ASHRAE Task Force for Building Decarbonization

This information is an interim product of the ASHRAE Task Force for Building Decarbonization and is provided for informational purposes only. The statements within are not intended and should not be relied upon as official statements of ASHRAE. More information can be found at www.ashrae.org/decarb.

Grid-Building Intersection Issues

Introduction

When a building is operational, it has a choice of both how to manage its electricity usage and where to obtain that electricity. The electricity can be site generated, obtained from on-site energy storage and obtained from the electric grid. In order to advance reductions in carbon, the building needs to have the ability to make both a carbon and a value judgement in these decisions. The amount of carbon in a central electric grid changes on a minute by minute basis, as does the cost to provide that electricity.

Buildings that respond to grid conditions and costs can play an increasingly key role in optimizing building operations and the grid for rapid and cost effective decarbonization without compromising building or occupant service quality. The ASHRAE Task Force on Building Decarbonization (TFBD) Working Group in the Grid-Building Intersection (WGGBI) recognizes buildings as grid assets and building owners and occupants as active partners to grid operators. The working group has identified three key areas needing additional guidance and clarification:

- The use of secure building-grid **communication** systems to enable integration of low-carbon distributed energy resources
- Identification of **value** to buildings and value to the grid of resilience and load flexibility enabled by controls, information systems, distributed energy resources and energy storage systems (electrical and thermal) on the customer side of the meter that are cost effective and responsive
- The **optimization of response** by buildings to signals from the grid

Communications

To fully unlock the combined decarbonization potential of buildings and the grids they are integrated in to, building-scale operational decisions must be informed by the real time carbon and cost signature of the electricity that they consume. The protocols that govern communication between building systems and the grid play an integral role to ensure that building-scale distributed energy resources are optimally coordinated for decarbonization.

Building-to-grid communication protocols must be secure, carry the information necessary to inform building system operations (real time as well as day ahead price and carbon signature of grid supplied electricity), capable of initiating automated responses from building systems, enable bi-directional communication and standardized sufficiently to allow for wide scale adoption. Each capability described here is a subject covered in detailed technical standards and policies. Grid operators can require compliance with a combination of existing or emerging standards to access rate schedules that incentivize building operations that support energy system decarbonization. Local distribution and high-voltage transmission infrastructure will become increasingly more complex as renewable energy generation resources, storage, and other distributed energy systems connect to various points on transmission lines, distribution lines, and substations. Grid operators and/or load serving entities will need to sense, analyze, and communicate grid conditions, renewable energy content with buildings operators and aggregators to maximize and optimize the use of clean, decarbonized energy from both the grid and behind the meter.

The decarbonized grid will require substantial advances in grid management system technologies, which will have to communicate and interact with millions of nodes across the entire grid, including at customer locations. Additionally, the traditional approach to grid management will evolve into more decentralized operation of grid assets, with edge computing helping solve localized issues. Policymakers and the market will have the opportunity to shape a common set of standards and requirements to reliably coordinate customer devices for grid use. Customers and other stakeholders such as device manufacturers will need to adopt these programs, and technology providers will need to build in the application.

The Value(s) of Carbon and Reducing Carbon at Buildings

There have been multiple values assigned to upstream energy production and building energy consumption, including traditional energy valuation as well as the value of carbon or carbon dioxide equivalent[1] emissions output of that energy. At a high level, there are two distinct values for the carbon component: the "policy" value used by decision-makers that indirectly affect building owners and operators, and the "market" value that directly affects building owners and operators as the market costs of carbon are reflected in energy bills or as separate operating costs. In some markets, values have fluctuated over time, and by orders of magnitude (e.g., increasing by over 100% in some years or over several years and decreasing by 25-50% in similar time frames).[1]

The "market" cost of carbon is determined by programs that have a direct impact on building owner energy bills, as the costs are directly translated into monthly bills (e.g., a "line item" cost per kWh of electricity or cost per therm of natural gas) or fees (e.g., $/ton cost over an allowed cap). Under a "cap and trade" program, building owners may be allowed to purchase carbon emission allowances for their building, and if they do not use all of their allowances due to higher energy efficiency, they can sell their excess allowances to other parties at a market price.

