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The carbon-neutral utility

Building a low-carbon economy through cleaner power

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A trend toward sustainable energy generation

There's little doubt that the push to use sustainable energy sources has gathered substantial momentum over the past five years. Commercial and residential customers of power utilities are increasingly showing a preference for "green" or renewable forms of energy.

IN addition, regulations in a wide variety of jurisdictions are demanding greater energy efficiency in the construction of new buildings, as well as in the generation and consumption of power. For example, the New York State Energy Research and Development Authority has established regulations for energy-efficient products and green residential buildings.[1] The State of California has, through a series of executive orders and senate bills, established a goal that 33 percent of electricity in the state be generated from renewable sources by 2020, increasing to 50 percent by 2030.[2]

At the same time, the development and initial adoption of a number of technologies by consumers, businesses, and utility companies are paving the way for both power consumers—individual customers as well as communities—and power producers—large-scale utilities—to become essentially carbon-neutral. These technologies not only give individual consumers an increasing ability to go "off the grid" with their own renewable energy sources, but also allow commercial consumers and communities to pursue the same goal on a larger scale. Large companies have made commitments to exclusively use green energy,[3] and commercial and government "aggregators" have arisen that offer inexpensive renewable energy to consumers across their local utility's grid. A prime example is Community Choice Aggregators, created by several counties in California, established under state law to provide an alternative to investor-owned utilities.[4]

This rising demand for sustainable energy forces utilities to make an unenviable choice: Either offer green energy as an option for those consumers who want it, or see their revenue base eroded. This choice is particularly stark for utilities that are vertically integrated, have existing generation assets, or whose residential and commercial rates are not fully decoupled.[5]

Both consumers and energy providers could benefit from understanding the technologies and associated economics and business models that are enabling this evolution toward sustainable energy. Consumers and energy providers alike have an interest in learning about technologies and techniques that could help them reduce their carbon footprint. For utilities, moreover, this understanding can help them navigate the potentially difficult decisions involved in "greening" their output, mitigating the risk of seeing demand and revenue cannibalized by distributed generation while offering consumers the choice to purchase energy generated from renewable sources, which many are coming to expect.

This article examines four types of technologies that are being used in sustainable energy generation, as well as their impact on consumer choice and power utilities' potential business models:

- **Energy efficiency technologies,** including smart home technologies, technologies used in smart/energy-neutral buildings, new interior and exterior lighting technologies, and sensor-based consumption
- **Generation technologies**, including renewables, domestic and community microgeneration, micronuclear power generation, and the shift from traditional coal to clean coal or gas generation for baseload

> These technologies not only give individual consumers an increasing ability to go "off the grid" with their own renewable energy sources, but also allow commercial consumers and communities to pursue the same goal on a larger scale.

- **Grid technologies**, which can enable the power grid to operate as an energy exchange that allows consumers to buy and sell energy on an open market; enabling technologies include grid modernization, blockchain for transaction settlement, microgrids, and domestic and grid-level storage
- **Carbon sequestration**, which can be achieved through engineering-based technologies or business/nature partnerships to remove carbon dioxide and other greenhouse gases from the atmosphere

While this article primarily focuses on power utilities, many of the principles discussed below can be applied to gas utilities as well as companies that consume significant amounts of energy.

Carbon neutrality: A working definition

THE concept of carbon neutrality is complex, although Merriam-Webster defines it simply as:

- Having or resulting in no net addition of carbon dioxide to the atmosphere, or
- Counterbalancing the emission of carbon dioxide with carbon offsets[6]

The complexity of this definition lies in defining exactly what constitutes "carbon released." For instance, is it the carbon released in generating electricity, or from customers burning gas? Does it include facilities and fleet carbon emissions? Measurements and claims around the amount of carbon released—and, hence, the practical impact of becoming carbon-neutral—can vary significantly depending on the definition used.

For purposes of this article, we propose to work with two simple definitions of carbon neutrality:

- A power utility is carbon-neutral when the carbon emissions released by the generation of power sold by the utility are zero, or are offset by sustainable carbon sequestration.
- A gas utility is carbon-neutral when the carbon emissions released from the use of the gas sold to customers are offset by sustainable carbon sequestration.

We recognize that these definitions may not satisfy some parties, as they do not include the carbon emissions of suppliers, of a utility's fleet vehicles (although conversion to an electric fleet would, by definition, eliminate these), and so on. Nonetheless, our definitions offer a practical approach to breaking down the issues surrounding carbon neutrality and the potential impacts of new technologies.

Forces driving the market toward carbon neutrality

THERE has been much discussion recently about potential changes to the US federal government's approach to regulation of the energy sector and how that may affect the country's generation mix. Projections show some sensitivity to policy changes, in particular slowing the shift from coal to natural gas. Yet overall projections still show an ever-increasing share of generation capacity shifting to renewables over the next 20 years.[7]

We see this trend toward a lower-carbon electricity grid continuing for three main reasons:

- **Consumer choice.** Both residential and commercial customers are increasingly demanding clean or renewable energy, with large technology companies leading the way. Many of these organizations, especially those with a global presence, are sensitive to the demands of both their customers and countries with a strong commitment to the Paris accord.

