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How to Build a Connected Community: Policies to Promote Grid-interactive Efficient Buildings and Demand Flexibility

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ABSTRACT

Efficient, connected, grid-interactive, smart, and flexible buildings are key to decarbonizing the U.S. energy economy, optimizing energy use, reducing electric consumers' bills, integrating variable renewable energy resources, and improving the reliability and performance of the nation's electricity grids. Such grid-interactive efficient buildings have high levels of energy efficiency layered with other distributed energy resources (DERs) and intelligent controls to provide demand flexibility.

Policy support is unfolding at the federal, state, and local levels to transform homes and workplaces into state-of-the-art energy-efficient buildings and community-level grid services. This paper starts by describing the potential benefits. Next, it highlights existing policies — with a focus on state-level actions — that support grid-interactive efficient building deployment and demand flexibility. Finally, it identifies current trends and gaps, policies and programs that promote grid-interactive efficient buildings, and aggregations of grid-interactive efficient buildings referred to as Virtual Power Plants.

Introduction

Buildings account for some 74% of electricity consumption in the U.S. power sector and typically a higher share at peak. Buildings also are responsible for 35% of U.S. energy-related CO_2 emissions, much of which is from electricity consumption. Recent research by the U.S. Department of Energy (DOE) and Berkeley Lab found that by 2030, buildings that combine energy efficiency, demand response, and other DERs to remake buildings into a clean and flexible resource (grid-interactive efficient buildings) can save up to $18 billion per year in U.S. power system costs, and $100-$200 billion by 2040.[1] Other benefits, not included in those savings, are:

- reduced power sector emissions,
- avoided or deferred need for distribution system capacity, and
- consumer benefits such as greater choice and control, and potentially improved building comfort.

The projected savings will be greater in a future with significant electrification of heating and transportation and penetration of variable renewables quicker than the study assumed.

Energy efficiency and demand flexibility in buildings can help achieve state policy goals such as reducing carbon emissions reductions, advancing energy equity (see "Crosscutting Strategies" text box), and enabling consumer choice. Some 24 states and the District of

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[1] DOE 2021.

Columbia have adopted greenhouse gas (GHG) emissions targets.[2] A 2021 Joint Agency Report by California's Public Utilities Commission (CPUC), Energy Commission, and Air Resources Board included prioritization of efficiency and load flexibility to minimize implementation costs of achieving 100% clean energy by 2045.

Overview of State Policies that Support Grid-interactive Efficient Buildings and Demand Flexibility

States can consider a number of options for policies, regulations, standards and programs[3] to support grid-interactive efficient buildings and demand flexibility. Figure 1 is a typology that states can use to assess their status and consider paths to enable greater building demand flexibility and energy efficiency to meet their own goals. Each policy category includes examples of actions states are taking today.[4]

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[2] Center for Climate and Energy Solutions. https://www.c2es.org/content/state-climate-policy/. Accessed May 24, 2022.

[3] For simplicity, we use the term "policies" in this paper for policies, regulations, standards and programs.

[4] For additional information on policy options and examples of states advancing demand flexibility and energy efficiency in buildings, see Schwartz et al. 2021.

Figure 1. State policy options for advancing demand flexibility (DF) and efficiency in buildings (reconfigured from Schwartz et al. 2021)

Building codes

- Value EE measures based on when savings occur
- Provide credit for DF measures through compliance paths
- Include grid-interactive requirements and open standards for communication and automated load management
- Allow use of a carbon emissions-based metric for compliance, based on predicted energy consumption and CO2 emission factors
- Incorporate new ASHRAE standards (e.g., 90.1, 189.1)

Appliance and equipment standards

- Include provisions for equipment capable of automated load management in response to a signal from the utility, aggregator, or regional grid operator

Resource Standards

- EE resource standards (EERS) include peak demand targets or a multiplier for energy savings during peak demand hours
- States requiring utilities to acquire all cost-effective EE account for the time-sensitive value of EE
- DR is included in EERS or is eligible to meet clean energy standards
- Load management standards encourage shifting electricity use to times with lower carbon emissions
- Storage requirements include thermal technologies

