COLUMBIA | SIPA
Center on Global Energy Policy

THE ROLE OF CORPORATE RENEWABLE POWER PURCHASE AGREEMENTS IN SUPPORTING US WIND AND SOLAR DEPLOYMENT

BY JAMES KOBUS, ALI IBRAHIM NASRALLAH, AND JIM GUIDERA

MARCH 2021

ABOUT THE CENTER ON GLOBAL ENERGY POLICY

The Center on Global Energy Policy at Columbia University SIPA advances smart, actionable and evidence-based energy and climate solutions through research, education and dialogue. Based at one of the world's top research universities, what sets CGEP apart is our ability to communicate academic research, scholarship and insights in formats and on timescales that are useful to decision makers. We bridge the gap between academic research and policy — complementing and strengthening the world-class research already underway at Columbia University, while providing support, expertise, and policy recommendations to foster stronger, evidence-based policy. Recently, Columbia University President Lee Bollinger announced the creation of a new Climate School — the first in the nation — to tackle the most urgent environmental and public health challenges facing humanity.

Visit us at www.energypolicy.columbia.edu

@ColumbiaUEnergy

ABOUT THE SCHOOL OF INTERNATIONAL AND PUBLIC AFFAIRS

SIPA's mission is to empower people to serve the global public interest. Our goal is to foster economic growth, sustainable development, social progress, and democratic governance by educating public policy professionals, producing policy-related research, and conveying the results to the world. Based in New York City, with a student body that is 50 percent international and educational partners in cities around the world, SIPA is the most global of public policy schools.

For more information, please visit www.sipa.columbia.edu

COLUMBIA | SIPA
Center on Global Energy Policy

THE ROLE OF CORPORATE RENEWABLE POWER PURCHASE AGREEMENTS IN SUPPORTING US WIND AND SOLAR DEPLOYMENT

BY JAMES KOBUS, ALI IBRAHIM NASRALLAH, AND JIM GUIDERA

MARCH 2021

Columbia University CGEP
1255 Amsterdam Ave.
New York, NY 10027
energypolicy.columbia.edu

@ColumbiaUenergy

ABOUT THE AUTHORS

James Kobus is a research analyst at LNZ Capital LP, where he focuses on investments in the power and clean technology industries. Prior to his work at LNZ Capital, James was a research assistant at the Columbia SIPA Center on Global Energy Policy. James has also worked as a power sector investment analyst at both The D. E. Shaw Group and Morgan Stanley. Through his work at GreenMax Capital Advisors, James has contributed to international development finance efforts including the World-Bank-funded Regional Off-Grid Electrification Project, aimed at scaling the off-grid solar market in West Africa. James holds a master of international affairs from Columbia SIPA, with a concentration in energy and environmental policy. He also holds a bachelor's degree from the University of Michigan, where he studied finance and philosophy.

Ali Nasrallah graduated from Columbia University with a master of public administration in development practice, where he focused on renewable energy and climate change. He also received a bachelor's degree in electrical engineering from the University of Jordan in Amman. Ali has worked in the energy industry in different roles with the private sector, business associations, academia, and as a consultant for public agencies. His experience spans regions such as the Middle East, Africa, South America, and North America.

Jim Guidera has been an adjunct professor of international energy project finance at Columbia SIPA since 2014. He has had a long career as an energy banker, including 20 years as the project finance group head at Credit Agricole CIB in New York, a leading lender to renewables and other energy projects in the North American market. He continues to consult on energy financing though Ghent Associates LLC.

ACKNOWLEDGMENTS

The authors would like to thank several anonymous reviewers who provided useful comments and feedback. The authors would also like to acknowledge Dr. Melissa Lott, Matthew Robinson, Christina Nelson, and Sarah La Monaca for their overall guidance and contributions to this paper. Finally, the authors would like to thank the numerous renewables PPA market participants and analysts whose input informed this study.

This policy paper represents the research and views of the authors. It does not necessarily represent the views of the Center on Global Energy Policy.

The paper may be subject to further revision. This work was made possible by support from the Center on Global Energy Policy. More information is available at https://energypolicy.columbia.edu/about/partners.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

In recent years, many of the world's biggest corporations, including Google, Facebook, Microsoft, and Apple, have pledged to power their businesses with increasing amounts of renewable energy in order to reduce their carbon footprints and contribute to efforts to address climate change. Such efforts have had an encouraging impact on US power sector decarbonization, with a material and increasing share of US wind and solar deployments now driven by the procurement preferences of corporate customers. The vast majority of corporate procurement of renewable energy has been secured via power purchase agreements (PPAs).

Going forward, a wider universe of companies is expected to look to such PPA agreements as a means of contributing to a low-carbon future, raising the question of how substantial these initiatives might be in supporting the overall transition to zero-carbon electricity. Indeed, a number of positive underlying trends are likely to facilitate continued growth in the corporate renewables PPA market. For example, electricity demand in the technology sector continues to grow rapidly, while renewables PPA penetration in the commercial and industrial sectors more broadly remains low, with room to grow. Additionally, expectations of continued declines in the costs of solar and wind technologies are likely to facilitate more procurement. Lastly, US companies are facing increased pressure from customers, employees, and institutional investors to improve their greenhouse gas emissions profiles.

At the same time, certain factors may constrain the size of the PPA market, such as market regulations that limit the feasibility of PPAs in certain regions and the need for renewable PPA prices to be competitive relative to wholesale power prices. Scale and creditworthiness requirements can also limit the universe of potential corporate buyers, and the financial risks brought about when signing long-term contracts may further deter some market participants. Finally, companies increasingly have alternative emission reduction mechanisms at their disposal, such as renewables energy credits (RECs), carbon offsets, and green tariff programs.

This student-led paper, from the Power Sector and Renewables Research Initiative at Columbia University's Center on Global Energy Policy, explores the drivers influencing the renewables PPA market and assesses whether these procurement initiatives by nonutility corporations are likely to continue growing in the United States at a rapid enough pace to support power sector deep decarbonization goals. The analysis finds that while robust private sector participation in recent years has been encouraging, the potential market size going forward may be smaller than previously projected, highlighting the need for comprehensive policy frameworks to support power sector decarbonization.

More specifically, the findings are as follows:

- **Under current policy conditions, the corporate renewables PPA market could drive between 218 and 296 TWh of demand equating to 55–85 GW of incremental solar and wind capacity additions in the United States through 2030 across**

three scenarios. While this range implies significant growth, the base case scenario suggesting additions of around 70 GW is below other projections and implies that recent procurement rates could slow.

- **These results, showing a wide range of potential outcomes and the possibility that PPAs may not drive as much renewable capacity additions as has been projected by other organizations, highlight the risk in overreliance on private sector actors to voluntarily address unpriced greenhouse gas externalities.** While renewables costs have fallen dramatically in recent years and the actions of many large US corporations have led to significant additions of zero-carbon generation resources, the market may not be deep enough to sustain its recent pace of annual procurements without further policy incentives.
- **More comprehensive policy frameworks are needed if US policy makers wish to achieve the rapid growth in renewable electricity that is needed to support broader decarbonization of the nation's economy.**[1] Effectively designed decarbonization policies could drive greater growth from traditional sources of renewable energy demand (e.g., utilities) while also making emissions reduction initiatives a more straightforward business decision for corporations. These could include federal carbon pricing, clean electricity standards, increased research and development (R&D) spending, green infrastructure investment, and the extension of federal tax credits. Initiatives to expand zero-carbon targets, corporate green tariff offerings, and firm REC values at the state and regional level could also accelerate renewable adoption.
- **The US corporate PPA market has been impacted by the COVID-19 pandemic, with some projects facing supply chain disruptions, financing bottlenecks, and higher offer prices.** As a result, 2020 renewables PPA transactions tracked below 2019 levels. It remains to be seen whether the pandemic will have any long-term impacts on corporate procurement initiatives.

A. BACKGROUND

The Intergovernmental Panel on Climate Change estimates that, relative to 2010 levels, a 45 percent reduction in net carbon dioxide (CO_2) emissions is needed by 2030 in order to limit global temperature rises to 1.5°C. Over the same period, a 25 percent reduction in emissions is required to keep the world on track for a 2.0°C increase.[2] The US power sector has made significant progress toward these targets, with 2018 CO_2 emissions having declined about 21.5 percent compared to 2010 levels.[3] This reduction has been largely due to reductions in coal power and switching to natural gas for power generation, and an increased use of renewables. However, economy-wide progress toward emissions reductions has been much slower, decreasing by roughly 6.5 percent from 2010 to 2018.[4]

Decarbonization scenario projections typically include increased levels of end-use electrification (e.g., of cooking, driving, and space heating and cooling) in parallel with the decarbonization of power sector supply. For example, in 2019, Evolved Energy Research (EER), in partnership with the UN-affiliated Deep Decarbonization Pathways Project, released a report titled *350 PPM Pathways for the United States*, which presented six different pathways to reduce CO_2 concentrations in the atmosphere to 350 parts per million (350 ppm) in 2100, which would likely allow warming to peak below 1.5°C and not exceed 1.0°C by century's end.[5] In these scenarios, the authors applied different assumptions across four key pillars of economy-wide decarbonization: power sector decarbonization, energy efficiency, end-use electrification, and carbon capture. EER has since updated its scenario projections internally and has shared the data with the authors of this report. Across their updated scenarios, EER modeling suggests that on average roughly 45 GW of combined wind and solar additions will be required annually through 2030 to meet decarbonization targets.[6]

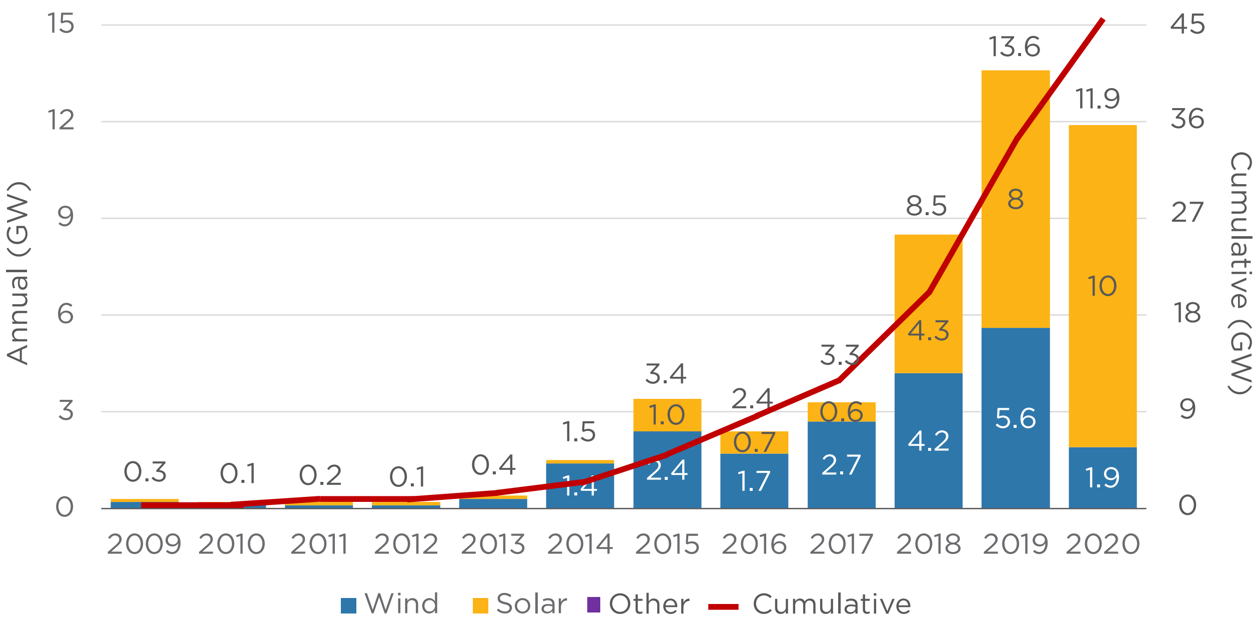
So far renewables additions in the United States materially lag the levels suggested by the EER models. According to estimates from BloombergNEF (BNEF), the United States added an estimated 21 and 33.8 GWs of new renewables capacity, respectively, in 2019 and 2020.[7] NextEra Energy, the world's largest private wind and solar energy developer, projects that annual installations will grow to 30–35 GW later in the decade.[8] Even if this robust growth transpires, however, the United States would still be tracking significantly below the levels needed to support global efforts to limit warming to below 2°C.

Achieving these levels of renewables deployment will require large amounts of capital. In some regions of the United States, regulated utilities are able to integrate renewables investments into their regulated cost structures, recouping a low-risk return over time from their ratepayers. Additionally, state-level renewable portfolio standards (RPS) that require utilities[9] to source a minimum defined share of their power from renewable sources have historically been a major driver of US renewable energy deployment.[10] While some states have been raising their RPS goals, many states have already met or are close to meeting their goals, moderating a historically important source of demand in many regions.[11]

For nonutility investors, a PPA or some other form of long-term revenue hedge has frequently been a routine requirement for their investments. Historically, the vast majority of PPAs have been signed with utility companies as buyers. However, in recent years a trend has emerged: for-profit corporate entities with material power loads have been entering into long-term PPAs directly with renewable developers of onshore wind and solar generation assets.

Figure 1 demonstrates the recent increase in corporate renewables procurement by tracking yearly announcements of corporate PPAs signed as well as green tariff commitments.[12] Since project completions tend to lag PPA signing, these procurements are a leading indicator of the increased renewables deployment to be enabled by corporate PPAs. While 2020 procurement was negatively impacted by the COVID-19 pandemic, as discussed in Section B of this report, the strong growth of US corporate procurement is clearly visible.

Figure 1: Corporate-driven renewable energy procurement since 2009



Source: "Sustainable Energy in America Factbook," Business Council for Sustainable Energy, Bloomberg New Energy Finance (BNEF), 2021 43, https://bcse.org/factbook/.

Note: Corporate procurement includes all categories of corporate procurement, including PPAs and green tariffs.

Further growth in the corporate PPA market is frequently projected as an important future driver of renewable capacity additions.[13] In 2019, Wood Mackenzie, for example, published a report in conjunction with the American Wind Energy Association, forecasting 85 GW of incremental US corporate renewable energy procurement through 2030.[14] On a global level, BNEF conducted a bottom-up assessment of the over 280 companies that have signed the RE100 pledge, committing to sourcing 100 percent renewable electricity by no later than 2050. Overall, BNEF estimated that demand from these companies alone will drive 93 GW of corporate wind and solar procurement by 2030.[15] The International Renewable Energy Agency (IRENA) has projected that global corporate renewable energy procurement would grow to a staggering 2,150 TWh by 2030,[16] which would suggest over 700–800 GW of new capacity globally depending on the assumed split between wind and solar and respective capacity factors.

Not all forecasts have been as optimistic. IHS Markit, in a recent October 2020 report, arrived at a lower forecast. The report forecasts that corporate contracting, in the defined "planning case," is likely to amount to between 200 and 225 TWh by 2030, enabling 44–72 GW of US wind and solar additions from 2021 to 2030.[17]

This paper arrives at scenario projections that are similarly below previous expectations. The 2030 scenario projections outlined suggest a range of 218–296 TWh, equating to 55–85 GW of capacity additions from 2021 to 2030. Differences in the TWh to GW conversion rates between reports are likely explained by differences in assumed capacity factors.

B. RECENT TRENDS IN THE US CORPORATE RENEWABLE PPA MARKET

This section summarizes recent overarching trends in the US corporate renewable PPA market to provide context for the subsequent discussion of potential future trends. For a detailed discussion on the mechanics of corporate PPAs, please see the appendix. Corporate PPAs are typically described as physical or virtual. This report's main focus is on *virtual* PPAs (VPPAs), which currently represent the vast majority of PPAs between corporations and renewable generation projects.[18] In contrast to physical PPAs, virtual PPAs do not require the physical delivery of the electricity produced by the renewable generator to the corporate buyer. Rather, a VPPA is a purely financial transaction in which the buyer agrees to virtually purchase electricity that is generated by the renewables project at a fixed price.[19]

Sustainability Goal Setting

Companies that are leading the movement to reduce greenhouse gas emissions have, in many cases, set public goals for increasing the percentage of their electricity consumption that can be matched by renewable sources. This percentage has become a key metric for measuring a corporate entity's commitment to sustainability. The number of companies with these types of targets has been steadily increasing over the past three years. Positive momentum for 100 percent renewable energy commitments among corporate entities has been enhanced by the public reporting of the Climate Group's RE100 initiative together with the Carbon Disclosure Project, among others. As one example, RE100 is a global initiative of influential businesses committed to 100 percent renewable electricity that was launched in 2014.[20]

The Matching Concept

These corporate goals are predominantly structured so that the corporation's aggregate annual electricity consumption is matched with renewable energy production that is not physically consumed by that corporation.[21] For example, when a corporation with an annual electricity load of 500,000 MWhs reports that its consumption is 50 percent renewable, it means that it has contracted for 250,000 MWhs of renewable electricity that is generated into the broader national electricity grid. In a VPPA, these electrons do not actually reach the corporation's facilities or match its demand curve on a subannual basis. Rather, the corporation's operations receive electricity from its local utility. The supply profile of the matching renewable electricity source has its own generation profile, not that of the corporation's load.

A Focus on "Additionality"

Corporations have been able to take credit for supporting renewable energy through four primary methods:

1. Deploying distributed renewable generation on-site, such as rooftop solar
2. Purchasing unbundled renewable energy certificates (RECs) that are generated by renewable electricity generation sources and sold separately from electricity

3. Purchasing electricity from local utility distribution companies via green tariff programs designed to provide compensation for renewable energy sources, such as hydro, wind, and solar, that the utilities have procured

4. Entering into PPAs directly with new renewable electricity generation suppliers (with the accompanying RECs included for retirement)

Advocates for increasing the pace of renewables deployment have increasingly discounted the purchase of unbundled RECs as the least impactful of these methods.[22] This is largely because existing renewable sources can continue to accrue RECs for sale to the market. In turn, REC purchases among green-minded corporations do not, in isolation, ensure that new *additional* renewable sources are being deployed. This *additionality* principle has become a priority among leading stakeholders in the energy transition, as highlighted by Google in its December 2016 white paper.[23]

Nonetheless, purchasing RECs continues to be an important method for companies that are not in the power sector to support renewable energy. REC sales provide an additional revenue stream for renewable electricity suppliers, apart from the power sales, usually through a state-administered auction process. When corporate entities seeking to be "green" participate in the REC market, they support REC values, and when they enter into *long-term* REC purchases, they add to the REC revenue streams. So, while not additional to the same degree as a corporation serving as an anchor offtaker on a PPA, the purchase of RECs still provides support for renewable generators.

"Green tariffs" refer to optional programs offered by utilities and approved by state public utility commissions. They allow larger commercial and industrial customers to buy bundled renewable electricity from a specific project through a special utility tariff rate. Under a green tariff, a distribution utility supplies an interconnected corporation with up to 100 percent renewable power and bundled RECs from projects either owned or contracted by the utility.[24] The corporations that participate in these tariff programs can claim to be contributing to additionality, where new projects are being constructed as a result. These tariffs require state regulatory approval and are currently available in 17 states (see the "State Policy Implications" section for more details).

Where a green tariff program is not available, a PPA creates certainty both in terms of power sales and REC sales for a renewables project. The resulting long-term revenue stream is often the critical piece that allows a renewable energy asset to raise the financing necessary to fund the large upfront capital costs inherent in such projects. Because PPAs directly enable new capacity that otherwise might not have been constructed, these projects are considered additional.[25]

A Partial Hedge of the Buyer's Power Costs

In addition to allowing corporations to meet their sustainability goals, VPPAs provide a hedge against market risk for both the generator's power sales revenues and the purchaser's power costs. The VPPA arrangement partially hedges the volumetric energy component of the purchaser's utility bill, which is largely based on the distribution utility's variable energy procurement costs. A VPPA does not, however, impact or provide a hedge against the other nonenergy components of the buyer's power bill (i.e., demand charges). How effective a VPPA may be as an energy hedge for the purchaser will depend on how the contract is structured along with other issues explained more fully in the appendix.

A physical PPA does have the potential to reduce the demand charge portion of a buyer's utility bill by reducing the buyer's peak demand as measured by its provider. However, logistical and regulatory issues limit the potential for these arrangements.[26]

C. IMPACT OF COVID-19 ON THE US RENEWABLES PPA MARKET

The scenarios presented in the next section of this report focus on long-term structural trends in the renewables PPA market in the United States. However, it is worth first discussing the near-term impact of the ongoing COVID-19 pandemic.

