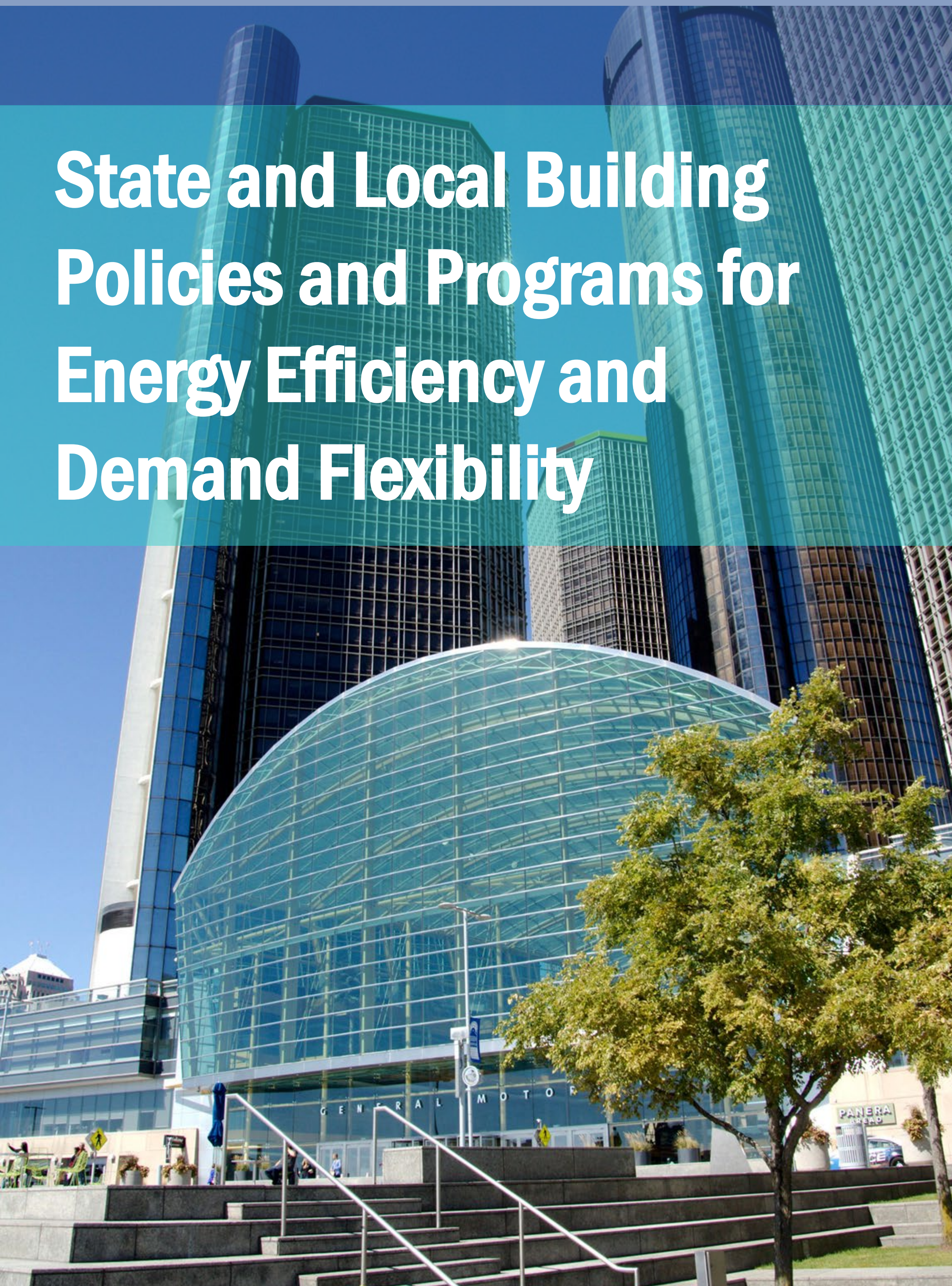
State and Local Building Policies and Programs for Energy Efficiency and Demand Flexibility



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Disclaimer

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Introduction

A growing number of states and localities are adopting policies and programs to improve building energy efficiency. State Energy Offices and other state and local policymakers and officials recognize that energy-efficient buildings deliver benefits that support multiple policy objectives, including reducing pollutant emissions, lowering energy-related costs, and improving building stock value and productivity. Expanding building energy efficiency policies and programs to include demand flexibility (DF) can amplify these benefits and more.

The advent of DF through smart building energy management, grid-interactive equipment, and other distributed energy resources (DERs) (demand response [DR], onsite power generation, thermal and electrical energy storage, and electric vehicles and their charging equipment) allows grid-interactive efficient buildings (GEBs) to adjust *when* as well as how energy is used, saved, and even sometimes exported to the grid. DF can lower costs, support energy reliability and resilience, and reduce emissions by decreasing stresses to the grid, increasing utilization of clean energy resources, and reducing reliance on higher emitting and higher cost generation. Within a building, facility, or even community, DF can coordinate critical loads with onsite generation and energy storage (including through microgrids) to support critical functions during an outage or energy emergency, further supporting resilience. DF expands benefits beyond what energy efficiency alone can provide.[1] Table 1 notes some of the more readily monetizable benefits to building owners that DF can deliver. Other economic, environmental, reliability, and resilience benefits accrue to owners, occupants, communities and society.

Table 1. Some Building Owner Value Streams from Demand Flexibility*

Energy costs	Lower electricity, natural gas, and other energy bills from reduced consumption due to energy efficiency and conservation.
Demand charges	Lower electricity bill demand charges from reducing peak building or facility demand.
Time-of-use and time-differentiated rates	Lower electricity bills from shifting usage of grid power from higher cost periods to lower cost periods; may include thermal or electrical energy storage; may include onsite generation.
Demand response programs	Compensation for reducing demand for grid power ("curtailment") during utility or grid operator declared periods of very high grid power demand ("DR events"); may include use of stored or onsite generated power; may include participation in a grid capacity market directly or indirectly (e.g., via DR service provider).
Grid service markets	Compensation for participation in grid service markets, such as for ancillary services, energy, and capacity (overlaps with DR programs); may involve export of onsite generated or stored power to grid; may include direct or indirect (via DR or other service provider) market participation.

* This table does not include utility or state incentives that may be offered for energy efficiency, storage, renewable generation, and other measures. Nor does it include other potential values that may or may not be readily monetizable (e.g., property value increase, insurance premium reduction, productivity improvement) but should be considered, such as enhanced energy reliability and resilience, power quality, building/facility operational benefits, occupant comfort and amenity, and environmental benefits (including emission reduction).

However, the growing building energy policy and program tool kit largely centers on energy efficiency, with key metrics being annual energy use and energy use intensity—EUI, a metric of energy

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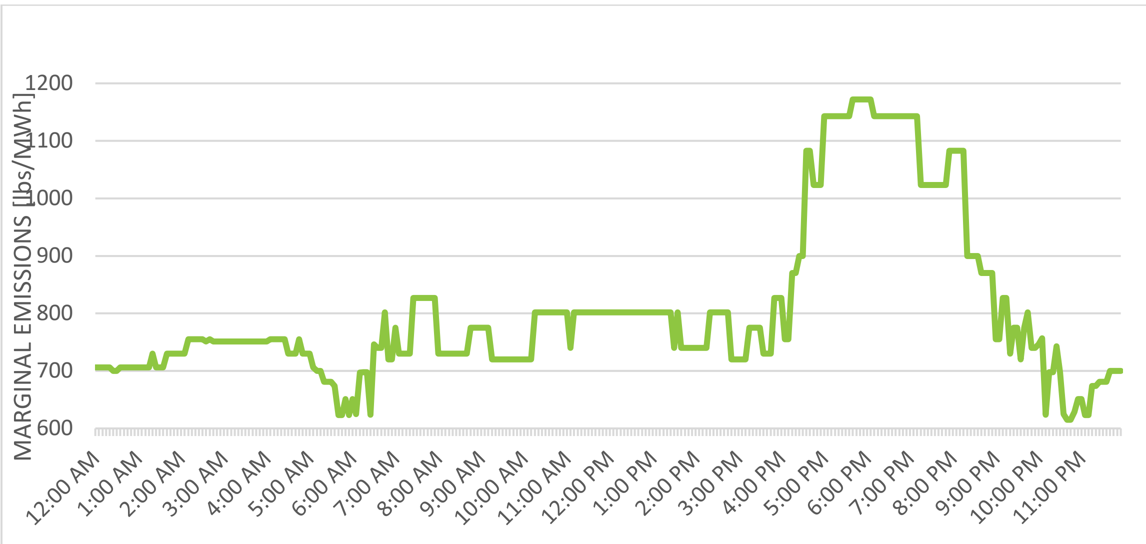
[1] Efficiency should generally be the first energy management priority. A highly energy efficient building with less energy demand to adjust will have less adverse impacts on the grid, costs, and emissions than a less efficient building that has more energy demand that can be adjusted.

consumption usually in British thermal units (Btu) per square foot of building space. These metrics are very useful, but they do not reflect that a kilowatt-hour (kWh) of electricity consumed at one time may have a very different cost, emissions profile, and effect on grid operations than a kWh may have when used at another time.[2] For example, Figure 1 shows marginal carbon dioxide (CO_2) emission rates over the course of a January day in the ISO-New England grid, with an almost two-fold difference in the marginal emission rate per megawatt-hour depending on time of day.

Figure 1. ISO-New England CO_2 Marginal Emissions Rates, January 5, 2017[3]



Source: WattTime (used with permission)

This report discusses a selection of building energy policies and program types that have focused on energy efficiency but that states and localities can modify and evolve to include DF and grid impact parameters. Among these are:

- energy benchmarking,[4]
- voluntary and mandatory building rating and labeling programs, and
- building performance standards.

