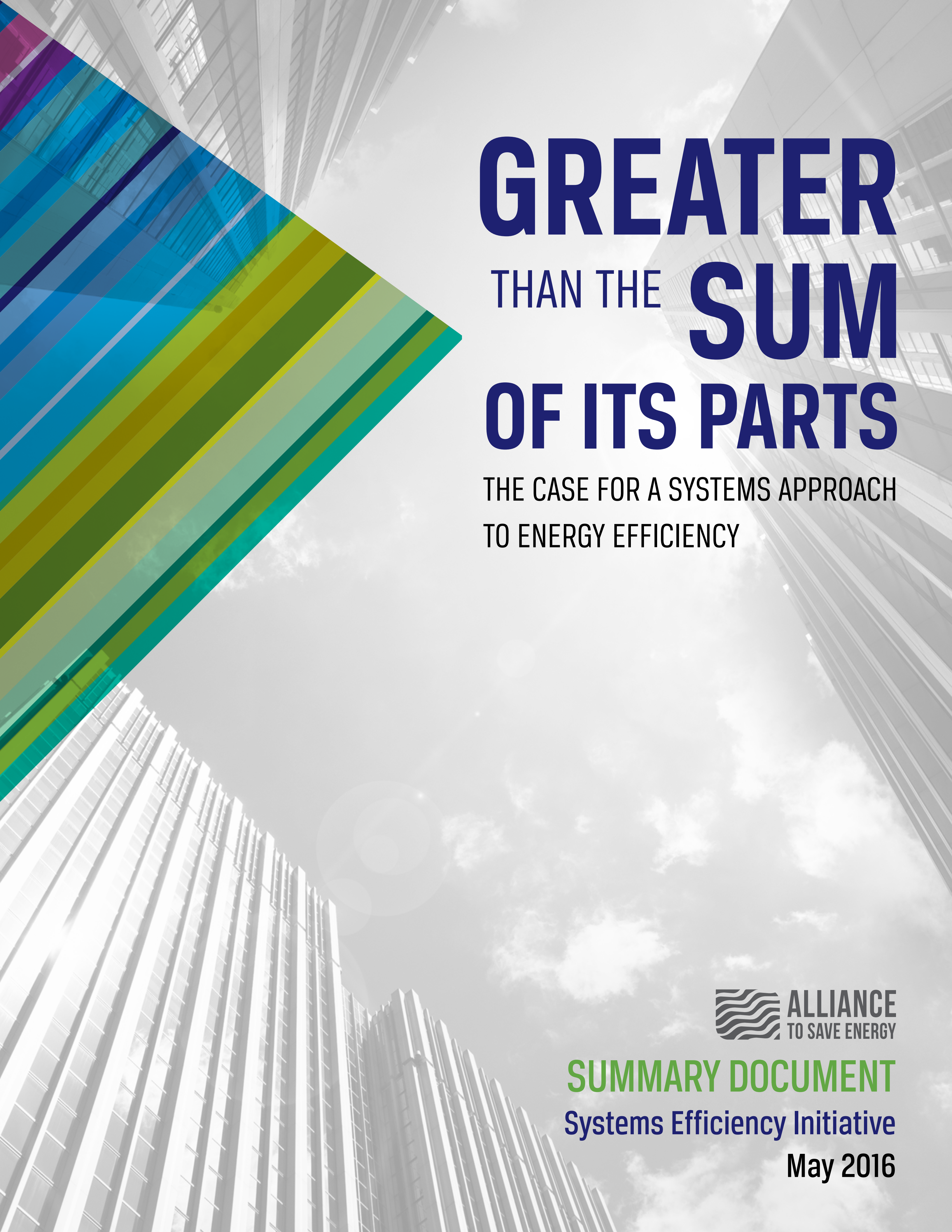

GREATER THAN THE SUM OF ITS PARTS

THE CASE FOR A SYSTEMS APPROACH TO ENERGY EFFICIENCY

ALLIANCE TO SAVE ENERGY

SUMMARY DOCUMENT

Systems Efficiency Initiative

May 2016

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TABLE OF CONTENTS

With energy consumption on the rise globally, and new technologies emerging in the market, both a critical need and an opportunity exist to look beyond traditional policy instruments to consider a new path to energy efficiency: ***systems-level efficiency in buildings.***

INTRODUCTION

Energy efficiency has long been recognized as the most cost-effective energy resource available and remains so even in the face of falling prices for renewable energy and low prices for electricity, natural gas, and oil. Study after study confirm that improving energy efficiency has multiple benefits—boosting economic performance, protecting the environment, and enhancing energy security.

The buildings sector—which accounts for roughly 40 percent of primary energy use (and a similar percentage of carbon emissions) in most countries—offers significant opportunities for deploying the energy efficiency resource.[1] Indeed, significant energy efficiency gains in buildings already have been made through policies and programs that focus on individual building components (e.g., appliance and equipment energy efficiency standards) or on whole buildings (e.g., building energy codes, benchmarking programs). However, with energy consumption on the rise globally, and new technologies emerging in the market, both a critical need and an opportunity exist to look beyond these traditional policy instruments to consider a new path to energy efficiency: ***systems-level efficiency in buildings.*** The energy savings potential of this approach—which considers the interactions of components within and among various building systems (whether powered by electricity or natural gas) and between the building and local climatic conditions—remains to be quantified, and the potential is largely untapped.

In addition to reducing energy use and associated costs to consumers, a systems approach has the potential to achieve significant non-energy benefits: reduced greenhouse gas emissions, improved grid reliability and resilience, water savings, extended equipment life and a consequent reduction in the waste stream, and increased occupant comfort and productivity. Studies have estimated that *the quantifiable non-energy benefits can add 25 to 50 percent to the total monetary benefits of energy efficiency*.[2,3]

Recognizing this opportunity, the Alliance to Save Energy launched the *Systems Efficiency Initiative (SEI)* in February 2015 to investigate the significant energy savings available through a systems-level efficiency approach to buildings and to develop

1 International Energy Agency. 2013. *Modernizing Building Energy Codes to Secure our Global Energy Future.* The IEA Policy Pathways Series. www.iea.org/publications/freepublications/publication/PolicyPathwaysModernisingBuildingEnergyCodes.pdf

2 Livingston, O.V., P.C. Cole, D.B. Elliot, and R. Bartlett. 2014. *Building Energy Codes Program: National Benefits Assessment, 1992-2040.* Rep. no. PNNL-22610 Rev 1. Pacific Northwest National Laboratory: Prepared for the U.S. Department of Energy. www.energycodes.gov/sites/default/files/documents/BenefitsReport_Final_March20142.pdf

3 Russell, C., B. Baatz, R. Cluett, and J. Amann. 2015. *Recognizing the Value of Energy Efficiency's Multiple Benefits.* Rep. no. IE1502. American Council for an Energy-Efficient Economy. aceee.org/research-report/ie1502

strategies for moving the market in this direction. The working thesis of the Initiative is that the consideration of building energy use from a systems perspective will become increasingly necessary to achieve future meaningful and cost-effective energy savings within the built environment.

The SEI brings together more than 50 industry stakeholders—including manufacturers, designers and builders, electric and natural gas utilities, building owners, and efficiency advocates—to focus on defining ways to achieve the next level of efficiency in buildings by optimizing building systems. The purpose of the initiative is to: (1) compile and build on research and lessons learned about systems efficiency by the U.S. building industry and in other countries, (2) educate the market about the increased economic and environmental benefits of taking into account building system opportunities and interactions, and (3) identify the tools—including research needs, policies, programs, investments and incentives—needed to thus transform the market. The SEI partners build consensus to:

1. Define a "systems approach";
2. Better understand and share information about the opportunities for systems-level energy efficiency in buildings; and,
3. Recommend near- and longer-term policies and actions to accelerate systems efficiency that build on the lessons learned from more than three decades of addressing component and whole-building efficiency.

