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APPROACHES TO REGULATING DISTRIBUTED GENERATION IN CENTRAL AMERICA

SUPPORT FOR NATIONAL ENERGY REGULATORS UNDER THE ENR-NARUC
CENTRAL AMERICA ENERGY REGULATORY PARTNERSHIP



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National
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List of Acronyms or Abbreviations

ARESEP	The Regulatory Authority of Public Services of Costa Rica (<i>La Autoridad Reguladora de los Servicios Públicos</i>)
ASEP	The National Public Services Authority of Panama (<i>La Autoridad Nacional de los Servicios Públicos</i>)
CNE	The National Energy Council of El Salvador (<i>Consejo Nacional de Energía</i>)
CNEE	The National Electricity Commission of Guatemala (<i>Comisión Nacional de Energía Eléctrica</i>)
CREE	The Regulatory Electricity Commission of Honduras (<i>Comisión Reguladora de Energía Eléctrica</i>)
DG	Distributed Generation
ENR/PSP	U.S. State Department, Bureau of Energy Resources, Power Sector Program
EV	Electric Vehicles
kW	Kilowatts
MER	Regional Electricity Market (<i>Mercado Eléctrico Regional</i>)
MW	Megawatt
NARUC	National Association of Regulatory Utility Commissioners
PUC	Public Utility Commission
RE	Renewable Energy
REM	Retail Electricity Market
ROBCP	Regulations for the Operation of the Transmission System and the Wholesale Market based on Production Costs (El Salvador)
SIGET	The General Superintendency of Electricity and Telecommunications of El Salvador (<i>General Superintendencia of Electricity and Telecommunications</i>)
ToU	Time of Use
WEM	Wholesale Electricity Market

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- The General Superintendency of Electricity and Telecommunications of El Salvador (SIGET)
- The National Electric Energy Commission of Guatemala (CNEE)
- The Regulatory Commission for Electric Energy of Honduras (CREE)
- The National Public Services Authority of Panama (ASEP)

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I. Executive Summary

On November 17, 2021, NARUC held a peer review with over 40 regulators from Costa Rica, El Salvador, Guatemala, Honduras, and Panama. Regulators from the United States and Argentina reviewed Honduras and El Salvador's Distributed Generation (DG) regulations and recommended ways to strengthen them. As a result of the peer review, the CREE/Honduras revised its framework to include NARUC's recommendations in March 2022. The revised *Technical Standard for Residential and Commercial User – Self Producers of Honduras* is pending official approval. SIGET/El Salvador also plans to update its DG framework based on the peer review, though its timeline for doing so has not been made official.

As for the recommendations, the U.S. experts highlighted the need to clearly delineate responsibility between users and distribution companies. Moreover, the experts suggested that the CREE consider (i) provisions for smaller users, including the use of simple meters that spin backwards; (ii) a “fast-track” approval process; (iii) a dispute resolution process; (iv) penalties for failure to meet requirements of the *Standard*; and (v) ensuring consistency between each article of the regulation.

DG will play an important role in increasing grid reliability and energy security through the use of geographically dispersed, smaller scale renewable energy resources. Thus, NARUC has produced this regional report for Central American regulators to further promote leading practices on DG and encourage a harmonized approach. Harmonizing DG regulations in the region will require developing technical and economic regulations for the participation of the DG in the national wholesale electricity markets (WEMs) and in the regional electricity market (MER), establishing:

- Minimum technical requirements for the connection and operation of the DG, including minimum installed capacity, interconnection rules, telemetric (automatic measurement and data transmission) requirements and forecasts about electricity injection into the national or regional transmission system, performance against frequency deviations, etc.
- An obligation to comply with all or some of the ancillary services requirements, depending on the provisions of the *Regulations for the Operation of the Transmission System and the Wholesale Market based on Production Costs (ROBCP of El Salvador)* and the *Regulations for the Regional Electricity Market (RMER)*
- Specifications that the injection or withdrawal of electricity from DG will have the same treatment as electricity injection or withdrawal from market participants connected at the national or regional transmission level

2. Introduction

With support from ENR/PSP, NARUC has engaged in a regional partnership with national energy regulators from Costa Rica, El Salvador, Guatemala, Honduras, and Panama as well as the regional grid operator (Ente Operador Regional) and regional regulator (Comisión Regional de Interconexión Eléctrica) in Central America since 2018. This partnership promotes regional electricity integration and clean energy deployment through building understanding and consensus on cross-cutting issues, with a focus on promoting regulatory frameworks to incentivize clean energy. NARUC's assistance is designed to support opening electricity markets and reduce barriers to power trade and development by strengthening regulatory frameworks in the region to improve governance and transparency in the power sector.

Distributed generation is the term used when electricity is generated from sources, often renewable energy sources, near the point of use instead of centralized generation sources from power plants.¹ Central American countries have been assessing the role of DG in reaching a range of energy sector goals, including reducing the cost of electricity, enhancing competitiveness and economic growth, increasing the security of energy supply, reducing system losses, and optimizing the development of generation capacity. DG is set to play an important role in increasing grid reliability using geographically dispersed, small-scale renewable energy (RE) resources.

Energy officials in the region are continually considering methodologies to evaluate the net economic benefits of deploying DG to achieve these objectives. Different countries in the region are at various stages of DG deployment based on their existing regulatory frameworks and sector and country development objectives. Several regulators have expressed concern about potentially overloading distribution infrastructure if injected DG capacity exceeds or overwhelms technical limits. In response, U.S. regulatory experts have offered recommendations for how to address these concerns.

The purpose of this report is to provide a high-level overview of the current objectives, challenges, and considered solutions related to DG development in the national and regional contexts of the five Central American countries that take part in the ENR-NARUC Central America Regulatory Partnership. It also outlines high-level regional priorities in further promoting DG in Central America and the relevant DG experience of U.S. regulators. Using this information, readers can learn about how to best harmonize approaches to DG development with a focus on facilitating RE integration and improving the resiliency of national and regional grids. The report is intended to be shared among the Central American partners to inform their decision making and help them to consider different approaches to implementing regulatory frameworks for DG.

