Building Our New Energy Future

What **Buildings Professionals** Need to Know about Changes Coming to the **Electricity Sector**

The Electrical Grid Today

The 20th-century electrical grid has served us well, but times are changing. As the grid's number one customer, the buildings sector has a critical role in these changes.

Changes to the Electrical Grid

Policies and new technologies are straining the outdated grid model. Buildings professionals can help lead the transition to a new 21st-century model for the electricity sector.

The Smart Grid

With a smart grid, buildings are transformed from the 20th-century model of passive loads on the grid to 21st-century dynamic partners in the electricity sector.

ASHRAE®

Shaping Tomorrow's Built Environment Today

Acknowledgments

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Message from Sheila Hayter, 2018 - 2019 ASHRAE President

If you are a buildings professional, it is highly likely you will experience significant changes in your professional practice during your career. That's because a rapid evolution is underway in the electricity sector that will also have a significant impact on the buildings sector. The result of this evolution is our new energy future. That new future is not far away. As a critical organization for buildings professionals, ASHRAE and its members must take an active role in the ongoing changes that will create this new energy future.

The American Institute of Architects (AIA) and the National Institute of Building Sciences (NIBS) made critical contributions to this publication. ASHRAE, AIA, and NIBS, encourage all buildings professionals to take three important steps toward the future:

Become aware. Read this document. Explore the resources within it. Put these issues on your radar now. Sign up for newsletters and read blogs about the topics discussed in this document, such as distributed energy resources (DERs), electric vehicles and buildings, Internet of Things (IoT), smart grid and buildings, the future of utilities, and high-performance building design, or whichever topic suits you. Find conferences to attend. Commit to continuous learning.

Get engaged. Get involved in ongoing conversations in the buildings sector. Find and join working groups and committees dedicated to designing, constructing, and operating smart, grid-responsive buildings. Join groups and committees committed to an evolution in buildings that are ready for more DERs, IoT, and the smart grid while ensuring essential occupant satisfaction and wellness. Start talking to your clients. Help them become aware. Help them plan for the future.

Participate in local, state, and regional activities. You can provide expertise to discussions with other stakeholders, such as utilities and the tech industry. Find ways to get involved in regulatory, policy, and code discussions that will affect our new energy future.

Start now. Our new energy future is happening right now. ASHRAE, AIA, and NIBS are supporting you as a leader in the buildings industry. If you're working on a new building or a major renovation, incorporate this knowledge into the design as much as possible.

Our new energy future is full of opportunities and challenges. Your expertise is invaluable to seizing those opportunities and addressing the challenges, especially as advocates for a built environment that serves humanity and promotes a sustainable world.

DID YOU KNOW?

Here are some "big picture" facts behind changes coming to the electricity sector.

Population Growth

9.7 Billon 2050

- 9.7 billion world population by 2050
- 66% expected to live in cities
- Compare to 7.2 billion and 53% in cities in 2014

5.8 Million

Increasing urbanization will result in construction of a city about the size of Singapore (5.8 million) each month until 2050

Increasing Demands for Electricity

85%

85% of world population has access to electricity now

15% of world population without electricity wants it

60%–70%+

Buildings use 60% of electricity worldwide

Buildings in the developed world use more than 70% of electricity

33% 2040

By 2040, 33% of all vehicles are projected to be electric

Burning Coal for Electricity

40%

40% of world electricity comes from burning coal

Future use of coal expected to remain flat

CO_2 70%

Coal contributes 70% of the carbon dioxide (CO_2) emissions from electricity generation

Coal contributes other emissions that are harmful to the environment and human health

Renewable Energy and Electrical Storage on the Rise

Renewables (biomass, hydropower, geothermal, wind, and solar) are the world's fastest-growing energy source

Battery technology is improving, and economies of scale are contributing to a downward trend in cost

Sources: The World Bank, United Nations Department of Economic and Social Affairs, United Nations Environment Programme, U.S. Environmental Protection Agency, Bloomberg New Energy Finance, World Energy Council, U.S. Energy Information Administration

Preparing for Our New Energy Future

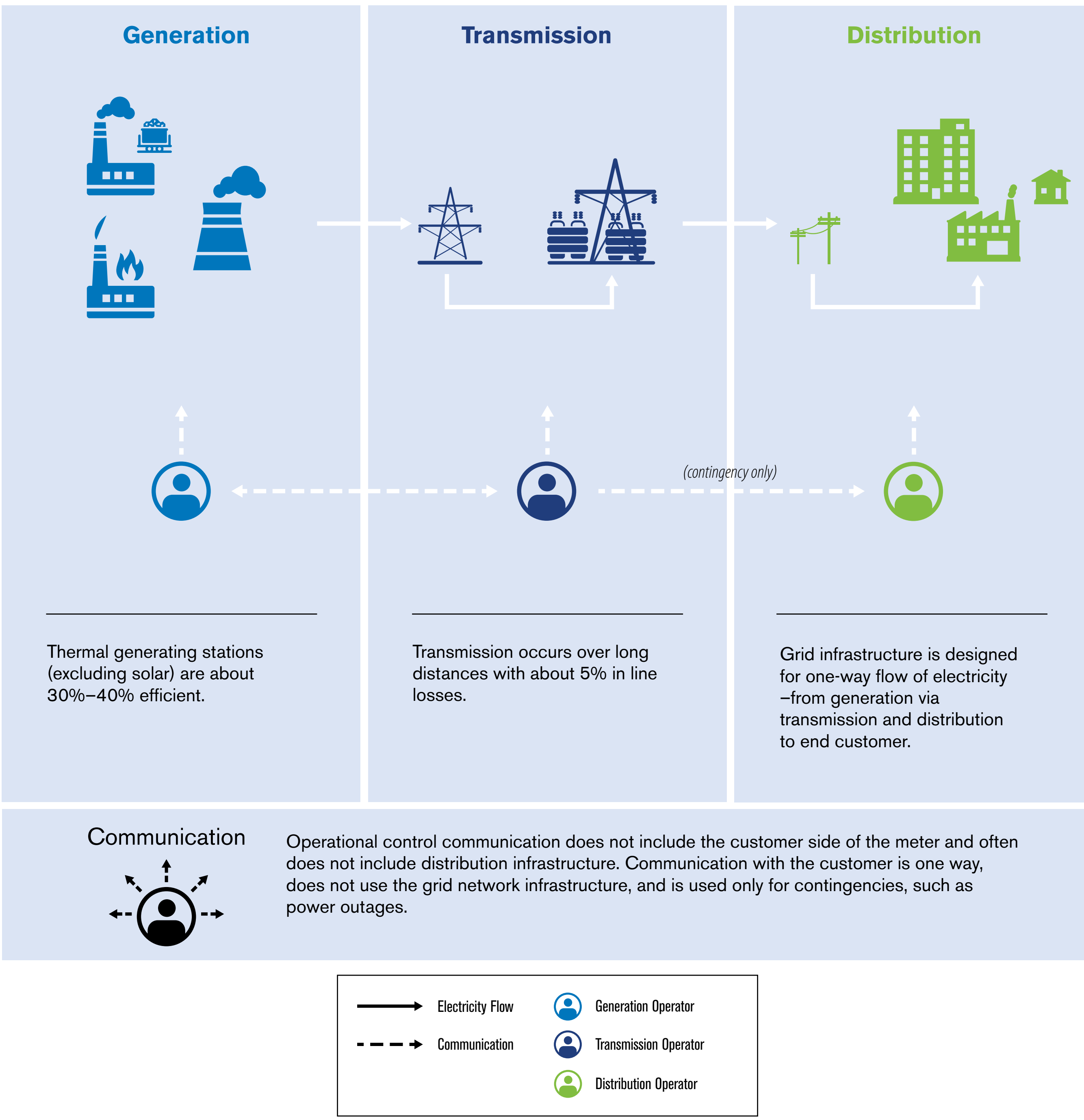
Since electric lights first appeared in buildings, the electrical grid and buildings have had an important relationship. To date, that relationship has largely been one-sided—the grid provides electricity, and buildings are passive consumers. However, new technologies and efforts to reduce energy costs and the environmental impacts of electricity generated from fossil fuel are rapidly transforming how buildings interact with the electrical grid. Additional drivers in this transformation include technological advancements and falling prices in renewable energy technology, batteries, sensors and controls, remote access technologies, and building management systems.