Utility Planning

- Integrated resource planning considers DF measures and time-sensitive value of EE
- Electricity system planning accounts for interactions between DERs and between DERs and other resources
- Distribution system planning considers EE, DR, and other DERs as non-wires alternatives
- Utilities provide access to system level data to support customer and third-party solutions
- Planning for DR is coordinated with the regional grid operator
- Utility planning related to DF includes equity strategies

Utility Programs

- EE program goals include peak demand reduction
- Cost-effectiveness assessments of EE programs consider time-sensitive value of savings
- EE program performance metrics include carbon emissions
- Requirements for DR programs include DR/DF potential studies
- DR program goals include significant increases in peak demand savings over time
- Requirements are established for new utility programs to reduce peak demand
- Programs for utility customers address equity
- Pay for performance programs reduce peak demand through EE + DF
- DR programs regularly tracked and evaluated
- Locational value informs incentive rates for EE and DR
- Programs address multiple DERs to achieve DF
- Utility programs are coordinated with state and local government programs and electricity markets

Advanced metering infrastructure and metering data

- Grid modernization plans provide a business case for AMI deployment, with costs and benefits monetized to the fullest extent possible
- AMI is in place, or deployment has been approved, for most utility customers
- Customers and their designated third party have granular and timely access to meter data
- Utilities provide energy management tools on web portal or customer mobile devices

Rate Design

- Demand charges for commercial customers are applied only to peak demand periods, or charges are higher during peak demand periods
- Time-based rates provide strong price signals for peak demand reductions
- Retail rates are more reflective of hourly system costs and location
- Robustness of approved programs is regularly tracked and evaluated

State Programs

- State EE incentive and financing programs incorporate DF or new DF mechanisms are established
- State lead by example programs demonstrate enabling technologies for DF and widely share results
- Benchmarking and transparency programs track and report on metrics for energy use, energy savings, peak demand reduction, and DF
- Home energy rating programs include DF measures
- State RD&D programs test approaches for increasing DF and quantifying benefits and costs

State Energy Planning

- DF is included as an explicit means to reach broader state energy goals in state master energy plans, resilience plans, renewable energy goals, decarbonization goals, and electrification plans

Related State Policies and Regulations

- Utilities and other program administrators have an opportunity to earn financial incentives for achieving or exceeding peak demand reduction and DF targets
- Revenue decoupling is in place for electric utilities
- Climate change policies consider the role of DF in reducing GHG emissions from buildings
- Grid modernization policies and regulations consider DF

State Policies and Regulations that Advance Grid-interactive Efficient Buildings, by Category

Building energy codes

State building energy codes are a fundamental tool to promote energy efficiency and demand flexibility in buildings. Among the opportunities for advancing grid-interactive efficient buildings through codes are: (1) valuing energy efficiency measures for code compliance based on when savings occur, (2) allowing demand flexibility to earn credit towards code compliance, and (3) requiring grid- connectivity and demand-flexible technologies.

California has pioneered all three of these building energy code options. The state's building energy code (Title 24) has included a Time Dependent Valuation (TDV) compliance metric (section 100.2) since 2005. The maximum energy consumption that a proposed building, or portion of a building, can be designed to consume is based on the TDV. The TDV energy calculation compares proposed designs to their energy budget under the performance compliance approach. TDV multipliers vary each hour of the year and by energy type, climate zone and building type.

The residential component of Title 24 (section 150.1(b)) requires solar PV installation in new construction. An alternative compliance path provides credit for demand flexibility measures. Builders can use energy efficiency, demand response, thermal storage, and energy storage to reduce the size of the required solar PV system by 40% or more, while maximizing benefits to homeowners, the grid and the environment. The allowable reduction is based on the TDV of modeled energy consumption of the building, accounting for its demand flexibility measures and solar generation.

The nonresidential component of Title 24 includes grid-interactive requirements and open standards for communication and automated load management so that certain types of buildings are demand response-ready. Additional Title 24 standards that promote demand flexibility include Occupant Controlled Smart Thermostats (Appendix JA5), Heat Pump Water Heater Demand Management (Appendix JA13) and Demand Management (Section 110.12).