NARUC collected the information included in this report from the five participating national regulators in preparation for, during, and following a virtual ENR-NARUC peer review on DG that was held in November 2021 and included a technical peer review of Honduran and El Salvadoran DG regulations. This peer review was part of a larger ENR/PSP effort to support Central American regulators in strengthening their oversight of the electricity sector as they progress toward regional integration. It built on previous NARUC and ENR/PSP engagements with Central American regulators and regional discussions exploring introductory topics related to DG, including the benefits of RE in diversifying power supply.

NARUC experts peer reviewed a draft regulation shared by the CREE/Honduras titled *Technical Standard for Residential and Commercial Autoproducer Users* and an existing regulation shared by SIGET/El Salvador titled *Standard for End Users Producing Electrical Energy with Renewable Resources*. Following the peer review, the CREE finalized its DG regulation in March 2022 and confirmed that it

¹ "Renewable Energy: Distributed Generation Policies and Programs." U.S. Department of Energy. <https://www.energy.gov/eere/spsc/renewable-energy-distributed-generation-policies-and-programs#:~:text=Distributed%20generation%20is%20the%20term,generation%20sources%20from%20power%20plants>

incorporated comments and suggestions received from NARUC. In addition, the CREE prepared a report noting how and where they incorporated comments from NARUC and other stakeholders.

While differences in current DG regulations in individual countries reflect specific country and power sector conditions, an effort to harmonize relevant DG regulations in the region will be of critical importance to establishing coordination between the dispatch of DG and the generation of the WEMs in individual countries, as well as with the MER. In this regard, harmonizing DG regulations will further enable the potential establishment of a distribution system operator to ensure coordination with national and regional market operators in operating and managing the DG electricity supply to the distribution systems.

The countries use different terms (users, self-producers, prosumers) which, generally, have a similar meaning of residential, commercial, and industrial users who produce and consume a portion of their own electricity needs and who may sell excess generated electricity back to utilities (see examples of such terms in the table below). We have chosen to use one single term in this report – “users self-producers” – to facilitate easier reading and understanding of the topics under discussion.

Table 1: Definitions of Users of Distributed Energy Resources by Countries and Regulators

Country and Regulator	Spanish	English
Costa Rica - ARESEP	Productor-consumidor con un sistema de generación distribuida para autoconsumo con fuentes renovables ²	Producer-consumer (prosumer) with a system for DG with renewable sources
El Salvador - SIGET	Usuarios finales productores de energía eléctrica con recursos renovables ³	End-users producers of electric energy with renewable resources
Guatemala - CNEE	Usuarios autoproductores con excedentes de energía ⁴	Users self-producers with energy surpluses
Honduras - CREE	Usuarios Autoproductores Residenciales y Comerciales ⁵	Residential and commercial users-self producers
Panama - ASEP	Clientes de las empresas de distribución eléctrica con autoconsumo con fuentes nuevas renovables y limpias ⁶	Clients of the electricity distribution companies with self-consumption with new renewable and clean sources

² “Decreto N° 39220-MINAE: Reglamento generación distribuida para autoconsumo con fuentes renovables: modelo de contratación medición neta sencilla.” Sistema Costarricense de Información Jurídica. http://www.pgrweb.go.cr/scij/Busqueda/Normativa/Normas/nrm_texto_completo.aspx?param1=NRTC&nValor1=1&nValor2=80310&nValor3=101897¶m2=1&strTipM=TC&IResultado=3&strSim=simp

³ “Norma Para Usuarios Finales Productores de Energía Eléctrica Con Recursos Renovables Anexo I del Acuerdo No.367-E-2017.” Superintendencia General de Electricidad y Telecomunicaciones. https://www.siget.gob.sv/wp-content/plugins/download-manager/viewer/viewer.php?dl=https://www.siget.gob.sv/wp-content/uploads/download-manager-files/Norma%20UPR_ANEXO%20%20DE%20ACUERDO%20367-E-2017.pdf

⁴ “Compendio de Normas Técnicas emitidas por la Comisión Nacional de Energía Eléctrica.” Comisión Nacional de Energía Eléctrica República de Guatemala. C.A. <https://www.cnee.gob.gt/estudioselectricos/Normas%20Técnicas/Recopilacion%20normas%20tecnicas%20CNEE.pdf>

⁵ “Norma Técnica de Usuarios Autoproductores Residenciales y Comerciales.” Comisión Reguladora de Energía Eléctrica. <https://www.cree.gob.hn/wp-content/uploads/2019/02/Propuesta-de-Norma-T%C3%A9cnica-de-Usuarios-Autoproductores-Residenciales-y-Comerciales.pdf>

⁶ “Procedimiento para Autoconsumo con Fuentes Nuevas, Renovables y Limpias.” Autoridad Nacional de los Servicios Públicos. https://www.asep.gob.pa/wp-content/uploads/COVER_2018/Autoconsumo_Renovables_Limpias/procedimiento_centrales_limpas_2017.pdf

3. Overview of National Goals, Challenges, and Considered Solutions Related to DG Regulation in Central America

This section provides an overview of the national goals, challenges, and considered solutions related to DG regulation in each of the five countries participating in the ENR-NARUC-Central America Regulatory Partnership. National regulators provided the information below to NARUC in October 2021 as well as during the technical peer review in November 2021.

A. Costa Rica – Public Services Regulatory Authority (ARESEP)



DG-Related Goals

- Add value to the power system in terms of resilience, stability, and efficiency through DG development
- Improve governance and regulation with a focus on integrating new technologies to materialize key DG benefits, including:
 - Alleviating peak load
 - Reducing investment needs in remote zones
 - Improving power system resiliency
 - Optimizing the use of resources and reducing power system costs

Challenges

- Reverse power flows from DG power plants to the distribution network affect voltage stability and the performance of consumers' electric appliances.
- Existing regulatory instruments need to be updated, and new ones must be designed as required by Law 10086⁷ on *Promotion and Regulation of Distributed Energy Resources from Renewable Sources*.

