The CFE Manager: A New Model for Driving Decarbonization Impact

Introduction

Google was an early pioneer of a transaction structure—the corporate power purchase agreement (PPA)—that has helped wind and solar power scale across the globe over the last decade. In 2010, we signed what at the time was the largest non-utility wind power PPA for a 114 MW project to serve the electric grid where we operate our data center in Iowa. Fast forward to today, and corporate PPAs are responsible for the deployment of tens of gigawatts (GW) of new clean energy capacity onto electricity grids each year. In 2021, corporations signed PPAs for 31.1 GW of new renewable energy capacity across the globe, a new record.[1]

PPAs helped Google become one of the largest non-utility purchasers of renewable energy in the world and were key in enabling us to match 100% of our global annual electricity consumption with renewable energy purchases, which we have accomplished every year since first hitting this milestone in 2017. PPAs are thus a core tool to scale clean energy deployment and will remain so in the future. However, as we have shifted our focus from simply purchasing clean energy to operating everywhere on 24/7 carbon-free energy (CFE) by 2030, we recognized that contractual innovations would be needed. We worked with partners to create a new purchasing method—the CFE Manager model—that builds on the existing PPA model to better match clean energy generation to our electricity demand at an hourly level while providing a number of additional business benefits. These benefits include better risk mitigation, scalability to meet growing electricity demand over time, and enhanced decarbonization impact.

Research indicates that hourly matching of electricity use with clean energy on the same grid has a transformative impact on electricity systems by leading to greater emissions reductions, faster retirement of fossil fuel capacity (replaced with equally reliable clean energy resources), and accelerated commercialization of innovative carbon-free energy technologies.[2] By sharing our experience with the CFE Manager approach, we hope to encourage other electricity consumers to use similar structures, helping advance decarbonization in this critical decade for climate action.

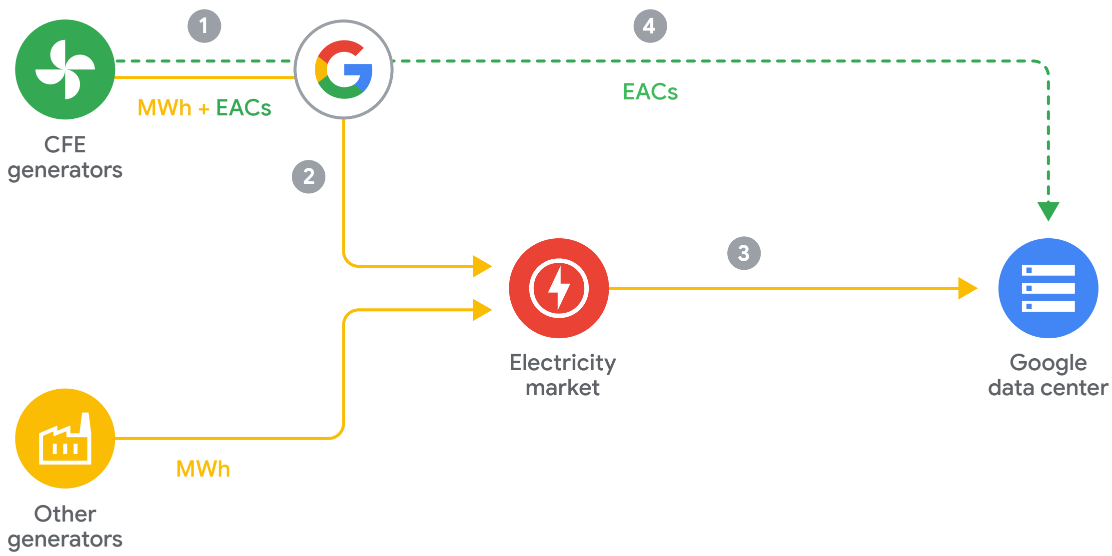
This paper introduces the CFE Manager model that we have pioneered with partners across the globe. The first section of the paper discusses the features of traditional PPAs, including their benefits and their limitations. Section two introduces the CFE Manager model, including the motivations for the model and key transaction principles. Section three highlights three case studies where Google has pursued the CFE Manager model. Section four discusses potential future innovations and applications in the marketplace.

