# Advancing Virtual Power Plants Through Energy Codes

## Introduction

Virtual power plants (VPPs) are homes and buildings that utilize the latest technology to connect to and communicate with the electric grid during periods of fluctuating demand using various equipment commonly found in a home. This may include thermostats, water heaters, and other devices that can send signals back and forth to and from the electric grid to determine when electricity is needed to power a neighborhood during periods when demand may be high or low. This technology allows for grid flexibility by making sure electricity is being delivered to the right place at the right time and is intended to alleviate strain on the grid.

It is projected that total energy consumption will increase by up to 15 percent between 2022 and 2050.[1] To meet this increasing demand, VPPs can decrease the grid's reliance on power generation facilities, which have historically been constructed near low-income communities and adversely impact marginalized populations. VPPs – also known as grid interactive homes and buildings – operate by making homes and buildings act like mini "virtual" power plants by providing power to the grid in times of need. VPPs share small amounts of electricity with the grid through communication features, where the utility or energy service provider send a signal when there is demand for more electricity, and a home or building responds by sharing energy with the grid, either by slightly adjusting the energy use of the home or building, or by sharing electricity produced on site with a battery storage system. RMI estimates that demand flexibility measures can save customers 10 to 40 percent annually on electricity bills and could avoid $13 billion per year in grid investments.[2] In New England, utilities have reduced the load of the Independent System Operator New England (ISO-NE) electric grid by 300 MW during peak demand from VPP related programs.[3]

This brief will look at the components of a VPP, explore national model code provisions that advance VPP technology, and provide examples of states that have adopted VPP provisions in their energy code. It will also lay out the challenges associated with VPPs and discuss future opportunities to incorporate VPP technology into energy codes.

### *Overview of Technology*

Demand response controls are available for heating and cooling systems through smart thermostats, and other equipment like lighting systems, water heaters, and more. These controls are intended to respond to a request from a utility through a signal that notifies the building that there is currently high demand on the electric grid. The building, through the demand response controls, will respond by lowering its energy use slightly during that

[1] https://www.eia.gov/outlooks/aeo/pdf/AEO2023_Narrative.pdf

[2] https://rmi.org/insight/the-economics-of-demand-flexibility/

[3] https://energizect.com/explore-solutions/demand-response-and-smart-devices/demand-response

peak, in order to support the grid capacity. As more homes and buildings adopt demand responsive controls, a utility can decrease the amount of energy produced from fossil fuel plants and other sources by shifting energy needs from existing sources, rather than producing new energy to meet demand.

Energy Storage Systems (ESS) are batteries that are available to homes and buildings that can store electricity using energy produced by an on-site renewable energy generation system. These systems can be employed to address challenges posed by the 'Duck Curve.' This curve represents a scenario where there is an abundance of solar energy production, leading to an electricity surplus compared to the immediate demand during specific times of the day. ESS can store electricity produced in a home or building during off-peak hours, such as in the middle of the day when people aren't typically home and bring that electricity back to the grid during peak hours when demand is higher, such as later in the evening when more people are home from work. These systems are also resilient during extreme weather events and can provide backup power when the electric grid is offline, which could save lives.

Energy benchmarking is when buildings track their operable energy use throughout the day and monitor how much energy is being used at various times. Utilities can use this data to better understand when peaks may occur, and to prepare for them ahead of time. Data may also be tracked year to year and provide metrics of energy savings which can be useful after a building is upgraded to compare the energy use before and after the retrofit.  In addition, by tracking this data, a utility may quantify how much energy savings can be directly attributed to an incentive program.

The technologies described in this section may be applied to energy codes in different ways depending on the jurisdiction. Several states have successfully incorporated VPP provisions into their code by including them as part of a point-based credit system or have developed "readiness" provisions that prepare a building for a future retrofit. Readiness provisions may extend to prewiring, where electric infrastructure and space is available for the future installation of an ESS. Readiness is also reflecting in ensuring a building is equipped to measure, monitor, record, and report energy consumption data, or include smart controls that make the building capable of interacting with the electric grid through demand response signals.

## Current Landscape of VPPs

In January 2021, NEEP developed a report called Emerging Codes and Standards for Grid-Interactive Buildings. The next section provides an update of how VPPs policies have advanced since this initial report was published, including advancements in the model code, and state-level incorporation of VPPs in code.

For more information on NEEP's prior work on VPPs, please see the Grid-Interactive Buildings Tri-Region Status Report published in January 2020, and our blog posts on the topic from 2019 and 2021.