This document is intended to explain the issues and terminology, as well as the challenges and opportunities, associated with changes underway in the electricity sector that affect buildings professionals.

THE ELECTRICAL GRID TODAY

> ***The supreme engineering achievement of the 20th century***
>
> – National Academy of Engineering

The current electrical grid model has served those with access to electricity very well for a long time, in some areas for more than 100 years. Although that model is changing, it is important to understand the mechanisms that got us to where we are today. The provision of electricity generally relies on three key components: generation, transmission, and distribution. Traditionally, utilities generate or buy electricity generated in large-scale bulk quantities from centralized power plants located remotely from end consumers, the majority of which are commercial and residential buildings. Traditional generation comes mostly from thermal plants (fossil fuel, nuclear, and geothermal) and hydroelectric projects. Wind and solar technologies, including solar thermal and electric, contribute a small but growing percentage of generation.



NREL

> **Designing, constructing, and operating a building that anticipates potential electricity fee structures without grid communication can lead to unnecessary occupant discomfort and an increase in emissions.**

Thermal power plants (excluding solar thermal) are only about 30%–40% efficient and are significant contributors to carbon and pollutant emissions. Generation assets are characterized by base load and peak generation. Base load assets are those that cannot be easily stopped and started (e.g., coal, hydroelectric, and nuclear). Peak generation assets provide shorter-term, variable generation capacity above the base load to meet peak demand. Peak demand is a time period (e.g., time of day or time of year) during which consumer demand for electricity is strongest, or at its "peak." A decision about which peak generation asset to deploy is generally based on cost, although, more recently, it is also being prioritized based on environmental impact.

After generation, electricity voltage gets stepped up and transmitted over long distances to more localized distribution, where voltage is stepped down and provided to consumers. That process can consume as much as 5% of the generated electricity through line losses.

The current electrical grid was designed to fulfill twentieth-century requirements. Electricity flows one way, and there is almost no information exchange between electricity providers and consumers, most of whom are in the buildings sector.

For larger consumers of electricity, fees for generation, transmission, and distribution are shown individually on their bill. At the residential level, the three fees are often blended into one. Consumption and cost data are typically provided in the aggregate each month, limiting the ability to ascertain what drove costs and consumption over the billing period. As far as communication is concerned, a utility usually doesn't know there's a problem until a customer calls to report an outage, and all communication takes place separate from the grid.

Buildings and the Grid Today

Buildings represent more than 70% of the electrical grid load in developed countries. Grid loads from buildings differ by climate and season and can change rapidly because of weather or activities within the building, or both. The traditional electrical grid model puts the onus on the grid to provide reliable generating capacity and a transmission and distribution system that responds to load changes instantaneously and meets peak demand. Forecast models are the only guide to what will be needed. In other words, buildings and the grid don't "talk," but the grid is expected to meet building demands anyway.

The electricity sector's business model is to sell electricity, but from a planning and infrastructure investment point of view, they don't want consumers to buy it all at the same time. Without the ability to communicate with consumers about loads, utilities have developed fee structures to send signals to consumers to use electricity consistent with the effective operation of the grid infrastructure. These fee structures can include:

- **Time of use rates**, in which the cost of electricity changes based on time of day.
- **Demand charges**, in which the real time power usage is monitored for a time period (typically monthly) and an additional charge is levied based on peak demand in kW for the time period.
- **Ratchets**, which are similar to demand charges but consider the peak consumption for an annual period.

These traditional fee structures influence the design and operation of buildings. For example, thermal storage may be used to shift cooling loads. Whereas this helps reduce peak load electricity fees, it can actually use more energy overall. When fossil fuels are used to generate power, this kind of load shifting can result in an increase in carbon emissions and other pollutants.

A building automation system (BAS) may be used to limit demand charges. The BAS monitors the peak electricity usage by the building and can shed internal loads (e.g., reset room temperature set points, reduce lighting) to stay under a prescribed electricity demand. But without two-way communication between the building and the grid, these measures can happen on days when there is actually no need to reduce loads for the benefit of the grid. Designing, constructing, and operating a building that anticipates potential electricity fee structures without grid communication can lead to unnecessary occupant discomfort and an increase in emissions.

That said, utility demand response programs have begun to close the gap caused by lack of communication between utilities and consumers. The utility and consumer enter into a relationship in which, under clearly defined conditions and communication methods, the utility offers incentives to reduce or shift loads. When the utility determines a load reduction is required, the consumer is notified. Notification may occur, for example, in anticipation of high demand, triggering a pre-determined system shut down or slow down by the BAS. The signal could also be automated.

Not only does the grid indirectly influence building design and operation, but also building design and operation influence the grid. Building operation may or may not align with utility goals. Demand response is a good example in which goals are aligned, whereas energy efficiency measures is a more complex topic.

The traditional business model of utilities selling electricity to be profitable conflicts with energy efficiency, yet utilities are often required by government policy and regulators to subsidize consumers to implement and operate such energy savings measures. Citizens and government and regulatory entities around the globe are enacting policies to encourage not only greater energy efficiency but also the use of renewable energy and the reduction of carbon emissions and other pollutants in the electricity and buildings sectors. These policies affect decision making in both sectors. Decisions that affect pricing structures on the utility side and consumption on the consumer side are not necessarily about profit or cost only. They are also about policy requirements. It is worth noting that in the United States, 80% of the reduction in carbon emissions between 2005 and 2016 came from the electricity sector.

Although policy often mandates utilities to implement energy efficiency programs, some also promote energy efficiency as a means of ensuring generation capacity without having to invest in new power plant construction and operation. Even so, utilities often struggle with an antiquated business model that conflicts with the needs of customers and societal values around efficient use of resources and the environment.

Zero Energy Buildings

Zero energy buildings (ZEBs) are an example of building design that is driven by societal values around energy efficiency and renewable energy. The design both responds to and puts stress on the current grid model. The U.S. Department of Energy (DOE) provides the following common definition of a ZEB: an energy-efficient building where, on a source energy basis, the actual annual delivered energy is less than or equal to the on-site renewable exported energy. (Source energy includes all the generation, transmission, and distribution losses in the electricity delivered to the building.)

Electricity is generated on site from renewable energy such as solar photovoltaics (PV). However, the building may still need electricity from the grid at times unless battery storage is available on the building site. When renewable generation or battery storage (or both) do not meet building loads, the grid fills the gap. When excess renewable energy is generated, it may be contributed to the grid.

The DOE ZEB definition has been expanded beyond single buildings to also include definitions for zero energy campuses, communities, and portfolios. This addressed some challenges initially faced by ZEBs. The requirement for on-site renewable generation, for example, limited equally environmentally friendly options such as power purchase agreements and community solar. The on-site generation criterion also discouraged urban density, thereby contributing to unwanted sprawl, which can also lead to poor walkability. With the expansion of the ZEB definition, the site in “on-site” can now be defined as a group of building sites in a specific locality that have renewable generation and that are owned by a single entity or multiple entities, or that are leased by a single entity.

ZEB design offers a strong path forward for a built environment that promotes the health and well-being of occupants while maximizing energy efficiency and using renewable energy. Even so, the definition must continue to evolve, at least in part because ZEBs may not be well aligned with the needs of the electricity sector. For example, if on-site generation fails, the expectation is that the utility will provide necessary power. However, the utility gets paid to supply electricity, not reliability. In many places, the utility is required to accept and pay for excess power from the ZEB, even if it is not available at a time when the utility needs it. Sharp variations in ZEB load profiles can be difficult for the grid to manage. At times, electricity peak demand coincides with reductions in renewable generation (e.g., late summer afternoons when cooling loads peak but solar PV generation begins to wane). This can result in a steep ramp up of demand for power. Additionally, the movement of electricity onto the grid from on-site generation was not part of the initial grid design. Changes in grid infrastructure, utility business models, and building load management will be necessary to align electricity and buildings sector requirements.

High-performance, low-energy-use buildings are critical for our future, and ZEBs will play an important role. The ZEB definition has and will continue to evolve to help achieve the high-performance goal. Aligning the goals and definition of ZEBs with the goals of the electricity sector, especially as utilities evolve in light of changing consumer demands and new technologies, will drive positive results.