Initially, the SEI focuses on new and totally renovated commercial and high-rise residential buildings.[4] This set of buildings affords large opportunities for energy savings—commercial buildings account for 46 percent of U.S. building energy use[5]—and relative flexibility for systemic changes. The members of the SEI recognize the importance of addressing system efficiency in the existing building stock as well, but acknowledge the added challenges of making system-level changes in such buildings.

4 Commercial buildings include office and retail space, medical facilities, educational facilities, and hotels and motels.

5 U.S. Department of Energy. 2012. "Chapter 3: Commercial Sector," *Buildings Energy Data Book.* http://buildingsdatabook.eren.doe.gov/ChapterIntro3.aspx

The Report characterizes the potential benefits of a building systems approach and prioritizes areas for further technical and policy research.

YEAR ONE SEI REPORT:

GREATER THAN THE SUM OF ITS PARTS

The April 2016 SEI Report, Greater than the Sum of its Parts, is the result of more than a year's worth of meetings and research, prompted by a recognized need for industry and policymaker consensus around systems efficiency. The Report characterizes the potential benefits of a building systems approach and prioritizes areas for further technical and policy research. These findings will provide input for specific SEI recommendations, to be developed during the second year of the Initiative, on how to better incorporate systems-level efficiency into current government and utility programs, and in federal and state legislation.

The Report identifies five strategies for a systems approach to achieve significant energy efficiency savings beyond those accruing through traditional approaches:

1. ***Break down silos.*** A systems-oriented approach will require creativity and a new level of collaboration across a range of stakeholders—including architects, engineers, designers, developers, and building operators—as well as between the building industry and policymakers.
2. ***Integrate systems.*** Integration both within and among systems operating in a building is vital to maximizing efficiency gains and opportunities.
3. ***Optimize operations through technology***. Controls and smart technologies are important for improving the efficiency of many types of systems.
4. ***Incorporate systems strategies through all phases of the building life cycle.*** Strategies to incorporate a systems approach should be applied during building design and construction, as well as during the operations and maintenance phases.
5. ***Think outside the building.*** Further opportunities for systems approaches exist beyond a building itself, across multiple buildings, and between a building and the electric grid.

The SEI Report provides working definitions of building systems, systems-efficient buildings, and other related concepts, as well as an overview of the energy use patterns and issues related to buildings, with a focus on U.S. commercial buildings. It then discusses both the achievements and the limitations of traditional (component and whole-building) efficiency approaches.

The main body of the Report outlines the benefits, challenges, opportunities and recommendations for next steps for a building systems approach, focusing on mechanical systems and lighting systems, miscellaneous electric loads (MELs), direct current (DC) power, and building-to-grid (B2G) integration opportunities. Finally, the Report discusses market and policy barriers facing the deployment of systems efficiency and a range of possible solutions for addressing through industry practices, government and utility policies and programs, and codes and standards.

This Summary Report provides an overview of the key recommendations from *Greater than the Sum of its Parts.* The following are highlights of these recommendations:

Develop new systems efficiency tools and procedures:

- Develop modeling procedures to more reliably predict system-level energy savings potential from mechanical, lighting, and other building systems—including the potential impacts of new technologies;
- Design system-level metrics that reflect real-world operating conditions and accommodate hybrid technologies;
- Conduct proof-of-concept evaluations and pilot tests to support a shift toward new system-level metrics;
- Modify testing procedures, ratings, and standards to reflect changes in metrics; and,
- Adopt common communications protocols to enable communication among various building systems.

Incorporate systems efficiency considerations into policies and programs:

- Encourage the incorporation of efficient system measurements and goals into voluntary rating programs, utility incentives, and building energy codes;
- Provide workforce training in the use and application of systems-oriented approaches, including through Internet and remote vocational programs;
- Promote initial and continuous commissioning of building systems to ensure that system and building-level energy targets are met both initially and on an ongoing basis;
- Use *Integrated Project Delivery* to help facilitate a holistic and cross-cutting approach to building system design, construction, and operation; and,
- Promote the adoption of sub-metering requirements and system-level energy benchmarking at the state and local levels.

Conduct additional research and analysis to make the case for a systems approach:

- Develop strategies for reducing MELs through increased efficiency and integrated controls;
- Conduct cost-benefit analyses of building AC/DC and DC/DC configurations, including microgrids, power conversion products, safety and end-use equipment, and control systems; and,
- Create compelling case studies to educate customers, developers, and policy makers about the energy and non-energy benefits of a systems approach.

The following Sections highlight the findings and recommendations for each of the building systems and topics discussed in the SEI Report. The full Report, *Greater than the Sum of its Parts*, may be read at www.ase.org/sei.

A building system *is a combination of equipment, operations, controls, accessories, and means of interconnection that use energy to perform a specific function.*

DEFINITIONS AND BACKGROUND

3.1 Defining Building Systems Efficiency

The members of the SEI agreed on the following definitions for the purposes of the Initiative, to ensure that SEI discussions take into account all aspects of building systems that contribute to the user experience:[6]

- A *building system* is a combination of equipment, operations, controls, accessories, and means of interconnection that use energy to perform a specific function. Building systems may be mechanical, such as climate control systems (heating, ventilating, air conditioning, and refrigeration—HVAC&R), or non-mechanical, such as lighting systems or office electronics.
- *Building system energy efficiency* is the ratio of (a) the services or functions provided by a building system to (b) the amount of energy that the system consumes directly, taking into account the thermal load imposed on other building systems.
- A *systems-efficient building* is a building in which multiple building systems (e.g., lighting, HVAC) are designed, installed, and operated to optimize performance collectively to provide a high level of service or functionality for a given level of energy use or input.

3.2 Building Energy Use

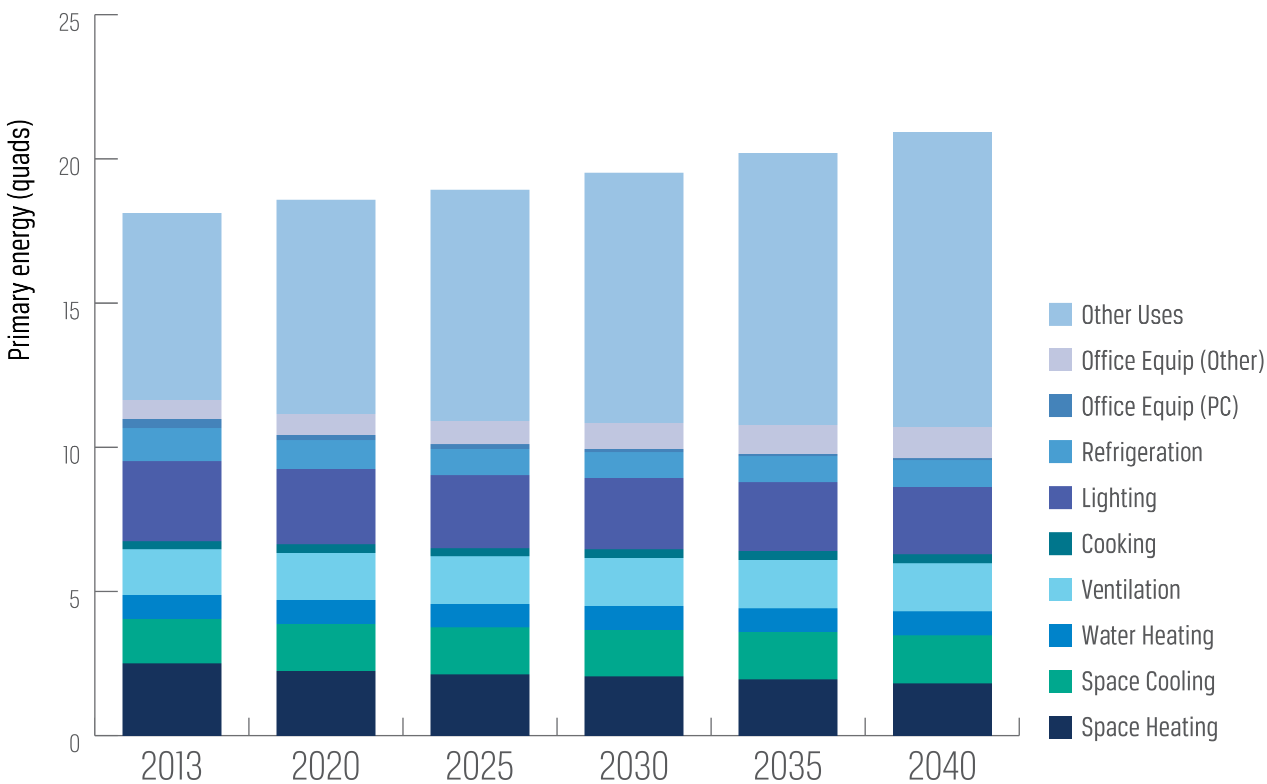
Two of the primary energy uses in U.S. commercial buildings are lighting and HVAC&R (Figure 1). Lighting uses an estimated 15 percent of primary energy and 20 percent of electricity in these buildings, while HVAC&R systems use about 37 percent of commercial building primary energy and 34 percent of electricity.[7] Building energy loads are highly dependent on ambient conditions, and change significantly as a function of the building type, time of day, season, and climate zone. Different building uses and the effects of climate zones on buildings can create opportunities to design systems approaches for saving energy in ways that consider the variance in building load profiles and regional climate conditions.

