Google

Achieving Our 100% Renewable Energy Purchasing Goal and Going Beyond

Introduction

In 2012, Google made a commitment to purchase enough renewable energy to match 100% of our operations, and we are excited to announce that we will reach that goal in 2017.

Reaching our 100% renewable purchasing goal means that Google will buy on an annual basis the same amount of megawatt-hours (MWh) of renewable energy—both the physical energy and its corresponding renewable energy certificates (REC)—as the amount of MWh of electricity that we consume for our operations around the world.

We will reach this milestone through a combination of direct purchases from renewable developers and through partnerships with our utility providers to purchase renewable energy. Google is the largest corporate renewable energy buyer on the planet, directly purchasing 2.6 gigawatts (GW) of renewable energy. We've signed renewable energy contracts in five countries across three continents. These contracts have driven the construction of renewable energy projects around the world and will generate more than $3.5 billion in capital investment by renewable energy project developers. The projects will provide tens of millions of dollars in local taxes for communities and lease revenues for landowners.

For us, reaching 100% renewable energy purchasing on a global and annual basis is just the beginning. In addition to continuing to aggressively move forward with renewable energy technologies like wind and solar, we will work to achieve the much more challenging long-term goal of powering our operations on a region-specific, 24-7 basis with clean, zero-carbon energy.

This more ambitious goal is a key next step necessary to drive clean energy from being an important but limited element of the global electricity supply portfolio today to a resource that fully and completely powers both our operations and the entire electric grid of the future.

We'll approach this challenge in three ways. First, as we continue to pursue renewable energy purchases as we grow, we will focus even more on regional renewable energy purchases in the local markets where we have data centers and operations. Second, we'll broaden the scope of energy sources to include technologies or services that enable 24-7 clean energy. And third, we'll work to promote policies that empower energy consumers to choose their energy supply, which we believe will help accelerate the transition to a 100% clean electricity grid while also driving economic growth.

This white paper describes our path to achieving the 100% renewable energy purchasing goal, discusses the lessons learned from seven years and 2.6 GW of renewable contracts, and outlines how we will continue our efforts to accelerate the transition to clean energy.

Google

PART I

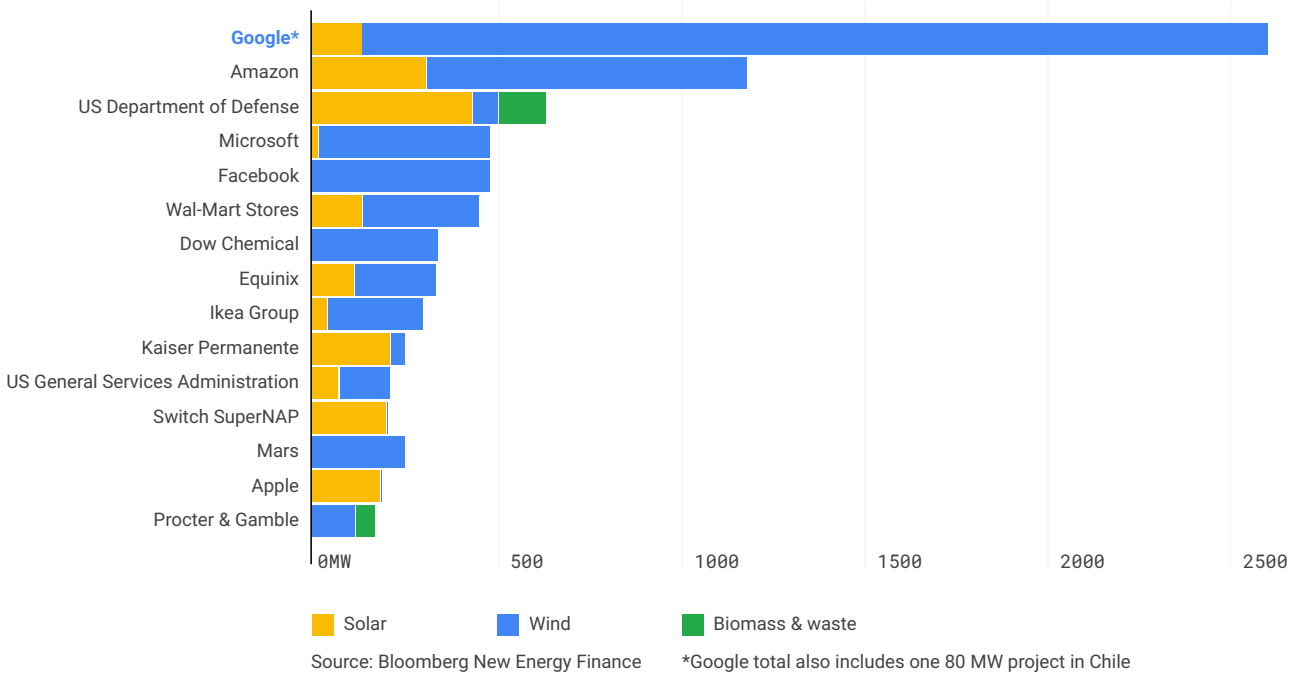
Achieving Our 100% Renewable Energy Purchasing Goal