1. The Traditional Corporate Power Purchase Agreement

Google has purchased the large majority of our clean energy to date through traditional PPA structures. A PPA is a contract to buy power over a specified period of time (typically between 10-20 years), often at a fixed price, from a particular clean energy facility. For the project owner, these agreements provide a secure, long-term revenue stream that allows them to raise the financing needed to develop, construct, and operate the project. For the clean energy buyer, PPAs offer predictable, stable prices for electricity, which reduces an energy buyer's exposure to volatile wholesale or retail power prices.[3]

There are a number of PPA models Google uses, depending on the structure of the electricity market where we operate. In geographies with deregulated wholesale and retail markets, which includes much of Europe and parts of the United States, we are able to "directly" purchase clean energy and have it delivered ("sleeved") to our retail electricity bill using the local grid. In markets with competitive wholesale markets but no retail competition, we can purchase clean power through a PPA at the wholesale level and sell the power back to the same grid where we buy power at the retail level (known as a "fixed-floating swap").[4]

FIGURE 1: TRADITIONAL PPA DIAGRAM



Energy Attribute Certificates (EACs) — Electricity — Bundle energy + EACs

1. Google purchases CFE and EACs directly from a CFE generator under a PPA
2. Google sells the CFE into the electricity grid at the wholesale level, where it's pooled with other energy sources
3. Google purchases retail electricity for our data center from the same electricity grid into which we sold our CFE
4. Google matches the EACs from our PPAs (in Step 1) to our electricity consumption at the data center

Under a PPA structure, clean energy buyers typically purchase both the electricity generated by the project and the energy attribute certificates (EACs) associated with each megawatt-hour that the project produces (referred to as a "bundled electricity purchase"). This allows the buyer to claim the use of the clean energy generated by the project. It is also how clean energy buyers validate claims such as being "100% renewable," which refers to matching annual electricity consumption with renewable energy purchases—a goal that Google has met since 2017.[5] The diagram in Figure 1 shows a typical PPA structure. In this structure, Google signs a PPA with a clean energy generator for both the electricity and EACs. The generator then sells the electricity into the broader electricity grid that provides electricity to Google's data center, and Google retires the EACs to match our consumption. Retiring an EAC means that the owner has used it and can no longer sell it to another party.

While Google and other large energy consumers have increased their use of PPAs in recent years, not all buyers are able to make use of these structures. Some electricity consumers may be too small or lack the creditworthiness needed to access the PPA market. Others, by virtue of the nature of their business, may be unable to commit to long-term PPA contracts, perhaps because they lease their buildings or the long-term prospects of the business are uncertain. Further, negotiating PPAs can be a time-intensive process and often requires specialized energy and legal expertise, which also come at an additional cost. Finally, PPAs can also have technical accounting implications that may be complicated to assess.

PPAs can provide a number of benefits for buyers that can access them, but PPAs also present risks the buyer must manage.[6] These include:

1. **Shape Risk:** Most PPAs for renewable energy projects commit the buyer to purchase all the electricity from the underlying generator (known as "as-produced"). Due to the variable nature of wind and solar energy, there will be a mismatch between the hourly production profile of the generator and the buyer's hourly electricity demand. Thus, buyers are exposed to the risk of high market prices when PPA energy production is less than facility demand and exposed to the risk of low market prices when PPA production exceeds facility demand. In some markets, "firming and shaping" products are available to help manage this financial risk.

2. **Cannibalization Risk:** As more zero-marginal-cost renewable energy is deployed on the same electricity grid and generated at the same time, it depresses market prices for electricity in those hours. This reduces the revenue earned by current and future renewable energy projects that share similar production profiles. This also exacerbates shape risk if production and demand are mismatched.

3. **Basis Risk:** This refers to the price difference between the market price where the electricity is generated (sold) and the market price where the electricity is purchased and consumed by the buyer. This risk is particularly pronounced when buyers sign agreements for renewable energy located in different grids than where they consume (such as under virtual PPA arrangements), but is also a feature of physical PPAs on the same grid if it contains multiple price nodes or zones.

Google has built a team and developed sophisticated tools and systems to manage the risks associated with our PPA portfolio. However, we recognize that PPA portfolio management is not core to the business of many companies, who therefore cannot dedicate significant resources to this task. In addition to the risks that PPAs entail, they are fundamentally a work-around; they are a way to access clean energy where it is not otherwise directly available from our retail electricity supplier.

As we embarked on our goal to operate entirely on 24/7 CFE by 2030, we asked ourselves whether a better model was possible. Could we develop structures that are optimized not simply to add more clean MWhs to grids but to better match them to our electricity demand when and where it occurs? Could we create a model that reduces risks for clean energy buyers? And could we create an approach that, in addition to being useful for Google, could enable all organizations to pursue 24/7 CFE?

