Performance Assessments of Demand Flexibility from Grid-Interactive Efficient Buildings: Issues and Considerations

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September 1, 2020

This presentation was supported by the U.S. Department of Energy's Building Technologies Office under Lawrence Berkeley National Laboratory Contract No. DE-AC02-05CH11231.

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- Actions State and Local Governments Can Take to Advance Demand Flexibility Assessments
- Summary
- Q&A

Please enter your questions in the Q&A box at any time. We'll discuss your questions following the presentation.

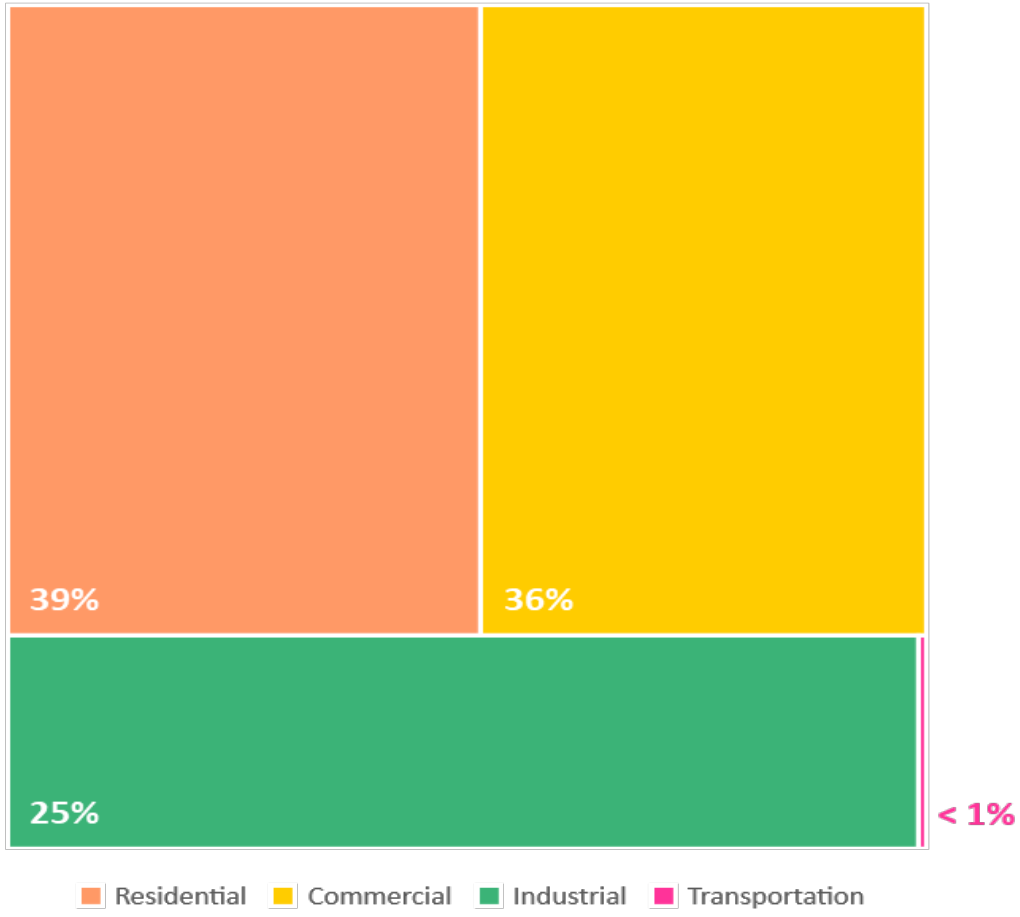
- The State and Local Energy Efficiency (SEE) Action Network offers resources, discussion forums, and technical assistance to state and local decision makers as they provide low-cost, reliable energy to their communities through energy efficiency.
- SEE Action reports on Grid-interactive Efficient Buildings
  - **Introduction for State and Local Governments:** Describes grid-interactive efficient buildings in the context of state and local government interests and outlines actions that state and local governments can take to advance demand flexibility.
  - **Determining Utility System Value of Demand Flexibility from Grid-Interactive Efficient Buildings:** Describes how current methods and practices that establish value to the electric utility system of investments in energy efficiency and other distributed energy resources (DERs) can be enhanced to determine the value of grid services provided by demand flexibility
  - **Performance Assessments of Demand Flexibility from Grid-Interactive Efficient Buildings: Issues and Considerations:** Summarizes current practices and opportunities to encourage robust and cost-effective assessments of demand flexibility performance and improve planning and implementation based on verified performance — **focus of this webinar**

Thanks to SEE Action Network Executive Group members who provided feedback on draft materials for these reports.

Introduction

Changes in electricity systems and grid operations require greater consideration of flexible loads.

- Increasing amounts of variable renewable energy
- Growth in electric vehicles
- Buildings (residential + commercial) account for about 75 percent of electricity consumption and in some regions up to 80 percent of peak demand.
- With many adjustable loads, buildings represent a large source for demand flexibility.



Source: U.S. Energy Information Administration (EIA), Monthly Energy Review. June 2019, Table 7.6. Commercial includes street lighting.