At Google, we care about energy for many reasons, but fundamentally it's because our business depends on it. In 2015, we consumed 5.7 terawatt-hours (TWh) of electricity across all of our operations,[1] which is nearly as much electricity as San Francisco used in the same year.[2] Our data centers—the engines of the Internet that power all of our products and services—run on electricity. Having a reliable and constant supply of electricity is important to ensure that we are able to continue delivering our products like Search, Gmail, YouTube, Maps, and Google Cloud whenever our customers need them.

Electricity is one of the largest components of our operating expenses at our data centers. Ensuring that we have a cost-competitive, predictably priced electricity supply is an important part of running our business in a responsible way.

Finally, the greenhouse gas (GHG) emissions associated with the electricity we use for our operations represent the majority of our total carbon footprint. We've been carbon neutral since 2007, when we started purchasing robust carbon offsets to "neutralize" emissions from our operations. We've known for years, however, that offsets were only a temporary solution and that we needed to find a more direct, sustainable way to address our footprint. As our renewable energy power purchase agreements (PPAs) have come online in the past seven years, we have used this newly created clean energy to reduce our environmental footprint. This means we have had to purchase proportionately fewer carbon offsets as our renewable energy purchasing has scaled up.

CUMULATIVE CORPORATE RENEWABLE ENERGY PURCHASING IN THE UNITED STATES, EUROPE, AND MEXICO–NOVEMBER 2016



Source: Bloomberg New Energy Finance

*Google total also includes one 80 MW project in Chile

[1] Alphabet's 2016 CDP climate change report. Retrieved from https://www.cdp.net/en/responses?utf8=%E2%9C%93&queries%5Bname%5D=alphabet.

[2] In 2015, San Francisco County consumed 5.804 TWh of electricity. California Energy Commission. Retrieved from http://ecdms.energy.ca.gov/elecbycounty.aspx.

Why renewable energy?

The science of climate change tells us that achieving absolute reductions in annual GHG emissions and sustainable long-term levels of GHGs in the atmosphere is an urgent global imperative. Businesses have an important role to play in driving robust, sustained action to transition to a clean energy economy.

