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Intelligent Low-Carbon Power Sourcing for Data Centers

A Working Paper from the Future of Internet Power Initiative

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About This Working Paper

This working paper aims to help data center users and operators develop practical strategies for sourcing low-carbon power and to improve shared understanding about the challenges and opportunities with low-carbon power sourcing that apply to data centers in many different situations. Commissioned by BSR's Future of Internet Power initiative, it is based on a literature review, as well as interviews with the individuals listed in the appendix. The report was written by Corinna Kester, Ryan Schuchard, and Aditi Mohapatra, with contributions from Sekita Grant. Please direct comments or questions to Ryan Schuchard at rschuchard@bsr.org.

About the Future of Internet Power Initiative

The Future of Internet Power initiative is a group of leading technology companies that share and promote best practices and develop a platform for driving low-carbon, sustainable power for data centers in collaboration with select utilities and policy makers. Future of Internet Power members include Adobe, eBay, Facebook, Hewlett-Packard, salesforce.com, and Symantec.

Based on the conclusions we draw in this paper, the Future of Internet Power initiative is pursuing the following for data center operations:

- **Combine resources and perspectives** among data center operators to drive more intelligent low-carbon power sourcing.
- **Develop the marketplace** for intelligent low-carbon power sourcing by informing policy makers about practical opportunities and promoting rules and incentives that foster such sourcing.
- **Empower companies** to source low-carbon power by building the internal commitment and insight needed to develop more creative cross-sector partnerships.

ABOUT BSR
BSR is a global nonprofit organization that works with its network of more than 250 member companies to build a just and sustainable world. From its offices in Asia, Europe, and North and South America, BSR develops sustainable business strategies and solutions through consulting, research, and cross-sector collaboration. Visit www.bsr.org for more information about BSR's more than 20 years of leadership in sustainability.

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Introduction

The ICT industry is an important enabler of sustainability solutions. Yet, it is also a driver of sustainability impacts, comprising approximately 1.9 percent of global greenhouse gas (GHG) emissions. Data centers represent almost 18 percent of these emissions, a number that is expected to grow.[1]

Efforts to reduce these impacts through increased efficiency are commonplace in the technology industry, and they are central to many companies' sustainability efforts, given the natural incentives to reduce costs. Furthermore, there are many industry initiatives and government resources available to companies that are effectively working to further improve the energy efficiency of data centers.[2]

A growing global population and increasing affluence will add hundreds of millions of new computer and mobile phone users in the next two decades, while advances in technology applications are multiplying the energy intensity required per user. The growing cumulative energy demand is outstripping gains from even rapidly improving efficiency.

For this reason, a key sustainability leverage point for data centers is their supply of power (e.g., the mix of coal, natural gas, renewables, and other feedstocks), which determines the level of climate impact resulting from a given unit of electricity. However, companies often have limited low-carbon options due to

[1] Global e-Sustainability Initiative, "SMARTer 2020: The Role of ICT in Driving a Sustainable Future," 2012, http://gesi.org/SMARTer2020.

[2] Sample initiatives include the Green Grid, the U.S. Department of Energy's (DOE) Federal Energy Management Program, and the U.S. Environmental Protection Agency's (EPA) Energy Star program.

geographical, policy, and utility constraints.[3] In light of these circumstances, companies have meaningful opportunities to advance sustainability by partnering with local electricity providers and policy makers to make sure that more of their power comes from low-carbon sources.

This paper outlines the importance of low-carbon power sourcing for data centers in the United States. It is intended to help data center users and operators develop practical low-carbon power sourcing strategies and to advance public dialogue about the challenges and opportunities inherent in low-carbon power sourcing.

In the first section, we describe the role energy sourcing plays in reducing the GHG emissions of data centers. We then outline the four primary types of data centers, along with each one's constraints and opportunities for low-carbon power sourcing. Next, we offer a strategy for sourcing low-carbon power, and finally, we summarize the low-carbon power options available to data center operators.

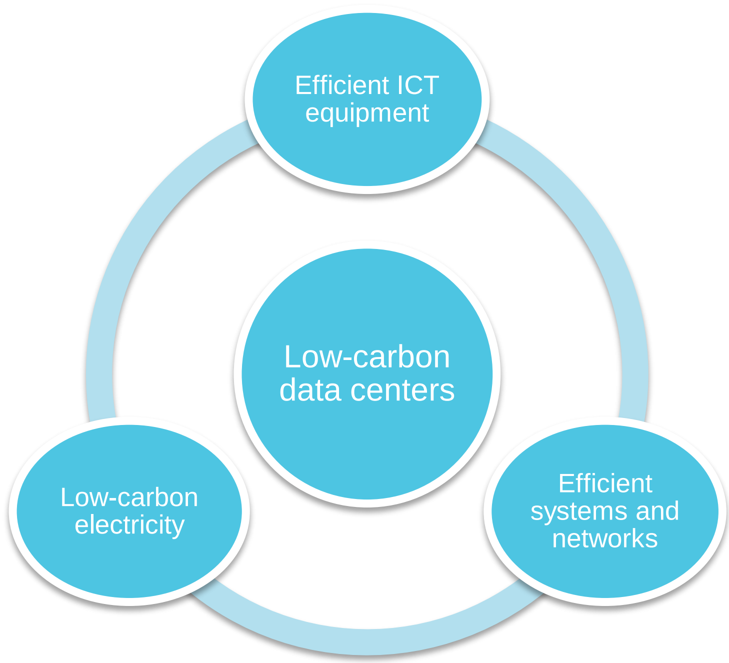
[3] For simplicity's sake, we use the term *low-carbon* in this paper to refer to electric power that has zero or low GHG emissions. Some people may wish to refer to *renewable energy* or *green power* instead.

Toward Intelligent Low-Carbon Power Sourcing

There are nearly 3 million data centers, occupying more than 600 million square feet of floor space, in use in the United States alone.[4] Data centers tend to be large energy users; the largest can use 100 times the energy of a typical office building or more.[5] Indeed, the amount of electricity used by data centers worldwide increased by about 56 percent from 2005 to 2010, to approximately 1 to 1.5 percent of total global electricity use.[6]

Reducing the GHG emissions resulting from society's growing data use will require a multifaceted approach, as shown in Figure 1. This approach includes optimizing the energy efficiency of data centers (both their IT equipment and supporting infrastructure) and reducing the carbon intensity of the electricity that the data center runs on. Both are necessary. According to researcher Jonathan Koomey, procuring low-carbon electricity is becoming the next chief lever after energy efficiency has reached its practical limit.[7]

Figure 1. Strategies for Low-Carbon Data Centers



The data center industry as a whole has focused on energy efficiency, improving its power usage effectiveness, or PUE, a common measure for efficiency, from

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[4] Timothy Prickett Morgan, "US Data Centers Get Bigger, But There Are Fewer of Them – Survey," The Register, 2012, http://www.theregister.co.uk/2012/10/22/idc_us_data_centers/

[5] National Renewable Energy Laboratory, "Best Practices Guide for Energy-Efficient Data Center Design," United States Department of Energy, 2011, http://www1.eere.energy.gov/femp/pdfs/eedatacenterbestpractices.pdf

[6] Jonathan Koomey, "Growth in Data Center Electricity Use, 2005 to 2010," Oakland, CA: Analytics Press, 2011, www.analyticspress.com/datacenters.html.