2. From Volume to Impact: The CFE Manager Model

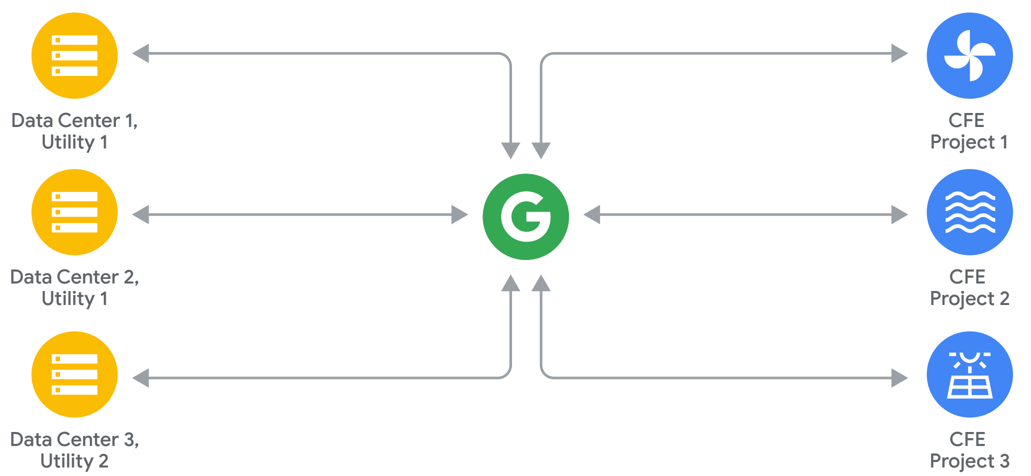
The CFE Manager model is a new type of retail electricity supply agreement that is optimized to deliver clean power when and where it's needed to decarbonize a grid user's electricity demand. Instead of purchasing as-produced clean energy from a specific generation asset to match annual electricity consumption, the CFE Manager model builds a portfolio of resources tailored to match hourly electricity demand. We announced our first agreement using this model with AES in 2021 (See the following section for a detailed case study).

We had a number of motivations to develop this new approach. First, moving beyond our 100% annual renewable energy match and toward 24/7 carbon-free energy increased the complexity of procurement via traditional PPAs. We now need to ensure not just that we purchase sufficient annual volumes of clean energy but that this energy better aligns with the time and location (on the same regional grid) where we consume power. Second, we wanted to develop a deal structure that was easily replicable from one region to another, and that could be adopted easily by other clean energy buyers. Finally, we wanted a model that enabled efficient scaling of our procurement; as our electricity demand increased, we sought to grow our clean energy without a proportional increase in dedicated staff resources.

The graphic below shows the mechanics of the CFE Manager model and how it differs from the traditional PPA approach. In this example, Google has three facilities served by two different utilities within a particular regional grid. Under the traditional PPA approach (Figure 2A), Google negotiates and signs individual PPAs with separate clean energy generators and simultaneously manages three separate retail energy supply agreements for our three facilities in the region. Each PPA includes a different price for the associated clean energy generation and each retail supply agreement has its own detailed pricing structure. Under the CFE Manager model (Figure 2B), Google tasks a CFE Manager to identify a portfolio of clean energy resources that can best supply Google's hourly electricity demand at a competitive price. The CFE Manager executes PPAs with individual generators, and is also responsible for firming and shaping (de-risking) the clean power supply and delivering it to Google's facilities. In return, Google pays a negotiated price under a retail power supply agreement with the CFE

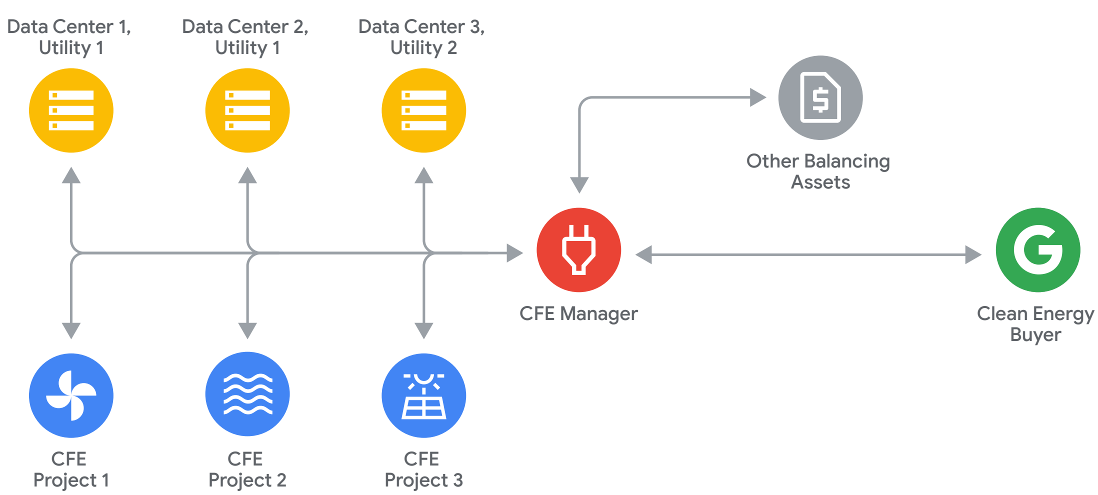
Manager. Using the contracted portfolio, the CFE manager guarantees that Google's hourly electricity consumption is met by a certain percentage of carbon-free energy over the course of the year.[7]

FIGURE 2A: IN THE TRADITIONAL PPA MODEL, THE CLEAN ENERGY BUYER MUST MANAGE MULTIPLE ENERGY SUPPLY AGREEMENTS FOR MULTIPLE DEMAND FACILITIES, AND MANAGE MULTIPLE PPAS WITH DIFFERENT CFE GENERATORS



PPAs	Supply Agreements	DC Sites	Effective Price	CFE %
3+	3+	3+	?	?

