Beyond “100% Renewable”: A New Vision for Corporate Leadership in Renewable Energy Procurement

An increasing number of corporations are declaring, and even achieving, 100% renewable energy goals. Could that spell bad news for a 100% renewable future?

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Over the past decade, large energy users, including corporations and cities, have assumed an active leadership role in shaping the future of the electric grid: by the end of 2018, over 100 U.S. cities and 166 global corporations had committed to procuring 100% of their annual energy consumption from renewable sources. The Intergovernmental Panel on Climate Change (IPCC) has forecasted that renewables will need to supply at least 70-85% of global electricity consumption within the next 30 years in order to avoid global temperatures rising above 1.5°C. Given that the commercial and industrial (C&I) sector consumes almost two-thirds of global end-use electricity, and that corporate procurement has been responsible for over 12% of all utility-scale wind and solar installed in the U.S., corporate leadership is critical for a rapid and complete transition to a fully-renewable future.

In late 2016, as Google was at the cusp of achieving its 100% renewable energy procurement goal, the company’s Senior Vice President of Technical Infrastructure, Urs Hölzle, declared that “100% renewable is just the beginning.” While it may seem strange for the world’s largest corporate buyer of renewables to argue that its monumental achievement “is just the first step,” this sentiment is rooted in the fact that current corporate “100% renewable” goals are not compatible with a 100% renewably-powered electric grid.

Because electricity is delivered at near the speed of light and is expensive to store, operating the power grid reliably requires supply to equal demand, every second of every day. This means that the main challenge of achieving a 100% renewable energy grid is not only a question of *how much* renewable energy is built, but rather whether we will be able to supply our fluctuating electricity demand with 100% renewable electrons *at each moment* throughout the day. When a corporation says that it is “100% renewable” it generally means that it has purchased the same volume of renewable electricity as the electricity it consumes in a year, but not necessarily at the same time as it is consumed. This approach threatens to win the battle, but lose the war: in the short run, procuring mismatched renewables does add carbon-free energy to the grid, but in the long run, it is not a sustainable pathway to full decarbonization.

In a white paper published in October 2018, Google detailed a vision of its next step beyond “100% renewable”: *24x7 carbon-free energy*. The company makes the distinction that while it currently “matches” 100% of its annual energy consumption with an equal quantity of electricity from renewable sources, it will now seek to “power” its operations with renewable energy produced in the same hour and in the same region as it is consumed.

But what are the practical implications of adopting a 24x7 carbon-free energy goal as a corporate buyer of renewables? This white paper builds upon Google’s vision to propose a practical framework for achieving a corporate 24x7 renewable energy goal. This paper is the first step to investigating the practicality and impact of achieving a 24x7 renewable vision, and seeks to build collaborations and partnerships that can help advance this research into the future.

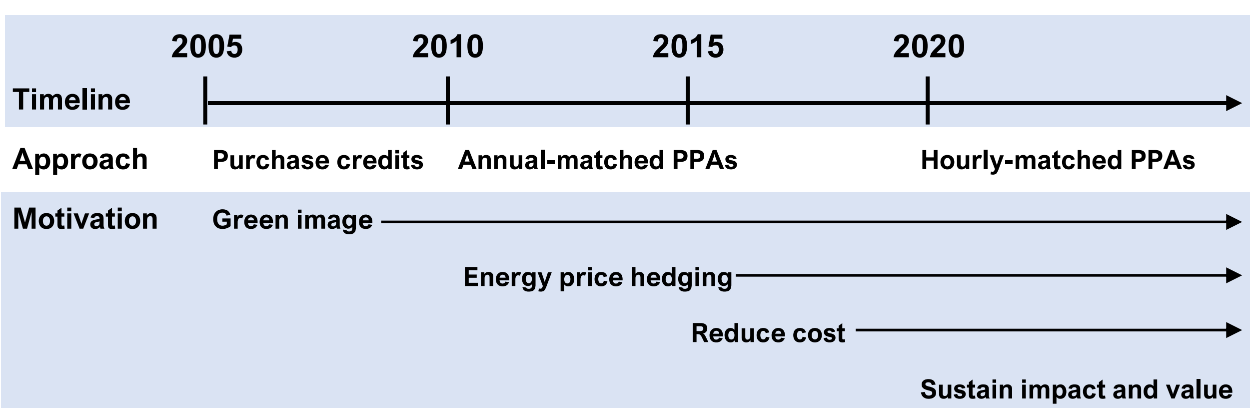
The Past, Present, and Future of Corporate Renewables Procurement