Considered Solutions

- Define the capacity of DG in consideration of circuit capacity and the related ability to carry surplus exchanges (between the user self-producer and the distribution company)
- Develop clear rules of interaction between users self-producers and distribution companies in terms of (i) load limits per circuit and (ii) network access requirements
- ARESEP is currently developing and updating regulatory instruments required by Law 10086 and is open to receiving donor support (note: ENR's Power Sector

⁷ Law 10086 was passed in January 2022 and is a revised version of Law 22.009.

	Program is providing advisory support on the law's implementation).
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Electricity generation in Costa Rica is 99.7% renewable. Therefore, in contrast to other countries in the region, the incorporation of DG does not necessarily have the objective of adding green generation to the system.

Challenges and Considered Solutions

As of January 2022, Law 10086 on the *Promotion and Regulation of Distributed Energy Resources from Renewable Sources* was approved in Costa Rica. The new law substantially improves the legal framework related to DG by stipulating the development of regulatory measures related to:

- Tariffs
- Technical requirements and procedures for integrating DG
- Instruments for integrating maximum small-scale capacity in the national power system
- Instruments for calculating the penetration capacity of DG in the national power system
- Informational requirements for DG
- A system for dispute resolution between DG users self-producers and distribution companies

ARESEP is currently developing and updating regulatory instruments required by Law 22.009, passed in October 2021, which will address the tariffs as well as technical requirements and procedures for distributed energy resources from renewable sources, among others. ARESEP noted that it is open to receiving donor support to assist in developing and updating regulatory instruments to ensure alignment with the Law and policy goals for DG, which ENR's Power Sector Program is providing through another activity.

ARESEP pursues regulatory measures that focus on the following key areas of critical importance for DG development:

- Balancing the output of DG with the needs of the National Power System by applying time-of-use (ToU) tariffs and a complete net billing system (i.e., reducing the electricity bill of the self-producing owner of DG, after a cost-benefit analysis by the distribution operator to determine the economic compensation for the energy surplus supplied to the distribution network)
- Applying network access and interconnection fees in accordance with total consumption and network capacity requirements⁸
- Defining the capacity of DG in consideration of circuit capacity and the related ability to carry surplus exchanges (between the user self-producer and the distribution company)
- Developing clear rules of interaction between users self-producers and distribution companies in terms of (i) load limits per circuit and (ii) network access requirements

⁸ Total consumption = total electricity consumption from all sources of power generation available in Costa Rica

The above measures are meant to address, among other things, the mitigation of the negative impact of reverse flows in the distribution networks on the quality of electricity supply caused by DG.

B. El Salvador – General Superintendence of Electricity and Telecommunications (SIGET)



DG-Related Goals

- Diversify the country's energy mix with RE
- Reduce dependence on oil and its derivatives
- Enhance regulation to enable taking full advantage of DG benefits
 - Meet the demand of individual consumers through arrangements for DG users self-producers
 - Regulate DG to balance the national electrical system, cutting out reverse flows to transmission networks
 - Update the current DG regulatory framework considering new technologies in the electricity market

Challenges	Considered Solutions
Concentrated DG reverse flows affect power system stability.	- Use new technologies such as energy storage, smart meters, and smart grids to improve load management and support the growing use of electric vehicles (EV). - Promote the implementation of energy management systems. - Update regulation of the WEM and the retail electricity market (REM) to reduce impact of reverse flows.
DG connected to the distribution grid in the REM can participate in the WEM and cause curtailment of generators participating in the WEM.	Harmonize the regulation of the WEM and the REM.
Create a regulation for DG to solve relevant situations that have affected the WEM and the REM in the last years.	Create a regulation for DG that includes guidelines for building new projects and operation of new and current DG capacities that minimize the negative effects on the national electrical system.

Challenges and Considered Solutions

Since 2010, the development of DG projects has grown significantly. As of June 2021, a total of 606 projects have been identified (e.g., photovoltaic, hydroelectric, thermal, biogas, and biomass technology) with a total capacity of 327.72 MW.⁹ The development of electricity generation from the use of RE resources has been driven by both the public and private sectors of El Salvador, with the aim of achieving compliance with the strategic guideline for *Diversification of the Energy Matrix and Promotion of Renewable Energy Sources* contained in the *Energy Policy of El Salvador 2010–2024* developed by the CNE.

In El Salvador, the electricity market is organized by a WEM and a REM. The latter is comprised of DG connected to the distribution network. The *National Energy Policy 2010-2024* of El Salvador enables end-users to install generation units from RE sources to meet their own demand. The strategy further allows DG owners – users self-producers with renewable sources of energy – under temporary and exceptional conditions and for short periods of time, to inject surplus DG energy into the electricity distribution network without commercial purposes.

This means DG owners cannot be paid directly and instead accumulate payment credits used to discount bills for electricity received from the distribution company. In addition to RE users self-producers connected to the distribution network, thermal power plants are also connected to the distribution network as distributed generators that can participate in the WEM.

SIGET is posed to adjust the regulatory framework to address the following challenges related to DG:

- Reverse flows from large concentrations of DG around circuits of low voltage (defined as below 115 kilovolts in El Salvador), related to certain substations, impact the power system's stability. In this regard, the use of energy management systems with new efficient technologies such as energy storage, smart meters, and smart grids must be enabled to improve load management and support the growing use of EV. Keeping these challenges in mind, at SIGET's request and as part of the ENR-NARUC peer review on DG held in November 2021, NARUC experts reviewed the current *Standard for End Users Producing Electrical Energy with Renewable Resources*¹⁰ and provided recommendations to improve the current system. Key recommendations from the peer review are presented in Annex III of this report.
- The rules of the two markets (the REM and the WEM) need to be harmonized so that the interaction between them brings maximum benefits and prevents inefficiencies. At present, all DG power plants participating in the REM can also participate in the WEM and can thus cause curtailment of RE generation within the WEM. In this regard, the regulation of the WEM and the REM must be harmonized to prevent such curtailments.