6 For a complete set of definitions, see the Glossary in the full SEI Report, *Greater than the Sum of its Parts*.

7 U.S. Energy Information Administration (EIA). 2015. 2012 *Commercial Buildings Energy Consumption Survey*. U.S. Department of Energy. https://www.eia.gov/consumption/commercial/data/2012/. Note: One half of the building stock in the 2012 CBECS survey was built before 1980 and the median age of buildings in 2012 was 32 years. Only 12 percent of existing commercial buildings have been built since 2003.

Although energy use for lighting and space heating in U.S. commercial buildings is decreasing, the overall energy intensity (energy use per floor area) for the commercial building stock has not declined significantly over the past several decades, and EIA projections show only a modest decrease in the future. This is largely due to envelope and equipment efficiency gains being offset by growth in plug and miscellaneous loads, which not only add directly to a building's energy use but also create additional cooling loads for mechanical systems; by 2035, these miscellaneous loads ("Other" in Figure 1) are projected to use as much energy as all the remaining end use categories combined.[8] As a result of the relatively stable energy intensity of commercial buildings, combined with growth in floor space, the overall energy use of U.S. commercial buildings is projected to continue to increase.

Figure 1. Projected U.S. Commercial Building Energy by End Use



Source: U.S. DOE 2015 Annual Energy Outlook, Reference Case, Table A5

8 The "other" category includes transformers, medical imaging and other medical equipment, elevators, escalators, off-road electric vehicles, laboratory fume hoods, laundry equipment, coffee brewers, water services, pumps, emergency generators, combined heat and power in commercial buildings, manufacturing performed in commercial buildings, and cooking (distillate), plus residual fuel oil, propane, coal, motor gasoline, kerosene, and marketed renewable fuels (biomass).

Exploring ways to improve the efficiency of entire systems—whether powered by electricity or natural gas—provides opportunities for designing creative solutions to achieve further energy savings.

SYSTEMS EFFICIENCY OPPORTUNITIES

The SEI Report looks in depth at lighting and HVAC&R systems, which account for more than one half of total primary energy use in commercial buildings.[9]

4.1 Mechanical Systems

A systems approach has the potential to greatly improve the energy efficiency of commercial building HVAC&R and other mechanical systems. This is partly due to the fact that some mechanical components are approaching technical and economic limitations for achieving further efficiency gains; as these limits are approached, the costs of marginal improvements may rise substantially. Exploring ways to improve the efficiency of entire systems—whether powered by electricity or natural gas—provides opportunities for designing creative solutions to achieve further energy savings.

In addition, building energy loads are highly dependent on ambient conditions, and change significantly as a function of the building type, season, and climate zone. Shifting to a systems approach offers the potential to design solutions for increasing mechanical system efficiency under different ambient conditions, and to revise standards and metrics to more accurately represent actual system performance.

Benefits and Opportunities of a Systems Approach to Mechanical Systems

As noted above, a systems approach that takes into account a diverse set of realistic operating conditions can provide new opportunities for building designers and operators to maximize the efficiency of entire systems—i.e., equipment, controls, accessories, and interconnections and the effective utilization of outside air to maintain comfort in buildings. For example, combinations of advancements in variable speed devices, fans, pumps and controls of such devices can result in system savings of 30–50 percent for HVAC systems.[10] Based on an analysis of more than 30 system-level HVAC efficiency measures, Navigant

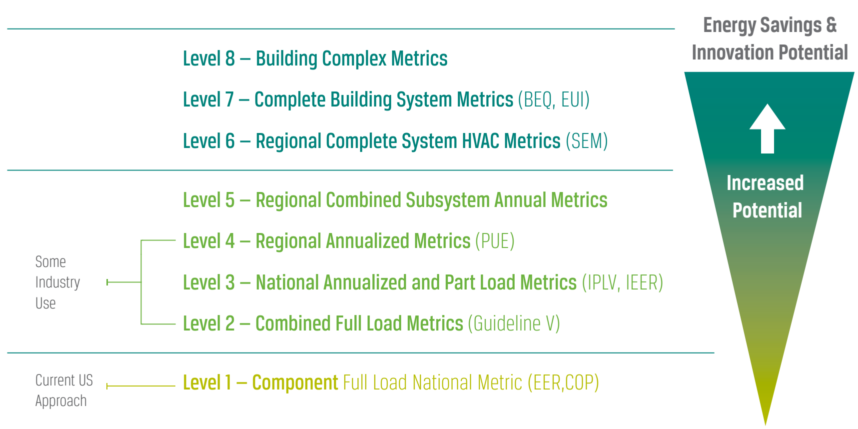
9 U.S. Department of Energy. 2012. "2010 Commercial Energy End-Use Splits, by Fuel Type." *Building Energy Data Book: 3.1 Commercial Sector Energy Consumption.* http://buildingsdatabook.eren.doe.gov/docs/xls_pdf/3.1.4.pdf

10 The ABB Group. 2014. *The ABB energy efficiency & productivity improvement plan: Efficient control of motor-driven applications.* ABB Limited: Warrington, Cheshire. http://publications.lib.chalmers.se/records/fulltext/146513.pdf

estimated that ***annual energy savings from each of these systems-related measures could range from about 0.05 quadrillion BTUs (quads) to about 1.0 quad*** (in the case of HVAC system commissioning and recommissioning), while noting that savings for each measure are generally interactive and are not simply additive.[11]

Moreover, a systems-oriented approach can help reduce the potential prescriptive regulatory burden by setting efficiency targets for building systems in ways that encourage the development of creative solutions. Opportunities also are increasing for building designers, contractors, and operators to leverage the ways in which building equipment and systems interface with each other, the building occupants, and the electric grid. Building management systems (BMS) and controls can be used to manage different building zones and systems separately to meet local loads and occupancy patterns, resulting in significant energy savings, peak demand reductions, and improvements in grid efficiency.

The HVAC&R industry has been exploring a variety of approaches to increase the efficiency of mechanical systems and subsystems. To reflect these efforts, the SEI Report includes a discussion of mechanical system and subsystem approaches to increase the scope of analysis beyond the component level. As the scope expands from one level to the next, different opportunities for energy savings emerge, as depicted in Figure 2 below. Level 1 corresponds to the component approach (adopting full load efficiency metrics at a common national rating condition) used for many mechanical system components. Level 2 begins to move away from the "lab conditions" method found in the traditional component approach and into "real-world" situations that equipment is more likely to experience. It combines full load efficiencies of two technologies. Level 3 includes part load and/or annualized metrics—e.g., integrated part-load value (*IPLV*). Some can still be at a component level, but the trend will be to include more components and subsystems. Level 4 evaluates systems at a higher level and on an annualized basis, and Level 5 uses combined annualized metrics (similar to Level 2) applied at a regional level. Levels 6 through 8 complete the transition from the component approach to depict varying types of systems approaches—first at a building system level, then using full building metrics, and finally involving multiple buildings, e.g., building complexes or districts.