Appliance and equipment standards

Policymakers can require that electricity-consuming appliances and equipment are capable of automated load management, in response to a signal. Washington and Oregon require new electric storage water heaters to include a grid-communications port that meets CTA-2045 or a similar communication standard. The California Energy Commission has an open proceeding investigating requirements that appliances are interoperable or open source, in response to Senate Bill 49 (2019), requiring the adoption and periodic updating of cost-effective appliance standards to facilitate deployment of flexible demand to reduce GHG emissions associated with wasteful energy consumption.[5]

Utility planning

Appropriately valuing energy savings, demand reduction, and demand flexibility in integrated resource planning and distribution system planning also are important strategies for advancing grid-interactive efficient buildings and Virtual Power Plants (Nemtzow 2022).

Oregon, South Carolina, Indiana, Washington, and Hawaii are among the states that require utilities to model energy efficiency and demand response on a par with other resources in resource plans. That allows consideration of the interaction between DERs, and between DERs and other resources, to identify a least cost, reliable electricity portfolio.

States can establish requirements for regulated utilities to file distribution system plans that consider the locational value of energy efficiency, demand response, and other DERs as non-wires alternatives for load relief, voltage support and reducing outages. Among the jurisdictions that have adopted this requirement are California, Colorado, Delaware, District of Columbia, Hawaii, Maine, Michigan, Minnesota, Nevada, New York and Rhode Island. Some states, including Hawaii and North Carolina, also have spearheaded efforts to integrate distribution system planning with generation and transmission planning (Schwartz 2020; Frick et al. 2021).

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[5] https://www.energy.ca.gov/proceedings/energy-commission-proceedings/flexible-demand-appliances

Crosscutting Strategies

Three related strategies cut across policies, regulations, standards, and programs to support grid-interactive efficient buildings and demand flexibility: advancing equity, using metrics and considering time-sensitive value.

Energy equity. Recently, states have increased consideration of energy equity in decision-making through legislation, governors' executive orders, and actions by PUCs and other state agencies. For example, Washington Senate Bill 5116 (2019) and Oregon HB 3141 (2021) require equity be considered in decision-making for energy efficiency programs. States like Connecticut are beginning to take similar actions for demand flexibility. Executive Order No. 21-3 established the Connecticut Equity and Environmental Justice Advisory Council to advise the Connecticut Department of Energy and Environmental Protection (DEEP) Commissioner on integrating environmental injustice and energy equity considerations for all programs, policies, and activities.

Using metrics. Appropriate metrics to align utility and state agency performance with state energy goals are needed to track and evaluate results of policies supporting demand flexibility. For example, the CPUC adopted the Total System Benefit metric to optimize energy and peak demand savings, plus GHG benefits, in a single metric for energy efficiency planning. The CPUC also is requiring this metric for the new Market Access Program for summer reliability, which relies on demand flexibility as well as energy efficiency.[6] How metrics are counted towards compliance with a state goal, as well as how performance is tracked and reported, also are important. Under Nevada's Renewable Portfolio Standard, energy efficiency savings receive a credit multiplier of 1.05; if savings occur during utility peak loads, the multiplier is 2.0.[7] Virginia's Lead by Example Energy Dashboard compiles, tracks, measures, and displays state agencies' energy use to highlight energy efficiency champions and best practices and pinpoint areas for needed efficiency measures toward achieving the state's energy goals.

Considering time-sensitive value. The time when efficiency reduces energy or demand, and when DERs generate or store electricity, determines their value to the grid (Eckman, Schwartz, and Leventis 2020). States have incorporated in policies and programs the timing of efficiency and other DER impacts to target savings when they are most valuable to the grid (Frick et al. 2019). For example, the Colorado Legislature required the state PUC to set goals for demand-side management plans to achieve peak demand reduction greater than or equal to 5% from 2019-2028, compared to a 2018 baseline. In Minnesota, load management is defined as an "activity, service or technology that changes the timing or efficiency of a customer's use of energy that allows a utility or customer to (1) respond to local and regional energy system conditions or (2) reduce peak demand for electricity or natural gas."