The motivations for, and sophistication of, corporate renewable energy procurement have evolved rapidly over the past decade. Starting in the mid-2000s, corporations, driven by increasing corporate social responsibility and sustainability concerns, started to seek out ways to green the impact of their operations. At that time, solar was not yet cost competitive with conventional electricity supply and contract instruments such as power purchase agreements (PPAs) were not yet widely tested, so the primary mechanism for corporations to buy renewable energy was through unbundled renewable energy certificates for wind power.

A renewable energy certificate, or REC, is a market instrument that represents 1 megawatt-hour (MWh) of electricity generated by a renewable generator. RECs were first developed to track compliance with renewable portfolio standard legislation, but a "voluntary market" has also developed for other non-utility buyers to track who owned the marketing rights to the green electricity. The owner of a renewable generator, whether it is a solar field or wind farm, can sell their RECs bundled with the electricity they generate, a product known as "green power," or the RECs can be stripped from the underlying electricity and sold "unbundled." These unbundled RECs essentially grant their owner the marketing right to call each MWh of electricity that they purchased from a non-renewable source "renewable." The electricity from which the REC was stripped becomes "null power" and is no longer considered to be renewable. Instead, null electricity takes on the average emissions factor of the grid in which it is located.

The concept is that demand for unbundled, voluntary RECs would help spur the construction of additional renewable energy on the grid, and that the price paid for the RECs would add a value stream for renewable energy developers to help finance new projects. Because the purchase of unbundled RECs represented a premium on top of the price that buyers were already paying for electricity—about $5 per MWh in 2008—demand for these RECs remained relatively low until prices dropped under $1 per MWh in 2010, where they have stayed through 2017.

Although these low REC prices made them accessible to more buyers—the number of customers for voluntary RECs nearly quadrupled from 2008 to 2012—it also called into question the additionality, and thus impact, of these investments. When combined with the fact that the average length of most unbundled REC contracts was under 5 years, this low cost meant that a company's investment in RECs became immaterial to the project financing of new renewable projects. Indeed, a 2013 study published in *Energy Policy* found that "the investment decisions of wind power



project developers in the United States are unlikely to have been altered by the voluntary REC market," and that consequently, "the claims by U.S. green power market retailers and promoters that voluntary market RECs result in additional wind power projects lack credibility."

Corporate leaders took note and started to adjust their strategy. Walmart, in its 2014 *Approach to Renewable Energy* document, stated: "We want to do more than just shift around ownership (and marketing rights) of existing renewable energy, so we have made a decision that under normal circumstances, we prefer not to simply offset our non-renewable power by purchasing standalone renewable energy credits (RECs) or other certificates. While REC purchasing may allow us to more quickly say we are supplied by 100% renewable energy, it provides less certainty about the change we're making in the world. […] In fact, some NGOs have expressed concern that big companies buying up RECs may not accurately reflect their contribution to the renewable future and may simply push paper around a static network."

Companies like Walmart had the opportunity to pivot their renewable strategy around this time due to the combination of a dramatic drop in the levelized cost of solar in 2011 and the emergence of a new contracting structure for procuring renewable energy: the virtual power purchase agreement. Bilateral, physical power purchase agreements (PPAs), which require the buyer to monetize the generated electrons by selling them into the wholesale electricity market, had existed as a contract instrument for all types of electricity generation for decades. A virtual PPA is a financial instrument similar to a contract for difference or fixed-for-floating swap, in which the generator exchanges its variable cash flow from selling its electricity into the spot market for a fixed cash flow paid by the buyer.

For corporations, improving their sustainability image remained important, as it helped market their products and recruit and retain young talent, but the virtual PPA introduced an additional motivation by mitigating price risk. By signing long-term PPAs at a fixed price, a corporation's ability to hedge volatile and increasing electricity costs became a primary motivation for increasing renewable energy procurement, especially for energy-intensive industries.