Source: Prepared 2015 by Richard Lord, UTC, for the SEI Greater than the Sum Report

11 Goetzler, W. R. Zogg, H. Hiraiwa, J. Burgos, and J. Young. 2011. *Energy Savings Potential and Research, Development, and Demonstration Opportunities for Commercial Building Heating, Ventilation, and Air Conditioning Systems: Final Report.* Navigant report for the U.S. Department of Energy.
www1.eere.energy.gov/library/asset_handler.aspx?src=http://www1.eere.energy.gov/buildings/pdfs/commercial_hvac_research_opportunities.pdf&id=6179

Figure 2. Mechanical System and Subsystem Structure

Challenges to Implementation

As noted, one challenge to implementing a systems approach involves the lack of HVAC&R metrics and modeling tools that reflect "real-world" operating conditions—e.g., part-load optimized systems operating under various conditions—and account for system-level efficiency improvements. Current industry component metrics also do not necessarily allow for creative solutions, including those involving the use of controls (e.g., optimized controls of ventilation).

Recommendations and Next Steps

Following are some of the actions the SEI recommends to move toward a systems approach for mechanical systems energy efficiency:

- Conduct proof-of-concept evaluations and implementation pilot tests to support a shift toward new, systems-level metrics.
- Design new system metrics, as needed, to better reflect real-world conditions, such as partial load operations and annualized efficiency targets. In addition, develop metrics to accommodate hybrid technologies (e.g., rooftop air-conditioners combined with exhaust energy recovery devices) within a given building system.
- Develop more accurate models, as necessary, to analyze mechanical systems at full and partial loads over an entire operating range, to better reflect ambient temperatures and realistic load profiles of proposed buildings, and to incorporate the use of controls to a greater extent.
- Create alternative simulation tools and approaches, using updated "benchmark" systems, buildings, and cities to establish better baselines against which to measure systems-oriented approaches.
- Examine the potential for continuous commissioning over the life of a system to achieve long-term energy savings.
- Provide workforce training in the use and application of systems-oriented approaches, e.g., leveraging the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) and other certification programs, community colleges, and additional established training centers.

A shift to systems-level metrics likely will take many years. Starting with lower-level subsystem approaches and demonstrating successes will help facilitate the transition to a more comprehensive systems-oriented approach.

4.2 Lighting Systems

While significant improvements have been made in the efficiency of individual lighting components, even more energy savings can be obtained by focusing on lighting systems as well. A systems approach to lighting combines efficiency goals with lighting quality objectives to meet the needs of the users of a space. An optimal lighting system consists of multiple components—including luminaires and other hardware (fixtures, sensors, and controls), software (scheduling, control algorithms, networking with each other and with other building sub-systems), interior design (surfaces, furniture/partition layouts, colors and textures), and daylighting sources (windows or skylights)—designed and operated to minimize energy use while maintaining lighting quality. Optimizing a lighting system thus means ***meeting both quality and energy goals by ensuring the right amount of***

light at the right place, at the right time, and using the right equipment.[12] Key opportunities for improving the efficiency of lighting systems include deploying lighting controls, integrating lighting systems with other building systems, and incorporating daylighting as part of a systems approach.

Benefits and Opportunities of a Systems Approach to Lighting

Lighting controls are the central nervous system of a lighting system. Lighting control components, such as occupancy sensors, light level sensors, and daylight sensors, take inputs from the external environment, process those inputs, and send the outputs to smart controllers, ballasts, or drivers that make decisions on how to operate the system. The wiring infrastructure and communications backbone link all of the lighting system components to enable them to operate in a manner that optimizes lighting and energy use in individual spaces and throughout a building, and to provide real-time information to facilitate energy management. One lighting controls study in two General Services Administration (GSA) federal office buildings ***resulted in measured savings of 33 percent*** of lighting energy.[13]

Incorporating daylight also is critical to systems-oriented energy efficiency and is one of the most challenging, yet effective, ways to optimize a lighting system. Introducing certain amounts of daylight into indoor spaces—e.g., by optimizing building orientation, façades, and interiors—can greatly reduce lighting energy consumption and provide a more pleasing visual environment. In combination with controls that automatically dim the electric lights based on daylight levels, ***daylight "harvesting" systems in commercial buildings can save 25-60 percent of lighting electricity consumption.***[14]

The interaction between a building's lighting system and the building envelope is particularly important in any effort to maximize the benefits of daylight and daylight management systems. In a monitored commercial building retrofit pilot project in Washington, DC, ***automated electrochromic windows and light dimming controls yielded weekday lighting energy savings of 91 percent compared to the previous lighting system, along with a 35 percent reduction in peak demand*** for lighting. Savings on an annual basis (including weekends and evenings) ranged from 39 percent to 48 percent.[15]

Challenges to Implementation

Some barriers to improving system-level lighting efficiency are policy- and market-oriented, as well as regulatory in nature. Still other barriers include human factors; issues of device compatibility, interchangeability, and security; and challenges related to measuring the energy performance of a lighting system. For example:

- *Policy barriers:* Financial incentives for lighting equipment are driven by specifications from energy efficiency programs and do not necessarily take into account lighting quality and other non-energy factors.

12 Raynham, P. 2012. From lecture delivered to International Association of Lighting Designers (IALD), 13 October 2012, Vancouver, BC, Canada.

13 Wei, J., F. Rubinstein, J. Shackelford, and A. Robinson. 2015. *Wireless Advanced Lighting Controls Retrofit Demonstration.* Lawrence Berkeley National Laboratory. Rep. no. LBNL-183791. http://eetd.lbl.gov/sites/all/files/wireless_advanced_lighting_controls_retrofit_demo_final-508a.pdf

14 Reinhart, C.F. 2002. "Effects of Interior Design on the Daylight Availability in Open Plan Offices." *Proceedings of the 2002 ACEEE Summer Study on Energy-Efficient Buildings.* http://web.mit.edu/tito_/www/Publications/aceee02_panel3_no37.pdf

15 Lee, E.S., E.S. Claybaugh, and M. LaFrance. 2012. "End User Impacts of Automated Electrochromic Windows in a Pilot Retrofit Application." *Energy and Buildings.* http://dx.doi.org/10.1016/j.enbuild.2011.12.003

- *Regulatory barriers:* Energy codes currently favor prescriptive approaches to lighting system compliance—i.e., they prescribe specific strategies to realize savings, such as the maximum connected lighting load (Watts per square foot) or physical characteristics of each building component. This method is relatively straightforward for compliance officials, but does not encourage the use of lighting controls; nor does the current lighting power density (LPD) metric, which is a static number based on connected load and thus creates the potential for over-use of lighting equipment in spaces that are adequately daylighted or unoccupied.[16]
- *Other factors:* Other factors include trade-offs between the benefits of daylighting and potential solar heat gains that can increase a building's cooling load; and the potential for occupants to circumvent daylighting systems, if these are not properly designed or controlled.

Recommendations and Next Steps

A systems approach can help address the types of challenges highlighted above by promoting the use of an energy-based metric, monitoring energy use at the system level, and installing automated, self-calibrating lighting control systems. Actions the SEI recommends to move toward a systems approach include:

- Conduct further modeling and analysis on: (1) the effects and benefits of reflective surfaces and other interior design aspects on energy efficiency (as well as associated non-energy benefits, such as minimizing glare); and, (2) the interaction of lighting and daylighting with heating and cooling loads to maximize overall energy efficiency.
- Develop a nationwide normative data collection strategy (e.g., benchmarking of lighting systems) to support a systems approach to improving lighting system design and operation.
- Refine system "boundary" definitions to better reflect lighting system interfaces (the points at which electric lighting interacts with daylighting, controls, and other building systems)—and measure and evaluate lighting system design and performance based on multiple criteria, including energy consumption, peak period demand, and lighting quality.
- Establish and implement common technical system design and procurement specifications to accelerate the uptake of lighting controls in buildings and to ensure that installation and programming remain simple and reliable.
- Build on the activities of the NEMA-initiated C-137 Committee to ensure compliance with the new Lighting System Standard and to increase the adoption of efficient lighting systems as part of voluntary rating programs, utility incentives, and building energy codes.
- Encourage commissioning and periodic re-commissioning of lighting systems to ensure that energy targets are met both initially and on an ongoing basis.
- Provide workforce training in the use and application of lighting system approaches.