Addressing these challenges will require significant capacity building for personnel from different relevant governmental and academic entities.

⁹ Source: SIGET – El Salvador's General Superintendence of Electricity and Telecommunications

¹⁰ The *Standard for End Users Producing Electrical Energy with Renewable Resources* is one of the many other regulations about DG. SIGET is working to update this standard to allow measures reducing reverse flows from DG users self-producers in the network.

C. Guatemala – National Electricity Commission (CNEE)



DG-Related Goals

- Continue to promote self-sufficiency in energy consumption through RE, including DG
- Generate 80% of Guatemala's total energy supply from renewable sources by 2027

Challenges	Considered Solutions
• DG development implies new options for energy sales that are outside the WEM framework. The CNEE must prevent the creation of barriers to market entry for new DG technologies.	• The CNEE must develop up-to-date analytical tools and train personnel to maintain technical rigor when analyzing increasingly complex and specialized challenges related to increasing the penetration of RE.
• An excessive supply of surplus energy to the distribution network may: ○ Create difficulties in managing further increases in surplus energy supplied to the network beyond the current levels ○ Increase network losses beyond an acceptable level as a tariff component ○ Set reverse energy flows in the network with varying quality ○ Create the need for additional network upgrades	• The CNEE is developing a guide to define the demand for users-self producers to limit the amount users can inject into the network and mitigate further excessive energy injections into the network.

Challenges and Considered Solutions

In 2008, Guatemala allowed the introduction of DG from RE sources, which has resulted in a high and controlled development of DG to date. This process was facilitated by increased access to the distribution network, which was ensured by Article 16 of the Regulation under the General Electricity Law of Guatemala, stipulating that “the distribution companies are obligated to allow connections to their facilities and necessary modifications and expansions to enable the functioning of renewable distributed generators.”

The CNEE's *Technical Standard for Renewable DG and Users-Self Producers with Energy Surplus* of 2008 (updated in 2014) defined renewable generators as: renewable distributed generators with a generation capacity of five MW or less from renewable energy resources connected to the distribution network with the possibility to participate in WEM transactions and bid for contracts to supply electricity to distribution companies.

In addition, the same *Technical Standard* provided a definition of users-self producers with energy surpluses (beyond their individual demand). Key elements of the CNEE's *Standard for Renewable DG and Users-Self Producers with Energy Surplus* are outlined in Annex I.

Key challenges to the development of DG are due to high levels of penetration and related impacts on the power system in terms of:

- Increasing losses beyond a level at which they can be recovered through tariffs
- Varying quality of power flows when the power flows are reversed (from DG units to the distribution company versus the power flow from the distribution company to the end-consumers)
- The need to prevent barriers to market entry when:
 - Introducing new DG technologies
 - Setting new market options for DG that are different from wholesale market practices

To address these challenges, the CNEE must have up-to-date analytical tools and trained personnel to maintain the required technical rigor when analyzing increasingly complex and specialized challenges related to the increasing penetration of DG based on RE. In addition, some users-self producers install generating capacity far beyond their individual demand because there is no limit in installing such capacity.

Renewable distributed generators have a capacity limit of five MW. This results in excessive energy surpluses injected into the network, triggering the need for additional network upgrades by the distribution company and creating difficulties for the distribution company in handling the increasing volumes of electricity supplied by DG. In this regard, the CNEE is developing a guide to define the demand of users-self producers to mitigate further excessive energy injections into the network.

D. Honduras – Regulatory Electricity Commission (CREE)



DG-Related Goals

- Develop a regulatory framework that guarantees access to electricity in a safe and sustainable way
- Support the implementation of DG in isolated systems in the country
- Diversify the electricity generation matrix and mitigate deficit in power supply by integrating DG from RE resources
- Decentralize electricity supply to reduce losses in the electricity grid
- Ensure adequate planning of the distribution network to enable DG integration

Challenges	Considered Solutions
• There is a lack of regulations that define critical aspects of DG.	• Adopt regulations related to: ○ Creating a methodology for calculating the tariff for the surplus energy supplied to the distribution network by users-self producers ○ Determining allowed DG installed capacity ○ Using energy storage jointly with DG ○ Providing criteria and procedures that guarantee DG's operational safety and compliance with applicable quality standards
• There is a need to develop a national regulatory framework in accordance with the provisions of Central American regional regulation.	• The CREE could develop mechanisms to consistently review its national regulatory framework with the aim of harmonizing it with regulations adopted by other countries in the region.
• There is a lack of policies and financial mechanisms within the framework of the <i>General Law of the Electricity Industry</i> that encourage the development of DG from RE sources.	• Strengthen the regulatory framework to promote investment in distribution and transmission networks • Develop regulations for generation equipment that inject surplus energy from users-self producers into the network • Ensure adequate planning of distribution networks that enable DG integration

• There is a lack of mechanisms for mitigating possible negative impacts as a result of integrating DG into electricity networks.	• Establish mechanisms for mitigating possible negative impacts as a result of integrating DG into electricity networks • Strengthen the CREE's regulatory framework to ensure adequate application of the <i>General Law of the Electricity Industry</i> and the integration of DG into the electricity grid
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To achieve its goals, the CREE has prepared the following regulations related to DG:

- *Technical Standard for Distributed Generation*¹¹
- *Technical Standard for Residential and Commercial (Electricity) Users-Self Producers*

During the November 2021 technical workshop, NARUC experts peer reviewed the *Technical Standard for Residential and Commercial (Electricity) Users-Self Producers* and provided recommendations on how to strengthen it. The CREE incorporated NARUC's comments and suggestions into the final regulation, which was adopted in May 2022 (see Annex II).