FIGURE 2B: WITH THE CFE MANAGER MODEL, THE CFE MANAGER TAKES RESPONSIBILITY FOR RETAIL ENERGY SUPPLY TO THE DEMAND FACILITIES, AND CONTRACTS WITH A PORTFOLIO OF CFE GENERATORS TO ACHIEVE A SPECIFIED HOURLY CFE PERCENTAGE



PPAs	Supply Agreements	DC Sites	Effective Price	CFE %
↓0	↓1	3+	Known	Guaranteed

For clean energy buyers like Google, the CFE Manager model provides a number of benefits. First, the new structure significantly reduces a buyer's transaction costs associated with traditional PPAs. Instead of negotiating multiple agreements with different PPA counterparties, there is only one agreement with one CFE Manager counterparty. Second, the CFE Manager model mitigates a number of the risks associated with PPAs discussed in the prior section, such as shape risk, cannibalization risk, and basis risk. In essence, it can shift many of these risks to the energy supplier, which, given established electricity market operations and existing generating portfolios, is also often the party best equipped to manage them. Third, the model is scalable; contracts can be designed so that the portfolio of clean energy projects grows over time, ensuring that a buyer's growing electricity demand is always met with clean energy. Fourth, because a CFE Manager can leverage a broad portfolio of CFE assets and a wide base of energy customers, they can offer better diversification and greater liquidity for clean energy buyers, which can enable shorter contract terms and more competitive costs compared to individual PPAs. Finally, the CFE Manager model can be optimized to enable buyers to achieve a high degree of hourly matching with clean energy because the CFE Manager has the benefit of a more diverse portfolio of CFE assets and risk-mitigation tools, like grid-scale batteries or their own in-house trading desk. This allows buyers to decarbonize a greater amount of their electricity demand and thus have a greater impact on the decarbonization of the electricity grid as a whole.[8]

CFE Manager Model Benefits for Buyers:

1. Lower transaction costs
2. Mitigation of PPA risks
3. Scalability
4. Diversification and Liquidity
5. Greater decarbonization of electricity demand

There are benefits for electricity suppliers as well. By developing new market offerings, retail electricity suppliers differentiate themselves in the marketplace. A CFE Manager can reduce their own market risks by aggregating electricity demand from different customer types (residential, commercial, industrial), and assembling a diverse portfolio of generating assets. The CFE Manager model also provides retail suppliers more flexibility, as they can choose the resources they use to meet their CFE delivery obligations.[9] Finally, suppliers can create a stable source of revenue by serving a growing customer load for an extended CFE Manager contract term as long as they continue to deliver the guaranteed hourly CFE.

3. The CFE Manager Model in Practice: Three Case Studies

This section presents three case studies of the CFE Manager model in practice that Google has executed in three different regions: Virginia, Germany, and California. While each agreement has its own particularities, there are a number of key transaction principles that guide Google's approach to negotiating these agreements:

1. **Predictable Price:** In each example, Google purchases retail electricity provided by a portfolio of projects at a predictable price (either fixed or indexed) from the CFE Manager for the duration of the supply contract. This preserves a key benefit of purchasing clean energy—accessing competitively priced power and mitigating exposure to electricity price volatility. The CFE Manager is able to lock in long-term, predictable pricing for the customer mainly because their back-end exposure is largely hedged by the hourly matching of fixed price wind and solar PPAs.

2. **Scalability:** Google's electricity demand, especially at our data centers, tends to grow steadily over time. Any supply structure should include the ability to match future load growth with additional CFE generation over time to ensure it meets CFE performance thresholds. We also seek to work with suppliers to build solutions that are scalable and replicable beyond Google.

3. **Additionality:** As discussed in Google's detailed 24/7 CFE methodology paper, additionality is an important principle of our energy procurement. By 'additionality', we mean that Google's actions directly support an increase in the amount of CFE in the electricity grid mix. This could include enabling deployment of clean electricity that is new to the grid, repowering existing assets to increase their output, or extending the lives of clean energy assets that might otherwise be retired.