4.3 Other Building Systems

Other building systems, including MELs and DC power, as well as the integration of multiple building systems and building-to-grid systems, are projected to have increasing impacts on building energy use and, as a result, offer opportunities to improve building efficiency.

16 While building codes do allow a credit toward the allowed LPD levels where lighting controls are present, this adjustment does not fully reflect the actual performance or energy savings from well-designed and operated controls.

4.3.1 Miscellaneous Electric Loads

Miscellaneous electric loads in commercial buildings, also often referred to as "plug" or "process" loads, are electric loads not related to HVAC&R or lighting systems. MELs in commercial buildings encompass a vast array of devices, ranging from computers, data center servers, and elevators to security systems and medical equipment. MELs are found in most buildings, although their mix, density, and share of total building energy use vary widely.

MELs offer significant opportunities for efficiency improvements when in operating mode and for reducing energy waste in "standby" or "sleep" mode. Because of their diversity and the large numbers of very small devices, however, measuring their energy savings is difficult, except in the aggregate—at a circuit or whole-building level. Yet MELs in the aggregate can easily account for 20 to 35 percent of total energy use in a commercial building and, by some estimates, can reach as high as 50 percent of the total electric load in a very efficient building that does not otherwise use a large amount of energy.[17,18,19]

Benefits and Opportunities of a Systems Approach to MELs

Although addressing the efficiency of MELs at the equipment level will result in some energy reductions, achieving even greater energy savings at lower cost might be possible by integrating MELs and/or MEL controls with other building systems. Intelligent monitoring and diagnostic tools serving multiple systems can lead to a more holistic analysis of and impact on building performance.

A combination of market forces and building code requirements is stimulating a new generation of controls that also log actual energy use of MELs over time. Examples of measured or estimated energy savings from the use of these controls include:[20]

- On/off controls proposed for water fountains, computer monitors, printers, copiers, and vending machines (as appropriate) across several buildings of Salem, NJ Community College ***are expected to save an estimated 22,000 kWh/year (35 percent).***
- A 60-acre theme park uses wireless controllers to manage plug loads—along with HVAC and lighting equipment—in approximately 90 buildings, rides, and other facilities. In addition to ***estimated electricity savings of over 1.2 million kilowatt-hours (kWh) per year,*** the facility reports significant peak load savings, due to remote monitoring and control.
- Occupant education and engagement also are critical to reducing the energy use of MELs. For instance, one study that focused on occupants' use of advanced power strips revealed reductions of ***27 to 69 percent in printer energy use*** and reductions of ***51 to 81 percent for miscellaneous equipment,*** depending on the type of control used.[21] New technologies being developed for activity monitoring of occupancy can help in MEL load management.

17 Kwatra, S., J. Amann, and H. Sachs. 2013. *Miscellaneous Energy Loads in Buildings.* ACEEE. http://aceee.org/research-report/a133

18 Lobato C., M. Sheppy, L. Brackney, S. Pless, and P. Torcellini. 2011. *Selecting a Control Strategy for Miscellaneous Electrical Loads.* National Renewable Energy Laboratory. Golden, CO.

19 McKenney, K., M. Guernsey, R. Ponoum, and J. Rosenfield. 2010. *Commercial Miscellaneous Electric Loads: Energy Consumption Characterization and Savings Potential in 2008 by Building Type.* Lexington, MA: TIAX LLC. http://zeroenergycbc.org/pdf/2010-05-26%20TIAX%20CMELs%20Final%20Report.pdf

20 The following examples are from manufacturer-sponsored case studies and have not been independently verified. Sources are from phone interviews with several manufacturers conducted in October-November 2015. For this Report, the sources have been "masked," because some of these data are proprietary or commercial-product specific.

21 Metzger, I., D. Cutler, and M. Sheppy. 2012. *Plug Load Control and Behavioral Change Research in GSA Office Buildings.* Tech. Rep., National Renewable Energy Laboratory (NREL), Golden, CO.

Challenges to Implementation

Challenges to improving MEL system efficiency include:

- A lack of sufficient industry and/or technical expertise in some markets, as well as occupant reluctance to accept controls on "their" MELs devices (e.g., controls that automatically transition the devices into low-power states);
- Significant staff time necessary to service and maintain MEL control systems and to review and act on monitored data and diagnostics; and,
- A lack of well-defined and accepted procedures to model these systems and reliably predict energy savings for initial investment purposes. [22]

For existing commercial buildings, cost is another key barrier to improving MEL system efficiency, which can require MEL equipment upgrades, electrical and control system upgrades, use of data analytics platforms, and technical support.

Recommendations and Next Steps

Following are some of the specific actions the SEI recommends to move toward a systems approach to improving the energy efficiency of MELs:

- Develop modeling procedures to more reliably predict system-level energy savings potential from MELs.
- Conduct case studies to compare savings and cost-effectiveness of MEL control methods at different levels of aggregation (i.e., single device, multiple MEL devices, and with other building system controls).
- Explore opportunities for active monitoring of occupancy for MEL controls.
- Enhance open-system protocols to facilitate the integration of MEL device controls with building management system (BMS) capabilities—for example, using occupancy sensors to turn off (or put in "standby" or "sleep" mode) computers and printers as well as lighting and/or zoned HVAC.
- Analyze the economic feasibility of expanding or increasing the stringency of California's current code requirement that 50 percent of all receptacles (i.e., electrical fittings connected to a power source and equipped to receive an insert) have automated controls. Based on the results, consider code modifications, including those that include system-level, integrated controls.

4.3.2 Direct Current Power

Direct current power systems within a building can reduce energy demand as well as contribute to grid balancing, expanded control options, and improved safety and reliability. DC distribution can deliver systems-oriented energy savings by:

- Reducing alternating current-to-DC (AC/DC) conversion losses and AC/AC transformer losses, in both active and "standby" modes; and,
- Making it more feasible to replace AC-driven devices with "native-DC" devices for computers, telecommunications, and consumer electronics, as well as for lighting, control systems, and motors (especially those in variable-load applications).

22 Note that PNNL (2011a, Section 5.2.3.2) describes a procedure used to quantify the savings from ANSI/ASHRAE/IES Standard 90.1-2013, Section 8.4.2—Automatic Receptacle Control.

Benefits and Opportunities of DC Power Systems

Recent market growth and reduced costs of photovoltaic (PV) systems in the U.S., investments in battery systems (which also are DC power sources), and an increasing percentage of building loads that operate internally on DC are creating new demand and expanding opportunities to generate, store, distribute, and consume DC power in commercial applications.[23] The largest opportunities for efficiency gains from using direct current power to run DC loads include motors, light-emitting diode (LED) lighting, office equipment, refrigeration appliances, data centers,[24] and fast-charging of electric and hybrid-electric vehicles, each requiring a potentially unique DC infrastructure from 12 to 380 Volts.

DC electrical distribution, combined with "smart" technologies that facilitate the multi-directional flow of power and communications, could help achieve additional system efficiency gains. One recent study found medium voltage DC distribution systems to be ***7 to 8 percent more efficient than AC distribution***.[25] In addition, based on a study of DC and AC microgrids in commercial buildings, a recent NREL report found ***2 to 5 percent electricity savings*** solely from switching to DC-powered lighting and ceiling fans.[26]

Challenges to Implementation

Barriers to deploying DC power more broadly include:

- Installation costs;
- Capital costs for equipment (typical with early stage technologies);
- Limited end-use DC product availability;
- Lack of consumer awareness;
- Limited availability of DC distribution control equipment; and,
- Insufficient workforce training.