Several other policies considered in this report include building energy codes (which apply to new construction and major renovations), appliance and equipment standards (that are not building policies per se but affect demand flexibility), and zoning and land-use regulation.[5, 6]

[2] Even energy efficiency measures can have differing time-differentiated impacts. For example, west-facing shading provides most energy savings during hot afternoons when air conditioning demand may be high, in contrast to LED exit lamps that provide the same energy use and savings at all hours, days, and seasons.
[3] Derived from Richardson, H., 2020, "Real-Time Emissions Load Shifting," NASEO-NARUC GEB Working Group Webinar: Emission Aspects of Demand Flexibility, June 4, 2020.
[4] Often building energy benchmarking is coupled with disclosure, also called transparency, requirements. They can also be linked to rating and labeling, additional actions (e.g., energy auditing, "tune-ups," and retrocommissioning), and building performance standards.
[5] This report does not discuss state and utility ratepayer-funded programs that can provide incentives for DF equipment and operations. Nor does this report address funding mechanisms such as Energy Savings Performance

This report also considers that state and local jurisdictions need appropriate capabilities to develop and implement DF-oriented policies. These include metering, data, metrics, and analytic tools, among others. It recognizes that DF-oriented features can be built onto energy efficiency policies in a staged or phased manner comporting with the jurisdiction's experience and resources.

As with building rating and labeling programs, some DF-oriented policies can be based on "asset ratings," i.e., the modeled performance of a building based on its construction and equipment characteristics, while others focus on actual building performance which depends on how it is operated and used. This report also notes proposed metrics to characterize building performance as grid assets, such as those developed by the GridOptimal Building Initiative.[7]

Table 2. summarizes some factors that can be incorporated into building policies to reflect DF capabilities or performance to augment energy efficiency metrics, characteristics, or requirements.

Table 2. Summary of Demand Flexibility Factors Applicable to Building Policies and Programs

Factor	Factor description	B&T[a]	Rating, labels[b]	BPS[c]	Codes[d]	Appl. stds.[e]	Zoning[f]
Peak Demand[g]	Monthly building peak electricity demand	x	x	x			x
Peak Demand Intensity	Monthly building peak electricity demand per sq. ft.	x	x	x			x
Coincident Peak Demand[h]	Building electricity demand during grid peak periods	x	x	x			
Localized Coincident Peak Demand	Building electricity demand during localized peak periods	x	x	x			x
DR Participation	Participation in demand response (DR) programs	x	x	x			x
DR/DF Capability	Building management system, equipment DR and DF capability	x	x	x	x	x	x
Time-Differentiated Emissions	Emissions calculation considers varied grid generation over time	x	x	x			
Time-Differentiated Cost-Effectiveness	Cost-effectiveness analysis considers time-of-use/time-differentiated utility rates and valuation				x	x	

Contracting (ESPC), Energy-as-a-Service (EaaS), Property Assessed Clean Energy (PACE) financing, and utility on-bill finance programs. NASEO, "Wringing More Value from Building Energy Operations and Upgrades: Monetizing Demand Flexibility in Public and Institutional Buildings" (https://www.naseo.org/data/sites/1/documents/publications/Wringing%20More%20Value%20Monetizing%20DF%20Feb%202021.pdf) explores public building procurement and service options, including ESPC and EaaS, as mechanisms to advance DF and GEBs

[6] Also not covered is the Low-Income Housing Tax Credit (LIHTC) Program in which state housing finance authorities allocate credits to qualifying projects and may use energy and environmental criteria that could include DF-related provisions. Bartolomei, D., nd, "State Strategies to Increase Energy and Water Efficiency in Low Income Housing Tax Credit Properties," Energy Efficiency for All, https://www.energyefficiencyforall.org/resources/state-strategies-to-increase-energy-efficiency-in-low-income-housing-tax-credit-properties/.

[7] New Buildings Institute, The GridOptimal Buildings Initiative, https://newbuildings.org/resource/gridoptimal/.

X denotes potential applicability of the factor for the policy or program
a Benchmarking and transparency
b Rating and labeling
c Building performance standards
d Building energy code
e Appliance and equipment standards
f Zoning and land use regulation
g As used in this report, there are multiple definitions for peak demand.
h A greenhouse gas or carbon emission coincident peak demand factor could also be considered for building electricity use during highest grid emissions periods. This would be a more complex factor.

Coverage of these policies and programs in this report is at a high level rather than comprehensive. Ideas for adding DF and grid-interactive parameters are exploratory, meant to incite additional investigation, analysis, and consideration. There are likely other DF-related factors and parameters that can be added as well as other policy and program options to consider.

Building Energy Efficiency Policies and Programs and Demand Flexibility

The increasing number of states and local jurisdictions adopting new building energy policies parallels growing variation of those policies and their interactions. Benchmarking, labeling, and performance standards for existing buildings are relatively new, evolving approaches that strongly interact. Hence, discussion of these approaches and means to advance DF aspects through them overlap considerably.

Building energy codes that govern new construction and major renovations are of a somewhat different nature, having been widely implemented for years and sometimes decades in many jurisdictions, revised periodically, and subject to state and local variation. However, their inclusion of time-differentiated energy use and DF is at a very early stage. The situation is similar with appliance energy standards, which have existed for years. Although appliance standards are not building policies per se, requiring grid-interactive capabilities can facilitate building level demand flexibility and provision of grid-services.

Finally, while zoning and land-use regulation have had significant impact on energy consumption patterns, by regulating land uses and development density, which, in turn, affect building and transportation energy use, so far there are few but increasing numbers of provisions that directly affect building or facility energy features and performance. Zoning and land-use policies may offer new opportunities to enhance energy efficiency and DF, including for siting of DERs and integration of electric vehicles (EVs) and their charging equipment (electric vehicle supply equipment—EVSE) with buildings and grid.

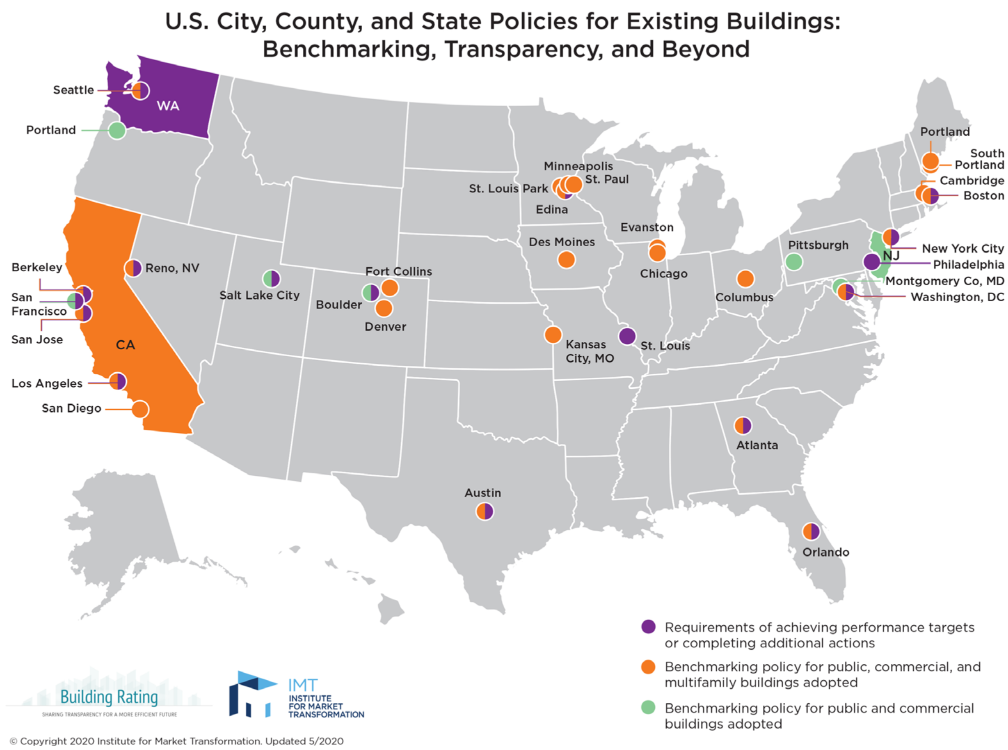
Same or similar metrics and parameters can apply to multiple policy and program types, though sometimes with differing specifics. Thus, some discussion points appear several times in this report, tailored to each policy and program type.

Benchmarking

As of May 2020, three states and at least 33 localities (cities and counties) in the United States had some form of building energy benchmarking policies in place.[8] (See Figure 2.) These are often coupled with transparency requirements (public disclosure of benchmarking data) and in some cases provisions for additional measures, such as periodic energy audits, building retrocommissioning or "tune-ups," and, in several cases described later, building performance standards.[9]

Benchmarking and transparency allow building owners to compare their energy performance with that of other peer buildings, helping to identify improvement opportunities. Transparency provisions disclose performance to occupants, potential tenants and buyers, and the public to encourage owners to improve their buildings' performance out of commercial self-interest. Better performing buildings are more attractive to potential buyers and tenants, which may raise their value. Also, owners may care about reputational impacts of their buildings' ratings.

Figure 2. U.S. Jurisdictions with Existing Building Benchmarking and Related Policies



Source: BuildingRating.org and Institute for Market Transformation (used with permission)

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[8] BuildingRating.org, "U.S. Building Benchmarking Policy Landscape," https://www.buildingrating.org/graphic/us-building-benchmarking-policy-landscape.

[9] Institute for Market Transformation (IMT), "Comparison of U.S. Commercial Building Energy Benchmarking and Transparency Policies," https://www.imt.org/wp-content/uploads/2020/10/IMT-Benchmarking-Matrix-Feb-2021.pdf.

Buildings covered by these policies differ by jurisdiction. They generally apply to larger commercial and public/governmental buildings; many include multifamily residential buildings too. Minimum building size applicability thresholds mostly range from 3,000 square feet [sf] to 50,000 sf, with some exceptions.