Increasingly, utility efficiency program planning and evaluation include a time-sensitive component. Connecticut's 2022-2024 Conservation Load Management Plans include peak demand reductions and active demand response strategies for utility customers such as modifying electric vehicle charging schedules or allowing smart thermostats to be adjusted remotely. In Texas, the state's Technical Reference Manual is updated annually to ensure a consistent definition of peak demand reduction across utilities and measures, as well as consistent energy values for evaluation. In California, the Database for Energy Efficient Resources defines peak period for energy efficiency savings calculations. The database was modified in 2018 to more closely align with the state's net load (CPUC resolution E-4952). Energy efficiency cost-effectiveness assessments also can include time-sensitive inputs. California and Massachusetts utilities have publicly available cost-benefit calculators for energy efficiency that provide hourly and seasonal values, respectively, to more accurately estimate its benefits.[8] Several New England states use standard Avoided Energy Supply Costs on an hourly basis to determine efficiency program cost-effectiveness.

Utility program design

A variety of utility program designs can encourage customers to align their electricity consumption with grid needs. One option is pay for performance programs, which provide incentive payments to customers for the efficiency savings that occur based on measurement. Consolidated Edison (ConEd) and the New York State Energy Research and Development Authority in New York are using this model for their Business Energy Pro program. Small and medium commercial customers with smart meters can participate in the program. They are compensated for savings measured from weather-normalized smart meter data. Seattle City and Light offers a similar program for its large commercial customers. Pacific Gas & Electric has offered its residential customers a pay for performance program since 2017.[9]

Utilities also can offer programs to address multiple DERs to achieve demand flexibility. For example:

- In Massachusetts, energy efficiency funds can be spent on active demand reduction (energy efficiency, demand response, and batteries).
- In Vermont, efficiency funds can be used to reduce GHG emissions through thermal and transportation efficiency.
- A portion of distributed solar incentives is allocated to heat pump water heaters in California, including a set-aside for vulnerable households, to shift load to off-peak periods.
- Southern Company offers a package of measures for its Georgia and Alabama Smart Neighborhood™ demonstration projects which integrate (among other things) energy efficiency, demand response, and storage technologies.
- In Hawaii, HECO is using Grid Services Purchase Agreements to aggregate, forecast, and coordinate DERs like PV, battery systems, and grid-enabled water heaters for energy, capacity, reserves, and frequency control to keep electric grids stable and reliable.
- The Arizona Corporation Commission required Arizona Public Service to file an aggregated distributed demand-side resources tariff on June 1, 2022, and compensate aggregators and customers for resulting benefits, including capacity, demand reduction, load shifting, locational value, voltage support, and ancillary and grid services. While the initial filing includes only storage, energy efficiency and demand response also are eligible for future offerings under the tariff.

Another program design option is considering the locational value of energy efficiency and other DERs to inform customer incentives. Portland General Electric's Smart Grid Testbed is evaluating a wide range of DER technologies and customer value propositions for demand flexibility, focused on three distribution substations representative of its service area. In New

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[6] See Proposed Decision, Order Instituting Rulemaking Concerning Energy Efficiency Rolling Portfolios, Policies, Programs, Evaluation, and Related Issues, Rulemaking 13-11-005, adopted December 2, 2021, https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M427/K959/427959221.PDF.

[7] Nevada portfolio energy credit trading program: https://puc.nv.gov/Renewable_Energy/RPS/PEC_Trading_Program/. Accessed May 24, 2022.

[8] Berkeley Lab recently developed a publicly available time-sensitive calculator: https://emp.lbl.gov/publications/time-sensitive-value-calculator.

[9] For more information, see https://www.recurve.com/blog/video-pg-es-residential-pay-for-performance-program.

York, the cost-effectiveness guidelines for efficiency programs include locational value. The state also has dynamic load management programs that are designed to maintain distribution system reliability. For example, ConEd has a program for Commercial System Relief (21 hour notice) and Distribution Load Relief (2 hour notice) that provide different payments based on location.

Coordination between utilities, regional grid operators, and state and local governments

Coordination between utilities and the regional grid operator is a critical component to promoting aggregation of DERs to enable the success of communities of efficient, grid-interactive buildings. For example, the CPUC requires that utilities coordinate with the California Independent System Operator (CAISO) to appropriately value demand response and establish Resource Adequacy (RA) requirements. Currently, event-based utility demand response programs receive capacity credit only if they are integrated into the CAISO market or embedded in the California Energy Commission's base case load forecast (CPUC Decision 15-11-042). RA capacity from utility demand response programs is allocated to load-serving entities as credits counted towards their RA requirements, as determined by CAISO (Decision 09-06-028). The CPUC also established a Load Shift Working Group to develop proposals for new models for demand response to integrate into CAISO markets (see final report).