Grid-interactive Efficient Buildings and Demand Flexibility

Grid-interactive Efficient Building (GEB)	An energy-efficient building that uses smart technologies and on-site DERs to provide demand flexibility while co-optimizing for energy cost, grid services, and occupant needs and preferences in a continuous and integrated way

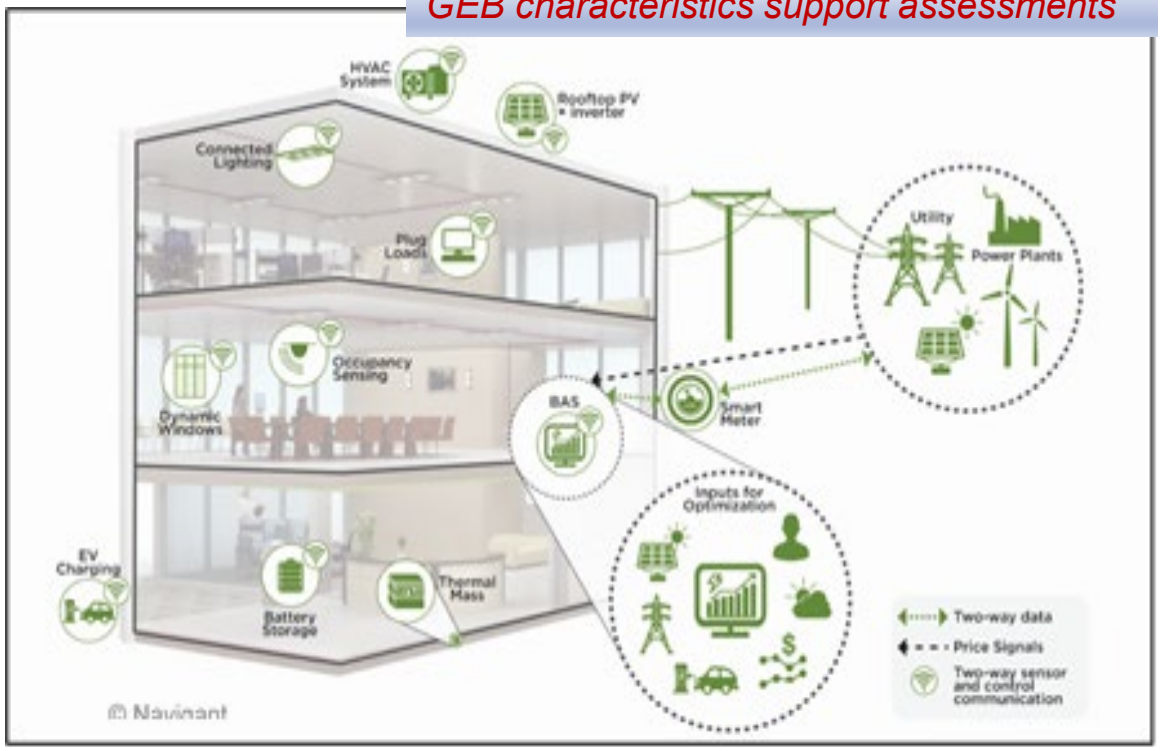
Demand Flexibility	Capability of DERs to adjust a building's load profile across different timescales

GEB characteristics support assessments

- *DER* – A resource sited close to customers that can provide all or some of their immediate power needs and/or can be used by the utility system to either reduce demand or provide supply to satisfy the energy, capacity, or ancillary service needs of the grid

- *Smart technologies for energy management* - Advanced controls, sensors, models, and analytics used to manage DERs. GEBs are characterized by their use of these technologies.