Introduction of Renewable Energy

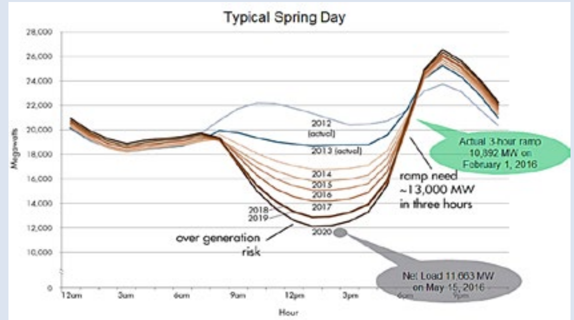
Societal demands for renewable energy are increasing, and costs for these technologies are decreasing. Use of renewable energy for electricity generation is only expected to grow, yet use of renewables stresses the existing electrical grid model. The benefits of renewable energy seem obvious for both the building owner and the electricity sector. The building owner can reduce energy costs by selling renewable electricity to the utility or using net metering to receive a credit from the utility for surplus electricity generated by renewable systems. The use of renewable energy also reduces emissions related to the building. The utility might also enjoy reduced peak demand and avoid large capital investment in new generation and transmission. It's important to note that wind and solar PV are not just for buildings. Utilities are also building large-scale wind and solar farms to supplement their generation assets.

The full benefits of renewable electricity are more difficult to realize within the traditional grid model. The traditional grid was designed for the fairly constant flow of electricity from high-quantity base load and relatively predictable but smaller-quantity peak load generation. It was not designed to accommodate widely distributed, smaller and intermittent (not constant) generation from sources such as solar PV and wind.

Also, transmission and distribution assets were designed to move electricity from remote generation to consumers. They were not, for example, designed to enable one building to share excess capacity with another nearby. The current grid is not designed to effectively monitor and manage the large quantities of bi-directional flows of electricity that are easy to envision as demand for and feasibility of renewable electricity grows.

Managing a very large and distributed number of generation assets with a variety of owners is even more complex. Electricity flows from high voltage to low voltage. For excess electricity to flow from a building back onto the grid, voltage has to be raised above grid voltage. With a large number of generation assets that aren't under the operational control of utilities, the grid quickly runs into voltage issues.

Duck Chart



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This "duck chart" graph, resulting from a multi-year analysis performed by the California Independent Service Operator (CAISO), illustrates challenges faced by the traditional grid as renewable generation increases.

The chart shows actual and projected net load on a typical spring day over several years. Net load is the difference between forecasted load and expected electricity production from variable generation resources (e.g., renewables).

Net MW load is indicated in the y axis and time of day on the x axis. The curve that forms the "belly" of the duck shows a steep reduction in net load as solar generation becomes available in the morning and increases toward mid-day. The curve up to the "neck" shows the steep ramp up in net load as solar resources begin to diminish in late afternoon and cease in the evening while demand remains relatively high.

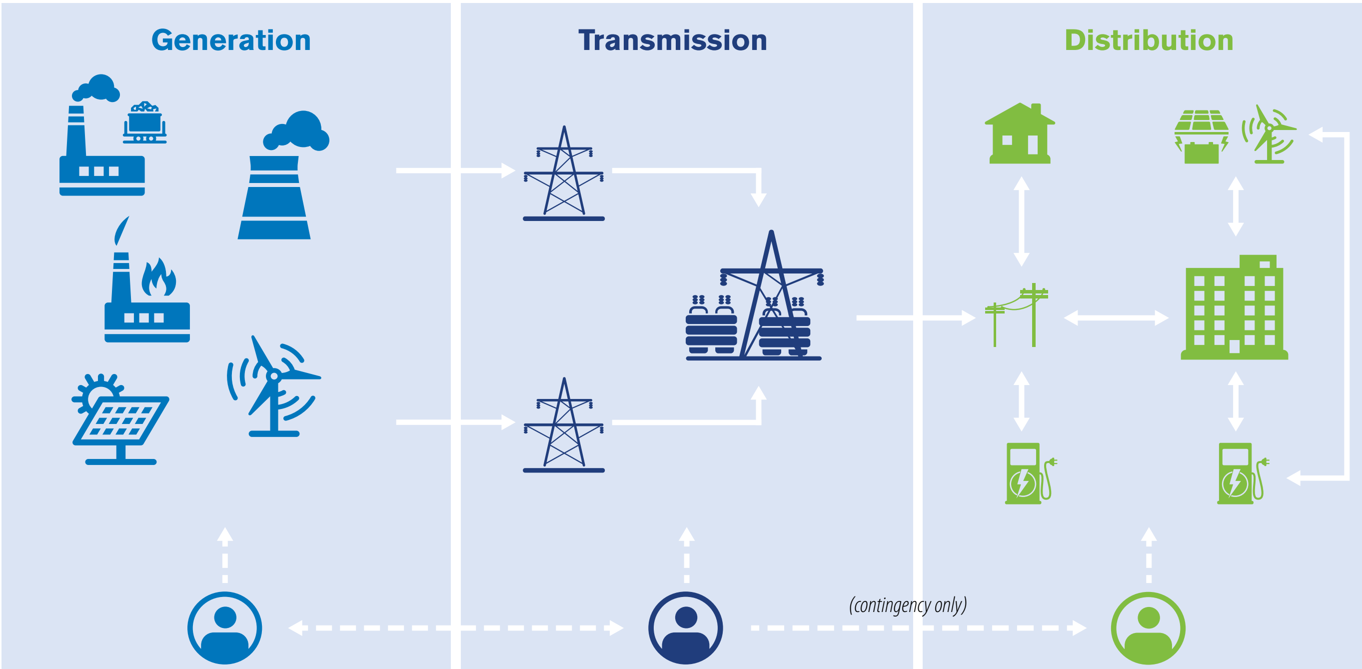
The CAISO projections are being realized at a faster pace than originally forecasted. California is also estimated to be about 10 years ahead of schedule on its policy goal of 50% of retail electricity from renewable generation by 2030.

Several challenges emerge for CAISO, including short steep ramps of increasing or decreasing demand, risk of oversupply of electricity, and decreased frequency response that can impact grid reliability.

CAISO suggests several solutions to these challenges. Many of these solutions will or can involve buildings, including increasing storage resources, enhancing demand response initiatives to better match grid conditions, implementing time of use rates for better use of renewable generation, and incorporating electric vehicle charging systems that are responsive to changing grid conditions.

CHANGES TO THE ELECTRICAL GRID

The traditional grid is already changing, as new technologies such as renewable energy and new strategies such as ZEB design demonstrate. Additional technological changes and increasing demands are expected to drive even more change to the physical grid and force utilities into new business models, potentially changing the fundamental market exchange of electricity.



Grid infrastructure is designed for large, controllable generation and one-way flow of electricity.

Solar and wind resources are intermittent. Without storage, they can challenge steady maintenance of supply and demand.

Utilities sell electricity for profit and maintain grid infrastructure to enable delivery of their product.

Owners of DERs may not buy as much electricity as other customers, but all benefit equally from the grid, creating potential inequities.

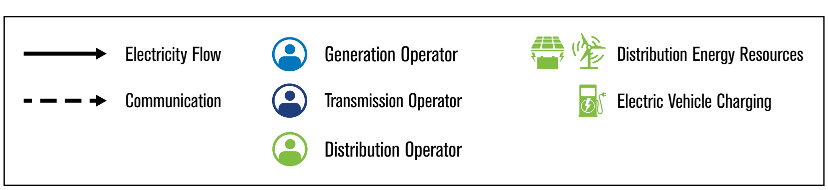
Electricity is now being supplied from the distribution portion of the grid, requiring bi-directional flow of electricity.

Net metering enables bi-directional flow of electricity from limited distributed generation but may not be the only solution for higher penetrations of distributed generation.

Communication

Operational control communication does not include the customer side of the meter and often does not include distribution infrastructure. Communication with the customer is one way, does not use the grid network infrastructure, and is used only for contingencies, such as power outages.

NREL



Changes in the electricity sector will result in challenges and opportunities for its number one customer, the buildings sector. Technological changes forecasted to impact both sectors include DERs (of which distributed generation from renewable energy is a key component), an increase in plug-in electric vehicles, IoT, and the smart grid.