- **Economics.** As the price of renewable energy sources continues to fall, they are increasingly becoming competitive with coal even without carbon taxes or other market-adjusting mechanisms. The cost of generation from solar and wind sources in particular has plummeted over the last few years and, even without subsidies, is at the point of being below that of coal for utility-scale generation (as shown in table 1). The trend is even more pronounced when one looks just at

Table 1. Projected levelized cost of electricity ($/MWh) over time by type of supply

Type of supply	2011	2012	2013	2014	2015	2016	2017	2018
Advanced nuclear	119.0	114.0	111.4	108.4	96.1	95.2	99.7	99.1
Coal—carbon capture						144.4	139.5	140.0
Coal—conventional	100.4	95.1	97.7	100.1	95.6	95.1	95.1	95.1
Gas—advanced combined cycle	79.3	62.2	63.1	65.6	64.4	72.6	55.8	56.5
Gas—conventional combined cycle	83.1	65.1	66.1	67.1	66.3	75.2	56.4	57.3
Geothermal	86.4	98.2	89.6	60.8	47.9	47.8	39.5	43.3
Hydroelectric	101.7	88.9	90.3	89.9	84.5	83.5	63.7	66.2
Solar PV	396.1	211.0	152.4	144.3	130.0	125.3	84.7	66.8
Wind (onshore)	149.3	96.1	96.0	86.6	80.3	73.6	50.9	52.2

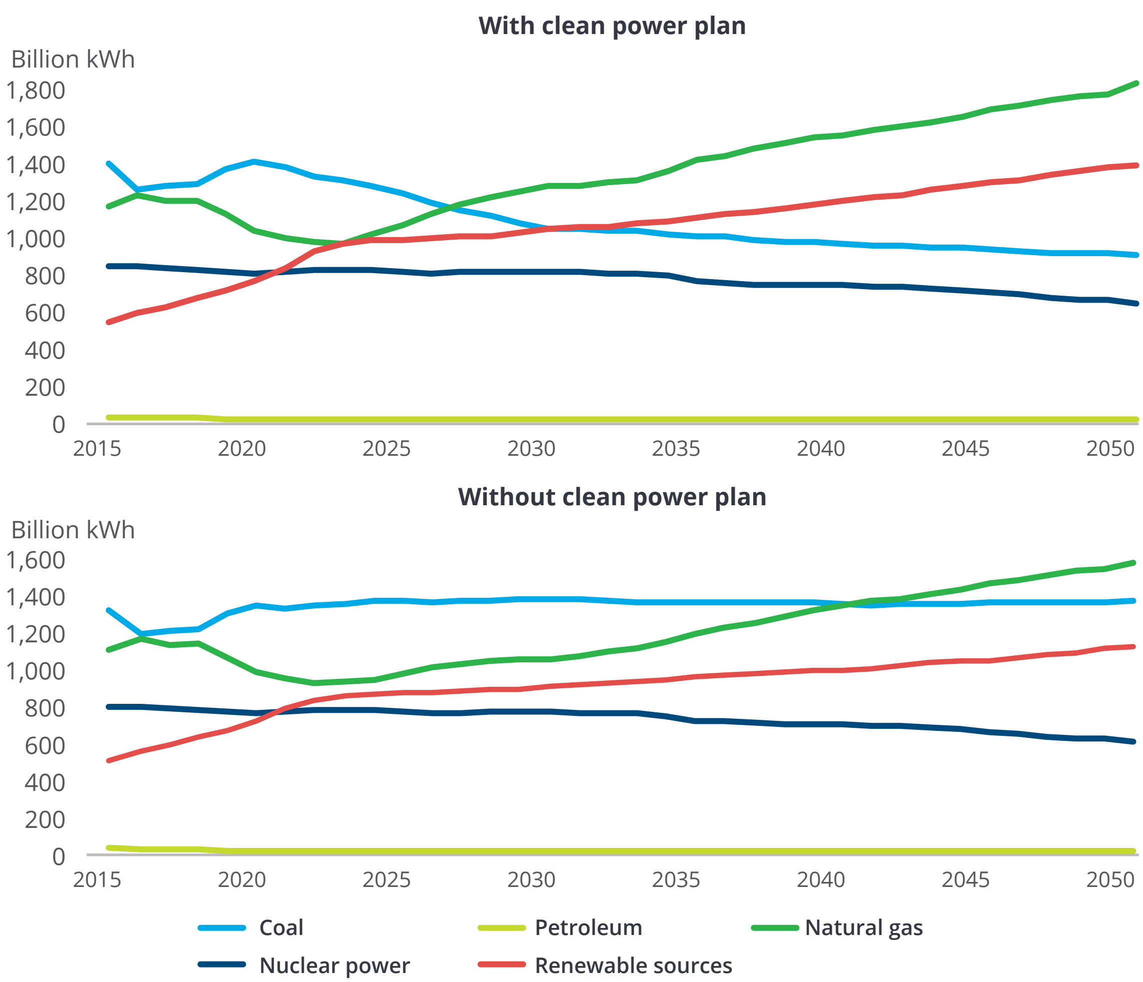
Source: US Energy Information Administration, *Annual Energy Outlook* (for years 2010–2017), https://www.eia.gov/outlooks/aeo/.