In addition, as renewable energy costs continued to drop throughout the 2010s, renewable energy PPAs started to become cheaper than generation delivered by their utility, eliminating the cost premium to green their electricity. For companies with large energy bills, the ability to procure cheaper energy (which happened to be renewable), became an additional motivation to sign renewable energy contracts. Google's stated reasoning for its renewable energy goals reflects these multiple motivations: "we strive to lead on climate change as a business imperative; we are a large electricity consumer that seeks to minimize our environmental footprint; and we are a growing business that prizes the cost-effectiveness and financial certainty of renewable power sources."

Since the mid-2010s, driven by the declining cost and risk of renewable energy PPAs, declaring a goal of achieving 100% renewable energy on an annual basis has become a hallmark of leadership in corporate sustainability. The publication of Google's October 2018 white paper on its emerging "24x7 carbon-free energy" strategy suggests that corporate procurement of renewable energy is at the cusp of its next evolution in sophistication and impact. Whether referred to as "24x7 carbon-free energy" or "100x100 renewable energy" (100% renewable energy, 100% of the time), the emergence of this new paradigm is being driven by an improved understanding of the influence that corporate renewable energy procurement has on the broader electric grid as well as the need to manage evolving risks.

A note on terminology: renewable, clean, and carbon-Free Energy

State, local, and corporate goals for energy transition often differ in their aims between "100% renewable" and "100% clean."

Renewable energy refers to sources that are naturally replenishing and most commonly refers to wind, solar, geothermal, tidal, wave, small hydropower, biogas, and certain kinds of biomass.

Clean (carbon-free) energy refers to sources that do not directly emit greenhouse gases, which includes the renewable sources listed above plus nuclear, large hydro, and fossil fuels with carbon capture and sequestration (CCS).

This paper does not take a position on whether corporations should strive for 100% renewable or 100% clean energy, so throughout this paper, the terms *renewable*, *clean*, and *carbon-free* will be used interchangeably to refer to the entire suite of clean and renewable technologies.

Just as a desire for greater impact helped spur the shift away from unbundled RECs to PPAs, a better understanding of the long-run impacts of corporate procurement on the electric grid is spurring a conversation about the 24x7 renewable energy model. In a 2018 interview on Greentech Media's "The Interchange" podcast, Brian Janous, the General Manager of Energy for Microsoft, recognized that "we are altering the market as we continue to develop more and more renewables," and that ultimately "a core value for us as a company is that we're going to leave a positive legacy with what we build." Taylor Sloane, who leads global commercial and industrial (C&I) market development for Fluence Energy, an energy storage provider, argues that "Procuring only renewable energy on a net basis is not a scalable solution to create a sustainable renewable energy market where everyone can achieve 100% renewable energy. Corporate renewable buyers should also consider how their procurement decision impacts the rest of the electric grid."

Every MWh of renewable energy a corporation buys that is mismatched with its demand can increase the long-term costs of renewable integration by requiring the deployment of grid-scale solutions, such as transmission capacity and energy storage, to balance the net demand. This mismatched procurement essentially shifts these costs to grid operators, utilities, and ultimately rate payers. Each individual corporation has the best knowledge of, and control over, its internal costs and operational flexibility, and thus is the best-informed market participant to buy the most cost-effective supply or demand-side resources that balance its demand.

Given that the contract length of many corporate PPAs is 20-25 years, the mismatched PPAs that corporations are signing today could end up being a liability as the grid continues to transform. The release of the Intergovernmental Panel on Climate Change (IPCC) *Special Report on Global Warming of 1.5 °C* in October 2018 reiterated the urgency of a rapid and complete transition to a low-carbon future. The report stated that limiting global warming to 1.5°C would require reducing GHG emissions 45% below 2010 levels by 2030 and achieving net zero emissions by 2050, which will require renewables to make up at least 70-85% of global electricity use. If we are to remain on track to achieve these levels of renewable integration, the challenge of balancing a majority-renewable grid will become a daily requirement within the next twenty years. The promise of focusing on 24x7 carbon-free energy *now*, Google argues, is " important for elevating carbon-free energy from being an important but limited element of the global electricity supply portfolio today, to a resource that fully powers our operations and ultimately the entire electric grid."