https://www.energy.gov/eere/buildings/grid-interactive-efficient-buildings

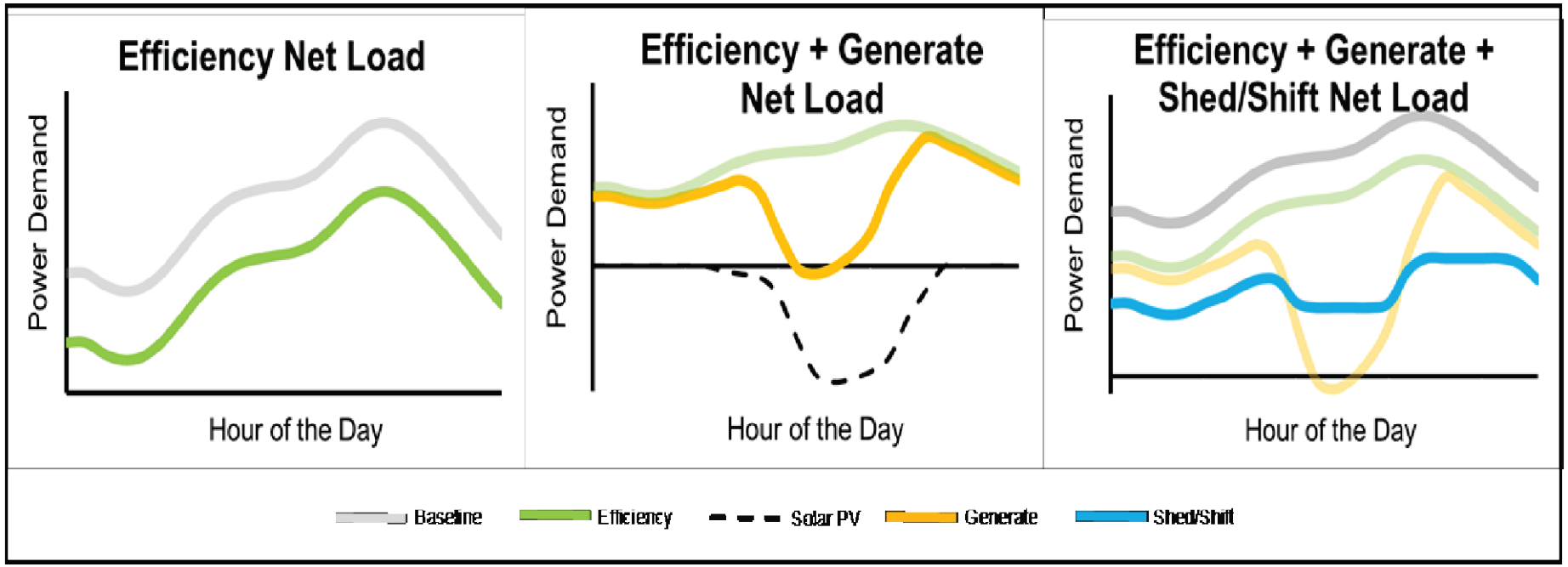


Demand-side Management Strategies to Manage Building (GEB) Loads

- *Energy efficiency:* Ongoing reduction in energy use while providing the same or improved level of building function
- Demand flexibility:
  - *Load shed*: Ability to reduce electricity use for a short time period and typically on short notice.
  - *Load shift*: Ability to change the timing of electricity use. In some situations, a shift may lead to changing the amount of electricity that is consumed.
  - *Modulate*: Ability to balance power supply/demand or reactive power draw/supply autonomously (within seconds to subseconds) in response to a signal from the grid operator during the dispatch period
  - *Generate*: Ability to generate electricity for onsite consumption and even dispatch electricity to the grid in response to a signal from the grid

Source: Neukomm et al. 2019

Managed GEBs - Example Daily Load Profile Options

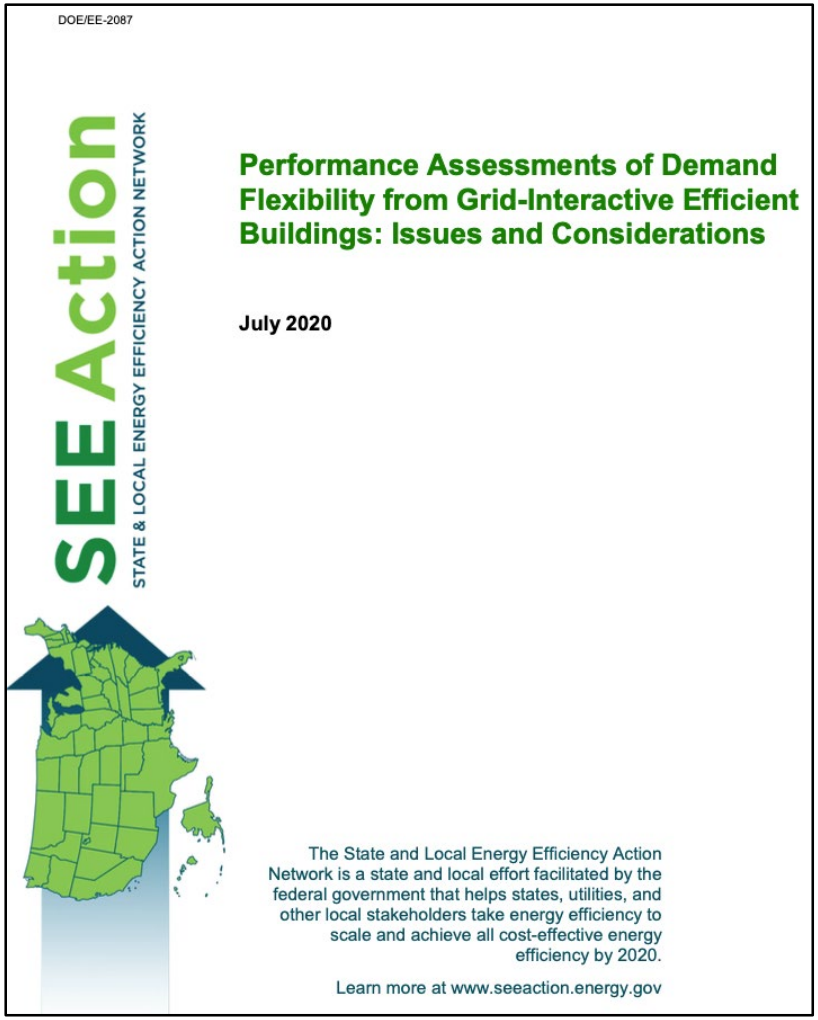


- ***Left:*** *Energy efficiency alone pushes down the load curve.*
- ***Middle:*** *Energy efficiency plus distributed generation (in this case, solar PV) reduce overall energy use, but the building's peak load coincides with utility peaks.*
- ***Right:*** *Adding load shedding and shifting flattens the building load profile, providing the greatest support to the grid.*

Source: Neukomm et al. 2019

Report on GEB Performance Assessments

- Explains basic concepts and fundamental considerations for assessing the actual demand flexibility performance of buildings:
  - Participating in demand flexibility programs
  - Responding to time-varying retail rates
- Provides information for designing demand flexibility performance assessments
- Identifies challenges and opportunities for advancing assessment practices as demand flexibility becomes more common and sophisticated
- Target audiences:
  - State and local governments, including utility regulators
  - Utilities, regional transmission operators (RTOs) and independent system operators (ISOs), and energy service providers including DER aggregators
  - Building system designers and building owners/operators
  - Researchers developing and testing assessment protocols



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Prepared by Steve Schiller, Lisa Schwartz and Sean Murphy, Berkeley Lab

https://emp.lbl.gov/publications/performance-assessments-demand

What Are Assessments and Why Are They Important?