Negative Drivers

1. **Supply Chain Impacts:** Renewable energy supply chains are highly globalized. US wind projects often source blades and turbines from international suppliers, and the ever-increasing size of wind structures necessitates intricate transportation processes. Moreover, the solar photovoltaic (PV) supply chain is highly exposed to the US-China trade relationship. Supply chain disruptions and in some cases sourcing from secondary suppliers has increased the costs of renewable energy projects. Many US projects have faced delays as a result of these dynamics, and some developers have faced force majeure notices.[27]

2. **Weak Demand Growth and Lower Wholesale Prices:** Recessionary conditions have led to weak commercial and industrial (C&I) electricity demand and lower wholesale electricity prices in some regions, both of which negatively impact demand for PPAs. The COVID-19 pandemic and subsequent economic lockdowns in early 2020 drove down weekday electricity demand in the central region of the United States and New York 9–13 percent in March and April. The demand in MISO (Midcontinent Independent System Operator) areas 2 and 7, which cover most of Michigan and Wisconsin and include a high concentration of industrial customers such as car manufacturers, dropped between 11 percent and 16 percent. Notably, Florida—which has a higher percentage of residential load (53 percent versus 36 percent for the aforementioned regions) and warmer temperatures—did not witness weekday electricity demand decreases.[28] While industrial demand has generally improved from these initial declines, commercial weakness has persisted in many regions of the United States.[29]

3. **Shifting Priorities and Financing Availability:** The decline in 2020 corporate procurement may have also been driven in part by government and business priorities shifting away from sustainability initiatives to more immediately pressing concerns. Additionally, some corporations may have become more risk averse when it comes to discretionary investments and long-term commitments. Businesses may also be more hesitant to pay a "green premium" for indirect, less tangible benefits during a recession or depression. Lastly, the recession has lowered the profits and resulting incentives for banks and other financial players to provide tax equity financing, which is an essential part of the capital structure for most renewable projects.

4. **Declining Credit Ratings:** Declining credit ratings among businesses resulting from the economic downturn could reduce the number of organizations that could realistically enter into long-term PPAs.

Positive Offsets

1. **Green Stimulus Packages:** Economic stimulus packages have provided incremental support for renewable energy projects. The US government passed a $2.2 trillion economic relief stimulus package in late March 2020, the largest stimulus in the history of the United States.[30] Although Democrats initially lobbied for the inclusion of renewable energy support, these provisions did not make it into the final bill.[31] However, on December 21, 2020, Congress passed the Consolidated Appropriations Act, 2021 which included a one-year extension of the wind production tax credit (PTC) at 60 percent of its original value and a two-year extension of the solar investment tax credit (ITC) at a level of 26 percent.[32] Further extensions or new incentives may result from the shift to Democratic control of the congressional and executive branches in 2021.

2. **Low Interest Rates:** Interest rates for low-risk assets have fallen to record lows as investors fled to safe haven assets in the midst of economic uncertainty. This drop could allow renewable energy projects to raise greater amounts of debt financing at more attractive rates.

3. **Increased Interest in Infrastructure Investments:** The recent volatility in financial markets could lead to an increased appetite by investors for infrastructure projects, including renewables, that have been described as "low-risk, stable-yield opportunities at a time of extraordinary market volatility."[33]

Overall Takeaways

In light of these drivers, several market forecasting firms lowered their overall renewables capacity forecasts at the onset of the pandemic.[34] However, the negative impacts of the pandemic on renewables deployment overall appear to have been less than initially feared. As noted earlier, BNEF data show that overall renewables deployment in the United States in 2020 exceeded that of 2019 despite the pandemic, which did not suppress the large volume of projects already on track for 2020 completion.

Corporate renewables procurement, however, was in fact negatively impacted by the pandemic, at least relative to record 2019 levels. BNEF reports that corporate procurements totaled 11.9 GW in 2020, below 2019's total of 13.6 GW and the first year-over-year reduction since 2016.[35] Additionally, LevelTen Energy has noted that solar and wind PPA offer prices rose 11.5 percent and 24.3 percent, respectively, in part due to COVID-19 disruptions.[36]

The essential question is whether corporate procurement initiatives impacted by COVID-19 will shift into later years or if overall deployment will decline over the long run. This paper seeks to look past these short-term disruptions to instead focus on the longer-term structural drivers of the US renewables PPA market.

D. GROWTH DRIVERS IN THE CORPORATE RENEWABLES PPA MARKET THROUGH 2030

US C&I electricity demand totaled about 2,307 TWh in 2019.[37] This pre-pandemic figure represents the total addressable corporate renewables PPA market in the widest sense. The rest of this section explores a number of positive and negative drivers that can, when combined, facilitate a more refined estimate of the longer-term addressable market. The authors explore the following drivers and constraints:

Factors driving growth in the corporate renewables PPA market:

1. A vast and largely untapped US C&I power demand pool
2. An increased focus on the sustainability profiles of US corporations
3. Rapid growth in technology-sector power demand
4. Continued cost declines for wind and solar

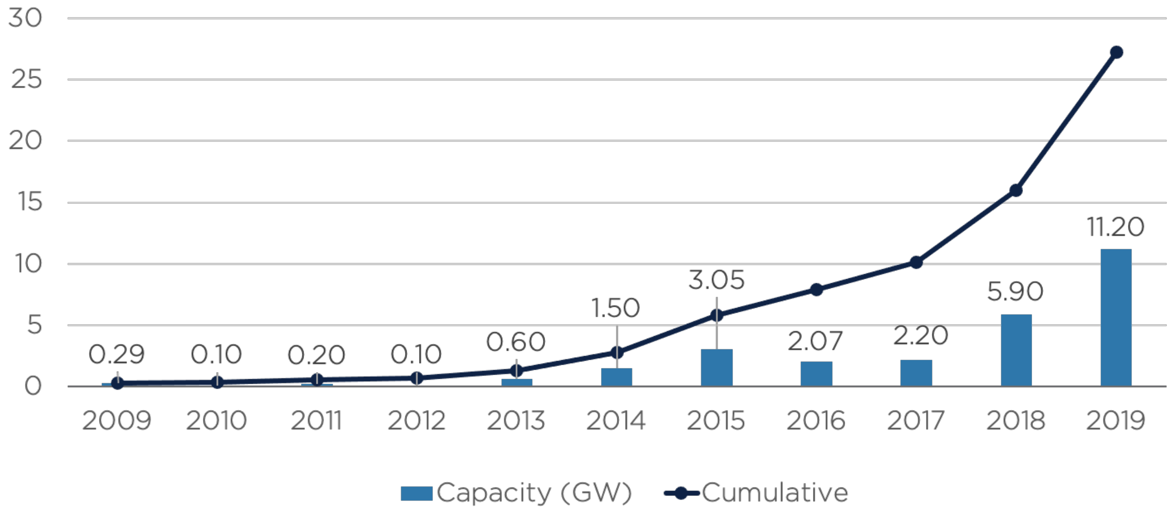
Constraints on the corporate renewables PPA market size:

1. Regulation that limits the feasibility of PPAs in some regional markets
2. The need for renewable PPA prices to be competitive relative to wholesale power prices
3. Scale and creditworthiness requirements
4. Financial risks and the existence of alternative emissions reduction mechanisms

Growth Driver #1: A Vast and Largely Untapped US C&I Power Demand Pool

The nascent corporate renewable PPA market is about 10 years old. Corporate demand accelerated rapidly from 2013 onward, and unprecedented growth took place in 2018 and 2019, as shown in Figure 2. According to publicly available BNEF data, at the end of 2019, the cumulative PPA capacity contracted from renewable energy sources (excluding green tariffs) was approximately 27.2 GW, with higher penetration of wind energy in comparison to solar.[38] The 11.2 GW of additional PPAs signed in 2019 alone represents more than 40 percent of the total corporate-contracted capacity since 2009.[39]

Figure 2: Growth in the US PPA market has been rapid



Source: Created by authors using annual BNEF Corporate Clean Energy press releases.

Note: These totals differ from Figure 1 due to the exclusion of green tariffs and other non-PPA corporate procurement initiatives from the total, leaving only PPA transactions. 2020 breakdown of corporate procurement not yet available. See Table 9 for full citation and calculations.

Assuming average capacity factors for solar and wind of 27 percent and 37 percent, respectively, these corporate PPAs would produce close to 80 TWh of electricity per year.[40] Given that total US commercial and industrial electricity demand was about 2,300 TWh in 2019, corporate renewable energy PPAs would represent only about 3.3 percent of US C&I electricity demand (Table 1). While the realistic total addressable market for corporate renewable PPAs is materially smaller than total C&I electricity demand—as discussed in this analysis—it is clear that there is still significant room for corporate renewables PPA penetration to increase.[41]

Table 1: Estimated renewable PPA penetration of annual C&I demand

Cumulative US solar PPA capacity (GW)	12.3
Assumed solar capacity factor	27%
Estimated annual US solar PPA generation (TWh)	29.0
Cumulative US wind PPA capacity (GW)	14.8
Assumed wind capacity factor	37%
Estimated annual US wind PPA generation (TWh)	47.9
2019 US C&I electricity demand (TWh)	2,307
Solar corporate PPA penetration	1.3%
Wind corporate PPA penetration	2.1%
Total corporate PPA penetration	**3.3%**

Source: Calculations by authors using data from the EIA and BNEF.[42]

Growth Driver #2: An Increased Focus on the Sustainability Profiles of US Corporations

A broad survey recently completed by RE100 compiled a variety of self-reported reasons that corporations are committing to 100 percent renewable electricity targets. Some of the explanations, such as cost savings and risk management, can directly enhance the bottom line of these businesses. Other cited reasons, however, may benefit these corporations more indirectly, such as by improving customer or employee retention. As more consumers incorporate broader societal concerns into their purchasing decisions, for example, it could make economic sense for a business to incur additional costs for sustainability initiatives in order to increase its sales. Moreover, employees are also increasingly seeking to work at businesses that emphasize sustainable values.[43] Corporations seeking to attract highly skilled employees may gain an advantage by crafting an image as a sustainable brand.[44]

Additionally, companies are facing increasing pressure from institutional investors to improve their sustainability performance, with 76 percent of RE100's respondents indicating that shareholder requests are an important driver for their efforts to source renewable electricity.[45] Overall, the Global Sustainable Investment Alliance estimates that "sustainable" investing assets under management totaled $30.7 trillion at the start of 2018, representing a 34 percent increase over the preceding two years.[46] And this total is widely anticipated to grow further. As sustainability factors are increasingly incorporated into investing decision criteria, companies that perform poorly on these metrics may face a cost of capital disadvantage. This provides another economic, self-interested incentive for corporations' to improve their sustainability profiles.

A number of other new platforms and alliances support corporate commitments to "green" their operations, with a significant focus on renewable electricity. Examples include the Carbon Disclosure Project, Corporate Renewable Buyers' Principles at the World Resources Institute, Renewable Energy Buyers Alliance (REBA), and the Business Renewables Center at the Rocky Mountain Institute.

Finally, as more companies commit to sourcing their electricity from renewables, the pressure is likely to rise for other players in their sector to follow suit. If there are cost savings for renewable procurement, companies that do not procure renewable electricity may be at a disadvantage. Further, as discussed, maintaining a corporate image of sustainability is becoming increasingly important for customer and employee retention. These reinforcing pressures may drive a positive feedback loop: as more companies become sustainable, those who lag behind could be put at a competitive disadvantage. This effect could push companies in the United States to be more aware of their relative sustainability portfolios and pursue renewable electricity procurement.

Growth Driver #3: Rapid Growth in Technology-Sector Power Demand

Information technology companies tend to have large and growing electricity loads, and many of these businesses already exceed 1 TWh of annual demand.[47] For example, Google's power usage doubled from around 5 TWh in 2014 to 10 TWh in 2018 (see appendix). Facebook's total electricity usage nearly doubled from 1.8 TWh to 3.4 TWh between 2016 and 2018 (see appendix). Microsoft saw its electricity usage more than double from 2014 to 2018, rising from 3.5 TWh to 7.6 TWh.

Table 2: Electricity consumption growth in the information technology sector

Company	Electricity usage 2014 (TWh)	Electricity usage 2017 (TWh)	Electricity usage 2018 (TWh)	Addition (TWh) 14-18	Addition (TWh) 17-18	Compound annual growth 14-18	YoY growth 17-18
Google	4.5	7.5	10	5.5	2.5	22.10%	33.30%
Facebook	1.04	2.46	3.42	2.38	0.96	34.70%	39.00%
Microsoft	3.5	6.3	7.6	4.1	1.3	21.40%	20.60%
Total	9.04	16.26	21.02	11.98	4.76	23.50%	29.30%

Source: Google's Environmental Report 2019; Facebook's Sustainable Data Centers; Microsoft's 2019 and 2016 Data Factsheets: Environmental Indicators.[48]

This growth in electricity usage has largely been driven by data centers, which consume 10–50 times the amount of electricity per unit of floor space of a typical commercial office building. Collectively, these data centers account for approximately 2 percent of the total US electricity use, and this total is expected to grow.[49] This large electricity demand growth from the big tech players is already driving renewables deployment as these companies work to meet not only increasing demand but also to work toward their sustainability commitments. Based on these trends, electricity demand growth from these data centers in the United States could drive continued renewable PPA demand, even from the existing players in the market. While recent 30 percent-plus annual growth rates might not be indicative of long-term trends, strong growth in this arena is still considered likely.[50]

A small number of technology companies have dominated the US corporate renewables PPA market to date. According to data from REBA, in 2019 seven companies (including Facebook, Google, AT&T, Microsoft, T-Mobile, Walmart, and Amazon) accounted for over 60 percent of total reported renewable energy purchases tracked by the organization.[51] This figure illustrates how the procurement decisions of a small number of large electricity consumers can significantly impact the market, a dynamic to be discussed in greater detail elsewhere in this report.

Alphabet Inc.'s subsidiary Google has been a particularly visible and significant leader in driving the deployment of new renewable energy generation sources and pushing the conversation of what it means to claim that a company's operations are powered with renewable electricity. In 2012, the company announced its goal of matching its annual power load with 100 percent renewable electricity procured. The company achieved this objective in 2017 through a combination of VPPAs, physical PPAs, and green tariffs. In many cases, Google actively collaborated with its local utilities to establish the green tariff program that it utilizes.

Since 2017 the company has articulated a more ambitious goal of more closely matching its load with carbon-free supplies on an hourly basis. In this regard, the company has been measuring and reporting on its progress toward the "24 × 7" carbon-free energy goal, taking into account both the renewable electricity that it has procured through PPAs and green tariffs and also from carbon-free electricity drawn from the local electricity generation mix. Furthermore, the company has signaled that it considers the availability of such sources in locating new facilities. Google has pledged to support R&D into innovative technologies, along with policies and market reforms that enable access to carbon-free infrastructure.[52] For example, Google has recently announced a new green tariff arrangement with Nevada Power that would enable the utility to provide new solar power combined with a battery storage hybrid project, which it claimed to be the biggest of its kind for a corporate customer when announced, to power a new Google data center.[53]

Other corporate decarbonization trends could also support increased demand for renewable electricity, as companies work to increasingly electrify (e.g., using electric fleet vehicles and equipment). Amazon, for example, recently revised its 100 percent renewable energy procurement commitment to be achieved by 2025, five years ahead of the previous schedule, and committed to a goal to be net-zero carbon by 2040.[54] To achieve these goals, the company has announced that it will procure 100,000 fully electric delivery vehicles worldwide, the largest order of electric delivery vehicles to date. Of these vehicles, 10,000 will start operations in 2021 with the full rollout being achieved by 2030.[55]

The Telecommunications Industry: A Historical Laggard, a Possible Big Player

Green America has estimated that the four largest companies in the telecommunications industry consume more than 30 TWh[56] of electricity each year on a combined basis (now the three largest companies, following the merger of T-Mobile and Sprint). This equates to around 1.3 percent of the total C&I electricity consumption in the United States when overlaid to the EIA figures referenced in Table 1. According to publicly available information, AT&T and Verizon represent around 25 TWh (83 percent) combined, T-Mobile represents 3.3 TWh (around 10 percent), and Sprint is responsible for the balance (2 TWh, 7 percent).[57] In the past the industry has been highlighted as a laggard when it comes to renewable electricity contracting,[58] but several telecommunications companies have recently made encouraging progress. T-Mobile, for example, has made public commitments to move to 100 percent renewable electricity and joined RE100, estimating that it will save $100 million in the next 15 years through their renewable electricity contracting.[59] Additionally, Verizon recently announced that it has entered into 13 VPPAs enabling approximately 1.7 GW of renewables capacity as a part of the company's efforts to achieve carbon neutrality by 2035.[60]

At the same time, the rollout of 5G equipment is expected to materially increase telecommunications companies' electricity demand. It has been estimated that between 2020 and 2030 the global electricity consumption from mobile networks will increase from 98 TWh to 316 TWh.[61] This growth could drive further demand for renewable electricity contracting. Depending on how aggressive the industry pursues sustainability initiatives, and PPA projects specifically, this industry could drive an additional 4–15 GW of renewable electricity procurement in the United States alone.

Table 3: Estimated additional growth in VPPAs that could be driven by telecommunications industry in the US

	% of demand met with renewables PPAs			
	25%	**50%**	**75%**	**100%**
Estimated Big 4 telecomm 2018 electricity usage (TWh)	30	30	30	30
Estimated Big 4 telecomm 2030 electricity usage (TWh)	38	38	38	38
Assumed percentage solar	65%	65%	65%	65%
Solar generation needed (TWh)	6.2	12.4	18.5	24.7
Solar generation needed (GWh)	6,183	12,365	18,548	24,731
Assumed solar capacity factor	27%	27%	27%	27%
Estimated incremental solar capacity (GW)	2.6	5.2	7.8	10.5
Assumed percentage wind	35%	35%	35%	35%
Wind generation needed (TWh)	3.3	6.7	10.0	13.3
Wind generation needed (GWh)	3,329	6,658	9,987	13,317
Assumed wind capacity factor	37%	37%	37%	37%
Estimated incremental wind capacity (GW)	1.03	2.05	3.08	4.11
Total estimated incremental solar and wind capacity (GW)	**3.6**	**7.3**	**10.9**	**14.6**

Source: Authors' calculations. 30 TWh figure cited from endnote 56.

Which Industries Will Drive Demand Growth From Here?

Conceptually, future growth could come from either (1) continued load growth from corporations that have already met their sustainability goals or (2) new businesses entering the PPA market. As will be discussed later in this paper, most corporations do not have sufficient loads to do repeated PPA deals. This means that a stream of new entrants may be required to sustain growth.

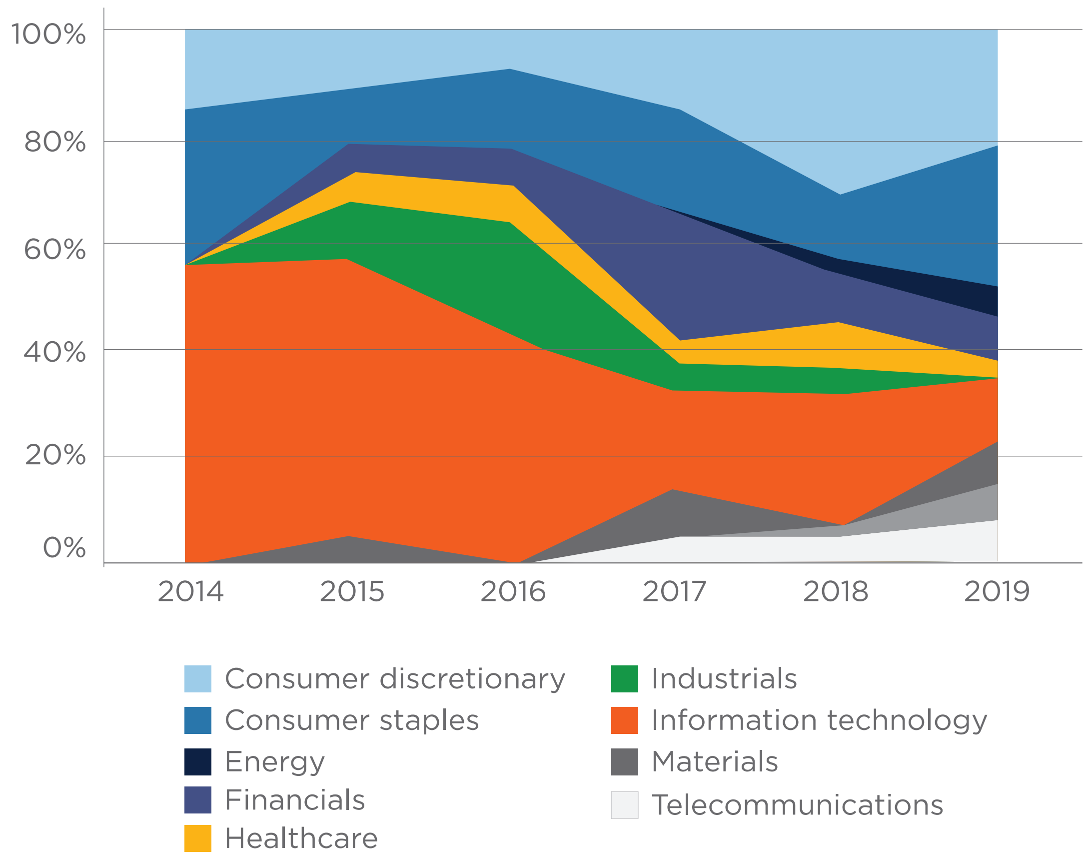
Growth could reasonably be expected to continue in the information technology sector, even as major players approach their sustainability goals. Increases in data use and computing power stemming from new technologies such as 5G could drive additional load growth in the United States. On the other hand, energy efficiency gains for data centers and other equipment, new methods of contracting renewable energy other than PPAs, and migration of data centers abroad could temper growth.