Most or all U.S. building benchmarking policies rely on the U.S. Environmental Protection Agency's (EPA) ENERGY STAR Portfolio Manager tool, which uses information about the building, its uses, and its energy consumption to develop a 1 to 100 score denoting how the subject building compares to peer buildings.[10] Property use details and weather are considered in the calculation. A score of 50 denotes median energy performance while 75 or higher represents high performance that may be eligible for ENERGY STAR certification. EUI is central to development of the score and often serves as a standalone metric to compare a building's performance to its peers and, perhaps, to policy objectives (e.g., EUI or EUI percent improvement targets). Portfolio Manager can also estimate a building's energy-related greenhouse gas footprint from onsite fuel combustion (such as natural gas and fuel oil), purchased electricity, and purchased steam, hot water, and chilled water from district energy systems. However, while Portfolio Manager or the use of fixed average per kWh emission rates provide a useful guide, they do not reflect that *when* electricity is consumed can have significant impact on a building's emission profile because the blend of grid generation and associated emissions varies over the course of a day and week, and seasonally.

NASEO is unaware of current benchmarking and transparency policies that include information on building peak demand, coincident peak demand (i.e., building demand during grid peak periods), or participation in demand response (DR) programs. Nor do these policies use time differentiation of electricity use to provide more accurate emission impact data. There are at least several ways that benchmarking and transparency policies can be enriched to reflect these other factors.[11]

	Peak Demand	Peak Demand Intensity	Coincident Peak Demand	Localized Coincident Peak Demand	DR Participation	DR/DF Capability	Time-Differentiated Emissions	Time-Differentiated Cost-Effectiveness
B&T	x	x	x	x	x	x	x	

Peak demand and demand intensity. Buildings subject to electric utility demand charges (most, if not all, larger buildings subject to benchmarking requirements), can report their monthly peak demand (kW) and demand intensity (kW/sf), analogous to their reporting of energy use (kWh, Btu) and EUI. The demand charge on a commercial electric bill is often based on the month's highest 15 minutes, 30 minutes, or hour of demand. To avoid skewing a building's report due to a single anomalous period of high demand, jurisdictions considering adding this factor in their benchmarking policy could have the

[10] Portfolio Manager also has modules for water consumption and waste disposal, not discussed here. U.S. EPA, ENERGY STAR, Portfolio Manager, https://www.energystar.gov/buildings/tools-and-resources/portfolio-manager-0.

[11] In addition to this report, see Mims Frick, N., 2020, "Incorporating Demand Flexibility into State Energy Goals," starting on slide 44 of the Grid Interactive Efficient Buildings Working Group Public Buildings and Potential Cohort Meeting (December 7, 2020) presentation, for discussion and some model benchmarking and transparency policy language, https://www.naseo.org/Data/Sites/1/v2_geb_meeting_dec_7_2020b.pdf.

building average its 10 highest hours of demand of the year. This would be consistent with what is called the *adjusted maximum reference demand* (AMRD) in the GridOptimal suite of demand flexibility metrics.[12]

Coincident peak demand. Coincident peak demand is a building's electricity demand during the electricity system's overall peak demand. A building that reduces or shifts demand for grid-supplied power away from those periods is more "grid friendly" in that it contributes less to grid stresses and costs (and, perhaps, emissions). The electric utility or grid operator may calculate monthly or annual system peaks; infrequently, utilities may use that for billing purposes too.[13] To avoid reporting based on unrepresentative, anomalous conditions, GridOptimal describes a *Grid Peak Contribution* metric based on a building's demand during the grid's top 5% of peak hours. More specifically, it divides a building's demand by its AMRD for each of the grid's highest 5% of demand hours of the year, then averages that result to derive a score.[14]

Localized coincident peak demand.[15] A variation of a coincident peak demand metric, subject to availability of requisite utility data, would be to evaluate a building's demand relative to peak demand at a distribution substation or other local area.[16] Building impacts on local electricity distribution are increasingly important factors in electric system operations and planning as distribution upgrade costs rise, more DERs (e.g., solar generation and batteries) are installed, and electrification of space and water heating and transportation (EVs) occurs. Like the system-level grid peak contribution metric, the localized version could be based on relative building demand during, say, the 5% highest demand hours on the substation or in the local area.

Demand response program participation. Benchmarking and transparency policy could be amended to require building owners to indicate their participation in utility or other grid operator (e.g., Independent System Operator/Regional Transmission Operator [ISO/RTO]) programs that may be available to them as well as use of a third party DR service provider (also called DR aggregator or curtailment service provider) to provide DR and DF services.

Demand response and demand flexibility capability. If DR programs are not currently available, building owners could be required to report on the capability of their building management systems and, as

[12] Miller, A., and K. Carbonnier, 2020, New Metrics for Evaluating Building-Grid Integration, 2020 ACEEE Summer Study on Energy Efficiency in Buildings https://newbuildings.org/wp-content/uploads/2020/11/NewMetricsForEvaluatingBuildingGridIntegration.pdf.

[13] For example, Ft. Collins (Colorado) Utilities, https://www.fcgov.com/utilities/business/manage-your-account/rates/electric/compare-facility-demand-and-coincident-peak

[14] Miller and Carbonnier, op. cit.

[15] IMT includes both coincident peak demand and localized coincident peak demand in its model building performance standard ordinance. As discussed here, such metrics can be applied to benchmarking, rating and labeling, and other policies and programs. See https://www.imt.org/resources/imt-model-bps-ordinance-summary/ for more on the model ordinance and related resources and "Opportunities to Advance Demand Flexibility with Building Performance Standards," https://www.imt.org/wp-content/uploads/2021/01/IMT-Opportunities-to-Advance-Demand-Flexibility-with-BPS.pdf.

[16] For example, Consolidated Edison has 50 substations serving 69 networks in its New York City service territory. "Appendix A – Con Edison Electric System Overview," http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7B30F9C052-25D8-4271-B096-DF90C69A55EB%7D

applicable, particular equipment, such as heating, ventilation, and air-conditioning (HVAC), water heaters, and lighting controls, to respond to future DR signals from the utility, grid operator (ISO/RTO), or a third party DR service provider, should such opportunities be made available. The Leadership in Energy and Environmental Design (LEED) rating system (discussed below in the rating and labeling section) has an optional Grid Harmonization credit that may provide useful ideas for benchmarking and transparency programs.[17]

Time-differentiated emissions calculation. Many benchmarking policies are driven not only by interest in energy efficiency and costs but also by emission concerns, including greenhouse gases (carbon dioxide equivalents [CO_2e]) and, sometimes, other emissions.[18] ENERGY STAR Portfolio Manager enables emissions estimation but does not include the time variation of power sector emissions. With hourly grid-power consumption data, several tools allow more accurate emissions impact estimates and, thus, would better identify building emissions performance. *Time-differentiated emissions quantification would also help State Energy Offices, environmental agencies, and local officials to better understand progress toward meeting policy targets.* The EPA AVoided Emissions and geneRation Tool (AVERT), WattTime, and, sometimes, utility or ISO/RTO data can provide hourly marginal power sector emissions estimates.[19] Other tools may also be available.[20]

Also, potentially useful for benchmarking policy development, the U.S. Green Building Council (USGBC) LEED Steering Committee approved a pilot "alternative compliance path" to earn Grid Harmonization points based on calculating and reporting GridOptimal metrics performance. These metrics cover several factors described above.[21] (See Appendix A for pertinent LEED provisions and Appendix B for a description of GridOptimal.)

Ratings and Labels

This section does not delve deeply into the details of specific rating, labeling, and related certification programs. Rather it centers on options to augment programs to better include and encourage DF features and performance.

Energy rating and labeling programs and policies are a form of disclosure that enable others (e.g., current or potential occupants and tenants, property buyers, or the public) to learn of a property's energy characteristics. Ratings and labels may reflect a building's or facility's actual performance (such as EUI used in benchmarking) or how it could perform based on its construction and equipment, also known as an "asset rating." The latter considers insulation, envelope and duct tightness, window characteristics, efficiency of HVAC, lighting fixtures, and building controls, among other factors. This is in

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[17] U.S. Green Building Council, LEED Grid Harmonization, https://www.usgbc.org/credits/existing-buildings-schools-existing-buildings-retail-existing-buildings-data-centers-exis-59?return=/credits/Existing%20Buildings/v4.1

[18] Clean Air Act criteria pollutants are ground-level ozone (component of "smog"), nitrogen oxides (NOx, a precursor of ground-level ozone; technically, nitrogen dioxide is the regulated NOx), particulate matter, sulfur dioxide, carbon monoxide, and lead.

[19] NASEO-NARUC GEB Working Group Webinar: Emission Aspects of Demand Flexibility (June 4, 2020) Colby Tucker (EPA), Henry Richardson (WattTime), Nancy Seidman (Regulatory Assistance Project) https://naseo.org/event?EventID=7215

[20] The National Renewable Energy Laboratory (NREL) has developed annually updated, long-run (to 2040) marginal emissions factor "Standard Scenarios" datasets by state and its Cambium scenario viewer that may be useful https://www.nrel.gov/analysis/standard-scenarios.html

[21] USGBC, LEED GridOptimal Building ACP, https://www.usgbc.org/credits/gridoptimal-152-v4.1.

contrast to how the building is actually operated, acknowledging that occupant and operator behavior have large impacts on energy performance. A well-designed and equipped building may be operated poorly, underperforming its potential, while a mediocre-equipped building may be operated well to outperform expectations. Ratings and labeling or certifications generally consider building types so that peer or similar buildings are compared, recognizing that office buildings, homes, hospitals, sports arenas, retail stores, warehouses, and other building types have different energy use characteristics.

There are both voluntary and mandatory rating and labeling programs. Since the 1990s, the LEED rating system has existed as a voluntary program that includes energy and non-energy environmental parameters, with certifications for building design and construction (BD+C: New Construction in LEED nomenclature) and existing building operations and maintenance (O+M in LEED nomenclature).[22] Certification to or otherwise meeting certain LEED or other criteria can complement other policy mechanisms, such as tax incentives and zoning and land-use processes (see below).