Distributed Energy Resources

DERs are a significant driver of change to the electrical grid. The traditional grid was designed for centralized generation and one-way flow of electricity. DERs change that, placing generation assets on the distribution component of the grid and forcing bi-directional flow of electricity. DERs are very often, although not always, associated with buildings. It is important for buildings professionals to educate themselves and their clients about DERs, because DERs represent critical technologies and strategies through which buildings evolve from passive consumers to active partners with the grid.

DERs include other familiar terms, including distributed energy systems, distributed generation, and distributed power. The tendency is to think of DERs as just physical assets (e.g., solar PV, wind, batteries), but DERs also include virtual assets, such as strategies to reduce or better manage loads. DERs include:

Distributed generation, which is made up of smaller electric generation units, from 3 kW to 50 MW. These smaller-scale (vs. large utility-scale) power sources are located across the electrical grid. They are usually, but not always, "behind" the meter, on the customer side, and close to the loads for which they provide power. These power sources can be connected to the grid or stand alone, and the output from multiple units can be aggregated to meet regular electricity demand. Distributed generation challenges the centralized generation model of the existing grid and is a driving force in changing the model of the grid from one-way to bi-directional electricity flow. Examples include:

- Solar PV, including rooftop solar arrays, building integrated photovoltaics, on-site ground-mounted solar arrays, community solar
- Wind turbines, including utility-scale (larger than 100 kW), small wind (100 kW and smaller) and offshore wind
- Generators using diesel, oil, natural gas, or a combination of fuels
- Co- and tri-generation
- Fuel cells
- Microturbines
- Reciprocating engines.

Community solar is a business model for distributed renewable generation in which electricity is usually generated off site (i.e., not on a building or building site) and provides power proportionally to the number of customers it serves. This is particularly beneficial to consumers who want solar PV but, for a variety of reasons, can't put solar PV on a building or own it themselves.

Electric storage options include batteries, even those in electric vehicles. Electric storage can help balance the grid and make it more flexible. It can be used when generation exceeds demand, and the stored energy can be released to meet demand at another time (e.g., when intermittent renewable generation is not meeting demand). Or, when a short-term peak in demand occurs, storage can reduce the need for short-term peak generation, which is often the most expensive generation. Renewable generation and storage combined can also help protect consumers and utilities from fluctuations in fuel costs because the costs for installations of such combined renewable/storage projects are usually fixed.

Nanogrids and **microgrids** are small (in relation to the overall grid), local electrical grids that use distributed generation and include sophisticated controls and battery storage. Their difference is one of scale. Nanogrids are smaller than microgrids, often residential or single-building in scale. They usually employ solar PV for generation, batteries for storage, and on-site "grid" components. Microgrids are larger, campus or multi-building in scale and employ a wider array and sometimes a combination of generation technologies (e.g., solar PV, wind, combined heat and power, generators) and storage. Their grid components are usually not located on site to a single building but often require their own dedicated space. They enable multiple buildings to share electricity and storage.

Nanogrids and microgrids are connected to the larger electrical grid at a point of common coupling that maintains voltage at the same level as the main grid and aligns frequency unless there is a reason to disconnect (e.g., outage or need to control electricity flowing back onto the grid). A switch can separate the the nanogrid or microgrid from the main grid automatically or manually, and the smaller grid then functions independently as an island (called "islanding").

Nanogrids and microgrids offer advantages for both utilities and consumers. They can compensate for the intermittency of renewables at the source of generation. They can provide backup power if the grid goes down. They may also be attractive to utilities and grid operators as a means of integrating increasing distributed generation. Offering services for customers on the nanogrid scale that include solar PV, energy management, and battery storage is a revenue-generating service that utilities in Europe and other parts of the world are beginning to offer.

In addition to distributed generation, storage, and nanogrids and microgrids, DERs also include technologies and programs that can have an impact on demand and load management on the grid. Although some are not physical assets, together they help utilities to ensure reliable and secure delivery of electricity. Additionally, they are distributed across the grid. For example, energy efficiency and demand-side management programs, demand response and energy management technologies (all mentioned in the previous section of this document) are considered DERs.

Third-party providers and **third-party aggregators** play an important role in DERs. Third-party providers offer an array of products and services to consumers or utilities. Aggregators offer products and services from multiple third-party providers. These products and services are distributed across the grid and include:

- Distributed generation, sometimes coupled with storage
- Energy efficiency products and services
- Billing software and services
- Energy management services
- Grid reliability products and services for utilities.

Plug-in Electric Vehicles

Worldwide use of electric vehicles (EVs) is expected to increase steadily, from about 1% of the global light-duty fleet today to 7% by 2030 and 33% by 2040. EVs will present both challenges and opportunities to the electrical grid and buildings. From the grid perspective, EVs are expected to be a significant factor in an increasing overall demand for electricity. As they face selling less and less electricity, utilities may be looking to a more electrified transportation sector as a real benefit to their business model. Opportunities and incentives for the buildings sector already exist in some markets and could expand in the future.

From a buildings perspective, EV owners will expect to have access to charging at home, at work, and in public locations. The impact this transformation will have on buildings may include:

- Benefits to the occupants from EV charging
- Converting a fossil-fuel fleet to electric
- EV charging incentives
- Future EV charging needs and expectations.

For the electricity and buildings sectors, EV charging has the potential to significantly change load patterns. HVAC and lighting loads, for example, are relatively predictable based on season and weather, but EV charging is based at least in part on personal preference, and that is more difficult to predict. Some utilities are already providing time of use electricity rates specifically to encourage EV charging during times of lower demand. EVs could increase demand charges for buildings. It's a good idea for anyone considering installing EV charging equipment to contact the local utility before work begins.

Because EV charging is often associated with buildings, it is important for buildings professionals to be aware of the challenges and opportunities EVs offer the grid. Whereas EVs are not expected to cause problems on larger electrical grid networks, they do have the potential to cause infrastructure problems at a local level. When a large enough number of EVs charge in the same area (called "cluster charging"), they can put significant strain on local transformers, causing localized brown- or blackouts. This localized problem has the potential to become even greater during peak demand.

On the other hand, the energy storage in EVs offers stability to both the grid and buildings, especially with distributed generation. EVs can, for example, offset the intermittency of solar PV or wind by charging mid-day or at night when these resources are at their peak generation, respectively. EVs can also minimize frequency and voltage fluctuation during a grid disturbance, benefitting both electricity providers and consumers.

Also, with dynamic pricing (see page 18) as an option, the owners of EVs could charge batteries when demand and price are low, then sell electricity back to the grid at a higher price when demand spikes. This makes sense financially and prevents grid overload.

The Internet of Things

In addition to DERs, the electrical and buildings sectors will see changes from the burgeoning IoT, which is expected to grow steadily into the future.

Simplistically, IoT is a network of everyday devices, appliances, and other objects equipped with computer chips and sensors that can collect and transmit data through the Internet. Take that concept and apply it to functions in commercial buildings, and you have Buildings Internet of Things, or Buildings IoT. Smart phones, wearable fitness and healthcare devices, smart appliances, and smart meters that use the Internet are all part of IoT. Buildings IoT devices can enable more cost-effective and energy efficient operation of building equipment and devices, such as HVAC, lighting, and security.

General consumers are already embracing IoT that relates to both the electricity sector and residential buildings. Many products offer Internet-enabled controls for features from lighting, plugs, HVAC, home safety and security, all the way to transforming an entire home to a smart home. IoT devices are also generally changing human expectations about the speed and ease with which we can control our immediate environment (e.g., tone and color of LED lighting, home entertainment choices, speaker volume), which has the potential to impact the electricity and buildings sectors.

A few hypothetical possibilities are worth considering. Although many IoT device manufacturers promise energy savings, these devices could actually result in greater use of electricity and change load patterns simply because they make operation of electric equipment so easy. IoT devices may also change expectations about the variety and granularity of information. Currently, we can install a smart thermostat, for example, and assume there's a correlation between its use and lower energy costs. Without information on the specific electric load of HVAC equipment, which can be difficult to ascertain in some buildings, such an assumption cannot be confirmed. We have smart watches that track biometric data such as heart rate and sleep quality to help us monitor our health. It seems quite possible that building occupants may want to easily compare biometric data with information about building operations such as lighting level and color to determine the impact of those measures on health also. If building occupants expect to operate more electric equipment more easily themselves, see more granular data on the operation of such equipment, and expect to be able to compare more data, at least some of the responsibility for providing these options is likely to fall to utilities and buildings professionals.