In addition to its grid impacts, the growth of corporate renewable energy procurement is also affecting the risk profile of these investments, further encouraging corporations to rethink their strategy. Shape risk is the primary concern, as it is exacerbated when project output does not correlate with the buyer's consumption. With increasing penetrations of a single type of renewables—primarily solar—wholesale market prices are driven down or even negative by the glut of solar production in the middle of the day, which reduces the value of the PPA. In addition, if there is not enough load to absorb this solar energy, solar operators may be forced to curtail their production, reducing the overall quantity of RECs that the offtaker can retire and use to make progress toward their renewable energy goals. Microsoft's Brian Janous calls shape risk "the biggest challenge that buyers really need to appreciate."

There is also an increasing potential of regulatory risk as energy procurement continues to decentralize due to expanding consumer choice, which regulators perceive as a potential threat to the reliability of the grid and success of decarbonization policies. In California, where renewables already generate about 30% of statewide electricity, the Public Utilities Commission has written that "There is a question whether the necessary capital investment needed to decarbonize the electric sector to meet the state's 2030 goals and beyond can be financed and, if so, delivered on time if the state transitions away from a few larger buyers to many small buyers." A 24x7 renewable energy approach gives corporate buyers of renewables the opportunity to get out ahead of such risk and better shape the terms of their continued participation in electricity markets.

Essential Elements of a 24x7 Renewable Energy Approach

In its white paper, Google lists three areas in which innovation will be necessary in order to enable 24x7 renewable energy: technology, policy, and business models. The first area, technology, addresses how corporate buyers can achieve 24x7 renewable energy: what are the technologies and management approaches on both the supply and demand side of the equation that will help them become 24x7 renewably-powered? The second pillar addresses the policy and market designs that will enable corporations to pursue and achieve a 24x7 renewable energy goal. The third pillar answers how commercial and industrial energy users of all sizes can adopt such a goal through streamlined transactions and business models that overcome the time, capital, and knowledge barriers that many smaller firms face.

Technology and Management	• Energy demand analysis • Diverse renewables portfolio • Load shaping and shifting • Energy storage • Prioritizing actions for impact
Policy and Market Design	• Consumer choice • Renewable marketing claims • Carbon accounting standards • Tracking RECs hourly • Improved price signals
Transactions and Business Models	• Bundled services • Online marketplaces • Software controls

I. Technology and Management

In order to arrive at a power grid that is powered by 100% renewable energy, 100% of the time, the system will have to manage the two characteristics that distinguish these types of resources: variability and intermittency. Variability refers to daily and seasonal fluctuations in the availability of renewable resources. For example, solar energy is only available during the day, and is available in greater quantities on summer days than winter days. Each renewable technology has a unique resource profile, but these fluctuations can be predicted, and thus variability can be planned for. Intermittency, on the other hand, refers to the intra-day, short term fluctuations in output that result from situations like clouds passing over the sun or sudden lulls in wind. Such intermittency is harder to predict far in advance, so it must be actively managed rather than planned for. Managing intermittency involves ramping up another dispatchable power plant or discharging energy storage to make up the shortfall.

These dual challenges raise an important question about over what timescale a 24x7 carbon-free energy goal should balance renewable supply with demand: every few seconds? Every 5 minutes? Every 15 minutes? Every hour? Unless the company is trying to operate one of its facilities as an islanded microgrid, it may not need to concern itself with balancing much of the intra-hour fluctuations in supply and demand or managing intermittency. In wholesale power markets, a vast majority of generation is committed on the hourly timescale in the day-ahead market based on predicted load for each hour of the next day. Any differences between these hourly load predictions and actual intra-hour demand are settled in fifteen minute and five-minute real time markets, with other fluctuations under that timescale managed directly by the system operator through automatic generation control every few seconds.

Balancing supply with demand on the real-time timescale is probably unrealistic for most corporate buyers, although to achieve true 100% matching, it may be necessary to leverage storage technology and automated controls to manage that balancing. Google's white paper assesses how well they match renewables to their load on an hourly basis, but it may be helpful for the larger collection of corporate buyers to discuss this through forums such as the Renewable Energy Buyer's Alliance (REBA), which is the member association representing businesses and organizations seeking to buy renewable energy in the U.S.

Achieving a 24x7 carbon-free target will require five main approaches: understanding a company's demand patterns throughout the year, procuring a diverse portfolio of renewable technologies whose output match a company's demand profile in each region, shaping and shifting the timing of loads to match the availability of these local renewables, investing in local energy storage to balance the difference, and prioritizing action in regions where they will displace the dirtiest fuels first.

