CLEAN ENERGY
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RENEWABLE ENERGY PROCUREMENT GUIDEBOOK FOR COLOMBIA

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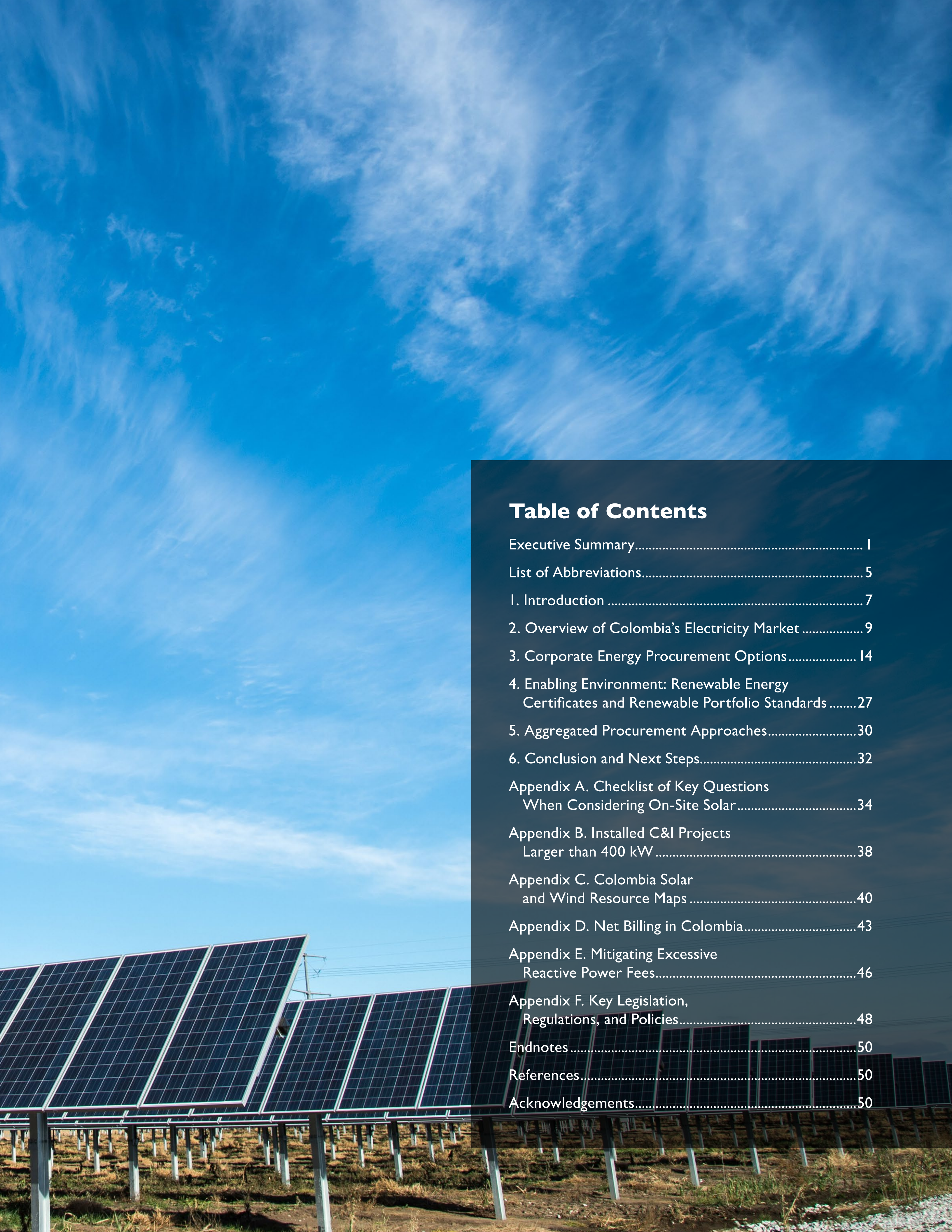


Table of Contents

EXECUTIVE SUMMARY

Highlights

- Over the past decade, Colombia's national government has introduced policies to encourage renewable energy deployment and investment throughout the country.
- National policies, along with the declining cost of renewable energy technologies, have opened significant opportunities for commercial and industrial customers in the country to procure renewable energy and save money on their electricity expenses.
- Across the country, leading corporations have started investing in cost-saving renewable energy procurement solutions.
- This guidebook outlines three primary procurement options currently available in Colombia for commercial and industrial customers interested in renewable energy: on-site turnkey purchases; on-site third-party power purchase agreements or leases; and off-site third-party power purchase agreements.
- Each of these three options has unique features and relevance to different types of customers. This guidebook provides additional context and details to help prospective renewable energy consumers assess which model best fits their needs and gain a better understanding of how to move forward with renewable energy procurement for their facilities in Colombia.

Context

Globally, there is a growing movement among commercial and industrial customers to shift their energy consumption to cleaner sources. More than 240 companies across the world have pledged to transition to 100 percent renewable electricity in the coming years (RE100 n.d.). In Colombia, commercial and industrial customers have started to explore available cost-saving renewable energy solutions but have not yet unlocked deployment at scale.

This guidebook is a knowledge product from the Clean Energy Investment Accelerator (CEIA), an innovative public-private partnership initiative that addresses barriers to scaling the deployment of clean energy solutions for commercial and industrial consumers in emerging markets. CEIA is jointly led by World Resources Institute (WRI), Allotrope Partners, and the U.S. National Renewable Energy Laboratory (NREL). CEIA aims to explore solutions for procuring renewable energy by helping purchasers overcome clean energy barriers, strengthening the local policy enabling environment, and unlocking a pipeline of private sector clean energy projects.

In Colombia, CEIA partners with public and private sector stakeholders to support the country in achieving its renewable energy goals. CEIA works with developers, service providers, and policymakers to develop and implement new renewable energy procurement solutions that can provide commercial and industrial customers with renewable energy at cost-competitive rates and encourage market growth.

There are three options available to commercial and industrial customers in Colombia to procure renewable energy:

1. **On-Site Turnkey Purchases:**[1] The customer purchases a renewable energy system up-front, which is installed on the customer's site. The customer operates and maintains the system.
2. **On-Site Third-Party Power Purchase Agreements or Leases:** A vendor provides financing, operates and maintains the renewable energy system installed at the customer's site, and sells the customer electricity by the kilowatt-hour.
3. **Off-Site Third-Party Power Purchase Agreements:** A vendor provides financing, operates and maintains the renewable energy system located outside the customer's site, and sells the customer electricity by the kilowatt-hour.

CEIA identified and validated the three available renewable energy procurement options through policy analysis, extensive stakeholder engagement, interviews with renewable energy experts in Colombia, and facilitation of the country's first aggregated on-site solar procurement processes for multiple companies.

This guidebook provides an overview of the procurement options, underlying policies and regulations, key considerations related to each option, and steps needed to move forward with each option. While the options outlined in this publication are not limited to a certain renewable generation technology, this publication primarily focuses on solar photovoltaic procurement options given the technology's accessibility in the market and attractive economics for commercial and industrial customers in Colombia.

LIST OF ABBREVIATIONS

ANDI	Asociación Nacional de Empresarios de Colombia; National Industrial Association of Colombia
Bolsa	Bolsa de energía; MEM’s wholesale spot market
CEIA	Clean Energy Investment Accelerator
C&I	commercial and industrial
CREG	Comisión de Regulación de Energía y Gas; Energy and Gas Regulatory Commission
distco	distribution company
genco	generation company
GWh	Gigawatt-hour
kVAr	kilo volt-amps reactive
kVarh	kilo volt-amp reactive hours
kW	kilowatt
kWh	kilowatt-hour
MEM	Mercado de Energía Mayorista; Wholesale Electricity Market
MME	Ministerio de Minas y Energía; Ministry of Energy and Mines
MW	megawatt
MWh	megawatt-hour
NREL	U.S. National Renewable Energy Laboratory
O&M	operations and maintenance
PPA	power purchase agreement
PV	photovoltaic
RE	renewable energy
REC	Renewable Energy Certificate
RFP	request for proposals
RPS	Renewable Portfolio Standard
transco	transmission company
UPME	Unidad de Planeación Minero Energética; Mining and Energy Planning Unit
WRI	World Resources Institute

1. INTRODUCTION

Colombia's clean energy market is rapidly evolving. Recent regulatory reforms, emerging renewable energy (RE) procurement options, and a growing ecosystem of established project developers are creating new opportunities for electricity consumers. Commercial and industrial (C&I) customers in Colombia often pay high and volatile prices for their electricity in part because the country still depends on hydropower for an average of more than 75 percent of generation annually (BloombergNEF 2019). In years with extreme dry seasons (a phenomenon also called El Niño), high spikes in pricing are a major burden for most of those customers. However, they now have the potential to secure cost savings and meet their sustainability goals through RE procurement, specifically solar photovoltaic (PV) and wind generation. **Market data in 2018 and 2019 show that solar companies in Colombia can provide C&I customers with on-site generation at significantly lower rates than current grid prices, offering cost savings in the range of 20 percent depending on a customer's unique circumstances**.[2] Yet, it can be challenging for companies to navigate the landscape of available purchasing options and to access the tools and expertise to move forward with the procurement option that best fits their needs. This guidebook serves as a resource for C&I customers seeking to understand their RE options in Colombia, drawing upon market studies, industry data, and first-hand experience in the Colombian RE procurement sector. It offers an overview of three major procurement models currently available to businesses, including key features, relevant customers, potential benefits, and considerations. The contents of this guidebook directly respond to requests from C&I customers interested in specific tools and templates that can support early-stage efforts to pursue RE solutions in Colombia.

1.1 The Clean Energy Investment Accelerator

The Clean Energy Investment Accelerator (CEIA) is an innovative public-private partnership initiative that addresses barriers to scaling the deployment of clean energy solutions for C&I consumers in emerging markets. CEIA is jointly led by World Resources Institute (WRI), Allotrope Partners, and the U.S. National Renewable Energy Laboratory (NREL), with support from the United States Government, Partnering for Green Growth and the Global Goals 2030 (P4G), and other sources. The CEIA model is built on three essential pillars for mobilizing clean energy investment at scale:

- **Purchasers:** C&I power purchasers create a demand signal for clean energy
- **Policy:** Effective policies and regulations allow clean energy to scale
- **Pipeline:** A robust pipeline of clean energy projects attracts investment

Since 2017, CEIA has partnered with public and private sector stakeholders to support Colombia in achieving its clean energy goals. CEIA works with buyers, service providers, and policymakers to develop and implement new procurement models that can provide customers with RE at highly competitive rates and encourage RE market growth.

In 2018, CEIA led Colombia's first aggregated on-site solar PV procurement process for a group of industrial consumers, in collaboration with the National Industrial Association of Colombia (Asociación Nacional de Empresarios de Colombia; ANDI). Together, CEIA and ANDI have worked to pilot aggregated approaches, helped ANDI's member companies navigate their RE options, and explored cost-effective on-site solar models. In September 2019, harnessing market insights and lessons learned, CEIA launched a second aggregated C&I on-site solar project pool. Through this project pool, CEIA continued exploring ways to support both C&I customers' pursuit of innovative clean energy solutions and the replication and scaling of effective models. CEIA's request for proposal (RFP) template,[3] including its bid evaluation guidelines and scoresheet template, is available for C&I companies to access, customize, and replicate, alongside additional resources on the CEIA website: **www.cleanenergyinvest.org/resources.**

2. OVERVIEW OF COLOMBIA'S ELECTRICITY MARKET

Colombia's 1991 Constitution initiated the deregulation of the country's electricity market (Zapata and Fajardo Villada 2019). Subsequent laws, particularly Laws 142 and 143 in 1994, gave form to the Wholesale Electricity Market (Mercado de Energía Mayorista; MEM), began breaking up state electricity monopolies, and introduced significant antitrust regulations (GoC 1994a, 1994b). These reforms created five tiers to the market's new structure, each with its own set of actors, as seen in Table 1. Under this new power sector regime, energy companies were forbidden from operating in more than one sector of electricity delivery. Companies could exclusively provide generation, transmission, or distribution services. However, generation companies ("gencos") and distribution companies ("distcos") were still permitted to engage in the retail marketing and sales (commercialization) of electricity.

The 1994 antitrust policy reforms allowed gencos and *comercializadoras* (which supply end-use customers with electricity) free access to the national grid, and the ability to contract directly with potential RE buyers for off-site energy (Rudnick and Velásquez 2019). Figure 1 shows how the energy reforms have diversified the actors in the market and increased competition in the electricity sector.

Colombia's Law 143 of 1994 (GoC 1994b) divided electricity end consumers into two customer groups:

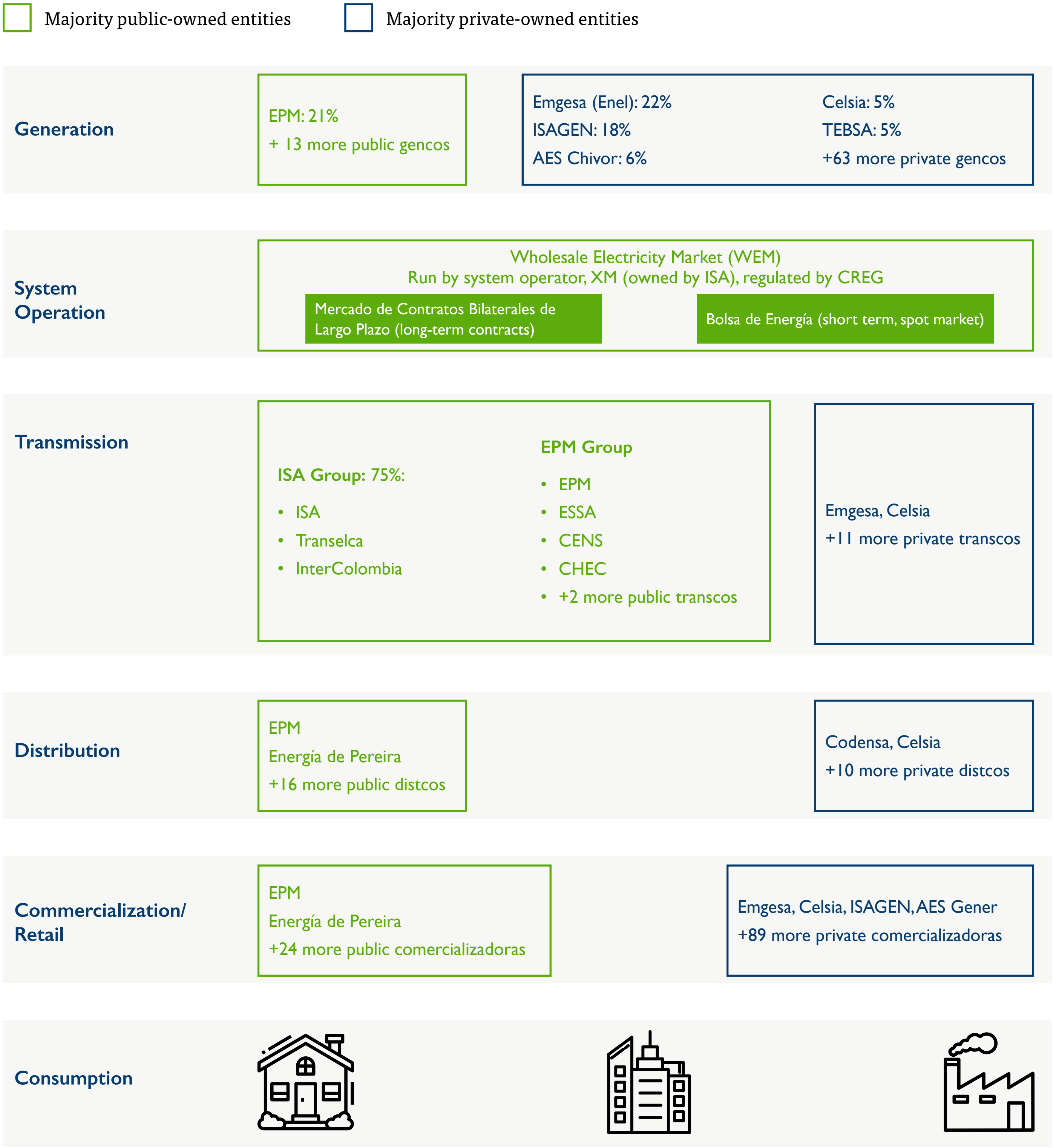
- **Regulated**: Includes all residential consumers and C&I customers with peak demand of 100 kilowatts (kW) or less and monthly energy consumption of less than or equal to 55,000 kilowatt-hours (kWh). C&I customers with demand of over 100 kW may also choose this structure. These customers pay according to a government-regulated tariff schedule established by Colombia's Commission for the Regulation of Energy and Gas (Comisión de Regulación de Energía y Gas; CREG).
- **Nonregulated**: Large-scale C&I consumers with peak demand of over 100 kW and/or monthly energy consumption of greater than or equal to 55,000 kWh can voluntarily request to transition to this group. They can negotiate with a comercializadora, or act as their own comercializadora and engage directly with gencos for short-term (minimum one year) or long-term electricity supply contracts.[4] Every C&I customer connected to the grid enters the market as a regulated user, and