the trend in cost for solar/wind versus coal/gas generation (figure 1). Coupled with abundant shale gas and the displacement of coal by combined cycle gas plants in new fossil fuel plants, lower-carbon generation options are becoming the norm.

- **Regulation.** The regulation of utilities in the United States is largely conducted at the state level, and many large markets such as California remain committed to cleaner energy sources. When coupled with the local definition of building codes and energy efficiency standards, these state regulations provide an added impetus to the market mechanisms described above. Internationally, many governments are committed to the Paris Agreement, with 147 of the 195 signatories ratifying it at the time of writing.[8] The agreement reached critical mass in October 2016 and went into effect in November 2016, an event celebrated by lighting the Eiffel Tower and Arc de Triomphe in green.

The current federal administration may not provide an added impetus toward reducing carbon emissions in the United States; however, this may simply not be needed with other forces and players driving the industry toward change.

Figure 1. Actual and projected US net electricity generation, 2015–2050



Source: US Energy Information Administration, *Annual Energy Outlook 2017*, Electricity supply, disposition, prices, and emissions (table), http://bit.ly/2pWfndR, accessed May 17, 2017.

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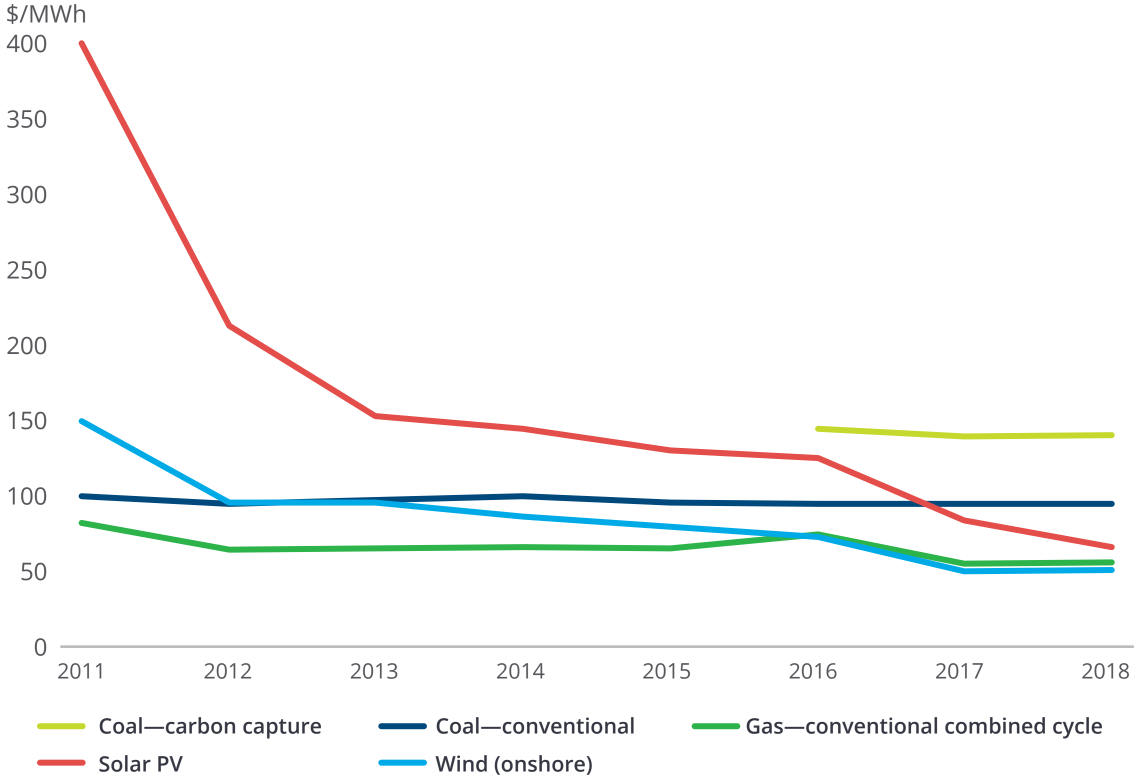
Figure 2. Projected levelized cost ($/MWh) of solar, wind, gas, and coal generation over time



Source: US Energy Information Administration, *Annual Energy Outlook* (for years 2010–2017), https://www.eia.gov-/outlooks/aeo/, accessed May 17, 2017.