Strategy 1: Analyze your energy demand. Powering an operation with 24x7 renewable energy will first require understanding the shape of a company's demand and the characteristics of its loads. After gathering interval electric meter data at least at the hourly scale, a company can begin to assess the patterns of its demand throughout the year. A company's demand profile is likely to differ for weekdays and weekends, and for each month of the year. Any submetering data or other inventory of various energy loads (e.g. lighting, HVAC, servers, machinery, vehicle chargers) can help a company understand what drives these patterns and will be useful for the second strategy. Another way to conceptually approach this goal is to reduce "net demand," or demand minus renewable supply, to zero for every hour of the year.

Strategy 2: Diversify your renewables portfolio. Once a company understands its demand profile, it can begin to assess which renewable resources are available to match these profiles. Achieving a 24x7 renewable energy goal with a single type of resource is unlikely; it will require a geographically and technologically diverse portfolio of renewables. Diversity is important to address both the variability and intermittency of renewables. Geographic diversity can help reduce the risks posed by intermittency, as a cloud passing over a single solar farm is unlikely to simultaneously affect the output of a solar farm in another location. Geographic diversity can also affect the supply profile of a single type of technology itself: the profile of a wind turbine will look different depending on whether it is offshore, on a mountain, or in an open plain.

While geographic diversity can be helpful, it is important to procure renewable resources within the same grid balancing area as the loads to which they will be matched. While much of the grid is interconnected, if the renewable generator is located too far away or in another balancing area, it is possible that its output will not electrically contribute to reducing a company's net load due to transmission congestion or local constraints on the grid. Onsite resources, such as rooftop solar or biodigesters, provide the most surety of impact since they are directly wired to the facility, but it is unrealistic for a large energy user to meet all its demand with renewable energy available onsite.

Technological diversity can help overcome the challenges of variability, since different renewable resources have different, and sometimes complementing, supply profiles. To date, almost all C&I power purchase agreements in the U.S. are for wind and solar. While wind and solar offer some level of complementary supply profiles—solar energy is most available during the day while wind typically blows the strongest at night—there are many other renewable technologies available to create a load-matched renewable portfolio. For example, in a recent industry perspective piece, Sol Systems described how after teaming with Cube Hydro, "the pairing of one solar plant with one run-of-river hydro plant was very simple and remarkably — though not completely — effective in matching the customer's load." On the supply side, there are many resources with diverse supply profiles that could be included in a carbon-free corporate energy portfolio: onshore and offshore wind, fixed and tracking solar PV, small hydro, geothermal, tidal and wave energy, and small modular nuclear reactors. Not all these technologies are currently cost-competitive, technologically mature, or available in every region, but they could play an increasingly important role in C&I carbon-free energy portfolios in the near future.

Strategy 3: Shape and shift your loads. In addition to a supply-side approach to matching their hourly load profile, corporations can meet renewables halfway, perhaps more cost-effectively, by adjusting the demand side of the equation as well.

A cornerstone of this demand-side approach has been, and will continue to be, energy efficiency. As Google puts it, "by minimizing our electricity needs, we have reduced the amount of carbon-free energy required to match our consumption." While some forms of energy efficiency will continue to be as simple as changing a light bulb, companies like Google and Microsoft are thinking about how to leverage big data, machine learning (ML), and artificial intelligence (AI) to achieve deeper energy efficiency. Part of the challenge of a 24x7 carbon-free energy approach is simply the amount of data that a company has to process and interpret on an hourly basis: "you have meter data, you have SCADA data, you have pricing points, you have hub settlements," as Neha Palmer of Google explains, "A big portion of ML and AI is getting the data into a format that's understandable." In addition to better understanding their energy data, Google has been putting machine learning to work reducing the cooling bill their data centers.

