities.

1. Antigua and Barbuda
2. Dominica
3. Grenada
4. Saint Lucia
5. Saint Vincent and the Grenadines

Further information on the frameworks existing in the territories listed above is provided in Section 2 of this document. It should be noted that while information was gathered for most of the OECS territories, no information was gathered for Martinique, Guadeloupe and the British Virgin Islands.

1.3 Objectives of Guidelines

As indicated above, a number of OECS territories have existing frameworks in place in order to facilitate integration of renewable energy in their electricity networks. These existing frameworks have differing characteristics, as described in Section 2 of this document. However, several territories do not have frameworks in place to facilitate interconnection of customer owned RE facilities, or have inadequate frameworks in place, despite there being strong customer interest, as expressed in consultation meetings with energy sector stakeholders from different OECS territories. This appears to be largely due to legacy electricity sector legislation which do not make clear allowances for these activities, and which largely restrict the generation of electricity to the incumbent electric utility. Electricity sector stakeholders across the region, however, being cognizant of these issues and how distributed generation can play a part in the energy transition, have in some cases been in the process of updating their electricity sector legislation to make accommodations for private participation in electricity generation, both at utility scale and distributed.

In addition to updated legislation, achieving the ambitious RE targets set by OECS member states also requires the appropriate regulatory mechanisms, policies and procedures to be in place, as part of the framework enabling greater investment in RE generation. In that regard, GGGI has, through this document, developed a set of guidelines to provide regulators and other energy sector decision makers across the OECS region with information that should prove useful in developing procedures for interconnection of customer-owned renewable energy facilities to the grid.

1.4 Scope and Structure of Document

This document was compiled to provide guidelines for developing procedures for interconnection of customer-owned renewable energy facilities to the grid.

This document is divided into five (5) sections, including this introduction and contains Appendices.

- Section 2: Overview of Existing OECS Frameworks for Interconnection of Customer Owned RE Facilities
- Section 3: Considerations and Guidelines in Developing Distributed Generation Frameworks
- Section 4: Summary of Major Considerations in Development of Renewable Energy DG Frameworks
- Section 5: Conclusions

2 Overview of Existing OECS Frameworks for Interconnection of Customer Owned RE Facilities

As indicated under Section 1.2, five OECS territories were found to have distributed generation frameworks in operation. These frameworks were reviewed as they can serve as reference points to each other, and to other territories in the region, as each territory aims to have the most appropriate framework in place to help in meeting their renewable energy targets, accounting for the specifics of their own local context. The frameworks reviewed were the following:

1. Antigua and Barbuda: Interconnection Policy Statement and Interconnection Procedures Guideline
2. Dominica: Distributed Renewable Energy Generation Policy
3. Grenada: Public Utilities Regulatory Commission Self-Generator Programme
4. Saint Lucia: NURC Notice No. 1 of 2016 (As Amended)
5. Saint Vincent and the Grenadines: Buy-All Sell All Programme

An overview of each of the frameworks indicated above, is provided in sections 2.1 to 2.5 below.

2.1 Antigua and Barbuda: Interconnection Policy Statement and Interconnection Procedures Guideline

The Interconnection Policy Statement and the Interconnection Procedures Guideline, published by the Antigua Public Utilities Authority (APUA), sets out the requirements and procedures for interconnection of renewable energy sourced power generation facilities with a rated capacity up to 50kW in Antigua and Barbuda.

The Interconnection Policy Statement sets out the authority under which APUA developed and published the policy statement and, among other things, it describes the general procedures, applicable fees and applicable codes and standards to be referenced when interconnecting renewable energy sourced power generation facilities with a rated capacity of 50kW or below. APUA's aim as stated in the policy statement is to allow for a maximum distributed non-fossil fueled power penetration level of fifteen percent of feeder/system yearly maximum demand.

As previously indicated, the accompanying document published by APUA to guide the process for interconnection of renewable energy power generation facilities, at or below 50kW in capacity, is the Interconnection Procedures Guideline. The stated objective of this procedures guideline is, in conjunction with the Interconnection Policy Statement, to set forth common interconnection requirements and a common interconnection process based on a common screening process for customers to expeditiously interconnect non-fossil fueled generation facilities in a safe and reliable manner with the utility's grid. The procedures guideline provides instructions to applicants, provides a review of the process and an outline of the utility's application review process and interconnection process, which vary depending on the capacity of the relevant facility. Unlike processes which exist in some other jurisdictions, the process laid out by APUA does not give capacity limit restrictions that are linked to customer class (residential, commercial, etc.). Instead, as indicated in Table 2 below, the process outlined includes interconnection review processes which vary depending on the capacity of the applicant's system (up to 50kW).

Table 2: APUA's General Guidelines for the Interconnection Process

APUA'S GENERAL GUIDELINES FOR THE INTERCONNECTION PROCESS	
Interconnection Review Process	**System Size**
Simplified Interconnection Process	0≤5kW
Fast Track Process with or without Supplemental Review	>5kW≤25kW
Full Interconnection Study Process	>25kW≤50kW

While neither the Interconnection Policy Statement nor the Interconnection Procedures Guideline indicate the compensation mechanism for energy supplied to the grid by, APUA, on their website, indicate the following:

- For systems up to 5kW, systems are configured primarily for self-supply, with excess energy supplied to the grid compensated at the avoided fuel cost; and
- For systems above 5kW, a "buy-all, sell-all" configuration is used, with all energy generated by the renewable energy facility, supplied to the grid, and compensated at the avoided fuel cost. The customer, in this instance, buys all their energy from the utility.

2.2 Dominica: Distributed Renewable Energy Generation Policy

The Distributed Renewable Energy Generation Policy (effective May 11, 2016) developed by the Dominica Electricity Services Limited (DOMLEC) and approved by Dominica's independent electricity regulator – the Independent Regulatory Commission (IRC), has the indicated purpose of allowing consumers of electricity, who are customers of DOMLEC, to be able to supply some or all their electricity needs using renewable energy, while connected to the grid. The policy is not intended for individuals interconnecting for the sole purpose of exporting energy to the grid.

The Distributed Renewable Energy Generation Policy was developed to address requests from customers desirous of installing embedded generation on to DOMLEC's distribution network. The policy details the process and DOMLEC's requirements for customer to connect a renewable energy distribution system, through the customer's interconnection point. The policy allows for interconnection of renewable energy distributed generation facilities up to 150kW in capacity, segregated into three (3) categories, as shown in Table 3 below.

Table 3: Distributed Renewable Energy Generation Policy Generation Categorizations

DISTRIBUTED RENEWABLE ENERGY GENERATION POLICY GENERATION CATEGORIZATIONS		
Category	**Maximum Output**	**Voltage Level**
1	≤3kW	230V
2	3≤75kW	230/400V or 11kV
3	75≤150kW	230/400V or 11kV

It should be noted that, as shown in Table 3 above, no categorizations are made based on customer classification (Residential, Commercial, Industrial, etc.). Additionally, while it appears participating customers are compensated for energy delivered to the grid, no clear indication is made in the policy regarding the compensation mechanism used.