With regards to new businesses entering the PPA market, as previously discussed, the telecommunications industry could become an important source of growth going forward. The four largest companies in this industry consume more than 30 TWh and could mobilize up to 14.6 GW in renewable energy PPA deployment, as estimated in Table 3.

Furthermore, nontechnology companies (e.g., retail, food production, oil and gas, health care, and real estate) could play an increasingly important role moving forward. In 2013, Walmart announced an objective of sourcing 7 TWh of renewable electricity.[62] AB InBev, the global parent of Anheuser-Busch, has also announced a target to match its worldwide load (6 TWh)[63] with 100 percent renewables by 2025. This company's US subsidiary is on its way to achieve its goal of purchasing 100 percent renewable electricity for the production of domestic brands through a sequence of PPAs, with three projects between 2017 and 2019. These projects include 3 MW of solar in New York, 152 MW of wind in Oklahoma, and 222 MW of solar in Texas.[64]

The oil and gas industry has also become a potential source of PPA growth. In 2019, companies including Occidental Petroleum, Chevron, and Energy Transfer Partners signed renewable electricity PPA agreements. In the previous year, ExxonMobil signed two PPA deals totaling 575 MW.[65] The significant electricity load profiles of these companies, combined with their experience in project finance and growing pressure from divestment movements, could drive these companies to increase their activity in this area.

Figure 3: Historical renewable energy procurement by industry



Credit: Graphic recreated with permission from Renewable Energy Buyers Alliance (REBA).

Source: REBA, as cited in BofA Global Research, US Alternative Energy, "C&I offtake: More sophistication, more solar, more new corporates," BofA Securities, February 18, 2020.

Opportunities for Smaller Loads, Aggregations

Companies with smaller, less concentrated loads are also finding ways to participate in corporate renewable PPAs. Aggregations can expand the universe of practically eligible corporate counterparts to companies with regional loads of less than 100 GWh, enabling renewables projects in the range of 50–100 MWs. These types of transactions have the potential to expand the VPPA market to engage with smaller corporations, moving beyond the large-load players that have dominated this market to date.

As one example, Starbucks has committed to 100 percent renewable energy by joining the RE100 group and already achieved that goal for its operations in the United States and Canada.[66] In 2019, Starbucks announced that it had entered into VPPAs with three projects, including 50 MW of wind in Oklahoma, 50 MW of solar in Texas, and 46 MW of solar in North

Carolina. In this arrangement, Starbucks contracted for a sufficient portion of the annual production of these three projects to match the annual loads of 3,000 Starbucks stores.[67] The remaining production was marketed to other buyers.[68]

Another shared transaction from 2019 included a group of five corporations—Bloomberg, Cox Enterprises, Gap, Salesforce, and Workday—with an aggregated 42.5 MW annual electricity load. This group of corporations utilized a single shared legal counsel and jointly signed a single VPPA, pooling their risk and reducing transaction costs.[69]

The scalability and replicability of these aggregation deals are still unclear. On one hand, technological platforms and legal framework innovations that help to aggregate interested buyers can help corporations with smaller loads to achieve economies of scale in VPPAs. On the other hand, these aggregations might prove themselves to be problematic and risky for the companies involved. For example, the risk of default by individual parties could shrink the pool of possible partners, leading corporations to only partner with well-established companies with high trustworthiness of continued operations and financial health.

Growth Driver #4: Continued Cost Declines for Wind and Solar

Growth in renewable energy deployment among corporate players has been largely preceded by drops in both wind and solar system costs. Utility-scale wind energy costs fell by 70 percent, while solar energy costs fell by 89 percent during the time period between 2009 and 2019, according to Lazard.[70] Additionally, the PTC and investment tax credit (ITC) have been essential in improving the economics of C&I contracting for renewable electricity.

According to IRENA, the global levelized cost of electricity (LCOE)[71] of utility-scale solar PV is projected to drop further, from $0.055–$0.22 per kWh in 2018 to $0.02–$0.08 per kWh in 2030.[72] As for wind, IRENA projects that the global LCOE for onshore systems will drop from $0.045–$0.10 per kWh in 2018 to $0.03–$0.05 per kWh in 2030. During the same period, IRENA envisions global offshore wind LCOE decreasing from $0.10–$0.195 to $0.05–$0.09 per kWh.[73]

It should be noted that potential benefits from further cost reductions will, based on current law, be offset to some degree by the phaseout of key federal tax credits in the United States. Historically, the federal ITC and PTC have been key enablers of renewable energy economics. The ITC has historically equated a tax credit equal to 30 percent of the capital costs of solar energy assets. The PTC provides an escalating $23 per MWh tax credit for the first 10 years of electricity generated by wind energy assets.[74] These benefits are meaningful and have allowed wind and solar projects to offer lower VPPA prices than would have been possible in absence of these credits. The final verdict on the degree to which the loss of tax credits will offset projected cost declines is still unclear. NextEra Energy, the world's largest private developer of wind and solar energy, forecasts that cost declines will fully offset the lost tax credits for solar energy but not for wind energy. The company projects that the roughly $20 per MWh levelized benefit of the PTC will be partially offset by about $10 per MWh of efficiency gains by 2024. For solar, the company estimates the approximately $13 per MWh levelized impact from the ITC phasedown to be more than offset by about $15 per MWh of efficiency gains.[75]

Of note is that projects deemed to have "commenced construction" (i.e., spending at least 5 percent of the project's total capital costs) are able to qualify for the full tax credit level in a given year so long as the developer completes the project within four years of "safe harboring" the project.[76] This in effect grants developers several years of tax credit eligibility beyond the formal phaseout schedule. Further, in light of the COVID-19 pandemic, the IRS issued Notice 2020-41 on May 27, 2020, which granted wind developers an extra year to finish construction work while still receiving the wind PTC per its original phaseout schedule. Table 4 below presents the formal tax credit phaseout schedules as well as the effective phaseout for developers that take advantage of the safe harbor policy. This table reflects the Consolidated Appropriations Act, 2021, passed on December 21 2020, which included a one-year extension of the wind PTC at 60 percent of its original value and a two-year extension of the solar ITC at a level of 26 percent relative to the previous phaseout schedule.[77]

Table 4: Scheduled phaseouts of the ITC and PTC

	Scheduled phaseout		Phaseout with safe harbor	
Year	**ITC**	**PTC (% of 2.3c / KWh)**	**ITC**	**PTC**
2016	30%	100%	30%	100%
2017	30%	80%	30%	100%
2018	30%	60%	30%	100%
2019	30%	40%	30%	100%
2020	26%	60%	30%	100%
2021	26%	60%	30%	100%
2022	26%	0%	30%	80%
2023	22%	0%	30%	40%
2024	10%	0%	26%	60%
2025	10%	0%	26%	60%
2026	10%	0%	26%	0%
2027	10%	0%	22%	0%

Source: McGuireWoods, SEIA, IRS.[78]

E. CONSTRAINTS ON THE CORPORATE RENEWABLES PPA MARKET SIZE

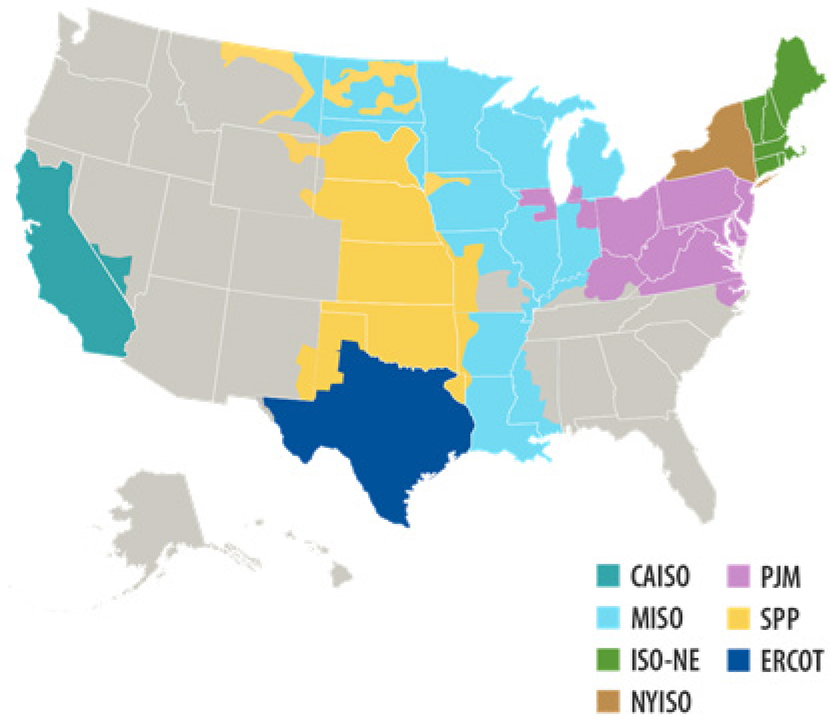
Constraint #1: Regulation That Limits the Feasibility of PPAs in Some Regional Markets

Within the United States, power generators, utilities, and transmission owners in some regions have formed independent system operators (ISOs). These ISOs are nonprofit organizations that self-regulate and share transmission responsibilities for the region. Regional ISOs oversee the commodity market for electricity in their respective jurisdictions by dispatching generation, managing power transmission and distribution, and ensuring that the region maintains sufficient generation capacity to reliably meet demand.[79]

In the wholesale electricity markets that are managed by ISOs, the price for electricity is determined by power price bids from generators on a day-ahead basis and in real time throughout the day. These bids refer to delivery hubs and are published as market indices so that market participants can see how the power price evolves.[80] These market indices are commonly specified in VPPAs as the reference for variable market prices to compare with the fixed price in the determination of settlement payments.

While roughly two-thirds of the United States is organized into wholesale markets operated by a regional ISO (Figure 4), large regions in the Southeast and the western United States still operate under a traditional, vertically integrated model, where the local utility has a monopoly on both generation and distribution of electricity. It is significantly more challenging to enter into VPPAs with renewables sources in these regions, as visible RTO-published index for calculating hedge settlements would be lacking.[81] Renewable generators would also need the local utility monopolies to cooperate in bilateral transactions absent from an open wholesale market for their output.

Figure 4: Overview of US wholesale electric power markets



Source: US EPA.[82]

Table 5 shows estimates of total C&I power demand in the markets where VPPAs are broadly feasible. Overall these markets contain about 68.5% of total US C&I power demand. Some portion of the remaining 31.5% C&I load might still become matched through VPPAs with renewable sources located in the other regions with ISO-managed power markets. Such a VPPA, where settlements against the strike price are indexed to the generator's regional power market while the corporate offtaker's power load is in a completely separate region, would not be a very effective hedge for the offtaker's power costs (see "Locational Basis Risk" in the appendix). However, the effectiveness of the price hedge may be a minor consideration for those corporations that prioritize the achievement of ambitious sustainability goals. Nevertheless, the absence of wholesale power markets in some regions of the United States will be a constraint for VPPAs in those regions.

Table 5: Estimated 2018 C&I power demand by ISO

Region	C&I demand (TWh)	% of analyzed C&I demand	% of total US C&I demand
CAISO	165	10.1%	6.9%
ERCOT	267	16.4%	11.2%
ISO-NE	70	4.3%	2.9%
MISO	406	24.9%	17.1%
NYISO	95	5.8%	4.0%
PJM	486	29.8%	20.4%
SPP	142	8.7%	6.0%
Total analyzed	**1,632**	**100.0%**	**68.5%**
Total US	**2,383**	**N/A**	**100.0%**

Source: Estimated based on state-level EIA, "Electricity Data Browser," accessed Aug. 27, 2020.

The vast majority of corporate PPAs are virtual, and these VPPAs are the primary focus of this report. However, it should be noted that a parallel regulatory constraint impacts physical PPAs. Briefly stated, physical PPAs are currently only feasible in the 18 states that allow nonutilities to supply customers with electricity (i.e., states with "retail choice").[83] In the rest of the United States, only the incumbent utility distribution monopoly is able to supply electricity to commercial and retail customers.

Constraint #2: The Need for Renewable PPA Prices to Be Competitive with Wholesale Power Prices

How Do Corporations Evaluate the Attractiveness of a Renewable PPA?

A PPA guarantees a revenue stream to the renewable electricity generator while also hedging a portion of the variable energy component of corporate buyer's power consumption costs for a specified amount of electricity on a long-term basis. Thus, it is reasonable to believe that corporate buyers would compare (1) the fixed PPA price and (2) the outlook for wholesale power prices they would expect to drive their variable energy costs in the absence of the PPA over the life of the contract. Setting aside sustainability priorities, it would be reasonable for businesses to tend to sign PPAs only when they offer fixed power prices that are competitive with the outlook for wholesale prices intended to be hedged. Some companies may also be willing to pay a premium for the general risk reduction that stems from locking in a fixed price for its electricity. Nevertheless, the need for VPPA fixed-price offer prices to be reasonably competitive with the outlook for variable market prices would be a limiting factor for corporations signing a long-term contract.

As discussed above, corporations may be willing to purchase voluntary RECs or pay a higher price for electricity from renewable sources given the benefits derived from enhancing a business's sustainability profile. This is sometimes referred to as a "green premium." The green premiums incurred by corporations to meet publicized sustainability goals do not necessarily deviate from "market behavior"; these costs have a brand-enhancing business rationale as discussed in a previous section, similar to advertising expenses or charitable sponsorships.

There are, however, limits to this sustainability-driven behavior. Public relations budgets have limits. Publicly traded companies answer to their boards of directors and ultimately their shareholders. It is unlikely a corporation would voluntarily pay an excessive premium relative to the outlook for its electricity costs.

In a 2015 survey by Baker McKenzie, power price risk,[84] and specifically the risk that wholesale power prices, might decline below the agreed strike price for a longer period of time than anticipated, was rated a "high risk" by 45 percent of the companies that responded to the survey. In fact, power price risk was the most highly cited risk among the corporate respondents.[85]

If wholesale prices were unexpectedly to prevail at lower levels for longer periods below the fixed price in the VPPA, the corporate counterpart would end up making net settlement payments to the generator that far exceed what it expected, thus realizing a material loss on the VPPA contract. When such a corporate counterpart has a sizable physical power load in the regional wholesale market where settlements are indexed, the financial loss on the contract can be largely offset by savings on its utility bills. Those corporations signing VPPAs with settlements indexed to markets where they do not have material power loads risk realizing losses on the PPA that may not be as effectively offset by savings on their physical power purchases. This risk is best managed by contracting at fixed prices that seem low when measured against the downside pricing outlook for the market where settlements are indexed.

In Which Regions Are Renewables PPAs Attractive Relative to Market Power Prices?

In order to estimate the order of magnitude of this constraint, the appendix contains illustrative assessments of renewable PPA economics in three regional markets selected as case studies. Forward power price curves, as published by S&P Global Market Intelligence, were used to represent an outlook for future power prices.[86] These forward price curves are compared with 25th percentile regional price offers collected by LevelTen Energy from potential wind and solar projects and published quarterly.

LevelTen Energy is an adviser that actively promotes transactions between project developers and corporate entities potentially shopping for corporate PPAs. To promote price transparency, LevelTen publishes a quarterly price tracker with price offers collected from renewable energy projects that are active in the LevelTen Marketplace. LevelTen collects these price quotes based on standard PPA terms (i.e., level price for 10- to 15-year terms, on a unit-contingent basis). It should be noted that the strike prices offered bilaterally in an actual negotiation in the marketplace would likely deviate from the aggregated index of prices: they may have customized terms (with shorter durations or step-ups) leading to strike prices that may be higher or lower than these standard price quotes. Nevertheless, these standard price offers were used for purposes of this analysis.[87]

The analysis detailed in the appendix made the following further assumptions:

- Corporations evaluate only the direct costs of a renewable PPA relative to the outlook for wholesale power prices. In other words, "green premium" considerations are set aside and adjusted for later in the report.[88]
- PPA offers are held constant based on data from the third quarter of 2020, as reported by LevelTen Energy.
- A 10-year time horizon was utilized, as regional forward power markets are not particularly liquid beyond this point.[89]
- "Peak" and "off-peak" pricing curves are shown for each market.[90] However, in practice, each corporation would compare the PPA offer price to forecasts for a blended average wholesale price based on the time periods that they would expect the wind or solar asset to be generating electricity.

The power prices presented in the appendix charts are averaged across many pricing hubs, each of which can vary substantially based on the local supply-demand balance. Therefore, even in regions where wind and solar PPAs do not appear attractive under this high-level framework, there may be subregions within that market where PPA deals are attractive to buyers. Similarly, in regions where these PPAs do appear attractive, there are likely some oversupplied local regions where the economics look less favorable.

Noted here is that in order to fully assess the attractiveness of a given PPA price offer, a comprehensive financial model would be required to estimate the probability-weighed present value of each PPA deal relative to the wholesale power prices a buyer would expect to pay in the absence of the PPA (e.g., using a Monte Carlo decision tree model to assess a wide variety of power price scenario projections). Moreover, one would need to analyze each contract on a granular, localized level. This level of detail was not possible in this analysis due to data limitations and regional variations.[91] With all of this in mind, these case studies are not meant to definitively answer whether all contracts in a given market are competitive but rather to illustrate how corporate offtakers approach PPA decision-making and to highlight the importance of economic competitiveness when sizing the corporate renewables PPA market.

Quantifying Regional Economics Constraint: Results

The appendix includes a high-level analysis of solar and wind PPA prices compared to forward power prices for three specific regions selected as case studies: the Electric Reliability Council of Texas (ERCOT), the Midcontinent Independent System Operator (MISO), and the PJM Interconnection.

Table 6 presents the results of these case studies as well as estimates for each major wholesale market in the United States. Overall, under the specified base case assumptions, corporate wind and solar PPAs were estimated to be financially attractive for around 60 percent of C&I demand within wholesale market regions before considering the other market constraints that are explored elsewhere in this analysis. Given the considerable amount of expert judgment that was applied in these estimates, an upside case and a downside case are also presented.

Importantly, these calculations set aside indirect "green premium" considerations and examine the PPA decision-making process from a direct cost savings point of view. As a result, in the final market size estimate, this constraint was relaxed by 30–50 percent across the base, upside, and downside cases. This adjustment captures the fact that, as previously discussed, some businesses are willing to pay a "green premium" while also acknowledging there is a limit to how big that premium can reasonably be.