Challenges and Considered Solutions

The electricity system of Honduras is facing challenges related to weak networks with very high technical and non-technical losses. Total distribution losses are around 35%. The system is also characterized by a deficit in electricity supply. In this context, DG is envisioned to mitigate the deficit in electricity supply and benefit from the significant solar energy potential in Honduras. Approved in 2014, the *General Electricity Industry Law* stipulates the creation of institutions vested with powers to set policies, develop regulations, operate the national interconnected system, and administer the WEM. In addition, the *Law* prescribes the separation of the activities in the electricity sector. However, it has not been fully implemented, which has led to challenges for DG development in the country caused by a lack of enabling policies and financial mechanisms for DG within the *General Electricity Industry Law*.

The CREE has also outlined challenges with introducing the national regulatory framework in accordance with the provisions of regional regulations, as well as with defining criteria for the analysis and mitigation of uncertainty and variability caused by the integration of DG from RE sources. The adoption of the following regulations is considered necessary by the CREE to cover the current regulatory gaps related to DG:

- A methodology for calculating the tariff for the excess electricity supplied to the network by users self-producers
- A regulation that defines the allowed installed capacity of DG
- A regulation concerning the use of energy storage jointly with DG
- Criteria and procedures that guarantee the operational safety and compliance of DG with applicable quality standards

¹¹ A final version of this standard remains to be prepared and has not been submitted yet to public consultation.

E. Panama – National Public Services Authority (ASEP)



DG-Related Goals

- Enable consumers to satisfy their own electricity consumption through the installation of DG equipment that uses renewable sources of energy with the option to sell the electricity surplus.

Challenges	Considered Solutions
• There is no technical assessment of the impact of DG on the network.	A public contracting process has been carried out for a consultancy that evaluated the technical and tariff impacts of incorporating distributed generation to the distribution network. For this purpose, the total capacity currently installed will be considered, which is 62 MW.

DG-Related Goals

ASEP's current DG objective is to enable customers to satisfy their own electricity consumption through the installation of DG equipment that uses renewable sources of energy with the option to sell the electricity surplus. This objective is advancing at the national level with support from the Ministry of Energy of Panama.

Challenges and Considered Solutions

Capacity Differentiation

DG connections need to take the technical limitations of reaching customers at various physical points of the network into consideration. Under the current regulations, the DG owner provides the investment required to strengthen the network to enable the specific DG connections. DG connections are subject to different regulatory requirements based on their capacity:

- DG facilities with an installed capacity of less than 500 kilowatts (kW) are regulated by the Standard for Electrical Installations.
- DG facilities with installed capacity between 500kW and 2,500kW are regulated through the following norms and mechanisms:
 - *Standard for Electrical Installations*
 - Remote supervision by the distribution company
 - Remote supervision by the National Dispatch Center through the distribution company related to the DG facility, in terms of variability of capacity (kW) and energy (megawatt hours) consumed and supplied to the network

- Control by the distribution company through a remote disconnect switch
- DG facilities with an installed capacity of greater than 2,500kW are regulated through the following:
 - *Standard for Electrical Installations*
 - Grid code for solar and wind power generation plants, except for metering, which is covered by the *Standard for Distributed Generation*
 - Operational rules for security, supervision, and control (for power plants based on RE sources other than solar and wind)

Controlled Penetration of DG

The level of DG penetration is limited to 10% of total demand (measured in MW) and 2% of total maximum annual electricity consumption (measured in gigawatt hours). ASEP reviews the level of DG penetration every three years.

Metering and Interconnections

The rights and responsibilities of the distribution company and the owner of the DG power plant, users self-producers, are defined by an interconnection agreement signed between the two parties. As part of the arrangement, a user-self producer is also required to install a bi-directional meter at their own expense to measure electricity consumption and supply through the distribution network. Under the interconnection contract, credits for electricity supply to the grid are reimbursed to the users self-producer semi-annually within a threshold of 25% of the total historical supply of electricity to the grid.

Access to the WEM

Users self-producers are prevented from accessing the WEM and selling directly to other consumers or third parties. More specifically, users self-producers may not participate in the hourly market for trading energy and capacity surpluses or the contract market (medium- and long-term contracts for energy and capacity) within the WEM. Furthermore, they are not allowed to sell energy to third parties, nor split their supply into different accounts for related properties. However, these restrictions do not apply to larger DG power plants (2,500 kW), which are allowed to access the WEM.

4. The Need to Harmonize DG Regulation Across the Region

Central American governments have established national energy policies goals related to the promotion of RE and reduction of carbon dioxide emissions. Within the broad range of actions toward achieving these goals, important changes have been made and continue to be made in national regulatory frameworks to incentivize investments in small-scale RE projects for individual consumption, or renewable DG.

However, the increased penetration of DG is affecting the stability and reliability of the related distribution networks as well as the demand/supply balance in the power markets. By reviewing and adapting existing regulatory frameworks, the regulators in the region could (i) ensure the required stability and reliability of the distribution networks, and (ii) balance the growth of DG in consideration of the actual demand and capacity of the related power systems. Therefore, it is important that countries in the region collaborate to achieve these goals by exchanging good practices and harmonizing standards and other regulations in consideration of their national contexts.

Developing symmetries among national DG regulations will be critical to establishing coordination between the dispatch of DG and the generation of the WEMs in individual countries, as well as with the MER. Harmonizing DG regulations will further enable the potential establishment of a distribution system operator to ensure coordination with national and regional market operators in operating and managing the DG electricity supply to the distribution systems.

NARUC also recommends that regulators analyze ways to harmonize DG regulations with regulations for installing and operating smart grids, advanced metering infrastructure, and small-scale energy storage systems along with regulations enhancing operations of wholesale markets accessible to DG.

The Diverse Goals of DG Development Reflect Country-Specific Priorities and a Broad Range of DG Benefits

Countries across Central America define the goals of DG development in relation to diversifying the energy mix and increasing the share of RE, reducing dependence on oil imports for power generation, improving access to electricity and meeting growing electricity demand, decentralizing energy supply and reducing power system losses and costs, enhancing energy self-sufficiency, alleviating peak load, optimizing the use of energy resources, and reducing the cost of power supply.