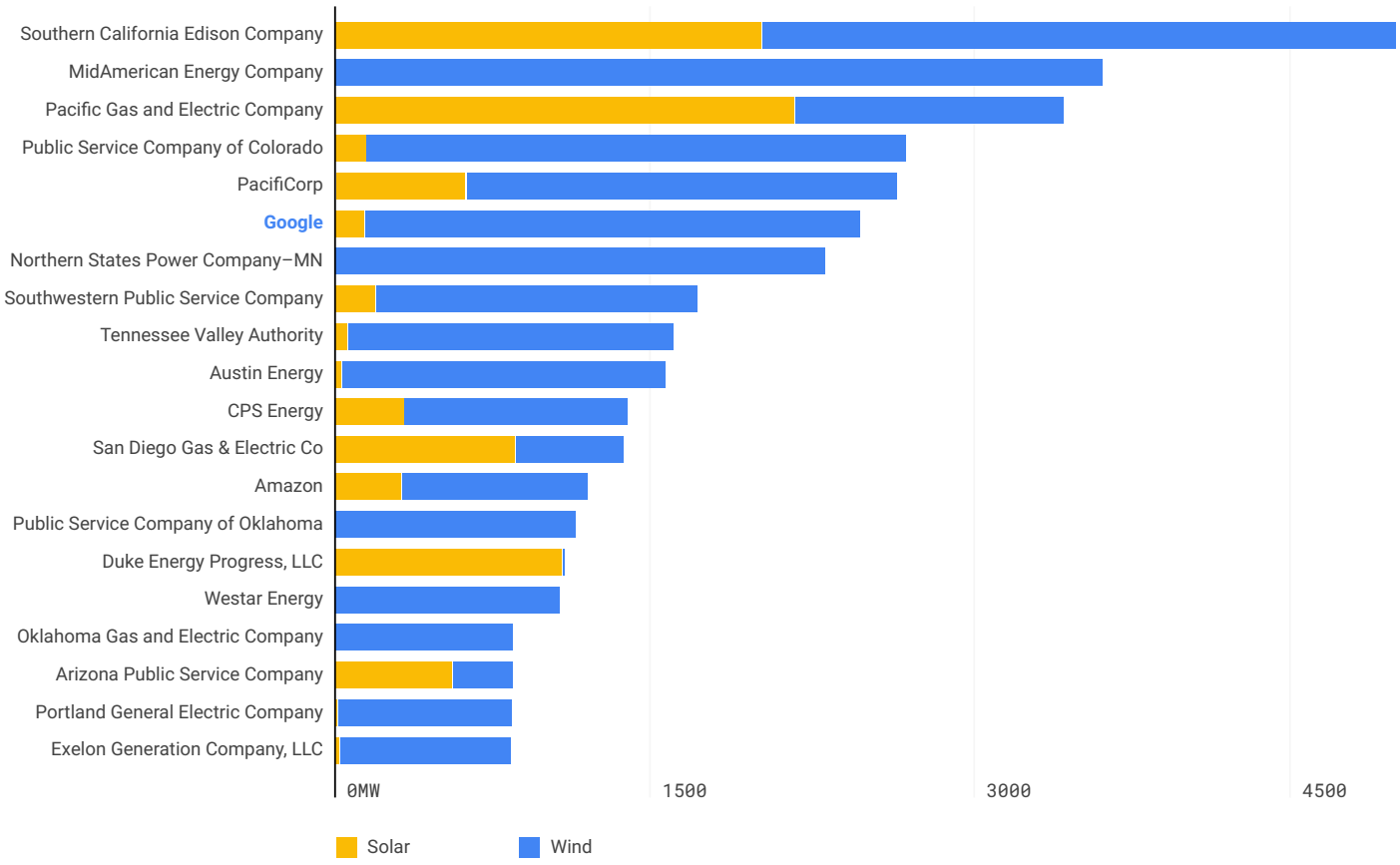
Google is committed to being part of the solution to solving global climate change, both through purchasing renewable energy to match the energy use of our own operations and by helping to create pathways for others to purchase clean energy themselves.

However, it's not just about fighting climate change. Purchasing energy from renewable resources also makes good business sense, for two key reasons:

1. **Renewables are cost-effective.**

   The cost to produce renewable energy technologies like wind and solar has come down precipitously in recent years. Since 2010, the levelized cost of wind has come down 60% and the levelized cost of solar has come down 80%.[3] In fact, in some areas, renewable energy is the cheapest form of energy available on the grid.[4]

LARGEST U.S. RENEWABLE ENERGY OFFTAKERS–BOTH UTILITIES AND CORPORATES–NOVEMBER 2016



Source: SNL Financial

[3] Retrieved from https://www.lazard.com/media/2390/lazards-levelized-cost-of-energy-analysis-90.pdf.

[4] Lawrence Berkeley National Laboratory. 2014 Wind Technologies Market Report. 2015. Retrieved from https://emp.lbl.gov/sites/all/files/lbnl-188167.pdf.

2. **Renewable energy inputs like wind and sunlight are essentially free, which means buying energy from renewables gives us great financial certainty.**
Having no fuel input for most renewables allows us to eliminate our exposure to fuel-price volatility and to smooth our financial planning over the long term. This means we can enter into long-term fixed-price agreements that set the price we pay for renewable energy from the start of a contract. If we can directly pass through this price to our retail electricity bill at our data center, we can reduce our exposure to volatile fuel prices and obtain certainty over our energy expenditure. This is especially helpful when managing a global portfolio of operations in a wide variety of markets.

Understanding our 100% renewable energy purchasing goal

Our 100% renewable energy purchasing goal means that we buy the same MWh of physical renewable energy—and its corresponding RECs—as the total amount of MWh of energy that we consume for our operations around the world. Our goal has been both annual and global in nature. Let's unpack that a bit more.

Our goal is annual in that we are comparing renewable energy supply with consumption for our operations over the course of a 12-month period, summing all the purchasing and usage over a calendar year. The reality of today's electricity grid means that we are unable to power our operations directly from wind and solar farms during every hour of the day.

We're still connected to the electricity grid and drawing power 24-7, even when wind and solar facilities located within that grid may not be producing energy. In some hours, we are purchasing more renewable energy than we are consuming for our operations, but over the course of a year our total global renewable energy purchases match up 100% to our global consumption.