Table 6: Renewables PPAs are estimated to be economically competitive for about 60 percent of C&I demand under base case assumptions

Solar economics

Region	Estimated 2030 C&I demand (TWh)	Solar economics	Solar addressable market (TWh)
California Independent System Operator (CAISO)	175	Generally competitive	114
Electric Reliability Council of Texas (ERCOT)	282	Generally competitive	183
ISO - New England (ISO-NE)	74	Varies regionally	17
Midcontintent Independent System Operator (MISO)	429	Varies regionally	140
New York ISO (NYISO)	100	Varies regionally	23
PJM Interconnection	513	Varies regionally	167
Southwest Power Pool (SPP)	151	Varies regionally	49
Total: deregulated markets	**1,724**		**692**
Total US	**2,518**		

Wind economics

Region	Estimated 2030 C&I demand (TWh)	Wind economics	Wind addressable market (TWh)
California Independent System Operator (CAISO)	175	Generally uncompetitive	6
Electric Reliability Council of Texas (ERCOT)	282	Generally competitive	99
ISO New England (ISO-NE)	74	Varies regionally	9
Midcontintent Independent System Operator (MISO)	429	Varies regionally	75
New York ISO (NYISO)	100	Varies regionally	12
PJM Interconn.	513	Varies regionally	90
Southwest Power Pool (SPP)	151	Generally competitive	53
Total: deregulated markets	**1,724**		**344**
Total US	**2,518**		

Solar & Wind economics

Region	Estimated 2030 C&I demand (TWh)	Solar & Wind addressable market (TWh)	% of 2030 C&I Demand From Wholesale Markets
California Independent System Operator (CAISO)	175	120	6.9%
Electric Reliability Council of Texas (ERCOT)	282	282	16.4%
ISO New England (ISO-NE)	74	26	1.5%
Midcontintent Independent System Operator (MISO)	429	215	12.4%
New York ISO (NYISO)	100	35	2.0%
PJM Interconn.	513	257	14.9%
Southwest Power Pool (SPP)	151	102	5.9%
Total: deregulated markets	**1,724**	**1,036**	**60.1%**
Total US	**2,518**		

Assumed share - solar / on-peak:	65%
Assumed share - wind / off-peak:	35%
Credit given for "generally competitive"	100%
Credit given for "generally uncompetitive"	10%
Credit given for "varies regionally" - NYISO and ISO-NE:	35%
Credit given for "varies regionally" - all other markets:	50%

Source: Authors' estimates.[92]

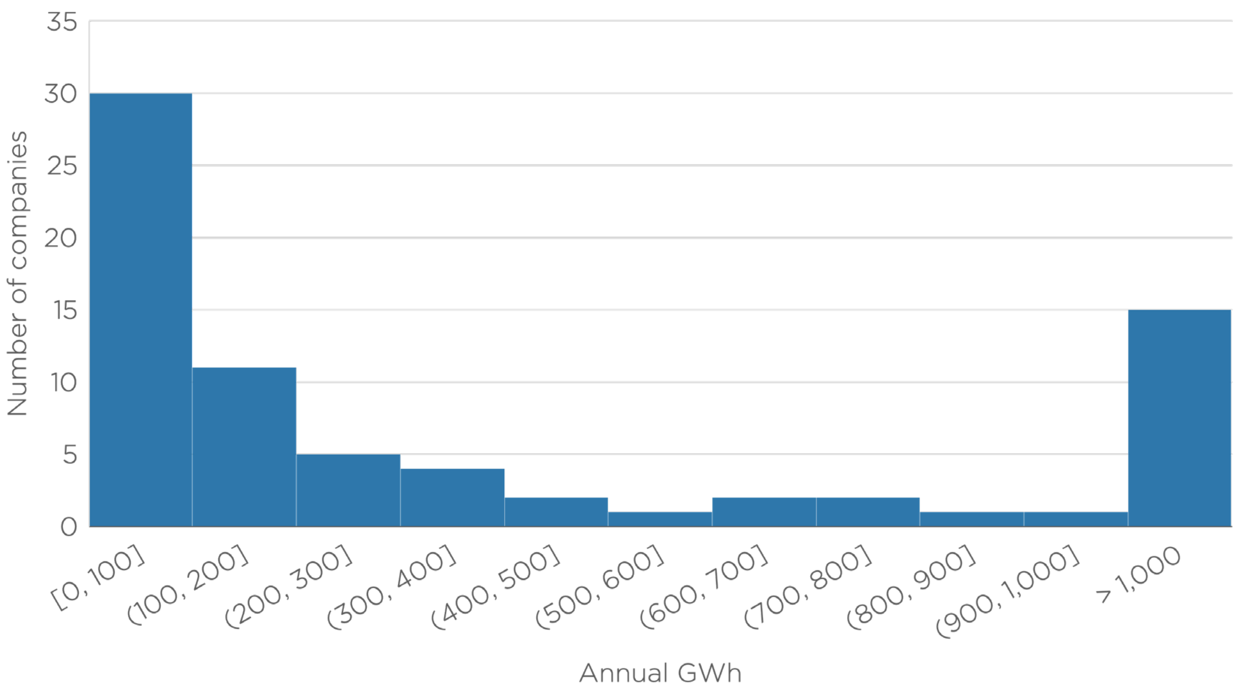
Constraint #3: Scale and Creditworthiness Requirements

Scale

Historically, the PPA market has been dominated by corporations that have large enough power loads to serve as either the sole or anchor offtaker for a utility-scale wind or solar facility. The authors estimate, based on historical project sizes, that a corporation needs to have at least 75–100 GWh of geographically concentrated power load to enable a renewable energy facility of meaningful size. According to data from the US Energy Information Administration (EIA), however, the average retail C&I customer consumes just about 0.110 GWh each year.[93] While this figure is a bit larger for wholesale C&I customers, at about 0.22 GWh annually,[94] it is clear that a large portion of C&I customers do not have enough electricity demand to make signing a corporate PPA practically achievable.

Unfortunately, detailed and comprehensive data on corporate electricity loads are difficult to obtain given the potentially sensitive nature of the information. This lack of accessible data makes it more difficult to quantify how large of a constraint the issue of scale truly is. As a proxy for scale, a 2019 analysis by Wood Mackenzie estimated the annual power load for the F1000 to be 1,200 TWh using the database of over 400 respondents to the 2018 corporate survey of the Carbon Disclosure Project, which equates to around 52 percent of 2019 C&I demand.[95] The EPA's Green Power Partnership has also published electricity demand data from a sample of 75 Fortune 500 companies, showing that about 64 percent of these companies (48 of the 75) had an annual load of greater than or equal to the estimated 75 GWh threshold required to sign a PPA.[96] The average annual demand was extremely high, at 941 GWh, but the median was 163 GWh (Figure 5). Figure 5 shows the histogram of the distribution and its elongated right tail.

Figure 5: Number of companies in EPA sample by annual electricity demand



Source: EPA–Green Power Partnership Fortune 500 Partners.

Note: This histogram excludes Walmart, the largest consumer with over 2,000 GWh of demand.

This highly skewed distribution suggests that the corporate renewables PPA market will be materially influenced by the decisions of a small number of megacorporations with outsize electricity demand profiles. The procurement decisions made by this relatively small group of companies could thus swing corporate PPA installations from the low to the high end of this paper's estimated market size range (or vice versa). The range of potential outcomes outlined in this paper is meant to capture this significant degree of uncertainty.

As discussed elsewhere in this report, aggregation structures are one partial solution to this issue of scale. But to date, aggregation customers have all been relatively large Fortune 1000 companies in their own right. Therefore, the issue of scale appears likely to remain a significant constraint on the renewables PPA market.

Overall, it is unclear if inclusion in the Fortune 1000 (which is determined by gross revenues, both domestic and international) is a reasonable proxy for the scale of a company's US power demand, given that the EPA data highlight that even some Fortune 500 companies do not have the necessary scale. However, a better method for estimating potential market size has not yet been identified, so the calculations in this report have adopted Wood Mackenzie's 48 percent as an estimate for the percentage of C&I load that is of insufficient scale to enter into a PPA. This estimate perhaps generously assumes that all companies in the Fortune 1000 have a US power load sufficient to enable a PPA deal.

Creditworthiness

The commercial banks that finance renewable energy projects generally require that buyers have investment-grade credit ratings unless some stronger guaranty or security is involved. Government-sponsored green banks may depart from this orthodoxy, and some commercial banks may also provide debt finance at reduced amounts if the buyers are not all considered to be investment grade. Nevertheless, the share of corporate demand coming from companies that have investment-grade credit ratings is a practical limit on the potential size of the PPA market.

The total share of corporate power load among investment-grade companies is not known. One survey that may inform a simplifying assumption comes from the Redbridge Debt and Treasury Advisory, which found that about 51 percent of Fortune 1000 companies among their survey sample rated "investment-grade," with higher percentages prevailing among the larger companies (85 percent of the Fortune 100; 58 percent of the Fortune 500), and about 38 percent of their Fortune 1000 sample explicitly having below investment-grade ratings.[97] The other 11 percent do not have credit ratings.

Due to data limitations, it was not possible to precisely estimate the percentage of the about 2,300 TWh of annual US C&I load held by investment-grade corporations that also have sufficient power loads to enter into corporate renewables PPAs. Accordingly, the base case projection below adopts a simplifying assumption that about 60 percent of the 1,200 TWh of load held by sufficiently scaled US corporations belongs to companies with sufficiently high credit ratings to enable financeable PPAs.

Constraint #4: Financial Risks and Alternative Emissions Reduction Mechanisms

Entering into long-term energy contracts brings financial complexities for corporate offtakers. This is because long-term PPAs with renewables are imperfect hedging mechanisms due to a range of risks and issues, including resource and operational risk, covariance risk, locational basis risk, derivative accounting, and a general reluctance to lock in 100 percent of power costs for extended periods of time. Each of these financial nuances is outlined in significant detail in the appendix.

While the effectiveness of the hedge may be a minor consideration for many corporations, it is reasonable to assume that these hedging imperfections and shortcomings will deter some portion of the eligible load (investment grade, sufficiently sized, etc.) from entering into renewable PPA transactions. That said, some public-facing companies have demonstrated their willingness to sign VPPAs with renewable projects with power loads in other parts of the country, such as Texas and Oklahoma, even when their load is not colocated. This is a sign that hedging imperfections may be a minor consideration for some companies.

Due to these financial risks or for other reasons, some corporations will elect to pursue emissions reductions via other avenues (e.g., REC purchases, green tariffs, etc.). Such options can enable corporations to improve their sustainability profiles and reduce footprints without locking themselves into 10-to-20-year commitments. Table 9 in the appendix breaks down the relative share of PPAs versus other forms of corporate procurement over the last several years.

The impact of these potentially overlapping constraints is difficult to quantify with precision, but the authors adopt the assumption that 20–25 percent of eligible companies will not participate in PPAs due to these shortcomings and alternatives.

F. PUTTING IT ALL TOGETHER: SIZING THE CORPORATE RENEWABLES PPA MARKET OVER THE NEXT DECADE

In the widest sense, the entirety of US C&I electricity demand can be considered the addressable market for corporate renewables PPAs. This work, however, attempts to arrive at a more refined estimate by quantifying the various positive and negative drivers discussed previously.

Three potential scenarios (base, upside, and downside) are presented in this section. Each scenario used 2019 C&I electricity demand as a starting point, before the application of a series of restrictive filters, as shown in Figure 7 for the base case.

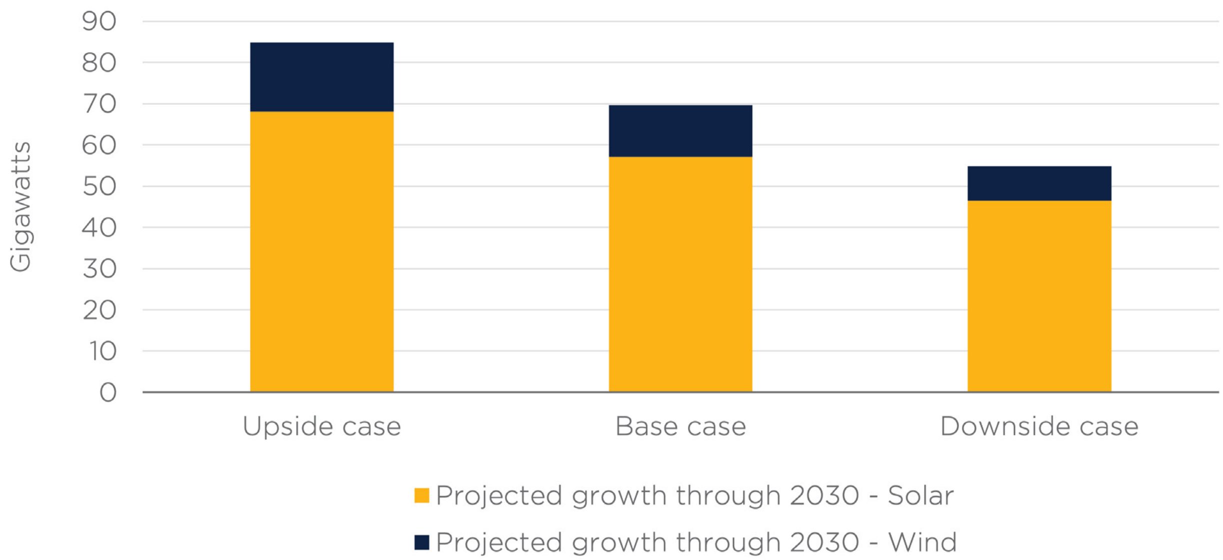
The authors utilized a 35 percent / 65 percent split between wind and solar to translate the initial TWh forecast into estimated GWs deployed, based on the relative economics of each generation technology and the fact that solar PPAs generally compare with the on-peak pricing outlook rather than off-peak pricing. The final capacity projections were also sensitive to the assumed capacity factors. According to EIA data, PV solar and wind capacity factors averaged 24.3 percent and 34.2 percent, respectively, in 2019 across all installed US facilities.[98] In order to translate the TWh scenario projections into capacity (GW) projections, this analysis utilizes moderately higher 27 percent and 37 percent capacity factors (for solar and wind, respectively) to account for technology improvements that have improved efficiency relative to older technologies that are still operating and therefore weighing down the 2019 averages for all cumulative assets. While capacity factors vary widely across regions and technology, the authors use an adjusted nationwide US average under the assumption that PPAs going forward will trend broadly in line with the historical geographical distribution of US renewables development.

As mentioned previously, the authors apply this methodology across three scenarios (base, upside, and downside) in order to provide a range of potential future PPA market sizes while simultaneously capturing the uncertainty and judgment inherent in many of the assumptions included in this analysis. Each scenario's output is a cumulative corporate renewables PPA market projection through 2030, broken down by resource type. As shown in Figure 6, the results of this analysis project between about 55 and about 85 GW of new wind and solar generation capacity through 2030.

The results of these three scenarios are presented in Table 10 in the appendix:

- Base: about 70 GW through 2030
- Upside: about 85 GW through 2030
- Downside: about 55 GW through 2030

Figure 6: Breakdown of the three corporate PPA growth scenarios by resource type



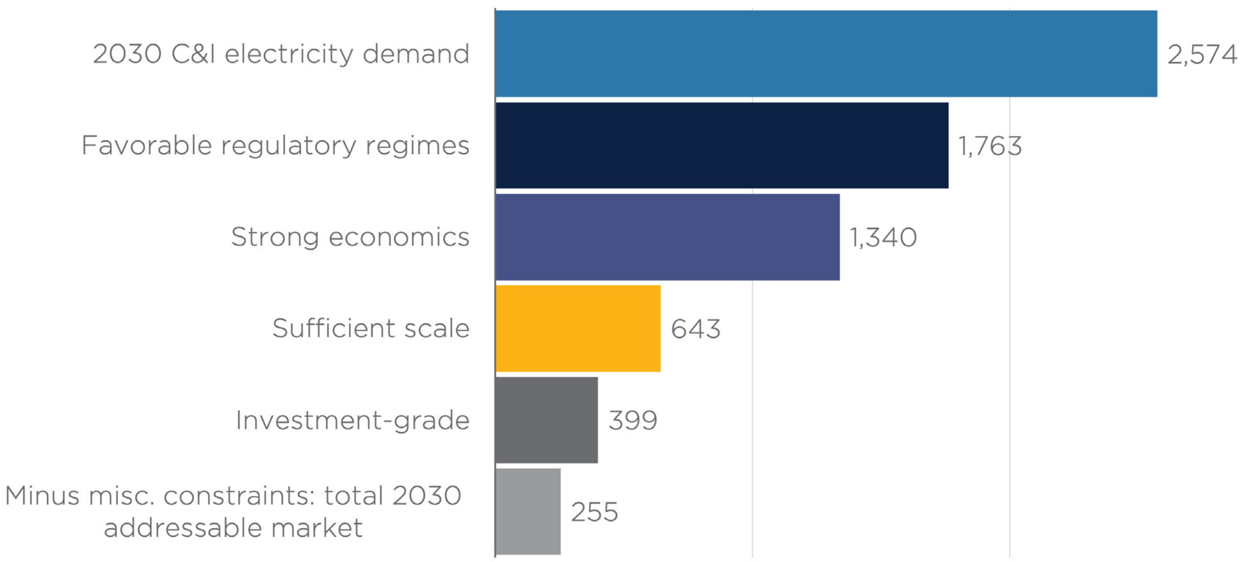
Source: Authors' estimates.

Base Scenario

All three scenarios utilize the entirety of C&I electricity demand as a starting point and then eliminate the estimated 31–32 percent of demand that lies within regulatory regimes where VPPAs are not typically feasible. Next, this paper estimated that renewable energy PPAs—wind and solar combined—appear economically competitive relative to market power prices in around 60 percent of wholesale markets, suggesting that 40 percent of C&I load may be deterred from entering a PPA for economic reasons. In the base scenario, the authors relax this constraint to account for the fact that many businesses are willing to pay a premium for renewable electricity, assuming that economic competitiveness concerns deter about 25 percent of C&I load rather than 40 percent. This scenario further assumes that companies outside of the Fortune 1000 (about 48 percent of C&I demand) do not have sufficient load to sign a renewable PPA. An additional about 38 percent of Fortune 1000 companies were eliminated due to their below investment-grade credit ratings. In line with historical averages,[99] about 20 percent of the C&I demand was then eliminated to account for C&I renewable procurement via non-PPA alternatives (e.g., green tariffs, RECs). The final 20 percent filter roughly estimates the remaining miscellaneous constraints that will likely deter some companies from entering the market, reflecting the fact that renewables PPAs are imperfect hedging instruments and that corporations tend to avoid overhedging their commodity exposure over the long term. Lastly, the base case assumes 1 percent annual demand growth among companies through 2030. Table 10 in the appendix outlines these calculations in full detail.

Overall, the base scenario projects about 255 TWh of annual corporate renewable PPA demand by 2030. Assuming a 65 percent / 35 percent split between solar and wind, this load equates to about 57 GW of incremental solar PPAs and about 13 GW of incremental wind PPAs, for a total of about 70 GWs. This total implies that 2019's more than 11 GW annual renewables PPA contracting pace will begin to slow.

Figure 7: Base case corporate PPA 2030 addressable market (TWh)



Source: Authors' calculations; EIA data.

Upside Scenario

The upside case also utilizes the entirety of C&I electricity demand as a starting point and then eliminates the about 31–32 percent of demand within regulatory regimes where VPPAs are not typically feasible. In this case, only 20 percent of C&I load is estimated to be deterred by economic competitiveness concerns to account for a larger portion of businesses willing to pay a green premium for their electricity. The 50 percent reduction in this constraint could also be interpreted to represent faster than expected renewables cost declines or increased power prices due to higher gas prices or the implementation of a carbon tax. All else equal, any of these scenarios would make the economics of renewables PPAs more attractive relative to wholesale power prices.

As in the base scenario, companies outside the Fortune 100 and demand from companies with below investment-grade credit metrics were then eliminated. The same 20 percent constraint was then applied to account for businesses electing to reduce their electricity emissions footprint via non-PPA alternatives. A slightly loosened 17 percent filter was included as a rough estimate of the remaining miscellaneous constraints that will likely deter some companies from entering the market, including the fact that renewables PPAs are imperfect hedging instruments and that corporations tend to avoid overhedging their commodity exposure over the long term. Lastly, the upside scenario assumed 1.5 percent annual demand growth among target companies through 2030, capturing the possibility of continued strong demand growth from key existing players in the PPA market (e.g., Google, Facebook, Amazon).

Overall, the upside case projects about 296 TWh of annual corporate renewable PPA demand by 2030. Assuming a 65 percent / 35 percent split between solar and wind, this equates to about 68 GW of incremental solar PPAs and about 17 GW of incremental wind PPAs, or about 85 GW in total.

Downside Scenario

As with the other two scenarios, the downside scenario utilizes the entirety of C&I electricity demand as a starting point and then eliminates the estimated 31–32 percent of demand within regulatory regimes where VPPAs are not typically feasible. In the downside scenario, concerns about the economic competitiveness of PPAs relative to wholesale power prices is estimated to deter about 28 percent of C&I load. Economic pressures could restrict the pool of businesses willing to pay a “green premium,” and depressed power prices could reduce the attractiveness of renewables PPAs.

As in the base scenario, companies outside the Fortune 100 and demand from companies with below investment-grade credit metrics were then eliminated. The same 20 percent constraint was then applied to account for businesses electing to reduce their electricity emissions footprint via non-PPA alternatives (e.g., green tariffs, RECs, etc.). A moderately more restrictive 23 percent filter was again included as a rough estimate for the remaining miscellaneous constraints that will likely deter some companies from entering the market, including the fact that renewables PPAs are imperfect hedging instruments and corporations tend to avoid overhedging their commodity exposure over the long term. To capture the potential impacts of increased energy efficiency, the downside case assumed 0.5 percent annual demand growth among target companies through 2030.

Overall, the downside case estimates about 218 TWh of annual corporate renewable PPA demand by 2030. Assuming a 65 percent / 35 percent split between solar and wind, this suggests about 47 GW of incremental solar PPAs and about 8.5 GW of incremental wind PPAs by 2030, for a total of about 55 GW. This total implies that 2019’s pace of more than 11 GWs would be meaningfully slow.

G. POLICY IMPLICATIONS

As discussed previously in this report, in order to achieve deep decarbonization targets, the United States will need to greatly accelerate its deployment of renewables in the power sector if it is going to support global efforts to limit warming to well below 2°C. The three scenarios explored in this report show that, while the corporate PPA market can substantially contribute toward these goals, additional action is needed to support power sector decarbonization and to make decarbonization an even more straightforward business decision for corporate entities.