What Are Assessments?

- *Assessments*, in some cases within seconds, quantify and document actual demand flexibility performance.
- For energy efficiency and demand response programs, assessments are called *measurement and verification* (M&V).
- Assessments of time-varying retail rates are called *impact evaluations*. This term also refers broadly to a wide range of assessments of actual performance.
- By any name, assessments of actual performance are fundamental to advancing demand flexibility for buildings.

Why Do Assessments? Generic Answer

- **Document impacts**: Document the demand management of projects and programs in order to determine how well they have met their goals — e.g., has there been a good use of the invested money and time?

  Provide proof of the effectiveness of efficiency and demand flexibility

- **Resource planning:** To support grid planning by understanding the historical and future resource contributions of efficiency and demand flexibility as compared to other energy resources.

  Provide data to support efficiency and demand flexibility as a reliable resource

- **Understand why the effects occurred:** Identify ways to improve current and future projects and programs as well as select future projects.

  "You can't manage what you don't measure"
  "Things that are measured tend to improve."

Why Do Assessments? Demand Flexibility Answer

Beyond serving as backbone of financial settlements:

- For utilities, regional grid operators, and utility regulators, assessments provide confirmation that buildings can reliably, cost-effectively and consistently provide demand flexibility.

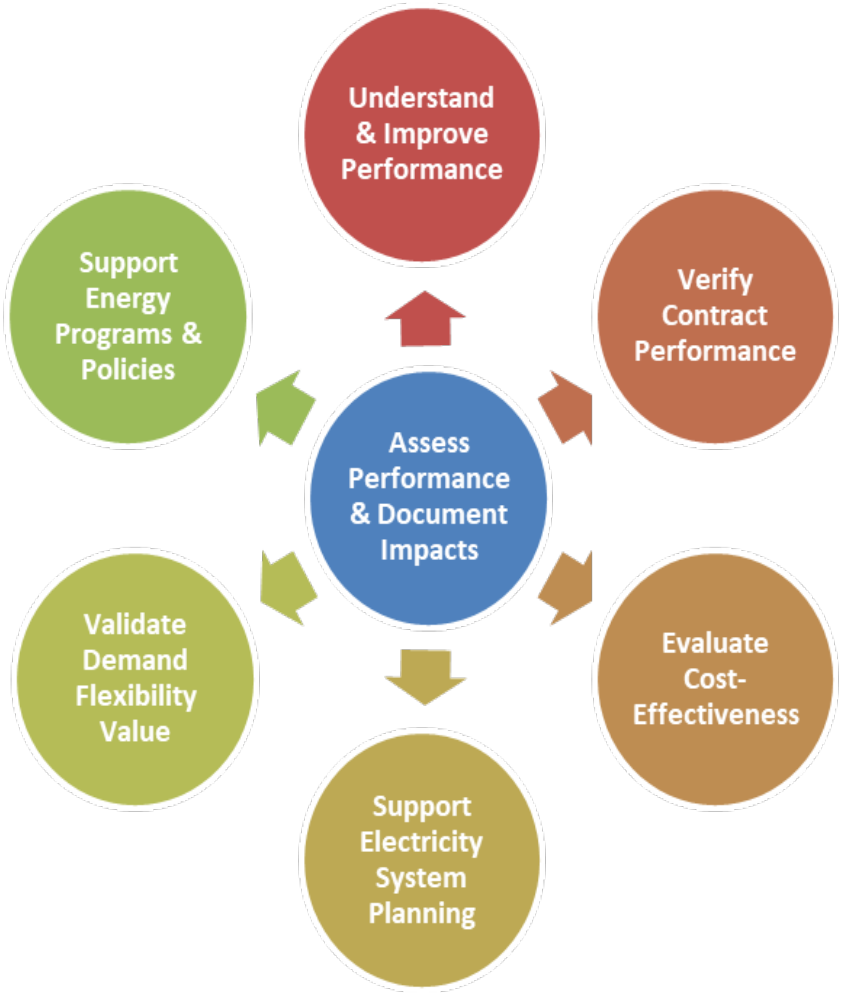
  Critical to acceptance of demand flexibility as a grid resource

- For building owners, operators, and occupants, assessments optimize building performance, provide confidence in the benefits (e.g., lower energy costs), and demonstrate acceptable non-energy impacts (e.g., building maintains comfort standards).

  Critical to optimizing demand flexibility performance and impacts

- For state and local governments, provide data needed to advance demand flexibility in support of their broader energy goals.

  Critical to advancing demand flexibility



Summary of Findings: Demand Flexibility Assessment Practices (in two slides)

Current assessment practices are working today.
But assessing performance will get tougher in the future.