Utilities will use IoT devices to improve business and grid operations. They are also predicted to provide services compatible with IoT devices to help consumers better manage their loads and thereby their costs. This helps utilities manage generation, transmission, distribution, and loads more effectively as well. In other words, IoT could become the way in which utilities "see" loads and partner with building occupants to manage those loads in the future.

ASHRAE and Our New Energy Future

Fortunately for the buildings sector, the experts who originally developed and continue to develop BACnet are well prepared for Buildings IoT with BACnet. BACnet, the data communication protocol for building automation and control networks (thus, "BACnet"), and its development is spearheaded by ASHRAE's Standing Standards Project Committee (SSPC) 135. Experts from all over the world participate. Although BACnet development originally began in the late 1980s, the protocol took Buildings IoT (even if it wasn't called that then) into account from the beginning. For example, the ability to link multiple buildings together using the Internet was in the original version. An early revision added BACnet/WS (Web Services) because as the Web emerged, the need to connect building information to Web-based applications of many kinds securely and in a consistent manner was recognized. BACnet/WS is comprehensive, making it possible to perform whatever operation is needed over the Internet. Most BACnet systems today use the Internet Protocol (IP) for a backbone network, allowing for much faster device communication, integration over longer distances, and the possibility of secured remote control from another location.

ASHRAE NEMA
FSGIM
Facility Smart Grid Information Model
SPC 201P

ASHRAE is also engaged in preparing for the smart grid. It partnered with the National Electric Manufacturers Association (NEMA) to develop the Facility Smart Grid Information Model (FSGIM), the intention of which is to guide the evolution of building automation systems to include features important to a smart grid. The FSGIM is an abstract information model of what the smart grid looks like from the perspective of a facility (defined as a residential, commercial, or industrial building, or a campus). The FSGIM is not a protocol, but it can be used to guide enhancements to BACnet and other protocols to help them adapt to the smart grid. The FSGIM models the information that would need to be exchanged within a facility and with outside services to participate in the smart grid.

In addition to supporting collection and analyses of more data from existing building systems, IoT also offers benefits to building operators by collecting information about a variety of things from other sources (e.g., occupant comfort and experience and weather). IoT enables these data to be analyzed and visualized more quickly to drive decisions. For example, IoT devices in buildings can be used to:

- **Increase occupant comfort** as occupants can provide feedback on comfort in near-real time, and this feedback can be viewed and used for immediate changes. Feedback can be aggregated into data that can be compared with other data to inform overall comfort settings. Sensors can be deployed to provide more granular data about temperature, humidity, air flow, and occupancy in discreet spaces, and those data can be used to inform settings.
- **Promote health and wellness** in the built environment by enabling better information about and control of systems that affect air quality. Devices will be used to ensure optimal lighting levels, color, and temperature, which are known to affect productivity and sleep. IoT devices can also be used to encourage healthy behavior such as regular breaks and movement.
- **Assist with maintenance** by monitoring equipment and systems more consistently than humans can and send alerts about a problem to the humans who can address or assign someone to address the problem.
- **Support energy efficiency** efforts by providing more information about occupant behavior to support a program of behavioral change. Occupancy, outdoor conditions, and occupant behavior data can be collected via building sensors and used so building systems can auto-adjust in a more efficient manner.
- **Enable use of cloud computing**, which has several benefits. Generally, the cloud offers the option to store a lot of data without the effort of purchasing, operating, and maintaining the same computing ability on site. It's also more secure than a single-point-of-failure on-site system because data are stored across multiple servers in multiple locations. Cloud services are also scalable, allowing the client to increase or decrease computing power as needed.

Those are just a few examples of how IoT can intersect with buildings. Just as smart phones and devices are changing human expectation about the speed and quality of information and the ability to receive assistance with everyday tasks, so is IoT likely to change the expectations of building occupants and building operations.

Project Examples

Jacobabad Institute of Medical Sciences, Sindh Province, Pakistan

adaptive technologies

This approximately 130-bed, 115,000-square-foot (107,000-square-meter) facility is currently spread over about 8 acres (3.25 hectares). It includes rooftop solar PV that produces approximately 490 MWh/year and a two-bank battery system, the first 6,900 Ah and the second 20,700 Ah.

SMUD and Sunverge Aggregated Distributed Energy Storage and Solar PV, California, United States

SMUD

The Sacramento Municipal Utility District (SMUD) and Sunverge Energy partnered to evaluate how high penetrations of renewable electricity generation can yield better results with customer-sited energy storage.

What might high penetrations look like? In 2016, approximately 28% of electricity generated in California came from a mix of renewable fuels, and the highest percentage of the mix was about 10% solar. The state has a policy mandate that 50% of electricity generated will come from renewable fuels by 2030, and solar is expected to make up the largest percentage of the mix.

The SMUD/Sunverge project includes a combination of 2.25-kW PV installations and 11.64-kWh Sunverge Energy Solar Integration Systems (SIS) installed on 34 homes. The SIS includes lithium-ion batteries (scalable from 7.7 kWh–19.4 kWh), a hybrid inverter (scalable to 6 kW), and advanced controls software and electronics that Sunverge promises will deliver power at the right time and the lowest possible price.

Pura Energía and Sonnen Solar Plus Storage Microgrid, Puerto Rico, United States

Sonnen

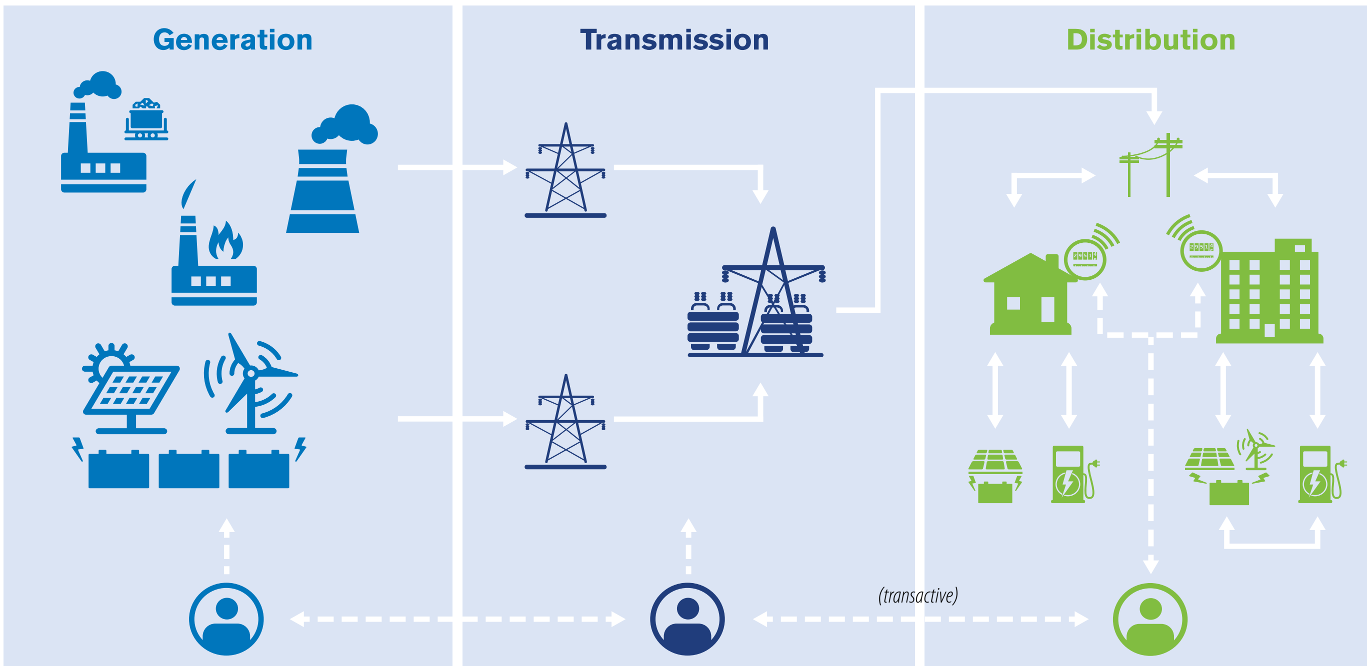
Sonnen

S.U. Matrullas is a school providing kindergarten through grade 9 education for about 150 students in a remote, mountain community in southern Puerto Rico. Even before Hurricane Maria hit Puerto Rico in September 2017, utility grid services were not reliable. After the hurricane, grid services were non-existent.