Table 1 | **Primary Electricity Market Participants**

PARTICIPANT	ROLE	OTHER SIMULTANEOUS ROLES PERMITTED	NUMBER OF ACTORS REGISTERED
Generation company ("genco")	Owns and operates one or more power plants. Sells its electricity on the MEM to *comercializadoras*, or directly to end-use, nonregulated customers.	Comercializadora (only to nonregulated customers)	82
System and market operator	XM (a subsidiary of the government-owned transco ISA) fills the roles of system operator and market operator.	Transco	1
Transmission company ("transco")	Owns and operates high voltage transmission lines as regulated natural monopolies. ISA is the largest of multiple transcos. All market participants have open access to the transmission network.	None (except ISA, which owns XM)	15
Distribution company ("distco")	Owns and operates distribution lines as regulated natural monopolies. All market participants have open access to the distribution network.	Comercializadora (to regulated and nonregulated customers)	38
Comercializadora	Also called suppliers, marketers, or retailers. Contract with gencos, or trade on the MEM, to supply end-use customers with electricity.	Genco Distco Customer (self-supplying)	120
Customer	Regulated customers buy electricity on a fixed tariff schedule from a comercializadora that is assigned to them. Nonregulated customers can negotiate, buying directly from a genco or from a comercializadora on the MEM.	Comercializadora (self-supplying)	Unknown

Note: Abbreviation: MEM: Mercado de Energía Mayorista (Wholesale Electricity Market).
Sources: Rudnick and Velásquez 2019; XM 2020b.

Figure 1 | **Colombia's Electricity Market Structure**



☐ Majority public-owned entities ☐ Majority private-owned entities

Generation	EPM: 21% + 13 more public gencos	Emgesa (Enel): 22% ISAGEN: 18% AES Chivor: 6% Celsia: 5% TEBSA: 5% +63 more private gencos
System Operation	Wholesale Electricity Market (WEM) Run by system operator, XM (owned by ISA), regulated by CREG Mercado de Contratos Bilaterales de Largo Plazo (long-term contracts) Bolsa de Energía (short term, spot market)	
Transmission	**ISA Group: 75%:** • ISA • Transelca • InterColombia **EPM Group** • EPM • ESSA • CENS • CHEC • +2 more public transcos	Emgesa, Celsia +11 more private transcos
Distribution	EPM Energía de Pereira +16 more public distcos	Codensa, Celsia +10 more private distcos
Commercialization/ Retail	EPM Energía de Pereira +24 more public comercializadoras	Emgesa, Celsia, ISAGEN, AES Gener +89 more private comercializadoras
Consumption		

Notes: Abbreviations: genco: generation company; transco: transmission company; distco: distribution company.
Source: Adapted from BloombergNEF (2019); updated from XM (2020b).

C&I consumers have the option of transitioning to the nonregulated market.

While both regulated and nonregulated customers can procure on-site RE, only nonregulated customers can contract for off-site power purchase agreements (PPAs) directly with third-party gencos or with gencos' comercializadoras.

Often, part of the intent of electricity market disaggregation and deregulation is to introduce competition into the sector, and thereby drive down prices. Nonetheless, as Figure 2 shows, Colombia's consumers across all sectors have faced significant price volatility over the past decade. In particular, commercial rates have varied up to 55 percent, and industrial rates up to 35 percent, from their 2010 baselines (BloombergNEF 2019).

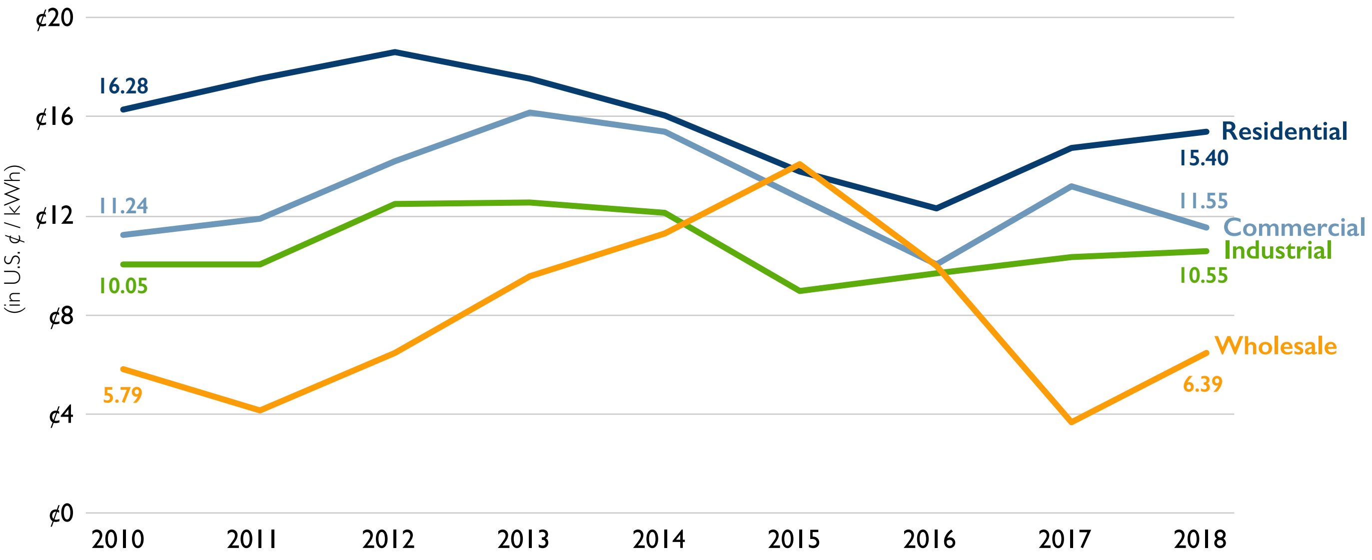
While grid retail electricity prices have fluctuated significantly in recent years, the cost for Colombian C&I customers to procure RE has declined substantially. By entering the RE market, C&I customers are able to not only fulfill their environmental and climate goals, but also potentially save money on their electricity bills every year.

Recognizing RE's increasingly low cost and the disruptions to the economics that can come with volatile energy costs due to fluctuating hydroelectric production in dry years,[5] the Colombian government included significant reforms intended to promote procurement of RE in its recent electricity market deregulation efforts. The government had set a goal of generating 6.5 percent of the country's electricity from non-hydro RE by the end of 2020 (The Business Year 2020). Yet, in 2019, wind and solar power combined sourced less than 1 percent of Colombia's electricity, while hydropower generated over 75 percent of all the country's electricity (XM 2020c). Even the recent auctions, which are projected to feed an additional 3,700 gigawatt-hours (GWh) of RE into the grid annually by 2022 (Castilhos Rypl 2019), will fall two years short of the government's goal, and even then, will add only enough RE power to equal approximately 4.9 percent of Colombia's total 2019 electricity generation (BP 2020).

Colombia set a new RE installed capacity goal of 4,000 megawatts (MW) (approximately 24 percent of all of Colombia's projected electricity capacity) by 2030 (IRENA 2019; UPME 2015). As seen in Figure 3, by August 2020, Colombia had installed a total of 18.4 MW of wind, and approximately 160 MW of solar.[6] Assuming the 2019 auction's 1,365 MW of RE come online by January 1, 2022, to reach the government's goal (Borda-Olarte et al. 2020; Gubinelli 2020), Colombia must still install an average of 280 MW every year for the subsequent nine years. This is equivalent to installing approximately 55 percent more capacity each year than what had cumulatively ever been built in the country through January 2020 (Kieffer et al. 2016).

In part to catalyze the C&I market to reach these ambitious targets, the government has established multiple incentive mechanisms to accelerate investment in RE. The array of new incentives includes directions to regulators to expedite

Figure 2 | **Electricity Prices in the Colombian Market from 2010 to 2018**



Note: Abbreviation: kWh: kilowatt-hour.
Source: BloombergNEF 2019.

permitting approval processes for RE installations, and policies to lower the procurement costs of both large- and small-scale RE installations, including the following:

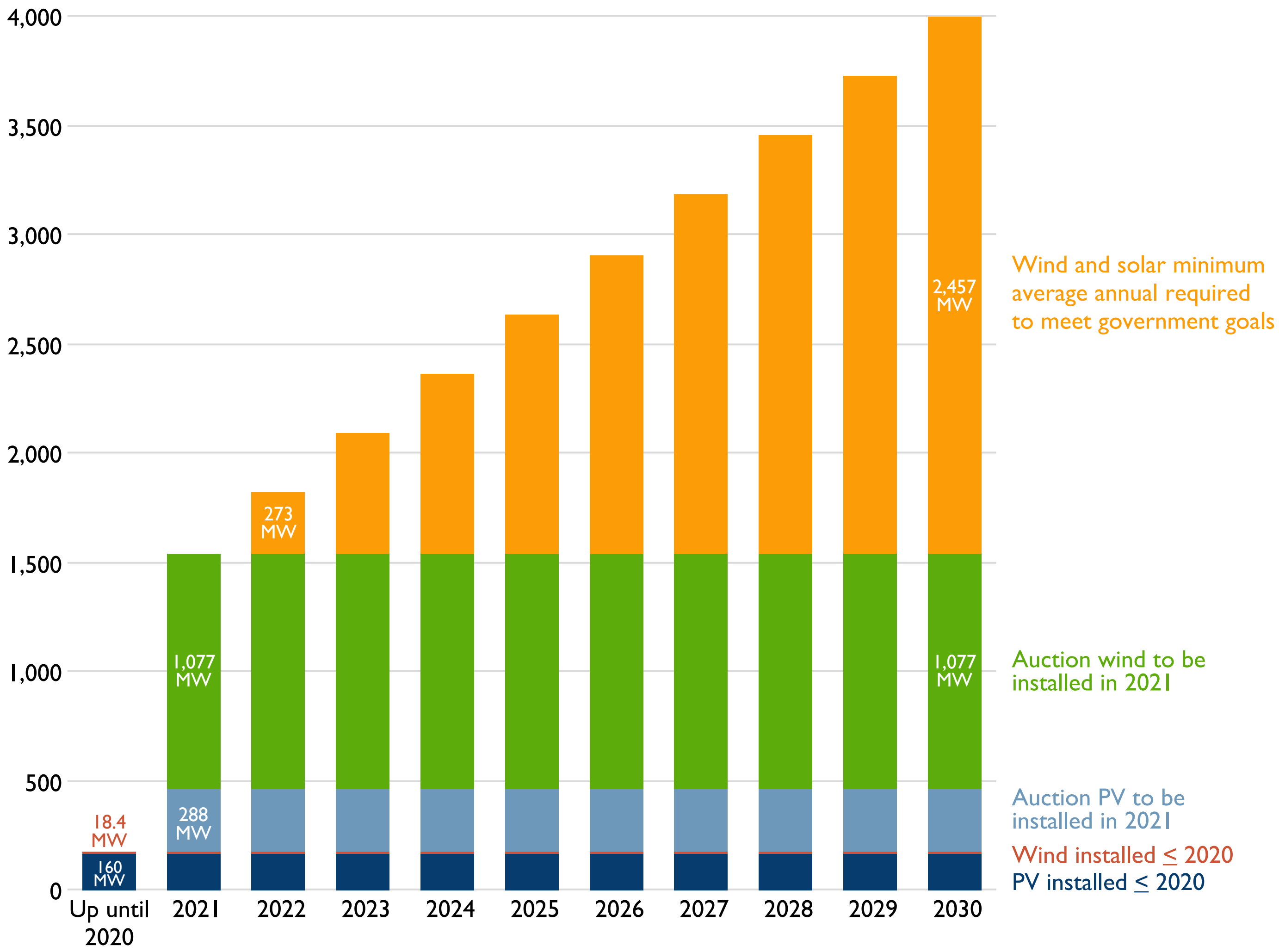
- A value added tax (VAT) exemption on solar and wind generation systems' most important components, listed by the government's Mining and Energy Planning Unit (Unidad de Planeación Minero Energética; UPME)
- Two income tax deduction mechanisms linked to the value of the installed system
- Tariff exemptions for importation of all RE components
- Net-billing regimes for both regulated and nonregulated, otherwise-eligible electricity consumers (GoC 2014)

3. CORPORATE ENERGY PROCUREMENT OPTIONS

3.1 Overview

Over the past decade, Colombia's government has introduced policies to encourage RE deployment and investment. These policies, combined with RE's rapid cost declines, have opened significant opportunities for C&I customers in Colombia to save money on electricity expenses, while making their operations more sustainable with minimal risk. Leading corporations across Colombia have started investing in RE, including Compañia Nacional de Chocolates, Ecopetrol, and Tecnoglass. Collectively, these three companies have already installed over US$25 million worth of solar electricity to power their facilities (Ojeda 2017; González 2019; MME 2017).