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Technology trends enabling carbon neutrality

UTILITIES and their customers are starting to embrace technologies that reduce the carbon footprint of their power use. They do this by reducing their overall energy consumption, by reducing the amount of carbon emitted in the generation of each kilowatt-hour of energy consumed, or by sequestering the carbon produced by power generation. These technologies fall into four broad categories.

Energy efficiency

Energy efficiency, a term that may also include demand-side management (DSM), is a broad category of approaches and technologies, which seeks to reduce the overall consumption of energy at a community, business, or residence. Consumers may adopt these technologies and approaches at their own homes or facilities, while utilities may seek new business models to promote, finance, or deliver them to customers within or outside their core service territory.

Energy efficiency approaches range from the decidedly low-tech to up-to-the-minute technological tools. Research and development of these technologies are being carried out by private companies, universities, and government departments. Some of these technologies may sound familiar, but new materials science discoveries and the use of sensors and other connected, Internet of Things technologies are taking many to a new level.

- **Insulation.** Wall, roof, window, door, pipe, and heating, ventilation, and air-conditioning (HVAC) ductwork insulation are all intended to prevent heat or cold loss from building walls, windows, doors, and roofs, or from the systems delivering hot and cold water and air before they reach their point of use. We are all familiar with fiberglass home insulation and hot water heater blankets, and ductwork and water pipe insulation has been available for years, though it is rarely fully deployed. Most recently, the industry has been applying new materials science to develop foams and other insulators that can be applied in hard-to-reach places or where traditional insulation is too bulky to be effectively deployed.[9]
- **Lighting.** The adoption of compact fluorescent lights (CFL) and light-emitting diode (LED) lighting systems has significantly reduced the amount of energy consumed for lighting in both residential and commercial settings. In a residential setting, used for approximately three hours a day, each such light bulb saves between $4.90 (CFL) and $5.30 (LED) a year. This yields payback periods as short as 11 months (CFL) to 1.5 years (LED) in a residential setting, and that can be far shorter in commercial applications.[10] In the next generation of lighting, with each light bulb equipped with its own sensor to adjust usage for natural light levels and occupancy, these effects can be multiplied. It is estimated that approximately 10 percent of residential energy consumption is for lighting; the widespread adoption of new lighting technologies could reduce this to 5 percent.[11]
- **Heat pumps.** A new generation of ultraefficient heat pumps allows heat and cold to be moved to where they are needed in commercial and residential buildings, reducing the need to use energy to heat and cool. These pumps can also be a very effective way to import or expel heat or cold at different times of day.

- **Appliances.** The world of household appliances has made significant incremental advances over the last 60 years. We are now poised to make some breakthrough changes—for instance, high-efficiency heat pumps for clothes dryers and new technologies that use magnetic cooling and water-based coolants to greatly reduce the energy consumption of refrigeration. A review of standards and regulations may also greatly reduce energy consumption in commercial applications. In particular, a review of the standards and temperatures used by the food industry could yield enormous energy savings around the world.

- **HVAC systems.** Many commercial and residential HVAC systems have two settings: on or off. This can create tremendous inefficiency as spaces are overheated and then cooled, and vice versa. Through the use of sensors and software that regulate the number of heating or cooling elements, an HVAC system can be fine-tuned to redistribute heat or cold throughout buildings at a fraction of the energy consumption of traditional heating and cooling systems.

- **Building orientation.** Used extensively in hot climates for new construction, this involves positioning new buildings so that the short side of the building is oriented to the sun, thereby reducing solar heating and cooling costs. The reverse is true in high latitudes, where buildings can be oriented to maximize their solar heating during the day.

- **Smart windows.** Smart windows are an extension of the technology used to electronically shade the windows on new airliners, reducing their weight and fuel consumption. Utilizing sen-sors and microprocessors, these adjust their shading to maximize the impact of natural lighting and heating when required, and minimize the level of solar gain under hot conditions. By using microprocessors and sensors, the same window units can be used to help regulate the energy consumption of buildings in hot, cold, or mixed climates.

- **Sensors.** In our ever-more-interconnected world, sensors are embedded in many of the technologies already described. By gauging temperature, humidity, light level, and other variables, environmental control systems can adjust to optimize occupants' comfort and energy usage. Smart thermostats that adjust heating and cooling to a building's daily occupancy rhythms, and allow a home or business owner to adjust heat and light levels remotely, can also drive significant savings. Many tenants in new office buildings "hotel" workers to save floor space, and would be able to confirm and colocate teams to optimize their heated, cooled, or lit areas' footprint. Coupled with intelligent apps that allow employees to customize their temperature and lighting needs, these systems can improve both energy efficiency and the occupants' comfort levels.