Our goal is global in that we are performing this calculation by summing renewable energy purchasing across all of our facilities around the world and by summing our energy consumption at all of our data centers and offices. We don't yet have a renewable supply source on each grid where we have operations, though this is our goal. Policies and regulations do not yet allow customers to purchase renewable energy in all of the markets where we have consumption.

While we work hand in hand with regulators and utilities in these areas to evolve the market structure to unlock renewable purchasing, we overbuy renewables on one grid to offset our inability to purchase renewables on another.

Our blog post about what it means to reach our 100% goal describes this in further detail. It also addresses issues like why we don't build renewable energy projects on our data center sites and how we use the grid to manage the intermittency of renewables.

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Our pathway to 100% renewable energy purchasing

When we committed to achieving 100% renewable energy purchasing for our operations back in 2012, we knew it was an ambitious goal and the path to achieving that target was not clear. We have aggressively employed a variety of purchasing tactics, some of which are closer than others to our ultimate goal to supply our operations with 24-7 clean energy. We use four primary tactics:

1. **"Direct" renewable purchasing**

   In Europe, deregulated wholesale and retail power markets make it possible for Google to directly purchase renewable energy and have it delivered to our data center retail bill using the local grid. We sign a PPA with a project developer on a grid where we operate a data center, as well as a separate "balancing agreement" with a competitive power market entity that helps deliver the PPA across the grid and that can also "firm and shape"[5] the energy so that we have constant, 24-7 electricity.

2. **"Offsetting" renewable PPAs (aka "fixed-floating swaps")**

   In geographies with regulated retail markets but deregulated wholesale markets, we purchase renewable energy at the wholesale level, retire the associated RECs, and sell the power back into the same grid from which we later draw power at the retail level. We describe this structure in our white paper about Google's green PPAs.

3. **Utility renewable energy tariffs**[6]

   In areas where retail markets are not open to competitive suppliers and particularly where there is no auction-based wholesale market, we worked with our utility provider to create a new class of rates called a "renewable energy tariff," in which the utility procures renewable energy on our behalf (described in our renewable energy tariff white paper) for sale and delivery to us.

4. **Grid-mix renewable content**

   In most geographies where we have consumption, the utility's grid mix contains energy from renewable resources that is not otherwise being purchased by specific consumers but rather is part of the "residual" mix. For each MWh of retail electricity that we consume at our data center, we count the portion that comes from residual renewables on the grid toward our 100% goal.[7] Further, we continue to support efforts to reduce the carbon emissions of the utility generation mix where we operate.[8]

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[5] "Firming and shaping" is the process of combining the output of a nondispatchable, intermittent resource (like a wind or solar farm) with the output of a dispatchable, nonintermittent resource (like a traditional gas-fired facility) over time to create a flat, constant electricity supply profile for a consumer. Retail electricity providers do this by purchasing enough firming energy on a wholesale market in a given hour to "balance out" whatever energy is being produced by a renewable resource, thereby ensuring that their customer is receiving a flat supply of electricity.

[6] A "tariff" is a utility industry term for a rate schedule.

[7] Data on the renewable content in a given utility's grid mix is provided to us by the Emissions & Generation Resource Integrated Database (eGRID), which is managed by the U.S. Environmental Protection Agency.

[8] For example, we joined with Amazon, Apple, and Microsoft to file a legal brief supporting the Environmental Protection Agency's Clean Power Plan, which aims to accelerate the transition to cleaner sources of electricity. More information is here: https://blog.google/topics/environment/google-unites-with-other-tech-companies/.

When pursuing any of the first three approaches above, Google is able to either lead or actively collaborate with a utility in the procurement process. This allows us to apply very high standards for what types of renewable energy projects we count toward our 100% goal. Specifically, we apply three key criteria in selecting projects:

1. **Additionality**

   To ensure that Google is the driver for bringing new clean energy onto the grid, we insist that all projects be "additional." This means that we seek to purchase energy from not yet constructed generation facilities that will be built above and beyond what's required by existing energy regulations (like state renewable energy standards). This approach also helps advance new technologies and drive economic growth in the regions where we operate.

2. **Physical energy bundled with its "renewable certification"**

   We purchase both the physical electricity and its corresponding "bundled" certification of renewable energy—a renewable energy certificate (REC) in the United States or a guarantee of origin (GoO) in Europe.[9] By purchasing physical energy bundled with these certifications, we provide all or nearly all of a project's cash flow over time, whereas buying "unbundled" RECs or GoOs provides only a small portion of a project's cash flow. We take care never to buy "unbundled" or "naked" RECs or GoOs, in which a renewable attribute is sold on an open market, independently of underlying physical energy.