Figure 3 | **Colombia's Current Installed and Potential Future Solar and Wind Capacity**



Note: Projected through 2021 and then minimum required through 2030 to meet the government's goals. Abbreviations: MW: megawatt; PV: photovoltaic.
Sources: Adapted from Borda-Olarte et al. (2020), Gubinelli (2020), and Kieffer et al. (2016).

This guidebook outlines three primary procurement options currently available to potential C&I RE consumers in Colombia:

1. **On-Site Turnkey Purchases:** The customer purchases an RE system up-front, which is installed on the customer's site. The customer operates and maintains the system. In Colombia, on-site turnkey purchases are also commonly referred to as engineering, procurement, and construction (EPC) purchases.
2. **On-Site Third-Party PPAs or Leases:** A vendor provides financing, operates and maintains the RE system installed at the customer's site, and sells the customer electricity by the kWh.
3. **Off-Site Third-Party PPAs:** A vendor provides financing, operates and maintains the RE system located outside the customer's site, and sells the customer electricity by the kWh.

As summarized in Table 2, each of the three options has its own notable features and relevance to different types of customers. This guidebook provides additional context and details to help prospective RE consumers assess which model best fits their needs and gain a better understanding of how to move forward with RE procurement for their facilities in Colombia.

Table 2 | **Summary of Procurement Options: Key Features and Relevant Customers**

	KEY FEATURES	**RELEVANT CUSTOMERS**
Option 1: On-site turnkey purchase	• Often lowest cost of electricity per kWh over system's lifetime; • Reduces electricity costs; • Requires investment up-front from the customer to purchase the system; • Customer is responsible (carrying cost and risk) for the PV system operations and maintenance; • Tax benefits available.	*Relevant for users that have:* • sufficient sunny rooftop or ground space; and • access to capital to purchase a system. *Most cost-effective for customers with:* • peak demand under 100 kW; • owned facilities planned to be in operation for 10 years or more; • businesses operating seven days per week; and • energy demand that aligns with likely hours of RE generation.
Option 2: On-site third-party PPA or lease	• Reduces electricity costs; • Offers instant savings on utility bills as there are no up-front costs and uses operational, not capital, budget; • The third-party system owner is responsible (carrying cost and risk) for ensuring the PV system operates well and produces the maximum possible electricity.	*Relevant for users that have:* • sufficient sunny rooftop or ground space; • limited access to capital for an outright system purchase or that focus on other investments that are key to business operations; and • the ability to sign long-term contracts (10–20 years). *Most cost-effective for customers with:* • peak demand under 100 kW; • businesses operating seven days per week; and • energy demand that aligns with likely hours of RE generation.
Option 3: Off-site third-party PPA	*This model is currently rare in Colombia but it can:* • Reduces electricity costs • offer instant savings on utility bills as there are no up-front costs and it uses operational, not capital, budget; • allow customers to buy RE from sources beyond solar (e.g., wind); • offer lower generation costs via economies of scale (but customers still must pay for transportation/wheeling fees); and • provide savings on a much larger percentage of custsomers' electricity bills.	*Relevant for users that have:* • flexibility to contract with gencos as nonregulated customers; • limited capital for an outright system purchase; • a site that may not be conducive to RE; • leased facilities or that are planning to move their operations in the next few years; and • the ability to sign long-term contracts (10–20 years). *Most cost-effective for nonregulated customers with:* • demand greater than 100 kW. • businesses NOT operating seven days per week,or energy demand that does NOT align with on-site generation.

Notes: Abbreviations: PPA: power purchase agreement; kWh: kilowatt-hour; PV: photovoltaic; RE: renewable energy; genco: generation company.
Source: Authors.

3.2 Procurement Option Details

Solar and wind generation are still relatively new in Colombia. However, such power sources appear to offer low-risk options for businesses seeking to reduce their energy costs and lock in stable energy prices, while simultaneously promoting sustainability and climate action. Nationally, recognized brands are beginning to invest in large-scale RE systems (See Appendix B for a table of RE installations greater than 400 kW). Tecnoglass (MME 2017) and Compañía Nacional de Chocolates (Ojeda 2017) have invested over $2.1 million each, installing solar systems on their own facilities for self-consumption. In 2018, Colombia's largest beverage firm, Postobon, signed a PPA for 6 MW of off-site solar to power 40 percent of its facility in the city of Yumbo (Morais 2018). In 2019, Ecopetrol, Colombia's largest single corporation, also invested over $20 million to install 21 MW of on-site solar electricity for self-consumption (Morais 2019). Both companies have stated that they expect their RE investments to bring them substantial savings; the companies have also pursued a variety of procurement options tailored to their unique circumstances.

The Colombian RE market has been rapidly growing, with multiple project developers—both Colombian and international—now operating and installing RE systems in the country. As of August 2020, 14 RE generation projects greater than 400 kW in scale have been documented as completed across all sectors in Colombia (see Appendix B for details). This is taking place in the context of a maturing RE market, as seen in Colombia's October 2019 RE auctions. Utility-scale providers were awarded eight contracts to sell over 3,700 GWh annually, starting no later than 2022, averaging $0.028 per kWh from five wind and three solar projects, totaling over 1,300 MW in peak capacity (BloombergNEF 2019). The results of these auctions are a high-profile indication that solar and wind prices are falling, and that Colombia's RE market is now attracting significant private sector investment. Generation prices of less than three cents per kWh will be available only to the utility-scale market actors that participated in the auction. However, C&I nonregulated consumers could benefit indirectly from the auction prices by contracting for PPAs with the auction buyers' comercializadoras, although their retail tariffs would include additional costs related to transmission, distribution, and other elements.

This section explains the three major procurement options open to potential C&I RE consumers in Colombia: on-site turnkey purchases; on-site third-party PPAs or leases; and off-site third-party PPAs. In addition to explaining each procurement option, this section analyzes potential benefits and key considerations for each and identifies customer characteristics that could influence which option would likely best meet a customer's needs.

3.3 Option 1: On-Site Turnkey Purchases

On-Site Turnkey Purchase Key Features

- Often lowest cost of electricity per kWh over system's lifetime;
- Reduces electricity costs;
- Requires investment up-front from the customer to purchase the system;
- Customer is responsible (carrying cost and risk) for the PV system operations and maintenance;
- Tax benefits available.

Relevant Customers

RELEVANT FOR USERS THAT HAVE:

- sufficient sunny rooftop or ground space; and
- access to capital to purchase a system.

MOST COST-EFFECTIVE FOR CUSTOMERS WITH:

- peak demand under 100 kW;
- owned facilities planned to be in operation for 10 years or more;
- businesses operating seven days per week; and
- energy demand that aligns with likely hours of RE generation.

With an **on-site system**, the C&I customer's RE system is installed in the same location where the energy is consumed. On-site systems can be built on a rooftop or on the ground, are almost always solar, and must connect directly to the building(s) consuming the electricity rather than have their electricity flow to the grid first. This type of system is often called "behind the meter" as customers consume all the electricity they can from the RE the system produces before pulling additional kWh from the grid.

On-site generation is permitted for all C&I customers in Colombia; however, certain conditions can impact the cost-effectiveness of choosing this model. For example, customers must have enough space on their rooftops or properties to construct a solar system; the potential installation area must have sufficient sun exposure; if customers rent their facilities, the property owners must own or authorize such an installation; and the potential installation surface must be in good shape to support the extra weight of the solar panels.

A **turnkey system** is one where customers pay for and own the system themselves—referred to in this way because customers are essentially able to "turn the key" and use the system. To purchase a turnkey system, customers must have access to sufficient cash and/or credit. Customers can either pay up-front with cash, finance the system through a loan secured from a bank or other financing institution, or a combination of the two (lenders often require a minimum cash investment).

Under the turnkey structure, customers own all the electricity the system generates. Once any loans are paid off, customers' costs are comprised almost exclusively of low operations and maintenance (O&M) costs for the system. Turnkey customers normally contract with solar O&M specialists to monitor and maintain the system, but O&M costs are generally low given that PV systems have no moving parts or fuel costs. Almost all standard solar modules are warrantied for 25 years. Inverters may need to be replaced after 10–15 years.

All on-site RE generation systems in Colombia are eligible for net billing (UPME 2015).[7] Net billing is an incentive program that allows customers that generate their own RE on-site to export excess electricity to the grid and receive remuneration from the electric utility. When excess power is generated, such as when a customer's load is low (e.g., during weekends), it is exported to the grid and the customer receives compensation back from the utility.

Net billing rates in Colombia vary depending on the size of the on-site system. Small systems (under 100 kW) receive the highest remuneration level with rates at 85–90 percent of the utility's electricity retail tariff. On the other hand, systems over 100 kW receive lower levels of remuneration (often equal to 30–40 percent or less of retail rates) and may face additional restrictions for systems larger than 1 MW (CREG 2018b). Customers should consider whether their current net-billing structure can offer additional economic benefits for their on-site solar PV system when determining whether to make a turnkey purchase. Net billing is explained in greater detail in Appendix D.

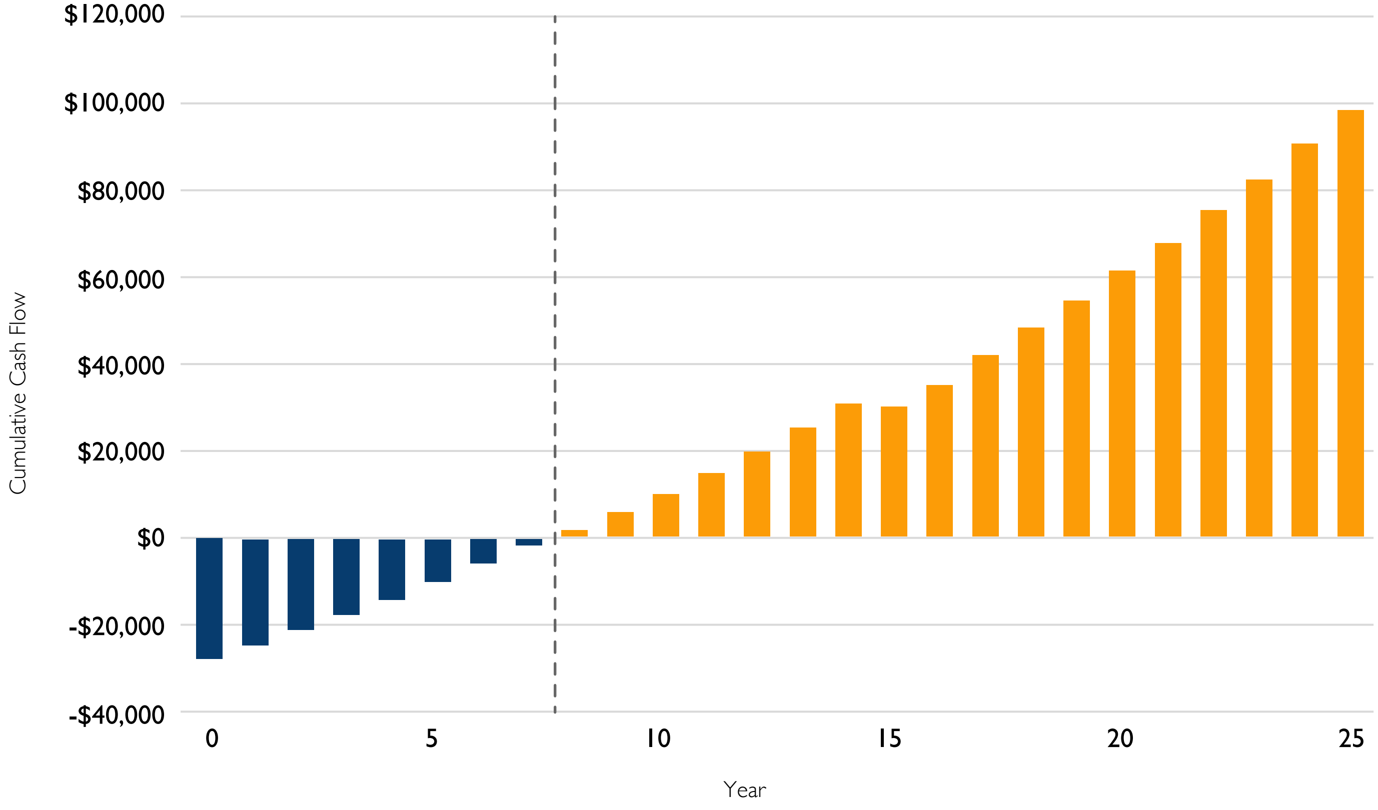
POTENTIAL BENEFITS OF ON-SITE TURNKEY PURCHASES

On-site turnkey systems can offer C&I customers the lowest price per kWh over the lifetime of the solar system. After any loans have been repaid, all electricity the system produces is inexpensive—composed almost only of O&M costs. As of 2018, multiple C&I customers in Colombia reported they had purchased on-site turnkey PV systems with a capital investment payback period as short as three years.[8] Figure 4 shows an example cash flow for a customer purchasing an on-site turnkey system. Additionally, even before the system has been paid off, the turnkey system can provide price stability for a notable portion of the customer's energy costs, which is beneficial to a company's operational planning. Customers whose facilities consume electricity during the same times as high solar generation hours (i.e., seven days per week during all daylight hours) can benefit the most from on-site systems as they replace utility energy directly with solar energy.

Colombia's government also provides two significant income tax benefits, plus major VAT and import tariff benefits, for turnkey RE purchases. First, for projects certified for self-generation by UPME, buyers can deduct 50 percent of the system's cost from their taxable income. Second, system buyers can additionally deduct up to 20 percent of the system's total cost off their taxable income each year for five years. These two deductions may be able to be executed simultaneously for a total of 150 percent of the system's cost (GoC 2014). Moreover, customers are exempt from paying the VAT on most of the costs for equipment and services to install on-site PV generation, as well as from paying import tariffs on "equipment, machinery, material and other supplies required and exclusively destined for renewable energy projects" (Rodrigues Bravo 2018).[9]

On-site systems allow customers to consume all the electricity produced, without paying multiple ancillary charges and taxes, such as for transmission, distribution, and other services that come with buying electricity delivered from off-site, using the grid. Collectively, such costs are called "wheeling fees," and are discussed in greater detail in Section 3.3. C&I customers pursuing on-site solutions avoid these fees for added savings.

Figure 4 | **Customer Cash Flow Example for an On-Site Turnkey Purchase**



Note: For illustrative purposes only.
Source: Adapted from Oroeco (2012).

ON-SITE TURNKEY CONSIDERATIONS

Turnkey purchases require an up-front investment or access to financing that may be cost prohibitive for some C&I customers. Purchasing a turnkey system typically offers the lowest per-kWh cost of electricity over the lifetime of the system, yet it may take several years for buyers to see their return on investment.[10] Additionally, under a turnkey purchase, customers are responsible for the system's O&M. C&I customers often secure a separate contract with an O&M provider.