Most LEED energy-related provisions concern energy efficiency and renewable energy. However, its Grid Harmonization provision offers BD+C and O+M points related to building-grid integration, including demand flexibility and management strategies.[23] As noted, LEED now has a pilot "alternative compliance path" for achieving Grid Harmonization points based on the GridOptimal set of metrics (see Appendix B).[24] Also, there are BD+C points available for including grid-interactive DF capabilities under "Electric Vehicle" and "Advanced Energy Metering" categories. See Appendix A for DF-pertinent provisions. LEED is currently used by many states and local governments for public building leadership-by-example policies and can be used as criteria for financial or land use approval incentives. According to USGBC, some jurisdictions with priority goals specify which credits a project must achieve to meet requirements or earn incentives, known as "directed use."[25] Jurisdictions with a priority for building-grid optimization could use this approach.

ENERGY STAR building certification is also a longstanding voluntary program, with over 2 million ENERGY STAR Certified Homes built and over 36,000 commercial buildings earning certification.[26] Other green building certifications, such as Green Globes, Passive House, and EarthCraft, also exist.[27, 28, 29, 30] Also, rating systems can interact and be cross referential. For example, some LEED points can be earned for

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[22] There are also LEED residential, interior design and construction (ID+C), and cities and communities rating systems. USGBC, LEED v4.1, https://www.usgbc.org/leed/v41.
[23] USGBC, LEED Grid Harmonization, op. cit.
[24] USGBC, LEED GridOptimal Building ACP, op. cit. and LEED v4.1 Grid Harmonization GridOptimal ACP Accompanying Guidance https://www.usgbc.org/resources/leed-v41-grid-harmonization-gridoptimal-acp-accompanying-guidance
[25] Beardsley, E., USGBC, personal communication, February 1, 2021.
[26] U.S. EPA, What is ENERGY STAR, https://www.energystar.gov/about and U.S. EPA, ENERGY STAR by the Numbers, https://www.energystar.gov/about/origins_mission/energy_star_numbers.
[27] Green Globes, http://www.greenglobes.com/home.asp.
[28] Passive House Institute US, Inc., https://www.phius.org/home-page.
[29] International Passive House Association, https://www.passivehouse-international.org/index.php?page_id=249.
[30] EarthCraft, https://earthcraft.org/.

meeting conditions that include achieving requisite ENERGY STAR criteria or Home Energy Rating System (HERS) Index scores.[31]

The widespread use of the ENERGY STAR Portfolio Manager reporting tool has made it the de facto standard for many existing mandatory commercial building energy policies as well as the basis for voluntary ENERGY STAR ratings and certifications. Its strengths as well as its weaknesses in not currently reflecting time-differentiated energy use and DF apply across policies as well. Thus, many of the DF options discussed for benchmarking and transparency policies also apply to commercial building rating and labeling programs.

Rating and labeling of single-family and small multifamily residential buildings is getting more attention as means to improve energy performance.[32] ENERGY STAR Certified Homes have been built for years. The HERS Index administered by the Residential Energy Services Network (RESNET)—mainly used for new homes—and U.S. Department of Energy Home Energy Score—mainly for existing homes—are among the more widely used U.S. home energy rating systems. Residential labeling and disclosure policies are being adopted as voluntary or mandatory programs in multiple states and localities across the United States.[33] However, the HERS Index, Home Energy Score, and state and local residential labeling policies center on energy efficiency and annual energy use and cost without inclusion of DF and time differentiation of energy use.

Residential Energy Labeling

Approaches to residential energy labeling can be described in three ways- asset based, operational, or automated. **Asset based** labels use standard test criteria to describe a home's performance under standardized conditions. Home Energy Score and the HERS Index are asset based. **Operational scores** are derived from actual energy consumption data through utility bills and/or delivered fuel records. ENERGY STAR Portfolio Manager scores are operational scores. **Automated scores** use utility data and public records to generate a score for a structure. Automated scores are less common with few widely used examples. For more information, visit NASEO's EMPRESS project: https://empress.naseo.org/home-energy-labeling-tools

While few, if any, single-family or small residential buildings are subject to demand charges and few are under TOU tariffs, their potential for DF to reduce grid stresses and costs is very large.[34] Utilities seek household participation in DR programs to shed and shift cooling, heating, and water heating loads through air conditioner, smart thermostat, and water heater controls. The emergence of home energy management systems (HEMS), residential solar generation, and battery storage lead to more opportunities for residential DF. There is a growing number of state, utility, and community choice aggregator residential battery or solar-plus-storage programs that allow utilities to tap those DERs for grid services as "virtual

[31] Green Building Certification, Inc. administers LEED as well as the RELi rating system for resilient design, PEER rating system for power system performance and electricity infrastructure, and others that may have complementary or overlapping provisions. Green Building Certification, Inc., https://www.gbci.org/.
[32] NASEO, Home Energy Labeling, https://naseo.org/issues/buildings/home-energy-labeling.
[33] NASEO has a map identifying state and local residential energy policies and further discussion; https://www.naseo.org/issues/buildings/home-energy-labeling.
[34] Saul Rinaldi, K., E. Bunnen, and S. Rogers, 2019, "Residential Grid-Interactive Efficient Building Technology and Policy: Harnessing the Power of Homes for a Clean, Affordable, Resilient Grid of the Future," https://www.naseo.org/data/sites/1/documents/publications/AnnDyl-NASEO-GEB-Report.pdf

power plants" while also offering household energy resilience in case of outage.[35] As EV numbers increase, the scope for managed EV charging—i.e., incentivizing or controlling charging to avoid peak periods and utilize times of low demand—is also increasing as are nascent vehicle-to-building-to-grid options that would allow EV batteries to feed power back to buildings and the grid as warranted by grid conditions.

While current residential energy labeling systems have not included DF, the option to do so is there. RESNET created a working group to explore options for incorporating time-differentiated energy use and demand flexibility in the HERS Index.[36]

Many of the approaches suggested for including DF in benchmarking and transparency policies can also apply to both voluntary and mandatory rating and labeling programs.

	Peak Demand	Peak Demand Intensity	Coincident Peak Demand	Localized Coincident Peak Demand	DR Participation	DR/DF Capability	Time-Differentiated Emissions	Time-Differentiated Cost-Effectiveness
Rating & labeling	x	x	x	x	x	x	x	

Peak demand and demand intensity. Monthly peak demand (kW) and demand intensity (kW/sf), analogous to energy use (kWh, Btu) and EUI, can be reported and possibly indexed with similar buildings to allow comparison. The ENERGY STAR Portfolio Manager demand tracking feature can be used. Alternatively, as discussed for benchmarking, averaging a building's 10 highest hours of demand of the year, consistent with GridOptimal's AMRD would buffer the impacts of one or two anomalous hours that would otherwise skew the metric.[37]

Coincident peak demand. Reporting of coincident peak demand—the building's demand during periods of peak grid demand—indicates "grid friendliness" of the building. It can help identify options for shedding and shifting demand (including using onsite generation and storage if available) to reduce grid stresses and cost. The GridOptimal *Grid Peak Contribution* metric that compares building demand (relative to its AMRD) during the grid's highest demand 5% of hours offers a useful metric.[38]

Localized coincident peak demand. If relevant utility data are available, a coincident peak demand metric at the distribution substation or other local areas can show a building's impact on local electricity distribution, helping illuminate options for DF and DERs to support electricity reliability, resilience, and power quality, enhance clean energy resources, accommodate greater electrification, and mitigate costs. A localized version of the *Grid Peak Contribution* metric could be used.

[35] Some examples noted in Spector, J., 2020, "10 Victories for Virtual Power Plants in 2020," https://www.greentechmedia.com/articles/read/10-victories-for-virtual-power-plants-in-2020 .
[36] RESNET, 2019, "New Working Group on When Energy is Used/Load Flexibility Into HERS Scores," https://www.resnet.us/articles/new-working-group-on-when-energy-is-used-load-flexibility-into-hers-scores/.
[37] Miller and Carbonnier, op. cit.
[38] Ibid.

Demand response program participation. Ratings and labels can note DR program participation where available or use of DR service provider services. The LEED Grid Harmonization optional credit provides template criteria and language for users of that rating system.

Demand response and demand flexibility capability. If DR programs are not currently available, a rating and labeling system can include a building's capability to respond to future DR signals from the utility, grid operator (ISO/RTO), or a third party DR service provider, and/or to take advantage of TOU rates or dynamic, real-time electricity pricing. The LEED Grid Harmonization optional credit offers criteria and language that may be useful for users of that rating system.

Time-differentiated emissions calculation. Going beyond fixed average emission rate factors and the ENERGY STAR Portfolio Manager emissions estimation tool, hourly grid power consumption combined with hourly emission rate estimates from the EPA AVERT tool, WattTime, or utility or ISO/RTO data can provide more accurate views of a building's energy-based emissions footprint.[39]

The LEED pilot Grid Harmonization alternative compliance path based on GridOptimal metrics can also be used as part of rating and labeling programs and policies. Indeed, LEED is such a voluntary system.

Building Performance Standards

Various jurisdictions augment their building energy benchmarking policies to include additional actions, such as performing periodic energy audits, retrocommissioning, or building "tune-ups." Other actions may also be obligated. For example, New York City requires applicable existing and new buildings to have certain tenant spaces submetered. The city also mandated certain existing buildings to have one-time lighting upgrades to meet newer building energy code.[40] Usually existing buildings are not compelled to meet newer energy code on a whole-building basis unless they undergo major renovation.[41]

The next evolution of policy derived from benchmarking is to require applicable buildings to meet minimum performance criteria. Building performance standards (BPS) (sometimes called building energy performance standards (BEPS)) are at an early stage of development and implementation.[42] At the time of this writing four U.S. jurisdictions—New York City; St. Louis, Missouri; Washington, DC; and Washington State—have adopted BPS.[43, 44, 45, 46] As with benchmarking, buildings are scored against

[39] NASEO-NARUC GEB Working Group Webinar: Emission Aspects of Demand Flexibility, op. cit.