DG Legislation, Standards, and Definitions Vary Across the Region

Guatemala, Honduras, and Panama have specific standards dedicated to DG by users self-producers (for their own use). In El Salvador, there are three regulations related to renewable DG, including end-users producing electricity from RE sources (i.e., self-generation for their own use). In January 2022, the new Law 10086 on the *Promotion and Regulation of Distributed Energy Resources from Renewable Sources* was approved in Costa Rica. The regulatory instruments required by Law 10086 are being developed and will enhance the current standard for DG based on RE for self-consumption.

DG regulations vary across the region in relation to procedures, legal and technical requirements for connecting DG to the distribution network, monitoring and regulating the level of DG penetration, methods of defining permissible installed DG capacity, arrangements for selling surplus DG energy to the grid, and crediting such surpluses to discount bills for electricity supplied from the network to users self-producers. In a similar way, the actual definition of DG varies in relation with (i) the level of capacity considered as DG, (ii) differentiating between end-users and users self-producers using RE sources of energy for own consumption, and (iii) accessing DG within national WEMs and the MER.

Harmonizing DG Legislation, Standards, and Definitions will Enhance Interoperability for National and Regional Electricity Markets

At present, DG supply of electricity to distribution companies reduces the amount of electricity that the distribution companies purchase through the national WEMs and the MER. This scenario is

aggravated during days of naturally low demand (e.g., weekends or holidays) and all days around noon when the photovoltaic distributed generation output is at its peak. During such times, the electricity supply may exceed demand, which subsequently leads to the need for reducing the baseload generation to the extent possible or curtailing renewable generators in the WEM.

In view of the above, it would also be useful to develop mechanisms to consistently review national regulatory frameworks with the aim of harmonizing them with regulations from other countries in the region. Harmonizing DG regulations in the region will require developing technical and economic regulations for the participation of the DG in the national WEMs and in the MER, establishing:

- Minimum technical requirements for the connection and operation of the DG, including minimum installed capacity, interconnection rules, telemetric (automatic measurement and data transmission) requirements and forecasts about electricity injection into the national or regional transmission system, performance against frequency deviations, etc.
- An obligation to comply with all or some of the ancillary services requirements, depending on the provisions of the *Regulations for the Operation of the Transmission System and the Wholesale Market based on Production Costs (ROBCP of El Salvador)* and the *Regulations for the Regional Electricity Market (RMER)*
- Specifications that the injection or withdrawal of electricity from DG will have the same treatment as electricity injection or withdrawal from market participants connected at the national or regional transmission level

Controlled Growth of DG Coupled with Grid Enhancement Measures Can Mitigate the Negative Impact of Excessive DG Electricity Supply

Excessive electricity supply from DG to the distribution network results in reverse power flows, which affect the stability of the grid. Excessive concentration of DG at a given section of the network can be prevented through (i) adequately defining allowed installed DG capacity in consideration of related demand and circuit capacity, (ii) establishing and monitoring certain levels of DG penetration as a share of total installed capacity and total annual electricity consumption within a power system, and (iii) providing higher prices for DG surplus energy to incentivize DG expansion and vice versa, reducing and even discontinuing payments for DG energy surplus to prevent DG expansion.

Clearly defining required due diligence and interconnection rules for DG along with responsibilities for grid enhancements to accommodate new DG capacity can also help prevent the installation of excessive DG capacity. Combining DG with energy storage and ensuring that the distribution company has the ability to disconnect a DG plant when there is excess power in the system are important methods of mitigating the intermittency of DG based on RE sources (solar and wind in particular) and its impact on network stability and reliability. Introducing smart grid technology can enhance grid reliability, and interconnection and fixed charges for DG can contribute to financing grid modernization.

Enhancing and harmonizing current DG standards and other related regulations along with building regulators' capacity to perform technical and policy analysis are critical success factors for the practical implementation of the above measures.

5. Highlights from the U.S. Regulatory Experience with DG

Analyzing U.S. DG regulatory frameworks may also help to provide solutions for Central American regulators to consider. Regulatory commissions in the United States seek to revise and adapt DG regulations to varying approaches to DG-related cost recovery, generation assets valuation, compensation (in relation to solar energy in particular), and net metering impact on utilities' revenue. Revising DG regulations has proved to be a complex and prolonged process, but helpful examples have arisen in relation to diversifying energy supply, ensuring the safety of operations, improving transparency in grid access, engaging public in regulatory proceedings, and applying dispute resolution mechanisms.

Compensation for DG Surplus

On occasion, regulatory commissions may increase compensation for energy surplus from DG when demand for such surplus increases, and reversely, reduce compensation when the regulator decides to disincentivize DG when it cannot be absorbed by the network. In this context, cross-subsidization of users self-producers may occur since such compensation is not based on cost, but on a legislative decision in consideration of achieving a certain target of renewable generation. In response to this development, state regulatory commissions hold periodic reviews of the amount and cost of energy consumed to evaluate costs and benefits linked to cross-subsidization. For example, Florida holds annual reviews of the needs of the regulated utilities in the state.

A number of states are taking varying paths to define compensation for DG surplus energy through changes in DG regulation. For example, Arizona, Indiana, and Louisiana are considering avoided costs by the distribution company as a basis to value injected energy in the distribution network, while California is using ToU rates. Virginia is countering the impact of net metering reducing utilities' revenue by introducing a compensatory fixed charge in the net metering tariff for users self-producers. This fixed charge must be paid to cover grid-related costs even if the users self-producers do not purchase energy from the distribution company and the energy component of their electricity bill may be zero.

Interconnection Rules

Florida provides a good example of explicitly formulating its Interconnection Rule with objectives to (i) promote the development of small customer-owned renewable generation, particularly solar and wind systems; (ii) diversify the types of fuel used to generate electricity, (iii) lessen dependence on fossil fuels, and (iv) minimize the volatility of fuel costs. Florida and Virginia also provide other examples of sound approaches to enabling DG interconnection through increasing the rigor and robustness of related studies, design reviews, and testing. In addition, Florida's application process for interconnection ensures exemplary transparency by issuing written notices to the applicants confirming receipt of their applications and performing physical inspections of their customer-owned DG facilities within established timelines. Florida's standard requirements for interconnections are typical for most U.S. states. Florida also applies a provision for conflict resolution that is suitable for consideration by the Central American regulators.