- **Reflective roofing.** New types of roofing materials are becoming available, which both insulate the interior and reflect heat away to reduce cooling costs.

Put together in a new building, these technologies can have radical impacts on an organization's energy consumption, and they are rapidly improving. For instance, Deloitte's Amsterdam office (called The Edge) incorporates many energy efficiency technologies and techniques, and, at the time of its opening in 2015, was declared the greenest, most intelligent building in the world.[12] It is now, in 2017, already being surpassed.

Consumers have a wide variety of options to reduce their energy consumption, and regulators are progressively enforcing the adoption of these technologies. For utilities, energy efficiency is the unseen threat, eroding revenue one kilowatt-hour at a time without the focused impact that, say, an aggregator would have. On the flip side, an opportunity for utilities can be to adopt new business models that support and create revenue from energy efficiency: by providing energy audits, for example, and/or by installing, leasing, or financing energy efficiency products.

SEATTLE CITY LIGHT: CARBON-NEUTRAL SINCE 2005

Seattle City Light is a municipally owned utility that provides electricity to approximately 423,000 customers in the metropolitan Seattle area. Its commitment to decarbonization started in 2005, when an Earth Day mayoral resolution set the goal for the utility to become carbon-neutral. This resolution was followed by and enacted through a series of city council resolutions over the following two years. The driving force behind this effort was both a local culture that values environmental sustainability, and the realization that the city relies on snowpack to provide cheap, plentiful hydroelectric power. The utility has been carbon-neutral since 2005, a unique achievement in North America.

The utility's first step toward carbon neutrality was to track all energy purchases and prepare a greenhouse gas inventory, which was then independently audited by the Climate Registry, a nonprofit greenhouse gas reporting organization governed by a number of US states and Canadian provinces. This inventory is now an annual activity, and includes calculating emissions from Seattle City Light's fleet of vehicles, buildings, power generation, purchases for its retail sales, and any other business activity consuming energy.

After divesting its fossil fuel-generating capacity in 2005, Seattle City Light was able to focus on its hydroelectric facilities, something enabled by the local geography. An aggressive energy efficiency program to reduce consumption—for example, by installing LED street lights and helping residential customers with energy audits and efficiency measures—is in place. This efficiency program, which has been in effect for 40 years, is supplemented by some small-scale and community solar power generation (not particularly enabled by the local climate), which also helps reduce overall demand.

Seattle City Light can fulfill most of the area's energy demand through its own generation fleet. Some power is purchased from Bonneville and a smaller percentage from other sources; these purchases include a mix of nuclear, hydroelectric, renewable, and fossil-generated power. The emissions from these purchases are calculated using regional mix standards from the EPA, and a final volume of emissions is then calculated.

Seattle City Light's total greenhouse gas emissions are typically between 100,000 and 300,000 metric tons per year. The utility offsets these emissions each year by purchasing offsets from a variety of certified sources.

Through this journey, Seattle City Light learned that the first step to decarbonization is to identify and quantify an organization's emissions. This allows leaders to target and reduce them until they can be offset in an economic fashion.

Generation technologies

Many generation technologies have been developed, have become economically viable, or have become miniaturized to the point of offering utilities the option to install them on a small, localized scale. In some cases, the cost and footprint of installing generation technologies have become sufficiently low for individual homeowners or businesses to install them. As noted above, projections for generating capacity show an increasing shift to natural gas and renewables. In addition, most projections only assess utility-scale facilities and ignore the generation capacity provided by microgeneration.

- **Gas generation.** Perhaps the largest-impact development for traditional utilities in recent years has been the availability of shale gas from formations such as Marcellus and Utica. With hundreds of years of estimated reserves and the cost of extraction continuing to fall, the replacement of aging coal-baseload generation with combined cycle gas plants has become commonplace. Natural gas is a more efficient form of fuel than coal, with carbon emissions of 0.98 lbs. carbon dioxide per kilowatt-hour as opposed to 2.11–2.31 lbs. carbon dioxide per kilowatt-hour for different types of coal and plant-based fuels.[13] Combined cycle gas plants also have the advantage of cycling more rapidly than coal plants, enabling them to adjust to the variable demand created by the ephemeral nature of renewable sources.

- **Micronuclear generation.** Nuclear energy, with zero carbon emissions, is very attractive from the perspective of reducing carbon emissions. However, the high cost of construction and public concerns following the Fukushima disaster have effectively eliminated the new deployment of nuclear power plants in many nations. That said, a new generation of micronuclear plants, leveraging a variety of technologies from the slow decay of spent reactor fuel to configurations similar to those used in nuclear naval vessels today, may be on the horizon.[14] The ability to use emissions-free, low-impact, and low-risk nuclear generation for microgrids, campuses, or industrial facilities has the potential to reduce emissions significantly.