In Colombia, if an on-site system is larger than 100 kW per customer, the owner must sign a mandatory "back-up" supply contract with the grid operator. The complex formulas for calculating these contracts' costs are printed in Chapter 10 of CREG's Resolution 015 of 2018 (CREG 2018a). However, components of these formulas reflect internal grid operators' costs, which they are not obligated to make public, thus making these back-up supply contracts difficult for customers to navigate (CREG 2018a, Ch. 12). Under the current regulatory structure, these added fees can lead to systems over 100 kW being significantly less cost-effective, even if a larger project would offset a greater percentage of a customer's consumption and economies of scale would make larger solar systems cheaper on a cost-per-kW basis. Such constraints can drive customers to install undersized on-site systems to avoid a back-up contract that could negatively impact the overall economics of the project (Critchley 2018). In interviews conducted by CEIA staff, some solar developers mentioned that they offer only system sizes under 100 kW to avoid the complications raised by this requirement.

Customers installing on-site systems may need to consider mitigation measures if their businesses, such as industrial factories, consume significant levels of reactive power. In December 2019, CREG issued a new regulation establishing potentially spiraling fees for customers with disproportionate ratios of reactive-to-active power (CREG 2019b; 2018a, Ch. 12; see Appendix E). The installation of on-site solar sometimes exacerbates this ratio. However, such risks can be significantly, and cost-effectively, mitigated by investments in either capacitors or equipment modernization. Greater details on this issue and potential mitigations are explained in Appendix E (Coddington and Reilly 2020).

C&I customers should work with an experienced and reputable solar developer or service provider to determine the optimal system size for their facility, taking into account their demand, potential net-billing compensation, potential reactive power fees, and other regulatory considerations.

3.4 Option 2: On-Site Third-Party PPAs or Leases

Key Features

- Reduces electricity costs
- Offer instant savings on utility bills as there are no up-front costs and use operational, not capital, budget
- The third-party system owner is responsible (carrying cost and risk) for ensuring the PV system operates well and produces the maximum possible electricity

Relevant Customers

RELEVANT FOR USERS THAT HAVE:

- sufficient sunny rooftop or ground space;
- limited access to capital for outright system purchase or that focus on other investments that are key to business operation; and
- the ability to sign long-term contracts (10–20 years).

MOST COST-EFFECTIVE FOR CUSTOMERS WITH:

- peak demand under 100 kW;
- businesses operating seven days per week; and
- energy demand that aligns with likely hours of RE generation.

Similar to the on-site turnkey option, under an on-site third-party PPA or lease model, the solar system is co-located at the customer's facility and requires sufficient roof or ground space, sun exposure, and property ownership. However, the two on-site models diverge in significant ways.

Under on-site third-party PPAs or leases, a customer does not own the physical solar generation system directly. Instead, a developer or service provider secures the financing, and installs and owns the system. The owner then operates and maintains the on-site solar installation for the lifetime of the contract. In the case of a PPA, the owner sells the RE to the customer; in the case of a lease, the owner rents the system to the customer and the customer then owns all the generated electricity, no matter how many kWh the system produces.

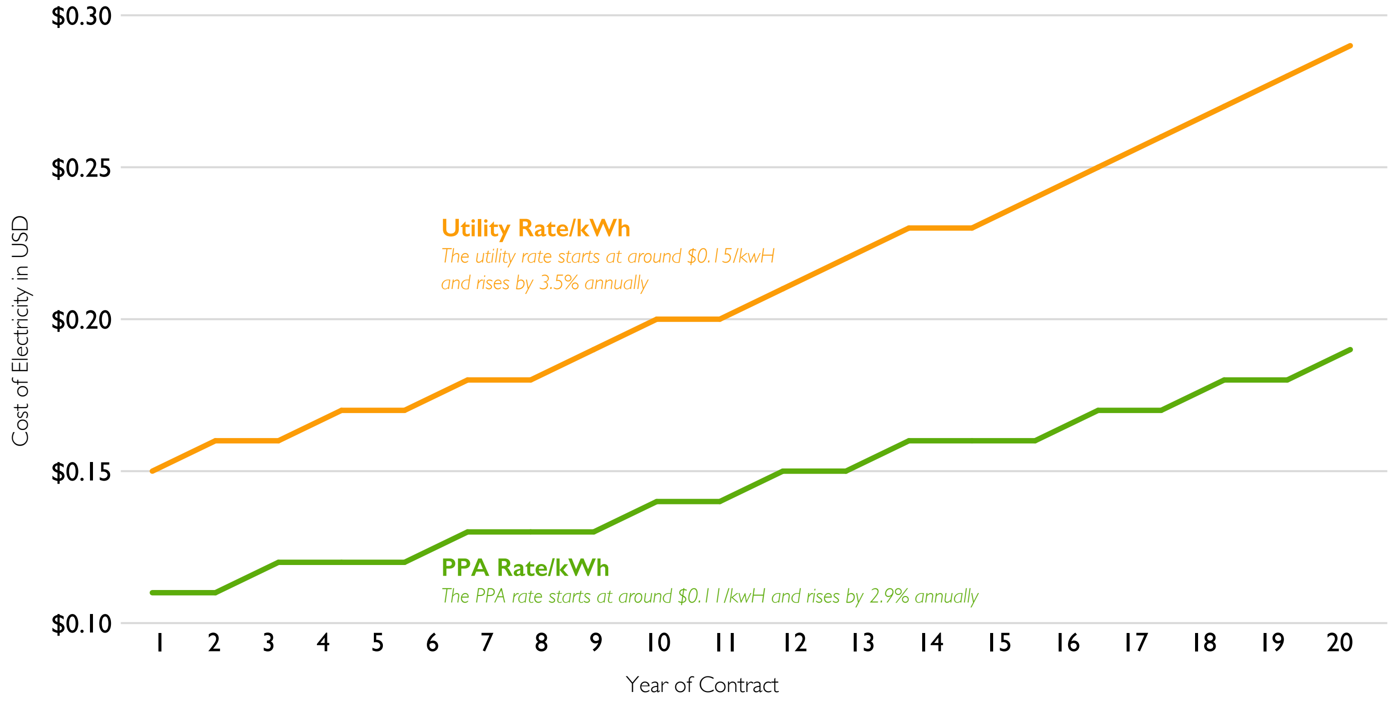
With the on-site **third-party PPA model**, the third party owns and operates the solar system and sells the electricity produced via the PPA to the customer at a pre-agreed upon price per kWh. This price is typically low enough to reduce the customer's monthly (or at least annual) retail electricity bills. All other costs (and associated risks) such as for O&M, replacement parts, and insurance are the responsibility of the third-party owner. The buyer pays no or very minimal costs up-front. Also, PPAs typically include an annual "escalator" that parallels anticipated increases for grid electricity tariffs, or for inflation. Some escalators are set at a predetermined rate while others track to an index. Figure 5 shows an example customer PPA rate, including an annual escalator, compared with a regular electricity bill.

Based on CEIA's experience collecting developer bids in response to requests for proposals (RFPs) for two aggregated projects, current on-site solar PPA contracts in Colombia often last for 10–20 years. However, many nonregulated C&I customers in Colombia are accustomed to signing contracts with their comercializadoras to procure hydropower or fossil fuel–based energy; those offers are typically contracted for one to two years (Rudnick and Velásquez 2019). Thus, some C&I buyers may face difficulties when seeking their executives' approval for long-term RE contracts. Reservations about PPA term lengths appear to be one—if not the most significant—reason why few third-party financed PPAs (either on-site or off-site) have been signed in Colombia to date. In fact, during an online solar conference in September 2020, 83 percent of Colombian solar professionals present agreed that the "absence of long term PPAs" was the "biggest challenge for the success of [an off-site] renewable energy project in Colombia" (Solar Pulse LATAM 2020).

At the PPA contract's end, developers report that customers typically have three available options: sign a new PPA (likely at a highly discounted price off their previous PPA); buy the solar system for a discounted price; or end the contract and have the system removed at the site owner's expense.

A **third-party lease** is another on-site financing option that is common in other markets globally. Under a lease, the third party still owns the system and leases the equipment to the customer, and the customer owns all the electricity generated. The customer pays a preset, fixed monthly rate to the third party at a cost that normally reduces the customer's monthly or annual retail electricity costs. In most cases, the customer can purchase the system at a discount at the end of the lease.

Figure 5 | **Customer Utility Rate vs. PPA Rate with Annual Escalator**



Notes: Abbreviations: kWh: kilowatt-hour; PPA: power purchase agreement. Illustrative example from the United States.
Source: Adapted from Solar Power Rocks (2020).

As shown in Table 3, RE systems financed by third parties have multiple characteristics that contrast with those of turnkey systems.

ON-SITE THIRD-PARTY PPA POTENTIAL BENEFITS

A key feature of the third-party PPA is that customers incur little or no up-front costs. Customers pay the PV system owners only for the RE generated, at a price lower than the customers' retail grid electricity costs (on average). Customers can pay for their RE out of operational costs, without incurring up-front capital expenditures, and can begin to see savings on their electricity bills immediately.

Additionally, the PPA's structure (electricity sold on a per-kWh-delivered basis) incentivizes the third-party owner to ensure that the system is properly operated and maintained and sustains its maximum production capacity over time. Customers are not responsible for O&M, insurance, or warranties, all of which are managed and paid for by the third party.

The on-site PPA model mirrors some of the potential benefits experienced through on-site turnkey systems. Customers can avoid wheeling fees associated with off-site generation as well as increase their price stability and predictability in support of long-term business planning. Customers whose facilities consume electricity during high solar generation hours (i.e., daylight hours, seven days per week) can benefit the most from on-site systems.

Table 3 | **Comparison of Turnkey and Third-Party Finance Structures**

CHARACTERISTICS	TURNKEY PURCHASE	THIRD-PARTY FINANCING (PPA OR LEASE)
Ownership	Customer PV developer or other outside investors (i.e., third party).	PV developer or other outside investors (i.e., third party).
Up-front capital investment	On customer's balance sheet (cash or loan/line of credit).	PV developer or other outside investors (i.e., third party).
Project financing	On customer's balance sheet (cash or loan/line of credit). Construction and project financing capital is sometimes bundled.	Financing from PV developer or other investors (i.e., third party).
Operations and maintenance	Customer's responsibility. Usually a separate contract with a PV developer or a third-party O&M provider is secured.	Cost included in PPA/lease.
Equipment warranties	Recommended for inclusion as part of the initial system procurement. May not cover the full life of all equipment (e.g., inverters) over project life.	Third-party owner manages the warranties and is responsible for PV system's operational risk beyond warranties.
Performance guarantees (minimum kWh production level or customer does not pay)	Production performance guarantees can be negotiated with project developers but are rare with a turnkey purchase. PV panel manufacturers typically provide production guarantees for 20–25 years on their panels.	Widely offered and included with PPAs, performance guarantees must be in contract language that includes annual minimum kWh guarantees and compensation rates in case of shortfalls.
Insurance	Customer's responsibility. May be included under existing insurance policy or require a separate policy.	Third-party owner is responsible for PV system's operational risk. Liability and property insurance responsibility should be clarified.
Lowest cost per kWh over PV system lifetime	Yes	No
Potential cash-flow positive in first year	No	Yes

Notes: Abbreviations: PPA: power purchase agreement; PV: photovoltaic; O&M: operations and maintenance; kWh: kilowatt-hour.
Source: Authors.

ON-SITE THIRD-PARTY PPA CONSIDERATIONS

Many C&I companies in Colombia find it difficult or unfamiliar to enter into long-term PPA contracts, so the length of contract terms can be a significant consideration. Additionally, the same mandatory back-up fees that apply for turnkey projects larger than 100 kW apply to on-site PPAs. The reactive power considerations described in Appendix E apply as well.

Over the long term, PPAs typically cost more on a per-kWh basis than turnkey purchases. Third-party-owned projects often incur a higher cost of capital to install than would an equally sized turnkey PV project via a loan for self-consumption. This increased cost is likely then passed on to the electricity consumers. Furthermore, PPA customers pay per kWh for several years, but still do not own the solar system at the end of the contract. The option to own the system may become available once the initial contract term has ended; if ownership is desired it is often structured into the contract.

Customers cannot benefit directly from tax incentives because the third party owns the system. Some savings may be passed through from the third party in the form of lower per-kWh prices. However, such savings may not be as large as compared with when customers can access the tax benefits directly under a turnkey purchase model.[11]

Net billing is possible under an on-site PPA. Net billing is a structure whereby the electricity is consumed on-site in real time and excess electricity production is generally exported to the utility grid and compensated at a predetermined sell rate (Zinaman et al. 2018). For every kWh consumed on-site in real time, customers avoid the retail rate of electricity. However, customers are obligated to buy 100 percent of the electricity generated at the PPA rate, including the excess they cannot consume. The customers' net-billing compensation is typically less than the per-kWh price they pay via their PPA. Therefore, on-site PPA customers typically don't generate as much value from excess kWh production. As a result, it is important under an on-site PPA with net billing that customers ensure that their systems are accurately sized to avoid negatively impacting the economics of the project. In some cases, C&I customers may sign consumption-based PPA contracts where the risk of excess energy is left to the investor/system owner.

3.5 Option 3: Off-Site Third-Party PPAs

Key Features

THIS MODEL IS CURRENTLY RARE, BUT CAN:

- offer instant savings on utility bills as there are no up-front costs, and it uses operational, not capital, budget;
- allow customers to buy RE from sources beyond solar (e.g., wind);
- offer lower generation costs from economies of scale (but customers still must pay for transportation/wheeling fees); and
- obtain savings on a much larger percentage of electricity bills.

Relevant Customers

RELEVANT FOR USERS THAT HAVE:

- flexibility to contract with gencos as nonregulated customers;
- limited capital for outright system purchases;
- a site that may not be conducive to RE;
- leased facilities or that are planning to move their operations in the next few years; and
- the ability to sign long-term contracts (10–20 years).

MOST COST-EFFECTIVE FOR CUSTOMERS WITH:

- demand greater than 100 kW; and
- energy demand that does NOT align with on-site generation or businesses not operating seven days per week.

Under an **off-site third-party PPA** model, a genco owns and operates a large-scale RE system in a different location than the customer. The system is physically connected to the grid and the RE genco sells its electricity to end users via either the wholesale market or a comercializadora. C&I off-site PPAs have been rare in Colombia to date, in part due to the typical length (10–20 years) of PPA contracts, which are often considered too long. These are available only to customers with peak demand over 100 kW and that choose to be nonregulated.

OFF-SITE THIRD-PARTY PPA POTENTIAL BENEFITS

A key benefit of this model is that there are no up-front costs, so consumers can see immediate savings compared with previous utility bills. Customers can also pay for renewable electricity out of their operational budgets, thus avoiding capital expenditures. Significantly, off-site PPA customers can often buy inexpensive RE to cover a much greater percentage (sometimes 100 percent) of their electricity loads than if they procured using an on-site PPA or turnkey model.

Off-site PPAs, like on-site PPAs, can provide customers with price stability and predictability by locking in long-term prices for kWh. Also, similar to on-site PPAs, based on the experience of developers, off-site PPAs typically include a price escalator (an annual per-kWh price increase)—escalators often rise less than the grid's retail price and allow the customer to save even more money each year.

Because off-site generation has no impact on consumers' reactive-to-active power consumption ratio, there are no risks of added fees from CREG's new reactive power regulations (CREG 2019b; see Appendix E).