[7] Eric Masanet, Arman Shehabi, and Jonathan Koomey, "Characteristics of Low-Carbon Data Centers," *Nature Climate Change*, Vol. 3, No. 7, July 2013, pp. 627–630, summarized at www.koomey.com/post/54013825367.

2.5 in 2007 to 1.65 in 2013.[8] The industry has also made significant gains through more efficient systems and networks, including through virtualization and power-proportional computing. It has been unable to advance as rapidly, however, in sourcing low-carbon power—an issue that is a primary driver for this research.

In the United States, renewable power sources make up a total of only about 12 percent of net electricity generation.[9] It varies greatly by state, however, ranging from 70 to 78 percent in the Pacific Northwest to less than 3 to 4 percent in West Virginia and Missouri.[10] States whose data centers are growing significantly include North Carolina (7.5 percent renewables), Virginia (5.5 percent renewables), and Utah (3.7 percent renewables).[11]

Much of the energy that most data centers use includes some mix of low-carbon power, and the centers can sometimes choose low-carbon sources through utility options and the development of new projects. However, there are many practical considerations surrounding low-carbon power that stand in the way of immediate large-scale deployment.

While data centers can generate power on-site through solar panels, wind turbines, fuel cells, and geothermal energy production, meeting a meaningful percentage of a facility's energy demand usually requires generating power off-site for two general reasons. One is that data centers are typically large energy users, while most renewable energy sources produce only a small amount of energy per square foot of land.[12] This is why Apple has sited a 100-plus-acre solar farm near, not at, a data center.[13]

Another is that renewable resources are intermittent, meaning they only provide power when the resource is available (e.g., the sun is shining on solar arrays, or the wind is blowing through wind turbines) and commercial electricity storage remains prohibitively expensive. Users need to build a portfolio of sources.

For both of these reasons, companies need to use power generated off-site, which in turn means that data center operators must collaborate with the electricity providers, such as independent power producers and utilities. However, the production, transmission, and distribution of power is governed by a complex system of rules and regulations that serve a variety of important nonenvironmental objectives, such as safety, reliability, and affordability, which vary by state and locality.

While some regulations may have sustainability objectives—as are found in renewable portfolio standards and decoupling policies[14]—others may limit companies' options for lower-carbon power sources, especially in regulated states where consumers cannot choose their electricity supplier.

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[8] Uptime Institute, "2013 Survey Results," http://uptimeinstitute.com/2013-survey-results.
[9] U.S. EPA, "Energy and You," February 19, 2014, www.epa.gov/cleanenergy/energy-and-you.
[10] U.S. Energy Information Administration, "U.S. Overview," www.eia.gov/state/.
[11] Ibid.
[12] Robert Wilson, "The Future of Energy: Why Power Density Matters," 2013, http://theenergycollective.com/robertwilson190/257481/why-power-density-matters.
[13] Katie Fehrenbacher, "Special Report: Apple's Ground-Breaking Bet on Its Clean Energy Infrastructure, with Exclusive Photos," Gigaom, 2013, http://gigaom.com/2013/11/18/apple-solar-farm-fuel-cell-farms-exclusive-photos-investigative-report/.
[14] *Decoupling* refers to the disassociation of a utility's profits from the amount of energy it sells. Utilities do not have to sell more energy in order to maintain or increase their rate of return, and decoupling often creates greater incentives for energy efficiency.

What this means is that data center operators—like other energy-intensive users—that are interested in sourcing low-carbon power need to work on two fronts: On one hand, they need to creatively partner with electricity providers to develop projects that work for them. On the other hand, they have a role to play in shaping and informing policies that help them do so effectively.

For these companies, sourcing low-carbon power intelligently includes the following principles:

» **Viable:** Power delivered must be reliably available or "firm" (steady). While renewables projects provide power at some points in time, they must generally be combined with other sources to be viable.

» **Affordable:** Low-carbon power can have economic benefits, such as low marginal prices (with a commercial solar deal going for 5¢ per kilowatt hour, kWh, in Austin, Texas, earlier this year) and fixed prices for many years.[15] However, much of the baseload power in the United States (power that can run all of the time) is still generally higher in carbon content due to the low direct cost of burning coal (and increasingly, natural gas) in the absence of effective prices on carbon. Since energy is a major cost for data centers, companies need power that is reasonably affordable.[16]

» **Scalable:** The power should be easy to expand so that it can provide a significant share of the electricity needed. This requirement explains why rooftop solar—which can typically cover only a few percentage points of peak demand for heavy energy users—is only part of the solution.

» **Additional:** The power should ideally be in addition to what a utility or developer would have generated anyway. This requirement introduces a complicated set of accounting issues that we will not explore in detail in this paper.[17]

» **Accountable:** Power purchasing contracts should conform to standard accounting and reporting principles in order to make ownership of the power clear.

These principles for intelligent low-carbon power sourcing are achievable and, in many cases, available. Yet, markets generally need to be developed to deliver them.

One reason is the lack of policies. Without effective prices on carbon, renewable generation sources depend on mandates, incentives, and generation upgrades to be made affordable. As an example, wind generation fluctuates with the Production Tax Credit (PTC), a fundamental driver of the addition of wind power. As one manager said, "Even where direct investment in a project or agreement to a significant PPA on that project occurs, it is dependent on the availability of the PTC."

Another is transaction costs. According to one manager, the financial risks in supplying spot power to an operating data center facility to firm up intermittent

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[15] Zachary Shahan, "Solar Less Than 5¢/kWh in Austin, Texas! (Cheaper Than Natural Gas, Coal, and Nuclear," Clean Technica, 2013, http://cleantechnica.com/2014/03/13/solar-sold-less-5%C2%A2kwh-austin-texas/.

[16] As part of the affordability principle, companies should seek projects, programs, and policies that reduce the greatest emissions for the lowest overall cost.