2.3 Grenada: Public Utilities Regulatory Commission Self-Generator Programme

The Public Utilities Regulatory Commission (PURC) – the independent electricity sector regulator for Grenada, has promulgated the "Self-Generator (SG) Programme". According to the SG Booklet, the programme is a twelve-month self-generator pilot programme (start date not indicated), which allows individuals to generate electricity from renewable energy resources primarily for their personal consumption and sell any excess to the grid, with an initial permit granted for fifteen years, subject to renewal, modification, or extension.

The SG Programme allows residential permit holders/ participants to generate up to 120% of their current average annual kilowatt-hour consumption, and non-residential participants are permitted to generate up to 60% of their current average annual kilowatt-hour consumption. The SG Booklet indicates an initial programme cap of 1MW. Participants are compensated for energy delivered to the grid via a net-metering arrangement.

2.4 Saint Lucia: NURC Notice No. 1 of 2016 (As Amended)

NURC Notice No. 1 of 2016 was developed pursuant to section 5 of Saint Lucia's Electricity Supply (Amendment) Act of 2016, in lieu of any specific legislation to govern solar PV generation in Saint Lucia. It outlines the application procedures to be used by individuals and entities who are seeking to interconnect solar PV systems to the grid. Timelines and processing fees are provided along with the steps required to gain approval from the NURC to proceed with construction, obtain other requisite approvals and to enter into an interconnection agreement with LUCELEC. Upon executing the said interconnection agreement, LUCELEC will then proceed to commission the solar PV system. Based on NURC Notice No. 1 of 2016, the NURC is expected to keep records of all relevant facilities, including copies of all interconnection agreements and details such as the approved capacity and the installed capacity.

Based on NURC Notice No. 1 of 2016, the capacity limits for interconnection of solar PV systems are:

- 5kWp for residential usage; and
- 25kWp for commercial usage.

During 2022, the application procedures outlined under NURC Notice No. 1 of 2016 were amended by NURC Notice No. 1 of 2022 to allow the NURC to receive and consider applications for interconnection of solar PV systems with capacities greater than 25kWp. The grounds on which such applications may be considered for approval by the NURC are:

i. National Significance
ii. Socio-Economic Benefit

It should be noted that neither NURC Notice No. 1 of 2016 nor NURC Notice No. 1 of 022 specify a compensation scheme for individuals or entities who utilize the process and have a solar PV facility interconnected with the grid. It is understood, however, that a net-metering scheme is what is utilized.

2.5 Saint Vincent and the Grenadines: Buy-All Sell All Programme

Based on consultations with energy sector stakeholders in Saint Vincent and the Grenadines, St. Vincent Electricity Services Limited (VINLEC) has a programme in place which facilitates VINLEC customers interconnecting solar PV facilities with capacities up to 10kW to the grid, with a "buy-all sell all" compensation mechanism used.

Customers are reportedly compensated via a credit on their bills for energy supplied to the grid, utilizing a utility determined feed-in-tariff rate. Customers are reportedly allowed to transfer credits on their accounts to other electric utility customers.

3 Considerations and Guidelines in Developing Distributed Generation Frameworks

As indicated in Section 2, existing frameworks for interconnection to the grid of customer owned renewable energy facilities exist in several OECS territories, each having their similarities, as well as unique characteristics. Nevertheless, in developing such frameworks there are key considerations that need to be accounted for. These are outlined in the sections below.

3.1 Legal Framework and Process Ownership Considerations

Electric utilities have traditionally operated within a vertically integrated structure, where a monopoly utility controls all aspects of generation, transmission, distribution and supply. Over time, however, many jurisdictions across the world have deviated from this structure, with competition brought particularly into the electricity generation and supply aspects. While the traditional vertically integrated structure is still widespread throughout the Caribbean, some countries including OECS Member States have been taking steps to allow for some level of private participation at the generation level. This has seen some territories, at a minimum, establish distributed generation programmes, as indicated previously.

Allowances for reforms in the functioning of the electricity sector, however, is dependent on legislation, and may require changes to electricity legislation if electricity sector decision makers in a given territory desire such reforms. In that regard, before distributed generation frameworks can be established, careful consideration has to be made regarding what is allowed for in existing legislation and how this aligns with any policy decision to establish a distributed generation framework. The roles of the major electricity sector stakeholders and which entity is the process owner for any such distributed generation framework, whether this be the energy ministry, the utility, an independent electric utility regulator, or some other entity, has to be clearly established in legislation. If it is found that the enabling electricity sector legislation and/or regulations require amendments, electricity sector decision makers will need to carefully consider and propose any amendments required.

3.2 Considerations for Setting Individual System Capacity Limits

Typically, in setting up a distributed generation programme that is to be generally accessible to all electricity customers in a specific jurisdiction, consideration is given to setting limits on the capacity for individual systems that can be interconnected to the grid by programme participants. In setting such limits, several factors may be taken into account. These include:

i. Legislative and Policy Requirements
ii. Average Demand of Expected DG Programme Participants
iii. Allowances for Broad Programme Participation

These are detailed below.

3.2.1 Legislative and Policy Requirements

The enabling legislation for the electricity sector as well as electricity sector policy, specifically as it pertains to any provisions relating to distributed generation and renewable energy have to be considered in setting up a distributed generation programme and in determining any applicable capacity limits. Such provisions may include those described below.

3.2.1.1 Requirements for Self-Supply

As indicated under section 3.1 any distributed energy resource (DER) scheme/programme that is being considered for implementation, is required to comply with the provisions of the legislation governing the electricity sector in the specific jurisdiction. In addition to such legislation providing allowance for a distributed energy resource programme, there may be specific requirements applicable to customer owned DERs. This may include requirements that such facilities be sized primarily for self-supply, with only "excess" energy supplied to the grid.

In instances such as that described above, where the enabling legislation indicates restrictions on the sizing of customer owned distributed generation facilities, a reasonable approach, which focuses on ensuring that individual systems are sized primarily for self-supply, is to set individual system capacity limits in relation to actual or estimated historic peak load for the building/customer site. In order to achieve this objective, a recommendation put forward by the National Renewable Energy Laboratory (NREL) is to size systems based on 100 – 120% of the customer's previous 12-month historic peak load. This would ensure that energy generated is primarily for self-supply, but with allowance for some level of export to the grid. While this approach is reasonable, there are some shortcomings, including the following:

i. Customers, particularly those at the domestic level, may not readily have demand data available, since utility bills for domestic customers many times include consumption information (kWh) and not demand information (kW). This could leave customers with some level of uncertainty regarding appropriate sizing for their renewable energy facility.
ii. Additional complexity would be introduced in the approval process, since each application would have to be individually assessed, regardless of the capacity of the facility being proposed, to see if it satisfies the criteria.
iii. This approach could potentially lead to systems with relatively large capacities for customers with high electricity demand. This could pose some technical challenges for the utility, which may be costly to deal with. Additionally, in a context where overall programme limits are set, as described under section 3.2.1.2, this could result in the overall programme limit being met by a relatively small number of DG programme participants.