- For decades, demand flexibility services (or at least load shedding) have been used as a grid resource. Existing assessment (M&V) practices are the basis for payments throughout the U.S. and overall meet current needs.
  - *Always opportunities for improvement, but for today's demand flexibility services, assessments are working.*
- However, advances in assessment practices will be required in a future with GEBs that provide continuous demand flexibility by integrating multiple DERs and flexibility modes (load shed, load shift, modulate, and generate).
  - *More sophisticated (and continuous) demand flexibility will require more sophisticated assessment practices.*
- Example assessment advances will include:
  - *New baseline constructs*
  - *Deploying more advanced metering and analytics*
  - *Further developing cybersecurity and privacy standards*
  - *Improving communication standards for increased interoperability*
  - *Establishing performance metrics and assessment procedures for load modulation*
  - *Keeping information actionable and straightforward*

3 Typical Days in the Life of a Future GEB

Tuesday

- Large commercial building's automation system receives a request from a demand flexibility aggregator to modify building operations on Wednesday
- Request takes the form of a requested load profile with specified hourly loads
- Building operator approves request

Wednesday (at building)

- Using machine learning software and results of actions taken for prior demand flexibility events, the building automation system controls multiple DERs to match requested load profile
- Automation system uses real-time metered data to control a generator, charge or discharge a battery storage system, and adjust demand of the building's electricity-consuming systems (e.g., ventilation, cooling, and lighting), while keeping building's performance within predefined parameters for occupant comfort and productivity

Wednesday (at aggregator)

- Automation system uses standardized communication protocols with cybersecurity and privacy protections to communicate real time data to aggregator
- Aggregated data are then communicated to grid operators, with compliance (or realization) rates and information on voltage and frequency of power delivered to managed building

Thursday

- Aggregator provides electronic report to building operator indicating whether the building provided the requested electricity load profile for each hour during the event, diagnostic information indicating how each DER contributed to the building's demand flexibility, and any recommendations for improved performance
- Data serve as basis for transaction settlements between aggregator, building owner and grid operator

Fundamental Considerations for Assessing Demand Flexibility Performance

5 Fundamental Considerations Define Assessments

- ***Assessment objectives***–What information is the assessment intended to provide and how will the information be used?
- ***Assessment boundary***–At what level will performance be assessed—multiple buildings, individual building, system or equipment level, by DER, by demand flexibility mode?
- ***Performance metrics***–What metrics will be assessed and how will they be defined (including temporal granularity)?
- ***Analysis methods***–How will metrics be calculated and with what expectations for certainty? Will baselines be used?
- ***Assessment implementation requirements***–What are the data collection, privacy, cybersecurity, and reporting requirements?

Effective performance assessments use data to quantify the amount and quality of demand flexibility provided by a building with respect to predefined performance metrics.

Objectives and Assessment Boundaries

- ***Assessment objectives***
  - Starting point for designing performance assessments
  - Assessment objectives vary based on audience for assessment and how assessment information will be used
  - Objectives inform selection of assessment boundary and performance metrics
  - In turn, objectives, assessment boundary, and performance metrics define other fundamental considerations—analysis methods and implementation requirements, including means for data collection

- ***Assessment boundary***
  - Primary focus of our report is assessing demand flexibility performance for a single building–at whole building or system/equipment/DER/demand flexibility mode level
  - Another assessment boundary is defined as all buildings participating in a particular program or tariff—*aggregation*
    - This "grouping" is an important assessment boundary because, in most cases, demand flexibility must be aggregated across a large number of buildings to reach a magnitude sufficient to serve as a meaningful resource for electricity systems.

Metrics – 4 Categories

- ***Quantity and timing of demand flexibility provided***
  - Example: amount of demand reduction during defined period in kilowatts (kW) or kilowatt-hours (kWh).
    - kW is the most common metric for demand flexibility today
- ***Quality of demand flexibility provided***
  - Examples: speed of achieving desired demand change and persistence of desired demand flexibility over long periods of time
- ***Attribution of impacts to equipment, DERs, flexibility mode, and/or building location*** (assessment boundary)
- ***Impacts on building owners and occupants***
  - Examples: energy cost savings and non-energy impacts such as comfort, health, and productivity

The most critical step in designing an assessment is determining appropriate performance metrics. Metrics are numbers, or other forms of information (e.g., categorical values), describing a process in a manner that indicates how well it is performing.