In Illinois, retail demand response products must satisfy requirements of the regional grid operator, including any applicable capacity or dispatch requirements (Public Act 099-0906). New England energy efficiency and demand response program administrators bid into ISO-NE forward capacity markets.

The Louisiana PSC began a proceeding in 2019 to develop rules for third-party aggregators in order to, among other goals, promote participation of demand response in Regional Transmission Operator wholesale markets and programs in a manner that preserves the Commission's jurisdiction, authority, and ability to regulate and monitor those efforts (Docket 35135).

Utility programs also can be coordinated with state and local government programs. For example, Ameren’s Income Qualified Initiative provides energy audits, installs energy efficiency measures and advanced thermostats, and provides whole-house retrofit services for state weatherization participants (evaluation plan), and ComEd provides data for customers to comply with local benchmarking requirements.

Metering and meter data

Advanced metering infrastructure (AMI) deployment and customer access to meter data can provide utilities and customers with important access to system level data. AMI is in place, or deployment has been approved, for most utility customers. Some 107 million smart meters were deployed as of 2020, covering 75% of U.S. households (Cooper and Shuster 2021; see DOE (2020) AMI in Review for status by state and utility).

Demand flexibility programs are often included in utility AMI proposals. For example, Atlantic City Electric’s AMI application (Docket EO20080541) includes programs to “enable customers and utilities to take advantage of technology to manage energy consumption, enhance opportunities for demand response and load shifting, and respond to price signals." The utility intends to incorporate air-conditioning load-shifting capabilities.

AMI enables utilities and third parties to provide customers with access to better information to allow them to align their energy use with grid needs, emissions reductions, and bill savings. States can establish policies on data access and privacy to enable energy efficiency and demand flexibility. The Hawaii PUC's Data Access and Privacy Policy includes requirements for data availability for customers, data hosting policies, third-party access, a data access and privacy framework, and customer usage data available through a customer portal. Texas offers a statewide online data portal, Smart Meter Texas,™ that provides 15-minute interval data to customers through a user dashboard. Energy management tools on a web portal or mobile device also provide customers access to energy information. In Maryland, PEPCO's Gateway Hub enables customers to use their cell phone to control and monitor their smart home (e.g., smart thermostat, plugs and switches) from any location.

Rate design

Historically, residential consumers have had limited rate design options. Most residential consumers enrolled in time-based rates — a small fraction of all residential customers — are on basic time of use rates with static on- and off-peak pricing.

Regulators can promote demand flexibility and energy efficiency by encouraging utilities to offer time-based rates with strong price signals and opt-out provisions. California and Colorado (Public Service of Colorado only) have adopted default time of use rates for residential customers. In Maryland, PEPCO's Peak Energy Savings Credit provides $1.25 per kilowatt-hour a customer saves below their average energy use on peak demand days. Enrollment is not required.

Another option is to consider rates more reflective of hourly system costs. Public Service of Colorado has a voluntary critical peak pricing rate for commercial customers. In Illinois, ComEd Hourly Pricing is available to residential customers, with rates based on wholesale market prices. In addition, demand charges can be based on the utility system peak, rather than a customer's highest, non-coincident peak demand. Rocky Mountain Power is among the utilities that has adopted such an approach for demand charges for large commercial customers.

Trends and Gaps

Trends—prevailing tendencies or inclinations—that we observed from our research include the following:

- States are beginning to incorporate demand flexibility in building energy codes and appliance and equipment standards.
- A growing number of states are including energy efficiency's time-varying and peak demand reduction value, as well as demand response, in energy efficiency resource standards. Some states are including demand response in clean energy standards.
- Utility planning requirements are slowly evolving to enhance valuation of energy efficiency and demand response for meeting resource needs for the bulk power system.
- Integration of utility programs for energy efficiency and demand response is increasing in tandem with peak demand reduction goals, but at a slow pace.
- Improvements are underway in a number of states related to assessing the cost-effectiveness, potential, tracking, and performance of energy efficiency and demand

flexibility, reflecting enhanced methodologies and additional metrics, such as time and locational value and GHG emissions.