3. **Proximity**

   To the greatest degree possible, we seek renewable energy projects that will operate on the same grids as our data centers. This creates a stronger physical and financial link between the renewable power we purchase and our operational electricity consumption, which helps deliver us the financial benefits we describe above.

Wholesale power purchase agreements—our first renewable purchasing structure

We signed our first PPA in 2010 for the output of 114 MW of renewable energy from the Story County II wind farm in Iowa. Since then, we've completed 19 more purchasing deals totaling 2.6 GW of renewable energy, making Google the largest corporate buyer of renewable energy on earth. Pioneering this buying method at scale has been key to our ability to reach 100% renewable energy purchasing for our operations, and we've been excited to see how many other companies have since used it to green their own operations.

Some of these PPAs are "direct" purchases in that competitive retail markets (for example, in areas like Europe and Chile) allow us to pass the obligations of a PPA that we negotiate through to our retail bill at our facilities. It gives us the greatest degree of control over our energy supply contract and directly delivers the financial value of renewables to our bill.

In areas with restrictive retail regulation, we use a fixed-floating swap approach. In these markets we purchase power directly from a renewable developer at a long-term fixed price, retire

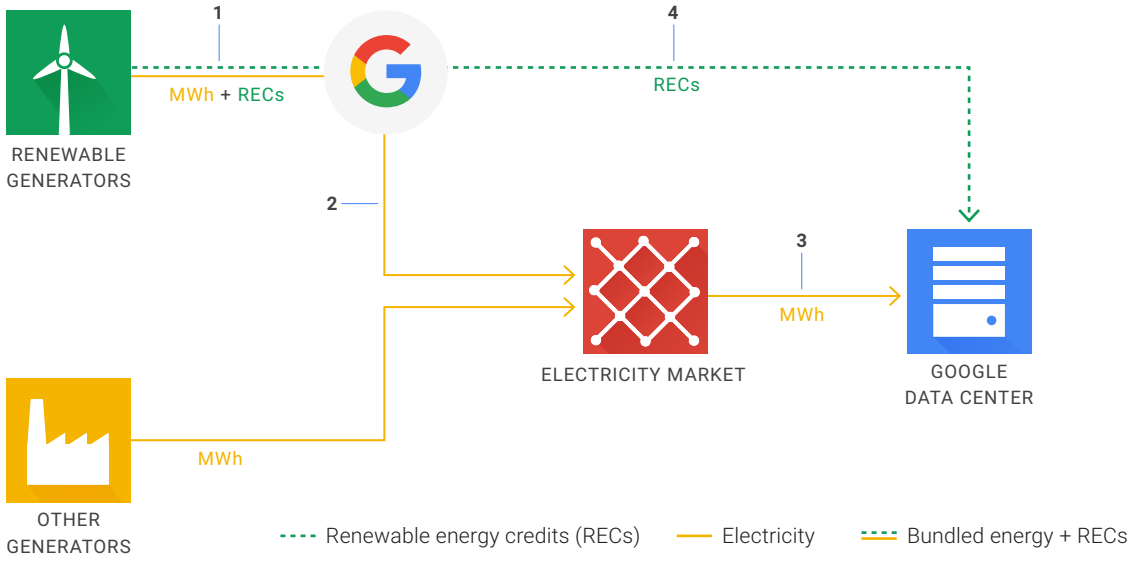
[9] In markets where renewable energy certification systems don't currently exist, we are supporting their development. For example, we provided a seed grant to the Center for Resource Solutions to begin laying the groundwork to establish REC systems in Asia, starting in Taiwan. More information is here: https://blog.google/topics/environment/laying-foundation-for-renewable-energy/.

the associated RECs, and then resell the physical electricity back into a wholesale market. Because we are locked into a single retail monopoly electricity supplier, we still must separately buy power from our local utility provider through a standard retail contract.

We've used fixed-floating swaps as a key method for getting to our 100% goal because—under the current regulatory model in most geographies where we have significant operations—it is the most scalable way to rapidly procure renewable energy. The model takes advantage of the flexibility and speed that deregulated energy markets offer. For example, in 2015, we ran a request for proposals for large wind PPAs in the deregulated wholesale markets of the central United States, which resulted in 848 MW of new renewable purchasing that year. It also gives us the ability to transfer the PPA to another buyer if we need to.

HOW FIXED-FLOATING SWAPS WORK

To get to our 100% goal as quickly as possible, one approach has been to purchase renewable energy in competitive wholesale markets. On grids in which we have a data center, we buy fixed-price renewables directly from a wind or solar farm and then resell it into the wholesale market at a floating (variable) market rate. We then buy smooth, 24/7 energy at the data center from our regulated utility and apply the RECs from our PPAs to that consumption.