The solar company Pura Energía and a U.S. subsidiary of the Germany company Sonnen worked with other public and private-sector sources to install an off-grid solar plus storage microgrid system. It consists of a 15-kW solar PV array, one 4-kW and one 8-kW battery (both lithium ion with inverters), and a back-up diesel generator. The microgrid system will provide electricity to keep the school open, and the school does not intend to connect to the larger grid.

THE SMART GRID

To optimize the use of DERs, improve overall grid infrastructure, and to ensure integration with IoT, the grid has to get smarter. A smart grid allows bi-directional flow of electricity and communication between electricity providers and consumers. With a smart grid, buildings are transformed from relatively passive loads on the grid to dynamic partners in the electricity sector, providing (potentially selling) electricity and exchanging information that allows for load balancing to support a stable and reliable grid.

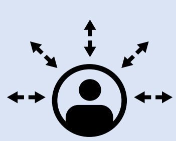


Bulk generation is evolving to greener sources, such as renewable energy and natural gas. Generation will include more flexible and fast-ramping resources, such as electricity storage, to keep up with the uncertainty and intermittency of utility-scale and distributed renewable generation.

Transmission operators can account for resources and assets from the distribution and bulk generation portions of the grid. Operators can include distribution when controlling grid operations.

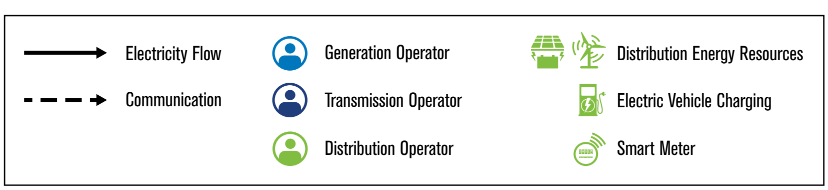
Utilities may become platforms that offer grid infrastructure for third-party providers and aggregators that sell electricity and/or energy services.

Communication



Communication-enabled grid infrastructure supports optimization of distributed energy resources. A decentralized approach brings generation closer to loads, reduces transmission losses and vulnerabilities and it increases the overall reliability, resiliency, and stability of the grid. Communication is bi-directional and closer to near-real time, enabling customers to better manage loads and costs. Electricity rates may be more dynamic. Smart buildings devices enable operation of smart equipment via the Internet.

NREL



The smart grid supports the implementation of more nuanced and effective demand management programs by the utility and implementation of more informed measures by the consumer. It also supports dynamic pricing (see page 18), which could be a win-win for consumers and utilities alike, allowing both to take greater advantage of variability on the grid, the wholesale electricity market, and DERs.

Smart digital meters are essential to the smart grid. They enable bi-directional, near-real-time communication between buildings and an area network about demand and supply. These meters can enable utilities to better control loads and thereby ensure greater grid reliability. Smart meters are also essential to consumers receiving better, more timely information about usage and pricing to inform choices about loads and costs. These choices can also reduce load on the grid. Although many buildings employ BAS and energy management software that give them insights into fluctuating loads and costs, most consumers don't have the benefit of such systems. Without smart meter technology, these consumers have no way of seeing those kinds of fluctuations.

Smart equipment and appliances also use sensors and software to communicate via an area network. Through a smart meter, utilities may be able to communicate with smart equipment and appliances to control loads. This would require a shift in the current utility-consumer relationship. The consumer would allow the utility to control loads on the consumer side of the meter. It remains to be seen to what degree this shift would be perceived as an unwanted intrusion or a societal benefit that optimizes the performance of the electrical infrastructure. Consumers can also use smart equipment and appliances to better control time of operation to take advantage of availability of less expensive electricity.

Smart meters, equipment, and appliances can be connected to customer interfaces that visualize information about energy supply, loads, and costs and enable informed decisions about which loads to add when. The interface would also allow utilities to communicate in near-real time with customers about any utility-controlled loads or outages.

As more and more buildings with distributed generation are on the grid, it is mutually beneficial to the owner of those DERs and the utility to operate on a smart grid. Renewable electricity is intermittent, but it can be designed with a diversity of systems (e.g., solar, wind, and biomass) to reduce intermittency and meet base load demand. A smart grid allows the utility to optimize grid operations to take full advantage of availability of electricity from intermittent sources, which may be owned by the utility, the customer, or another third party. A smart grid could enable the non-utility owner of electricity and the utility to establish a stronger business relationship that allows the owner to sell its electricity and the utility to buy that electricity or distribute it for a fee on the grid for others to buy.

The smart grid also faces some challenges, not the least of which is human safety. When the electrical grid integrates bi-directional flow of electricity, the task of preventing that electricity from harming workers, first responders, and building occupants becomes more challenging.

Interoperability is another key challenge faced by the smart grid, which will include increasing numbers of DERs and DER owners; smart buildings, equipment, appliances, and electronic devices; and more sophisticated communications. Interoperability is the ability of all of these components (e.g., networks, systems, devices, and applications) to work together effectively and exchange and use information securely without causing inconvenience or problems.

The smart grid both supports and challenges resiliency in buildings. To support resiliency, for example, a priority on life safety and emergency structures can be built into the electrical grid. However, cybersecurity issues must be addressed to ensure resilience.

Benefits of Our New Energy Future

It's important to emphasize that there are many potential positive benefits to changes coming to the electricity sector and buildings. A proliferation of DERs can enhance resilience for buildings and communities, as well as the grid. These changes offer great promise in reducing carbon emissions and other pollutants to help meet policy goals and to improve environmental quality. They also offer more possibilities for reducing energy costs. And with better communication and information exchange through IoT and the smart grid, there are opportunities to better manage the gaps between design, construction, and operations. This information-rich environment will facilitate feedback for an entire integrated design team, as well as commissioning and operations teams, thereby providing more opportunities to maintain design intent. Our new energy future also promises to open up new practice areas and business opportunities for buildings professionals.

Utilities of the Future

There is little question that utilities of the future will operate differently than they do today. Most utilities are profit driven but also regulated because they provide tremendous societal benefits. Historically, utilities have been profitable with regulation because they sold their products and services at enormous economies of scale. But with changes such as increasing DERs with a diversity of ownership, including third-party providers that are not as heavily regulated, that scale is shrinking.

The traditional role of utilities is already and will continue to evolve as they sell less of their traditional product—electricity. However, there's really only one system that facilitates market exchange for all the new owners, providers, products, and services in the electricity sector—the grid. Although it is likely to be very different than it is now, the grid will continue to be necessary to the electricity sector, and utilities are the experts in the grid.

A few key ideas about the future of utilities are explored here, and the resources section of this document offers more.

- Utilities have to modernize—the twentieth-century model on which their current operations are largely based simply will not work moving into the future.
- What utilities should and should not do, offer, and be responsible for needs to be clearly defined. Also needing clear definition: What should be left to a competitive marketplace of individual "prosumers" (consumers who both buy electricity and generate electricity that they can sell) and third-party providers and aggregators of an array of energy services? Future utility business models will likely range between two diverse models. On one end of the spectrum, the utility "manages" the grid infrastructure, providing a reliable platform on which to integrate a diverse set of offerings from a diverse set of providers. This model is analogous to charging tolls for the reliability of roadways. On the other end of the spectrum, a utility expands its own assets to offer more services to consumers. This would be a bit like owning and charging fees for use of the roadway and the vehicles on it, as well as the fuel or electricity the vehicles consume.
- To ensure ongoing societal benefits, regulation will continue to be important.

Electricity Markets of the Future

As we consider changes to the electricity sector, a number of challenges about the way in which we buy, sell, and pay for electricity become apparent. This document has already discussed some of the fee structures utilities currently use, in the absence of other more nuanced communication methods, to encourage consumption patterns that optimize base load and peak generation and generally help to balance the grid. But communication isn't the only problem. Regulated utilities are also required to set rates for electricity and grid infrastructure services ahead of time, despite the fact that there are specific and fluctuating costs associated with electricity at the very moment it is generated. Also, electricity generated from different resources (e.g., coal plant vs. solar PV) has different costs. Utilities, however, are beholden to preset fees they can charge, and customers usually pay monthly for their electricity usage. Utilities also face concerns about continuing profitability and their ability to sell electricity at an affordable price because they sell less of it. There is also a proliferation of new owners of generation and energy services, from a single building owner to community solar to third-party providers, as well as storage and nanogrids and microgrids coming into play. To make the most of these resources, the larger grid continues to be critical. Current rate- and price-setting, billing, and payment methods may not be particularly sustainable or even beneficial moving into the future.