[17] One key issue is whether energy projects that count toward renewable portfolio standards (RPS) or state-by-state mandates that call for minimum percentages of renewable power to be developed should be considered as additional. If renewable power generation is required by mandate, it is arguably not additional to what would have happened anyway.

wind power cannot reasonably be managed at a facility with a demand of 10–30 megawatts (MW). Rather, it is more effective to manage the larger grid within a utility operating area to provide the full range of generating capacity to balance the system, as demonstrated by problems with managing wind power and solar energy generation in the Columbia River Valley and Germany. Some data center operators make their large purchases using a contract for differences where the power is generated, the RECs (renewable energy credits) stripped, and the power immediately sold into the grid on the spot market. It is unlikely that many companies will be able to enter into what is essentially a long-term price hedging contract—which is an expensive proposition for the sole benefit of claiming “additionality.”

Most companies’ clearest option for buying wind power is through a utility that is supplying renewable-generated electricity as a “green power” option (typically at premiums) or as RECs from a new project or from companies that promise to reinvest the profits in wind generation. However, these options may be unaffordable over time, since companies seek to realize cost benefits (or neutrality) from renewable purchases to make them viable over the long term. The required procurement and contracting models have not been established to make this option viable.

Opportunities for Different Types of Data Centers

We have established that intelligently sourcing low-carbon power should be a priority for data centers. However, this recommendation masks the important reality that how we define a data center and the way that a given center relates to power sourcing can vary vastly in nature. In this section, we explore different situations that data centers find themselves in with respect to sourcing low-carbon power.

To be sure, data centers as a group have much in common, including complex technical infrastructure, strong energy demand, and an emphasis on power quality, security, and reliability. And, when it comes to sourcing low-carbon power, data centers also face a set of similar constraints. Their immediate options for low-carbon power sourcing are constrained by what is locally available. Often, the cheapest baseload energy has the highest carbon content. And data center siting must take into account a long list of technical considerations, including power availability and reliability, availability of fiber optic broadband, the ability to mitigate the risk of natural disasters and hazards, and overall costs.

Despite these commonalities, however, the around 3 million data centers in the United States face different sets of challenges and opportunities when it comes to sourcing low-carbon power.[18] What follows is a summary of issues and opportunities for low-carbon power sourcing among the four types of data centers, divided up based on ownership, function, and size. There are three types that a company owns and operates itself (cloud, enterprise, and managed), followed by a fourth (rented) that could be any of the other three, but is distinguished in that the company operating the facilities does not own them.[19] A single company can use a mix of any or all of these data center types in order to meet their diverse business and operational needs.

Cloud

The data centers that companies like eBay operate can be thought of as cloud data centers. They run on one or a few industrial-scale, missions-critical applications that serve customers—in eBay's case, an online marketplace for customers on all types of devices around the world. Cloud data centers are generally used for applications that drive heavily information-based businesses; other cloud data center operators include Facebook, Google, Apple, and Amazon, among others.

Cloud is perhaps the most iconic data center category because it is the largest, consuming 10–100 MW of power per center. A modestly sized (10 MW) cloud facility can use the same amount of energy as a small town, at a cost of around US$300,000 per month.[20] The largest cloud facilities—at the time of this paper's publication—are run by Apple (100 MW) and Google (60–100 MW) and are both

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[18] Timothy Prickett Morgan, "US Data Centers Get Bigger, But There Are Fewer of Them – Survey," The Register, 2012, http://www.theregister.co.uk/2012/10/22/idc_us_data_centers/

[19] An additional owned-and-operated data center not covered in detail here is the public scientific computing data center. This data center is unique in that it runs computing jobs that can be queued up, meaning that facilities do not need to respond to changes in demand. As these are less applicable for business, we did not include that model in our research. For more, see Jonathan Koomey, "The *NYT* article on Power, Pollution, and the Internet: My Initial Comments," September 25, 2012, www.koomey.com/post/32281701993.

[20] Gavin Hudson, "How Much Energy Does the Internet Use?," Clean Technica, __date?__, http://cleantechnica.com/2012/06/01/how-much-energy-does-the-internet-use/.

in North Carolina.[21] Among the four data center types, the cloud is the smallest in terms of number, though the number and size are growing as more companies move to cloud technology in order to boost their operational efficiency and increase their IT agility.[22]

Among data centers, cloud facilities tend to have the most sophisticated energy management systems because they are new and thus have fairly standardized workload times, as well as the latest processor memory and storage systems with improved power management. There is strong potential for cost savings from the economies of scale associated with large investments in energy efficiency, and cloud facilities are typically fully owned and operated by the same company, which helps to align incentives and reduce transaction costs.

Also, most cloud operators' data centers are so closely connected with the core business that they receive ongoing attention from many internal and external stakeholders. As a result, they are the most efficient of data centers, scoring the best in PUE, a measure of the amount of energy wasted by noncomputing devices, such as lighting and cooling.[23] The average PUE for cloud data centers is around 1.1 (a score of 1.0 is considered perfect).[24]

Furthermore, cloud facilities are also less restricted by hardware, which allows them to achieve much higher utilization. As PUE starts to reach practical limits, higher utilization is a fairly untapped opportunity for lowering energy use.[25]

CONSTRAINTS

Despite the size and sophistication of cloud facilities, they face many of the same basic constraints as other data centers when securing low-carbon power. Since they need to use more power than can be generated on-site (even one of the largest solar installations—a 20-MW array at Apple's Maiden, North Carolina, facility—provides only 10 percent of its center's power needs and the power it provides is intermittent), low-carbon power sourcing generally requires operators to make arrangements to develop power off-site.[26] However, the data centers may not have access to low-carbon power if they are located in a jurisdiction where retail options for power procurement are unavailable or difficult to negotiate due to market regulations. Furthermore, data center operators may be unable to develop on-site projects that are cost-effective with prevailing laws and regulations.

Cloud facilities also face unique constraints compared with other data center types. Because they represent large, fixed assets for missions-critical components, a number of physical and technical requirements for siting limit where they can be located. Cloud data centers require a large, affordable, and stable power supply, and they need to be located strategically within the telecommunications network to provide rapid communication to users. Furthermore, companies must strategically space new data centers between

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[21] Katie Fehrenbacher, "The Era of the 100 MW Data Center," Gigaom, January 31, 2012, http://gigaom.com/2012/01/31/the-era-of-the-100-mw-data-center/.
[22] International Data Corporation, "_title?__," __date?__, www.idc.com/getdoc.jsp?containerId=prUS23724512.
[23] For more information about PUE, see: The Green Grid, "The Green Grid Data Center Power Efficiency Metrics: PUE and DCiE," 2007, www.thegreengrid.org.
[24] Jonathan Koomey, "The *NYT* article on Power, Pollution, and the Internet: My Initial Comments," September 25, 2012, www.koomey.com/post/32281701993.
[25] Jonathan Koomey, "4 Reason Why Cloud Computing Is Efficient," Gigaom, July 25, 2011, http://gigaom.com/2011/07/25/4-reasons-why-cloud-computing-is-efficient/.
[26] Greenpeace International, "How Clean Is Your Cloud?," April 2012, www.greenpeace.org/international/Global/international/publications/climate/2012/iCoal/HowCleanisYourCloud.pdf.

existing data centers in order to optimize customer response times. These business requirements dictate siting and thus can place limits on the available options for low-carbon power sourcing.