1. FIXED- PRICE PPA

Google purchases bundled physical renewable energy and RECs directly from a wind or solar farm using a negotiated, long-term, fixed- price structure. These contracts are called power purchase agreements (PPAs).

2. FLOATING WHOLESALE MARKET SALE

Google sells the physical renewable electricity into the competitive wholesale energy market (utility grid) at the floating market price, where it's pooled with other energy sources (such as wind, solar, hydropower, coal, and nuclear).

3. REGULATED RETAIL PURCHASE

Our data center buys electricity at regulated rates from our utility, which is supplying us from the same grid into which we sold our physical renewable PPA electricity. Our utility uses the grid to balance out intermittency and deliver us smooth 24/7 electricity.

4. APPLY RECS TO CONSUMPTION

We strip off the newly created RECs from our PPAs (in step 1) and match them to the retail electricity that we purchase at the data center. Over a year, the total number of RECs we apply equals the total consumption at our data center.

For all the benefits of fixed-floating swaps, however, the model also creates unnecessary layers of complexity and dilutes the financial benefits that we receive as an end user. Because of restrictive retail market structures, we are essentially buying power twice and selling it once—buying once at the competitive wholesale level and again at the regulated retail level, while we also sell at the competitive wholesale level. Since these two prices aren't always correlated, we don't reduce our exposure to market price volatility quite as much. Further, these structures also require significant resources and expertise to execute, as well as a long-term commitment from the buyer, so they aren't scalable options for many smaller companies that want to purchase renewable power.

A first step toward an opt-in model for purchasing renewables—utility renewable energy tariffs

We've pioneered the fixed-floating swap model to help us achieve our 100% goal as quickly as possible, but we also want to help create simpler, more scalable approaches to purchasing renewables that are accessible to a greater number of buyers.

In an ideal world, large energy consumers like Google could simply ask our retail energy provider (whether competitive or regulated) to sell us the renewable energy that we'd like to buy. This means selling us competitively priced, scalable renewable energy from a newly constructed wind or solar farm within the time frame we need to meet the growing demand for data center services and with enough contractual flexibility to meet the needs of our business. It also means "firming and shaping" the renewables with dispatchable resources to deliver constant, 24-7 power.

To begin moving toward this model, we've worked with our regulated utilities on programs to empower customers with options to purchase renewable energy. In 2013, we worked with Duke Energy in North Carolina to create one of the first renewable energy tariffs, which allow customers in fully regulated territories to apply to their utility to purchase renewable energy from dedicated projects. We are also working with stakeholders to create similar programs in Georgia and Taiwan.

Programs like these are first steps toward ensuring the electricity service model is agile and responsive to customer demands. Customers need only apply to their local utility provider to participate, making renewable energy accessible to a wide variety of customers—both large and small—without the need for these customers to have their own energy procurement teams. Further, because customers of these programs pay for the renewable energy from their retail bill, tariffs can be structured to more directly deliver the financial benefits that renewables provide.

Since 2013, we've seen similar renewable energy tariff programs emerge in eight states.[10] However, uptake of these programs is slow, and they remain largely unsubscribed. Many of these programs lack the responsiveness and agility that customers require; it can take many years from application to receipt of renewable energy supply. Moreover, the financial structure that customers need to make the business case to their management—cost-competitive renewables delivered directly and without unnecessary fees—is often lacking.

Although these programs have been a helpful first step toward a purchasing structure that mirrors our ideal model, there is more work to do to make these programs as customer-centric as modern consumers demand.

[10] World Resources Institute. 2016. Retrived from http://buyersprinciples.org/resources/.

Lessons learned from seven years of renewable energy procurement

1. **Competitive energy markets have provided the fastest path to purchasing renewables.**

   The flexibility, accessibility, and responsiveness to customer demands that come with competitive markets make it easy for customers to purchase the products they desire. In fact, of all of the corporate renewable energy purchasing deals that were signed in 2015 and the first half of 2016, 91% occurred in either competitive wholesale markets or retail markets.[11] Google's experience is no different; 19 of our 20 renewable energy purchases since 2010 have occurred in either competitive retail markets where Google can obtain delivery to its facility or auction-based wholesale markets that allow us to efficiently liquidate PPAs through the fixed-floating swap model.

   It's certainly possible for utilities in regulated markets to mimic the responsiveness and agility of competitive markets, but our experience is that this is difficult to implement. Most utility regulatory regimes do not provide the right incentives for utilities to meet customer calls for new products or to create innovative solutions to unique customer needs.