[40] City of New York, 2009, Local Law No. 88, https://www1.nyc.gov/assets/buildings/local_laws/ll88of2009.pdf.

[41] One exception is the City of Boulder (Colorado) SmartRegs which requires rental housing units built before 2001 to meet a checklist based assessment or achieve a HERS Index rating of better than 120, approximating compliance with the 1999 International Energy Conservation Code (IECC), in order to obtain or renew a rental license. More information on SmartRegs is available at https://bouldercolorado.gov/plan-develop/smartregs.

[42] IMT provides extensive BPS resources, including a model ordinance that contains provisions for grid and localized coincident peak electric demand metrics and criteria. https://www.imt.org/resources/imt-model-bps-ordinance-summary/.

[43] City of New York, Local Law No. 97, https://www1.nyc.gov/assets/buildings/local_laws/ll97of2019.pdf and City of New York, Local Law No. 147, https://www1.nyc.gov/assets/buildings/local_laws/ll147of2019.pdf.

[44] City of St. Louis, Board Bill Number 219: Session 2019-2020, Building Energy Performance Standard (BEPS), https://www.stlouis-mo.gov/government/city-laws/board-bills/boardbill.cfm?bbDetail=true&BBId=13504.

[45] Department of Energy and Environment (Washington, DC), Building Energy Performance Standards, https://doee.dc.gov/node/1406676.

similar buildings by type and use (office buildings, multifamily residences, retail stores, etc.) with certain exemptions and adjustments. Also, similar to benchmarking, these policies phase in over time, generally starting with larger buildings (over 50,000 sf) and may also do so by type (government, commercial, multifamily).

While a BPS can, in principle, use varied metrics and tools, currently they mostly rely on the ENERGY STAR Portfolio Manager, using its score or its underlying EUI basis as the main metrics for performance as is done for benchmarking. New York City's policy, however, uses greenhouse gas emissions in tons of carbon dioxide equivalents (CO_2e) per square foot as the primary metric. The New York City policy establishes emissions factors for purchased electricity, direct fuel use (natural gas and fuel oil), and district steam, and directs the city's Buildings Department to determine such factors for other energy systems and sources, including DERs and fuel cells.[47] BPS are to be tightened over time, periodically adjusting minimum required Portfolio Manager score or maximum allowable EUI, or, for New York City, tightening tons CO_2e per sf requirements. Owners of buildings that do not achieve requisite performance will be required to take corrective actions and/or may be liable for alternative compliance payments or penalties.

Thus far, BPSs do not include DF or time differentiation factors. However, there is one case that opens opportunity for these factors to be included. The New York City law provides that the utility electricity emissions coefficient for the first compliance period (2024-2029) "at the owner's option, shall be calculated based on time of use in accordance with referenced emissions factors promulgated by rules of the department."[48] The law also gives the Department of Buildings discretion to establish different limits, metrics, and methods of calculation for 2030 and beyond, opening opportunities for time differentiation and DF to be better accommodated and encouraged through the policy.

There are multiple opportunities for BPS to incorporate time-differentiated energy use in emissions calculations and to encourage or require DF energy management capabilities and practices to reduce building contributions to grid stresses, costs, and emissions.[49] The Institute for Market Transformations (IMT) has developed model BPS language and related resources, opening an opportunity to include pertinent emissions, peak demand, coincident peak demand, and localized coincident peak demand metrics and standards.[50] The menu of options for including DF in BPS is consistent with that for benchmarking and transparency policies and for rating and labeling programs.[51]

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[46] Washington State Department of Commerce, Clean Buildings, https://www.commerce.wa.gov/growing-the-economy/energy/buildings/.
[47] City of New York, Local Law 147, op. cit.
[48] Ibid.
[49] IMT, 2021, "Opportunities to Advance Demand Flexibility with Building Performance Standards," https://www.imt.org/wp-content/uploads/2021/01/IMT-Opportunities-to-Advance-Demand-Flexibility-with-BPS.pdf.
[50] See IMT, "Exploring Building Performance Standards" resource page https://www.imt.org/how-we-drive-demand/building-policies-and-programs/exploring-building-performance-standards/ and IMT, "Model Ordinance for Building Performance Standards," https://www.imt.org/resources/model-ordinance-for-building-performance-standards/.
[51] In addition to this report, see Mims Frick, N., 2020, "Incorporating Demand Flexibility into State Energy Goals," starting on slide 44 of the Grid Interactive Efficient Buildings Working Group Public Buildings and Potential Cohort

	Peak Demand	Peak Demand Intensity	Coincident Peak Demand	Localized Coincident Peak Demand	DR Participation	DR/DF Capability	Time-Differentiated Emissions	Time-Differentiated Cost-Effectiveness
BPS	x	x	x	x	x	x	x	

Peak demand and demand intensity. Monthly peak demand (kW) and demand intensity (kW/sf), analogous to energy use (kWh, Btu) and EUI, performance standards can be established based on building types and usage as with other standards under the BPS. The ENERGY STAR Portfolio Manager demand tracking feature can be used.[52] Alternatively, as discussed for benchmarking, averaging a building's 10 highest hours of demand of the year, consistent with GridOptimal's AMRD would buffer the impacts of one or few anomalous hours that would otherwise skew the metric.[53]

Coincident peak demand. As described previously, building demand during periods of highest grid demand is an indicator of a building's "grid friendliness." A BPS can establish coincident peak demand standards based on building type and usage. The GridOptimal *Grid Peak Contribution* metric that compares building demand (relative to its AMRD) during the grid's highest demand 5% of hours offers a useful metric on which to base minimum performance standards.[54]

Localized coincident peak demand. Also previously described, a localized (e.g., substation level) coincident peak demand metric can indicate a building's impact on local electricity distribution. If relevant utility data are available, a localized *Grid Peak Contribution* metric could be used for developing a performance standard. However, differing conditions at substations or other localized areas within a city, county, or state may militate against implementing specific localized coincident peak performance standards.

Demand response program participation. A BPS could mandate program participation for applicable buildings where DR programs are available.

Demand response and demand flexibility capability. A BPS could include requirements for buildings to be capable of responding to DR signals from the utility, grid operator (ISO/RTO), or a third party DR service provider, and/or to take advantage of TOU rates or dynamic, real-time electricity pricing. The LEED Grid Harmonization credit provides example criteria and language for users of that rating system.[55]

Time-differentiated emissions calculation. A BPS that includes emission performance criteria can incorporate either an option (as in New York City's BPS) or a requirement for considering time-differentiated grid generation emissions factors. Hourly grid power consumption combined with hourly emission rate estimations from the EPA AVERT tool, WattTime, or utility or ISO/RTO data provide more

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Meeting (December 7, 2020) presentation for discussion and some model building performance standard policy language https://www.naseo.org/Data/Sites/1/v2_geb_meeting_dec_7_2020b.pdf.

[52] ENERGY STAR, How to Track Electric Demand in Portfolio Manager, https://www.energystar.gov/buildings/tools-and-resources/how_track_electric_demand_portfolio_manager

[53] Miller and Carbonnier, op. cit.

[54] Ibid.

[55] USCBC, LEED Grid Harmonization, op. cit.

accurate views of a building's energy-based emissions footprint than use of fixed emission rate factors or the ENERGY STAR Portfolio Manager emissions estimation tool.[56]

A BPS could also require reporting and achieving points under the LEED pilot Grid Harmonization alternative compliance path to address several pertinent DF parameters.[57]

Building Energy Codes

Building energy codes, which set minimum energy efficiency requirements for new and renovated buildings, provide major energy and energy cost savings as well as emission avoidance.[58] They are adopted at state and local levels of government, mostly based, with some variation, on two models, the International Code Council's International Energy Conservation Code (IECC) that largely applies to low-rise residential buildings, and ASHRAE Standard 90.1[59] that applies to commercial and high-rise multifamily residential buildings.[60, 61] Some states authorize local governments to adopt "stretch codes" that are more stringent than the statewide code.

Historically, building energy codes focus on cost-effective energy savings through energy efficiency without considering TOU, DR, or other DF approaches though they have potential to do so.[62] For example, recent versions of ASHRAE Standard 90.1 model code prescriptive requirements for commercial buildings specify various active controls for HVAC, lighting, hot water, elevators, and other systems but they do not address automation to effect time-differentiated control of energy use, DR, and, more broadly, DF.[63] Cost-effectiveness determinations, such as those performed by U.S. DOE on national model codes, use blended fixed utility electricity rates (energy and demand charges) that do not include TOU considerations or DR programs.[64]

Time-differentiation and DF factor can be included in building energy codes in at least two ways. First, cost-effectiveness analyses of code provisions can consider time differentiation of energy use and savings. Second, DF and DR capability or DF/GEB-ready functionality can be directly required by code.

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[56] NASEO-NARUC GEB Working Group Webinar: Emission Aspects of Demand Flexibility, op. cit.

[57] USGBC, LEED GridOptimal Building ACP, op. cit.

[58] U.S. Department of Energy, "Why Building energy Codes?," https://www.energycodes.gov/about/why-building-energy-codes.

[59] Formally, ASHRAE Standard 90.1 is ANSI/ASHRAE/IES Standard 90.1, an American National Standards Institute standard published by the ASHRAE, co-sponsored by the Illuminating Engineering Society

[60] In a few cases, such as California's Title 24, code is not directly based on the national model codes.

[61] Montgomery County (Maryland) is one of the few jurisdictions that uses the International Green Construction Code (IgCC) as building code; Washington, DC also uses the IgCC but in conjunction IECC and ASHRAE Standard 90.1-based codes; noted in Arlington County (VA), 2020, "Updates to the Green Building Incentive Policy for Site Plan Projects" https://environment.arlingtonva.us/wp-content/uploads/sites/13/2020/12/Board_Report_35-FINAL.pdf.