OPPORTUNITIES

Even with siting restrictions, cloud data centers can have a substantial impact on carbon emissions by locating facilities in places that have natural cooling and low-carbon power sources readily available. Also, because they typically have large, predictable, and long-term energy expenditures, their buying power can help them negotiate with utilities and renewable energy power developers to establish new sources of low-carbon power at a manageable cost. In a similar vein, because cloud facilities frequently bring multiple benefits to communities, including jobs and ancillary economic development, they may be in a position to develop coalitions with governments and others to increase an area's supply of low-carbon power.

Enterprise

Like the cloud facilities described above, enterprise data centers are owned and operated by the company. However, instead of serving one or a few industrial-scale processes that interact directly with the company's customers, enterprise centers support a wide array of internal applications, such as secure processing facilities for banking and high-performance computing centers for company R&D. Also called in-house data centers, enterprise facilities may be found on many scales (in server closets, portable data center pods, and dedicated, stand-alone facilities).

These individual centers are much smaller than cloud facilities—with power demand generally measured in kilowatts (KW) rather than MW—and many are the smallest type, Tier 1, which is essentially a server room. However, collectively the enterprise category is the largest, representing around 70 percent of the data center market and taking up the most floor area and total electricity use.[27] Enterprise data centers are found in all sectors and geographies and are widely distributed and varied in type.

Their energy management practices vary widely.[28] The latest network equipment is very sophisticated. However, enterprise settings also include many instances where equipment is old, obsolete, and not optimized. Inefficiency is more common among enterprise facilities because they are not always part of the core revenue-generating business and can be physically decentralized and spread across departments. As a result, enterprise facilities on average are less efficient than cloud facilities (e.g., with an average PUE of 1.8 to 1.9[29]), and therefore, energy efficiency improvement tends to be the most significant opportunity for carbon reduction. Enterprise data centers vary widely in their age, efficiency, and size; some are state-of-the-art facilities core to business operations, while others are decentralized and poorly optimized.

CONSTRAINTS

Compared with cloud facilities, the more decentralized and lower-intensity energy use associated with enterprise facilities means that individual sites may not have

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27 Markus Nispel, "What Makes the Enterprise Data Center Different?," Enterprise Data Center Transformation blog, Extreme Networks, April 4, 2013, http://blogs.enterasys.com/what-makes-the-enterprise-data-center-different/.

28 Jonathan Koomey, "How Green Is the Internet? Summit: Internet Infrastructure," YouTube, June 7, 2013, www.youtube.com/watch?v=O8-LDLyKaBM.

29 Jonathan Koomey, "The *NYT* article on Power, Pollution, and the Internet: My Initial Comments," September 25, 2012, www.koomey.com/post/32281701993.

the same buying power. In addition, data center sites may have reduced economic incentives for investment in energy efficiency and low-carbon power due to fewer economies of scale. Lastly, the lines of ownership may be fragmented if the facilities' management is spread across many departments. These factors may combine to make energy management across a company's fleet of enterprise facilities more costly.

OPPORTUNITIES

While individual enterprise facilities may face the constraints mentioned above, at least some of a company's enterprise facilities are likely in states or regions where the wider company has a profile and relationships that can be leveraged to negotiate with utilities, renewable energy developers, and policy makers for acquiring more low-carbon power.

In addition, while enterprise facilities have low relative energy intensity (e.g., energy use per gigabyte of data served) compared with other types of data centers, they still tend to be one of a company's largest sources of energy use, which can make them a solid focal point for GHG reductions, and in turn, deserving of preferential criteria for investments by the finance department.

Enterprise facilities can benefit from thinking of low-carbon power sourcing as part of an overall portfolio for low-carbon power development. Energy efficiency is rightly considered to be the desired "first fuel." But at the same time, it is short-sighted not to include low-carbon power sourcing as part of reducing overall corporate GHG emissions. Intelligent data center operators will look for economically attractive opportunities to invest in or procure low-carbon power as part of a portfolio of carbon-reduction initiatives.

Managed

Managed data centers are used for midsized applications mentioned in the two categories above (enterprise and cloud) but managed by one company on behalf of another. However, they combine many different clients in one place, and therefore, can be quite large. They are typically used to run web commerce, process secure transactions online, back up off-site data, ensure business continuity, and act as hubs for telecommunication companies to exchange traffic.

Managed data center providers include household names such as Hewlett-Packard and Dell, as well as those specializing in B2B services, such as Equinix, Interxion, Telehouse CoreSite, Telx, TelecityGroup, and Global Switch. A recent count of these providers put the number of facilities at a little more than 400.[30] And this number is growing. A 2012 study projected that as more companies outsource their data center needs, more than a quarter of the data center floor space in the United States will be owned by providers of managed facilities.[31] Shifting operations to managed data centers with better economies of scale could be one path to increased efficiency in enterprise data centers.

Arrangements for managed data centers range from hands-off wholesale contracts where the operator rents out secure powered rooms to more involved retail services where the operator provides a turnkey suite of equipment, bandwidth, storage, networking, cooling, and staff support.

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[30] John Edwards, "Grow Your Data Center with Colocation," Computerworld, July 11, 2011, www.computerworld.com/s/article/9218207/Grow_your_data_center_with_colocation.

[31] Timothy Prickett Morgan, "US Data Centers Get Bigger, But There Are Fewer of Them – Survey," The Register, 2012, http://www.theregister.co.uk/2012/10/22/idc_us_data_centers/

Managed operators typically provide services to many customers at once in a colocated (colo) facility. Also, some managed operators build data centers to spec for corporate data users (sometimes called "trade" data centers).

Although they vary in scale, managed centers tend to be on the medium to large size, ranging from 5 to 20 MW. They also tend to be sophisticated, generally Tier 3 and 4. Managed facilities serve anywhere from one to thousands of clients in a single colo facility for diverse business needs. Contract relationships last from weeks to years.

As a result of the different relationships that operators have with customers, energy management practices within managed facilities vary widely. As large energy users, they generally have a cost driver to reduce energy use and have economies of scale to incentivize energy efficiency investments. However, in many cases, the customer controls the specific IT equipment that is installed in the data center and the managed operator plays a more hands-off role. Depending on the customer's sophistication, inefficient equipment and practices that are not optimized may persist in these types of facilities.