- **Wind.** As noted above, the cost per kilowatt-hour of wind-generated electricity has dropped significantly over the last 10 years, to the point of being competitive with coal. Perhaps as important for the future has been the growth in small wind turbine capacity,[15] as these have become both more efficient and less expensive to buy and install. With an average home needing a 2–10 kilowatt turbine, the cost typically runs between $3,000 and $8,000 per kilowatt-hour, and leasing options are available.[16] In areas of easily accessed 12- to 14-mile-per-hour winds, such a turbine can be a viable option for homeowners to significantly reduce their reliance on the grid and their overall energy footprint.

- **Hydro.** Hydroelectric power continues to be a cheap, plentiful source of renewable energy, as long as one has the terrain for a dam or hydro-diversion facility.

- **Geothermal.** At its simplest, geothermal heating technologies have not changed: Drill a well in a geologically active region, pump water in, take steam out, and generate electricity. Newer technologies use improved heat pumps and buried pipe networks to both heat a home or business in winter and cool the same space during summer using the difference between surface temperatures and those a few feet below the surface, which remain at a fairly constant 45–75°F year-round, depending on latitude.[17]

- **Solar.** Like wind, solar power systems continue to drop in cost and improve in efficiency beyond the traditional black photovoltaic panels on roofs. The use of community solar power generators, where individual companies or homeowners can buy into solar farms without having the panels installed on their property, provides another option for adopting solar. A variety of solar technologies allows generation to be embedded into the fabric of a building without the aesthetic or space considerations of traditional panels:

  - **Roof tiles and slates.** The latest solar panels are not the traditional large, ugly black panels that we often think of when we imagine photovoltaic cells. These can be sized, shaped, and in some cases colored to follow the contours and architecture of traditional buildings. They can blend into the background and make the deployment of large-scale solar power more aesthetically pleasing, to the point that, for new construction, power generation can literally be built into the woodwork.

  - **Windows.** Photovoltaic films for high-rise office buildings are now available, and their efficiency and cost are making them an attractive option for high-rise office buildings to use to generate a significant portion of their energy use. When coupled with rooftop wind power, some large buildings can become a self-sustaining microgrid in their own right.

  - **Paint.** The next generation of exterior paints will likely have the capability to turn any paintable surface with suitable sun exposure into a generation asset. While the paint's generation capacity is currently low, the potential surface area that residential and commercial buildings could leverage is enormous.

When coupled with storage solutions, examined in more depth in the next section, these generation technologies could allow businesses or homeowners to generate and store a significant percentage of their own power consumption. For utilities, the installation, capital funding, leasing, or maintenance of these systems can all provide opportunities to create new businesses and business models.

Grid technologies

For all of these technologies to work together, power grids must be transformed. Instead of a mechanism for unidirectional energy transfer from large generating stations to consumers, the grid needs to evolve into a multidirectional digital energy exchange. To enable load balancing, which would require complete, exact information about what is happening at any point in time, a grid would need to generate, store, and evaluate a vast amount of data, and it would depend on a wide variety of devices in the field to manage the operational activities and financial effects of this dynamic interchange.

- **Microgrids.** Microgrids are small, typically self-contained grids that may serve a business or industrial campus, a neighborhood of resi-

MASDAR CITY: THE VALUE OF AN INTEGRATED APPROACH

Masdar City broke ground in 2008 with the goal of providing a high quality of life with a low environmental footprint. Located in Abu Dhabi, the city is designed around a clean-tech cluster, with a graduate school at the center surrounded by tenant companies focused on clean technology. In addition to its goal of using 100 percent renewable energy, Masdar City is a fossil-free zone seeking to achieve zero waste and zero emissions. According to a recent conversation with Khaled Awad, Masdar City's former director of property development, the keys to developing programs like this are demand management and the recognition that carbon neutrality has to be part of an integrated macroeconomic strategy.

When asked about the lessons the Masdar City experience could provide for designing a carbon-neutrality program, Awad was clear: "Demand management rather than just economically optimized supply." The challenge for utility executives, therefore, is to understand how to monetize demand management and energy efficiency measures to offset revenue losses from them. Another important enabler for Masdar City is its multi-utility approach, where water, trash, and power reduction targets are pursued together by a single provider. This integration is easier to achieve where utilities are provided by a public entity than where they are distributed across several investor-owned organizations. Vertically integrated utilities, especially investor-owned utilities, may find it more challenging to develop integrated approaches with other utilities and government agencies to spur economic development and demand management sales opportunities.

Despite the challenges, seeking a way to overcome them may be worth considering, especially for municipal utilities for whom financing a carbon-neutral approach may be as much of a challenge as anything else. By forging a series of integrated partnerships across government agencies and vendors, Masdar City was able to attract investment because of investor interest in waste management, water reduction, transportation efficiency, urban agriculture, and other integrated smart city solutions.