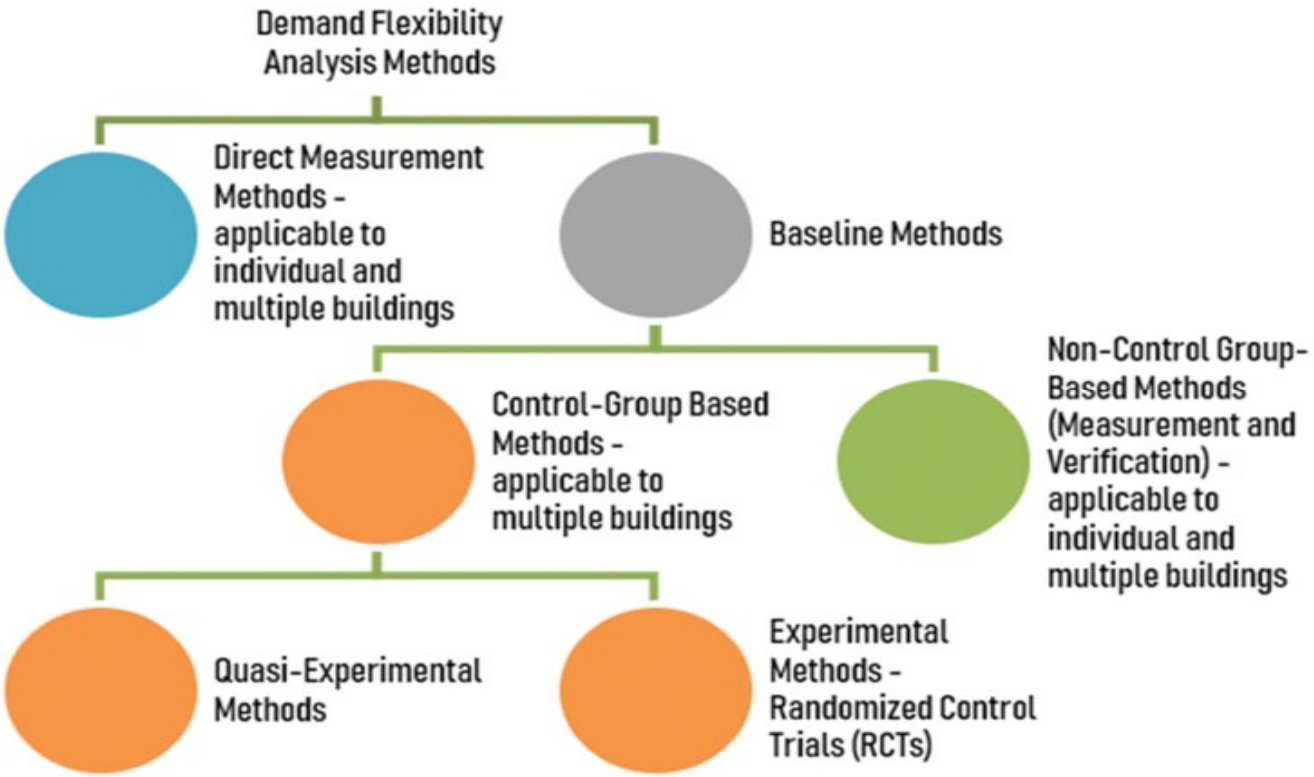
Metrics Beyond Performance Assessment

- ***Ability to perform***
  - Verification of a participant's *ability* to take demand flexibility actions to provide grid services in the future, providing an indication of the *potential* of the building to perform.

- ***Predictability***
  - Discussions with RTOs and ISOs for our report emphasized the importance of predictability of load. Grid operators do not serve "savings," they serve load.
  - Understanding whether loads participating in demand flexibility programs and time-varying retail rates will meet expected load profiles with respect to magnitude as well as shape.

These examples demonstrate that information of interest to program implementers and others should be determined in the program design stage, so that data collection and assessments meet program needs and support their effectiveness.

Demand Flexibility Analysis Methods



- Analysis methods may use direct measurement methods or baseline methods.
- Control group methods do not apply to individual building assessments.

Applying Different Analysis Methods for Efficiency and Various Demand Flexibility Modes and Programs

		Applications						
		Efficiency or Demand Flexibility Mode					Program Type	
Analysis Method		**Efficiency**	**Shed**	**Shift**	**Modulate**	**Generate**	**Dispatchable Programs (Event-based)**	**Non-Dispatchable Programs (e.g., tariffs for time-varying rates)**
Direct Measurement					■	■	■	■
Baseline Methods								
Measurement and Verification		■	■	■	■		■	■
Control Group Methods	Experimental Methods	■	■	■			■	■
	Quasi-Experimental Methods	■	■	■			■	■

Typical or expected applications of analysis methods for energy efficiency and demand flexibility

Analysis Involves Baselines or Direct Measurements
(or something else)

- For most types of demand flexibility today, a counterfactual scenario (commonly referred to as the *baseline*) is the basis for assessing performance for providing grid services.
  - For example, the amount of load shed during a specific time period is equal to the difference between the actual load of the building and a counterfactual scenario, defined as the load that would have occurred in the absence of the subject demand flexibility program or time-varying retail rate.

- Reliably defining baselines can be difficult – and may be more so when demand flexibility becomes more common.

Possible Options for Addressing Baseline Issues

- ***Greater reliance on non-dispatchable, price-driven regimes (e.g., critical peak pricing, real-time pricing)***

- ***Development of new performance metrics based on meeting desired load shapes*** (A load shape is a curve that represents load as a function of time. Load shapes contain information on how electricity use changes over the day, as a composite of end uses.)
  - Utilities and grid operators need predictability to serve loads — need to know if actual loads met expectations for demand flexibility in terms of magnitude as well as load shape.
  - A performance metric could be whether the desired load shape and magnitude matched what the building provided.

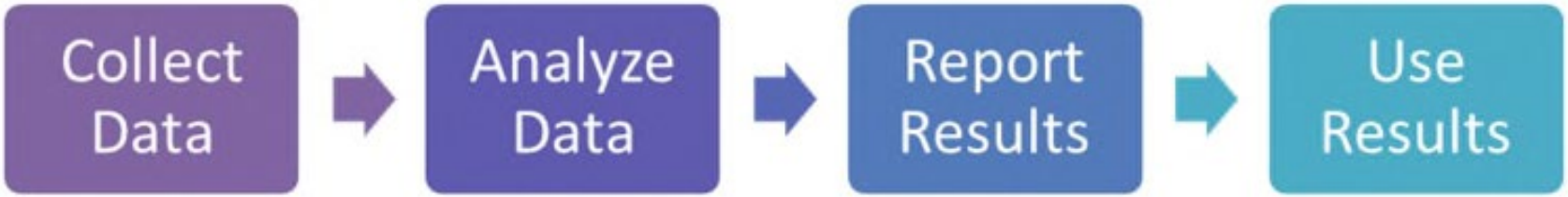
- ***Other metrics that do not rely on baselines***
  - Shaping options, where total energy savings for a period could be allocated or "shaped " among all hours in that period based on load level
  - Annual or monthly peak demand—e.g., the highest 15-minute demand in a year or month, perhaps similar to ratchet provisions in some electricity tariffs
  - Load factor—e.g., the annual average demand divided by the annual peak demand
  - Peak ratio—e.g., the 5% highest demand in a year divided by the annual peak demand

Now it's time to implement the assessment.