CONSTRAINTS

As managed data center operators act in a somewhat similar role to building managers, a key constraint is that they are subject to the requirements and behaviors of the customers using their facilities. Also, unlike many of the branded companies who use their facilities, managed data center operators offer business-to-business services where they may interact less with end-use customers and, therefore, feel less recognized for their leadership.

Another factor that may work against energy management for managed facilities is requirements for security and reliability, which may increase power requirements. At the extreme end, the most physically robust centers are known as Tier 4 data centers, which require continuous cooling technology and multiple, independent, dual-powered systems with sufficient redundant capacity.[32] Existing energy efficiency measures can help to mitigate extra power requirements, but they require added investment.[33]

OPPORTUNITIES

Managed facility operators have opportunities to increase low-carbon power sourcing in their roles as builders and managers of data centers. As builders, they can educate customers about the choices for low-carbon power that are associated with siting decisions. As managers, they can offer packages that give customers incentives for better performance. In addition, because they often bring multiple customers together in one place, managed data center operators can leverage their relationships to create more scale for deals with utilities and power developers, as well as for getting the attention of policy makers.

Rented

Salesforce.com and some of its peers, such as Symantec and Adobe, rent data center operations for their cloud-based applications from facilities owned and managed by others. Renting provides flexibility while the companies adapt and

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[32] For a summary of the four data center tiers, see the Uptime Institute's "Data Center Site Infrastructure Tier Standard: Topology," 2010, http://uptimeinstitute.com/component/docman/doc_download/5-tiers-standard-topology.

[33] Arif Mohamed, "How to Make a Tier 4 Data Center Energy Efficient," Computer Weekly, February 2010, www.computerweekly.com/feature/How-to-make-a-Tier-4-data-centre-energy-efficient.

expand in a rapidly changing market. Other companies rent data centers for enterprise applications in an effort to increase their efficiency.

The actual square footage that companies rent ranges from very small (such as a single server or part of a server) to very large (for companies using managed facilities to run significant portions of their business). In most cases, the rented space is part of a facility that includes a number of customers, as described above. More and more companies are opting to rent; in fact, most large companies outsource at least part of their data center services.

For companies that have older enterprise assets, outsourcing by renting can present an opportunity to improve their efficiency. One study has shown that migrating locally hosted services to large data centers could reduce energy costs by 87 percent.[34] However, when companies outsource data centers, they inherently lose some control over energy management, since the third party that manages the center traditionally oversees its electricity use and related choices.

CONSTRAINTS

The core constraint to low-carbon power sourcing for companies that rent data center space is that they generally lose direct control over energy management. A result is the split incentives (or principle-agent) problem, where the data center customer does not directly pay for energy use, which means they have a reduced cost incentive to invest in energy efficiency. Indeed, companies that rent data centers can have difficulty obtaining even basic information about a given center's energy use.[35]

OPPORTUNITIES

The split incentives problem mentioned above happens in other sectors of the economy and is addressable. Companies that rent data center space can select partners that already offer low-carbon power options. Another possibility is to structure buyer-supplier agreements in ways that give both parties incentives and offer them recognition for better performance. Use of low-carbon power could be part of the vendor selection criteria, just as it has become part of the site selection criteria. Lastly, customers can educate the marketplace about this issue's importance to their business, thereby encouraging business partners to offer more low-carbon power options.

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[34] Tessel Renzenbrink, "How Much Electricity Does the Internet Use?," Tech the Future, June 13, 2013, www.techthefuture.com/technology/how-much-electricity-does-the-internet-use/.

[35] Based on interview with company member of Future of Internet Power .

Developing a Low-Carbon Power Strategy

Though the constraints and opportunities for different types of data center operators vary, the core approach to sourcing low-carbon power is the same. This section outlines a method for low-carbon power sourcing and identifies questions for companies to consider as they develop their strategy. Important factors include aligning with existing corporate sustainability, energy risk, and economic goals; understanding available options for low-carbon power; and prioritizing public policy and procurement opportunities.

Setting Goals

The first consideration for sourcing low-carbon power is assessing alignment with existing energy sourcing goals and the company's overarching sustainability objectives. This process typically includes conducting peer benchmarking, gaining internal buy-in, and engaging with external stakeholders.

Key questions include:

- What are the economic and reliability benefits of low-carbon energy procurement?
  - What is our future power demand curve?
  - What is the cost volatility of grid prices, historically and into the future?
  - How can we hedge the grid's economic volatility with low-carbon energy resources?
  - How can low-carbon energy resources help provide a reliable flow of energy?
- What are the sustainability benefits of low-carbon energy procurement?
  - What are our sustainability and energy procurement goals, and where does low-carbon power fit in?
  - What policies impact (or may in the future impact) the cost of emitting carbon? What are the impacts or expected impacts?
- What are the costs of low-carbon power procurement?
  - What are the economic costs?
  - What are the reliability concerns (e.g., resource intermittency)?
- What do we "count" as sustainable, low-carbon power?
  - Are we focusing on carbon reduction overall or renewable energy, in particular?
  - Will we emphasize or avoid any specific types of low-carbon power?
- What is the current GHG emissions baseline at our data centers?[36]
- What level of sustainable, low-carbon power would we like to procure?
- How will we measure our progress toward low-carbon power procurement goals?
  - By the amount of GHGs reduced?
  - By the amount of low-carbon power generated or used?

[36] Nonprofit Carbon Monitoring for Action (CARMA) tracks each utility's energy mix, and the EPA provides data on GHG emissions for each grid region via the Emissions and Generation Resource Integrated Database (eGRID).