[62] However, California's Title 24 building code has included time dependent valuation (TDV) considerations. https://energycodeace.com/site/custom/public/reference-ace/index.html#!Documents/section102calculationoftimedependentvaluationtdvenergy.htm.

[63] Franconi, E., J. Lerond, C. Nambiar, D. Kim, M. Rosenberg, and J. Williams, 2020, "Opening the Door to Grid-Interactive Efficient Buildings with Building Energy Codes," 2020 ACEEE Summer Study on Energy Efficiency in Buildings.

[64] Ibid.

Regarding the first, cost-effectiveness analyses, Franconi, et al., (2020) evaluated the cost-effectiveness of a series of energy efficiency, DF, and battery energy storage measures for a simulated prototype medium-sized office building in three locations (New York City; Rochester, Michigan; Tampa, Florida) using an ASHRAE blended fixed national rate, an ASHRAE blended “moderate” TOU rate, and a Consolidated Edison “aggressive” TOU rate.[65] Depending on simulated building location, several measures became cost-effective or improved cost-effectiveness under one or the other or both TOU rates.

In California, under the California Energy Commission (the state’s Energy Office), the Title 24 building energy code includes a Time Dependent Valuation (TDV) code compliance metric for electricity, natural gas, and propane. “The concept behind TDV is that energy efficiency measure savings should be valued differently depending on which hours of the year the savings occur, to better reflect the actual costs of energy to consumers, to the utility system, and to society.”[66] The 2022 TDV metric for electricity will incorporate various component electricity system and emission-related costs to develop hourly avoided costs for energy saved.[67] The 2019 version of the code, that came into force in 2020, includes an Energy Design Rating (EDR)-based compliance path for homes that resembles the RESNET HERS Index except that it includes TDV factors.[68] Illustrating the relevance to DR, batteries for storing solar-generated power can count toward code compliance by lowering (i.e., making more favorable) a home’s EDR.

A second building code approach would be to require that buildings be built with capabilities to perform DF, including managing TOU and participating in DR programs.

	Peak Demand	Peak Demand Intensity	Coincident Peak Demand	Localized Coincident Peak Demand	DR Participation	DR/DF Capability	Time-Differentiated Emissions	Time-Differentiated Cost-Effectiveness
Codes						x		x

Two possible options for DF consideration in building energy code are:

Demand response and demand flexibility capability. Code can include directly (or via BPS, discussed previously) requirements for applicable buildings to be capable of responding to DR signals from the utility, grid operator (ISO/RTO), or a third party DR service provider, and/or to take advantage of TOU rates or dynamic, real-time electricity pricing. Grid harmonization criteria similar to those appearing in LEED may provide useful ideas.[69]

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[65] Ibid.

[66] Energy+Environmental Economics, 2020, “Time Dependent Valuation of Energy for Developing Building Efficiency Standards: 2022 Time Dependent Valuation (TDV) and Source Energy Metric Data Sources and Inputs,” (May 2020), https://drive.google.com/file/d/1xOg-BF8OAmBCypLncB-m_DuRchNcs25p/view

.[67] Ibid.

[68] Meres, R., 2019, “New CA Energy Code Moves State to Closer Alignment to RESNET HERS® Index” https://www.resnet.us/articles/new-ca-energy-code-moves-state-to-closer-alignment-to-resnet-hers-index/

[69] USGBC, LEED Grid Harmonization, op. cit.

Time-differentiated cost-effectiveness analyses. Cost-effectiveness analyses of building energy code (in whole or for particular provisions) should consider timing of energy use and savings. TOU rates rather than fixed rates can be used. These could be nationally based[70] but local utility rates would be more accurate. A more complex TDV-type analysis that holistically includes hourly marginal electricity or energy system costs and social and environmental costs can also be considered.

Appliance Standards

Appliance and equipment energy efficiency standards regulate the minimum energy efficiency performance of various new equipment. Air conditioners, heat pumps, water heaters, light bulbs, and many white goods, among other types of household and commercial equipment are subject to federal efficiency standards that pre-empt state or local efficiency regulation.[71] States can regulate other, non-federally regulated equipment for energy efficiency.[72] However, grid-interactive/responsive functionality and DF capabilities have not been federally regulated and are now starting to garner state energy policy and manufacturer attention. In addition to regulation, voluntary programs can highlight or incentivize products that are more efficient than required by regulation and that may include DF functionality. For example, starting in 2013, the U.S. EPA ENERGY STAR program has developed "connected criteria" that include DF factors for various products.[73] Jurisdictions can consider using such criteria for voluntary and incentivized (e.g., utility incentives, tax abatement) programs and potentially for mandated standards.

In 2019, Washington State enacted a first-in-the-nation water heater standard requires new electric storage water heaters to include a grid-communications port that meets CTA-2045 or similar communication standards.[74] Administered by the Washington State Department of Commerce (the State Energy Office), the rule came into force for heat pump water heaters on January 1, 2021 and will come into force for electric resistance water heaters on January 1, 2022 that have input of 12 kW or less, are rated at 40 to 120 gallons storage volume, and supply water at 180° F. or less. The Washington State standard was enacted to enable utility water heating load management programs that support the state's 100-percent clean energy standard (Clean Energy Transformation Act). The Oregon Department of Energy (i.e., the State Energy Office) is undertaking a similar rulemaking.[75]

The California Energy Commission, pursuant to Senate Bill 49 Flexible Demand Appliance Standards, is developing pertinent state appliance standards that "will promote technologies to schedule, shift, and

[70] The ASHRAE Standard 90.1-2022 Workplan offers a TOU blended national rate as an optional alternative to fixed blended rates; in Franconi et al., op. cit.
[71] Appliance Standards Awareness Project, The Basics, https://appliance-standards.org/basics.
[72] Appliance Standards Awareness Project, State Standards, https://appliance-standards.org/states.
[73] U.S. EPA, "Connected Criteria for ENERGY STAR Products," https://www.energystar.gov/products/spec/connected_criteria_energy_star_products_pd.
[74] Vorpahl, S., 2020, "Grid-Ready Water Heaters in Washington State: 19.260 RCW and 194-24 WAC," in NASEO-NARUC GEB Working Group Webinar: Grid-interactive Appliances, https://www.naseo.org/Data/Sites/1/vorpahl-naseo-geb-grid-water-heater-webinar-07-24-2020.pdf.
[75] Oregon Department of Energy, 2020, "Energy Efficiency Standards Rulemaking, " Filing certificate with final rules via https://www.oregon.gov/energy/Get-Involved/Pages/EE-Standards-Rulemaking.aspx.

curtail appliance operations to support grid reliability, benefit consumers, and reduce greenhouse gas emissions associated with electricity generation."[76]

As with building energy codes, appliance standards and voluntary programs undergo cost-effectiveness analyses. Thus, as with building energy codes, cost-effectiveness analyses for appliance standards could be undertaken with consideration of time-differentiated energy use and savings. National blended or (better) state or local utility TOU rate structures can be used rather than non-time-differentiated rates. A more complex and holistic TDV approach can also be considered.

	Peak Demand	Peak Demand Intensity	Coincident Peak Demand	Localized Coincident Peak Demand	DR Participation	DR/DF Capability	Time-Differentiated Emissions	Time-Differentiated Cost-Effectiveness
Appliance stds.						x		x

Options for DF factor inclusion in appliance standards and pertinent voluntary programs can include:

Demand response and demand flexibility capability. Appliance standards can require that new applicable equipment be capable of responding to DR signals from the utility, grid operator (ISO/RTO), or a third party DR service provider. Voluntary programs can recognize and incentivize products with such capabilities. Existing DF-relevant standards (e.g., Washington State water heater requiements) and ENERGY STAR Connected Criteria can be considered.

Time-differentiated cost-effectiveness analyses. Cost-effectiveness analyses of appliance standards should consider timing of energy use and savings. TOU rates rather than fixed rates can be used. These could be nationally based[77] but local utility rates would be more accurate. A TDV-type analysis that more holistically includes hourly marginal electricity or energy system costs and social and environmental costs can also be considered.

Zoning and Land-use Regulation

Primarily a tool of local (municipal and county) governments, zoning ordinances and related land-use regulation and permitting is used, often in accordance with a city or county plan, to regulate land uses including density, size, location, and types of buildings and their allowable uses in the jurisdiction. Such rules may condition or prohibit certain land uses; reserve green and open spaces; require building set-backs; include vehicle parking facilities; accommodate pedestrian and transit facilities; govern building height, size, and appearance; etc. They interact with transportation planning, stormwater management regulation, and sometimes with state environmental review laws. And they have large impacts on energy use in buildings and transportation, and, thus, on emissions.

[76] California Energy Commission, 2020, Introduction to Flexible Demand Appliance Standards, https://www.energy.ca.gov/event/2020-12/lead-commissioner-workshop-senate-bill-49-flexible-demand-appliance-standards.

[77] The ASHRAE Standard 90.1-2022 Workplan offers a TOU blended national rate as an optional alternative to fixed blended rates; in Franconi et al., op. cit.

Well-crafted zoning and land-use laws and regulations can complement building energy codes and other programs and policies to advance energy efficiency, distributed clean energy deployment, and, in principle, DF and GEBs. However, if poorly designed, such rules and procedures can impede these favorable energy advances by prohibiting or encumbering certain equipment and functions, such as EVSE, solar and other onsite generation, and batteries.