Beyond simply *reducing* energy, a 24x7 commitment to carbon-free electricity will require companies to manage *when* they use energy through load shaping and load shifting. Load shaping refers to strategic, long-term actions that affect the demand profile of a load's normal operation. This could include strategically prioritizing energy efficiency projects that reduce demand during a specific set of hours, changing the scheduling of certain operations to shift load from one time period into another, and planning new loads to best match available renewable supply. Load shifting, on the other hand, refers to short-term actions that represent a departure from typical daily operations. This could include participating in specific demand response events or making ad-hoc adjustments the schedule of operations to deal with intra-day balancing needs. This is where submeter data and an inventory of specific load types at each facility is useful, as it enables managers to understand sources of flexibility in the energy they use.

Every type of commercial and industrial facility is going to have a different demand shape that may be more or less challenging to power 24/7 with renewable energy. For example, a data center has a consistently flat hourly demand profile, an office building peaks in the middle of the day and powers down at night, and an agricultural processing facility may have unpredictable seasonal loads based on a particular year's harvest. By unleashing the potential of flexibility to shape and shift loads, a corporation will be better able to cost-effectively achieve its 24x7 renewable energy goal by matching its operations to the shape of the least-cost portfolio of renewable energy supply.

Strategy 4: Use storage to fill in the gaps. Despite the best efforts of a company to leverage the first two strategies, there will be certain hours of net demand that cannot be reduced to zero with discrete additions of renewable supply or shaped demand. In addition, there may be unexpected or sub-hourly deviation of supply or load from forecasted schedules that a company desires to manage. Managing these situations will be best accomplished by energy storage technologies paired with automated controls. Energy storage technologies are diverse and are primarily distinguished by the length of time they can store energy. Short-term energy storage is best for handling the intra-hour balancing needs, while longer duration storage can help address intra-day, multi-day, or even seasonal variability of renewables. Many storage technologies may still be more expensive than other supply-side or demand-side approaches to balancing, but they have the advantage of being able to arbitrage time-of-day electricity rates and earn revenue by providing ancillary grid services.

Leveraging supply, demand, and storage resources together can be a powerful approach to serve existing commercial loads. In a recent report, the Rocky Mountain Institute demonstrated how combining these three strategies and assembling a diverse portfolio of solar, wind, efficiency, demand response, and storage could mimic the generation profile of a natural gas power plant. In many of their scenarios, the demand side solutions played the dominant role, followed by a mix of solar and wind, and filled in with a small percentage of energy storage.

Strategy 5: Prioritize investments for impact. Once a company knows *which* renewable resources it needs to procure in each location where it operates, it will still need a way of determining how to *prioritize* these investments in order to maximize their climate mitigation impact. When a new solar plant comes online, it does not cause every single other generator supplying the grid to slightly reduce production; rather, most power plants will continue their same level of production while a handful of the most expensive powerplants "on the margin" will reduce output or completely shut off to accommodate the new, cheaper solar supply. Thus, a company would want to prioritize a wind farm for a facility in Kentucky, where it is more likely to displace a coal plant, over a solar farm for a facility in California, where it would displace cleaner natural gas, since it will have a greater impact on reducing "marginal emissions." Companies can use tools like WattTime's Marginal Emissions API to assess the marginal emissions impact of each renewable energy investment or demand shifting decision in order to help prioritize them in terms of climate impact.

II. Policy and Market Design

Once corporate buyers understand how they can achieve 24x7 renewable energy, there still must be a solid business rationale for their leadership to accept this goal. Some of the reasons why corporations are considering 24x7 renewable energy are discussed above but mainstreaming this approach as a best business practice will require the help of deliberate policy and market design. These policy and market design actions fall into four main categories: consumer choice and access, marketing claims, tracking and certifying hourly renewable energy, and price signals that improve the economic value of adopting a 24x7 renewable energy approach.

Consumer Choice and Market Access. Especially for companies with a global footprint, there is a possibility that some operations may be located in energy markets that have not been restructured, and which do not allow individual end users to bilaterally procure renewable energy. Without consumer choice, powering a facility with 24x7 renewable energy is a non-starter unless the incumbent utility is willing to offer a product that delivers that service. In its white paper, Google suggested that in regions like the Asia and the Southeastern U.S., there is "a critical need to evolve utility regulation and energy business models at the state and regional levels" in order to allow corporate buyers to deploy carbon-free energy worldwide.

Renewable Energy Marketing Claims. One avenue to encourage widespread adoption of 24x7 renewable energy goals would be to adapt the rules that govern how companies can market and report their renewable energy and decarbonization claims.