Recommendations and Next Steps

To help overcome these barriers, the industry will need to develop products and systems that offer a better performance/cost ratio for standardized DC solutions across multiple building applications; provide at least the same capabilities (e.g., efficiency, control, longevity) as equivalent AC solutions; and are cost-effective from an overall system perspective. Following are additional efforts that would help advance the contributions of DC power to improving building systems efficiency:

- Conduct in-depth cost-benefit analyses of building AC/DC and DC/DC configurations, including microgrids, power conversion products, safety and end-use equipment, and control systems;

23 Kann, S., M. Shiao, C. Honeyman, T. Kimbis, J. Baca, S. Rumery, J. Jones, and L. Cooper. 2015. *U.S. Solar Market Insight Q1 2015 Executive Summary.* Greentech Media, Inc. and Solar Energy Industries Association. http://www.seia.org/sites/default/files/resources/Y3pV3Vn7QKQ12015SMI_0.pdf

24 Ton, M., W. Tschudi, and B. Fortenbery. 2008. *DC Power for Improved Data Center Efficiency.* Lawrence Berkeley National Laboratory.

25 Navigant. 2013. *DC Power for Commercial Buildings.* Navigant Research. Report: 4Q. 2013. http://www.navigantresearch.com/research/dc-power-for-commercial-buildings

26 Fregosi, D., S. Ravula, D. Brhlik, and J. Saussele. 2015. "A Comparative Study of DC and AC Microgrids in Commercial Buildings Across Different Climates and Operating Profiles." NREL Report 63959. *IEEE First International Conference on Microgrids.* Atlanta, GA. http://www.nrel.gov/docs/fy15osti/63959.pdf

- Develop techno-economic models of hybrid AC/DC distribution network types for building classes with critical decision paths and financial impacts;[27]
- Expand existing power and communication standards to support DC system designs—such as Power over Ethernet (POE) or USB Power Delivery (PD), a branch of the USB standard providing higher power; and,
- Drive development of roadmaps and standards for DC distribution equipment and voltages across the full building ecosystem.

4.3.3 Multi-System Integration

As noted, a systems-efficient building can only be achieved by optimizing the integrated performance of multiple building systems, including both electric and natural gas-powered systems. Integrated control solutions might be more easily applied to large (i.e., over 50,000 square feet) commercial buildings with more experienced design teams, but smaller buildings also can benefit from some degree of integration.

Benefits and Opportunities of Multi-System Integration

The controls and feedback found in integrated building systems help buildings operate at peak efficiency. The processes and tools provided through systems integration also provide a path toward improving performance over time.

Understanding the ways in which integration across building systems might add to (or reduce) the benefits of optimizing individual systems is a complex challenge. One example is the joint control of HVAC and window systems. One study compared the measured energy performance of a typical floor in the New York Times headquarters building—with an all glass facade and fixed exterior shading, interior automated motorized shading, dimmable lighting and underfloor air distribution—to the calculated energy of an ASHRAE 90.1 code compliant building. The measured data showed 26 percent annual electrical energy savings, 22 percent peak electric savings, 51 percent heating energy savings, and 56 percent lighting savings.[28] Another exploratory study that compared base case smart controls of window and HVAC systems with "predictive" controls (that can forecast probable weather and occupancy) in four U.S. climates found a wide range of savings from these advanced controls, ***from no savings (and, in a few cases, losses) up to approximately 7 percent savings in lighting and cooling energy.*** [29] Researchers at Lawrence Berkeley National Laboratory (LBNL) are continuing to explore such joint optimization issues through modeling as well as research in the FlexLab facility.

Challenges to Implementation

27 Techno-economic modeling is a type of modeling carried out to help ensure that market-driven prices for new technologies can be achieved.

28 Lee, E.S., L.L. Fernandes, B. Coffey, A. McNeil, R. Clear, T. Webster, F. Bauman, D. Dickerhoff, D. Heinzerling, and T. Hoyt. 2014. *A Post-Occupancy Monitored Evaluation of the Dimmable Lighting, Automated Shading, and Underfloor Air Distribution System in The New York Times Building.* Lawrence Berkeley National Laboratory, Report 6023E. http://escholarship.org/uc/item/6rx4v52b

29 Coffey, Brian. 2012. "Integrated Control of Operable Fenestration Systems and Thermally Massive HVAC Systems." *LBNL Technical Report to the California Energy Commission Public Interest Energy Research (PIER) Program.* https://buildings.lbl.gov/sites/all/files/mpc-shading-thermal-mass.pdf

Barriers to multi-systems integration include a lack of common standards and communications protocols; suppliers' preference for proprietary rather than open-systems software; and an industry structure and delivery system with few crossover points among systems for lighting, HVAC, envelope, office electronics, and plug-in equipment. Other challenges include obsolete control systems, lack of "intelligence" capabilities to facilitate integration with other systems (with the possible exception of HVAC systems), lack of expertise, and up-front costs paired with uncertain returns on investment.

Although multi-system integration opportunities in existing buildings may be more limited and costly than in new construction, the potential for efficiency gains from replacing or upgrading control systems may be comparable in both new and existing buildings. New technologies—such as wireless communications and network integration (connecting systems and/or devices to an existing Internet protocol network)—have the potential to reduce the costs and complexity of system upgrades for existing buildings. Integrated system retrofits can be implemented through a variety of approaches, including:

- Retro-commissioning: A process either to return a building to its original operating parameters or modify its operations to improve performance;
- Sequenced planned retrofits: Systematic upgrades and improvements to a building's systems;
- Energy retrofits: Large-scale upgrades across systems, including HVAC, lighting, and controls;
- Building renovations: Improvements to building systems that are implemented as part of a larger planned renovation of a building; and,
- Deep energy retrofits: Extensive, coordinated changes to building systems, including to the building envelope.[30] Deep retrofits may only be economically effective when implemented as part of a larger building renovation.

Recommendations and Next Steps

Scaling up multi-systems integration will require:

- Collecting data and conducting modeling to support cost-benefit analyses;
- Packaging solutions for smaller buildings;
- Using a common set of sensors, communications links, and monitoring and control software to manage multiple systems;
- Adopting common communications protocols to enable communication among various building systems; and,
- Expanding financing options to help building owners finance and pay for system-level retrofits over time using accrued energy savings, with minimal transaction costs.

30 New Buildings Institute (NBI). 2011. "A case for deep savings." *11 Case Studies of Deep Energy Retrofits in support of NEEA's Existing Building Renewal Initiative and NBI's Getting to 50 work.* http://newbuildings.org/sites/default/files/DeepSavings_11CaseStudies.pdf

4.3.4 Building-to-Grid (B2G) Integration

As a result of the convergence of "smart" sensing, metering, and control technologies with remote and wireless connectivity that enable two-way (or multi-directional) flow of power and information, and "big data" analytics[31] for buildings and the grid, buildings now can act as distributed energy assets. This B2G integration is envisioned as a seamless, dynamic, and cost-effective end-to-end electricity system, capable of balancing demand and capacity requirements (both within and across buildings), while also facilitating the integration and scaling-up of renewable generation, combined heat and power, distributed natural gas generation, energy storage, and electric vehicles. B2G integration also will empower building owners, operators, and tenants to better manage their energy use and costs and dynamically participate in energy markets. DOE's Office of Energy Efficiency and Renewable Energy has noted that: "As electricity demand continues to increase, integrating buildings and the electricity grid is a key step to increasing energy efficiency . . . ."[32]

The SEI considers B2G integration to be both an important system in and of itself, one that extends beyond the building's boundary, and a key method of integrating other building systems, including HVAC, lighting, and MELs. Ideally, much of the same communications and control infrastructure needed to integrate system- or building-level monitoring and controls can provide a foundation for B2G interactions—such as demand response and "ancillary grid services"—that both improve grid reliability and create an added source of revenue (under proper market or regulatory conditions) to a building owner. A related concept, the "Internet-of-Things" (IoT), envisions fully interoperable connections among devices and systems: within a single building (or industrial facility), between a building and the electric grid (or a microgrid), and directly among devices and/or systems within a building and with outside service providers—all communicating via the Internet.