The off-site PPA model also allows customers to access RE generation sources other than solar. It is extremely rare to develop an on-site wind turbine that is cost effective for C&I customers. But in contracting for an off-site PPA, customers can compare technologies and could find that it is significantly less expensive to buy wind energy than produce their own solar energy.

In other markets globally, this model has been particularly attractive to customers that lack sufficient space appropriate for their own PV systems. This model can also be particularly attractive to customers that rent their facilities or are considering plans to move their operations in the next few years, if they are able to negotiate a short-term or transferable PPA.

OFF-SITE THIRD-PARTY PPA CONSIDERATIONS

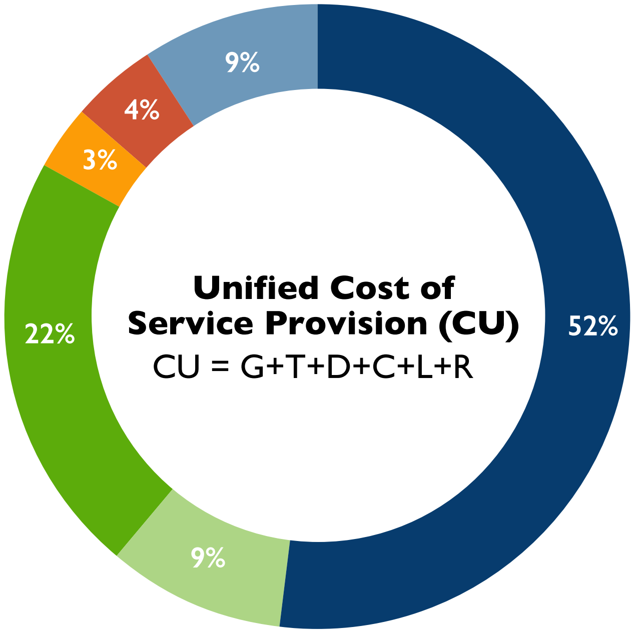
Off-site PPAs have not yet been widely used for RE in Colombia, in part because of the same PPA-term-length issues that on-site PPAs face. In some instances, utilization has also been restricted due to CREG's Resolution 131 of 1998 (Article 4), which mandates that customers may buy electricity only from a single comercializadora and restricts the options available for customers to contract for off-site RE PPAs to three scenarios (CREG 1998):

1. The customer finds a comercializadora (out of the 141 available) willing to both act as a conduit for the contracted genco's RE and provide the rest of the customer's electricity from other sources.
2. The customer enters into an agreement with an RE genco that has its own comercializadora. Then the RE genco's comercializadora can supplement its own renewable electricity with other genco contracts, or with electricity from Colombia's electricity wholesale spot market, Bolsa de Energía (Bolsa),[12] to satisfy 100 percent of the customer's needs.
3. A customer large enough to establish its own comercializadora can then contract with multiple gencos on its own.

In off-site PPAs, customers' per-kWh electricity bills are composed of both generation fees (the costs for which customers negotiate directly with the genco) and wheeling fees. The retail tariff of a grid-provided, regulated commercial kWh depends on a number of factors. The different tariff costs generally fall within a range but vary somewhat. Figure 6 shows a real-world example of a company's electricity bill components where the customer must pay wheeling fees because each kWh of its RE is generated off-site and requires transport via the grid to its facility, incurring multiple ancillary costs. Such expenses for using the grid do not exist for electricity consumed from an on-site generation system. The elements comprising wheeling fees are set by rate formulas in CREG Resolution 097 of 2008 (CREG 2008). However, wheeling fees are case specific and can vary depending on factors such as voltage level, transmission line congestion, and size of the distribution network.

On the other hand, because off-site generation has no impact on consumers' reactive-to-active power consumption ratio, potential reactive power fees would not apply (see Appendix E).

Figure 6 | **Regulated Tariff Cost Components of Each kWh of Electricity Delivered to Customers from the Grid**



Generation (G)
Cost of producing energy using different sources (e.g., hydro, gas, diesel, coal, wind, solar).

Transmission (T)
Cost of transporting energy from the production sites to the edge of regional distribution networks or large consumption sites.

Distribution (D)
Cost of distributing energy from the edge of the regional networks to the final user.

Commercialization (C)
Cost of buying and selling energy—includes the costs of billing, meter reading, and customer service (among others).

Losses (L)
Disaggregated costs of energy efficiency losses incurred while transmitting energy to the final user.

Restrictions (R)
Costs that are created by network conditions such as congestion, which limit the system's energy transport capacity.

Note: Illustrative example of a company's electricity bill components
Source: Figure translated and adapted from CREG (2018c).

4. ENABLING ENVIRONMENT: RENEWABLE ENERGY CERTIFICATES AND RENEWABLE PORTFOLIO STANDARDS

Policy tools such as renewable energy certificate (REC) tracking systems[13] and renewable portfolio standards (RPSs) have successfully incentivized C&I RE investments around the world. In recent years, multiple major Colombian corporations (e.g., Bimbo, Makro) evidently have begun to see value in investing in RECs as they have contracted with an international organization that issues such certificates (EPM 2017). Moreover, Colombia's grid and MEM operator, XM, recently developed and launched its own REC certification, tracking, and retirement platform, thus the relevance of RECs in Colombia will likely grow over time.

4.1 Renewable Energy Certificates

Box 1 | Double Counting

Sometimes, the same renewable megawatt-hours can be incorrectly counted more than once. Whether deliberately or inadvertently, this wrongly gives the appearance that more renewable energy has been created and more fossil fueled electricity has been displaced than is the case. A strong renewable energy certificate (REC) system helps prevent double counting by closely tracking the "renewable attributes" of the electricity from its generation through its consumption (and the REC's "retirement").

A REC is a mechanism that separates the environmental attributes (e.g., avoided emissions, proof of "green-ness" of electricity's generation source) from the parallel electric power commodity, simultaneously produced. The two products, RECs and commodity electricity, can be verified and sold "bundled" together, or they can be sold separately ("unbundled") (Holt and Bird 2005). A REC tracking system (through a registry) provides independent validation that each REC generated is consumed only once (no matter how many times it is bought and sold) and is in fact from a renewable source. Market participants register to participate in an REC tracking system, and each REC (generally in megawatt-hour [MWh] units) receives an independent and unique serial number. This number is logged with the hour and date the REC's MWh was generated, along with attributes of the power plant that created the REC (e.g., wind, solar). Once a bundled REC's MWh has been consumed, the REC is "retired" and taken out of circulation. Buyers of unbundled RECs can simply retire their RECs independent of any power consumption.

The REC itself endures and its existence is noted in the tracking system even after it has been retired. This way, REC consumers can validate the quantity of renewable power they have used.

Some countries have a formal REC market where unbundled RECs are sold and bought by those seeking to claim RE generation's renewable attributes. The advantages of a formal REC market accrue to both RE power plant owners and RE consumers. Even if a genco doesn't have a signed PPA with a specific customer to buy the genco's RE MWh, the genco can sell its unbundled electricity on the standard open market. The genco can then secure additional revenue by selling its RECs separately on the REC market. Simultaneously, customers that have not signed a bundled PPA that covers 100 percent of their electricity can benefit by purchasing the most inexpensive generic power available, and then purchase separate unbundled RECs to claim that they are using RE power generation (Cory and Swezey 2007).

Historically, although Colombia has lacked an institutionalized market for REC trading, gencos have been able to generate validated RECs through a variety of international certification institutions, which customers in Colombia and other markets can buy. For example, "International REC (I-REC) Standard" is an international nonprofit service provider that has certified two hydropower generation plants and Colombia's first wind farm, Jepirachi. These three facilities are all owned by the Colombian genco Empresas Públicas de Medellín (EPM) and now generate I-RECs. By June 2017, 25 nonregulated customers were buying EPM's electricity exclusively bundled with I-RECs to validate the electricity's RE origins. EPM's list of bundled I-REC customers includes many companies prominent in Colombia such as Grupo Nutresa, Cartón de Colombia, Peldar, Bimbo, and Makro (EPM 2017).

In December 2020, Colombia's grid and wholesale electricity operator, XM, launched the country's first domestic REC registry and tracking system, called "EcoGox," which will allow gencos to apply to issue RECs for every unit of RE produced (EcoGox 2020).[14] These RECs will be tracked and transferred via an online platform, until they are retired and EcoGox issues the customer a redemption certificate (EcoGox 2020).

4.2 Renewable Portfolio Standards

With its September 2019 Resolution 40715, Colombia's Ministry of Energy and Mines (Ministerio de Minas y Energía; MME) mandated that by the end of 2022 all Colombian comercializadoras servicing the regulated market must meet an RE purchase quota, known as a Renewable Portfolio Standard (RPS).[15] Under the RPS, 10 percent of the electricity each comercializadora delivers to its regulated customers must come from long-term RE contracts with gencos. This RPS helped drive the success of Colombia's October 2019 RE auction, as it guaranteed comercializadoras would buy up to a certain level of RE being built.

The RPS currently has rules to govern which RE power plants can count toward compliance, and which ratepayers must meet the mandate. Comercializadoras do not receive any credit against their mandatory RPS when their customers use on-site solar. Therefore, the current RPS incentivizes comercializadoras to buy RE only from large solar and wind farms. Some RPS policies in other countries have a separate tier that requires the utility to purchase RECs (and sometimes electric generation) from behind-the-meter, customer on-site generation (Cory and Swezey 2007). By using an REC certification and tracking system, these countries also ensure that only those kWh from customers with on-site RE systems—that are compensated by the utility for their RECs—can be counted toward the RPS. Systems that are paid for and installed by customers without utility compensation are separate voluntary customer purchases that are above and beyond utility RPS mandates. Again, REC tracking systems ensure that each REC is consumed and retired only once.

Comercializadoras also do not receive RPS credit for any RE provided to nonregulated customers. Resolution 40715 states that at some point in the future MME may issue an RPS for the nonregulated market. Doing so would significantly increase comercializadoras' incentives for helping their nonregulated customers procure off-site RE PPAs.[16] However, MME has not expressed an intention to fulfill this mandate and expand the RPS in the near term.

5. AGGREGATED PROCUREMENT APPROACHES

Smaller customers can take advantage of economies of scale with an aggregated procurement approach, where multiple companies partner to procure power and environmental attributes as a group. Joining together for a group purchase helps to achieve economies of scale and harness cost reductions in prices offered by project developers. Another aggregated procurement approach is if one customer seeks to procure RE for multiple facilities across separate locations. Figure 7 shows the steps customers can take to enter into an aggregated procurement process.

A broad portfolio of projects may attract more competitive financing and thus lower the effective energy prices for participating buyers. When multiple creditworthy PV purchasers are pooled together to create a portfolio of projects much greater in scale than any one of the pooled projects, the risk to capital investors is diversified so transaction costs can be lowered. This can reduce the effective cost of capital and thereby positively impact the developer's project economics as well as increase the buyer's cost savings.

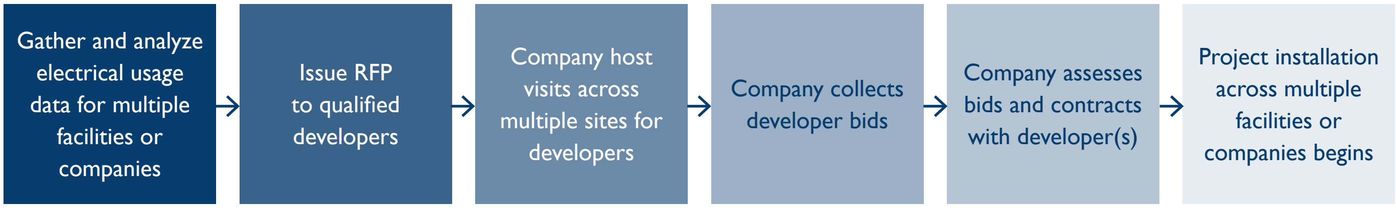
Aggregated procurement has been proven to be an effective model in the United States, Europe, and India with emerging efforts to replicate various approaches in other markets.

Extensive evidence globally demonstrates that larger C&I solar projects cost less per installed kW than smaller commercial and residential projects. These cost advantages have been tracked over time in the United States, with December 2019 calculations showing an average of 51.4 percent in cost savings for larger-scale (greater than 10 kW) C&I solar systems.[17]

CEIA is spearheading aggregated procurement approaches in Colombia as well as in Indonesia, Mexico, the Philippines, and Vietnam. In 2019, CEIA supported a major clothing chain in Mexico with an aggregated procurement of an off-site third-party PPA serving 75 facilities spread across 30 of Mexico's 32 states. The final negotiated PPA price offered a cost savings of more than 35 percent compared with their average annual electricity rates.

In 2018, CEIA initiated Colombia's first known aggregated solar procurement process together with ANDI, and several of its member companies from ANDI's "Large Energy Consumers Chamber" (Cámara de Grandes Consumidores de Energía). These companies collectively averaged 28,000 MWh of minimum consumption per month. CEIA narrowed the customer pool to companies that were interested in on-site solar systems and well-positioned to optimize this model's economic benefits by operating their businesses seven days a week. Through an RFP process, the buyers collectively sought solar bids for seven facilities averaging a total monthly

Figure 7 | **Key Steps for Customers to Take in Aggregated Procurement**



Note: Abbreviation: RFP: request for proposal.
Source: Authors.