Liability Insurance

Some states had included a requirement in their DG regulations for DG owners to acquire liability insurance to cover potential damages to distribution networks caused by injecting surplus DG energy. Given the fact that the utilities/distribution companies already have their own insurance for their facilities, including their distribution networks, the additional insurance requirement by the regulators has become an entry barrier for DG. Therefore, liability insurance requirements by regulators have been subsequently repealed. As an example, in the above context, In Florida, a Commissioner has raised the possibility of repealing the current requirement for users-self producers to maintain a general liability insurance for personal and property damage to a third party for \$1 million and \$2 million respectively for Tier 2 and Tier 3 generation facilities.

ANNEX I: Key Elements of Guatemala's Technical Standard for Renewable Distributed Generation and Users-Self Producers with Energy Surplus

DG Definition

Guatemala's *Technical Standard for Renewable DG and Users-Self Producers with Energy Surplus* of 2008 (updated in 2014) provides the following definitions. Distributed generators are defined only as renewable distributed generators:

- Having generation capacity of less than five MW from renewable energy sources to be used to supply power to the market and not for owner consumption
- Connected to the distribution network with access to the WEM
- Having the ability to sell energy to other actors in the market and bid for contracts with distribution companies

Users-self producers with energy surpluses are defined as a sub-group of all users purchasing power from the distribution companies, injecting energy surpluses from renewable sources of generation located at their facilities into the distribution system for own consumption. Users-self producers do not receive remuneration for the surplus of energy supplied to the distribution system. Instead, such surpluses account for a credit toward reducing the bill of the user self-producer for electricity purchased from the distribution company. Any user-self producer can inform the distribution company that they want to supply their surplus of renewable energy to the distribution system in accordance with the above definition for users-self producers. The distribution company then carries out a mandatory technical inspection of the facility. Upon a positive outcome of the inspection, it installs a bi-directional meter at the new facility within a period not longer than 28 days upon receipt of the user-self producer's notification.¹²

Network Connections and Access to Markets

Renewable distributed generators can connect to the distribution network upon agreeing to perform required actions to maintain network stability as defined by a study commissioned by the distribution company. The General Electricity Law also guarantees access of renewable distributed generators to the national WEM. At the same time, it allows distribution companies to sign contracts with the renewable distributed generators through a bidding process. Furthermore, renewable distributed generators can sell part or all of their output to one or more traders (or large users) and can also sell electricity to the MER or to Mexico through international transactions in compliance with available regulations. The users-self producers are responsible for not damaging or affecting the performance of the distribution network. Therefore, they must install a protection system preventing users self-producers from injecting electricity into the network when (i) the voltage of the distribution network is outside the established acceptable range, or (ii) the characteristics of the electricity supplied by the user self-producer to the network are outside an acceptable range. The regulator is responsible for verifying that the new connection is compliant with the standard requirements.

Network Charges and Credits for Supplied Electricity

Renewable distributed generators are exempt from paying a charge for using the distribution network as they supply power in a "reverse flow" directed to the distribution company. The "reverse flow" is considered insignificant in comparison with the main predominant and opposite flow from the distribution company to end consumers, which then entails a payment of network charges.

¹² See Article 28 of the Guatemalan Standard for Renewable Distributed Generation and Users-Self Producers with Energy Surplus, 2008, 2014 update

ANNEX II: Key Peer Review Recommendations on the *Technical Standard for Residential and Commercial User – Self Producers of Honduras*

In November 2021, NARUC convened a virtual regulatory workshop with energy regulators and operators from Central American countries in which U.S. regulatory experts performed a detailed review of Honduras' regulations regarding DG, including the *Technical Standard for Residential and Commercial User – Self Producers of Honduras*. The U.S. experts then offered the following recommendations for consideration, which the Honduran regulator (the CREE) ultimately adopted in March 2022. The regulation is pending official approval.

As for the recommendations, the U.S. experts highlighted the need to clearly delineate responsibility between users and distribution companies. Moreover, the experts suggested that the CREE consider (i) provisions for smaller users, including the use of simple meters that spin backwards; (ii) a “fast-track” approval process; (iii) a dispute resolution process; (iv) penalties for failure to meet requirements of the *Standard*; and (v) ensure consistency between each article of the regulation.

Connections to the Distribution Network

- Clearly delineate responsibility between users and distribution companies
- Clarify the value ranges of low, medium, and high voltage mentioned in the *Standard*
- Grant users more than five business days to correct any inconsistencies in their connection applications, especially in the case of residential users
- Stipulate clearly that an approval of an application to connect to the network is granted only with an explicit communication from the distribution company and lack of response implies denial and not approval

Net Metering

- Extend the opportunity for users self-producers to sell surplus energy to the network beyond “exceptional occasions and for a limited time.” Limiting the opportunity to sell surplus energy through the network disincentivizes DG development. However, this arrangement may lead to the need to strengthen and expand network capacity. Therefore, a decision should be made in consideration of the specific demand-supply situation in the country and the network conditions.
- Set obligations for the distributions companies to buy all the surplus energy injected by the users-self producers to enhance incentives for DG

Metering

- Consider provisions for smaller users, allowing:
 - The use of simple meters that spin backwards
 - A “fast-track” approval process for applications to connect DG to the network
 - Incorporation of additional minimum characteristics of bi-directional metering equipment; otherwise, the characteristics of the bi-directional meters provided by different suppliers could complicate the meter readings and potentially impact future demand forecasts
 - Consideration of the convenience of allowing the user to supply the bi-directional meter according to minimum established characteristics

Demand and Allowed DG Capacity

- Consider seasonal variations that could impact average monthly consumption when analyzing demand
- Define the size of allowable energy storage systems since storage may result in total generation capacity to be greater than demand
- Provide justification for the five MW DG system cap

Taxation

- Consider the following two alternatives for establishing the tax base (the monetary value subject to taxes) and select the most advantageous one:
 - One alternative is to apply tax to the total bill for electricity submitted by the distribution company to a user self-producer and then reduce the amount of the bill, including taxes, by the amount of credit earned by the user self-producer for supplying energy surplus to the distribution company.
 - The second alternative is to discount the electricity bill to users-self producers by the amount of credits they have earned for supplying energy to the network and only then apply the tax to the reduced/discounted amount of the bill.