4. **Full Service:** We expect the CFE Manager to act as our all-in retail energy supplier for the duration of the contract. This means providing energy shaping, firming, and balancing services and continuously monitoring the market for potential new projects to add to the CFE portfolio. Many CFE Managers also provide added customer features such as real-time CFE dashboards, invoice auditing, market settlement validation, and bespoke analytics.

5. **Hourly Certification:** Significant progress has been made in recent years to create new systems to track and certify carbon-free energy at an hourly level through Time-based Energy Attribute Certificates (T-EACs).[10] We include a requirement in each CFE Manager agreement that, once T-EACs systems are created within a particular market, they will be used to certify our CFE purchases at an hourly level.

There are also important risk allocation decisions associated with the CFE Manager model that any agreement must address in order for it to work for both parties. These risks are included in the table listed in Appendix 1. In any retail supply agreement, the buyer and the seller must determine which party is best positioned to bear these risks.

Case Study 1: Virginia Agreement with AES

Google announced its first CFE Manager deal with AES in May of 2021. Google selected AES to be our CFE Manager for three of our data centers in Virginia, which are within the PJM regional electricity grid. Under the agreement, Google pays a fixed price for its retail electricity over ten years. AES is contractually committed to providing a minimum of 90% hourly carbon-free energy, based on our 24/7 CFE methodology.[11] The energy supply will be provided by a 500 MW portfolio of new-to-the-grid clean energy assets assembled by AES, which includes wind projects, solar projects, and grid-scale battery storage projects.

This agreement provides a number of benefits for Google. First, delivering clean energy at a fixed price reduces our exposure to various risks, including market price risk, shape, and basis risks associated with the clean energy portfolio. As CFE Manager, AES manages these risks, which are fully reflected in the agreed retail energy price. Second, the agreement is designed to scale along with Google's electricity demand. When requested by Google, AES is tasked with identifying additional clean energy projects to add to the portfolio to maintain the CFE Score. Third, the agreement provides electricity at competitive costs. We expect to pay a modest premium for the electricity delivered under the contract when compared to undifferentiated market power purchases, however the premium is comparable to what we would expect if we signed our own individual PPAs for similar volumes of clean energy in this market. Finally, the structure includes a minimum guarantee of hourly delivered carbon-free energy, enabling us to more predictably decarbonize our facilities' electricity consumption.

There are a number of novel contractual terms included in this agreement:

- **Forecasted Grid CFE:** Google provides AES a forecast of Grid CFE over the life of the contract. AES uses this forecast to build a portfolio of clean energy projects that will meet the 90% CFE performance target.[12]

- **Annual CFE Guarantee:** under the agreement, AES guarantees to deliver a 90% annual CFE Score for Google's facilities. The agreement includes damages and incentives for under- and over-performance against the target, respectively.

- **Minimum hourly CFE:** The agreement includes a provision that sets a floor for the amount of CFE delivered at any hour of the agreement.

To construct a supply portfolio under this agreement, AES modeled the expected production and cost of many different combinations of clean energy assets, which resulted in different estimated CFE scores and prices. We worked with AES to identify the portfolio that achieved our target CFE score at a competitive price. In addition, AES conducted a detailed risk analysis of what would be required to meet the minimum hourly CFE guarantee in the contract, which informed the agreement negotiations. AES' willingness and ability to model and price many different supply options and do so in a transparent and timely manner helped both parties get comfortable with the structure and finalize this first-of-its-kind agreement.

Case Study 2: Germany Agreement with ENGIE

In August of 2021, Google signed our second CFE Manager agreement and the first such agreement in Europe with French utility ENGIE. Under the agreement, Google will purchase electricity from 23 renewable projects in five German states. These include a new 39 MW solar PV project and a 113 MW portfolio of existing wind farms that will have their lives extended as a result of the contract between Google and ENGIE. The agreement ensures that starting in 2022, Google's operations in Germany operate at nearly 80% carbon-free energy on an hourly basis.

This agreement is unique in several respects. First, it is the first CFE Manager agreement that includes a life extension of renewable generation, in this case from wind turbines. The wind projects included under this agreement are all at least two decades old and initially benefited from the 20-year German feed-in tariff subsidy scheme ("EEG"). The CFE Manager contract provides additional guaranteed revenue streams, without which these projects may be dismantled due to their high operating and maintenance expenses. The life-extension contract enables them to continue operating and delivering carbon-free power. Second, the term of the contract with ENGIE, at three years, is shorter than typical PPA agreements. Contracts to extend the life of CFE assets are typically shorter than those for new assets since project owners seek contracts that align with the timeline of the projects' existing operating licenses. Shorter term lengths also preserve the option to pursue a repowering of the project (increasing the capacity) in the future.