To address these concerns, a modified approach may be used, where capacity limits are set for recognized groupings of customers taking part in an established distributed generation programme, with limits based on the expected peak demand for a "typical DG programme participant" in the distributed generation programme, within recognized customer groups (residential, commercial, etc.).

3.2.1.2 Overall Programme Limits

In addition to legislative requirements that may limit the types of distributed generation programmes that can be implemented, overall capacity limits may also be put in place, capping participation in such programmes to a pre-determined level, whether in absolute (MW) terms or as a percentage of historic peak load or some other reference. Such limits may be put in place as a result of system planning processes conducted by the entity with responsibility for planning the electricity sector, or by some other process. System planning processes may include activities such as development of an Integrated Resource & Resiliency Plan, which typically, among other things, includes a schedule for addition and retirement of generation assets over the medium to long-term, and may include a capacity allocation for addition of distributed renewable energy facilities.

In setting such overall system capacity limits, a number of factors may be taken into account. These include:

i. Potential grid impacts of higher levels of distributed renewable energy penetration.
ii. The potential loss of utility revenue and the ability of the utility to recover the costs of investment in the grid.
iii. Cross-subsidization across rate classes.
iv. Depending on the compensation mechanism for excess energy sold to the grid, there may be over-subsidization of distributed renewable energy facilities, as installed systems costs continue to decrease.

Capacity limits set in consideration of the above factors, can be used as triggers for review of the programme and to determine whether any adjustments are warranted.

3.2.2 Average Demand of Expected DG Programme Participants

As indicated under section 3.2.1.1, individual system capacity limits applicable to DG programme participants can be set with reference to the participant's historic peak load. However, as described, also under section 3.2.1.1, this approach can have drawbacks. Instead, if absolute limits are set (possibly by defined customer groupings), consideration should be made for the average peak demand of programme participants. In making such a consideration, however, it has to be taken into account that the average peak demand for expected DG programme participants within defined customer groups is typically significantly higher than the average peak demand for the whole customer group. This is particularly true for residential customer groups, where DG programme participants are found in many jurisdictions to be wealthier than average customers with consequently higher peak demand values.

3.2.3 Allowances for Broad DG Programme Participation

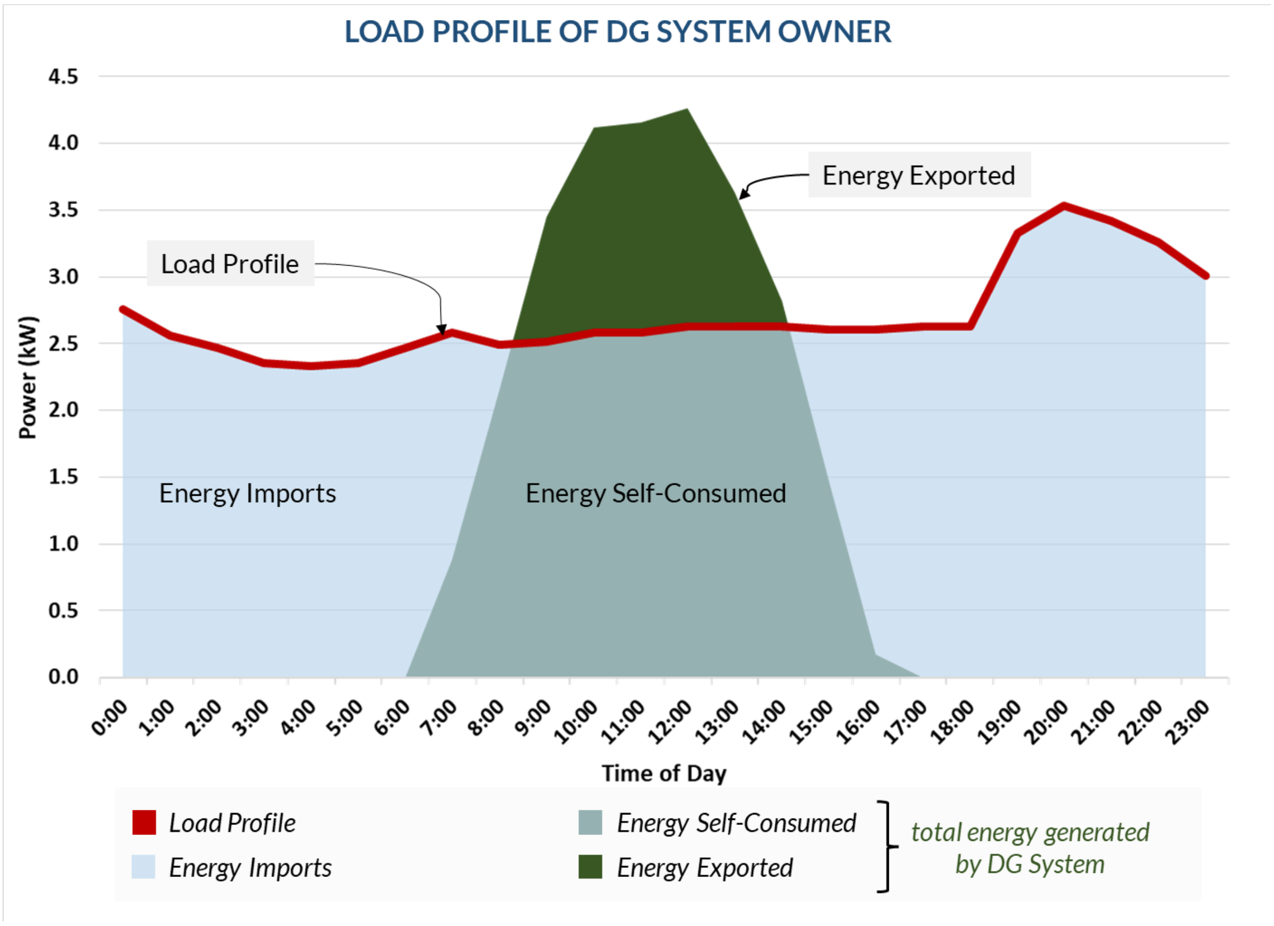
As previously indicated, renewable energy distributed generation programs are viewed by energy sector decision makers in many jurisdictions as one of several approaches forming part of their renewable energy transition strategy, helping in efforts to achieve renewable energy targets. Renewable energy DG programmes also allow for customers to have the opportunity to participate in the renewable energy transition and can be seen as an opportunity for customers to appreciably lower their electricity bills, particularly in jurisdictions with high electricity rates, such as the OECS region.

The ability to lower electricity bills may be seen as a major benefit by potential programme participants, and those with relatively high demand and the financial means may therefore seek to maximize their DG system capacity, within any established individual system capacity limits. As such, with higher individual system capacity limits, it is likely that the average DG system capacity will be higher, which may result in overall programme limits being reached in a shorter time, but with less electric utility customers being given the opportunity to participate in the DG programme. Process owners therefore have to be cognizant of this when setting individual system capacity limits, if one of their goals with a DG programme is to allow for broad customer participation in the programme.