## *Inclusion in National Model Codes*

National model codes such as the International Energy Conservation Code (IECC) are updated every three years to account for new advancements in technology and innovation. Between the 2021 and 2024 versions of the IECC, new provisions have been added to support the integration of VPP technology.

- The 2021 IECC , which has provisions for both residential and commercial buildings, introduces grid interactive technology for commercial buildings in several ways:
    - Table C404.2 outlines minimum performance requirements for a "grid-enabled" electric water heater, with a definition noted in Footnote f.
    - Section C405.12 outlines "readiness" requirements for energy monitoring for commercial buildings over 25,000 square feet, meaning that a new building must be prepared to monitor energy use in the future, which makes it easier to track energy use through benchmarking. Section C406.10 also has efficiency credits that can be earned through energy monitoring.

  The 2024 IECC draft[4] expands on VPP technology by adding new sections related to "demand response" for commercial and residential buildings.

- Commercial Provisions in the 2024 IECC
    - Section C403.4.6 adds requirements for demand response controls for electric heating and cooling systems. Systems must be able to adjust the operating set point for heating and cooling by up to four degrees Fahrenheit when responding to a demand response signal.
    - Section C404.10 outlines new requirements for demand response controls for electric storage water heaters of a particular size and input rating using ANSI/CTA-2045-B or another equivalent approved standard.
    - Section C405.2.8 outlines requirements for demand response controls for interior lighting in several occupancy types over a certain size. The demand response controls should be capable of reducing output to 80 percent or less of full power after receiving a demand response signal.
    - Section C405.13[5] also expands the "readiness" requirements for energy monitoring for commercial buildings, changing the requirement from 25,000 square feet in the 2021 IECC to 10,000 square feet in the 2024 IECC.
    - Section C405.16 adds new provisions for electrical ESS readiness, by requiring either an installed ESS, or having sufficient capacity and space for the future installation of an ESS.
- Residential Provisions in the 2024 IECC
    - R403.5.5 outlines new requirements for demand responsive controls for electric storage water heaters, like the commercial provisions outlined in C404.10. The difference is that the standard for the controls also provides an option for AHRI Standard 1430-2022 (1-P) which will be required after July 1, 2025.

[4] The 2024 IECC is currently being developed and provisions are subject to change

[5] Which is an updated section number in the 2024 IECC for C405.12 in the 2021 IECC

- Section R408 outlines a point-based system of additional efficiency credits that a building professional may choose from to advance energy efficiency. R408.2.8 includes an option for a demand responsive thermostat, with similar requirements to C403.4.6 that is worth one credit.

- Appendix RD outlines optional requirements for electrical energy storage provisions for residential buildings, similar to those noted in Section C405.16 for commercial buildings.

- The 2021 International Green Construction Code (IgCC) is an optional model code developed by the International Code Council that sets "above code" energy efficiency measures for commercial buildings. Several states and communities have adopted different versions of the IgCC as a stretch code. The 2021 IgCC has provisions for VPPs as outlined below:
  - Section 701.3.3 requires commercial buildings to include measurement devices with remote communication capability to collect energy consumption data for all energy supply sources like gas, electricity and district energy and communicate that data to a data acquisition system.
  - Section 701.3.4 requires that building controls include automated demand response infrastructure capable of receiving demand response requests from a utility, electrical system operator, or third-party demand response program provider. This provision includes exceptions for buildings under 5,000 square feet of conditioned floor area, and for buildings that have thermal or electrical ESS.

## *Current Jurisdictions that Incorporate VPPs in Codes*

California's Building Energy Standards also known as Title 24, includes mandatory requirements for demand management in Section 110.12 for buildings other than healthcare facilities. These requirements extend to demand responsive controls for zonal heating, ventilation and air conditioning (HVAC), lighting, electronic message centers, and receptacle controls.

The 2023 Vermont Residential Energy Building Standards require a certain number of credits for compliance with base and stretch code. The provisions for earning credits are outlined in Table R402.1.2.3 and there are options that extend to demand responsive controls, energy monitoring, and battery storage.

Maryland, through COMAR 09.12.57 has adopted the 2021 edition of the IgCC as a stretch code, which includes demand responsive and energy monitoring provisions outlined in the previous section.

New York and Rhode Island are on track to skip the adoption of the 2021 IECC in favor of adopting the 2024 IECC, which offers more opportunities to incorporate VPP provisions when it becomes available.

Each of these states have taken steps to incorporate VPPs into their energy code. More states should consider adding provisions that advance VPP technology because they can improve grid flexibility, promote energy independence and resilience, and help residents and business owners save money on their annual utility bills.