Awad went on to assert that a carbon-neutral strategy would likely be challenging if narrowly defined because it is difficult to achieve a positive internal rate of return or net present value. He recommends positioning carbon neutrality as part of a broader economic development plan where macroeconomic benefits are pursued collectively, "In simple terms, it is difficult for anyone to demonstrate financial value in carbon-neutral endeavors, especially when the oil price is $55. My recommendation is for utilities not to start a carbon-neutral initiative independently from other infrastructure elements. The silo principle that governs how cities are managed today will simply fail, financially and otherwise, in a carbon-neutral project."

dential dwellings, or other facilities. Their generation capability can usually meet minimum nonpeak demand. Rather than being wholly self-contained, a microgrid may be connected to the local utility grid to supply or draw power at times of unusual levels of generation or demand.

- **Smart meters.** Smart meters are the workhorses of the digital grid, recording the two-way flows of energy to and from the grid at any point of consumption or generation. As a result, they are the brokers that enable every grid user to take energy from or supply energy to the grid, and that can allow microgrids to manage both themselves and their draw on or supply to the broader utility grid.

- **Blockchain.** If smart meters are workhorses of the grid, blockchain could be the financial language that allows hundreds of thousands or millions of households to buy and sell electricity to each other and the utility or grid operator safely and securely. By providing an independently verified trusted ledger to record each smart meter's transactions, blockchain can allow the financial impacts of millions of hourly grid activities to be settled fairly and honestly. This capability is being pioneered in the insurance industry today,[18] with trial peer-to-peer insurance markets recreating Lloyd's Coffee House for the digital age.

- **DSM.** DSM enables a grid operator to switch devices around the grid on and off at times of peak or low demand, thus allowing for improved load balancing. This can improve grid resilience and help even out the sometimes unequally distributed, transitory nature of renewable energy sources.

- **Storage.** Storage, like DSM, is a tool to manage fluctuations in load due to changes in supply and demand. While most press coverage focuses on residential storage solutions, utilities are experimenting with substation and grid-level battery storage. These are becoming transformational technologies in their own right due to their potential to provide flexible resilience for the utility or microgrid as a whole.

Together, these grid technologies can give a utility the opportunity to manage its existing grid as a physical energy exchange. It could create business models based on enabling other parties to buy and sell energy through the utility's asset, deriving value by facilitating that exchange. For consumers, these systems can create the option to buy and sell energy when they have excess supply or demand.

Carbon sequestration

This year, the first "clean coal" plant came online at Petra Nova, not far from Houston. Another, the Kemper plant in Mississippi, comes online later in 2017[19] (although recent press reports have questioned the economic viability of this and plants like it).[20] At both plants, the carbon captured is piped to nearby oilfields and pumped into the reservoir to enhance oil recovery. These plants represent a significant step forward in carbon sequestration approaches, and offer a way for coal to continue to be a generation fuel in a "greener" age.

Constraints do exist for "clean" coal plant operation. The need for a suitable nearby geologic formation to act as the carbon store can limit the geographical range of such plants. Another limiting factor can be their high cost. Clean coal plants may be two to three times as expensive per megawatt-hour produced as a combined cycle gas plant (see table 1), and they can require ongoing operational costs that make them more expensive compared to their natural gas or renewable competitors.

An alternative method for carbon sequestration has, however, been available for considerably longer. Trees are quite efficient at taking carbon dioxide from the atmosphere and storing it in solid form. Accordingly, many afforestation and reforestation programs are being conducted by governments, nongovernmental organizations (NGOs), corporations, and private citizens. The largest programs have grabbed headlines, with India's proposed $6.2 billion program to reforest 12 percent of the country being the largest effort to date. As the world's third-largest greenhouse gas emitter, India plans to meet its 2030 goal of a 35 percent reduction from 2005 emission levels by sequestering 2.5 to 3 billion tons of carbon dioxide through reforestation.[21]

Smaller-scale programs can also have a large net impact. For instance, various programs, such as Philadelphia's TreePhilly initiative, seek to add urban tree canopy coverage.[22] This reduces a city's energy footprint by lowering temperatures and cooling costs while simultaneously sequestering up to 48 lbs. of carbon per tree per year.

By partnering with local or international governments, and/or NGOs, utilities can create programs to offset, sequester, or otherwise bring to zero their net carbon emissions when coupled with the deployment of the technologies described above. These programs can be executed on a small, local scale, or by supporting larger-scale initiatives such as rainforest restoration.

BHUTAN: MAKING THE MOST OF NATURAL RESOURCES

Bhutan is a landlocked mountain kingdom in the Himalayas. It competes with another place for the title of the "happiest place on Earth," being most famous for measuring Gross National Happiness and cherishing this measure of economic growth above the more conventional Gross Domestic Product (GDP). Despite this, at $2,836,[23] Bhutan has one of the highest GDPs per capita in Asia, outpacing its neighbors in India, China, and Nepal.