3.3 Overview of Compensation Mechanisms for Energy Supplied to the Grid

Utility customers who participate in a distributed generation programme, with excess energy being sold to the grid are sometimes referred to as "prosumers". Such generators are one of two major classes of non-utility generators, with the other being independent power producers (IPPs). Unlike IPPs however, which are primarily in the business of electricity generation, often entering into long-term agreements for the sale of electricity to a utility or some other buyer, prosumers are utility customers who own power generation facilities that can satisfy a portion of their electricity demand. In instances where electricity demand exceeds generation, the prosumer purchases electricity from the utility, and in instances where generation exceeds electricity demand, the excess can be supplied to the utility's network. An example of the energy exchange that a prosumer may face during a typical day is illustrated in Figure 1 below, which shows periods of self-consumption, energy exports and energy imports.

Figure 1: Example of Typical DG System Owner Energy Exchange



As illustrated in Figure 1 above, DG system owners are at times supplying electricity to the grid, and at other times purchasing electricity from the grid. This creates issues with traditional metering and billing systems designed for unidirectional power flows. A number of different strategies have been put forward to account for the quantity of energy supplied to the grid, and that purchased from the grid by a prosumer, with some strategies more attractive to the prosumer, and some more attractive to the utility. In selecting an appropriate strategy, considerations have to be made on the technology/number of meters that are to be used, and the compensation methodology for any excess energy supplied to the grid by the prosumer. Policies and guidelines established to facilitate participation in a distributed generation programme therefore must be clear to all wishing to participate in the programme and should include what strategy is to be used to account for energy supplied and purchased by prosumers.

3.3.1 Billing Methodologies

Billing methodologies typically used in distributed generation programmes include the following:

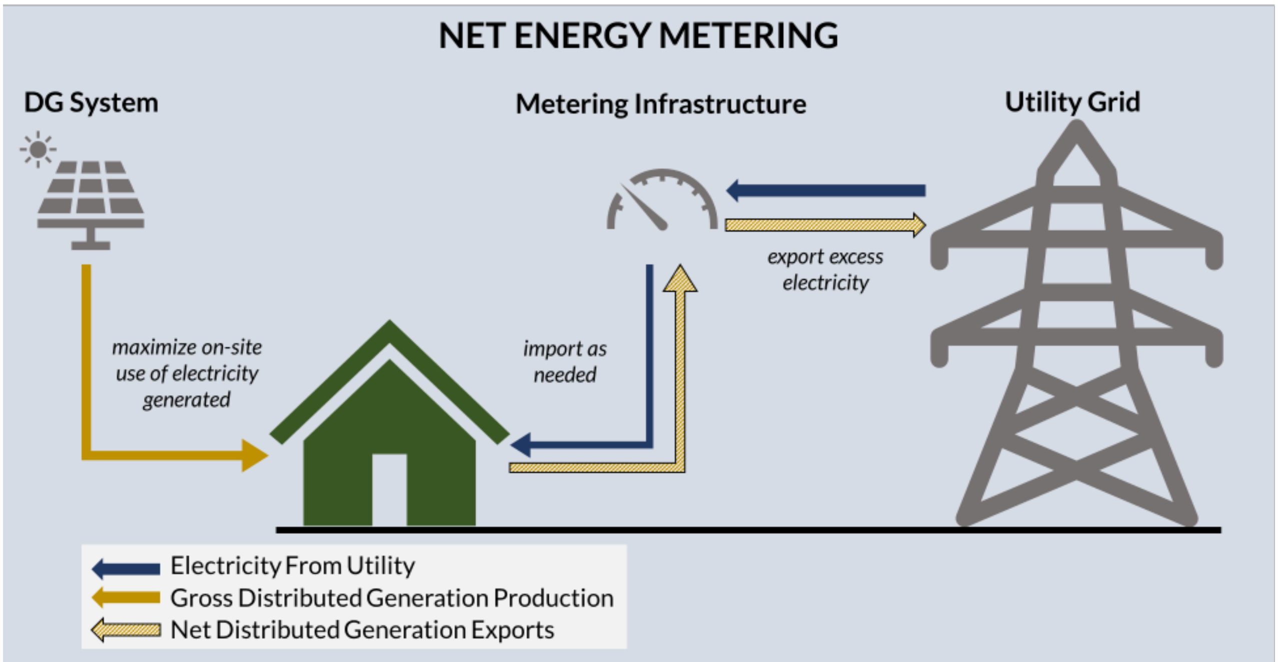
- Net energy metering;
- Net billing; and
- Gross metering.

These methodologies are described below.

3.3.1.1 Net Energy Metering

When utilizing the net energy metering methodology (also called net metering for short), excess electricity generated by the prosumer is exported to the grid and has the same price as the electricity supplied by the utility. Exported electricity is credited to the prosumer's account and subsequently adjusted against imports from the grid. Different metering configurations can be used to implement net metering, the most basic of which would be to utilize a meter which advances for electricity imports and reverses for electricity exports. However, it could also be implemented using two unidirectional meters or a bi-directional meter, which discretely records electricity flows in both directions. It should be noted that, while utilizing a metering configuration of two unidirectional meters or a single bi-directional meter have advantages over utilizing a meter that advances for electricity imports and reverses for electricity exports, these configurations will indicate electricity imported from the grid and not the total electricity used by the customer; and will separately indicate the electricity exported to the grid, not the total electricity generated by the prosumer's generation facility. A simplified illustration of a net-metering configuration is shown in Figure 2 below.

Figure 2: Illustration of Net-Metering Operation



A net metering arrangement is generally considered attractive by prosumers, when retail rates are higher than RE generation rates. Benefits of a net metering arrangement includes:

i. It is a relatively simple mechanism for both prosumers and utilities to understand and implement.
ii. It can easily be incorporated into existing electricity tariff structures.
iii. It can often make use of the existing metering technologies being used.

There are also, however, challenges with net metering arrangements. These include:

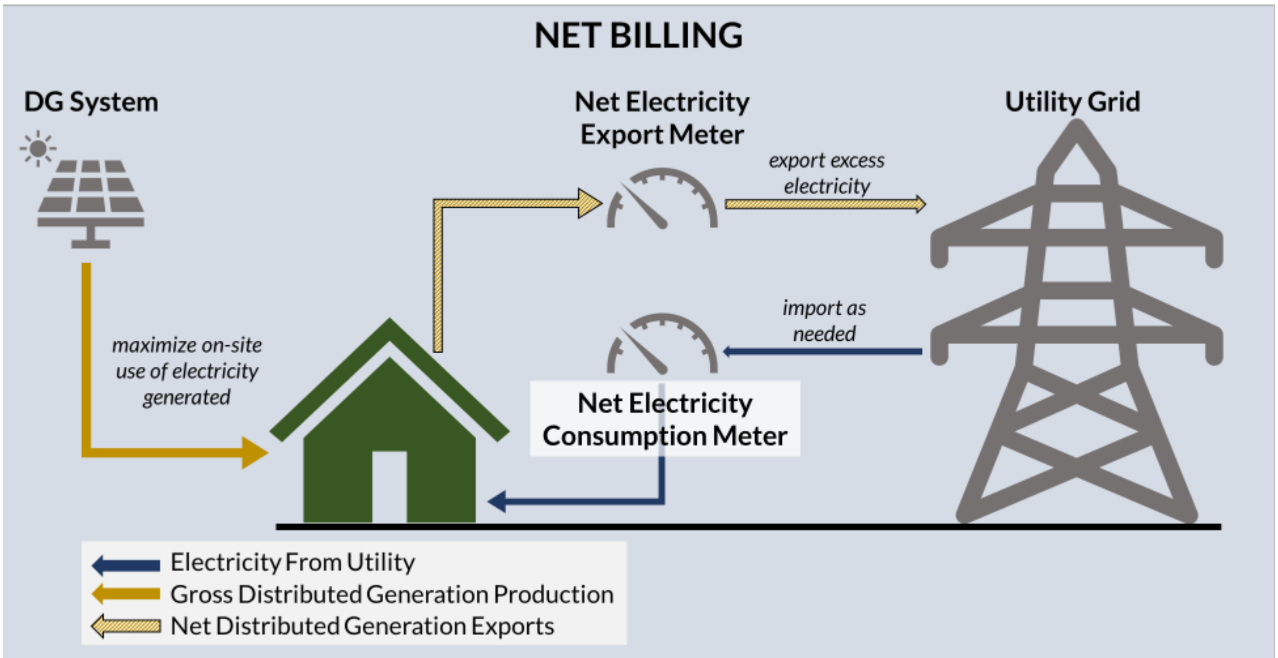
i. It is often considered an imprecise method for compensating excess generation, as the retail electricity rate may not reflect the value of the electricity supplied by the prosumer to the utility.
ii. As it requires self-consumption prior to export, net metering leads to reduced utility electricity sales.
iii. At higher levels of participation in DG programmes, utilities may experience revenue impairment issues if the retail rate paid for excess generation is higher than the actual value.
iv. Utility customers who do not participate in distributed generation programmes may experience increases in their electricity rates, if participation in the programme is sufficiently high.

3.3.1.2 Net Billing

The net billing methodology is similar to net energy metering in that the DG system owner can consume electricity generated from their DG system in real time and export any excess to the grid. The main difference between the two methodologies is that, for net billing, the rate the DG system owner receives for excess energy to the grid is different from the rate paid for energy consumed from the grid, therefore, metering systems that discretely record energy exported to the grid and energy consumed, have to be utilized.

Typically, when the net billing methodology is utilized, the rate received by the DG system owner for excess electricity supplied to the utility's grid is less than the retail rate. This is usually to take into account the utility's costs for transmission, distribution and other fixed costs. However, in some instances, based on policy decision, higher rates can be used for excess electricity supplied to the grid by DG system owners in order to incentivize and promote participation in renewable energy DG programmes. A simplified illustration of a net billing operation is shown in Figure 3 below.

Figure 3: Illustration of Net Billing Operation



Benefits of a net billing arrangement include:

i. It allows for a more precise approach to compensating DG system owners for electricity supplied to the grid, relative to net energy metering.
ii. If selling rates are set below retail rates, it encourages self-consumption.

In addition to the above benefits, net billing also has challenges. These include:

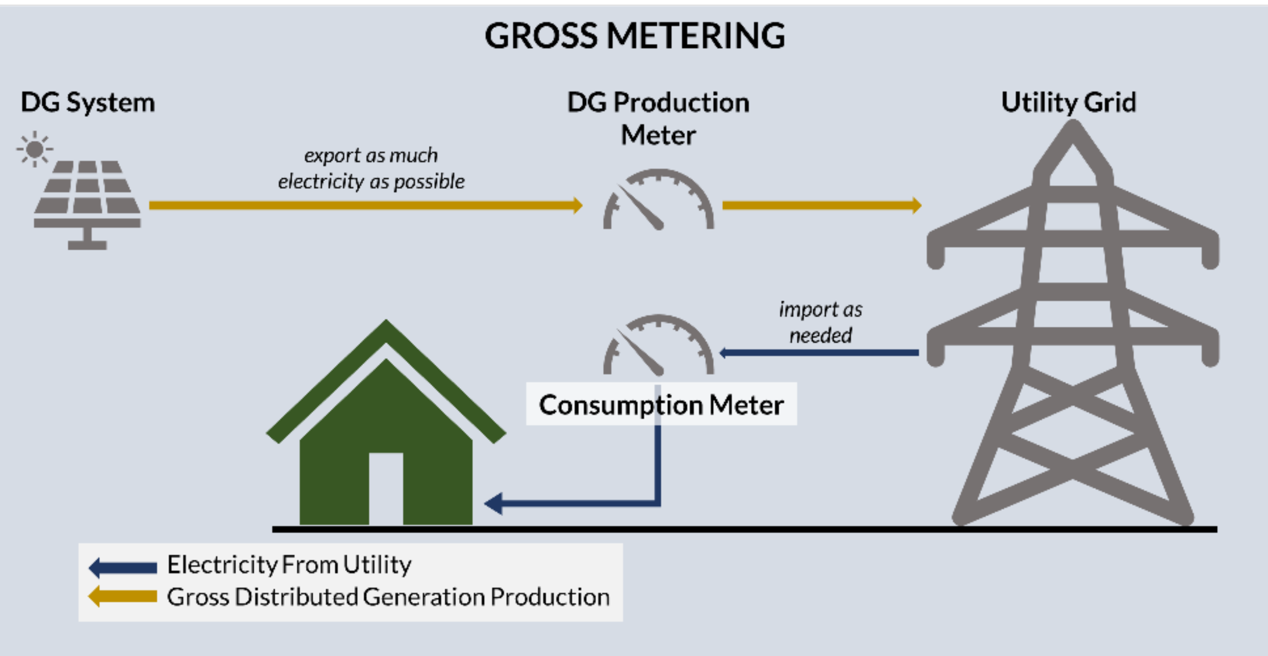
i. As with net energy metering, net billing requires self-consumption of electricity prior to export and can therefore lead to lost utility sales.
ii. Utilities may suffer revenue issues, if the rate paid to DG programme participants, for energy exported to the grid is higher than the retail rate for electricity. This challenge typically materializes as participation in such programmes increase.

3.3.1.3 Gross Metering

For the gross metering methodology, also called "buy all, sell all", grid connected DG systems generate and supply energy entirely to the grid, compensated at a standardized rate. In parallel, all consumption from the grid is separately metered and priced at the retail rate, independent of electricity generated by their DG system.

Unlike net energy metering and net billing, participants in a gross metering programme do not directly consume the electricity generated by their DG systems. Instead, the DG system exports all electricity to the grid which is compensated at a predetermined rate, through billing credits or cash. While rates used to compensate participants in a gross metering programme are typically a fixed volumetric rate, dynamic rates can also be applied. These dynamic rates may include time of day pricing schemes, or even more complex pricing schemes. The level at which the compensation rate is set will influence the value proposition for potential participants, which in turn impacts the level of customer participation. A simplified illustration of a gross metering operation is shown in Figure 4 below.