Here are some key terms and concepts about how rate setting, pricing, billing, and payments could change in our new energy future.

Rate making is the regulatory process through which utilities set the prices they charge for product. A logical response to selling less electricity could be to raise prices, but the rate making process may not allow for that, so utilities may not always be enthusiastic about energy efficiency and DERs. Electricity rate decoupling may be one answer to this dilemma.

Rate decoupling allows the utility to break the link between the amount of energy they sell and revenue they collect to cover their costs. It allows them to ensure they receive fair and reasonable compensation for their fixed costs while customers pay a fair amount too. This policy tool can incentivize utilities to continue supporting energy efficiency programs and greater penetration of DERs, despite the fact that these programs result in the utilities selling less electricity.

Utilities and customers alike may wish to exchange electricity using **dynamic pricing**, which means prices change over time and are not known with certainty ahead of time. DOE indicates that some smart grid options for dynamic pricing include:

- **Real-time pricing** rates that usually apply to usage on an hourly basis
- **Variable peak pricing** is a hybrid of time of use and real-time pricing. Different periods for pricing, such as on-peak and off-peak, are defined in advance, but the price for on-peak varies by utility and market conditions.

- **Critical peak pricing** occurs when utilities observe or anticipate high wholesale market prices or system emergency conditions, called a "critical event." The price for electricity during a critical event increases substantially for a specified time period. **Critical peak rebates** occur as critical peak pricing does, but the customer is refunded at a predetermined value for any reduction in consumption relative to what the utility deemed the customer was expected to consume.

Transactive energy is another important concept that has the potential to influence rates, prices, and billing. Transactive energy is a new approach supported by the smart grid that enables a free-market exchange of electricity and related services between energy producers—be they utilities, individual DER owners, or third-party providers—and energy consumers based on the true value of the electricity and services.

Using transactive energy as a more widespread approach, electricity prices are based on the real-time cost of generation. Dynamic pricing can be used to incentivize consumer behavior. Consumers can have the option to manage their energy behavior and costs in light of near-real time information about their own electricity usage and pricing information from the utility. And, if the consumer owns distributed energy that can be exchanged or sold on the grid, dynamic cost information can be used to maximize the financial benefit of those resources.

Blockchain is another important topic to consider when thinking about electricity markets in the future. Blockchain is the distributed ledger for transactions that is behind Bitcoin cryptocurrency, but it also has the potential to be used to trade anything of value, including electricity. According to Energyweb.org, a non-profit organization focused on use of blockchain in the energy sector, "Blockchain technology has the potential to reduce transaction costs in the energy sector, enable active participation of a larger number of market participants (consumers and devices) and, as a consequence, accelerate the transition towards a cleaner, more resilient, and more cost effective system." The basic idea is that blockchain technology could be used to securely and quickly enable electricity transactions between third-party generation and a utility or consumers, between a utility and consumers, or consumer to consumer. These transactions can occur closer to the time and at the price at which electricity is actually generated, instead of, for example, buying and selling of electricity occurring on a monthly or longer cycle as it is today.

BUILDING DESIGN AND OPERATION IN OUR NEW ENERGY FUTURE

We know that buildings are the grid's number one customer already and that buildings are likely to become more active partners in the electricity sector. That means design and operation of buildings will also change, which will affect building owners, professionals, and policy makers.

> **"All efforts related to energy efficiency and cost reduction must support the priority of wellness because we build buildings for people."**

Building Owners

Ultimately, the purpose of buildings is to facilitate essential activities such as shelter, education, commerce, and healing. To carry out many of these functions, the salaries and benefits of the people who occupy buildings is often the largest expense for building owners. The building owner who leases space to tenants is also focused on building occupant experience as a critical measure of the quality of their service. Wellness in the built environment—anything that improves quality of life and productivity and reduces absenteeism and illness—must be the number one goal for buildings. All efforts related to energy efficiency and cost reduction must support the priority of wellness because we build buildings for people.

The second-highest cost in buildings is usually energy, so any changes to the building that affect interaction with the electricity sector will have an impact on the building owner. Currently, when considering a building project, the design team advises the owner on energy-related decisions. On behalf of the building owner, the design team first investigates opportunities for passive energy efficiency measures, followed by active measures. They identify the availability of energy at the proposed site, preliminary energy costs (for modeling and code compliance), requirements for transformer vaults and other building requirements, and the options for incentive programs.

The cost of new energy technologies is changing rapidly. For example, it is expected that within five years solar PV will be one of the lowest-cost methods to produce electricity. Electric storage cost is also declining quickly. The design team members will need to educate themselves and building owners about new technologies and keep current with ongoing changes to make the best business decisions. It may mean designing capabilities into a building project in anticipation of changes related to the availability, feasibility, and affordability of new technologies that are forecasted to occur during the life of the building.

In the future, the interaction between a building project and the grid will create many new opportunities and challenges. These issues will arise very early in the project, possibly even influencing the choice of site. The building owner will need expert advice, including strong research about available options as well as an explanation of the pros and cons. For example, researching DERs could lead to many important discussions, including: Will the building have a nanogrid or be part of a microgrid? Will there be on-site power generation? What about on-site battery storage and charging stations for EVs? Who is paying for all of this? Can a third-party provider or third-party aggregator provide and operate a solution for a fee or even profit sharing? What is the strategy to allow these operators necessary access to parts of the facility? Is additional building space required, and what costs could it add to the project?

Regardless of which choices are made concerning building interaction with the grid, the billing structure for electricity will most likely change radically. Most fee structures today are based on the amount of electricity delivered to the building (e.g., US$/kWh) and possibly a fee for the peak rate for the delivered electricity (e.g., US$/kW peak for the billing period). A new billing structure will have to reflect the cost of the infrastructure. Most building owners will want to be connected to the larger grid for resiliency, the cost of which will likely take the form of a service rather than the cost of energy used.

Incentives (and possibly regulations) to make the building grid friendly will also likely increase. These new incentives will influence how the building is designed and constructed, as well as how the building is operated. To optimize the building and grid interactions, including those related to new billing structures and incentives, the grid will want to "see and know" more than ever about generation, distribution, and loads related to the building, which leads to discussions about security and privacy.

Building projects under consideration right now–whether new or renovations of existing buildings–are going to operate in the new energy future. The building designer should advise the building owner to consider options right now to make the transition as smooth and cost effective as possible, even if the path forward is not fully defined yet.

Design and Construction Professionals

The responsibility to deliver grid-friendly buildings that excel at wellness will fall heavily on design and construction professionals. All available DERs and smart-grid interaction will have to be integrated into design and construction.

Adding additional DER technologies and including additional strategies for the smart grid may involve a larger and more multidisciplinary team. Design and construction firms will have to gain expertise about DER technologies and smart-grid strategies. Additionally, as systems grow in complexity and there is more interaction between the grid and buildings, the need for high-performance building design becomes more important than ever.

High-performance building design and an integrated team approach have always been important, but with changes coming to the electricity sector, and the field of stakeholders and technical experts becoming wider, this approach becomes critically important. High-performance building design requires an integrated design approach and an integrated team process. Rather than approaching design with specialists and experts working separately from each other, the "integrated" design approach brings together building stakeholders and the multidisciplinary technical planning, design, construction, and operations team to look at project objectives, building materials, and building systems from all perspectives.

The impact of the smart grid and IoT also should not be underestimated. Today, most existing buildings have only one meter and submetering is considered a luxury. In the near future, IoT systems may know about everything in the building, from the EV in the parking lot to the water heater. IoT systems may also know each occupant's expectation about comfort in near-real time throughout the day.

The smart grid will interact with building infrastructure and will almost certainly impact how buildings are designed, even including things such as the building envelope. The responsibility for meeting the requirements of a smart grid, while not compromising on occupant wellness, will fall to the integrated design team.