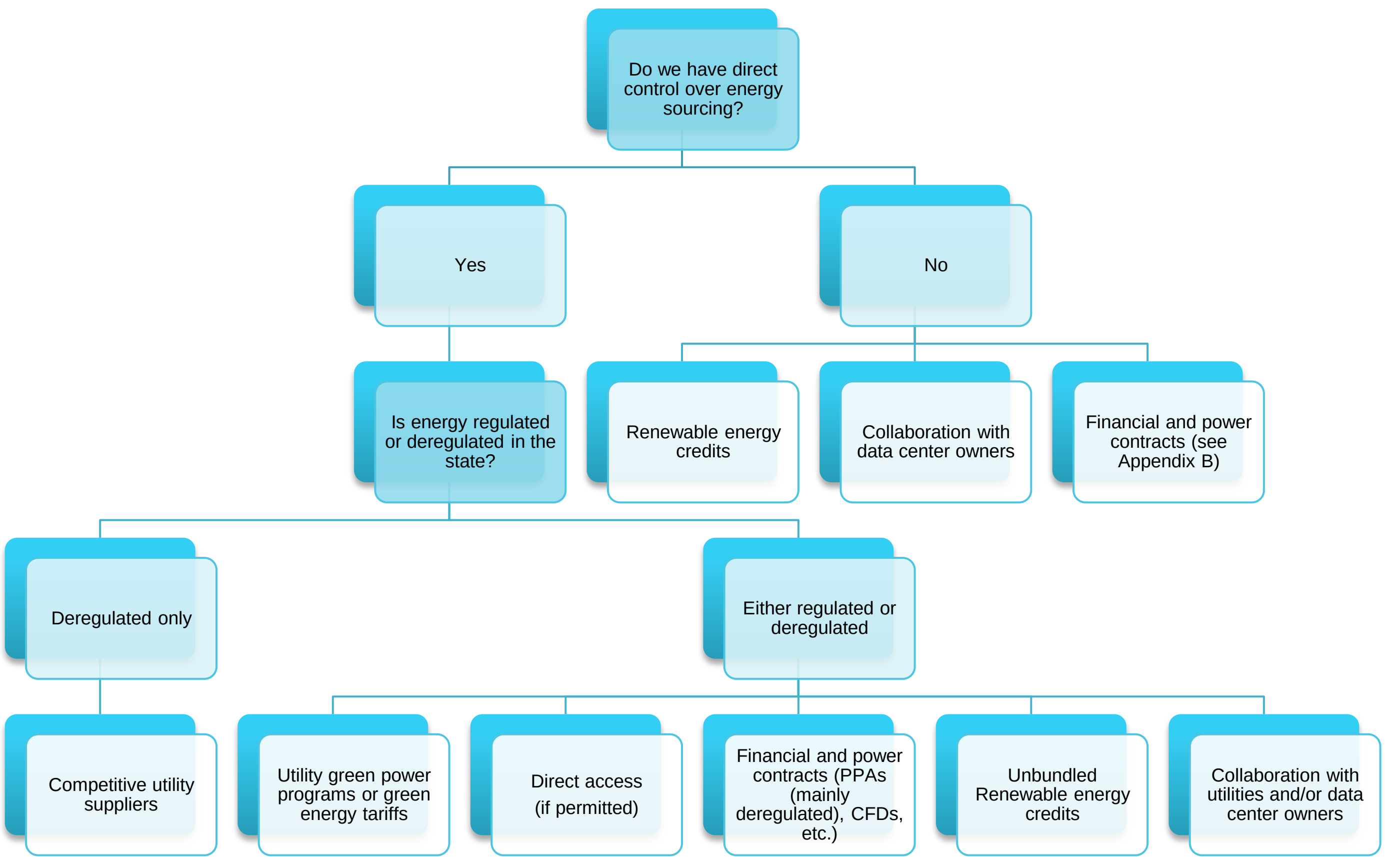
- By the percentage of our total usage that comes from low-carbon sources?

Identifying Options

One of the primary challenges in low-carbon power sourcing is adapting to the significant diversity in state regulations and utility offerings. Though there may be a limited number of low-carbon options in each data center location, a company must confront numerous options when considering its full operating portfolio. In general, these options fall into two categories: *working within the constraints and incentives* of existing regulations and programs, or seeking to *change those constraints and incentives* through utility partnerships and policy advocacy.

Figure 2 outlines a basic decision tree to guide corporate purchasers of renewable energy seeking to operate *within the constraints* of existing offerings. The process identifies two key factors that dictate a company's options: whether the company has direct control over energy procurement and whether the state energy market is regulated or deregulated. (Please refer to Appendix A for an in-depth summary of each low-carbon power sourcing option.)[37]

Figure 2. Decision Tree for Low-Carbon Power Sourcing



[37] This illustrative decision tree focuses on procurement and so does not include on-site renewable energy development.

Prioritizing Opportunities

Companies will benefit from prioritizing the opportunities that produce the largest reductions in GHG emissions and fit within budgetary and logistical constraints. As described above, the five principles can be used to guide low-carbon power sourcing; efforts should be viable, affordable, scalable, additional, and accountable. Table 1 in Appendix A provides more detail on the low-carbon power sourcing options listed above and how they compare across each of these criteria.

Ways Forward

As users of large amounts of power, data center operations have a promising opportunity to develop the marketplace for renewable electricity. Doing so is a natural component of a portfolio approach for energy and sustainability that includes maximizing energy efficiency, sourcing low-carbon power, and working with utilities and policy makers to encourage additional low-carbon power sourcing options.

Though challenges stand in the way of sourcing low-carbon power for data centers, there are also significant opportunities to lower carbon emissions by working closely with utilities, renewable energy developers, and policy makers to ensure a favorable landscape for low-carbon power sourcing. As large energy purchasers, companies with data centers have unique leverage with utilities that less energy-intensive industries do not have.

When developing a low-carbon power sourcing strategy, companies should prioritize the approaches that produce the largest reductions in GHG emissions. These projects should be *additional* (a utility or developer would not have generated the power anyway), *accountable* (conforming to reporting and transparency standards), *scalable* (easily capable of being expanded), and *affordable*.

At the same time, data center operators have a significant amount of leverage with policy makers and utilities. As a result, data centers can benefit from seeking to influence energy policy and expanding the available opportunities for cost-effective and impactful renewable energy procurement. By publicizing their low-carbon power needs and policy perspectives, companies can remove energy procurement barriers for themselves and their peers, enabling significant reductions in GHG emissions across the data center industry and beyond.

Appendix A: Existing Low-Carbon Power Options

This section outlines the available options, both on-site and grid-supplied, for data center companies to take advantage of existing low-carbon power programs.

On-Site or Self-Generated

For energy sources installed on-site, the power source and data center are linked by dedicated wires and may or may not be integrated into the electrical grid. Energy sources that directly supply the power needs of data centers require companies to consider land availability, financing, and ongoing maintenance. Typical on-site sources of low-carbon power are wind turbines, solar panels, and fuel cells; these power sources may be solely dedicated to the data center or may be connected to the grid as well. They can also be owned and managed entirely by the company or owned and/or managed by third parties. Examples of directly supplied energy within the data center sector include eBay's 600-KW solar array at their Utah data center[38] and Microsoft's trial of biogas fuel cells via a reclamation facility in Wyoming.[39]

However, because data centers have limited land and require a large, continuous supply of power, on-site generation typically provides a small portion of a center's energy. Some companies have responded by installing energy sources adjacent to data centers, as Apple did by constructing a 20-MW solar facility on land surrounding its data center in North Carolina,[40] though most technology companies have sought grid-supplied, low-carbon power as their primary method of meeting GHG reduction and clean energy goals.