Figure 4: Illustration of Gross Metering Operation



Benefits of a gross metering arrangement include:

i. Considering the longer-term contracts typically associated with gross-metering arrangements, they provide a simple and predictable value proposition to both DG system owners and utilities, over the duration of the contract.
ii. From the perspective of the utility, gross metering arrangements do not change customer consumption patterns, and as such there is less of an incentive for utilities to attempt to recover costs through additional fixed charges. Cross subsidization issues are also minimized.

iii. Gross metering rates can be adjusted throughout the lifetime of a programme for new customers to steer the market towards a desired level of programme participation.

In addition to the benefits indicated above, gross metering programmes also have challenges. These include:

i. If the value of the electricity supplied by the RE DG systems is not well understood, customers participating in such a programme could potentially be over or undercompensated, potentially leading to shifting of cost burdens to some classes of customers.
ii. If gross metering rates are lower than the retail rate of electricity, which is a common practice, customers may be incentivized to illegally configure their DG system to self-consume electricity instead of exporting it all to the grid, potentially leading to the revenue issues associated with net energy metering arrangements.

3.3.2 Energy Pricing Methodologies

The three methodologies described under section 3.3.1 make allowances for DG system owners to be compensated for energy sold to the grid. As part of making a determination on which of the three methodologies is most appropriate, consideration has to be given to the value proposition of renewable energy distributed generation to the utility, ratepayers and to the society in general. Additionally, consideration has to be given to how compensation levels for energy supplied to the grid by DG system owners align with the value of renewable energy distributed generation to the utility and other rate payers. The net billing and gross metering methodologies, in particular, allow for more flexibility in determining compensation levels, since these methodologies allow for energy supplied to the grid by DG system owners to be priced differently to the retail electricity rate. Therefore, for these two methodologies, the process owner, in consultation with stakeholders, has to make a reasoned determination regarding compensation to DG system owners, including the methodology to be used to determine the appropriate level of compensation.

When making a determination on compensation levels for distributed renewable energy supplied to the grid, the impacts on the utility, and shifting of costs to some rate payers have to be assessed. Such assessments should take into account short and long-term perspectives, as the benefits of distributed renewable energy generation may not always be realized immediately. Short-term rate increases, for example, may be followed by longer term decreases through deferred or avoided generation investments, and other benefits.

In many instances, the value of distributed renewable energy is not well understood, and DG system owners may be overcompensated or undercompensated for energy sold to the grid. Overcompensation can exacerbate cost shifting to other ratepayers, and can, in some cases, accelerate participation in DG programmes, while under compensation can overburden DG system owners and hinder participation in DG programmes.

There are several methods that can be used to determine compensation levels for renewable energy DG programme participants. These include, among others, the following:

- A reference project approach; and
- An avoided cost approach.

These approaches are described below

3.3.2.1 Reference Project

This approach involves estimating the costs of incoming DG systems by applying the concepts of project evaluation, with projects evaluated according to the following characteristics:

i. Project technical characteristics – technology type, capacity factor, useful life, operation and maintenance costs, etc.
ii. Initial acquisition/investment costs

iii. Financing assumptions – cost of debt, return on equity, etc.
iv. General market data – inflation, tax rates, currency exchange rates, etc.

Based on this information, the cash flow of the project is then estimated. An advantage of this approach is that allows estimation of efficient compensation levels for renewable energy distributed generation by technology type, and therefore diversity in renewable energy technologies can be encouraged. One disadvantage, however, is that there may be information asymmetry between the process owner and project developers.

3.3.2.2 Avoided Costs

Avoided costs are typically considered in one of two ways: private avoided costs and social avoided costs. These are described below.

Private Avoided Costs

The private avoided costs approach estimates the avoided costs of incorporating renewable energy technologies into the electricity system versus a scenario where energy is solely provided by conventional technologies (typically fossil fuels). In other words, this approach examines the scenario where candidate plants are commissioned to satisfy growth in electricity demand and compares this to a scenario where these investments are deferred or avoided. There are differing approaches to calculating this value, however the intention is to provide a reference for pricing energy supplied by distributed renewable energy systems. A major advantage of this method is that it does not increase retail electricity rates. A negative aspect, however, is that it does not promote technology diversification.

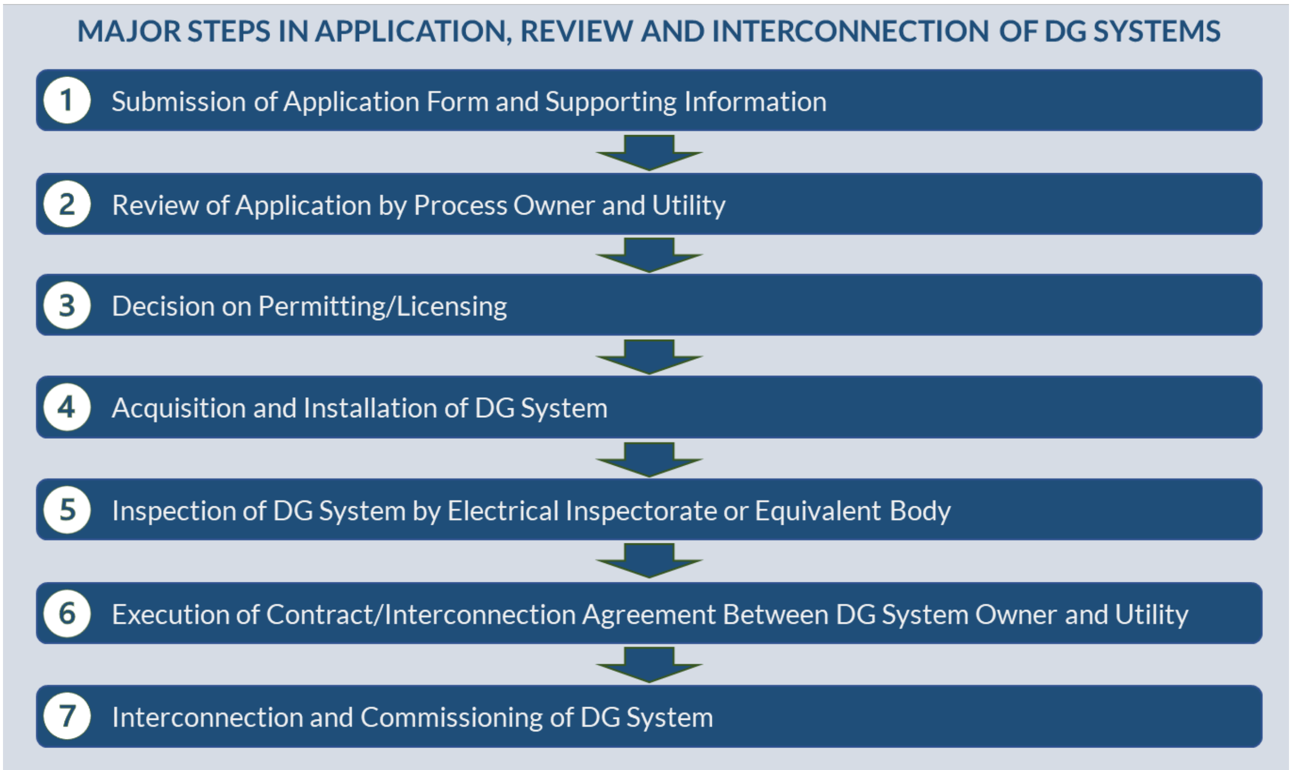
Social Avoided Costs

In addition to the approach described above, avoided costs can also be determined by considering external factors. These include impacts on the environment, social impacts and economic impacts such as foreign exchange savings and increased energy independence, in instances where fossil fuels are imported. Consideration of these externalities can be used as justification for increased compensation to distributed renewable energy facilities. However, while identifying externalities may not be complex, quantifying them can become strongly subjective, with estimates sometimes varying widely across evaluators.