"Interaction" between buildings and the Grid has traditionally been a relatively simple sales transaction. Energy flowed from utilities or energy suppliers to buildings and money flowed from buildings to utilities or energy suppliers. The value of the electricity was based on the volume (kWh energy), maximum amount (kW demand), and, in some areas, the time of day when energy was used. But "Interaction" implies interplay and cooperation, little of which have happened in the past. With the advent of renewables, and their variable availability, combined with energy storage the value of buildings and grid operators, working cooperatively again, is greatly enhanced.

However, the measurement of this value, which in the future may revolve around carbon, is not as easy to quantify. It is dynamic, varying locally, seasonally, and by time of day. Ideally, a building which can interact cooperatively with the Grid will be able to capitalize on the value of carbon reduction, by modifying its loads to correspond with low carbon electricity availability.[2]

---

[1] ***carbon dioxide equivalent (CO_2e):*** a measure used to compare the impact of various greenhouse gases based on their global warming potential (GWP). *CO_2e* approximates the time-integrated warming effect of a unit mass of a given greenhouse gas relative to that of carbon dioxide (CO_2). GWP is an index for estimating the relative global warming contribution of atmospheric emissions of a particular greenhouse gas compared to emissions of an equal mass of CO_2.

[2] https://www.greenbiz.com/article/show-me-money-business-opportunity-grid-interactive-buildings

Optimized Responses

Any building responding to the grid requires both energy resources (demand or supply) with which to respond, as well as controls to facilitate the response. There are many resources that buildings can deploy in response to grid signals. These include Distributed Energy Resources (DERs) like batteries, thermal energy storage, solar PV and inverter control, other on-site electric or thermal energy generators and combined heat and power. They can also include flexibility of building loads: methods have been developed for flexible control of HVAC systems (a passive form of thermal storage), lighting, electric vehicle charging, water heating, heat and cold storage systems and more.

In order for these resources to interact with and be responsive to the grid (thereby providing value to their owners), they need direction. Resources could be directed by: the utility (e.g. real-time rates, automated utility or direct load control of water heaters), building facility management (e.g., in response to a signal from the energy grid operator), independently in response to local changes (e.g. an on-site generator that automatically starts up in the event of an outage), or as part of more comprehensive building automation with other systems. There is a trend toward more comprehensive, centralized automation of these systems within the building using a variety of tools. But it is still rare to find a single unified building automation system that covers not only conventional building loads but also DERs.

Energy resources for grid response, and their associated controls, are still a dynamic area of development and several issues need to be addressed in the industry:

- **Control sequences** have been improved over the years to maximize energy efficiency, but additional development of sequences is needed for grid interactivity (including use of artificial intelligence).
- **Complexity** of control, interfaces, interoperability, and value streams is a barrier, especially for commissioning and operation of these systems. Improvements in **interoperability** are specifically needed to both reduce cost and improve usability, including continuing the shift toward more centralized control.
- **Knowledge** of both the **design and operation** of these systems and their controls needs to be expanded across the industry for them to reach mainstream acceptance. This includes development of **better tools** to facilitate cost-effective design and improved operations.
- **Tradeoffs between different value streams** need to be better understood and controlled. For example, building resilience (keeping a battery fully charged for backup) and load shaping (flexing battery usage in response to the grid) may both be values provided by the same resource, it may be unclear how to balance them. Also, better **utility mechanisms** are needed for utilities and their customers (building owners) to cooperate and negotiate control responses based on their differing values.
- **Comfort and occupant needs** (e.g., productivity) remain paramount even as building systems are flexed to benefit owner and grid values; the impacts of flexing on occupants needs to be both better understood and addressed. There have been situations where demand response systems / controls have been disabled after one occupant complaint during a demand response event.
- **Cybersecurity** is a critical consideration to ensure trust and robust operation in these systems (as with any control and communication-based technology) and continues to need improvement across the industry.
- **Building codes**, including energy codes, often do not address these types of equipment. It should be noted that many “green” building standards (such as the International Green Construction Code (IgCC) Powered by ANSI/ASHRAE/ICC/USGBC/IES Standard 189.1) do contain language related to demand response and/or grid interactivity.