2. **Access to renewables at the retail level is critical to the business case for renewable energy.**

   Wholesale renewable energy PPAs have proved to be a successful method for large companies to rapidly procure renewables, but it is only a partial solution. Without the ability to easily purchase renewables at the retail level—rather than being required to use complex swap structures—companies will not be able to take full advantage of the financial benefits that renewables provide.

   Regulatory models must evolve to enable customers to directly place the benefits and costs of renewables—energy prices, capacity credits, etc.—on their retail bills. Even if in some markets renewables appear to be more expensive than traditional grid power today, the long-term economics make them an attractive energy source. But this can be realized only if buyers have full access to renewable economics at the retail level.

3. **Complex PPA contracts aren't for everyone, and regulated utilities need to become truly customer-centric to meet the demands of the market.**

   Renewable energy PPAs have worked for large customers like Google, but they are complicated and not every company or consumer has the time and resources to commit to pursuing them. Without robust buy-as-you-go renewable energy programs offered by utilities and competitive energy suppliers, most consumers won't be able to opt in to purchase green energy.

   The lack of such options available in the market today is largely the result of a fundamental disconnect between the demands of modern electricity consumers and the regulated utility business models that were designed for a bygone era. Meeting the demands of today's market will require an evolution of business and regulatory models to align utilities' incentives so that they are rewarded for the value that they deliver to their customers.

[11] Retrieved from http://rebuyers.org/wp-content/uploads/2016/05/2016-REBA-Summit-Fireside-Chat.pdf.

4. **Cost-competitiveness is critical to unlocking renewable energy for all.**

Renewables have experienced tremendous cost declines, with the levelized cost of wind and solar dropping 60% and 80%, respectively, in six years. In some geographies, they are now the cheapest source of energy available, with generation-weighted average levelized wind PPA prices that are below the average cost of wholesale energy on the grid.[12] This precipitous drop in cost has been instrumental in shaping the business case for corporate renewable energy purchasing, and it will be key to the future success of the renewables sector.

Unleashing the power of customer demand for renewables by unlocking retail energy markets can drive continued growth in volume, leading to economies of scale that spur a new wave of cost reductions. This virtuous cycle may be a self-sustaining model to achieve widespread adoption of increasingly cost-effective energy at scale.

5. **High levels of intermittent renewables can be managed reliably and cost-effectively, but it requires larger, more integrated, more liquid markets.**

There's much evidence to show that, despite their intermittent production, renewable energy resources like wind and solar can indeed be integrated into a grid at scale and at a low cost. In many U.S. states, integrating intermittent wind resources into the grid often costs below $5 per MWh (a fraction of the overall energy cost), even for states with wind penetrations up to or exceeding 40% of peak load.[13] The Southwest Power Pool conducted a study in 2016 showing that it can reliably manage wind penetration levels of up to 60% with the addition of transmission upgrades and system tools. [14]

The key to managing this intermittency at low cost has been the ability to use large, interconnected, highly integrated electricity grids and associated liquid wholesale markets. As renewable penetrations grow, it will be critical to shift from balkanized, isolated electricity markets to regional, interconnected grids and markets. This will create larger balancing areas to better manage intermittency, increase price efficiency through greater liquidity and market transparency, and allow renewables to be delivered from distant but resource-rich geographies to the load centers where they are needed.

We know, however, that there is an upper limit to the portion of intermittent renewable energy that can be effectively integrated on a grid. Over the long term, clean and reliable baseload energy will be a critical component of achieving a truly carbon-neutral electricity grid.

[12] Average levelized wind PPA prices in 2014 in "interior" states (Arizona, Colorado, Iowa, Kansas, Minnesota, Missouri, Montana, Nebraska, North Dakota, Oklahoma, South Dakota, Texas, and Wyoming) were comparable to or lower than the average annual wholesale power prices in those states. Lawrence Berkeley National Laboratory. 2014 Wind Technologies Market Report. 2015. Retrieved from https://emp.lbl.gov/sites/all/files/lbnl-188167.pdf.

[13] Lawrence Berkeley National Laboratory. 2015 Wind Technologies Market Report. 2016. Retrieved from https://emp.lbl.gov/publications/2015-wind-technologies-market-report.

[14] 2016 Wind Integration Study. Southwest Power Pool. 2016. Retrieved from https://www.spp.org/documents/34200/2016%20wind%20integration%20study%20(wis)%20final.pdf.