3.4 Overview of Typical Application and Interconnection Process

The specific steps required for a DG system owner to interconnect and commission their renewable energy distributed generation system so that energy can be supplied to the utility's grid will depend on the overall electricity governance framework and on which entity is the process owner. Nevertheless, the major steps involved in application and interconnection procedures, where applications are received, reviewed, approval granted (or denied), and DG systems interconnected and commissioned typically include most or all those shown in Figure 5.

Figure 5: Flowchart Showing Major Steps in Application, Review and Interconnection of DG Systems



The major steps indicated in Figure 5 are described below.

3.4.1 Submission of Application Form and Supporting Information

In order to facilitate participation in a distributed generation programme being implemented, the process owner should have clear application procedures outlined and published, which set out a standardized approach and set of requirements, including and fees required to be paid, for potential DG programme participants (applicants) to submit an application to the process owner for consideration in granting approval for the proposed DG system to be interconnected to the grid. Such application procedures should also include indicative timelines for the respective steps.

In addition to publishing application procedures, the process owner should also make available an application form (in hard copy and/or electronic) which guides potential DG programme participants in submitting the information required for processing of the application. Such an application may also be accompanied by a checklist which indicates all supporting information to be submitted with the application form. The application form should also clearly indicate how the application should be submitted.

Application forms, as referenced above, should typically request the following:

1. Applicant identification details and proof of identity.
   - In cases where the applicant is a company, proof of incorporation may also be required.
2. Evidence that the applicant is a current customer of the utility.
   - This is usually provided by submitting recent utility bills.
3. Evidence of property ownership and permission from property owner (if not the applicant).
   - Property location should correspond to the utility account details.
4. Technical design drawings of the proposed DG system.
5. Technical specifications of the major components of the proposed DG system.
6. Test certificates for major system components demonstrating compliance with applicable local and international standards.
   - Applicable international standards could include UL 1703: Standard for Flat-Plate

Photovoltaic Modules and Panels and UL 1741: Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources. Additionally, the local standards body may also indicate specific standards that need to be complied with for DG system components.

7. Payment of an application processing fee.

3.4.1.1 Application Processing Fees

As indicated above, submission of an application for approval and interconnection of a renewable energy DG system normally requires fees to be paid. These usually include a processing fee required by the process owner. Different approaches can used to determine these fees; however, a simple approach is to determine processing fees based on the staff to be involved in the process, their daily rates and estimated time to be spent processing the application.

3.4.1.2 Application Processing Timelines

As indicated above, published procedures that set out the approach for the processing of applications for approval and interconnection of DG systems should include indicative processing timelines. The process owner should endeavour to adhere to indicated timelines, as in some jurisdictions extended processing timelines have been a source of discontent with potential DG programme participants and may even be a deterrent for participation in the programme.

3.4.2 Review of Application by Process Owner and Utility

Upon receiving an application for approval and interconnection of a DG system there are several steps the process owner would typically take. These include:

1. Ensuring that all required information has been submitted.
2. Checking to ensure the capacity of the proposed DG system is within individual system limits established. Additionally, the process owner should ensure that granting approval for the proposed DG system would not result in any overall programme capacity limits being violated.
3. Informing the applicant within a standard time that a properly completed application has been submitted or indicating to the applicant any issues that may need to be addressed before the application can be further processed.
4. If basic application requirements are satisfied, the application would then be subjected to a technical review to ensure the proposed DG system design would satisfy the utility's requirements for interconnection. This aspect of the review is often times performed by the utility itself, although the process owner (if not the utility) may also utilize the services of other qualified individuals to perform this review.

3.4.3 Decision on Permitting/Licensing

Based on the outcome of the review of the details of the application submitted, including review of the technical information, the process owner will decide on whether or not the proposed DG system is approved for construction/installation and interconnection to the grid. Such approval may be given by granting a permit or licence to the applicant. A permit or licence which would serve as the official authorization for the potential DG system owner to interconnect and operate the proposed DG system, is typically granted for a specific validity period (subject to renewal) and can often to come with a number of conditions, these include:

1. That a permit or licence fee be paid prior to issuance of the permit or licence.
2. That approvals for construction/installation of the proposed DG system be obtained from planning authorities, electrical inspection authorities, etc., as applicable.
3. That the proposed DG system be installed/constructed and interconnected within a specified timeframe.

3.4.4 Acquisition and Installation of DG System

As indicated above, a condition of a permit or licence granted is typically that the relevant DG system be installed and interconnected within a specified timeframe. As such, upon receiving the permit or licence, the applicant would then proceed to secure the necessary financing and install/construct the DG system within the specified timeframe.

3.4.5 Inspection of DG System by Electrical Inspectorate or Equivalent Body

Upon installation/construction of the DG system the applicant would apply to the electrical inspectorate, or equivalent body, for inspection and certification of the installed DG system. Upon inspection and testing the electrical inspectorate will normally issue a certificate of approval for interconnection of the DG system to the grid, if all the required standards are met.

3.4.6 Execution of Contract/Interconnection Agreement Between DG System Owner and Utility

Upon receipt of an electrical inspection certificate, and being granted any other required approvals, the applicant will then communicate with the process owner and/or utility, providing evidence that all required approvals have been obtained, and indicating intent to proceed with having their DG system interconnected to the utility's grid. The utility would typically then proceed with conducting any additional checks it may deem necessary and engage the DG system owner regarding executing any required interconnection agreement/contract governing the supply of electricity to the grid by the relevant DG system. Interconnection agreements/contracts would outline the terms of any compensation mechanism in place for energy supplied to the grid and would include conditions specific to the DG system owner, conditions specific to the utility and conditions applicable to both parties.

3.4.7 Interconnection and Commissioning of DG System

Upon execution of any required interconnection agreement/contract, the utility would then proceed to interconnect the DG system to the grid and undertake the required commissioning exercises. On conclusion of its commissioning exercises, the utility would then proceed to provide a commissioning report to the relevant stakeholders, including the process owner, which would provide all relevant details including the date the DG system is commissioned.