There are multiple efforts to fashion clean energy-favorable local land regulations and processes. State, regional, and local authorities have developed model zoning rules and frameworks to support photovoltaic siting, permitting, and inspections.[78] The New York State Energy Research and Development Authority (the state's Energy Office) developed the "New York Battery Energy Storage System Guidebook for Local Governments" to provide localities model law and permitting language and discussion of relevant state fire prevention and building code to enable them to support battery deployment in their jurisdictions.[79] EV and charging infrastructure (EVSE) deployment can also benefit from well-designed zoning, permitting, and related rules and procedures.[80, 81] At times, such rules can interact or overlap with building codes; for example, requiring a proportion of multifamily residential or commercial development parking to have EVSE or to have "EV-ready" wiring in new or renovated buildings.[82]

Zoning and land-use processes can work in conjunction with existing rating, labeling, and certification programs as criteria for approvals or to provide incentive for higher performance. For example, in Alexandria, Virginia, under its 2019 Green Building Policy, projects requiring Development Site Plans or Special Use Permits must meet certain green building standards that comport with at least LEED Silver or analogous levels in the Green Globes or EarthCraft rating systems.[83] Arlington County (Virginia) has a longstanding program to offer development density bonuses for projects meeting certain LEED standards (most recently LEED Gold) or, for multifamily residences, EarthCraft certification.[84]

As with other policies discussed in this report, zoning and land-use rules and processes can potentially incentivize or require DF capabilities and performance for projects that need approvals. Further, there is a potential convergence of interests between local land-use officials and utility planners to advance DF, DERs, and GEBs to moderate electricity distribution system costs while supporting energy reliability, resilience, and environmental goals.

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[78] Day, M., 2017, "Best Practices in Zoning for Solar," National Renewable Energy Laboratory, https://www.nrel.gov/state-local-tribal/blog/posts/best-practices-in-zoning-for-solar.html.

[79] New York State Energy Research and Development Authority, 2020, "New York State Battery Energy Storage System Guidebook," https://www.nyserda.ny.gov/All%20Programs/Programs/Clean%20Energy%20Siting/Battery%20Energy%20Storage%20Guidebook.

[80] Cooke, C., and B. Ross, 2019, "Summary of Best Practices in Electric Vehicle Ordinances," Great Plains Institute, https://www.betterenergy.org/wp-content/uploads/2019/06/GPI_EV_Ordinance_Summary_web.pdf.

[81] U.S. Department of Energy, Alternative Fuels Data Center, 2015, "Plug-in Electric Vehicle Deployment Policy Tools: Zoning, Codes, and Parking Ordinances," https://afdc.energy.gov/bulletins/technology-bulletin-2015-08.html.

[82] Cooke and Ross, 2019, op. cit.

[83] City of Alexandria (Virginia), "2019 Green Building Policy" https://www.alexandriava.gov/uploadedFiles/planning/info/GreenBuildingPolicy2019CCApproved.pdf.

[84] Arlington County (Virginia), 2020, "Updates to the Green Building Incentive Policy for Site Plan Projects" https://environment.arlingtonva.us/wp-content/uploads/sites/13/2020/12/Board_Report_35-FINAL.pdf

Zoning and land-use processes can work in concert with utility system planning to identify and incentivize locations where DERs and GEBs can be most beneficial. For example, developments served by substations facing greater stresses and congestion may be well suited for incentives to encourage—or require—DERs and DF as “non-wires solutions” (also called “non-wires alternatives”) in lieu of or complement to conventional utility distribution system upgrades.

Energy-related factors, including DF capabilities (e.g., grid responsiveness of building management systems, EVSE, and HVAC) can be made requirements for approvals or permits, or they can be bases for offering tax concessions, density bonuses, or other zoning flexibility incentives (property uses, building height and size, setbacks, parking requirements, etc.).

	Peak Demand	Peak Demand Intensity	Coincident Peak Demand	Localized Coincident Peak Demand	DR Participation	DR/DF Capability	Time-Differentiated Emissions	Time-Differentiated Cost-Effectiveness
Zoning	x	x		x	x	x		

Approaches for incorporating DR considerations in zoning and land-use parallel those for other policies examined in this report, including:

Peak demand and demand intensity. Expected monthly peak demand (kW) and demand intensity (kW/sf), analogous to energy use (kWh, Btu) and EUI, of the planned development and its impacts on local electricity distribution can (as authority allows) be factors considered for zoning and land-use approvals, permits, and incentives such as tax abatement or zoning flexibility.

Coincident peak demand. The planned development’s expected contributions to electricity system peak demand, including design and operational measures to mitigate coincident peak demand, can be considered in zoning and land-use approval and permitting processes and for offering possible tax abatement, zoning flexibility, or other incentives. The LEED Grid Harmonization credits offer example criteria that could adapted for approvals or offering incentives.[85]

Localized coincident peak demand. Reducing a planned development’s localized (substation or other local area) coincident peak load, particularly in areas where grid congestion and stresses occur or may develop, can be considered by local authorities and the electric distribution utility for accommodating new or expanded development and land use changes. Zoning and land-use officials may, in collaboration with the local electric utility, consider (as authority allows) requiring or encouraging DF measures and DERs to mitigate local power system stresses or even to enhance the quality, reliability, and resilience of electric service as non-wires solutions or alternatives to traditional utility distribution system upgrades. Again, LEED Grid Harmonization criteria may be useful.

Demand response program participation. Zoning and land-use officials, if authority allows, can consider conditioning approvals or permits, or offering tax and flexibility incentives based on commitment to participate in available DR programs.

[85] USGBC, LEED Grid Harmonization, op.cit.

Demand response and demand flexibility capability. If authority allows, zoning and land-use officials could require buildings and facilities to be capable of responding to DR signals from the utility, grid operator (ISO/RTO), or a third party DR service provider, and/or to take advantage of TOU rates or dynamic, real-time electricity pricing. The LEED Grid Harmonization optional credit provides criteria and language used in that rating system.[86]

Capabilities and Needs for Demand Flexibility Policies and Programs

States and local governments have varying levels of capabilities, experience, and resources to enact and implement building energy policies and programs. Most implement and enforce building energy codes, though, as noted, without DF aspects as yet. Relatively few states have their own appliance standards and grid interactive appliance standard criteria and requirements are still emerging. Most localities have zoning and land-use regulation, some with environmental and energy aspects, though DF considerations are nascent. A growing number implement benchmarking and transparency policies and rating and labeling programs. And some are building off of these to establish BPSs.

All of the building-related energy policies and programs discussed in this report can be crafted to significantly advance DF technologies and implementation. *State Energy Offices, other pertinent state agencies, and local governments can build on existing policies and programs to add DF criteria and considerations.* The growing set of jurisdictions that have benchmarking and transparency policies can evolve them into BPSs while also adding DF features. Those jurisdictions also provide models and lessons from which others can learn to embark on building energy policies and programs.

For jurisdictions new to these policies and programs, it is a likely that a phased approach that starts with energy efficiency and established energy use and EUI bases then later adds more complex and dynamic DF metrics and criteria makes sense. Including DF aspects requires additional data, tools, and metrics as well as capabilities of the regulating jurisdiction, subject property owners, and, likely, utilities.

Fundamental to DF is the time dimension. Some DF and DR can be performed in the absence of advanced or smart meters. However, such meters may be required for implementing others and, importantly, are often needed to evaluate performance and base compensation and credit for provision of grid services. Utilities and grid operators (ISO/RTO) need to act—and equipment respond--on hourly or finer intervals (down to seconds or less for some ancillary services). Hourly or finer (30 or 15 minute) data on buildings and from the grid should be used to determine peak and coincident peak demand. Localized peak demand metrics would require such time-differentiated data at the substation or other local area. Thus, hourly or finer building demand and grid data are needed for many DF policies discussed.

Greenhouse gas and sometimes Clean Air Act criteria air pollutant emissions drive many jurisdictions' interest in building energy policies. Energy efficiency reduces both onsite emissions (from natural gas, oil, and propane fueled heating, hot water, and cooking) and those from electric power generation. However, grid-generated power emission rates vary over time—hourly, daily, and seasonally--as different generators are dispatched to meet changing levels of demand. Time-differentiated demand for grid-supplied power can be translated into estimated emissions via several approaches. For example, WattTime is a non-profit organization that offers a service to estimate real-time emissions

[86] USGBC, LEED Grid Harmonization, op. cit.

based on time and location of use that can be used for real-time DF to reduce emissions as well as to assess ex post a building's performance.[87] The U.S. EPA's AVERT tool can be used to estimate hourly emissions on a regional basis from a building's past electricity usage and as well as to project future grid-related emissions performance.[88] Utilities and ISOs/RTOs may also provide time-differentiated emission rate data. These approaches can be used not only to assess existing building emission performance but also to evaluate technological and operational options to improve performance, such as scheduling loads and using energy storage to mitigate emissions.

Metrics to characterize coincident peaks; shedding and shifting; flexibility and responsiveness; and cost, resilience, and environmental impacts are still emerging. This is a challenge relative to relying on total energy use, EUI, and current ENERGY STAR Portfolio Manager scoring. The GridOptimal Building Initiative developed a set of eight metrics concerning a building's energy efficiency and demand performance as well as its flexibility (ability to modify demand, plus a resiliency metric on function during electric outage). These are described in Appendix B and can be considered for policy and program application.

Jurisdictions enacting or considering DF requirements or incentives should also pay attention to standards and interoperability, cybersecurity, and data privacy. Open communications standards that avoid limitations and costs of relying on proprietary systems may be preferred. Open standards like OpenADR and CTA-2045 are emerging for exchange of signals between the grid, buildings, and equipment. Cybersecurity is a vital factor; vulnerabilities can turn grid-supportive DF capabilities into disruptive and damaging forces.[89] Customer privacy concerns also require attention.

DF consideration for policies and programs are more complex than for pure energy efficiency. Fortunately, data, tools, approaches, and experience are growing.

Summary

States and local governments are implementing a growing number of policies and programs to advance energy efficiency in buildings. State Energy Offices and other state and local authorities are driven by goals of saving energy, reducing costs, enhancing building stock, reducing greenhouse gas and other emissions, and supporting energy system reliability and resilience. These can be further advanced and amplified by including DF considerations, provisions, incentives, and requirements in building policies and programs.