Furthermore, as this paper's upside and downside scenario projections illustrate, new corporate procurement of renewable electricity is subject to a number of uncertainties, and the range of outcomes is wide. It is possible that private-sector procurement of renewable energy will be materially higher than seen in the base scenario. But it is also possible that falling power prices or a variety of other constraints could lead to corporate PPAs at levels that are well below the base scenario projections.

Renewables' costs have fallen dramatically in recent years, and signing a solar or wind PPA in many regions makes economic sense for many companies. However, given the outlined constraints, the corporate PPA market does not appear deep enough to compensate sustainably for muted demand from utilities and other more traditional sources. While large, creditworthy corporations will be able to continue to utilize renewables PPAs as a mechanism for emissions reductions, eventually this pool of buyers will be exhausted and smaller and less creditworthy businesses will have more difficulty utilizing these structures.

Negative economic externalities, such as greenhouse gas emissions, are defined as such because the private costs of mitigating the externality generally outweigh the private benefits of doing so. Therefore, while the actions of many large US corporations have led to significant additions of zero-carbon generation resources, relying on private-sector actors to voluntarily address unpriced greenhouse gas externalities would be a high-risk decarbonization strategy.

If US policy makers hope to achieve the rapid renewable energy growth necessary to transform the country's energy system, more comprehensive policy frameworks are needed to account for these externalities. New policies could drive greater growth from traditional sources of renewable energy demand (e.g., utilities) while simultaneously making emissions reduction initiatives a more straightforward business decision for US companies.

Federal Policy Implications

Colleagues at the Columbia SIPA Center on Global Energy Policy have explored federal policy tools that would help to drive both corporate and economy-wide decarbonization. In December 2019, Noah Kaufman testified before the House Subcommittee on Environment and Climate Change, arguing that a carbon price should be a central part of any comprehensive climate policy.[100] Kaufman, along with Justin Gundlach and Ron Minsk, have further studied the interaction of a carbon tax and other potential climate policies, recommending that complementary policies be considered alongside carbon pricing. These complementary policies could include increased R&D spending and encouraging energy efficiency investment, among others.[101] In September 2020, Varun Sivaram, Colin Cunliff, David Hart, Julio Friedmann, and David Sandalow published through the SIPA Center on Global Energy Policy *Energizing America, A Roadmap to Launch a National Energy Innovation Mission*, calling for a tripling of federal energy research, development, and demonstration (RD&D) spending over the next five years. The book provides detailed line-item recommendations for Congress to fund 10 "technology pillars," each representing a critical decarbonization need, and designed to unlock a virtuous cycle of public and private investment.[102]

Additional complementary options include direct federal investment in low-carbon infrastructure and incentives designed to catalyze greater private-sector investment in transmission and grid modernization projects. For example, the Federal Energy Regulatory Commission (FERC), which regulates interstate electric transmission assets, has utilized specialized profit incentives (often referred to as "ROE-adder" incentives) and accelerated cost recovery mechanisms to direct private capital toward preferred initiatives.[103] A recent report from CGEP and NYU School of Law's Institute on Policy Integrity explores authorities that are held by both the US Department of Energy and FERC that could be used to support the siting and permitting of new, long-distance transmission lines.[104]

These policies could make clean energy investments a more straightforward decision for corporate entities, driving renewable energy deployment closer to the levels needed to achieve deep decarbonization. Carbon pricing of some form would put renewable energy generating assets on a more level playing field with coal and natural gas plants, whose operating costs in most markets currently do not fully reflect their negative greenhouse gas externalities. A 2018 study completed by the Rhodium Group in conjunction with the Columbia Center on Global Energy Policy estimated that a carbon tax would raise renewables penetration by 2030 from 27 percent in their base case to between 29 percent and 41 percent, depending on the level of the tax.[105] A carbon price would also encourage businesses to internalize carbon externalities in a more direct and predictable way, rather than relying on corporate entities to take action on their own accord.

Further extensions of the ITC and PTC would be another effective option for increasing renewable energy deployment and improving economics for corporate offtakers. Although economists generally consider these tax credits less economically efficient relative to other emissions reductions policies,[106] their existing legislative status may make this option more politically feasible. As noted above, the scheduled phaseout for wind energy tax benefits will eventually put upward pressure on the PPA prices offered by developers to corporations for wind projects. A further extension of these credits could enable wind and solar developers to offer lower PPA prices especially in the absence of an adequate carbon tax. Alternatively, Dr. Varun Sivaram and Dr. Noah Kaufman have further explored the possibility of the "Next Generation of Federal Clean Energy Tax Credits," which would target emerging low-carbon technologies such as carbon capture and storage, dispatchable renewable technologies, and energy storage.[107]

Combinations of these policies could facilitate greater renewable energy deployment in the United States, both by corporate entities and traditional market participants. While some options are more economically efficient than others, all appear to be worthwhile options in supporting accelerated deployment of renewable power generation resources. Without these policies, renewable energy deployment is projected to fall well short of deep decarbonization goals.

State-Level Policies

State-level electric sector policies have in many cases focused on expanding RPS targets, grid modernization, and supporting distributed generation, among other initiatives.[108] These programs could lead to utilities incurring higher costs for RECs, capacity payments, and other investment obligations that are likely to be recovered via higher demand charges for ratepayers. At the same time, having more wind, solar, and storage in the generation mix could put downward pressure on the electricity prices that are bid into wholesale energy markets. Interestingly, these dynamics may then lead to a scenario that elevates the nonenergy components of customer power bills, which VPPAs do not hedge against, while at the same time decreasing the energy-related volumetric component of utility bills, which VPPAs do hedge—absent upward pressure from carbon pricing or other sources. In other words, while promoting renewables growth overall, these policies may lessen the economic competitiveness of corporate renewable VPPAs.

An unexpected takeaway, then, is that policies designed to accelerate the transformation of the power sector to lower carbon sources may gradually weaken the rationale for corporations to hedge the volumetric energy component of their power bills via physical or virtual PPAs. There are other policies available, however, that could facilitate continued corporate renewable energy procurement in the face of these dynamics.

Firming REC Values

In many states, REC values are determined by variable supply and demand, leading to price volatility. The base demand that drives REC values stem from utilities that purchase RECs in order to comply with the state's RPS targets (i.e., compliance RECs). Incremental demand from corporations that voluntarily purchase RECs to support their own sustainability goals adds upward pressure to market-based REC values, while the achievement of RPS targets leads to downward pressure.[109] Having short-term market forces determine REC values tends to undermine confidence in REC revenues, making renewables financing more challenging. In turn, state policies to raise or provide floors on long-term REC values could support financing for projects with lower-priced PPAs.

Alternatively, raising RPS targets coupled with other measures can both raise REC values and add value certainty. In New York, a program of long-term REC awards with revenue floors, has evolved. First introduced to support offshore wind, the designated projects sell their generation capacity into the wholesale energy and capacity markets and are trued up for the difference between evolving prices in those markets and the fixed floor in the OREC award by a state agency. That agency, the New York State Energy Research and Development Authority (NYSERDA), will ultimately pass those true-up costs to customers of the state's distribution utilities.[110] This "index REC" structure, where long-term REC awards from NYSERDA assure a fixed revenue floor from the sum of an offshore generator's REC revenues and its wholesale power market sales, has been extended to new *onshore* wind and solar projects in 2020.[111]

California also requires that utilities enter into long-term contracts for portions of their REC purchases.[112] Many states have carved out special RPS for solar (SRECs) to focus support for distributed solar deployment. These policies can complement corporate PPA markets as higher and firm REC revenues could allow renewables developers to offer lower power prices.

The additionality benefits that result from corporations retiring purchased RECs can still be integrated into these higher-priced REC scenarios using a REC swap. These swaps allow projects to sell their high-priced compliance RECs to the in-state utilities or state agencies paying the highest prices and purchase lower-priced out-of-state RECs for transfer to and retirement by the corporate PPA counterpart.[113]

Expanding Green Tariff Programs

Participation in green tariff programs has emerged as an increasingly important way for corporations to support renewable energy additionality without having to commit to 10-to-20-year fixed-price contracts. In these programs, distribution utilities either construct or procure renewable energy on behalf of interested corporate customers. A designated, typically premium cost, rate is then charged to customers who elect to participate. Corporations in the United States sourced over 5 GW of renewable electricity capacity via green tariffs between 2017 and 2019, according to Bloomberg New Energy Finance.[114] Often, utilities in the regulated power markets have offered these programs after prodding from large-load customers such as Google, Facebook, and Walmart.[115]

Green tariff programs of one form or another are currently available in 17 states.[116] Many utilities in the wholesale markets are not well positioned to offer green tariffs due to regulatory limits on owning generation, but there is room for utilities in other regimes to offer these options.

Expanding these programs among the states raises the prospect of involving a broader share of the US C&I load into renewable energy purchase commitments. With the utility as the intermediary between generator and buyer, these programs can involve corporations that would not have the scale, credit rating, long-term hedging appetite, or energy markets expertise to enter into physical or virtual PPAs.

H. CONCLUSION

Renewable energy procurement efforts by for-profit corporations in recent years have had an encouraging impact on power sector decarbonization efforts, with a significant and increasing share of wind and solar deployment now driven by the procurement decisions of corporations outside of the traditional power sector. It is therefore reasonable to state that renewable deployments in the United States would have looked meaningfully different if private-sector actors had not voluntarily taken steps to reduce their emissions.

This paper quantified the impact of a number of positive and negative factors that could reasonably impact the PPA market going forward, projecting that the corporate PPA market could drive between 218 and 296 TWh of demand equating to 55–85 GW of incremental renewables capacity through 2030. The about 70 GW Base Scenario projection appears to be below current market expectations and implies that 2019's more than 11 GW pace of annual procurement is likely to slow. While large, creditworthy corporations will continue to utilize renewables PPAs as a mechanism for emissions reductions, eventually this pool of buyers will be exhausted, and smaller, less creditworthy, and more price-sensitive businesses will face challenges utilizing these structures. Even the most optimistic scenario indicates overall renewables deployment that is well below the levels needed to achieve deep decarbonization in the United States. The COVID-19 pandemic is further dampening the market due to the factors outlined in section B, though it remains to be seen if these factors will prove transient or have a longer-term impact on corporate procurement initiatives.

These results demonstrate that relying on private-sector actors to voluntarily address unpriced greenhouse gas externalities would be a speculative decarbonization strategy. Instead, if US policy makers wish to achieve the rapid renewable energy growth necessary to transform the country's power sector, more comprehensive policy frameworks are needed. New policies could drive greater growth from the traditional utility sources of renewable energy demand and make emissions reduction initiatives a more straightforward business decision for US companies. This report has explored policy tools available to the federal government, including but not limited to a federal carbon pricing policy. Increased R&D spending, green infrastructure investment, and the extension of federal tax credits may also be considered. Policy tools at the state level include initiatives to firm REC values and the expansion of green tariff offerings to corporate customers.

I . APPENDIX

How PPAs with Renewables Work

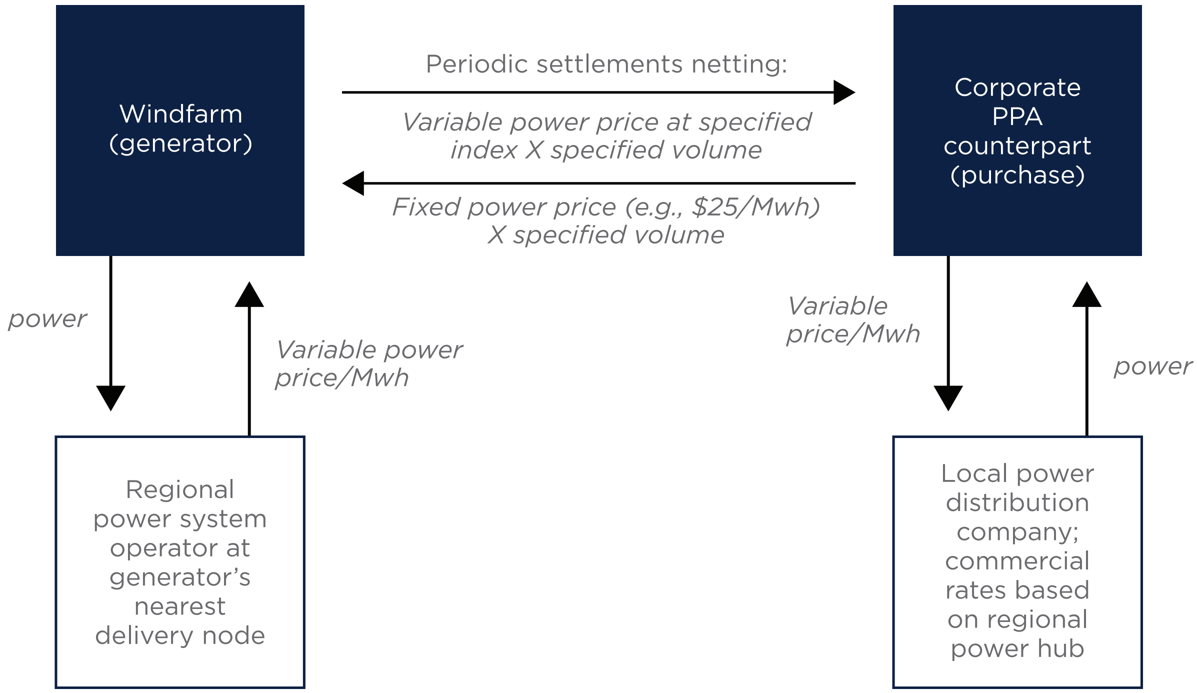
Corporate PPAs are typically described as physical or virtual.[117] With a physical PPA, the generator delivers electricity to the power purchaser through connections to a common power grid. The buyer takes delivery of the electricity as well as the associated RECs in a physical arrangement, with the generator typically being responsible for the cost of moving power to the physical location of the buyer. Physical PPAs between off-site wind and solar projects and corporate buyers do occur, but these arrangements are less common because of logistical and regulatory issues.[118] With regard to distributed generation (e.g., rooftop or on-site solar panels), a commercial entity may use a physical PPA to contract with a third-party owner of solar panels on its roof or adjacent land. This report does not focus on these kinds of distributed generation projects, as their size is limited by the available site or roof area, and the economics are measured against higher retail power costs avoided and earned (when net-metering subsidies are available).

This report's main focus is VPPAs, which currently represent the vast majority of PPAs between corporations and renewable generation projects. In contrast to physical PPAs, virtual PPAs do not require the physical delivery of the electricity produced by the renewable generator to the corporate buyer. Rather, a VPPA is a purely financial transaction, where the buyer agrees to virtually purchase electricity that is generated by the renewables project at a fixed price. In practice, the renewables generator sells its electricity into its local electricity market, while the buyer receives its electricity from its own local grid. Since market electricity prices can vary between locations, the terms of a VPPA will specify whether the fixed price is to be compared with the market price experienced by the generator or the one experienced by the buyer. In the former case, when the generator receives a higher rate from its local market than the fixed price specified in its VPPA, then the difference is owed to the buyer. Conversely, when the renewable generator receives a market price that is lower than the fixed price in its VPPA, then the buyer owes the difference.[119] Periodically, the amounts owed by each party are settled via payment from the party owing the higher net amount.

While there can be variations in how VPPAs work, Figure 8 illustrates a common structure. In this example, a corporate buyer commits to virtually purchasing a specified volume of electricity from a wind farm project for a set number of years at a fixed price of $25 per MWh.[120] The project delivers all of the electricity that it produces into the local hourly priced spot market at its nearest delivery node. On the other side of the equation, the corporate buyer purchases all of the electricity that it physically requires from its local power distribution utility, with the energy component linked to the variable power prices at the nearest pricing hub for its local regional power market. Periodically (typically monthly or quarterly) a net settlement payment is owed from the generator to the buyer—or vice versa—based on the difference between the fixed price and the actual prices in the market specified in the VPPA.

Figure 8: Typical virtual power purchase agreement contract structure

VPPA Example: **power price swap** hedging generator **revenues**



Source: Authors' illustration.

VPPA contracts are frequently *unit contingent*, which means the settlement payments are owed only for the MWhs that the generator actually produces and supplies to the local electricity grid. This condition is a favorable term for renewable electricity generators as it spares them from settling payments for hours when their solar or wind generators may not have been operating (e.g., due to low solar irradiance or wind levels).

Case Studies: Comparing Forward Prices with the PPA Price Offers from Wind and Solar Sources

This section is to provide more background on the analysis of solar and wind PPA prices compared to forward power prices for specific regions summarized earlier (constraint #2): ERCOT, MISO, and the PJM Interconnection. These regions are featured as high-level case studies meant to illustrate the decision-making process of corporate offtakers when evaluating whether to sign a PPA, recognizing there would be broad variation among the price offers individual projects might formulate within a region. As noted earlier, the regional differences among the price offers being measured arise from a range of regional variables: development and installment costs, quality of wind and solar resources, and other revenue sources that may be available apart from energy sales, such as capacity sales. Regional differences in the forward prices being compared would relate to the types of generation supply and load growth outlook among the different regions. The lowest 25th percentile LevelTen PPA offer prices are utilized, under the assumption that the lowest cost PPA offers are most likely to win project bids.

Forward prices for electricity are quoted on the Intercontinental Exchange (ICE) for "on-peak" and "off-peak" hours as of November 18, 2020. These forward market contracts generally define "on-peak" hours as 6:00 or 7:00 a.m. to 11:00 p.m. or 12:00 midnight on weekdays, with all other weekday hours and all weekend hours defined as "off-peak" (Table 7). The variations in the forward market definitions of when "on-peak" starts and ends are linked to regions and time of year.

Table 7: Market-specific on/off-peak pricing details

Daily, monthly, and annual on- and off-peak assumptions									
	ISO-NE	**NYISO**	**PJM**	**MISO**	**SPP**	**ERCOT**	**CAISO**	**AESO (Alberta)**	**IESO (Ontario)**
On-peak hours	HB 7 - 22	HB 7 - 22	HB 7 - 22	HB 6 - 21	HB 6 - 21	HB 6 - 21	HB 6 - 21	HB 7 - 22	HB 7 - 22
Off-peak hours	HB 0 - 6, 23	HB 0 - 6, 23	HB 0 - 6, 23	HB 0 - 5, 22 - 23	HB 0 - 5, 22 - 23	HB 0 - 5, 22 - 23	HB 0 - 5, 22 - 23	HB 0 - 6, 23	HB 0 - 6, 23
Days with peak hours*	5 x 16	5 x 16	5 x 16	5 x 16	5 x 16	5 x 16	6 x 16	7 x 16	5 x 16
Time zone**	ET	ET	ET	EST	CT	CT	PT	MT	ET
Daylight savings adjustment?	yes	yes	yes	no***	yes	yes	yes	yes	yes
NERC holiday schedule observed?	yes	yes	yes	yes	yes	yes	yes	no	yes

Source: "ISO/RTO Hourly Price & Load Data," S&P Global, accessed Aug. 27, 2020.

Note: For consistency across ISO's, hours in the day are displayed as hour beginning (HB) 0–23.
** 5 x 16 is Monday–Friday. 6 x 16 is Monday–Saturday. 7 x 16 is Sunday–Saturday. Each indicates 16 peak hours per day with the remaining hours as off-peak.*
***ET = Eastern Prevailing, EST = Eastern Standard Time, CT = Central Prevailing, MT = Mountain Time, PT = Pacific Prevaling Time.*
**** Hourly and sub-hourly data is usually displayed in SNL using prevailing time only; however, MISO peak, off peak, and around the clock calculated values assume Eastern Standard Time year-round.*

Solar projects have production curves that correspond to the solar irradiance at their particular location throughout each day. This production will occur generally during most, but not all, hours that are "on-peak" during weekdays and "off-peak" hours during weekends, as defined in forward market contracts. As a unit-contingent solar resource can be expected to roughly produce about 70 percent of its electricity during on-peak hours (i.e., five out of seven days of the week) and about 30 percent during off-peak hours, it is fair to assume that a corporate buyer that is considering a solar PPA will compare a price offer with the market outlook for peak pricing.

Wind projects have a production curve that corresponds to wind strength. Wind production varies according to the location of the project, season of the year, time of day, and weather. Broadly speaking, onshore wind farm production is strongest at nighttime, with a majority of the power that it produces occurring during hours the forward market contracts would define as off-peak (exceptions exist, of course). When measuring whether a PPA is financially attractive, the price offers should fall between the on-peak and off-peak forward power price projections.