This agreement is also built around a grid CFE forecast (similar to the AES agreement), and ENGIE has committed to a minimum annual CFE target (CFE Score) over the term of the contract. In the event of underperformance on the annual CFE Score, ENGIE is responsible for penalties that are tied to the market value of emissions allowances (EUAs) under the EU Emissions Trading Scheme (ETS). This aligns ENGIE's interests with Google's goal to minimize the carbon footprint of our operations and provides an additional incentive to ENGIE to meet the guaranteed CFE Score under the contract.

While ENGIE will meet this target using their own contracted CFE assets, Google retains the option to secure third-party PPAs to be managed by ENGIE. For example, Google recently signed a 50 MW offshore wind PPA with the power company Orsted from a project in the German North Sea. When this project begins generating electricity in 2025, the electricity under contract will be sleeved to ENGIE under the CFE Manager agreement and will further increase Google's CFE score in Germany. This is an important provision that provides additional flexibility and ensures that Google can still leverage its purchasing power in the PPA market, even after appointing a CFE Manager.

Finally, one additional benefit of working with ENGIE has been their data-driven approach and support for data sharing and analytics related to the assets under contract. For instance, ENGIE has developed an API that makes it easy to integrate and share our granular data with third-party partners, such as the cleantech software provider Flexidao, to enable broader portfolio management and 24/7 CFE accounting across regions in Europe.

Case Study 3: California Agreement with Silicon Valley Clean Energy

In June 2022, Google signed its first CFE Manager agreement to supply our office campuses in Silicon Valley. For this agreement, we worked with Silicon Valley Clean Energy (SVCE), a public community choice energy aggregation (CCA) entity that was formed in 2016 by thirteen neighboring communities and serves 270,000 business and residential customers. CCAs are entities created by local governments that allow municipalities to procure power on behalf of their residents and businesses while still receiving transmission and distribution services from the regional utility. This model has grown significantly in recent years. In California, CCAs now provide electricity service to over 200 communities representing 28% of electricity demand in the territories of the state's three main investor-owned utilities.

Under the agreement, Google will buy electricity from SVCE, which will supply Google with carbon-free energy for a term of 10 years under its new Green Prime Direct program. The electricity generated under Google's existing PPA with the Golden Hills wind farm, signed in 2015, will become part of the portfolio of clean energy SVCE provides to Google. In addition, SVCE will execute additional clean energy PPAs on behalf of Google to increase our hourly CFE match. We expect that future assets under this agreement will include solar PV, battery storage, and firm carbon-free energy sources like geothermal, which could collectively bring the hourly CFE for our Silicon Valley offices to 92% by 2027.

There are a number of key benefits of this agreement for Google. First, SVCE will take on the responsibility of procuring PPAs on Google's behalf, which improves the efficiency of our procurement processes. Second, the agreement is scalable: SVCE will negotiate and contract with additional CFE resources to increase and maintain our agreed CFE target percentage over time as our electricity consumption grows. Third, the agreement is replicable by other CCAs across the country, in addition to traditional electric utilities in vertically integrated markets (see next section). Google is actively seeking to replicate this structure with partners elsewhere.

The agreement also helps SVCE accelerate their own efforts to become 24/7 carbon-free. Since the organization's launch, SVCE's generation portfolio has been carbon-free as measured on an annual basis, and it is now moving toward 24/7 carbon-free energy. They can eventually offer this same product to other customers that are interested in matching their hourly electricity demand with carbon-free energy and, in so doing, accelerate broader electric grid decarbonization.[13]

Case Study Comparison Table

	PJM (AES)	GERMANY (ENGIE)	CALIFORNIA (SVCE)
Capacity procured	500 MW	152 MW	TBD
Technologies included	Solar PV, wind, lithium-ion battery storage	Wind (asset-life extension), solar	Wind, solar, storage, geothermal (expected)
Google facilities covered	Three Google data centers in Virginia	Google's operations in Germany	Google's office campuses in Mountain View and Sunnyvale, California
CFE Guarantee	90%	Nearly 80% starting in 2022	At least 92% by 2027
Initial Term length	10 years	3 years	10 years
Price	Fixed	Indexed	Indexed
Additionality	Yes	Yes	Yes

4. Future Considerations

The CFE Manager model can provide many benefits for clean energy buyers. It can reduce procurement risks, provide competitively priced clean energy supply, decarbonize a buyer's electricity demand more effectively, and accelerate the decarbonization of electricity grids. However, there are some potential challenges to successfully deploying this model. This section discusses two of those challenges and ways that they might be addressed in the future.

a. Vertically Integrated Utility Territories

The CFE Manager case studies in this paper describe agreements that have been signed in locations with competitive wholesale or retail electricity markets. As we discuss in our Policy Roadmap for 24/7 Carbon-free Energy, we have found that independent, regional, and competitive electricity markets are most conducive to quickly and reliably deploying clean energy while reducing costs for consumers. That is why we support the development and expansion of competitive electricity markets where they don't exist today, such as in the Western and Southeastern United States. However, electric utilities in vertically integrated service territories without competitive markets can also learn from the CFE Manager model and create products to meet their customers' requests for around-the-clock clean power.