The Federal Trade Commission, for example, has published specific guidelines for renewable energy claims to help avoid any "unfair or deceptive acts or practices in or affecting commerce," as prohibited by Section 5 of the FTC Act. These guides currently allow a marketer to claim the use of renewable energy if they have "matched such non-renewable energy use with renewable energy certificates." This FTC guide does not currently well-define specifically what it means to "match" energy use with RECs, or on what timescale, but it implied that this would be on an annual basis. Reworking these "green guides" to better define that renewable energy claims must be matched on an hourly basis would force companies to adopt this strategy if they want to market their operations as "100% renewable."

Besides federal regulation, current greenhouse gas accounting protocols, such as the "GHG Protocol Corporate Accounting and Reporting Standard," have an influential effect on how companies approach and report their renewable energy purchases. The accounting guidance for "scope 2 emissions," or emissions from purchased electricity, allows for market instruments such as RECs to be counted as a zero-emissions attribute for any electricity consumed in the same reporting year, thus allowing companies to report zero market-based scope 2 emissions if the quantity of RECs they retire equals the annual quantity of electricity consumed. Updating the guidance with at least an option to use an hourly accounting methodology or requirement to report both net annual and hourly-matched scope 2 emissions would begin to introduce more corporations to this idea and the importance of this concept.

Tracking Hourly Renewable Energy Transactions. If regulations and accounting standards were to require hourly accounting, there needs to be a simple and verifiable way for corporations to track the renewable energy attributes that they own on an hourly basis through the REC market. One concept is "T-RECs," or Time-matched Renewable Energy Certificates. Currently, each REC is stamped with information such as the renewable fuel type, the location of the generator, and the vintage (year that the energy was generated) but they include no timestamp or information about the hour and day that the energy was produced. Currently, a 2019 vintage REC (i.e. any MWh of renewable energy that was certified to have been produced in 2019) can be retired with any MWh of electricity consumed in 2019. While companies could theoretically access hourly production data from renewable generators from which they purchase energy, RECs are the underlying mechanism for validating marketing claims and GHG accounting, so this information would ultimately need to be built into the RECs themselves. Implementation of hourly REC attributes would need to be led by the various renewable energy tracking systems or registries who are responsible for creating RECs, such as APX or M-RETS.

Since these "T-RECs" would need to be retired against load occurring in a specific hour, there might also need to be a system in place for tracking and verifying hourly load. This verification is currently handled at the annual level through accounting standards such as the GHG Protocol, but it may be helpful for future research to explore whether some form of tradable load certificates would be a helpful market instrument for realizing this hourly matching.

Improving Price Signals. In addition to pushes from regulation and voluntary standards, corporate buyers of renewables will also need a financial pull to incentivize load-matched renewable energy procurement. In contrast to Google's vision-setting approach to 24x7 carbon-free energy, Microsoft offers a competing, market-responsive approach to optimizing their impact on the electric grid. "Am I as an individual consumer best positioned to determine how to integrate that resource or match my load to that resource? Is it better left to the market?" Microsoft's Brian Janous asks. "While it's true I could match one to one my renewables […] I don't think that's necessarily the best outcome in the long run if say there's a controllable load out there that would offer curtailment at a marginal rate that's far less than the cost of my battery. I think the value of the grid is we can design markets that lead to the least cost and most efficient solution." So, what does Microsoft want? "We want access to price signals whether it be real time pricing or ancillary service markets. All of these enables us to do the optimization behind our meter and ensures we're putting in the appropriate technology in the right place. [… If] I don't have a price signal telling me to put that in behind my meter then I'm not going to incur the added expense." Getting price signals correct, however, can be difficult and puts a large burden on market design, especially in the face of rapidly changing grid needs.

While the point that an individual consumer might not be best positioned to think about system wide renewable integration needs is important, the large scale of corporate participation in renewables procurement necessitates companies to accept some level of responsibility for thinking through these issues, even if the market has not yet internalized the long-run costs of mismatched procurement on the grid. Despite differences in vision and approach, Google's Neha Palmer agrees that well-designed markets will be necessary to make the technologies available that can allow a 24x7 renewable energy approach to scale: "I always say I'm technology-agnostic but not cost-agnostic. […] We have to run a business and do this in a cost-effective manner."