Electric Reliability Council of Texas

ERCOT is an ISO within the state of Texas and is not subject to the jurisdiction of the FERC. This market contains some of the strongest wind and solar resources in the country and has experienced significant growth in renewable generation capacity over the past 15 years. ERCOT's own Capacity, Demand, and Reserves (CDR) report projects that this growth will continue to accelerate (Table 8). This ISO expects over about 13.6 GW of new utility-scale solar capacity and over 4.4 GW of new onshore wind capacity by 2023e, based entirely on identified projects.[121] Analysts at Rystad Energy project that wind will overtake coal generation in the state for the first time at some point in 2020.[122]

Table 8: ERCOT summer capacity forecast (2021–2025)

Resources, MW	2021	2022	2023	2024	2025
Installed capacity, thermal/hydro	64,026	64,096	64,096	64,096	64,096
Switchable capacity, MW	3,490	3,490	3,490	3,490	3,490
Less: switchable capacity unavailable to ERCOT, MW	-542	-542	-542	-542	-542
Available mothballed capacity, MW	588	470	470	470	470
Capacity from private use networks	3,259	3,172	3,167	3,122	3,082
Coastal wind, peak average capacity contribution (63% of installed capacity)	2,188	2,188	2,188	2,188	2,188
Panhandle wind, peak average capacity contribution (29% of installed capacity)	1,279	1,279	1,279	1,279	1,279
Other wind, peak average capacity contribution (16% of installed capacity)	3,251	3,251	3,251	3,251	3,251
Solar utility-scale, peak average capacity contribution (76% of installed capacity)	3,069	3,069	3,069	3,069	3,069
Storage, peak average capacity contribution (0% of installed capacity)	0	0	0	0	0
RMR capacity to be under contract	0	0	0	0	0
Capacity pending retirment, MW	-235	-235	-235	-235	-235
Operational generation capacity, MW	**80,373**	**80,238**	**80,233**	**80,188**	**80,148**
Non-synchronous ties, capacity contribution (68% of installed capacity)	850	850	850	850	850
Planned resources (not wind, solar or storage) with signed IA, air permits and water rights	816	1,199	1,199	1,199	1,199
Planned coastal wind with signed IA, peak average capacity contribution (63% of installed capacity)	829	952	1,088	1,088	1,088
Planned panhandle wind with signed IA, peak average capacity contribution (29% of installed capacity)	0	49	93	93	93
Planned other wind with signed IA, peak average capacity contribution (16% of installed capacity)	935	2,046	2,141	2,217	2,217
Planned solar utility scale, peak average capacity contribution (76% of installed capacity)	3,039	12,312	13,645	14,333	14,333
Planned storage, peak average capacity contribution (0% of installed capacity)	0	0	0	0	0
Total capacity MW	**86,842**	**97,646**	**99,249**	**99,968**	**99,928**

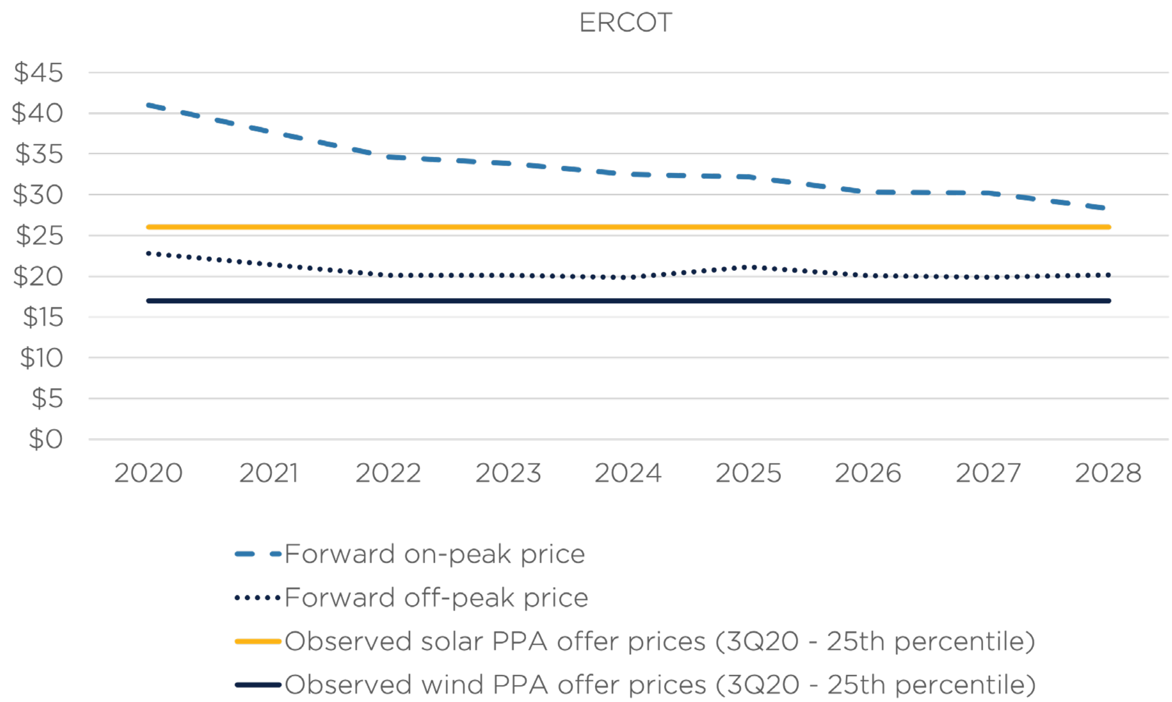
Source: December 2020 ERCOT CDR Report.[123]

In principle, VPPAs are a better hedging proposition in ERCOT than some other markets because the volumetric energy-linked component of a buyer's power costs can be more volatile than in regions with capacity markets. The ERCOT market does not have a capacity market, which is a distinct contrast with the design of the wholesale power markets in the Northeast and mid-Atlantic. Capacity markets aim to ensure that there is adequate generation in the market to achieve a comfortable reserve margin of generation supply over peak demand; in consequence scarcity pricing is limited in the energy markets. In ERCOT, peaking plants are rewarded when the reserve margin becomes low and demand exceeds supply (e.g., on atypically warm days). This market structure can lead to price spikes approaching the market's mandated cap of $9,000 per MWh.[124]

The 25th percentile ERCOT wind PPA offer prices quoted by LevelTen are about $17 per MWh as of the third quarter of 2020. While these prices have increased relative to 2019 quotes, ERCOT still offers some of the most attractive wind economics in the country. These offers appear financially compelling relative to current ERCOT forward curves, sitting below off-peak forward pricing in most regions. This would translate to savings for corporate buyers relative to buying power in the open market.

Solar PPA offers in ERCOT have been more expensive than wind offers. But in most years, they remain attractive relative to on-peak pricing. Forward on-peak pricing across ERCOT averages around about $40 per MWh over the next year but declines to below $30 per MWh by the end of the decade. This steep downward slope in on-peak pricing may raise some questions regarding the long-term economics of solar PPAs, but significant savings can certainly be realized for a period of time, importantly in the early years, which are weighted more heavily in cost NPV estimates.

Figure 9: Solar and wind PPA offer prices relative to forward ERCOT power prices



Source: "Power Forwards & Futures," S&P Global, accessed Nov. 18, 2020; LevelTen Energy.

Note: Prices are an average across all reported MISO hubs.

Midcontinent Independent System Operator

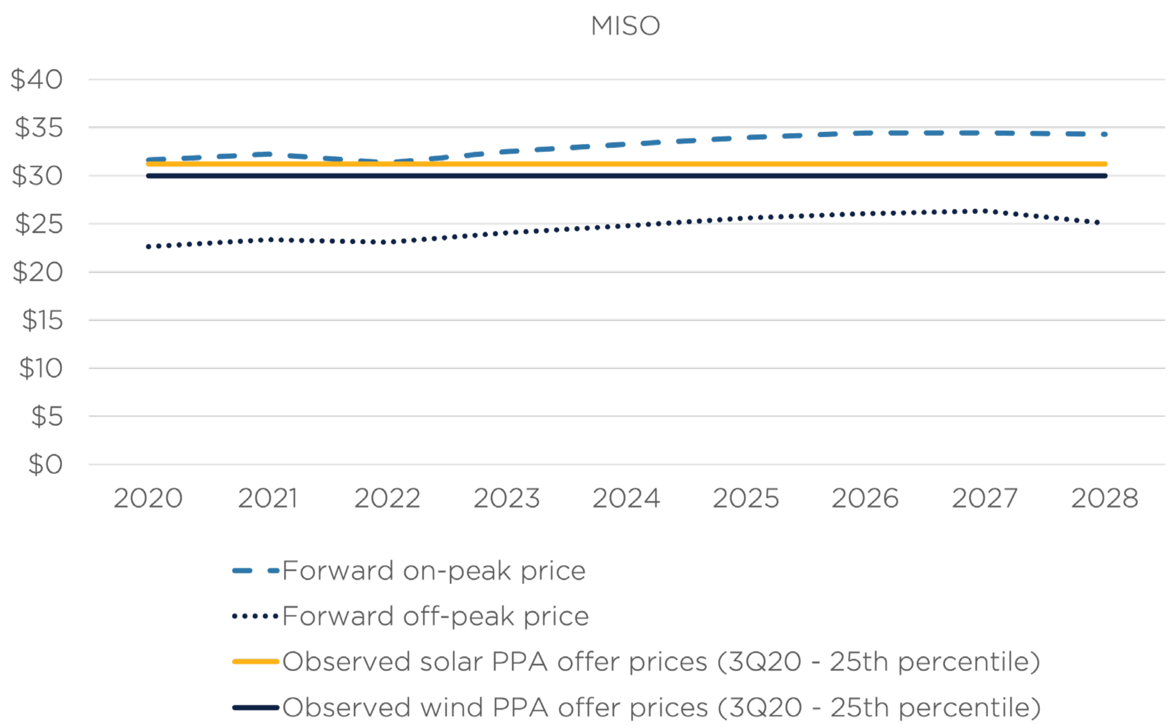
MISO manages electricity service across 15 US states and the Canadian province of Manitoba. In addition to its electricity market, MISO operates a Planning Resource Auction, which is a capacity auction that compensates certain electric generating assets for their capacity in addition to the electricity that they generate.[125] Intermittent wind and solar assets are typically only given credit for a portion of their nameplate capacity when participating in these capacity markets. As mentioned earlier in this text (constraint #2), it is assumed that the price offers from renewable sources being compared here have been formulated by sponsors taking capacity revenues into consideration to the extent such revenues may be applicable. The existence of a capacity market, in theory, tends to lower wholesale power prices and thus the variable portion of a businesses' electricity bill (i.e., the portion of the bill that PPAs are intended to hedge).

Given the vast territory across which MISO operates, diverse power price drivers among its submarkets, and intermixed regulated generation, it is difficult to make generalizations about renewables economics across the whole ISO. With that caveat in mind, this analysis attempted to make some high-level inferences using available data.

Wind PPA offer prices were quoted by LevelTen across three regions within MISO, with the average 25th percentile price (P25) coming in at about $30 per MWh in the third quarter of 2020. These wind PPA offer prices are in between off-peak and on-peak prices, measured using an average across all hubs within the MISO market. This result suggests that the economic competitiveness of wind PPAs likely varies regionally within MISO, with some regions likely competitive, while others are not.

Solar PPA offer prices were compiled by LevelTen across six different pricing zones, as far north as Minnesota and as far south as Louisiana. The average P25 solar PPA price across all of these zones was about $31 per MWh, marginally below average on-peak forward prices in most years. This suggests that solar PPAs are on the cusp of being an attractive option for corporations that are looking to hedge their on-peak pricing exposure in MISO, albeit with significant regional variation (Figure 10).

Figure 10: Solar and wind PPA offer prices relative to forward MISO power prices



Source: "Power Forwards & Futures," S&P Global, accessed Nov. 18, 2020; LevelTen Energy.

Note: Prices are an average across all reported MISO hubs.

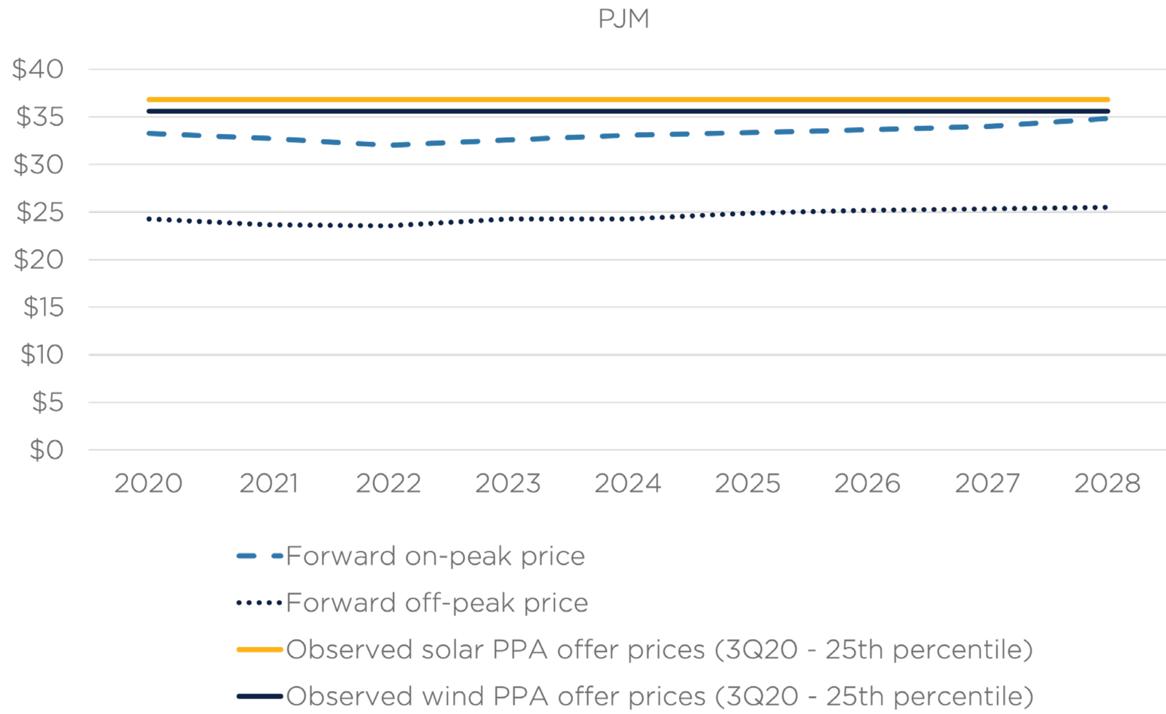
PJM Interconnection

The PJM Interconnection regional transmission organization (RTO) operates across 13 states in the mid-Atlantic and Midwest regions of the United States. Similar to MISO, PJM operates a Base Residual Auction that compensates electricity-generating assets to ensure that adequate capacity is available on a rolling three-year basis. As with the other regions, this section presents some high-level takeaways on the PJM market, though in practice each wind and solar PPA offer would need to be evaluated relative to local, rather than region-wide, power prices. Broadly speaking, power prices are typically higher near the population centers in the eastern part of the market, which could make individual PPA offers more competitive in these regions.

Wind PPA offers in the region have seen a significant increase over the past year and are now at about $36 per MWh at the 25th percentile, above even on-peak pricing. Depending on the shape of both the wind generation and the local power pricing within PJM's many subzones, though, a wind PPA could make financial sense for an offtaker in the region.

Solar PPA offers are currently at around $37 per MWh, similarly above on-peak pricing. Given that solar projects tend to compete more with on-peak pricing, these projects may be more viable than wind in the region despite slightly higher PPA pricing. Generally, though, one would not expect a significant amount of solar PPA activity in PJM based on economics alone, except in certain supply-constrained corners of the market where power prices may be higher.

Figure 11: Solar and wind PPA offer prices relative to forward PJM power prices



Source: "Power Forwards & Futures," S&P Global, accessed Nov. 18, 2020; LevelTen Energy.

Note: Prices are an average across all reported MISO hubs.

Expanding on Constraint #4: Financial Risks and the Existence of Alternative Emissions Reduction Mechanisms

As already noted, the power price hedge affected by a VPPA may be critical for the generation project's financing prospects, but the hedge element may be of minor importance to a segment of participating corporations. The issues described below relating to the effectiveness of the power price hedge in a VPPA for the corporate counterpart may have low priority for those corporations where electricity cost is a relatively minor part of their total operating costs. For the large tech companies with the highest power loads, more attention is likely to be paid to power price hedge and its effectiveness.

Resource and Operational Risk

Renewable generation sources exhibit some shortcomings as hedge counterparties, compared with standard commodity price hedges. In standard hedges (i.e., those arranged directly with banks or other commodity hedge providers), traders and corporate entities can negotiate a contract that defines for settlements the particular blocks of hours (e.g., weekly, monthly, on-peak, off-peak) to which they are most price sensitive. These contracts can also use a settlement index that is linked to the power-pricing hub most relevant to the corporations' power demand.

By comparison, standard unit-contingent PPAs with wind and solar projects introduce uncertainty with regards to the time periods and prices that will be effectively hedged for the buyer. Forecasts of seasonal production for wind and solar resources have become fairly reliable, but production over shorter periods can vary significantly (i.e., resource risk), which can impact their ability to closely match a buyer's power load. Renewable resources can also have their production limited by maintenance issues or transmission curtailments—such as when regional wind production exceeds regional load (i.e., operational risk).

For these reasons, unit-contingent PPAs may not effectively hedge the corporate counterpart for high-priced periods. This uncertainty had already led to some pushback from PPA buyers. For example, Microsoft has promoted a form of PPA based on a "proxy generation" curve that would shift some of the resource and operating risk to the generator.[126] Volume-firming insurance products have also emerged in the market.[127] While these terms and products can mitigate the resource and operating risk for offtakers, they may add complexity and costs to VPPA arrangements.

Covariance Risk

As renewables deployment increases within a region, the periods of highest wind generation or solar production will tend to correlate with power oversupply and consequently lower power prices as the market becomes saturated with zero-marginal cost electricity. This phenomenon exposes PPA buyers to the risk that market prices may evolve over time to become reliably below the strike price when the renewable generator is producing the highest volumes (i.e., covariance risk). In turn, the net settlement payments owed by the buyer may grow to much higher levels for longer periods than expected.[128]

Locational Basis Risk

Variable market power prices can differ between the location where the generator is delivering power to the grid and the location where the buyer receives power. The terms of a VPPA will specify a locational index defining the market prices that are measured against the fixed price for determining settlement payments. If the VPPA defines the generator's delivery node as the index for the variable market prices, this presents a risk for the corporate buyer. Namely, the risk is that settlement payments will not be matched to the variable price experience (i.e., "locational basis risk"). For example, if the generator's node is the specified index and market prices are $2 per MWh higher than the fixed price at the generator's node but $5 per MWh higher than the fixed price at the buyer's local electricity hub, then the buyer will be owed just the $2/MWh difference above the fixed price of the generator even though the buyer paid $5 per MWh above the fixed price. In this case, the VPPA would not have fully hedged the buyer's electricity price down to the fixed price.

There is evidence that recent VPPAs have been negotiated to refer to the buyer's local index for market prices, pushing basis risk onto the generators. This pushback from the corporate side of contracts, along with the shift to generators of resource and operating risk mentioned above, signals that corporations are bargaining for VPPA terms more generous to the buyer. The negotiation leverage may be shifting toward the demand side of the PPA market.[129]

Accounting Issues

An area of complexity for corporations involved in VPPAs is derivative accounting. These contracts may or may not meet the definition of a derivative depending on whether the agreement includes volumetric guarantees or default provisions that indicate a minimum volume.[130] Unless properly structured, a power price hedge might need to be marked to market on the company's books with periodic revaluations adding unwanted volatility to reported earnings.

Limits on Overhedging

Interviews with risk management and financial structuring analysts conducted as part of the research process for this report indicate that businesses in other industries traditionally do not fix the cost of *all* of their input or energy cost exposure for the long term. In order to capture the potential benefits of lower prices, companies typically employ dynamic strategies to cap as well as fix prices for a range of terms and involve at least some portion of their long-term exposure as an unhedged or "open" position.[131]

Given the historically low wind and solar price offers and the expected phaseout of tax benefits for renewables, 2019–22 may be an optimal time for corporate offtakers to lock in renewable PPAs at attractive price offers. There is also reason to pause over fully hedging at today's price offers if renewable energy technologies are expected to experience further significant cost declines. Continued softening of natural gas prices and the oversupply of all generation types compared with load can push prices down in the wholesale energy markets.

Companies matching all of their loads with fixed-price PPAs may be able to lay off some of their fixed-price exposures through offsetting hedges such as selling into forward markets and other commodity derivative products. Nevertheless, it is reasonable to assume that many corporations pursuing renewable energy targets will refrain from entering into agreements equivalent to 100 percent of their load for long periods in order to avoid potentially overpaying if market energy prices decline over the course of the agreement. This constraint may be beginning to manifest; discussions with market participants over the course of this analysis indicated that the average PPA contract length has been decreasing from 15 to 20 years historically, to about 10 years today.