- The number of states requiring utilities to file distribution system plans for PUC review, including consideration of non-wires alternatives (energy efficiency, demand response, storage, distributed generation, and managed vehicle charging), is rapidly increasing.
- Formal coordination of utility DR planning and programs with regional grid operators remains nascent in most areas; however, CPUC and regional PUC organizations (e.g., New England Conference of Public Utilities Commissioners and Organization of MISO States) regularly engage in regional transmission operator/independent system operator meetings and proceedings.
- Availability of AMI, data access, and time-varying rates is increasing.
- States are beginning to explore the role of demand flexibility in meeting other energy goals — e.g., decarbonization, grid modernization, electrification and renewable energy. Related energy plans, policies, programs, and regulations are beginning to reflect demand flexibility's potential contributions.
- The number of states with revenue decoupling for electric utilities has remained relatively stable in recent years.
- A growing number of states are refining energy efficiency and demand response performance incentives for utilities to target demand reduction when and where it is most valuable.

Despite numerous actions taken to promote energy efficiency and demand flexibility, significant gaps remain. Among them:

- **Building energy codes and appliance/equipment standards** - Changes in building energy codes, building performance standards, and appliance standards to address time-varying value of energy efficiency and demand flexibility, open standards for communication, and automated load management are nascent. Lack of standards discourages innovation in technologies and services.
- **Resource standards** - Most energy efficiency resource standards do not address efficiency's contribution to peak demand reduction or account for the time-varying value of efficiency, and most resource procurement requirements do not specify demand response/demand flexibility.
- **Utility planning** - Most utility integrated resource plans do not analyze energy efficiency and demand response in a manner comparable to analysis of supply-side resources, and states do not require transparent distribution system planning, including analysis of non-wires alternatives. Those that do lack experience in reviewing filed plans. Utility resource and program planning is not well-coordinated with regional grid operators.
- **Equity** - Utility plans traditionally have not included equity strategies in a systematic way. Equitable distribution of program benefits often is not considered in program design, evaluation, and reporting.
- **Utility programs** - Energy efficiency program goals often do not include peak demand reduction, energy efficiency and demand response programs remain largely siloed, multi-DER programs (e.g., energy efficiency + demand response + storage)

are rare, and the customer value proposition for demand flexibility is not well understood. Cost-effectiveness for energy efficiency programs and portfolios do not fully account for all potential benefits or account for time and locational value.

- **Potential assessments** for demand response are not regularly performed. Demand response programs typically are targeted to a narrow set of potential grid services. Most of these programs are for load shedding, not load shifting — important for integrating variable renewable energy resources and managing increased electrification.
- **AMI, meter data, and rate design** - Most customers do not have access to granular energy usage data, time-varying rates, or automated equipment and services. Participation rates in most time-varying rates are low, and most retail rate designs are not sufficiently granular in time and do not vary by location.
- **State programs** - Energy efficiency incentive and financing programs typically do not include a full range of potential demand response measures or use metrics that encourage demand response/demand flexibility measures. Most state lead-by-example programs focus on annual energy savings rather than peak demand reduction or load-shifting. Energy-saving performance contracting does not incorporate demand savings.
- **State energy planning, policies, and regulations -** Demand flexibility would help states achieve their energy goals, but most states do not consider time-sensitive value of energy efficiency or demand flexibility in their energy plans, policies, and regulations.

Conclusion

This paper presented a typology of demand flexibility policies, regulations, standards, and programs to support grid-interactive efficient buildings, demand flexibility, and Virtual Power Plants in 10 categories: building energy codes, appliance and equipment standards, resource standards, utility planning, utility programs, advanced metering infrastructure and metering data, rate design, state programs, state energy planning, and related state policies and regulations. We provide many examples of policy actions states are taking today in each category. States (and other jurisdictions) can review these policy options and examples to assess their status toward enabling advances in energy efficiency, demand flexibility, and grid-interactive buildings to take advantage of lessons learned. Accordingly, states can tailor such policy solutions – based on their market conditions, climate, building stock, utility and regulatory environment, resources and other state-specific factors – to cost-effectively achieve their own energy-related goals.

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