Today, a number of utilities have "green tariff" programs, whereby they purchase or own renewable energy that is dedicated to a particular set of customers. One example is Georgia Power's Commercial & Industrial Renewable Energy Development Initiative, where the utility has procured up to 200 MW of renewable energy generation through PPAs that they then sleeve to their C&I customers. Green tariff programs have helped create access to renewable energy in vertically integrated territories, but they have been capped in size and limited in scope by the utilities that manage them. They should instead be expanded and restructured to increase their impact on electricity decarbonization. Instead of a green tariff where one type of technology is deployed on behalf of customers, utilities should create "24/7 carbon-free energy tariffs" that meet their customers' demand with an increasing share of carbon-free electricity on an hourly basis.

There are some existing examples of structures that move in this direction. In Nevada, we worked with our utility partner NV Energy under a new tariff to purchase electricity from a new solar PV and storage project that at the time was the largest such purchase of solar and storage for a corporate customer.[14] Under this agreement, the benefits of the battery system are shared; when the storage is needed most and is most valuable to the system in the summer peaking hours, the utility can dispatch it for the benefit of all ratepayers. During the rest of the year, we can use the battery to better match our electricity demand with CFE.

It is also notable that Georgia Power proposed a Carbon Free-Energy—Around the Clock (CFE-ATC) program as part of their 2022 Integrated Resource Plan (IRP), which would more fully decarbonize electricity delivered to participating customers through a combination of new renewable energy and battery energy storage resources. However, it is only available for customers with a minimum peak load of 25 MW, and overall renewable energy procurement for the program is capped at 650 MW.[15] Broadening customer eligibility criteria for this and similar programs will accelerate customer-driven grid decarbonization.

Today, vertically integrated utilities already serve as electricity managers on behalf of their customers by providing generation procurement, risk management, and electricity delivery services. Unfortunately, many are unable or unwilling to provide competitive and innovative structures to meet the needs of advanced energy buyers. Electricity consumers—from cities to national governments to large corporate customers—are increasingly demanding around-the-clock clean power. We hope to see utilities work closely with their customers and leverage existing software solutions to develop and implement innovative tariff structures to meet this need, allowing energy buyers to help accelerate the clean energy transition.

b. Aggregation

While Google has developed the CFE Manager model as a key tool to help us achieve 24/7 CFE, other customers may be unable to pursue such a model on their own. Some customers may have small or highly distributed electricity loads, which could make competitively priced retail CFE supply arrangements more difficult to achieve. One potential solution to this challenge is pooling the demand of a customer's multiple facilities or that of multiple customers to create economies of scale.

As described earlier in this paper, aggregation is a key risk management tool for CFE Managers. CFE Managers can combine a diverse portfolio of generation assets and a diverse customer base to effectively manage the risks associated with their obligations under any particular CFE Manager agreement. Similarly, aggregation can help clean energy customers reduce risks and improve access to competitive prices for around-the-clock clean power.

A number of organizations are working on tools that can enable PPA and retail supply aggregation across diverse customer groups. For instance, LevelTen Energy has developed a PPA marketplace where buyers can find clean energy projects, build portfolios, and run analytics. Google is supporting LevelTen Energy to develop software solutions to help clean energy consumers meet 24/7 carbon-free energy matching goals.

In addition, the widespread adoption of time-based energy attribute certificates (T-EACs) could facilitate aggregated clean energy purchasing. Clean energy buyers could purchase clean energy to match different hours of their consumption to move toward their 24/7 CFE goals while certifying the matching with new granular instruments. A liquid exchange for T-EACs would also increase the accessibility and affordability of high CFE targets and help 24/7 CFE participants hedge against uncertainties like forecast errors.[16]

Conclusion

The corporate power purchase agreement (PPA) has been an important tool to help scale renewable energy technologies like wind and solar power across the globe and will remain so in the future. However, as buyers and suppliers shift their focus from simply deploying more clean energy to delivering around-the-clock clean energy and completely decarbonizing electricity consumption, new contractual innovations are needed.

The CFE Manager model described in this paper provides a new way for buyers of clean energy to reduce risks associated with clean energy procurement while increasing the impact of their energy purchasing on decarbonization. CFE Manager agreements can reduce transaction costs; mitigate a number of financial risks associated with traditional PPAs; create scalable pathways to clean energy procurement; increase diversification and liquidity; and allow buyers to achieve a high degree of hourly matching with clean energy.