Businesses May Elect to Pursue Emissions Reductions via Other Means

As discussed elsewhere in this report, corporate renewables PPAs are not the only means available to for-profit entities to reduce their electricity emissions profile. Alternative options include RECs, green tariffs, carbon offset programs, and even distributed generation. It follows that not all businesses that have sustainability targets will elect to meet their goals using PPAs. As discussed previously, green tariffs in particular have begun to expand as an alternative option. Moreover, industry leaders such as Google and Microsoft have begun to consider broader "zero-carbon" energy procurement strategies that are designed to incorporate technologies beyond wind and solar, including, but not limited to, hydro, nuclear, and carbon capture.[132] While these initiatives are undoubtedly positive for decarbonization efforts overall, they may lead to less procurement of wind and solar PPAs specifically.

Further, as outlined above, it is no small task for buyers to analyze the complexities of their wholesale power price exposure and the intricate risks that must be managed when signing a long-term PPA. Not all companies have access to the capital and institutional expertise needed to assess something as complex as a corporate renewable PPA. Some organizations (e.g., REBA) work with companies to help them to overcome these barriers. But not all companies will choose to engage on these issues and/or be comfortable locking in their electricity prices—which can be a meaningful expense—for a 10-plus years.

On a global level, just about 32 percent of C&I renewable energy procurement has been arranged via VPPAs, according to a Wood Mackenzie analysis of Climate Disclosure Project data.[133] In the United States, according to data from Bloomberg New Energy Finance, VPPAs appear to be a much more popular option, representing about 80 percent of all identifiable corporate procurement from 2016 to 2019. While it is possible that green tariffs will take an even greater share going forward, the market size projections in the following section assume that 80 percent of C&I procurement comes in the form of corporate PPAs.

Table 9: About 80 percent of identified US corporate renewable energy procurement was conducted via VPPAs from 2016–2019

Company	2016	2017	2018	2019	2016–2019 total
Corporate PPA procurement (GW)	2.4	2.8	5.9	11.2	22.3
Non-PPA corporate procurement (GW)	0.0	0.5	2.6	2.4	5.5
Total corporate procurement (GW)	**2.4**	**3.3**	**8.5**	**13.6**	**27.8**

Source: Compiled from annual BNEF Corporate Clean Energy press releases and annual BNEF Sustainability Factbooks.[134]

Some Businesses May Not Prioritize Emissions Reductions

A portion of businesses are either not overly concerned with sustainability issues or do not have the resources to act on their concerns. Addressing a businesses' environmental footprint requires money, time, and other resources that many businesses cannot afford to dedicate to the issue. It is difficult to reasonably estimate what portion of C&I businesses will fall under this constraint, but it is a limitation nonetheless.

Overview of Projections for Base, Upside, and Downside Scenarios

Table 10: Overview of base, upside, and downside scenario projections

	Base case		Upside case		Downside case	
	TWh	% impact	TWh	% impact	TWh	% impact
2019 C&I electricity demand	2,307		2,307		2,307	
Less: portion in infeasible regulatory regimes for corporate PPAs	-727	-32%	-727	-32%	-727	-32%
C&I demand in favorable regulatory regimes for corporate PPAs	1,580		1,580		1,580	
Less: estimated ~40% of regions with unfavorable PPA economics (relaxed by 30-50% to acct for "green premium" considerations)	-379	-24%	-316	-20%	-442	-28%
C&I demand with favorable regulation & strong economics	1,201		1,264		1,138	
Less: C&I demand from companies with insufficient scale	-625	-52%	-657	-52%	-592	-52%
C&I demand with favorable regulation, strong economics, & scale	576		607		546	

continued on next page

	Base case		Upside case		Downside case	
	TWh	% impact	TWh	% impact	TWh	% impact
Less: ~38% companies with non-Investment-grade credit ratings	-219	-38%	-231	-38%	-208	-38%
C&I demand with Ffvorable regulation, strong economics, scale & investment-grade	357		376		339	
Less: businesses reducing emissions via non-PPA alternatives or to not reducing emissions at all	-71	-20%	-75	-20%	-69	-20%
C&I demand with favorable regulation, strong economics, scale & investment-grade	286		301		269	
Less: miscellaneous constraints (hedging shortcomings, not hedging 100% of load, etc.)	-57	-20%	-50	-17%	-63	-23%
Total addressable market - current	229		251		206	
Assumed 1%/1.5%/0.5% load growth among target companies	26	12%	45	18%	12	6%
Total 2030 addressable market	**255**		**296**		**218**	
Assumed share - solar	65%		65%		65%	
Assumed capacity factor - solar	27%		27%		27%	
2030 Penetration forecast - solar (GW)	69.4		80.5		59.2	
Current penetration - solar (GW)	12.3		12.3		12.3	
Expected growth through 2030 - solar (GW)	**57.1**		**68.2**		**46.9**	
Assumed share - wind	35%		35%		35%	
Assumed capacity factor - wind	37%		37%		37%	
2030 Penetration forecast - wind (GW)	27.2		31.6		23.2	
Current penetration - wind (GW)	14.8		14.8		14.8	
Expected growth through 2030 - wind (GW)	**12.5**		**16.8**		**8.5**	
2030 Penetration forecast - solar and wind (GW)	96.6		112.1		82.4	
Current penetration - solar and wind (GW)	27.0		27.0		27.0	
Expected growth through 2030 - solar and wind (GW)	**69.6**		**85.0**		**55.4**	

Source: Authors' estimates.

Base case note: About 68.5 percent of total C&I in favorable regulatory regimes from Table 5; about 60 percent of favorable regulatory regions also have attractive economics per Table 6; Wood Mackenzie estimates that about 48 percent of C&I demand comes from F100; about 38 percent of F100 companies are rated non-investment grade.

NOTES

1. Of note is strong agreement in the literature that the most affordable pathways to a reliable, zero-carbon power sector include a mix of technologies across three broad pillars: (1) zero-marginal-cost variable power plants (e.g., wind and solar); (2) firm, dispatchable zero-carbon power plants (e.g., nuclear; hydro; and natural gas with carbon capture, utilization, and storage); and (3) energy storage, including both short-duration (e.g., batteries) and long-duration (e.g., green hydrogen) options. This report focuses on PPAs that support two technologies—wind and solar power—that fall under the first of these pillars. For example, see J. Jenkins and S. Thernstrom, "Deep Decarbonization of the Electric Power Sector: Insights from Recent Literature," Energy Innovation Reform Project, March 2017, https://www.innovationreform.org/wp-content/uploads/2018/02/EIRP-Deep-Decarb-Lit-Review-Jenkins-Thernstrom-March-2017.pdf.

2. V. Masson-Delmotte et al., eds., "Summary for Policymakers," in *Global Warming of 1.5°C: An IPCC Special Report on the Impacts of Global Warming of 1.5°C above Pre-industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty* (2018), 12, https://www.ipcc.ch/sr15/chapter/spm/.

3. "Emissions from Energy Consumption at Conventional Power Plants and Combined-Heat-and-Power Plants," EIA, accessed January 8, 2021, https://www.eia.gov/electricity/annual/html/epa_09_01.html.

4. "Greenhouse Gas Inventory Data Explorer," EPA, accessed January 8, 2021, https://cfpub.epa.gov/ghgdata/inventoryexplorer/#iallsectors/carbondioxide/inventsect/all.

5. Ben Haley et al., "350 PPM Pathways for the United States: US Deep Decarbonation Pathways Project," Evolved Energy Research, May 8, 2019, https://docs.wixstatic.com/ugd/294abc_95dfdf602afe4e11a184ee65ba565e60.pdf.

6. Authors' correspondence with Ben Haley, Ryan Jones, and Gabe Kwok at Evolved Energy Research, April 14, 2020.

7. *Sustainable Energy in America Factbook*, Business Council for Sustainable Energy, Bloomberg New Energy Finance (BNEF), 2021, 22, https://bcse.org/factbook.

8. "February/March 2020 Investors Presentation," NextEra Energy, accessed January 8, 2021, slide 32, http://www.investor.nexteraenergy.com/~/media/Files/N/NEE-IR/news-and-events/events-and-presentations/2020/02-25-2020/February%20March%202020%20Investor%20Presentation_vF2.pdf.

9. RPS are usually imposed on a defined class of "load-serving entities" (LSEs), which usually includes public and investor-owned utilities, cooperative utilities, and electricity retailers. This study uses the word *utilities* to refer to that broader class.

10. "State Renewable Portfolio Standards and Goals," NSCL, April 17, 2020, https://www.ncsl.org/research/energy/renewable-portfolio-standards.aspx.

11. "States' Renewable Energy Ambitions," NCSL, February 4, 2019, https://www.ncsl.org/research/energy/states-renewable-energy-ambitions.aspx.

12. *Sustainable Energy in America Factbook*, Business Council for Sustainable Energy, Bloomberg New Energy Finance (BNEF), 2021, 43, https://bcse.org/factbook.

13. "Solar Market Insight Report 2019 Year in Review," SEIA/Wood Mackenzie Power and Renewables, March 17, 2020, https://www.seia.org/research-resources/solar-market-insight-report-2019-year-review.

14. "Corporates Usher in New Wave of US Wind and Solar Growth," Wood Mackenzie, August 20, 2019, https://www.woodmac.com/our-expertise/focus/Power Renewables/corporates-usher-in-new-wave-of-u.s.-wind-and-solar-growth/.

15. "Corporate Clean Energy Buying Grew 18% in 2020 Despite Mountain of Adversity," BNEF, January 26, 2021, https://about.bnef.com/blog/corporate-clean-energy-buying-grew-18-in-2020-despite-mountain-of-adversity/.

16. "Corporate Sourcing of Renewables: Market and Industry Trends—REmade Index 2018," IRENA, 2018, https://irena.org/-/media/Files/IRENA/Agency/Publication/2018/May/IRENA_Corporate_sourcing_2018.pdf.

17. The IHS Markit report on corporate procurement potential estimated between 200 and 225 TWh of corporate load as a "planning case" with just under 300 TWh as their "high case." Based on their capacity factor assumptions, these contracted loads could enable between 44 and 72 GWs through 2030. Kevin Adler, "Corporate US Renewable Procurement Outlook: Optimism amid a Pessimistic Year," IHS Markit, November 22, 2020, https://ihsmarkit.com/research-analysis/corporate-us-renewable-procurement-outlook-optimism-amid.html.

18. "Corporate Clean Energy Buying Leapt 44% in 2019, Sets New Record," BNEF, January 28, 2020, https://about.bnef.com/blog/corporate-clean-energy-buying-leapt-44-in-2019-sets-new-record/.

19. Rachit Kansal, "Virtual Power Purchase Agreement: Introduction to the Virtual Power Purchase Agreement," Rocky Mountain Institute, 2019, https://rmi.org/insight/virtual-power-purchase-agreement/; Sarah Penndorf, "Renewable Energy Power Purchase Agreements," 3Degrees, February 5, 2018, https://3degreesinc.com/resources/ppas-power-purchase-agreements/.

20. "Going Above and Beyond, the Future of Renewable Energy Leadership," RE100, September 16, 2020, https://www.there100.org/our-work/news/going-above-and-beyond-future-renewable-energy-leadership.

21. "Achieving Our 100% Renewable Energy Purchasing Goal and Going Beyond," Google,

December 2016, https://static.googleusercontent.com/media/www.google.com/en//green/pdf/achieving-100-renewable-energy-purchasing-goal.pdf.

22. "Corporate Statements about the Use of Renewable Energy: What Does 100% Renewable Really Mean?," Environmental Law Institute, January 2019, https://www.eli.org/sites/default/files/eli-pubs/corporate-renewables.pdf.

23. "Achieving Our 100% Renewable Energy Purchasing Goal and Going Beyond," Google, December 2016, https://static.googleusercontent.com/media/www.google.com/es//green/pdf/achieving-100-renewable-energy-purchasing-goal.pdf.

24. "Utility Green Tariffs," EPA, accessed January 7, 2021, https://www.epa.gov/greenpower/utility-green-tariffs.

25. Typically, an important element of the VPPA transaction is the transfer of the RECs bundled with the output of the renewable energy generator to the corporate buyer. The buyer may have the option to resell the RECs into the market, but the additionality objective for most corporate participants is better served by retiring the RECs.

26. Sarah Penndorf, "Renewable Energy Power Purchase Agreements," 3Degrees, February 5, 2018, https://3degreesinc.com/resources/ppas-power-purchase-agreements/.

27. "Updated: Outlook for US Renewable Energy Projects following COVID-19," Baker Mckenzie, June 1, 2020, https://www.bakermckenzie.com/en/insight/publications/2020/06/outlook-for-us-renewable-energy-projects.

28. "Daily Electricity Demand Impacts from COVID-19 Mitigation Efforts Differ by Region," EIA, May 7, 2020, https://www.eia.gov/todayinenergy/detail.php?id=43636.

29. "Third Quarter 2020 Earnings Conference Call Transcript," Ameren Corporation, November 5, 2020, https://s21.q4cdn.com/448935352/files/doc_financials/2020/q3/Ameren-Corporation-q3-2020-earnings-call-FINAL.pdf; note: this is one example of many utilities that have reported persisting C&I demand weakness.

30. Lauren Fedor, "Donald Trump Signs $2tn Coronavirus Stimulus into Law," *Financial Times*, March 27, 2020, https://www.ft.com/content/2c70c1d5-b14e-4584-bd32-bb674dde3d9a; Jordan Fabian and Justin Sink, "Trump Signs $2 Trillion Virus Bill, Largest Ever U.S. Stimulus," March 27, 2020, https://www.bloomberg.com/news/articles/2020-03-27/trump-signs-2-trillion-virus-bill-largest-ever-u-s-stimulus?sref=aPcjMv7J.

31. Jeff St. John, "Senate Strikes Deal on Coronavirus Stimulus Package That Excludes Help for Renewables," *Green Tech Media*, March 25, 2020, https://www.greentechmedia.com/articles/read/clean-energy-assistance-wont-be-part-of-massive-coronavirus-stimulus-bill.

32. Catherine Morehouse, "Federal Stimulus Includes Wind, Solar Tax Credit Extensions, Adds First US Offshore Wind Tax Credit," Utility Dive, December 22, 2020, https://www.utilitydive.com/news/federal-stimulus-includes-wind-solar-tax-credit-extensions-adds-first-us/592572/.

33. Russell Gold, "Wind, Solar Farms Are Seen as Havens in Coronavirus Storm," *Wall Street Journal*, March 31, 2020, https://www.wsj.com/articles/wind-solar-farms-are-seen-as-havens-in-coronavirus-storm-11585656003.

34. Will Mathis and Jeremy Hodges, "Wind-Power Industry Heads for Record Year," *Bloomberg Green*, March 31, 2020, https://www.bloomberg.com/news/articles/2020-03-31/wind-industry-heads-for-record-year-even-as-outlook-scaled-back.

35. "Sustainable Energy in America Factbook" Business Council for Sustainable Energy, Bloomberg New Energy Finance (BNEF), 2021: 43, https://bcse.org/factbook/.

36. "LevelTen Energy PPA Price Index—Q4 2020," LevelTen Energy, accessed January 17, 2021, 7, https://leveltenenergy.com/blog/ppa-price-index/q4-2020/.

37. "Table 5.1. Sales of Electricity to Ultimate Customers—Electric Power Monthly July 2020," EIA, accessed May 26, 2020, https://www.eia.gov/electricity/monthly/.

38. Helen Dewhurst, "Corporate PPA Deal Tracker," Bloomberg, May 2019; Kyle Harrison, "Corporate PPA Deal Tracker," Bloomberg, February 2020.

39. "Corporate Clean Energy Buying Leapt 44% in 2019, Sets New Record," BNEF, January 28, 2020, https://about.bnef.com/blog/corporate-clean-energy-buying-leapt-44-in-2019-sets-new-record.

40. Capacity factors above the historical US fleet averages are chosen, given that most corporate PPA deals were done in the last three years. "Table 6.07.B. Capacity Factors for Utility Scale Generators Primarily Using Non-fossil Fuels," EIA, May 26, 2020, https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_6_07_b.

41. "Table 5.1. Sales of Electricity to Ultimate Customers—Electric Power Monthly July 2020," EIA, accessed May 26, 2020, https://www.eia.gov/electricity/monthly/.

42. "Table 5.1. Sales of Electricity to Ultimate Customers—Electric Power Monthly July 2020," EIA, accessed May 26, 2020, https://www.eia.gov/electricity/monthly/.;"Table 6.07.B. Capacity Factors for Utility Scale Generators Primarily Using Non-fossil Fuels," EIA, May 26, 2020, https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_6_07_b.; "2020 Sustainable Energy in America Factbook," BNEF, Business Council for Sustainable Energy, accessed January 9, 2021, https://data.bloomberglp.com/professional/sites/24/BNEF-BCSE-2020-Sustainable-Energy-in-Amercia-Factbook_FINAL.pdf.

43. Constant Alarcon and Marie Reynolds, "RE100 Progress and Insights Annual Report," *RE100*, December 2019, https://www.there100.org/sites/re100/files/2020-09/RE100ProgressandInsightsAnnualReport2019.pdf.

44. Russell Gold, "New Source of Climate Pressure for Companies: Workers," *Wall Street Journal*, February 16, 2020, https://www.wsj.com/articles/new-source-of-climate-pressure-for-companies-workers-11581861601?mod=searchresults&page=1&pos=10&mod=article_inline.

45. Constant Alarcon and Marie Reynolds, "RE100 Progress and Insights Annual Report,"

RE100, December 2019, https://www.there100.org/sites/re100/files/2020-09/RE100ProgressandInsightsAnnualReport2019.pdf.

46. "2018 Global Sustainable Investment Review", Global Sustainable Investment Alliance April 1, 2019, http://www.gsi-alliance.org/wp-content/uploads/2019/06/GSIR_Review2018F.pdf.

47. 1 TWh is the equivalent of 1,000,000 MWhs.

48. "Environmental Report 2019," Google, 2019, https://services.google.com/fh/files/misc/google_2019-environmental-report.pdf.; "Sustainable Data Centers," Facebook, accessed August 24, 2020, https://sustainability.fb.com/innovation-for-our-world/sustainable-data-centers/.; "2019 Data Factsheet: Environmental Indicators," Microsoft, 2019, https://query.prod.cms.rt.microsoft.com/cms/api/am/binary/RE3455q ; "2016 Data Factsheet: Environmental Indicators," Microsoft, 2016, http://download.microsoft.com/download/0/1/4/014D812D-B2E3-43A0-A89A-16E3C7CD46EE/2016_Data_Factsheet_Environmental_Indicators.pdf.

49. "Data Centers and Servers," Office of Energy Efficiency and Renewable Energy, Department of Energy, accessed January 10, 2021, https://www.energy.gov/eere/buildings/data-centers-and-servers.

50. "Data Centers and Servers," Office of Energy Efficiency and Renewable Energy, Department of Energy, accessed January 17, 2021, https://www.energy.gov/eere/buildings/data-centers-and-servers.

51. "REBA Deal Tracker," REBA, accessed January 10, 2021, https://rebuyers.org/deal-tracker/.

52. "Moving toward 24 × 7 Carbon-Free Energy at Google Data Centers," Google, October 2018, https://storage.googleapis.com/gweb-sustainability.appspot.com/pdf/24x7-carbon-free-energy-data-centers.pdf.

53. Garrett Hering, "Google, NV Energy Propose World's Largest Corporate Solar-plus-Storage Deal," S&P Global, January 7, 2020, https://www.spglobal.com/platts/en/market-insights/latest-news/electric-power/010720-google-nv-energy-propose-worlds-largest-corporate-solar-plus-storage-deal#:~:text=New%20York-,Google%2C%20NV%20Energy%20propose%20world's,corporate%20solar%2Dplus%2Dstorage%20deal&text=New%20York%20%E2%80%94%20Affiliates%20of%20Google,deal%20for%20a%20corporate%20customer.

54. "Amazon Launches a $2 Billion Climate Pledge Fund," Amazon Day One, June 23, 2020, https://blog.aboutamazon.com/sustainability/amazon-launches-a-2-billion-climate-pledge-fund?_amp=true.

55. "Sustainability: Thinking Big," Amazon, December 2019, https://sustainability.aboutamazon.com/download-pdf.

56. Michael Weingartner and Beth Porter, "Clean Energy Is Calling," Green America, April 2019, https://www.greenamerica.org/sites/default/files/2019-05/GA_Telecoms_Report_Final%20%281%29.pdf.

57. "Magenta Is Going Green," T-Mobile, https://www.t-mobile.com/responsibility/sustainability/renewable-energy.