Benefits and Opportunities of a B2G Systems Approach

While the SEI has not yet quantified the potential benefits from B2G integration, types of benefits include energy savings from improved efficiency on both the customer and the utility sides of the meter; peak demand savings; and other energy and non-energy benefits (notably grid reliability and energy security).

Challenges to Implementation

Building owners/operators are not likely to invest in B2G-capable end-use devices in the absence of utility "smart grid" infrastructure, standardized communications protocols, and rate-setting policies and market mechanisms that provide a suitable sharing of benefits between a utility (or grid operator) and its customers. B2G integration also may be challenging for small- to medium-sized buildings, given the level of investment and operator supervision likely required.

31 "Big data" refers to extremely large data sets that may be analyzed computationally to reveal patterns, trends, and associations, especially relating to human behavior and interactions.

32 U.S. Department of Energy (DOE). No date. "About Buildings-to-Grid Integration." Office of Energy Efficiency & Renewable Energy.

Recommendations and Next Steps

Areas of innovation needed to encourage B2G integration include:

- Open architecture platforms that facilitate the interoperability of systems and applications;
- Highly-automated, easy-to-deploy, cost-efficient sensors and controls for new and older building systems;
- Data standardization and quality assurance;
- Appropriate regulatory and rate structure frameworks; and,
- Workforce training on building science, systems integration, and diagnostics.

This approach facilitates an optimized design and construction process through increased opportunities for collaboration and consultation, and can include an expanded engagement of operations personnel.

MARKET AND POLICY BARRIERS AND SOLUTIONS

Barriers to adopting a systems efficiency approach can be addressed through a variety of solutions—including technologies, market-based strategies, industry-developed standards and metrics, training and certification, changes to codes and standards, and other innovative policies and programs.

5.1 Addressing Fragmentation and Process Disconnects

The buildings sector is not currently structured to generate systems-focused building solutions. The industry generally is highly fragmented—with design decisions, construction practices, and building operations divided into distinct disciplines with little consultation among the various actors. Related process disconnects exist in procurement. Because the prevailing "design-bid-build" project delivery method separates the design from the construction functions, the potential performance benefits and life-cycle cost reductions that could be realized in building systems through closer collaboration across the design and construction teams are lost.

While some developers have attempted to address this disconnect between design and construction teams through a single "design-build" contract, a more comprehensive solution is the *Integrated Project Delivery* model.[33] Integrating people, systems, business structures and practices as a team working under a single contract, this concept begins at the earliest stages of design and continues throughout project hand-over to the client—and in some cases beyond, where "design-build-operate" is within the contract scope.[34] This approach facilitates an optimized design and construction process through increased opportunities for collaboration and consultation, and can include an expanded engagement of operations personnel. Several new practices are emerging within the industry, such as pre-installation testing and commissioning, which allow building professionals to determine how various systems and devices actually perform in relation to one another throughout the life of the building.

33 Cheng, Renee. 2015. *Integration at its Finest: Success in High-Performance Building Design and Project Delivery in the Federal Sector.* U.S. General Services Administration. http://www.gsa.gov/portal/mediaId/226139/fileName/Integration_at_its_finest_(Interactive_PDF)_2.action

34 For more information see http://info.aia.org/siteobjects/files/ipd_guide_2007.pdf.

The allocation of fees, times of engagement, and risks also are fundamental to the design and construction processes. Today's common procurement methods allocate a significant share of the design fees early in the project timeline. The lack of funds beyond this stage may exacerbate the disconnect between design, construction, and start-up commissioning, and can inhibit coordination later in the project.

Specific recommendations to address barriers related to market structure and industry practices include:

- Incentivize owners to demand, and contractors to offer, *Integrated Project Delivery* to promote a team approach to a project's design, construction, and operational phases;
- Increase the focus on actual, measured building and system performance through new and emerging contracting tools, voluntary energy rating systems and disclosure, and advances in codes, policies, and practices; and,
- Support the expanded use of commissioning, monitoring, and diagnostics to facilitate a systems approach and help ensure that performance requirements are met throughout a project's life cycle.

5.2 Government Policies and Programs

Public sector policies and programs provide significant opportunities for improving building energy performance through systems-focused approaches. Because the federal government is one of the largest building owners in the U.S., policies and efforts to improve efficiency in federally-owned buildings can influence the overall building market.

In addition, policies and programs implemented at the federal, state, and local levels—e.g., tax incentives, energy efficiency labeling, building codes—can affect the extent to which a systems approach is undertaken during the design, construction, and operation of all buildings. One example involves depreciation treatment in the federal tax code. Currently, equipment attached to a commercial building is depreciated over the life of the building (now set at 39 years), even though much of this equipment has a far shorter service life. When equipment fails before it has depreciated completely, an incentive exists to repair rather than replace it, to avoid having to write off the non-depreciated value. ***Shortening the equipment depreciation period to better reflect a product's typical life span would alleviate this disincentive.***

Another key opportunity involves the incorporation of a systems approach into building energy codes and standards. Many minimum requirements for new and renovated buildings in the U.S. are based on model codes and standards developed by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) and the International Codes Council (ICC), and then adopted—sometimes with changes—by the relevant state or local authority. Because the development of prescriptive systems-based code requirements may be prohibitively complex, ***performance requirements may provide a greater opportunity to address systems impacts through codes***. Ideally, the code development process will shift over time to one in which building system performance is the starting point and prescriptive options are developed based on measurable performance criteria.[35] One ***possible goal may be the adoption of outcome-based requirements,*** which focus on the overall energy use of an occupied building during actual periods of operation and automatically account for system interactions.

Challenges facing the development and adoption of systems-focused and outcome-based code requirements include the need to incorporate new technologies, resource availability within agencies responsible for code enforcement, and the complexity of accounting for operational energy use. Tools and guidance on design and construction methods to meet such outcome-based requirements also are needed for the architecture, engineering, and construction (AEC) community.[36]

Specific policy and program recommendations for addressing barriers to a systems approach include the following:

- Expand on and accelerate pilot programs to ensure that public building construction and renovations incorporate building system efficiency;
- Reform the federal tax code to ensure that the depreciable life of equipment reflects a product's typical useful life span, with an incentive to upgrade efficiency, when equipment is replaced;
- Design performance metrics, testing and rating methods, and mechanisms for third-party certification of systems energy performance to support code compliance; and,
- Incorporate systems-level requirements and operations-focused criteria into baseline codes, "stretch" codes,[37] and rating systems to ensure efficient long-term performance and integration among design, construction, and operations.

5.3 Energy Benchmarking, Disclosure, and Labeling

Building energy benchmarking—measuring a building's energy use and comparing it to the average energy use for similar buildings—is an important process for monitoring facility energy use and understanding overall building performance. Building energy benchmarking and disclosure programs, whether voluntary or mandatory, are beginning to have impacts on the building market: When building owners collect and report energy performance information, prospective buyers or tenants can factor energy use into their market evaluations. As developers and building owners recognize that relative energy performance has a market value, they begin to require their design teams to address building performance as part of design contracts. Linking benchmarking data with building characteristics can thus prove extremely valuable in understanding how various design, construction, and operational decisions affect overall energy performance.

Benchmarking also is important to help monitor facility energy use, understand overall building performance, and allocate

35 Conover, D., M. Rosenberg, M. Halverson, Z. Taylor, and E. Makela. 2013. *Alternative Formats to Achieve More Efficient Energy Codes for Commercial Buildings.* ASHRAE Transactions 119 (1).

36 Colker, R., M. Frankel, and J. Edelson. 2011. "Getting to Outcome-Based Building Performance: Report from a Seattle Summit on Performance Outcomes," New Buildings Institute, National Institute of Building Sciences. *Event Report.* Web. http://newbuildings.org/sites/default/files/Performance_Outcomes_Summit_Report_5-15.pdf

37 Also known as "above minimum" codes, which allow building owners/designers to voluntarily exceed minimum codes, or allow cities or counties to adopt more stringent codes than are required statewide.

capital investments for owners of a portfolio of buildings. The U.S. Environmental Protection Agency (EPA) Energy Star Portfolio Manager software tool is a common reporting mechanism used both for voluntary and mandatory benchmarking and disclosure programs to help track energy management progress and prioritize energy-saving investments. Complementing the Energy Star "operational" rating with an "asset" rating such as DOE's Building Energy Asset Score[38] can provide a more complete basis for benchmarking and comparing the energy performance of commercial buildings than either rating tool taken alone.