Grid-Supplied

Often, companies seek to use energy sources linked to the grid because that approach offers significantly more low-carbon power options and an overall greater energy supply. Off-site energy generation allows sourcing from a greater number of options, including solar power, wind energy, landfill gas, combined heat and power, geothermal energy, etc.

When they rely on grid-supplied energy, companies must work with utilities, which manage and distribute energy across the grid. Engagement with utilities takes several forms, ranging from the use of utility-offered procurement programs to the cocreation or adaptation of new approaches for low-carbon power sourcing.

Utilities vary significantly in the types of low-carbon power they offer; some do not offer dedicated programs, while others offer purchasers multiple options. In deregulated markets, companies can choose an energy provider with a lower carbon profile or one that provides greater access to low-carbon offerings. For a full list of existing offerings, please refer to the U.S. DOE's list of green power marketers.

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[38] Lori Duvall, "eBay's Topaz Data Center Gets Even Greener," Green Team Talks, eBay, 2012, http://green.ebay.com/greenteam/blog/eBays-Topaz-Data-Center-Gets-Even-Greener/8508.

[39] James Murray, "Microsoft to Debut Sewage-Powered Data Center," GreenBiz.com, November 26, 2012, www.greenbiz.com/blog/2012/11/26/microsoft-debut-sewage-powered-data-center.

[40] "Apple Owns Biggest Private Solar Power System in US," Fox News, March 22, 2013, www.foxnews.com/tech/2013/03/22/apple-owns-biggest-private-solar-power-system-in-us/.

Four of the most common utility offerings are described below.

- **Green power programs:** More than 860 utilities have some sort of green power or green pricing program, in which customers can purchase green energy (often regular power plus RECs) at a price premium. While these programs offer low-carbon power, they can come at a premium. The DOE has published a list of the top 10 utility green power programs for residential units.
- **Direct access:** Direct access is an optional program through which some utilities allow power users to purchase energy from a power generation source other than the utility itself. The options often include conventional as well as low-carbon power sources, and the program allows large purchasers to identify and procure lower-cost sources of energy than might otherwise be offered by the utility. In many cases, state regulations determine whether buyers have the option of direct access.
- **Shared renewables:** Shared renewable programs, also known as community renewables, allow energy users to pool resources to invest in a new renewable energy project, whose output they are credited for. These projects may or may not be through their local utility. While similar to direct access programs, shared renewables make it easier for smaller energy users to secure renewable energy. Another benefit of these programs is that, by swapping out a conventional energy generation rate for a stably priced renewable one, the customer is able to lock in a stable price for energy over an extended period of time, often as long as 20 years. In these programs, both utilities and third parties can play a significant role in identifying and supporting the development of renewable energy projects. For more information, please see the Interstate Renewable Energy Council's model rules for shared renewable programs.
- **Special tariffs:** Special green energy tariffs offer a way to have a dedicated non-REC offering to large customer classes.[41] These special tariffs can enable utilities to offer low-carbon power while maintaining the same costs for their customer base. Green tariffs are usually designed to be isolated from the rest of the rate base; the utility procures or dedicates specific renewable energy facilities to supply the tariff and passes on those procurement costs to participating customers. Often the tariff is designed to be a fixed price over a longer term and, therefore, provide some protection against price volatility. Typically the relevant public utilities commission (PUC) must approve these tariffs, which adds complexity to their implementation.

  There are usually no financial or stakeholder incentives for a utility to offer special tariffs for individual customers. Tariffs specifically aimed at developing new sources of low-carbon power are starting to be developed; one example is Duke Energy's pilot green tariff in North Carolina.[42] Once it has been approved at the state level, a green tariff offers a straightforward way for energy buyers to support the expansion of low-carbon power.

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[41] Letha Tawney, "Above and Beyond: Green Tariff Design for Traditional Utilities," World Resources Institute, 2014, www.wri.org/sites/default/files/green-tariff-design-final.pdf.

[42] "Duke Energy Carolinas Files Green Source Rider with North Carolina Regulators," Duke Energy, November 15, 2013, www.duke-energy.com/news/releases/2013111501.asp.

In addition to working with utilities and electricity suppliers, companies can also opt to contract directly with energy producers or other intermediaries in order to secure low-carbon power. Options include:

» **Unbundled renewable energy credits:** An REC is a contract for the environmental, social, and other nonpower benefits of renewable electricity generation. An REC can be sold separately from the electricity generated by a renewable source. They are purchased on the open market and so are not dependent on local regulatory requirements. RECs should be certified in order to ensure that the environmental benefits are credible and have not been "double-sold"; Green-e is well-respected and the only certification program in the United States. For the most part, RECs help support existing renewable energy facilities; however, companies that want to help bring new low-carbon power sources online should prioritize the other approaches outlined in this document.

» **Power purchase agreements:** A power purchase agreement (PPA) is a contract between an energy producer and an energy buyer. They can be signed either with an existing or new facility and are allowed only in certain states. The PPA contract lays out how much electricity the supplier has promised to place on the grid and how much the consumer will use from it. A PPA often guarantees an electricity price, in addition to guaranteeing the supply, and in the case of low-carbon power, can also include the transfer of RECs. A PPA can be used to guarantee the market demand for a certain amount of low-carbon power and helps energy project developers secure financing, a key challenge for the developers of new low-carbon power sources.

» **Contract for differences:** A contract for differences (CDF) is a financial agreement that helps share energy price risk between an energy buyer and supplier. The two parties agree upon a contracted energy price and set up a payment scheme to make up the difference between the preset contracted price and the variable market price. A contract for differences is a financial instrument, not an energy purchase, but can be a key part of ensuring long-term price stability as part of low-carbon power sourcing. For additional details, please read this case study about Concordia University in Austin, Texas, which illustrates the key principles.

Figure 3 outlines the most common approaches for increasing the use of low-carbon power for data centers and assesses whether they are additional, accountable, scalable, and affordable. As highlighted above, the approach recommended for a particular company depends on the level of control it has over the energy sourcing, costs, complexity, and GHG impact of each procurement option.