58. Michael Weingartner and Beth Porter, "Clean Energy Is Calling," Green America, April 2019, https://www.greenamerica.org/sites/default/files/2019-05/GA_Telecoms_Report_Final%20%281%29.pdf.

59. "Magenta Goes Green: T-Mobile Commits to 100% Renewable Energy," T-Mobile, January 28, 2018, https://www.t-mobile.com/news/tmobile-commits-renewable-energy.

60. "Verizon Becomes a Leading Corporate Buyer of U.S. Renewable Energy," Verizon Communications, January 29, 2021, https://www.verizon.com/about/news/verizon-becomes-leading-corporate-buyer-us-renewable-energy.

61. Anders S. G. Andrae, "Hypotheses for Primary Energy Use, Electricity Use and CO_2 Emissions of Global Computing and Its Shares of the Total between 2020 and 2030," *WESAS Transactions on Power Systems* 15, March 2020, https://www.researchgate.net/publication/339900068_Hypotheses_for_primary_energy_use_electricity_use_and_CO2_emissions_of_global_computing_and_its_shares_of_the_total_between_2020_and_2030.

62. David Ozment, "Walmart's Commitment to Solar," May 9, 2014, https://corporate.walmart.com/newsroom/sustainability/20140509/walmarts-commitment-to-solar.

63. "Anheuser-Busch and Enel Green Power Announce Renewable Energy Partnership," Anheuser-Busch, September 13, 2017, https://www.anheuser-busch.com/newsroom/2017/09/anheuser-busch-and-enel-green-power-announce-renewable-energy-pa.html.

64. "Proudly Brewed with Wind and Solar Energy," Anheuser-Busch, accessed January 10, 2021, https://www.anheuser-busch.com/community/initiative/renewable-electricity.html.; Emma Foehringer Merchant, "Anheuser-Busch Embraces Solar to Power Past Its 100% Renewables Target," June 4, 2019, https://www.greentechmedia.com/articles/read/anheuser-busch-announces-222-megawatt-solar-project-with-recurrent-energy#:~:text=In%202017%2C%20Anheuser-Busch%20committed,megawatts%20of%20wind%20in%20Oklahoma.

65. "Corporate Clean Energy Buying Leapt 44% in 2019, Sets New Record," BNEF, January 28, 2020, https://about.bnef.com/blog/corporate-clean-energy-buying-leapt-44-in-2019-sets-new-record/.

66. Bonnie Rochma, "'This Store Is Powered by Sunshine': Solar and Wind Power Fuel Starbucks Stores," Starbucks, September 13, 2018, https://stories.starbucks.com/stories/2018/solar-and-wind-power-fuel-starbucks-store/.

67. Emma Foehringer Merchant, "Starbucks Buys Aggregated Wind and Solar Portfolio With Help from LevelTen," *Green Tech Media*, June 5, 2019, https://www.greentechmedia.com/articles/read/starbucks-buys-aggregated-wind-and-solar-portfolio-with-help-from-levelten.

68. Bryce Smith, "LevelTen Creates Groundbreaking Renewable Energy Portfolio to Support More Than 3,000 US Starbucks Stores," *LevelTen Energy*, June 5, 2019, https://

leveltenenergy.com/blog/company-news/starbucks-ppa-portfolio/.

69. "LevelTen Energy, Together with Bloomberg, Cox Enterprises, Gap Inc., Salesforce and Workday, Forge New Path to Corporate Renewable Energy Procurement," *LevelTen Energy*, January 17, 2019, https://leveltenenergy.com/blog/company-news/corporate-renewable-energy-aggregation-group/.

70. "Lazard's Levelized Cost of Energy Analysis—Version 13.0," Lazard, November 2019, https://www.lazard.com/media/451086/lazards-levelized-cost-of-energy-version-130-vf.pdf.

71. LCOE reported from IRENA includes technology costs with no mention of subsidies.

72. "Future of Solar Photovoltaic: Deployment, Investment, Technology, Grid Integration and Socio-economic Aspects," IRENA, November 2019, https://www.irena.org/publications/2019/Nov/Future-of-Solar-Photovoltaic.

73. "Future of Wind: Deployment, Investment, Technology, Grid Integration and Socio-economic Aspects," IRENA, October 2019, https://www.irena.org/publications/2019/Oct/Future-of-wind.

74. "Tax Credits and Solar Tariffs Affect Timing of Projected Renewable Power Plant Deployment," EIA, May 15, 2018, https://www.eia.gov/todayinenergy/detail.php?id=36212.

75. "February/March 2020 Investors Presentation," NextEra Energy, accessed January 10, 2020, slides 28 and 29, http://www.investor.nexteraenergy.com/~/media/Files/N/NEE-IR/news-and-events/events-and-presentations/2020/02-25-2020/February%20March%202020%20Investor%20Presentation_vF2.pdf.

76. "What Happened to Wind Energy? Explaining the Production Tax Credit," *Silver Tax Group*, November 8, 2019, https://silvertaxgroup.com/production-tax-credit/.

77. Catherine Morehouse, "Federal Stimulus Includes Wind, Solar Tax Credit Extensions, Adds First US Offshore Wind Tax Credit," Utility Dive, December 22, 2020, https://www.utilitydive.com/news/federal-stimulus-includes-wind-solar-tax-credit-extensions-adds-first-us/592572/.

78. "Wind PTC and Solar ITC Gain COVID-19 Construction Relief from IRS," McGuireWoods, May 29, 2020, https://www.mcguirewoods.com/client-resources/Alerts/2020/5/wind-ptc-and-solar-itc-gain-covid-19-construction-relief-from-irs; "Treasury, IRS Provide Safe Harbor for Taxpayers That Develop Renewable Energy Projects," IRS, May 27, 2020; https://www.irs.gov/newsroom/treasury-irs-provide-safe-harbor-for-taxpayers-that-develop-renewable-energy-projects; Catherine Morehouse, "Federal Stimulus Includes Wind, Solar Tax Credit Extensions, Adds First US Offshore Wind Tax Credit," Utility Dive, December 22, 2020, https://www.utilitydive.com/news/federal-stimulus-includes-wind-solar-tax-credit-extensions-adds-first-us/592572/.

79. Maryssa Baron, "Energy Markets 101," LevelTen Energy, October 10, 2019, https://leveltenenergy.com/blog/clean-energy-experts/energy-market.

80. A trading hub is an aggregation of nodes within a wholesale market. Rachit Kansal, "Virtual Power Purchase Agreement," RMI, 2019, https://rmi.org/insight/virtual-power-purchase-agreement.

81. Sarah Penndorf, "Renewable Energy Purchase Agreements," *3 Degrees*, February 2018, https://3degreesinc.com/resources/ppas-power-purchase-agreements/; Maryssa Baron, "Energy Markets 101," *LevelTen Energy*, October 10, 2019, https://leveltenenergy.com/blog/clean-energy-experts/energy-market.

82. "US Electricity Grid and Markets," EPA, accessed January 18, 2021, https://www.epa.gov/greenpower/us-electricity-grid-markets.

83. "US Electricity Grid and Markets," EPA, accessed January 17, 2021, https://www.epa.gov/greenpower/us-electricity-grid-markets.

84. Specifically, the risk that wholesale power prices might decline below the agreed fixed price in a PPA agreement for a longer period of time than anticipated.

85. "The Rise of the Corporate PPAs: A New Driver for Renewables," Baker McKenzie, 2015, 15, https://www.bakermckenzie.com/-/media/files/insight/publications/2015/12/the-rise-of-corporate-ppas/risecorporateppas.pdf?la=en.

86. It is worth noting that forward markets can be volatile and subject to change on a daily basis.

87. A 10-year level-price offer collected from a wind or solar project under development will deviate from the oft-cited levelized cost of energy (LCOE) metric for measuring source competitiveness in several respects. VPPA price offers can be lower than LCOE to reflect other potential revenue sources, such as payments for capacity, ancillary services, and REC revenue if they are not bundled with the price offer. VPPA also can be lower than LCOE when expected equity returns are not levelized and instead are expected to be concentrated in the years after the VPPA has expired.

88. In the final assessment of the constraint, several adjustments are made to take into account the possibility that some businesses are willing to pay a premium for their electricity costs, among other factors.

89. To date, PPAs have typically been 10 and 20 years in length. A future refinement on this analysis could include the application of a discounted cash flow model that captures the entire 10-to-20-year contract period in order to fully assess particular deals.

90. In reality, each buyer would likely compare the PPA offer price to the blended average wholesale price forecast scenarios for the time periods during which they would expect the wind or solar asset to be generating electricity.

91. Various wholesale price forecasts would be compared, which would involve different scenarios for the price drivers, such as evolving supply/demand balances, generation mix, gas prices, and other factors. A practice enabled by LevelTen is to compare the fixed price offers with multiple wholesale price scenarios that are run to arrive at estimates of

how competitively the price offer compares with price outlooks with various degrees of probability. For example, a price offer determined to have a 1 out of 100 probability (P-99) of turning out to be higher than the variable price by a present-value cost of $1 million might be viewed as an acceptable "worst case" scenario by a buyer with a loss tolerance in the range of $1 million.

92. Analyses similar to the ERCOT and PJM sections were performed for each of the other major wholesale power markets. 65 percent of demand is estimated to occur during "on-peak" hours, when solar is the favored technology, while 35 percent of demand is estimated to occur during "off-peak" hours, when wind is the favored technology. For each market, if solar or wind PPA prices were deemed competitive relative to forward prices, 100 percent of the demand was credited to the initial market size. If the technology was deemed to be "potentially competitive" due to variations in local subregion pricing, 60 percent of the demand was credited to the initial market size. 30 percent was used instead of 60 percent in NYISO and ISO-NE in consideration of the low level of corporate PPA contracting in those markets. Model is available upon request.

93. "2018 Utility Bundled Retail Sales—Industrial," EIA, accessed January 17, 2021, https://www.eia.gov/electricity/sales_revenue_price/pdf/table8.pdf; EIA, "2018 Utility Bundled Retail Sales—Commercial," accessed January 17, 2021, https://www.eia.gov/electricity/sales_revenue_price/pdf/table7.pdf.

94. "Sales to Ultimate Customers (Megawatt Hours) by State by Sector by Provider, 1990–2018," EIA, accessed November 15, 2020, https://www.eia.gov/electricity/data.php#sales.

95. "Analysis of Corporate and Industrial Wind Energy Demand in the United States," Wood MacKenzie, 2019, https://www.woodmac.com/our-expertise/focus/Power--Renewables/corporates-usher-in-new-wave-of-u.s.-wind-and-solar-growth/.

96. "Green Power Partnership Fortune 500 Partners List," EPA, July 27, 2020, https://www.epa.gov/sites/production/files/2020-01/documents/fortune500_jan2020.pdf.

97. "Redbridge Survey of Fortune 1000 Uncovers Funding Strategies," Redbridge Debt and Treasury Advisory, February 14, 2018, https://www.redbridgedta.com/market-intelligence/redbridge-survey-of-fortune-1000-uncovers-funding-strategies/.

98. "Table 6.07.B. Capacity Factors for Utility Scale Generators Primarily Using Non-fossil Fuels," EIA, May 26, 2020, https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_6_07_b.

99. As shown in table 9, non-PPA corporate procurement totaled around 20 percent of 2016–19 procurement.

100. Noah Kaufman, "Solutions for Economy-wide Deep Decarbonization," *Center on Global Energy Policy*, December 5, 2019, https://energypolicy.columbia.edu/research/testimony/solutions-economy-wide-deep-decarbonization.

101. Justin Gundlach, Ron Minsk, Noah Kaufman, "Interactions between a Federal Carbon Tax

and Other Climate Policies," CGEP, March 6, 2019, https://energypolicy.columbia.edu/research/report/interactions-between-federal-carbon-tax-and-other-climate-policies.

102. Varun Sivaram, Colin Cunliff, David Hart, Julio Friedmann, and David Sandalow, "Energizing America: A Roadmap to Launch a National Energy Innovation Mission," September 2020, https://www.energypolicy.columbia.edu/sites/default/files/file-uploads/EnergizingAmerica_FINAL_EXECUTIVE%20SUMMARY.pdf.

103. Paul Ciampoli, "FERC Seeks Comment on Transmission Incentives, ROEs," *American Public Power Association*, March 21, 2019, https://www.publicpower.org/periodical/article/ferc-seeks-comment-transmission-incentives-roes.

104. Avi Zevin, Sam Walsh, Justin Gundlach, and Isabel Carey, "Building a New Grid without New Legislation: A Path to Revitalizing Federal Transmission Authorities," December 14, 2020, https://www.energypolicy.columbia.edu/research/report/building-new-grid-without-new-legislation-path-revitalizing-federal-transmission-authorities.

105. John Larsen, Shashank Mohan, Peter Marsters, and Whitney Herndon, "Energy and Environmental Implications of a Carbon Tax in the United States," *Center on Global Energy Policy*, July 2018, https://energypolicy.columbia.edu/sites/default/files/pictures/CGEP_Energy_Environmental_Impacts_CarbonTax_FINAL.pdf.

106. Varun Sivaram and Noah Kaufman, "The Next Generation of Federal Clean Electricity Tax Credits," *Center on Global Energy Policy*, June 3, 2019, https://energypolicy.columbia.edu/research/commentary/next-generation-federal-clean-electricity-tax-credits.

107. Varun Sivaram and Noah Kaufman, "The Next Generation of Federal Clean Electricity Tax Credits," *Center on Global Energy Policy*, June 3, 2019, https://energypolicy.columbia.edu/research/commentary/next-generation-federal-clean-electricity-tax-credits.

108. Glen Anderson, Megan Cleveland, and Daniel Shea, "Modernizing the Electric Grid: State Role and Policy Options," *National Conference of State Legislatures*, November 2019, 21–26, https://www.ncsl.org/Portals/1/Documents/energy/Modernizing-the-Electri-Grid_112519_34226.pdf.

109. "Corporate Statements about the Use of Renewable Energy: What Does 100% Renewable Really Mean?," Environmental Law Institute, January 2019, https://www.eli.org/sites/default/files/eli-pubs/corporate-renewables.pdf.

110. "Fact Sheet: Offshore Wind Contracts and Phase One Report," New York State, accessed January 8, 2021, https://www.nyserda.ny.gov/-/media/Files/Programs/offshore-wind/osw-phase-1-fact-sheet.pdf.

111. Cullen Howe, "NY PSC Approves Measure to Lower Costs for Clean Energy," *NRDC*, January 23, 2020, https://www.nrdc.org/experts/cullen-howe/ny-psc-approves-measure-lower-costs-clean-energy; "Order Modifying Tier 1 Renewable Procurements," NY PSC, January 16, 2020, 20, http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7b1F9CA0EB-3968-41DB-BBE0-C251A3FE52DE%7d.

112. The Clean Energy and Pollution Reduction Act (SB350) provides commencing in 2021 for 65 percent of RPS requirements be met by contracts of at least 10 years. "Renewables Portfolio Standard (RPS) Program," California Public Utilities Commission, accessed February 11, 2021, https://www.cpuc.ca.gov/rps/.

113. "Corporate Statements about the Use of Renewable Energy: What Does 100% Renewable Really Mean?," Environmental Law Institute, January 2019, https://www.eli.org/sites/default/files/eli-pubs/corporate-renewables.pdf; "What Is a REC and How Do They Work," Urban Grid, June 25, 2019, https://www.urbangridsolar.com/what-is-a-rec-how-do-they-work/.

114. The "Non-PPA" Corporate Procurement documented in table 9 in the appendix is primarily green tariff procurement.

115. Joel Makower, "How Google and Walmart Work with Utilities to Procure Green Power," *GreenBiz*, April 9, 2018, https://www.greenbiz.com/article/how-google-and-walmart-work-utilities-procure-clean-power; "Designing and Implementing Renewable Energy Tariffs," Facebook, April 2017, https://www.facebook.com/notes/green-on-facebook/designing-and-implementing-renewable-energy-tariffs/1645979022084014/.

116. "Green Tariffs Map," World Resources Institute, https://www.wri.org/green-tariffs-map.

117. Virtual PPAs are also referred to as "synthetic PPAs" or "contracts for difference."

118. Sarah Penndorf, "Renewable energy power purchase agreements," 3Degrees, February 5, 2018, https://3degreesinc.com/resources/ppas-power-purchase-agreements/.

119. Rachit Kansal, "Virtual Power Purchase Agreement: Introduction to the Virtual Power Purchase Agreement," *Rocky Mountain Institute*, 2019, https://rmi.org/insight/virtual-power-purchase-agreement/.

120. This fixed price is commonly referred to as the "strike price."

121. "Report on the Capacity, Demand and Reserves (CDR) in the ERCOT Region, 2021–2030," ERCOT, December 16, 2020, http://www.ercot.com/content/wcm/lists/167023/CapacityDemandandReserveReport-Dec2019.pdf.

122. "Red States Go Green: Texas Wind Power on Track to Outpace Coal by 2020," *Rystad Energy*, September 19, 2019, https://www.rystadenergy.com/newsevents/news/press-releases/red-states-go-green-texas-wind-power-on-track-to-outpace-coal-by-2020/.

123. ERCOT, "Report on the Capacity, Demand and Reserves (CDR) in the ERCOT Region, 2021–2030," December 16, 2020, http://www.ercot.com/content/wcm/lists/167023/CapacityDemandandReserveReport-Dec2019.pdf.

124. Chris Martin and Naureen S. Malik, "Power Blows Past $9,000 Cap in Texas as Heat Triggers Emergency," *Bloomberg*, August 13, 2019, https://www.bloomberg.com/news/articles/2019-08-13/texas-power-prices-briefly-surpass-9-000-amid-searing-heat.

125. MISO, "MISO Clears Seventh Annual Planning Resource Auction," April 12, 2019, https://

www.misoenergy.org/about/media-center/miso-clears-seventh-annual-planning-resource-auction/.

126. Kenneth Davies, Giji M. John, and Lee Taylor, “Proxy Generation PPAs: The Next Evolution of PPAs for the Corporate and Industrial Buyer,” *Microsoft, Orrick, REsurety*, 2018, https://orrick.blob.core.windows.net/orrick-cdn/Proxy_Generation_PPAs.pdf.

127. Lee Taylor, “The Next Generation of Risk Management for Renewable Energy,” *North American Windpower*, May 16, 2019, https://nawindpower.com/the-next-generation-of-risk-management-for-renewable-energy.

128. “Renewable Energy Risk Management: The Benefits and Risks of a VPPA”, Urban Grid, March 20, 2019, https://www.urbangridsolar.com/renewable-energy-risk-management/.

129. “Renewable Energy Risk Management: The Benefits and Risks of a VPPA”, Urban Grid, March 20, 2019, https://www.urbangridsolar.com/renewable-energy-risk-management/.

130. Matt Smith, “Wind Farm Derivative Accounting and Dodd-Frank Reporting Considerations,” Renewable Energy World, February 5, 2018, https://www.renewableenergyworld.com/2018/02/05/wind-farm-derivative-accounting-and-dodd-frank-reporting-considerations/#gref.

131. “Renewable Energy Risk Management: The Benefits and Risks of a VPPA,” Urban Grid, March 20, 2019, https://www.urbangridsolar.com/renewable-energy-risk-management/.

132. Brad Smith, “Microsoft Will Be Carbon Negative by 2030,” *Microsoft*, January 16, 2020, https://blogs.microsoft.com/blog/2020/01/16/microsoft-will-be-carbon-negative-by-2030/; Google, “Moving toward 24 × 7 Carbon-Free Energy at Google Data Centers,” October 2018, https://storage.googleapis.com/gweb-sustainability.appspot.com/pdf/24x7-carbon-free-energy-data-centers.pdf.

133. “Corporates Usher In New Wave of US Wind and Solar Growth,” Wood Mackenzie, August 20, 2019, https://www.woodmac.com/our-expertise/focus/Power--Renewables/corporates-usher-in-new-wave-of-u.s.-wind-and-solar-growth/.

134. “Corporate Clean Energy Buying Leapt 44% in 2019, Sets New Record,” BNEF, January 28, 2020, https://about.bnef.com/blog/corporate-clean-energy-buying-leapt-44-in-2019-sets-new-record/; “Corporate Clean Energy Buying Surged to New Record in 2018,” BNEF, January 28, 2019, https://about.bnef.com/blog/corporate-clean-energy-buying-surged-new-record-2018/; “Corporations Purchased Record Amounts of Clean Power in 2017,” BNEF, January 22, 2018, https://about.bnef.com/blog/corporations-purchased-record-amounts-of-clean-power-in-2017/; “2020 Sustainable Energy in America Factbook,” BNEF, Business Council for Sustainable Energy, accessed January 9, 2021, https://data.bloomberglp.com/professional/sites/24/BNEF-BCSE-2020-Sustainable-Energy-in-Amercia-Factbook_FINAL.pdf.

COLUMBIA | SIPA
Center on Global Energy Policy