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PART II

100% Renewable Energy Purchasing Is Just the Beginning

Reaching 100% renewable energy purchasing for our operations is an important milestone, and we remain committed to this achievement even as our energy use grows. But to ultimately tackle the emissions associated with our electricity consumption, we need to move beyond our global, annual matching method to ensure that hour by hour our operations are powered by clean energy. A key hurdle here remains the variability of renewable energy technologies like wind and solar.

For Google, reaching our 100% goal on a global and annual basis is just the beginning. In addition to continuing to aggressively move forward with renewables like wind and solar, we will work to achieve the greater, longer-term challenge of powering our operations on a region-specific, 24-7 basis with clean, zero-carbon energy.

This more ambitious approach is an important next step toward achieving a truly zero-carbon electricity grid.

We believe tackling this long-term goal is best approached in the following three ways:

- Taking more of a regional approach to renewable energy procurement and working to maximize the amount of renewable energy we buy in regions where we operate
- Widening the technology lens to undertake projects and services that address the challenge ofobtaining cost-effective clean energy on an hour-by-hour basis every day of the year
- Working to promote policies that empower energy consumers and accelerate the transition to 100% clean energy–powered electricity grids in a way that makes sense for all energy customers

1. Taking a regional approach to renewable energy procurement

Today, Google overbuys renewable energy in regions like the central United States and Northern Europe, taking advantage of favorable market conditions to purchase enough renewable energy to offset our inability to purchase it in other locations. In order to meet the longer-term challenge of matching our electricity consumption with clean energy, we will shift efforts more toward purchasing renewables and other forms of clean energy on the same grids where we operate.

This means actively looking for renewable energy projects in every grid where we have significant operations. In many of these markets, there is currently no path to purchase renewables, so we'll work with utilities and other local stakeholders to advance new purchasing pathways, as we have done in North Carolina and elsewhere.

Importantly, on each grid we'll strive to have a direct financial tie between specific clean energy resources and our final retail energy bill. Having the ability to place the economics of a clean energy project on our retail bill, like we are able to do in places like Northern Europe and Chile, is critical to the business case for renewable purchasing.

2. Pursuing technology approaches that advance 24-7 clean energy

As we search for renewable energy projects in every market where we have significant operations, we'll also keep in mind our ultimate goal of 24-7 clean energy. This means that as part of our energy supply portfolio, we will need to address the variability associated with renewables through advanced technological approaches, among other means.

To this end, in complement to our wind and solar purchasing, in the future we may pursue dispatchable, zero-carbon generation energy options for our portfolio. These options could include purchasing energy from technologies like renewables paired with utility-scale energy storage, advanced nuclear power, geothermal energy, low-impact hydro, demand response and energy efficiency resources, or others.

Some of these resources are either not mature enough for commercial deployment or not cost-effective at the scale necessary for large commercial operations. However, as with renewable energy technological development, we expect that a combination of technical innovations, economies of scale, and public policy will speed the pace of adoption and bring costs down over time. As we search for new technological approaches for our energy supply portfolio, we will look for opportunities to advance technologies or business models that accelerate the transition to 24-7 clean energy.

3. Promoting energy policies that empower consumers and accelerate the transition to 24-7 clean energy while driving economic growth

We recognize that establishing an advanced energy and climate policy architecture is critical to driving electricity grids around the world to become 100% clean, resilient, customer-centric energy systems.

Governments can play a role in helping to accelerate the transition to a clean energy grid through a variety of advanced energy policies. Most critically, they can help the market correctly price the full array of impacts and benefits from energy technologies—particularly those associated with GHG emissions. The science of climate change shows that GHG emissions have tangible, adverse effects that pose long-term threats to our planet, our population, and our businesses. Governments should help markets account for the impacts of these emissions—for example, by creating revenue-neutral, economy-wide mechanisms that "internalize the externality" of GHG emissions.

Governments can also play a key role in getting us closer to 24-7 clean energy by scaling up investment in research and development to drive down the cost curves for emergent but expensive technologies while also ensuring that we don't miss the next breakthrough energy technology. (These could include advanced nuclear, utility-scale energy storage, carbon capture and storage, etc.) Financial incentives that facilitate deployment can help bring energy technologies to maturity and generate economic growth. Investments in energy infrastructure like transmission lines can help bring clean energy from resource-rich geographies to the load centers where it is used.

Lastly, making retail and wholesale energy markets more nimble and customer-centric is critical to enabling any electricity customer who wants clean power to purchase it. This means evolving utility regulation and business models at the state and regional levels. Our experience has shown that energy markets that prioritize customer choice at the retail level and unlock cost-efficiencies through large, regional markets at the wholesale level are effective at rapidly scaling up clean energy while delivering many other benefits to consumers.