4 Summary of Major Considerations in Development of Renewable Energy DG Frameworks

The key guidelines and considerations in developing frameworks for interconnection of customer owned renewable energy distributed generation facilities, as identified by GGGI, have been described in section 3. These considerations are summarized below.

1. In developing renewable energy distributed generation frameworks, the existing electricity sector legislation has to be examined to see if it allows for power to be supplied to the grid by entities other than the incumbent electric utility, and specifically, if private individuals or entities are legally allowed to interconnect and export power generated by renewable energy facilities to the public grid. If this is not the case, electricity sector decision makers will need to carefully consider and propose to law makers any amendments that need to be made.

2. A key aspect of setting up a renewable energy distributed generation framework is determining indicative limits on the generating capacity of power generation systems that are approved for interconnection, subject to the allowances of the framework. Several considerations to be taken into account in setting such a limit include the following:
    a. Legislative or policy restrictions that apply to distributed generation facilities. These may include requirements that renewable energy distributed generation facilities be sized primarily for self-supply, and thus sized with reference to the applicable customer's demand; and restrictions on the aggregate capacity of renewable energy distributed generation systems that can be interconnected to the public grid.
    b. As described under section 3.2.1.1, there can be drawbacks to setting limits on individual DG system capacities that are based on each applicant's peak demand. Instead, it may be preferred that indicative limits are set based on defined customer groupings (e.g., domestic customer class, commercial customer class, etc.). In order to set such indicative limits, the process owner would be required to have a clear idea of the range of demand figures for typical DG programme participants, bearing in mind that DG programme participants tend to have electricity demand figures significantly higher than the average demand for the customer group.
    c. As indicated above in 2.a, there may be policy restrictions in place that limit the aggregate capacity for renewable energy distributed generation systems that may be interconnected to the grid. In the event that one of the process owner's aims in establishing a DG programme is to have broad customer participation, the process owner may have to consider aggregate capacity restrictions in setting capacity limits for individual systems, since higher individual system limits may lead to higher average installed system sizes, and consequently less participants in the DG programme.

3. Renewable energy DG programme participants can utilize power generation technologies such as solar PV or wind turbine generators to satisfy a portion of their electricity demand. Due to the intermittent nature of these technologies, the DG system may in some instances be supplying some of the participant's electricity needs, with the remainder being supplied by the grid, while in other instances the DG system may be generating more than the participant's needs, leaving potential for the excess energy to be supplied to the grid. This dynamic energy interchange may create issues with traditional metering and billing systems designed for unidirectional power flows. Several billing and metering methodologies, along with energy pricing methodologies, have been devised to handle these issues, which would need to be considered by the process owner in developing a renewable energy DG programme. Some of these methodologies are indicated below.
   a. Three billing methodologies which are typically used in renewable energy DG programmes are net energy metering, net billing and gross metering (also referred to as "buy-all, sell-all"). These are briefly described below.
      - Net Energy Metering – The DG programme participant utilizes as much of the energy generated by the DG system as possible, with any excess energy generated being supplied to the grid. The DG programme participant is compensated at retail electricity rates for energy supplied to the grid.
      - Net Billing – Similar to net energy metering in that the DG programme participant can consume electricity generated from the DG system in real time and export any excess to the grid. The main difference is that, for net billing, the rate that the DG programme participant receives for excess energy supplied to the grid is different from the retail electricity rate. It therefore requires metering systems capable of discretely measuring electricity exports to the grid and electricity imports from the utility.
      - Gross Metering – Energy generated by the DG system is supplied in entirety to the grid, with the DG programme participant compensated at a standardized rate. In parallel, all the participant's electricity demand is supplied by the utility, is separately metered, and priced at the retail electricity rate.
   b. Of the three (3) billing methodologies described above, net billing and gross metering allow for energy supplied to the grid to be priced differently to the retail electricity rate. As such, if the process owner determines that one of these two (2) billing methodologies will be incorporated into a renewable DG programme being developed, an appropriate energy pricing system has to be included to compensate DG programme participants for energy supplied to the grid. Several methods can be used to determine compensation levels, including those described below.
      - Reference Project Approach – Involves estimating the costs of incoming renewable energy DG systems by applying the concepts of project evaluation, taking into account technical characteristics, acquisition/investment costs, financing assumptions, general market data, among other things.
      - Avoided Costs Approach – This can be categorized in two ways: private avoided costs and social avoided costs. The private avoided costs approach estimates the avoided costs of incorporating renewable energy technologies into the electricity system versus a scenario where electricity is solely supplied by conventional technologies. As it pertains to social avoided costs, external factors are included in making determinations on avoided costs. These include impacts on the environment, social impacts and economic impacts such as foreign exchange savings and increased energy independence.

4. With all the above considerations taken into account, it is necessary for DG programme process owners to outline and publish clear procedures so that interested individuals and entities have a clear understanding of the requirements to be met when submitting an application to the process owner for consideration in granting approval to participate in an established DG programme. Such application procedures should clearly indicate any required fees and provide indicative timelines for processing of applications. Process owners should endeavour to adhere to indicated timelines, as in some jurisdictions extended processing timelines have been a source of discontent with potential DG programme participants and may even be a deterrent for participation in the programme.

5 Conclusions

OECS territories, in general, have set ambitious renewable energy targets, as expressed in their respective Nationally Determined Contributions (NDC) documents submitted to the UNFCCC, as well as their most recent national energy policy documents. Achieving such targets requires multiple kinds of interventions, including increasing the use of distributed renewable energy power generation. Facilitating increased use of renewable energy distributed generation facilities, particularly by private individuals and entities, requires the enabling legal and regulatory structure to be in place including a clear framework which outlines the requirements to be satisfied for interconnection of distributed generation facilities. Developing such a framework requires several considerations to be made. These include, among other things, the following:

- The legal and regulatory framework in place including policy decisions pertaining to renewable energy distributed generation programmes.
- Capacity restrictions on individual systems.
- Billing mechanisms to account for energy exported to the grid.
- Methodologies for pricing energy exported to the grid.

As indicated in sections 1 and 2 of this document, a number of OECS territories have existing frameworks in place to facilitate interconnection of renewable energy distributed generation facilities with the public grid. However, some territories do not have existing frameworks, or have inadequate frameworks in place. In light of this, GGGI has developed a set of guidelines, as presented in section 3 and summarized in section 4 of this document, to provide guidance to regional electricity sector decision makers in developing or improving their own frameworks for integration of renewable energy distributed generation power generation facilities in electricity networks across the OECS region.

Guidelines presented in this document, as indicated, are of a general nature and are only intended to provide guidance in developing or improving country-specific frameworks. As there are differences in the legal and regulatory framework governing the electricity sector across OECS territories, it is expected that specific frameworks set up in the respective territories may have their own peculiarities.

GGGI understands that some territories in the OECS region require direct assistance in developing or improving their specific renewable energy distributed generation frameworks and has already embarked on providing such direct and targeted assistance. It is expected that these interventions will assist territories in achieving their renewable energy targets.

Appendices

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