California has noted that adding demand flexible technology to their energy code "*enables buildings to be responsive to climate change*" and helps achieve their climate goals.[6]

States can take the lead on advancing VPPs in several ways. By adding VPP provisions to their energy code, states can promote grid flexibility and create model code language that may be adopted by other jurisdictions. States can also determine what technology is on the horizon and prepare to find a way to incorporate that innovative technology into their code when it becomes widely available. Additionally, states can create incentive programs that reduce upfront costs associated with demand flexible technology to expand their use. State energy offices can also coordinate with other departments responsible for energy code development on proposals to include in future code revisions and can engage in the public stakeholder process to advance VPP provisions during a code update cycle.

## *Limitations to VPP Technology*

Safety concerns about battery failures of on-site energy storage systems are common barriers to their adoption. Thermal runaway, which is the term used for the rapid uncontrolled release of heat energy from a battery cell, could lead to fires or explosions that are difficult to extinguish. Factors such as extreme heat, flooding, seismic activity, and rodent damage to wiring can also lead to battery failure. The National Fire Protection Agency (NFPA) developed an Energy Storage System Safety Fact Sheet, which provides safety recommendations to the designer/installer, authority having jurisdiction, and fire service. NFPA 855 outlines the standard for the installation of energy storage systems, which provides guidance on best practices for installation. Additionally, it is important that a jurisdiction's building and fire codes are complementary to their energy code, so that the inclusion of energy storage systems follow all necessary and essential safety precautions.

Grid interactive technology may also make buildings and homes vulnerable to cyber-attacks. Texas A&M University in partnership with the United States Department of Energy has developed Cyber Defense and Resilient System (CYDRES), which "*aims to provide a real-time advanced building resilient platform through multi-layer prevention and adaption mechanisms to monitor, detect, and respond to cyber-attacks and physical system faults*".[7] This could provide additional support to VPPs to reduce the risk of a cyber-security attack, and help the utility or electric service provider be prepared to respond to potential threats.

Aging Infrastructure is another potential concern. Many power grids have aging components that require maintenance and upgrades and may not be equipped to handle the increasing demand for electricity associated with the technology needed to incorporate communication with VPPs.

[6] As noted in the abstract of their 2022 Building Energy Efficiency Standards on page iv.

[7] https://www.energy.gov/sites/default/files/2021-09/bto-peer-2021-securing-geb-cydres.pdf

### *Future Opportunities to Advance VPPs through Energy Codes*

The United States Department of Energy has developed a National Roadmap for Grid-Interactive Efficient Buildings, which provides recommendations to expand codes and standards to incorporate demand flexibility and to identify opportunities to link funding and programs to demand flexible code actions. The Bipartisan Infrastructure Law (BIL)[8] and the Inflation Reduction Act (IRA)[9] provide an enormous federal investment of $1.2 billion for energy code updates, which could significantly advance this technology in the market. NEEP has previously shared recommendations on how the BIL and IRA can accelerate grid interactive resources. State energy offices and utilities should think about how to align these incentives with code updates, so that funding can be distributed to promote this technology alongside new grid interactive code provisions. This will allow building professionals to better understand the technology through code training and to invest in grid interactive devices for future projects.

Since national model energy codes are updated every three years, there is room to incorporate innovative technology into the code to advance grid interactive measures. It is expected that grid interactive provisions will be expanded in future code cycles to account for state-level emissions reductions targets. States and communities can also take the lead in these efforts by incorporating grid interactive technology into their base and stretch energy codes, like the examples provided in California, Vermont, Maryland; or adopt the latest model codes when they become available that incorporate grid interactive technology like New York and Rhode Island.

## Conclusion

Technological advancements such as demand response controls, smart thermostats, energy storage systems, and energy benchmarking offer new approaches for decarbonizing the electric grid by decentralizing energy production. This also allows energy sharing between buildings in a community instead of relying solely on a fossil fuel plant to generate new power to meet an increasing demand. Energy code provisions may help advance grid interactive technology so that new homes can rapidly incorporate cutting-edge devices when they become available on the market. Grid flexibility will become increasingly important as states strive to achieve emissions reductions targets. It is important to make sure that new energy codes continue to evolve to adapt to the latest technology, so states and utilities will have the tools needed to effectively decarbonize the electric grid.

[8] In Section 40511 of the Bipartisan Infrastructure Law, $225 million in funding has been appropriated for energy codes

[9] In Section 50131 of the Inflation Reduction Act, $1 billion in funding has been appropriated for energy codes