When as well as how much energy is used or saved has significant impacts on costs, emissions, power quality, and reliability and resilience. New capabilities allow building management systems and energy-using equipment to adjust, schedule, and manage energy use to avoid grid peak periods, take advantage of TOU electricity rates, enhance renewable energy utilization, and reduce emissions. They can

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[87] WattTime, https://www.watttime.org/.

[88] U.S. EPA, AVoided Emissions and geneRation Tool (AVERT), https://www.epa.gov/statelocalenergy/avoided-emissions-and-generation-tool-avert.

[89] The U.S. Government Accountability Office reported a simulation finding that a cyberattack on high-wattage smart home appliances (e.g., air conditioners) could manipulate demand across the grid and cause an outage by synchronously switching on all compromised devices. U.S. Government Accountability Office, 2019, "Critical Infrastructure Protection: Actions Needed to Address Significant Cybersecurity Risks Facing the Electric Grid," https://www.gao.gov/assets/710/701079.pdf.

coordinate with other DERs, including onsite generation and energy storage, and even with EVs and their charging equipment to provide grid services and also support building or facility resilience during periods of grid stress or outage.

Though nascent, jurisdictions can add DF-oriented factors and metrics to existing policy and program approaches such as:

- benchmarking and transparency,
- ratings and labeling,
- building performance standards,
- building energy codes,
- appliance energy standards, and
- zoning and land-use regulation

Among pertinent DF factors are:

- peak demand and demand intensity,
- coincident and localized coincident peak demand,
- demand response program participation,
- demand response and demand flexibility capability,
- time-differentiated emissions calculations, and
- time-differentiated cost-effectiveness analyses

New metrics, beyond established total energy consumption, EUI, and ENERGY STAR Portfolio Manager scores are emerging—such as the GridOptimal Initiative's suite—to quantify and qualify more complex DF characteristics. Building rating and certification systems are also starting to address this area, such as through the LEED Grid Harmonization criteria and a new pilot path using GridOptimal. These can be useful for State Energy Offices and others as they develop pertinent policies and programs.

This is a new and quickly evolving area, particularly as technologies, utility regulatory regimes, and business models change, and as energy policy economic, environmental, and resilience emphases grow. This report is meant to identify opportunities, possibilities, and general direction for policy and program exploration. Demand flexibility will surely grow in importance.

Resources

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Miller, A., and K. Carbonnier, 2020, "New Metrics for Evaluating Building-Grid Integration," 2020 ACEEE Summer Study on Energy Efficiency in Buildings https://newbuildings.org/wp-content/uploads/2020/11/NewMetricsForEvaluatingBuildingGridIntegration.pdf.

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U.S. Department of Energy, 2019, Grid-interactive Efficient Buildings: Overview, https://www.energy.gov/sites/prod/files/2019/04/f61/bto-geb_overview-4.15.19.pdf.

U.S. Department of Energy, Federal Energy Management Program (FEMP), Demand Response and Time-Variable Pricing Programs, https://www.energy.gov/eere/femp/demand-response-and-time-variable-pricing-programs.

U.S. Green Building Council, LEED, LEED Credit Library, https://www.usgbc.org/credits?Version=%22v4.1%22&Rating+System=%22New+Construction%22.

Appendix A: LEED Credits Applicable to Demand Flexibility

LEED credits are available for DF-relevant features or practices for both new building design and construction (BD+C) and existing building operations and maintenance (O&M). These include in LEED v4.1 the following:[90]

Electric Vehicles (LEED BD+C; 1 possible point): Includes option to provide electric vehicle supply equipment (EVSE) meeting certain criteria, including capability of responding to TOU market signals.[91] Projects pursuing Grid Harmonization credit should incorporate EVSE into DR program or load flexibility and management strategies.

Minimum Energy Performance (LEED BD+C; required): Provides the option of using hourly grid greenhouse gas emissions profiles from EPA's AVERT tool for calculation of baseline and proposed buildings performance rating.[92] The use of hourly bases can also influence points available under **Optimize Energy Performance** (LEED BD+C; 18 possible points) but DF measures are not required to achieve all potential points.[93]

Advanced Energy Metering (LEED BD+C; 1 possible point): Electricity meters must record consumption and demand; must use local area network, building automation system, wireless network, or comparable communications infrastructure; have data remotely accessible; and be capable of recording hourly, daily, monthly, and annual energy use.[94]

Grid Harmonization (LEED BD+C; 2 possible points and O+M; 1 possible point):

- if DR programs are available, requires participation, meeting program requirements, and inclusion of DR processes in building commissioning and O&M; or
- have infrastructure in place to take advantage of future DR programs or dynamic, real-time pricing with plans to be able to shed at least 10% of annual on-peak electricity demand; and/or
- establish and implement "load flexibility and management strategies" based on analysis of building load shape and peak loads as compared to grid peak load or peak carbon emissions; using interval meters with communications capabilities and building automation system that can accept external price signals; and demonstrating one or more of the following:
    - peak load optimization to lower on-peak load at least 10 percent compared to peak electrical demand,
    - flexible operating scenarios to shift at least 10 percent of peak load by two hours,
    - on-site thermal and/or electrical storage to lower on-peak load at least 10 percent compared to peak electrical demand, and

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[90] There may be other pertinent or interacting credits. Not all versions of the LEED rating system were examined. The descriptions below are abridged to provide gist. Readers should consult LEED for full details.

[91] USGBC, LEED Electric Vehicles, https://www.usgbc.org/credits/new-construction-core-and-shell-retail-new-construction-healthcare-data-centers-new-construc?return=/credits/New%20Construction/v4.1.

[92] USGBC, LEED Minimum Energy Performance, https://www.usgbc.org/credits/new-construction-core-and-shell-schools-new-construction-retail-new-construction-data-21?return=/credits/New%20Construction/v4.1.

[93] USGBC, LEED Optimize Energy Performance, https://www.usgbc.org/credits/new-construction-core-and-shell-warehouse-and-distribution-centers-new-construction?return=/credits/New%20Construction/v4.1.

[94] USGBC, LEED Advanced Energy Metering, https://www.usgbc.org/credits/new-construction-schools-new-construction-retail-new-construction-healthcare-data-centers-15?return=/credits/New%20Construction/v4.1.

- grid-resilience technologies to leverage islanding, part-load operation, and other strategies.[95, 96]

GridOptimal Building ACP (Grid Harmonization Pilot Alternative Compliance Path, LEED BD+C, 3 possible points):

- Option 1: Calculate and report GridOptimal performance (1 point) (see Appendix B) metrics for baseline and proposed building cases using the LEED GridOptimal Calculator for:
    - grid peak contribution,
    - grid carbon alignment,
    - site renewable utilization efficiency.
    - short-term demand flexibility,
    - long-term demand flexibility, and
    - dispatchable demand flexibility.
- Option 2: Across-the Board Improvement is Option 1 plus demonstrating requisite score improvements for at least three GridOptimal Metrics (up to 2 points plus 1 "innovation point").
- Option 3: Focused Area Improvement is Option 1 plus demonstrating greater requisite score improvement for at least one of the six GridOptimal metrics (up to 2 points plus 1 "innovation point").[97]

These provisions can be useful for State Energy Offices, other state agencies, and local officials to consider in developing DF building policies and programs.

[95] USGBC, LEED Grid Harmonization (New Construction), https://www.usgbc.org/credits/new-construction-core-and-shell-schools-new-construction-retail-new-construction-healthc-175?return=/credits/New%20Construction/v4.1

[96] USGBC, LEED Grid Harmonization (Existing Buildings), https://www.usgbc.org/credits/existing-buildings-schools-existing-buildings-retail-existing-buildings-data-centers-exis-59?return=/credits/Existing%20Buildings/v4.1

[97] USGBC, LEED GridOptimal Building ACP, https://www.usgbc.org/credits/gridoptimal-152-v4.1 and LEED v4.1 Grid Harmonization GridOptimal ACP Accompanying Guidance https://www.usgbc.org/resources/leed-v41-grid-harmonization-gridoptimal-acp-accompanying-guidance

Appendix B: GridOptimal Metrics

The multi-stakeholder GridOptimal Buildings Initiative, led by the New Buildings Institute in partnership with the USGBC, developed a set of metrics to describe a building's performance with respect to the grid. Such metrics can be applied to policies and programs described in this report—benchmarking and transparency, ratings and labeling, building performance standards, and, potentially, building energy codes and zoning and land-use regulation—as well as others, such as utility incentive programs and energy project financing.

The eight proposed metrics include four that reflect a building's performance and four that that denote building capabilities for DF. Each metric is presented as a dimensionless 0 to 100 percent scale with a higher number being more favorable or "grid friendly" (with greater than 100 percent possible for some metrics). The eight metrics are separate, not designed to be combined into a single score.

Table B-1. GridOptimal Summary Metrics

Metric	**What is being measured**
Grid Peak Contribution	Degree to which building demand contributes to load on the grid during system peak hours.
Onsite Renewable Utilization Efficiency	Building's consumption of renewable energy generated onsite (not exported to grid) over a year.
Grid Carbon Alignment	Degree to which the building's demand contributes to upstream (grid) carbon emissions over a year.
Energy Efficiency Versus Baseline	Percent better than energy code requires (annual total energy use).
Short-Term Demand Flexibility	Building's ability to reduce (shed) demand for one hour.
Long-Term Demand Flexibility	Building's ability to reduce (shed) demand for four hours.
Dispatchable Flexibility	Building's ability to automatically reduce (shed) demand for 15 minutes, controlled by utility or third party.
Resiliency	Building ability to island from grid and/or provide energy for critical loads for four to 24 hours; motor soft start capability to help grid restart after outage.

Source: Miller, A., and K. Carbonnier, 2020, "New Metrics for Evaluating Building-Grid Integration," 2020 ACEEE Summer Study on Energy Efficiency in Buildings.