Dispute Resolution and Penalties for Non-Compliance

- Include provisions for (i) a dispute resolution process and (ii) penalties for the DG owner for failure to meet the requirements of the *Standard*
- Establish penalties to be imposed on the distribution company in instances where it fails to meet the timelines, procedures, or process requirements contained in the *Standard*

Useful Regulations Originally Included in the *Standard*

- A requirement that distribution companies provide updated information about the distribution system (including a study to analyze current distribution flows) as well as conduct a pre-feasibility analysis, which would help to proactively identify any concerns relating to individual DG systems

ANNEX III: Recommendations for updating SIGET's *Standard for End Users Producing Electrical Energy with Renewable Resources*

During the virtual ENR-NARUC peer review on DG held in November 2021, NARUC reviewed SIGET's *Standard* and shared relevant experience and insights for its consideration. In addition, regional participants provided insights and comments in relation to the *Standard* with arrangements related to (i) demand management; (ii) use of energy storage; (iii) managing incentives; (iv) ToU tariffs; (v) connection and fixed charges for grid modernization; and (vi) safety. SIGET intends to update its *Standard* with NARUC's recommendations and does not currently have a timeline in place for making these updates.

Demand Management

In response to the increased penetration of DG in the state of Vermont, incentives were put into place by law/the legislature, and signed by the Governor, which increase demand for electricity from DG by requiring utilities to incentivize users to shift activities such as cooking, water, and space heating to using electricity instead of gas and oil. Vermont legislature has also encouraged the use of EVs and DG-based electric charging stations. The Vermont PUC is adjudicating the programs that encourage EVs to make sure utilities are doing so according to the law and at least cost.

Use of Energy Storage

SIGET could also consider encouraging the use of storage to manage the DG surplus energy supplied to the grid and thereby increase the power system's resilience to outages. This approach could be combined with ensuring control over DG storage use by the distribution company to facilitate feeding some of the stored energy into the grid during times of peak demand, which would help to avoid using additional fossil fuel power plants at that time.

Managing Incentives

When DG penetration reaches a level at which DG reverse flows in the network can impact network stability, the utility could eliminate the credits/payments for supplying surplus DG energy to the network. This measure could eliminate incentives for installing additional DG capacity beyond desired levels.

ToU Tariffs

Low tariffs for solar power during the day and higher tariffs at times of peak demand later in the day would provide incentives for storing solar energy during the day when demand is low and releasing it later in the day to the grid during peak load.

Grid Modernization Financing

Grid modernization is important for counterbalancing the destabilizing impact of DG reverse flows on the grid. In this regard, SIGET could consider setting up DG interconnection charges and fixed charges for DG at an appropriate level, which could be further invested in grid upgrades.

Safety Measures

Panama's experience with indicating the location of the disconnecting switch in the country's DG *Standard* is an approach that could be considered by other countries as well.

ANNEX IV: List of DG Regulations

Country/ Regulator	Does the country have specific DG regulations	Name of the regulation (Spanish)	Name of the regulation (English)
Costa Rica (ARESEP)	Yes	Ley N° 10086 “Promoción y regulación de recursos energéticos distribuidos a partir de fuentes renovables” (Regulatory instruments have been drafted and are pending.) Decreto N° 39220-MINAE: Reglamento generación distribuida para autoconsumo con fuentes renovables: modelo de contratación medición neta sencilla	Promotion and Regulation of Distributed Energy Resources from Renewable Sources Regulation of Distributed Generation for Self-Consumption with Renewable Sources: Contracting Model for Simple Net Metering
El Salvador (SIGET)	Yes	Normativa Técnica para Caracterizar los Proyectos que aprovechan las Fuentes Renovables en la Generación de Energía Eléctrica. Acuerdo No. 162-E-2012 Norma Para Usuarios Finales Productores de Energía Eléctrica Con Recursos Renovables Anexo I del Acuerdo No.367-E-2017 Norma Sobre Procesos de Libre Concurrencia Para Contratos de Largo Plazo Respalados con Generación Distribuida Renovable, Anexo I Acuerdo No.120-E-2013	Technical Standards to Define Projects Using Renewable Energy for Generation of Electricity. Agreement No. 162-E-2012 Standards for End-Users Producers of Electricity with Renewable Energy Resources. Annex I, Agreement No.367-E-2017 Rules for Competitive Bidding for Long-Term Contracts Supported by Renewable Distributed Generation, Annex I, Agreement No.120-E-2013
Guatemala (CNEE)	Yes	Norma Técnica para la Conexión, Operación, Control y Comercialización de la Generación Distribuida Renovable – NTGDR– y Usuarios Autoprodutores con Excedentes de Energía Normas Técnicas del Servicio de Distribución –NTSD Normas Técnicas de Diseño y Operación de las Instalaciones de Distribución –NTDOID	Technical Standard for Connections, Operations, Control and Marketing of Renewable Distributed Energy – NTDR- and Users- Self Producers with Energy Surpluses Technical Standard for Distribution – NTSD Technical Standard for Design and Operation of Network Facilities
Honduras (CREE)	Yes	Norma Técnica de Usuarios Autoprodutores Residenciales y Comerciales (2019) (official adoption of 2022 is pending)	Technical Standard for Residential and Commercial Users- Self Producers (official adoption of 2022 is pending)
Panama (ASEP)	Yes	Procedimiento para Autoconsumo con Fuentes Nuevas, Renovables y Limpias	Procedure for Self-consumption with New, Clean Renewable Sources

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