In the case of retrofits, pre-retrofit benchmarking data can help demonstrate the value of post-retrofit results to owners, financiers, insurance underwriters, and appraisers. Over time, the design and construction communities will be able to incorporate data from actual, measured energy use to determine how past projects have been performing and incorporate lessons learned into future projects. Thus far, these feedback loops generally have been lacking.

Benchmarking typically is conducted at the whole-building level. To the extent practical, however, sub-metering and benchmarking at the systems level would be extremely valuable to measure and compare the efficiencies of various building systems. Specific recommendations for promoting a systems approach to benchmarking include:

- Encourage system-level energy benchmarking at the state and local levels, building on the efforts of standards development organizations to create test procedures, simulation tools, and minimum efficiency requirements to allow building owners and designers to perform "apples to apples" comparisons; and,
- Promote the incorporation of sub-metering requirements into building codes by state and local governments to support future systems-level benchmarking.

5.4 Other Recommendations

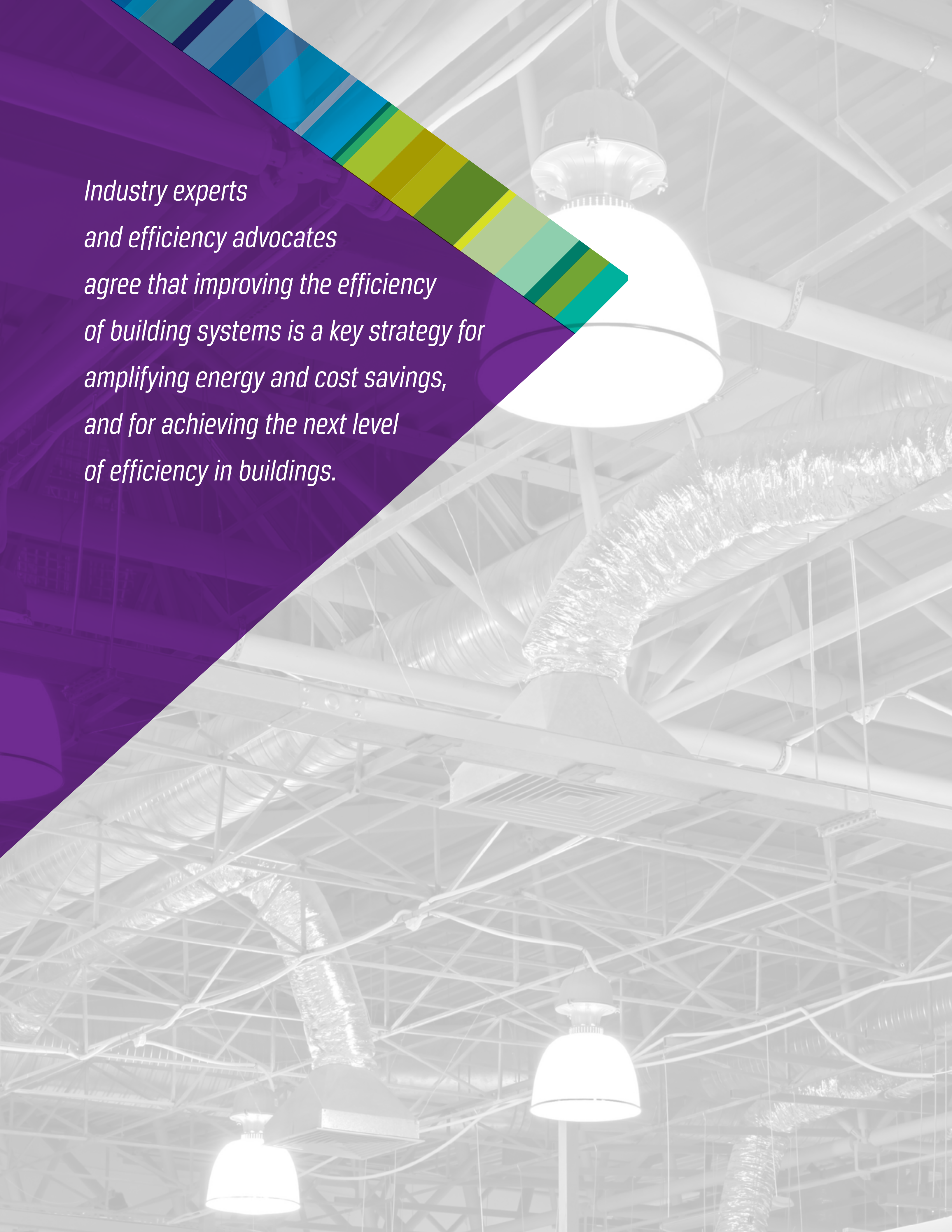
Other recommendations to encourage a market shift toward a systems-oriented efficiency approach include promoting programs by electric and natural gas utilities, financial institutions, or government agencies that:[39]

- Incorporate requirements and provide incentives based on actual, measured reductions in energy use by selected building systems; and,
- Offer leasing or third-party programs to customers with limited capital to increase systems-efficiency upgrades in existing buildings.

In addition, access to enhanced design and engineering tools as well as training and certification programs will be important for design engineers, operating personnel, and state, city, and county code officials. Training is needed to enhance knowledge of systems-level efficiency measures and commissioning techniques.

38 http://energy.gov/eere/buildings/building-energy-asset-score

39 Utilities spend over $7 billion per year on energy efficiency incentive programs that award energy rebates. The National Renewable Energy Laboratory has developed the EDAPT (Energy Design Assistance Program Tracker) to help utilities run these programs more efficiently. (Molina, M. 2014. "The Best Value for America's Energy Dollar: A National Review of the Cost of Utility Energy Efficiency Programs," American Council for an Energy-Efficient Economy. Rep. no. U1402; and Elling, J., L. Brackney, and N. Long. 2014. "Energy Design Assistance Project Tracker (EDAPT): A Web-Based Tool for Utility Design Assistance Program Management," *ACEEE 2014 Summer Study on Energy Efficiency in Buildings.*)



Industry experts and efficiency advocates agree that improving the efficiency of building systems is a key strategy for amplifying energy and cost savings, and for achieving the next level of efficiency in buildings.

NEXT STEPS FOR SEI

The April 2016 SEI Report, *Greater than the Sum of its Parts*, contains preliminary conclusions about opportunities for greater efficiency through a systems approach. During its second phase, the Alliance to Save Energy-led SEI will gather feedback from a broad range of stakeholders in the buildings industry as well as from local, state, and national policymakers to expand awareness of the Initiative and inform further analysis on the potential energy savings and other benefits of a systems approach.[40] Topics identified for possible additional analysis include the integration of HVAC&R and lighting systems with the building envelope and with electrochromic windows, indoor environmental quality and its impact on human productivity, integrated procurement, and opportunities for open-systems software and interoperable hardware.

Ultimately, the SEI will develop a set of policy recommendations that form a roadmap to accelerate energy efficiency and productivity in buildings through a systems focus. The roadmap will propose specific recommended actions, including:

- Roles of specific stakeholders;
- Suggested timetables; and,
- Required resources.

Recommendations will focus on areas of highest potential gains for systems-level energy savings, possibly including development of new systems metrics; proposed changes to building codes, equipment standards, and green building rating systems; and federal and state tax incentives to support systems efficiency. The roadmap also will address opportunities to incorporate systems-oriented content into professional and technical training and certification curricula.

Industry experts and efficiency advocates agree that improving the efficiency of building systems is a key strategy for amplifying energy and cost savings, and for achieving the next level of efficiency in buildings. The Systems Efficiency Initiative provides a critical forum for understanding the energy savings potential of a systems approach and for developing strategies to achieve these savings.

40 For information about participating in the Systems Efficiency Initiative, please contact LVanWie@ase.org.