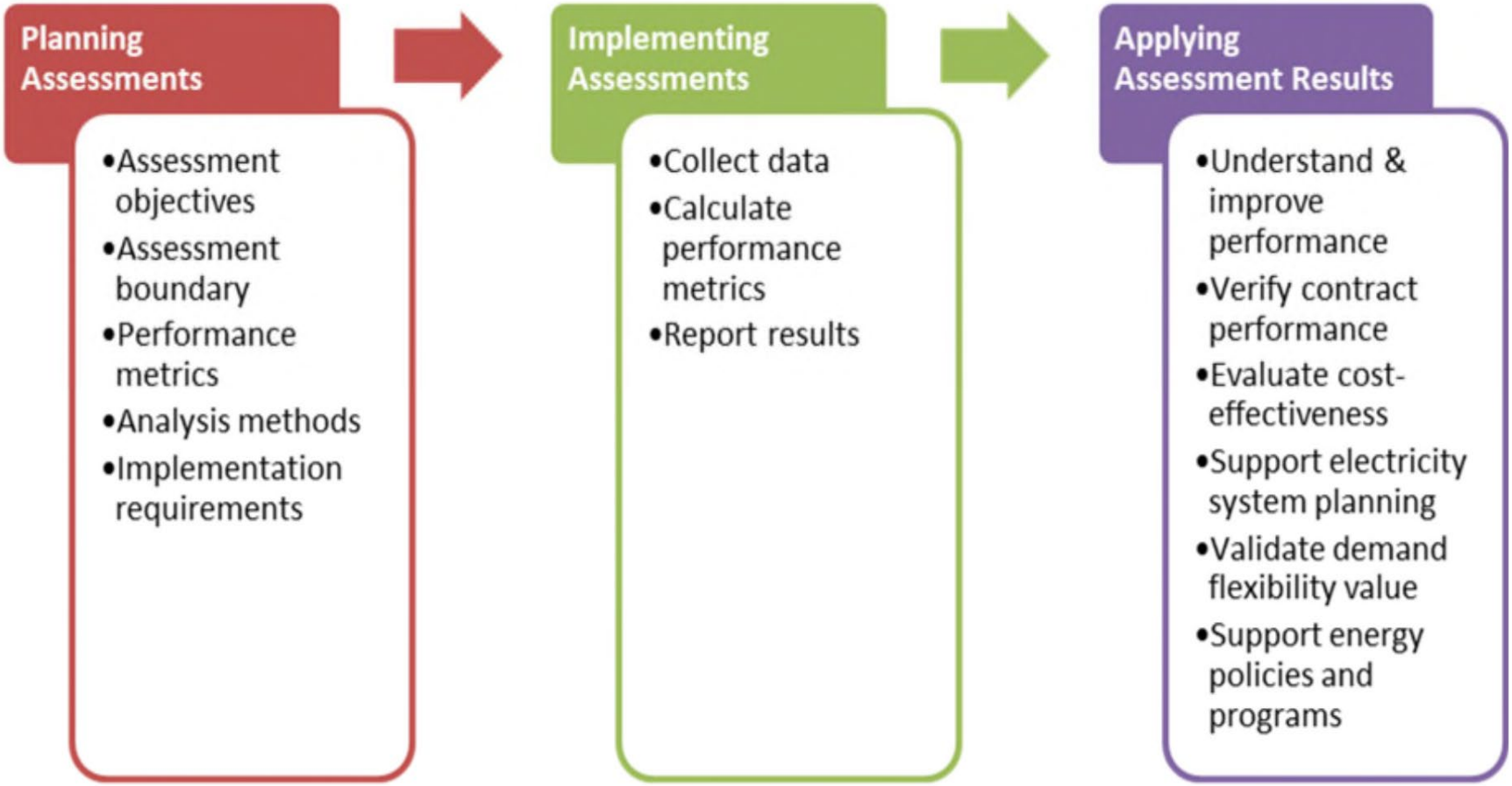
Assessing performance is more than just reading meters.

- How will the necessary data be collected (with consideration of privacy and cybersecurity)?
- What analysis tools will be used?
- What are the assessment reporting requirements, including who conducts the assessments?

Addressing these topics is a fundamental part of designing a successful assessment. Assessment planning is often iterative and influenced by practical realities of implementation.



Assessment Phases: Where the 5 basic considerations affect planning, implementation and applying results



Development Needs for Demand Flexibility Assessments

Assessment Practices Today and in the Future

While existing practices are sufficient for most applications today, in order to meet the full potential of GEBs, modified or new assessment approaches will be needed to assess demand flexibility performance in the future.

Assessments today can build on existing approaches for performance verification.

- Demand response M&V protocols for utility programs and wholesale electricity markets
- Advanced M&V (M&V 2.0) practices that use smart meter data and automated analytics
- Practices related to metering and data quality standards, measurement protocols, counterfactual scenario definitions, and using independent third parties
- Approaches to data privacy and cybersecurity, as well as installation of building automation systems and advanced metering infrastructure

Future changes in demand flexibility will require updates to assessment practices.