Figure 3. Common Low-Carbon Power Sourcing Options

Option	Available To	Cost	Complexity	Viable?	Affordable?	Additional?	Scalable?	Accountable?	Sources
Renewable energy credits (RECs)	All companies	Always a cost premium	**Low:** Well-developed marketplace and widely available	Yes	Generally not on a large scale	Yes, if REC is bundled; if not, it depends on agreement.	Yes	Depends on agreement	List of REC Marketers (DOE)
Power contracts (PPAs, "Green" PPAs)	All companies	Direct contracting with energy producer enables lower-cost options, as well as long-term fixed prices.	**High:** Requires experience with energy contracts and involves some risk	Depends on agreement	Depends on agreement	Yes, if RECS are not sold	Yes	Yes	Green PPAs (Google)
Financial hedging ("contract for differences")	All companies where legally allowed	Depends, based on difference between strike price and spot market price	**High:** Requires experience with energy contracts and involves some risk	Depends on agreement	Depends on agreement	Depends on agreement	Yes	Depends on agreement	Renewable Energy Hedging (EPA/NextEra)
On-site or self-generated renewables	Owners or lessee of a dedicated data center	Varies, depending on location and technology	**Medium:** Technically complicated, but with a well-developed marketplace	Depends on agreement	Depends on agreement	Yes, if RECs are not sold	Usually not	Yes	Guide to Purchasing Green Power (EPA)
Utility green power programs	Offered by about 25% of utilities	Frequently a cost premium, but increasingly with a stable price hedge benefit	**Low:** Standardized utility program	Usually yes (if available)	Usually yes (if available)	It depends; only a dozen or so programs nationwide directly finance the creation of new projects.	Yes	Yes, generally	List of utility green power programs (DOE)
Competitive suppliers	Owners or lessee of a dedicated data center	Varies, depending on location and technology	**Medium:** Technically complicated, but with a well-developed marketplace	Depends on agreement	Depends on agreement	Depends on agreement	Yes	Yes	

Appendix B: Policies That Promote New Low-Carbon Power Options

Low-carbon power sourcing can be a challenge for companies, given the diversity of state regulations and the lack of scalable, cost-effective programs in some regions. As a result, it is a leadership opportunity—and sometimes a necessity—for companies to work with utilities and policy makers to make more low-carbon sourcing options available.

Companies can support numerous policy options, as described below. In practice, a company's specific policy priorities depend on its operating locations (given significant diversity in state energy regulation), sourcing goals, and appetite for advocacy.[43]

In general, it is helpful to begin sourcing efforts in states that have already shown support for cleaner energy, for example, through renewable portfolio standards or tax incentives. In addition, these states provide a good starting point for companies new to low-carbon power sourcing, as it allows companies to build their capacity and early success stories in low-carbon power sourcing. Once they gain greater familiarity with the complexities of state energy policy, companies should focus their engagement efforts on states that represent their largest energy use.

- **Energy procurement programs:** For utilities without energy procurement programs like direct access or green energy tariffs, companies can work with policy officials to ensure that utilities offer low-carbon power options. This is especially important in regulated environments, where companies have little choice about the energy provider they use. For example, Iowa's bill HF 577 mandates that all electric utilities in the state offer their customers green power options.[44]
- **Incentive programs:** A variety of financial incentives are available for developers of low-carbon power sources; examples include tax incentives, rebates, and low-cost financing. Companies can encourage policy makers to maintain existing incentive programs and to develop new ones. For a database of available incentives, please see the Database of State Incentives for Renewables and Efficiency at www.dsireusa.org.
- **Feed-in tariff:** Policy officials can promote the development of renewable energy by guaranteeing a feed-in tariff, which allows developers to plan the financing of new energy facilities by guaranteeing a specific price per kWh of electricity. In many cases, prices differ depending on the specific renewable energy technology as a means to promote a market for new technologies and allowing them to become cost-competitive with existing energy sources.
- **Integrated resource plans:** An integrated resource plan outlines how a utility will add and retire energy resources in a cost-effective manner while maintaining reliability. Ideally, these plans also include a strategy to decrease carbon emissions and increase clean energy generation over time. Data center operators can encourage utilities, through direct collaboration or via policy advocacy, to develop such plans and include ambitious carbon reduction targets as well as low-carbon procurement options. For more

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[43] This list focuses on the policies of greatest relevance to large commercial energy users, such as data centers. A number of other policies, not listed here, are more relevant for residential and small commercial energy users, such as net metering programs, etc.

[44] "Green Pricing Programs," Center for Climate and Energy Solutions, www.c2es.org/us-states-regions/policy-maps/green-pricing-programs.

information, please see this analysis by the American Clean Skies Foundation.

- **Renewable portfolio standard:** A renewable portfolio standard (RPS) requires energy companies to produce a specified fraction of their electricity from renewable energy sources, which increases the grid's overall percentage of renewable energy, thereby reducing energy users' carbon footprint. As of January 2012, 30 out of 50 U.S. states (60 percent) have an RPS in place. Companies can help reduce the overall GHG emissions of electricity production (which also reduces each energy user's GHG emissions) by supporting strong RPSs.
- **Tax incentives:** Tax incentives, such as the Production Tax Credit (PTC) and Investment Tax Credit (ITC), help improve the financial case for investing in low-carbon power sources by reducing investors' and developers' tax burden, typically proportional to the amount of low-carbon energy produced. The PTC is provided per kWh of energy produced over a set time period, and the ITC is based on a percentage of investment expenditure. Companies can support national and state policy that encourages tax incentives, thereby helping create a more favorable environment for investments in new low-carbon power projects.
- **Grid interconnection:** One constraint for new power projects is the level of difficulty and length of time required for them to be connected to the existing electricity grid. Utility policies regard grid interconnection as important to incentivizing the development of new low-carbon power sources. Because these policies are often overseen by a state regulatory commission, companies could work with utilties and regulatory bodies to ensure that the grid interconnection process is transparent, affordable, and timely.
- **Infrastructure and other utility charges:** Utilities levy a variety of charges on energy users; depending on how they are set up, the charges can make it more difficult for energy users to switch to lower-carbon sources. For example, standby and departing load charges were adopted to prevent the remaining utility customers from bearing a greater portion of fixed costs when some customers leave the utility system to take advantage of alternative sourcing options. Demand charges are fixed fees based on a company's maximum demand, in KW, during a billing period. This charge is based on the premise that commercial customers who require peaks of power from the grid should pay a share of the infrastructure and maintenance costs associated with the capacity to provide that power when needed. Because these charges can affect the cost effectiveness of low-carbon power, companies have an opportunity to work with utilities and policy makers to create cost structures that support new low-carbon power projects.

The most fruitful policy advocacy opportunities are those where companies have notable leverage, such as a planned new facility or a number of existing facilities, there is some utility and/or regulatory openness to new low-carbon power programs, and where a broad, multistakeholder coalition can be developed to support the change.

Interviewees

Individuals from the following organizations were interviewed as part of this research:

» Adobe
» CERES
» David Gardiner & Associates
» eBay
» Equinix
» Facebook
» Greenpeace
» Hewlett-Packard
» National Renewable Energy Laboratory
» Natural Resources Defense Council
» Pacific Gas & Electric
» salesforce.com
» Symantec
» World Resources Institute
» World Wildlife Fund