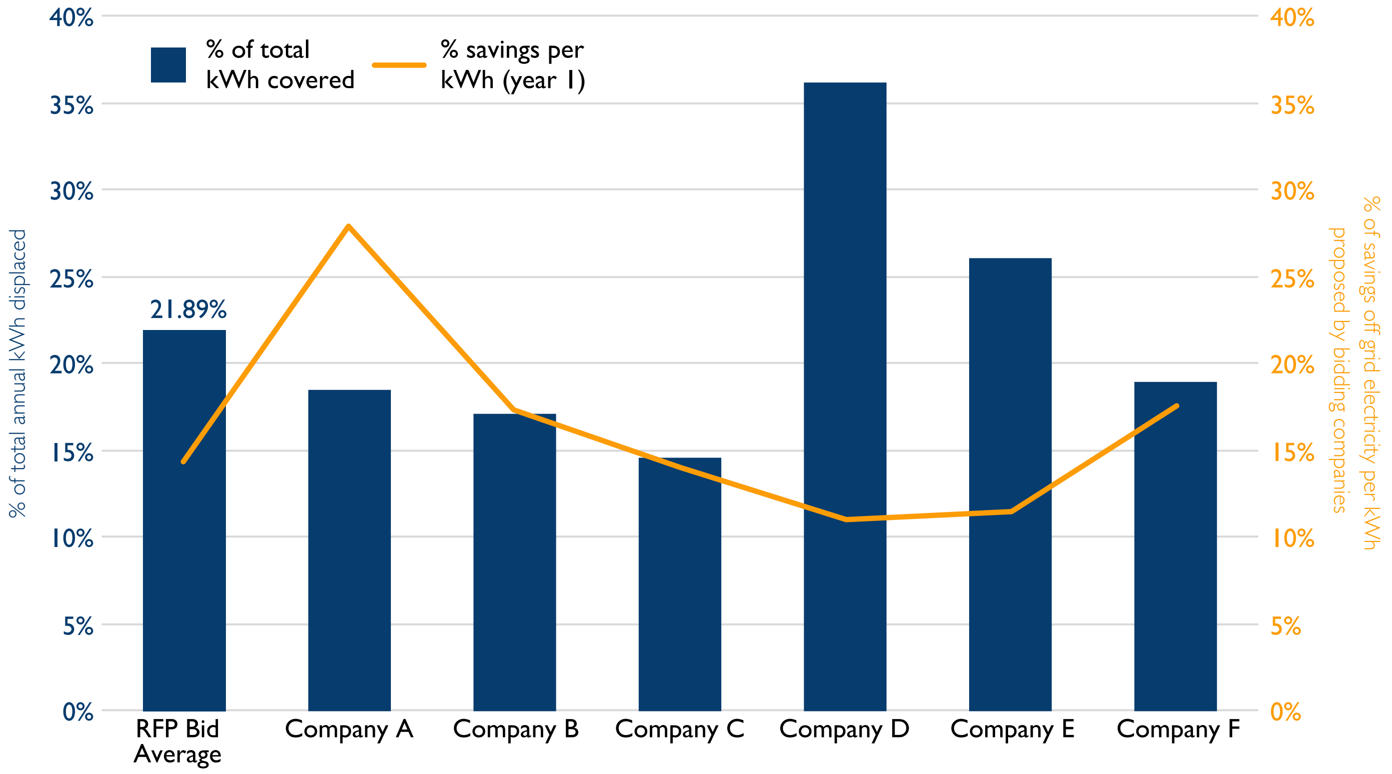
consumption of just over 8,000 MWh. Each of the most competitive bids proposed a portfolio of installations, which when aggregated totaled close to 5 MW of installed solar capacity averaging $0.098 per watt. These proposed prices were much lower than benchmark prices for smaller projects in Colombia.

Based on lessons learned from the first aggregated procurement process, CEIA, also in partnership with ANDI, issued an RFP in late 2019 on behalf of a second pool of four interested nonregulated customers for both on-site turnkey and on-site third-party PPA options across seven facilities. Results from the second RFP process (see Figure 8) highlighted key shifts indicating increasing development of the Colombia on-site solar market:

- Developers exhibited more robust experience implementing new RE projects in Colombia compared with previous limited regional experience.
- Shorter contract terms for PPAs, which are more attractive to buyers, were being offered, with an average term of 14 years and terms as short as 8 years.
- Developers offered an average cost savings of 14 percent for the buyer companies, further demonstrating the cost-competitiveness of RE in Colombia, even for projects smaller than 1 MW.

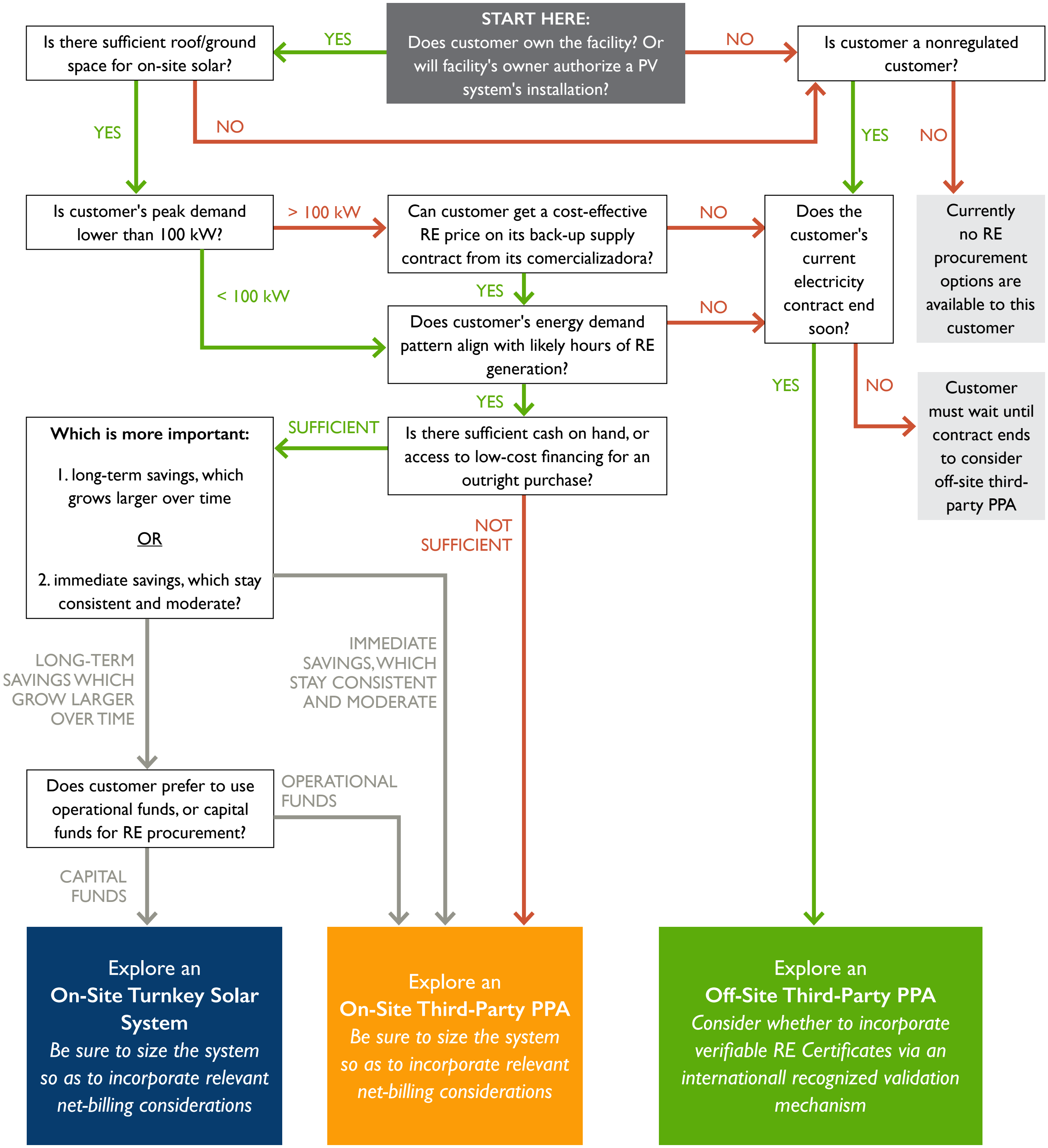
CEIA is continuing to explore ways to support additional buyers and market stakeholders in implementing and replicating aggregated procurement approaches for on-site and off-site RE in 2020 and beyond.

Figure 8 | **2019 CEIA RFP Bids' Proposed % of Electricity Displacement and % Price Savings per kWh**



Source: Authors.

Figure 9 | **Decision Tree for RE C&I Procurement in Colombia**



Notes: Abbreviations: PV: photovoltaic; kW: kilowatt; RE: renewable energy; PPA: power purchase agreement.
Source: Authors.

6. CONCLUSION AND NEXT STEPS

A combination of electricity market regulatory reforms, the global fall in RE costs and prices, and related factors have brought Colombia's renewables sector to a tipping point. C&I electricity customers are beginning to explore their renewable electricity options and Colombia's energy transition is well-positioned to scale up over the coming years. Our data and interviews show that, for many C&I customers, RE can provide significant cost savings over the short and long terms, while simultaneously supporting goals such as increasing sustainability, reducing pollution, and fighting climate change.

In the Colombian market today, three major procurement models are currently available to C&I customers: on-site turnkey purchases; on-site third-party PPAs or leases; and off-site third-party PPAs. The decision tree in Figure 9 can be a useful starting point to help companies determine which option is best positioned to meet their needs.

Considering their unique circumstances, electricity customers are likely to find that at least one option among the three models can result in economic benefits for them. With the support of this guidebook, interested customers are encouraged to begin exploring their options in the market and engage prospective vendors regarding the RE option that best fits their needs.

Steps to Move Forward with a C&I Customer's Preferred Option:

- For exploring on-site options, the checklist in Appendix A can help companies identify key questions to consider.
- For on-site turnkey purchases, companies should consult internally on the amount of investment they are able to invest in an RE system.
- For on-site or off-site PPAs, companies should consult their internal policy and legal teams on their eligibility to sign a long-term (10–20 year) PPA.
- For all three options, companies should consider developing and launching a competitive RFP that outlines the preliminary system and service requirements as well as desired contract terms.
    - The RFP should also articulate the bidding process structure and invite established local technology providers or RE developers to submit bids. CEIA has released an RFP template to support companies interested in customizing and replicating an aggregated RFP approach.
- Upon receiving bids, customers should do the following:
    - Enlist support from internal or external RE technical experts to assess the costs, services, and track records of the developers under consideration. CEIA's RFP template also includes bid evaluation guidelines and a scoresheet template to help companies assess the bids they receive.
    - Be clear as to whether O&M services will be included in the overall contract or obtained through a separate contract.
    - Estimate the expected net benefit compared with the status quo.
    - Work with a lawyer or the internal legal team to finalize contract terms that are acceptable for the buyer company.

To request more information on the contents of this guide, or to learn more about CEIA, visit **www.cleanenergyinvest.org.**

APPENDIX A. CHECKLIST OF KEY QUESTIONS WHEN CONSIDERING ON-SITE SOLAR

Solar PV costs have been dropping for years and continue to fall, so C&I facilities will increasingly have opportunities to save money by using on-site solar generation. The following checklist provides key questions for C&I facility operators to consider when exploring on-site solar options, which include but are not limited to questions regarding site ownership, physical characteristics of the site, operational practices, and access to financing. This checklist is not intended to be a comprehensive resource, but rather a high-level introduction to key factors that can impact whether or not C&I facilities meet the right conditions to explore cost-effective procurement of an on-site solar system.

C&I customers that decide that on-site solar may be of interest should review their answers to the following questions:

☐ Does the company own the facility or have a long-term facility lease?

☐ Does the company have space available on its roof for solar panels and/or sufficient land for a ground-mounted system to satisfy its desired generation level?

☐ Is the grid connection appropriate for the scale of PV system being considered?

☐ Is the roof structurally sound and will it be in place for the duration of the economic life of the PV system (typically 20–25 years)? If not, is the company willing to make the investment to make the roof structurally sound (cost varies by building)?

☐ Is the area where the solar panels would be located free of trees, walls, buildings, or other structures that would create shade?

☐ Does the site's operational schedule and electricity consumption generally align with daytime solar production?

☐ Does the company allow the use of an operational budget to lease equipment? Or does the company's budget allow for equipment to be purchased with a capital budget?

☐ *If the company is interested in a solar* PPA, could it sign at least a 10-20-year contract?

C&I customers that answer "yes" to all questions above are well positioned to consider installing an on-site PV system (turnkey or PPA). In that case, the next step would be to contact a solar energy expert to perform a more detailed technical and engineering feasibility assessment and launch a competitive RFP.

If the answer to some of these questions was "no," there may still be other beneficial RE procurement options. The following sections provide a deeper look at the considerations listed above and a more detailed explanation of financing options for on-site PV electricity in Colombia.

Facility Ownership

DIRECT OWNERSHIP OR FACILITY LEASE

Whether a facility operator owns or leases the building and land influences solar PV investment decisions. Landlords are sometimes not incentivized to invest in PV on behalf of their tenants if there is not a profitable investment or cost-saving opportunity for the owner. Generally, a company's ownership or long-term lease of land and buildings allows for easier decision-making when committing to an on-site PV investment or contract.

Action Items:

- Customers leasing their facilities should determine land and building leasing agreement conditions to see if the contract term is sufficiently long to enable a payback on the PV system (e.g., a facility lease of at least 15 years).
- Customers should explore whether the commercial landlord or industrial park would be interested in providing solar energy as an aggregated service to tenants. Joint ownership of the solar energy and shared savings could convince the landlord that the project makes sense.

Solar Site's Physical Characteristics

AVAILABILITY OF ROOF OR LAND SPACE FOR SOLAR PANELS

Solar PV systems require approximately five to six square meters of space for each kW installed. The system should be free from barriers and impediments such as walls, vents, skylights, air-conditioner equipment, and walkways that can make access for O&M either difficult or dangerous.

STRUCTURAL SOUNDNESS AND REMAINING LIFETIME OF ROOF

Prior to installing a rooftop PV system, a structural engineer must determine if the building's roof is structurally capable of holding approximately 10–15 kilograms per square meter, which is the general range of weight bearing load for solar panels and the mounting structure. This is usually done by the company installing the system. Additionally, because PV systems are designed to last 20–25 years, the building owner must determine the remaining lifetime of the current roof. If the building currently has an old roof in need of repairs or replacement, a PV system should not be installed until the repairs or replacement has been completed. A ground-mounted PV system could be a good alternative if there is sufficient space on the facility's property.

SHADING BARRIERS AND SUNLIGHT EXPOSURE

The optimal tilt and azimuth of a solar array's positioning are significantly site-dependent; nonetheless, a number of core principles generally apply. A PV system designed to maximize exposure to the sun should be tilted at about the same angle as the latitude of the installation site (about five degrees in most of Colombia). However, it is typically recommended that panels be installed at a tilt of 10–12 degrees to allow rainfall to trickle down the panels, and ease access to panels' back sides, reducing O&M costs.

To collect maximum sunlight during daylight hours, a PV system should face as close to true south as possible. The location where the PV system will be placed must be checked for shadows from trees, walls, or nearby buildings. Minimal shadows throughout daylight hours—particularly between 10 a.m. and 3 p.m.—is ideal. Obstructions casting shadows across a PV site are sometimes inevitable. In this case, a solar expert must execute a detailed analysis of sunlight time and direction in order to accurately estimate the shadows' impact on solar energy output. However, utilities might prefer that PV systems face southwest or west to optimize the use of daylight in the later afternoon and early evening hours when energy use is at its peak (Wald 2014). And there are some larger systems that face southeast or east in order to fit more panels on the same land and be paid more under the right market conditions (Stoker 2018).

Action Items:

- Customers considering a rooftop installation must ensure the PV provider conducts a structural engineering assessment before starting installation. This may require both a professional engineer stamp and signature by the local government's building department.

- Project engineers should check for shade from trees or other structures that might impact solar energy production—considering plans for future building construction is also important to, for example, make sure that sunlight potential will not be affected.

Building Operations

OPERATIONAL SCHEDULE AND ELECTRICITY CONSUMPTION PATTERNS

PV systems can typically generate electricity every day of the year. However, production varies based on both weather and other conditions, and tends to be greatest midday when sun exposure is most direct. A PV system should be designed so that the building directly consumes as much solar electricity as possible. Does the business operate on a year-round basis? Does its electricity demand remain stable day to day, or does it often fluctuate? Businesses and facilities that do not operate year-round, or that have long periods of very low electricity consumption, might not be suitable for an on-site PV system. However, this depends in part on current net-billing policies.