New players will be involved in the project from the earliest stages. Possibilities include project staff with knowledge of grid-friendly design and technology, tech and IT professionals (especially as IoT and the smart grid become prevalent), and utility representatives or third-party providers (or both). There is an opportunity for designers and builders to expand their service offerings and become experts in grid-friendly buildings for new construction and renovations.

Building Operators

Even with full commitment from the building owner and to a high-performance building design and construction approach, fulfillment of a grid-integrated building that delivers on wellness to its occupants relies on building operation. No one knows better than building operators, who strive for occupant satisfaction every day, that buildings are for people. In our new energy future, building operators will still manage and respond to feedback about occupant satisfaction. They will also manage increased data about building systems and conditions combined with much more complex control strategies. This information will likely be provided by IoT devices, systems, and interfaces, possibly including even social media. As we have seen already with existing smart devices, IoT changes expectations around the speed and ease with which we can control our immediate surroundings. IoT will allow for a veritable flood of data, information, and instructions that will require a building to adapt in near-real time to the needs of its occupants.

Additionally, the relationship between building operators, utilities, and third-party providers and aggregators is likely to only get more involved. A smart grid will be looking for near-real-time information on electricity-related building operations as it seeks to find the best balance between generation, transmission, distribution, and consumption. For example, a smart grid may "ask" buildings to reduce peak loads, charge batteries from on-site generation, charge batteries with grid generation, or request to use on-site generation in synch with near-real-time grid conditions. Building operators will be required to gain expertise in operating grid-friendly buildings, and employers will be required to recognize the critical role building operators will play in the new energy future.

Policy Makers

There is a key role for policy makers in our new energy future too, especially as the electricity marketplace transitions to a transactive energy approach (see page 19). Definitions of high-performance buildings will likely have to evolve to support changes in the electricity sector. For example, some metrics exist today for the designation of ZEBs that require on-site renewable electricity, and some building projects don't lend themselves to on-site power generation. As was discussed earlier, the DOE definition of ZEB has evolved to address this issue. Architecture 2030's recent release of ZERO Code for new commercial, institutional, and mid- to high-rise residential buildings is another example of a necessary evolution in high-performance building designations.

The ZERO Code includes prescriptive and performance paths for building energy efficiency compliance. It incorporates the latest ASHRAE Standard 90.1 requirements for minimum building energy efficiency. Other standards can also be accommodated, such as the ASHRAE Standard 189.1, or any building energy efficiency standards that are more stringent than ASHRAE Standard 90.1.

The ZERO Code offers code adaptable language and a flexible approach for incorporating renewable energy through on-site generation, off-site procurement, or both. Through this flexible approach, the ZERO Code is applicable to new buildings with limited on-site renewable energy generating capacity, such as those in dense urban environments.

Greater proliferation of EVs provides another opportunity for policy makers. Buildings represent most of the locations where EVs can be charged, and the need for required infrastructure raises questions. For example: Who is responsible for delivering this infrastructure? How will the energy cost to charge vehicles be accounted for in high-performance buildings?

Maintaining resiliency, privacy, and security will also require guidance. The expectation of the building occupant is that, if the building generation, nanogrid, or microgrid fails, the building's connection to the larger grid will provide resiliency. Conversely, the building could provide resiliency for the grid if it experiences problems or failure. This raises questions, such as: How will these exchanges of mutually beneficial resilience be accomplished? How will the cost for resiliency be shared?

The potential for the smart grid and IoT is phenomenal, but the challenge of cybersecurity, both personal and related to building operations, becomes even more difficult. Coordinated efforts to deliver this security will be essential.

CONCLUSION

Our new energy future has many exciting opportunities and challenges. As DER technologies and strategies, EVs, and IoT continue to proliferate, and the traditional grid evolves to a smart grid, the relationship between buildings and the grid will change. Buildings will become active partners in the electricity sector. Instead of passive loads on the distribution end of a grid that sends electricity one way, buildings will generate electricity that can be distributed to neighboring loads or the larger grid distribution network.

Through on-site or EV batteries, buildings will offer critical energy storage solutions to benefit their own operations and the larger grid. In addition to generating income from traditional building occupancy, building owners will have the opportunity to sell electricity and energy services.

The role of utilities will likely shift from a focus on selling electricity to selling grid infrastructure and energy services, fundamentally changing the traditional relationship between utilities and their buildings customers. The market exchange of electricity will also likely change, evolving with the smart grid to a transactive energy approach (see page 19) that enables a free-market exchange of electricity and energy services between a diversity of providers, including utilities, building owners, and third parties.

Our new energy future holds great promise, and buildings professionals will be critical to realizing the opportunities and identifying and solving the challenges along the way. Buildings professionals will be essential in safeguarding wellness and sustainability for the built environment and the people it serves.

Design, construction, commissioning, maintenance, and operations processes and teams are likely to change. There will also be other businesses and entire industry sectors seeking to realize opportunities. The technology sector is already engaged in building automation and controls, and renewable generation and energy storage. The electricity sector has been working on issues related to DERs and the smart grid for several years. Data will be critically important in our new energy future, and any company with an interest in “our” data is already thinking about this future.

These industries see the opportunities, and they are mobilizing. Buildings professionals must be part of the research, development, and policy changes; the conferences, meetings, and conversations to ensure the evolution to our new energy future benefits the buildings industry and the clients we serve. But most importantly, buildings professionals must be involved to ensure our new energy future serves all humanity and promotes a sustainable world.

Resources

ASHRAE (ashrae.org)
ASHRAE develops standards and guidelines that are recognized as the leading documents on the topics they address, including building energy performance, indoor environment and comfort, specific HVAC&R acceptable equipment performance, the smart grid, and many other focus areas. Some standards that may be of interest to the reader of this document include 90.1, 90.2, 90.4, 189.1, 62.1, 62.2, 55, 100, 135, and 201.

National Institute of Building Sciences (wbdg.org)
The National Institute of Building Sciences' Whole Building Design Guide is a rich source of information for buildings professionals preparing for a new energy future. In addition to whole building design itself, these guidelines include additional topics such as ZEBs, building integrated photovoltaics, distributed energy resources, smart controls and mobile technology, as well as a long list of topics related to resiliency, security, and wellness in the built environment.

Architecture 2030 (architecture2030.org)
Architecture 2030 is a non-profit organization that issued the following 2030 Challenge to the global architecture and building community: All new buildings, developments, and major renovations shall be carbon-neutral by 2030. The group's projects include:

- 2030 Palette, which offers sustainable planning, landscape, and building design actions in the form of visual swatches.
- 2030 Districts, a private-sector-led effort to establish a global network of high-performance building districts and cities striving for a built environment that mitigates and adapts to climate change.
- The AIA+2030 Online and Professional Series, which enables design professionals to create buildings that meet the energy reduction targets of the 2030 Challenge.

National Institute of Standards and Technology
The National Institute of Standards and Technology (NIST) published its NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 3.0, which reflects advances in smart grid technologies and developments from NIST's collaborative work with industry stakeholders. This widely used document provides key information about the possible architectures of a future smart grid, as well as critical standards, needed standards, and more. The publication is available at: dx.doi.org/10.6028/NIST.SP.1108r3

New Buildings Institute (newbuildings.org)
The New Buildings Institute offers resources on high-performance buildings practices, including ZEBs. With the U.S. Green Building Council, it also recently launched a Grid-Optimal Initiative to address buildings and grid changes such as those discussed in this document.

Rocky Mountain Institute (rmi.org)
The Rocky Mountain Institute is working on and has information about the buildings, electricity, and transportation sectors in a new energy future.

U.S. Department of Energy
DOE offers several resources:

- The Buildings-to-Grid Integration effort in the Building Technologies Office (BTO) is coordinating strategies and activities with stakeholders to address the integration and optimization of homes and commercial buildings with the nation's electrical grid. This resource includes access to publications as well as information about meetings and their proceedings. Information is available at: energy.gov/eere/buildings/buildings-grid-integration-0
- BTO also launched a "Buildings to Grid" article series in September 2017, which is easiest to find with an online key word search, "DOE Buildings to Grid blog."
- The Energy Department's Berkeley Lab also has a Future Electric Utility Regulation series featuring publications and recorded webinars about utilities of the future. These resources are available at: emp.lbl.gov/projects/feur

ASHRAE

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AIA

National Institute of BUILDING SCIENCES