- Continuous or near-continuous demand flexibility
- Using multiple demand flexibility modes
- Load modulation in sub-seconds to seconds
- Increased use of combinations of DERs
- Demand flexibility provided at the individual end-use level or individual device level
- Managed electric vehicle charging
- Reduced complexity for consumers and other market participants

Drivers for Development Needs

Priority Development Areas	Drivers
Related to baselines	Increased use of integrated shift and shed Buildings providing multiple grid services, potentially in response to multiple programs Increased number of events including the potential for continuous demand flexibility
Related to assessment practices	Need to understand contributions of individual equipment or a particular building system (e.g., water heating system), DER, or flexibility mode Large volumes of short interval data Need for analyzing impact information quickly to support grid operation
Related to modulation services (e.g., frequency and voltage support)	Demand-side modulation services (e.g., frequency and voltage support) become more common, potentially continuous, autonomous, and providing very fast response

Extent of Development Needs

	Efficiency	Shed	Shift	Modulate	Generate*	Multiple Flexibility Modes, Dispatched Frequently
Performance Metrics	○	○	○	◑	○	◑
Analysis Methods	○	○	○	◑	○	◑
Baseline Definition	◑	◑	●	●	NA	●
Assessment Implementation Requirements	◑	◑	◑	●	◑	◑

○ = *limited development needs*

◑ = *low to moderate development needs*

● = *significant development needs*

*Generate includes discharge from electricity storage

Note: Objectives and assessment boundaries do not have development needs. Objectives are defined by the assessment sponsors; the assessment boundary flows from these objectives.

Planning for Future GEB Assessments

Planning Assessments – Key Takeaways

- When developing demand flexibility projects and projects, don't forget about assessment needs
  - *How you are going to assess results and judge success?*
- Take into account five considerations that define assessments:
  - *Assessment objectives*
  - *Assessment boundary*
  - *Performance metrics*
  - *Analysis methods*
  - *Assessment implementation requirements*–What are data collection, privacy, cybersecurity, and reporting requirements – including who will do the reporting?
- Today's practices can suffice for today's demand flexibility options, but if you are developing more sophisticated demand flexibility options, or plan to utilize modulation or demand flexibility on a regular basis – new strategies (e.g., new baseline constructs) and implementation support (e.g., privacy, communication, and cybersecurity) are likely to be needed.

Actions State and Local Governments Can Take to Advance Demand Flexibility Assessments

Multiple Roles Can Support Assessment Practices

State and local governments can play important roles to support reliable and cost-effective performance assessments for demand flexibility as well as for energy efficiency.

Types of Actions	State and Local Government Roles			
	Regulate Jurisdictional Utilities	Operate Demand Flexibility Programs	Establish Codes and Standards	Operational Responsibilities for Public Buildings
Encourage assessments and share results	X	X		X
Adopt current best practices	X	X	X	X
Support advances in assessment practices	X	X		
Improve access to data from existing utility billing meters	X	X		
Consider improvements in metering infrastructure and related standards and protocols (including for utility service connections)	X	X	X	

Actions State and Local Governments Can Consider
In Order of Priority and Ease of Implementation

- **Encourage performance assessments, provide technical assistance, and share results** – for example:
  - Lead by example in public buildings
  - Provide technical assistance to building owners and operators
  - Disseminate assessment results
- **Adopt current best practices for demand flexibility assessments** – for example:
  - Support standardized protocols for demand flexibility assessments
  - Ensure consistency in the valuation of DERs and their demand flexibility attributes using a common benefit-cost analysis framework
- **Support advances in assessment practices** – for example:
  - Establish pilot programs for public buildings to test not only demand flexibility options, but also assessment approaches
  - Use assessment results to indicate the potential and role of demand flexibility in statewide energy plans and building energy code and appliance standard updates

Actions State and Local Governments Can Consider, *continued*

- **Improve access to data from existing and future utility billing meters** – for example:
  - Adopt data access provisions in agreements and regulations
  - Adopt cybersecurity, privacy and interoperability standards/protocols
- **Consider improvements in demand flexibility infrastructure** – for example**:**
  - Encouraging sub-metering capabilities and automation enhancements through incentives
  - Encouraging demand flexibility-ready equipment through codes and standards
- **Improve coordination across programs and markets to simplify implementation of demand flexibility**
  - Encouraging coordination among utilities and other market actors in jurisdiction
  - Providing market assessments

Summary

Measuring Up for Demand Flexibility

- Assessments determine the quantity and quality of grid services.
- Assessment information can be used to improve demand flexibility performance, assess its impact and cost-effectiveness, and support its consideration in electricity system planning.
- Governments can take actions in partnership with stakeholders to advance practices for demand flexibility performance assessments.
- To a large degree, current best practices are sufficient for assessing basic grid services currently provided through demand flexibility.
- Advances in assessment practices will be required in a future with buildings providing continuous demand flexibility by integrating multiple DERs and demand-side strategies.
- Example assessment advances include:
  - New baseline constructs
  - Deploying more advanced metering and analytics
  - Further developing cybersecurity and privacy standards
  - Improving communication standards for increased interoperability
  - Establishing load modulation performance metrics/procedures
  - Keeping information actionable and straightforward

ASSESSING DEMAND FLEXIBILITY

Q&A

ASSESSING DEMAND FLEXIBILITY

Thank You

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