Bhutan is committed to carbon neutrality as a country, with a constitutional requirement that 60 percent of its land be retained as forest. A series of targets and measures have been established as part of the Gross National Happiness program, which is founded on four pillars:

- Equitable and equal socioeconomic development
- Preservation and promotion of cultural and spiritual heritage
- Conservation of the environment
- Good governance practices, which are interwoven, complementary, and consistent

Each is designed to reduce poverty, promote equality, and ensure that economic development comes without unacceptable environmental impacts.

GDP has grown rapidly in recent years with the expansion of the tourism and service industries, as well as some construction and industrialization. A major driver for this growth has been Bhutan's hydroelectric power industry. Four major run-of-the-river generation schemes were developed in the 1960s that produce a power surplus through the wetter months of the year, which is exported to power-hungry India. Small hydroelectric schemes provide the local power supply for more remote areas, and these are increasingly supplemented by renewables in the form of small-scale solar and wind.

In the dry summer months, power is imported from fossil fuel plants, predominantly coal, in India. Bhutan also imports hydrocarbons for transportation and cooking gas, there being no natural oil or gas resources in the country. These are more than offset by the nation's sustainable forestry practices such that Bhutan is not just carbon-neutral, but carbon-negative, the only country on Earth that sequesters more carbon dioxide than it produces.

The implementation of energy efficiency measures, local generation from renewables, and carbon offsets from sustainable forestry all contribute to the effort to ensure that as Bhutan's demand for energy grows, its carbon footprint does not. As with Seattle City Light, the combination of available hydroelectric sources and a commitment to energy efficiency, new renewable energy sources, and sustainable carbon offsets is the key to carbon neutrality.

Challenges for utilities

UTILITIES may face a number of challenges that they will need to overcome or bypass in order to reduce their carbon footprint.

- **Existing generation fleet.** Retiring a coal or other fossil fuel plant before it has finished its planned life could remove that asset from the rate base or have other cost or revenue impacts. This makes early retirement an unlikely scenario. Hence, utilities should plan decarbonization as a journey and not as an event.
- **Long-term fuel contracts.** In some cases, a long-term contract may commit either a utility or a business to a particular source of power. Similar to working with an existing fossil fuel fleet, addressing such contracts requires a long-term transition plan.
- **Geography.** Some regions are simply more suited to renewables or a reduced carbon footprint than others. Iceland has an abundant supply of hydrothermal power, Rajasthan has more than 325 days of sunshine per year and is ideal for utility-scale solar,[24] Bhutan, plentiful hydro-diversion potential, and Pennsylvania, abundant shale gas. Geography can be destiny in terms of what is possible today, or with new infrastructure tomorrow.
- **Regulators/investors.** In some cases, owners, regulators, or investors may be wedded to a particular fuel source for historical or local economic reasons.

What should I do now?

Whether you are a significant energy consumer or a utility, here are some steps that you should consider now to position yourself for the new low-carbon economy:

- **Drive from the top.** Without a C-suite mandate, any initiative quickly loses focus and fails to deliver. If you are serious about decarbonization, then the effort deserves leadership attention.
- **Understand your energy consumption.** Through sensors and data collection, figure out what and how energy is consumed in your network. In understanding consumption, also understand the associated costs and how these are likely to change under a new model.
- **Revamp and renew energy efficiency programs.** Finding the right ecosystem of providers to take advantage of the latest energy efficiency breakthroughs is critical.
- **Determine your role in microgeneration.** As a business or homeowner, do you install generation technologies? As a utility, are you the organization installing, leasing, or owning the equipment; working with an ecosystem of partners; or acting as a grid operator to allow residences and businesses to buy and sell energy through you? Each role has a fundamentally different business model, as well as different potential regulatory implications.
- **Place some bets.** Explore the technologies that make the most sense for your situation, both economically and politically. Experiment, learn from success and failure, refine your approach, and experiment again.
- **Raise the issue with your regulator.** Investor-owned utilities should discuss this topic and its likely impact on rate structures and models with their regulators. They should start gauging the level of support for decarbonization and its regulatory impact now in order to be able to deploy technologies as they develop.
- **Set goals and ruthlessly manage to them.**
- **Repeat.**

In closing, economics and consumer demand are driving forward the trend toward decarbonization. While these pressures may not apply equally in every country or geographic region, the economic forces in play make the pursuit of decarbonization a likely global trend for the foreseeable future. As renewables become increasingly cheaper, the grid more flexible and resilient, and gas the fossil fuel of choice, the goal of carbon neutrality is becoming achievable. While our case studies suggest that decarbonization can be achieved rapidly in some circumstances, the cost and timeline of achieving this goal vary greatly according to a utility's or consumer's regulatory environment, geography, and existing generation fleet. Hence, each utility and energy consumer must develop its own unique plan for implementation. By understanding your consumption and energy market now, you can better position your organization for success in the new low-carbon marketplace.

The economic forces in play make the pursuit of decarbonization a likely global trend for the foreseeable future.

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