COMPANY'S OPERATIONAL FUTURE

PV systems are designed—and PV panels are typically warrantied—to generate electricity for 25 years or more. If a company is going to invest in solar assets or is considering an on-site PPA, the PV system should be used for as long as possible. As a rule of thumb, if a business may move locations in less than six years, pursuing an on-site PV system may not be an optimal choice. However, on-site solar may be considered a strong selling point when placing facilities on the market, and could help attract interested buyers, due in part to lower operating costs.

Action Items:

- Customers should work with an energy manager or other expert to analyze utility bills, ideally looking at average use over the past two years to understand daily, seasonal, and annual electricity consumption patterns. The tariff structure should also be examined (e.g., special utility offerings, capacity charges, reactive energy charges).
- Customers should meet with their chief operations officer to discuss operational horizons, and whether the company intends to stay in its current facility for at least six years. If the company intends to move, potential contingencies can be explored.

BUSINESS AND FINANCING COMPANY'S INVESTMENT POLICY

As of 2018, Colombia C&I PV energy users typically have a capital investment payback period of between 4 and 10 years.[18] Some companies have guidelines mandating that new capital investments must have a payback period of three years or less. Other companies have no such requirements, but simply prefer not to invest their own capital in solar assets. In both of these cases, it is advisable for such companies to consider third-party solar service contracts (PPAs/leases/rentals) in which the C&I customer is not required to commit a capital outlay for the solar assets but can reduce marginal electricity costs immediately. Typically, solar vendors require electricity consumers to sign a contract for multiple years—oftentimes a minimum of 10 years and sometimes up to 20 years. C&I customers that are not able to sign a long-term contract may find it difficult to find a solar vendor that will provide the solar service PPA.

Action Items:

- Companies should consult with their chief financial officer to determine whether they have payback-period requirements that would limit a turnkey capital investment. Alternatively, companies should explore with their legal department whether they can sign PPA contracts with a typical minimum length of 10 years.

APPENDIX B. INSTALLED C&I PROJECTS LARGER THAN 400 KW

Table A1 shows the proliferation of RE projects larger than 400 kW since 2016, with nearly a dozen projects having been commissioned by December 2019. Dozens more projects are anticipated over the next few years, and RE deployment must scale even more rapidly to meet the Colombian government's RE goals over the coming decade.

Table A1 | **RE Projects above 400 kW Commissioned in Colombia**

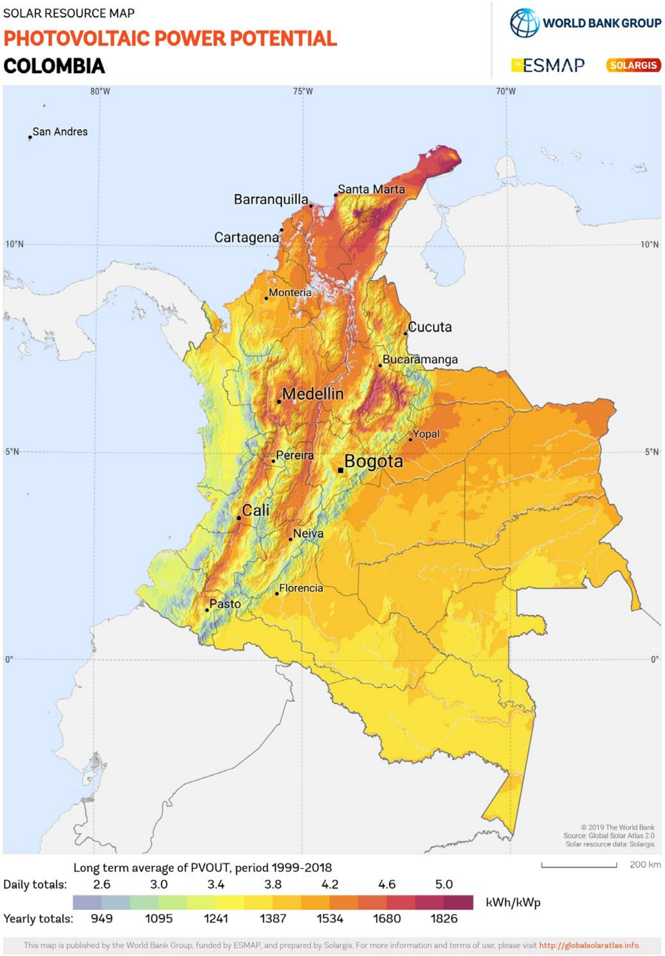
YEAR	PLANT NAME	DEVELOPER	PLANT PURPOSE	GENERATION SOURCE	PLANT SIZE
2004	Jepirachi[a]	EPM	Sell to utilities	Onshore wind	19.50 MW
2017	Yumbo[b]	Celsia	Sell to utilities	Solar PV	9.80 MW
2017	Tecnoglass[c]	Panasonic LA	Self-generation	Solar PV	2.47 MW
2017	International Center for Tropical Agriculture[d]	Celsia	Self-generation	Solar PV	0.90 MW
2017	Proyecto Urab^{a}e	SolarGreen SAS	Self-generation	Solar PV	0.50 MW
2017	Autonomous University of the West at Cal^{i}f	Celsia	Self-generation	Solar PV	0.40 MW
2018	Celsia Solar Bolívar[g]	Empresa de Energía del Pacífico SA ESP	Sell to utilities	Solar PV	8.06 MW
2018	Compañia Nacional de Chocolates[h]	Celsia	Self-generation	Solar PV	2.13 MW
2018	Cartagena de Indias Convention Center[i]	Celsia	Self-generation	Solar PV	0.44 MW
2018	Instalación Medellín – Antioqui^{a}j	SolarGreen SAS	Self-generation	Solar PV	0.42 MW
2019	El Paso[k]	Codesa - Enel Green Power	Sell to grid	Solar PV	86.20 MW
2019	ECOPETROL[l]	AES Colombia	Self-generation	Solar PV	21.00 MW
2019	Bogotá Airport[m]	Celsia and Odinsa	Self-generation	Solar PV	2.80 MW
2020	Celsia Solar Espinal[n]	Celsia	Sell to grid	Solar PV	9.90 MW
2020	Khiron Life Sciences[o]	ReFeel	Self-generation	Solar PV	1.00 MW
2020	Parque Solar Bosques de los Llanos 1[p]	Trina Solar	Sell to grid	Solar PV	27.23 MW

a. The Wind Power 2019.
b. Zlatoper 2019.
c. MME 2017.
d. Celsia 2017b.
e. Solar Green 2017.
f. Celsia 2017a.
g. Power Colombia 2018.
h. Ojeda 2017.
i. ICCA 2018.
j. Solar Green 2018.
k. ANDESCO 2019.
l. Morais 2019.
m. Odinsa 2018.
n. XM 2020a.
o. Forbes Colombia 2020.
p. Dinero.com 2020.

APPENDIX C. COLOMBIA SOLAR AND WIND RESOURCE MAPS

Colombia is well-positioned to rapidly scale up its RE market due to the country's strong resource potential. Colombia has tremendous solar resources (as seen in Figure A1), as large areas of the country are characterized by high exposure to the sun and high altitudes. The country also has significant wind resources. Colombia's northeast Caribbean coast, and its Andean mountain spine starting in the southwest near the Pacific coast (as seen in Figure A3) represent potentially highly productive sites for erecting wind turbines. This, along with the country's expansive electricity grid (as seen in Figure A2), would more easily allow for the interconnection of RE assets.

Figure A1 | **Colombia's Solar Resources**

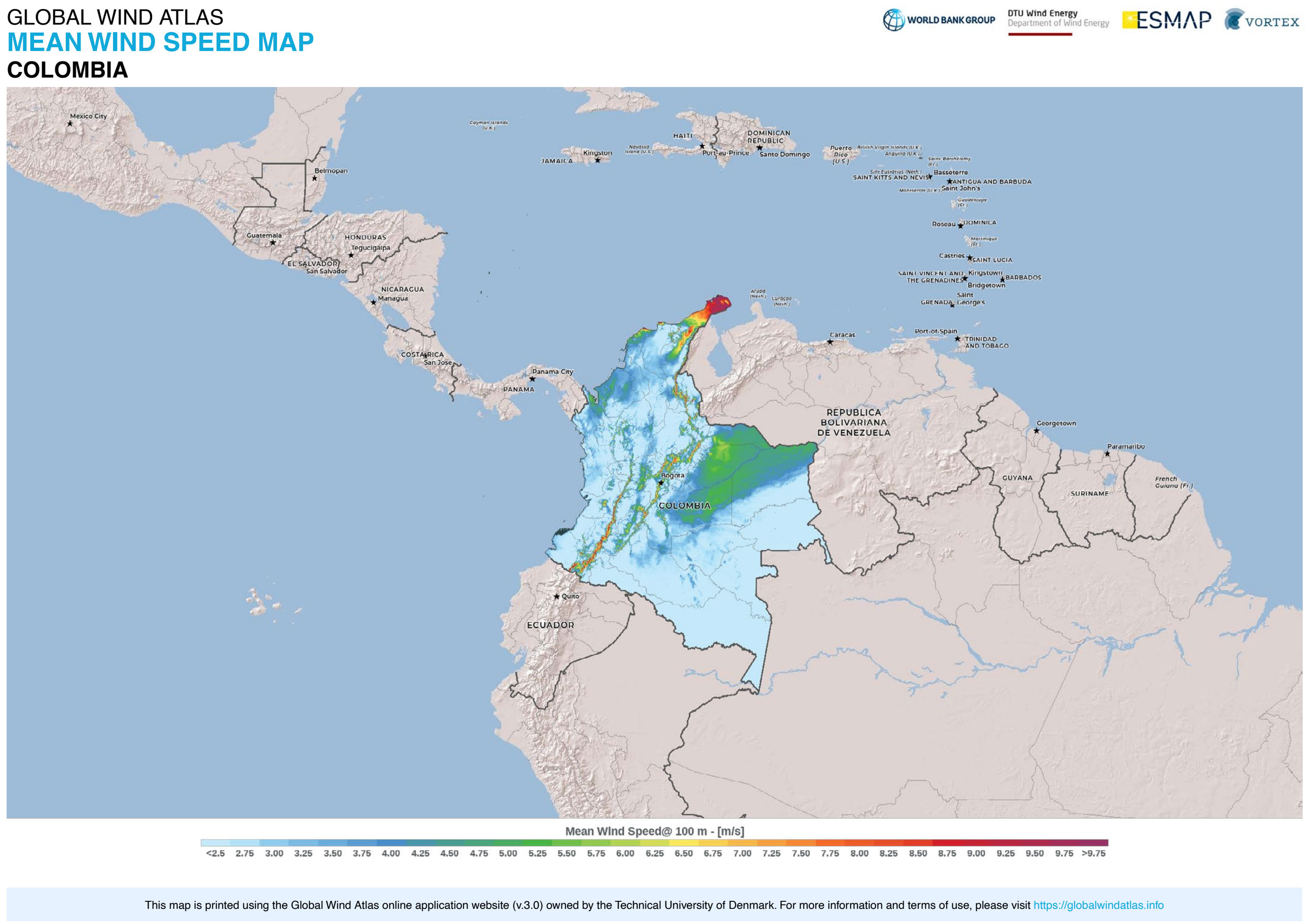


Source: World Bank Group et al. 2019.

Figure A2 | **Colombia's Electricity Grid**

Source: GENI 2020.

Figure A2 | **Colombia's Wind Resources**



This map is printed using the Global Wind Atlas online application website (v.3.0) owned by the Technical University of Denmark. For more information and terms of use, please visit https://globalwindatlas.info

Source: NREL and USAID n.d.

APPENDIX D. NET BILLING IN COLOMBIA

All on-site RE generation systems in Colombia are eligible for net billing. This is a process whereby, if the PV system is large enough, whenever the solar system is generating more electricity than the C&I customer is consuming, the excess generation can be pushed to the grid. The customer's retail energy supplier, its comercializadora, receives this renewable electricity, and in exchange compensates the customer with "credits" (in some cases, C&I customers with demand of 5 MW or more can sell their excess to other market actors for cash).

The level of compensation or value of the energy credit is determined through a complex set of formulas.[19] In general, credits from systems of 100 kW or smaller are worth more than those from systems larger than 100 kW. However, even excess-energy credits from the same PV system can be worth varying amounts at different times. Energy credits for solar kWh that a small customer pushes to the grid, up to and equal to the number of kWh the customer pulled from the grid that month, are worth about 85–90 percent as much as it costs the customer to buy a kWh from its retail electricity supplier. However, the customer receives very little compensation for each additional solar kWh beyond the number of kWh the customer has consumed from the grid. Moreover, no energy credit is ever worth more than the customer's retail cost to buy a kWh from the grid. Table A2 summarizes the official net-billing compensation regime.

Table A2 | **Compensation for C&I Net Billing**

MONTHLY NET-BILLING REMUNERATION			
SOLAR GENERATION SYSTEM SIZE		**FOR EACH EXCESS SOLAR KWH, LESS THAN OR EQUAL TO # OF KWH PULLED FROM GRID**	**FOR EACH EXCESS SOLAR KWH, GREATER THAN # OF KWH PULLED FROM GRID**
≤ 100 kW	"Small-scale self-generation"[a]	• Comercializadora must buy customer's excess at retail price ***minus*** the commercialization costs • = 85–90% of retail electricity price	Hourly generation-only wholesale market price or spot price
101 kW–1 MW	"Small-scale self-generation"[b]	• Regulated customers: Generation-only price • Nonregulated customers:Value negotiated with comercializadora • = 30–40% of retail electricity price	Hourly generation-only wholesale market price or spot price
1–5 MW	"Large-scale self-generation"[c]	Same as for "small-scale self-generation"	Same as for "small-scale self-generation"
5 MW–<10 MW	"Generation with minor plants"[c]	**Customer's Choice:** • Sell directly to a comercializadora at hourly generation-only spot price **or** in the course of public auctions[d] —OR— • Sell to multiple buyers at negotiated prices	
10 MW–<20 MW[e]	"Generation with minor plants"[f]	**Customer's Choice:** • Use central dispatch and sell excess generation for set one-day PPA on the Bolsa, one day in advance —OR— • One of the three options open to 5–<10 MW self-generation	

Notes:

[a] CREG Resolution 030 of 2018, Article 17.

[b] CREG Resolution 030 of 2018, Article 17

[c] CREG Resolution 086 de 1996, Article 3.

[d] The public auction (or "public call") mechanism is detailed in CREG Resolution 020 of 1996, Article 5.

[e] CREG Resolution 024 of 2015, Article 12.

[f] CREG Resolution 086 of 1996, Article 3.

Sources: CREG 1996, 2015, 2018b.

Figure A4 helps illustrate how the electricity produced by an on-site solar system is more valuable when immediately consumed on-site (in real time) than any excess electricity production that is sold onto the grid. The figure shows the electricity consumption pattern for a commercial facility with an on-site solar 75 kW "small-scale self-generation" system. On an average day, in this illustrative example, the solar system produces 636 kWh, 536 of which are used in real time on-site. That leaves 100 kWh of excess solar generated throughout the day, which is pushed to the grid if it isn't immediately consumed. Additionally, though, throughout the night the facility pulls 100 kWh from the grid.