III. Transactions and Business Models

While price signals and effective policy may be all that companies like Google, Microsoft, and Walmart would need to pursue a 24x7 renewable energy goal, there are many small and medium enterprises who may not have dedicated staff to manage energy procurement contracts and sustainability strategy. Trailblazers like Google may be to develop bespoke solutions for gathering and understanding demand data, structuring RFP processes, assembling load-matched portfolios, and developing ML and AI platforms for shifting and shaping loads, but for 24x7 renewable energy to scale, third parties will need to help reduce transaction costs and overcome the time, knowledge, and cost barriers that preclude small and medium enterprises from participating.

Bundled Services. On the procurement side, aggregators, energy service companies, or even traditional utilities may be best positioned to offer portfolios of renewables with diverse technology mixes, rather than renewable energy developers themselves. The above example of Sol Systems teaming with Cube Hydro to offer solar PV + run-of-river hydro load-matching to a customer would not likely be scalable due to differences in business models between different developers. While solar developers are used to transacting with low-return, low-risk PPAs, hydro operators are more comfortable selling power into the merchant power market where returns are larger but more volatile, making a blended offering difficult to structure. There may be an opportunity for electric utilities, community choice aggregators, and other energy service providers to leverage their experience procuring energy and transacting in wholesale electricity markets and offer hourly load-matched renewables through a green tariff.

Online Marketplaces. Structuring and running an RFP process for renewable energy can be a lengthy and costly process. Platforms offered by companies like LevelTen Energy, which automate the RFP process and act as a marketplace for blended renewable energy portfolios, may overcome such challenges and streamline the process, especially for buyers who are seeking energy from multiple different energy sources.

Software Controls. On the demand side, there is also an opportunity for innovative software platforms to automate much of the load shaping and shifting decision-making. In addition to using the DeepMind machine learning software to optimize the output of its wind farms, Google has demonstrated how DeepMind can improve the energy performance of its data centers. Machine learning and artificial intelligence could be trained to parse a company's demand data and optimize operational schedules based on a company's renewable energy portfolio. California-based startup Extensible Energy has also developed a "Solar Load Balancing Software" that integrates data from a company's rooftop solar array and localized solar irradiance forecasts with HVAC controls to shift space conditioning loads to times when onsite solar is most available. It is imaginable that such software could also integrate data from a company's offsite renewable energy projects to help automatically shift loads and help companies achieve 24x7 renewable energy. Companies may also be able to build from the research that has gone into microgrid controllers, which must balance local supply and demand when a microgrid is islanded from the rest of the grid, to optimize a 24x7 renewable portfolio.

Is “24x7 Renewable” the Future of Corporate Energy Procurement?

While the world’s largest corporate buyer of renewable energy is moving forward with a 24x7 carbon-free energy goal, there are many questions that have yet to be answered before this approach can start to scale. This white paper represents only the beginning of a larger research agenda that seeks to investigate best practices for decarbonizing commercial and industrial energy use. As I continue this work, I am seeking dialogue, partnerships, and funding that will allow me to expand this research and address unanswered questions, including:

- How well does a 24x7 approach address emerging risks of renewable procurement?
- To what extent are existing corporate renewable energy contracts already matched with hourly load?
- Is it possible to balance commercial and industrial demand profiles with renewable technologies that are currently economically competitive, or will it depend on integrating technologies that are not yet as cheap as solar, wind, and hydro?
- How flexible are typical commercial and industrial loads, and how cheaply can demand flexibility contribute to achieving 24x7 renewable energy compared to procuring more diverse supply technologies?
- What is an appropriate accounting mechanism for 24x7 renewable energy and at what level of balancing could a company declare that it is truly powered by 100% renewables?
- To what extent would a 24x7 renewable approach accelerate the pace of society’s transition toward a 100% renewable grid?
- Would a 24x7 renewable approach increase or decrease the costs of energy transition to the firm and to society, as compared to the current mismatched approach?
- What short run economic efficiencies or inefficiencies might be created by individual corporations balancing their renewables on an hourly basis compared to a central planner balancing it at a regional level? What level of cost shifting or long-run inefficiencies are created by the current mismatched procurement approach?

If any readers of this paper have interest in discussing this paper or opportunities for future collaboration related to this topic, I invite your outreach to grmiller@ucdavis.edu.

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