As Google progresses toward our own goal of operating on 24/7 CFE by 2030, we are dedicated to supporting and enabling others toward progress on their own clean energy journeys. This is why we and our partners launched the global 24/7 Carbon-free Energy Compact—a set of commitments and actions from energy buyers, energy suppliers, governments, system operators, solutions providers, investors, and other organizations to advance 24/7 CFE. We hope that this paper encourages other clean energy buyers and suppliers to consider the CFE Manager model as a way to expand their contribution to decarbonizing electricity, and we are excited to see that others have already signed similar agreements. We stand ready to work with energy suppliers, utilities, and other clean energy buyers to scale this model for more customers and help enable 24/7 CFE for all.

Appendix 1: CFE Manager Contract Risks

RISK CATEGORY	DESCRIPTION	RISK GENERALLY SITS WITH
Grid CFE risk	What happens if grid CFE actuals end up much higher or lower than forecast at the time of contract execution?	Google
Load forecast risk	What happens if Google load materializes much higher or lower than forecast at the time of contract execution?	Google
Energy market risk (assuming fixed or collared price)	What happens if projections of energy prices in the relevant market at the time of contract execution end up being wrong? Who benefits or realizes the downside?	Seller
Project development risk	What happens if the project runs into issues with land acquisition, interconnection, permitting, or construction?	Seller
Seller-contracted CFE performance risk/operational risk	What happens if resource doesn't generate/dispatch as much as forecasted due to repairs, operational issues, etc.?	Seller
Google-contracted CFE performance risk/operational risk	What happens if third-party assets with Google PPAs , not under the control of the Seller, do not generate/dispatch as much as forecasted?	Google or Seller

Endnotes

Click the source number to return to the relevant page in this paper.

1. Bloomberg New Energy Finance, Corporate Clean Energy Buying Tops 30GW Mark in Record Year (2022).

2. Q. Xu, A. Manocha, N. Patankar, J.D. Jenkins, System-level Impacts of 24/7 Carbon-free Electricity Procurement, Princeton University Zero-carbon Energy Systems Research and Optimization (ZERO) Laboratory (2021).

3. PPAs can offer buyers electricity at a fixed price over the term of the contract, or can be indexed to particular benchmarks, such as the rate of inflation.

4. Another option that many organizations use is a "virtual PPA," which is a contract that includes a fixed payment to a clean energy provider, but does not involve the physical delivery of energy from the clean energy provider to the customer. Under this type of arrangement, the buyer receives the EACs and the power is sold into the marketplace where it is generated.

5. Technically, to claim to be "100% renewable," clean energy buyers need only purchase the EACs associated with renewable energy, even if they are "unbundled" from the underlying electricity. Google has historically utilized PPAs for "bundled" electricity and EACs to ensure that our purchases lead to additional clean energy deployed on grids. Historically, the price of EACs has been the smallest portion of a clean energy project's revenue stream.

6. For a good overview of the various risks associated with Corporate PPAs and risk mitigation mechanisms, see: RE-Source Platform, Risk Mitigation Mechanisms for Corporate Renewable PPAs (2021).

7. This calculation, also known as the Annual CFE Score, is listed as equation 4 in our detailed 24/7 CFE methodology paper.

8. For more detail on the impacts of 24/7 CFE procurement on electricity grid decarbonization, see: Q. Xu, A. Manocha, N. Patankar, J.D. Jenkins, System-level Impacts of 24/7 Carbon-free Electricity Procurement, Princeton University Zero-carbon Energy Systems Research and Optimization (ZERO) Laboratory (2021).

9. This could include procurement and delivery of physical CFE resources, or procurement of granular certificates that are tied to the timing and location of a customer's load.

10. EnergyTag is a multi-stakeholder initiative that has created the first global standard for granular energy certificates. Google has supported this organization since its inception.

11. The PJM grid CFE in 2021 was 40%.

12. There are a number of public forecasts of grid CFE that can be used for this purpose. In the United States, the National Renewable Energy Laboratory (NREL) Cambium dataset provides modeled data that could form the basis of similar CFE Manager agreements. See: https://www.nrel.gov/analysis/cambium.html

13. For a more detailed case study of this agreement between Google and SVCE, please see this case study produced by SVCE.

14. The project, announced in 2020, consists of a 350 MW solar PV installation and 280 MW of lithium-ion storage.

15. Details of the program can be accessed at: https://psc.ga.gov/search/facts-docket/?docketId=44280

16. Q. Xu, A. Manocha, N. Patankar, J.D. Jenkins, Electricity System and Market Impacts of Time-based Attribute Trading and 24x7 Carbon-free Electricity Procurement, Princeton University Zero-carbon Energy Systems Research and Optimization (ZERO) Laboratory (2022).