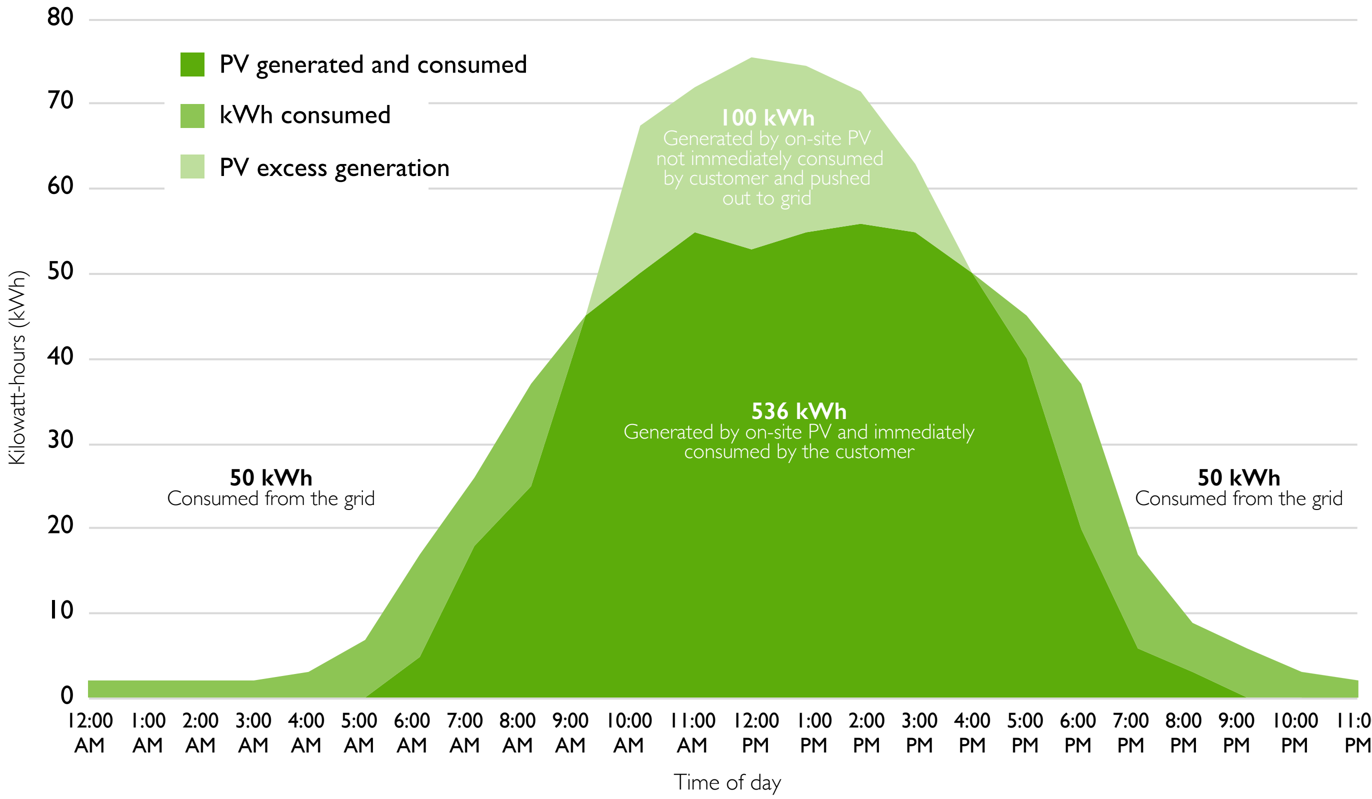
At the end of the day, the facility is technically energy neutral, as the solar has produced the same number of kWh as have been consumed on-site. However, the consumer's compensation for each excess kWh pushed to the grid is always lower than the amount of money it must pay its comercializadora for each kWh it pulls from the grid.

In this example, the consumer has a small-scale self-generation (smaller than 100 kW) PV system and consumes 100 kWh from the grid. Therefore, the consumer may effectively sell up to 100 excess solar kWh to the grid at the retail price of electricity, minus the commercialization cost (about 10–15 percent of the retail price).

Whenever the consumer generates more solar kWh than it pulls from the grid though, it receives an even lower price for its additional kWh. In this example, suppose the consumer pushes 125 solar kWh to the grid, and still pulls only 100 kWh from the grid. The consumer still receives a price of retail minus 10–15 percent for the first 100 kWh. But for each of the additional 25 kWh, the consumer only receives a price equal to the spot price on the wholesale market for 1 kWh of electricity generation. This can equal anywhere from 30 to 50 percent of the commercial retail price.

It is important to remember that the compensation scenario depicted above applies only to customers with small-scale self-generation systems. For customers whose systems are larger than 100 kW, unless negotiated otherwise with their comercializadora, compensation for almost all of their excess solar kWh will only be equal to the cost of generation.

Figure A4 | **Example of Daily Grid Consumption, Instant PV Self-Consumption, and Excess PV Pushed to the Grid**



Notes: Abbreviations: PV: photovoltaic.
Source: Authors.

APPENDIX E. MITIGATING EXCESSIVE REACTIVE POWER FEES

In December 2019, CREG implemented Resolution 199 of 2019 as an amendment to its January 2018 Resolution 015 of 2018, Chapter 12 (CREG 2018a, 2019b). This new amendment could have important cost implications for large energy users that consume significant amounts of electricity to power motors and want to invest in on-site solar. However, cost-effective mechanisms exist that a potential on-site solar customer could implement, in collaboration with a prospective solar PV developer, to mitigate such a regulatory challenge.

The vast majority of electricity loads consume "active" power. In contrast, "reactive" electricity (which accounts for only 10–20 percent of all power delivered in an electric grid) is used specifically to power motors and is thus essential for industrial purposes. Most governments globally require utilities to deliver a certain percentage of their power as reactive power, which is measured in kilo volt-amps reactive (kVar) or kilo volt-amp reactive hours (kVarh), while simultaneously permitting the utilities to charge only for active power (measured in kW or kWh). However, some electricity regulators, like Colombia's, authorize utilities to charge customers for reactive power.

When utilities charge for reactive power, it is normally at a very low rate or limited to when reactive power makes up a certain percentage of a customer's total power consumption. Currently in Colombia, customers pay nothing for their reactive power if their reactive kVarh are below a certain level in relation to their kWh of active power consumption in a given month. This maximum ratio of kVarh to kWh (often between 30 and 40 percent) is set monthly by Colombia's utility regulator for each customer's specific distribution network. Any time customers cross this maximum ratio, they must pay a fee for each additional kVarh. Typically, this fee is minimal for major industrial consumers (equivalent to $0.50–$3.00 per month).

With the new regulations (CREG 2018a, 2019b), if a customer installs an on-site PV system that lowers its active power kWh drawn from the grid, while the number of kVarh remains steady, the customer's kVarh/kWh ratio may increase significantly. Moreover, if this ratio exceeds 50 percent in any 10 days of a month, for each of 13 consecutive months, the customer's kVarh charges multiply every month. In month 13 the charges double, then triple, then quadruple, and multiply every month until the customer is charged 12 times its original monthly per-kVarh charge. In an illustrative scenario, an industrial customer that installs on-site PV to generate 20 percent of its kWh consumption could see its monthly reactive power fees increase in two years from $2.90 to over $24,000 every month.

Customers can eliminate or significantly reduce these charges by proactively pursuing the following cost-effective actions:

- **Investing in more modern, energy-efficient equipment.** Oftentimes, high kVarh consumption is caused by a customer's machinery being antiquated and inefficient. A factory that invests in machinery upgrades can lower both its kWh and, disproportionately, its kVarh consumption. This saves on kWh costs and reduces the chance for kVarh ratio penalties. Newer equipment may also increase throughput of the final product as well.
- **Installing capacitors.** Capacitors are equipment that can convert active power into reactive power. A factory with capacitors can increase the number of kWh it draws from the grid (which the capacitor changes to kVar for the factory's machines), while dramatically lowering the kVarh. This rebalances the customer's kVarh/kWh ratio and eliminates the customer's risk of incurring excessive reactive power fees.

APPENDIX F. KEY LEGISLATION, REGULATIONS, AND POLICIES

AGENCY	TITLE	DESCRIPTION
GoC	Law 142 of 1994	Reformed Colombia's energy market. Established WEM and independent market operator. Established the general regulations for electricity service provision to users.
GoC	Law 143 of 1994	Deregulated the energy market, in part by dismantling the vertical integration of monopolistic entities and introducing competition sector-wide. Established regimes for electricity generation, transmission, distribution, and commercialization activities.
CREG	Resolution 86 of 1996	Established sales and dispatch mechanisms for "small generators" with installed capacity of less than 20 MW.
CREG	Resolution 128 of 1996	Established the participation limits (in terms of market share) for market actors in generation, distribution, and commercialization.
CREG	Resolution 131 of 1998	Established nonregulated market users connected to the National Interconnected System and set the conditions for their participation.
CREG	Resolution 071 of 2006	Established remuneration methodology and other rules for reliability charges and firms' energy obligations in the WEM.
MME	Order 2469 of 2014	Established guidelines for the delivery to the national grid of self-generated surpluses.
GoC	Law 1715 of 2014	"The Renewable Energy Law" established mechanisms for use and integration of renewable self-generation into the national grid.
MME	Decree 2143 of 2015	Established guidelines for the application of RE incentives including the removal of import tariffs on renewable generation equipment, a 50% income tax credit, accelerated asset depreciation, and VAT exemption to promote investment.
CREG	Resolution 024 of 2015	Established conditions for "large self-generators" to connect to, and gain access to, the national grid for backup generation.
UPME	Resolution 0281 of 2015	Set limit definitions for "small-scale" (<100 kW) self-generation.
MME	Decree 348 of 2017	Established guidelines for small-scale PV self-generation, including for net billing.
CREG	Resolution 015 of 2018	Set remuneration framework for excess electricity distributed to the grid by self-generators.
CREG	Resolution 030 of 2018	Established conditions for grid integration, connection, and measurements for small-scale and large-scale (1–5 MW) self-generators.
CREG	Resolution 114 of 2018	Authorized independent third parties to create new energy sales mechanisms.
CREG	Resolution 40791 of 2018	Set implementation mechanisms to promote long-term (10-, 15-, or 20-year) PPAs.
CREG	Resolution 40795 of 2018	Set implementation mechanisms to promote long-term (10-year) PPAs. Directs UPME to publish RE auction regulations.
CREG	Resolution 199 of 2019	Added details to implementation of reactive power fees.
MME	Resolution 49715 of 2019	Mandated that comercializadoras procure at least 10% of the energy they sell to regulated customers from solar, biomass, micro-hydro, wind, or tidal power.

Notes: Abbreviations: GoC: gobierno de Colombia (government of Colombia); CREG: Comisión de Regulación de Energía y Gas (Commission for the Regulation of Energy and Gas); MME: Ministerio de Minas y Energía (Ministry of Energy and Mines); WEM: Wholesale Electricity Market; MW: megawatt; VAT: value added tax; kW: kilowatt; PV: photovoltaic; PPA: power purchase agreement; UPME: Unidad de Planeación Minero Energética (Mining and Energy Planning Unit).
Source: Authors.

ENDNOTES

1. In Colombia, on-site turnkey purchases are also commonly referred to as engineering, procurement, and construction (EPC) purchases.

2. Based on CEIA reviews of dozens of actual bids submitted in response to requests for proposals, issued in 2018 and 2019 on behalf of multiple C&I scale consumers, for on-site renewable generation.

3. To download a copy of the CEIA RFP template, visit https://tinyurl.com/CEIA-RFP-Template.

4. "Long-term" contracts in Colombia hold "periods of greater than or equal to . . . ten (10) years" (MME 2019).

5. Colombia's heavy dependence on hydroelectricity creates operational cost risk for businesses, as during low-rainfall years, fossil fueled generation has historically covered the shortfall, but at much higher prices (Mancero 2016).

6. See Appendix B for a list of Colombia's major solar and wind installations that have been commissioned through August 2020.

7. Net billing is very similar to the more commonly used term net metering. According to the Clean Energy Solutions Center, "The primary difference between net-billing and net metering is that there are differing rates used to value the excess energy fed into the grid and energy received from the grid under net-billing," whereas, under net metering, the compensation received for excess kWh pushed to the grid is equal to the retail electricity rate. See Clean Energy Solutions Center. n.d. "Net Metering and Net Billing." https://cleanenergysolutions.org/instruments/net-metering-net-billing.

8. Multiple Colombian C&I customers that purchased PV systems have said this to CEIA staff.

9. These are simplified explanations of the text in Colombia's Law 1715 of 2014 (GoC 2014). However, before taking any action on taxes along these lines, a company must consult a certified accountant or other tax expert.

10. Depending on the extent to which a company can avail itself of the tax incentives, CEIA's cash flow analysis shows that companies can begin to see net positive returns in four to six years.

11. This is a simplified explanation of the text in Colombia's Law 1715 of 2014, Articles 11 and 14, and Chapter II (GoC 2014). However, CEIA does not give tax advice; before taking any action on taxes along these lines, companies must consult a certified accountant or other tax expert.

12. The MEM is divided into two major components: the short-term spot market, the Bolsa; and the long-term, bilateral contracts market for nonregulated users, the Mercado de Contratos Bilaterales de Largo Plazo (Superintendencia n.d.).

13. For more information, see Lau, C., and J. Aga, 2008, Bottom Line on Renewable Energy Certificates (Washington, DC: World Resources Institute), https://www.wri.org/publication/bottom-line-renewable-energy-certificates; and for more details, see U.S. Environmental Protection Agency, n.d., "Renewable Energy Tracking Systems," https://www.epa.gov/greenpower/renewable-energy-tracking-systems.

14. Each EcoGox REC will include the following: the name of the generator; generator technology; REC serial number, entry date of operation; installed capacity of the generator in MW; quantity of monthly energy generated in kWh; month and year of generation; if the generator is participating in carbon offset markets; community social impacts; a QR (Quick Response) code to verify the existence of the certificate on the platform; and logos of EcoGox and the generator (EcoGox 2020).

15. Adhering to an RPS means a company must have documentation that a given percentage or more of the kWh of its electricity (in the case of a comercializadora, the kWh it sells) is derived from RE generation sources. Under Colombia's new 10 percent RPS, hydro-generation of any scale does not qualify.

16. For more information, see MME (2019).

17. Modeled U.S. national average installed system costs for the third quarter of 2019. Residential (0–10 kW) = $2.84 per watt. C&I ("non-residential") (10 kW–2 MW) = $1.38 per watt (Perea et al. 2019).

18. According to project developers who have spoken with CEIA.

19. The specific formulas are outlined in three Colombian government regulatory documents: CREG Resolution 015 of 2018, which was updated with amendments in CREG Resolution 036 of 2019 and CREG Resolution 030 of 2018 (CREG 2018a, 2018b, 2019a).

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