OpenEfficiency PLATFORM

ASSESSMENT OF COMMON BARRIERS TO COMMERCIAL WHOLE-BUILDING ENERGY EFFICIENCY PROGRAMS AND POTENTIAL SOLUTIONS

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PERFORMANCE SYSTEMS DEVELOPMENT

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OpenEfficiency PLATFORM

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Introduction

Because new and existing commercial buildings offer the potential for significant energy savings, energy efficiency program administrators seek ways to design and implement effective whole-building programs to deliver those savings. While the barriers to increasing energy efficiency in commercial buildings have been well studied, *less research has focused on the barriers to implementing effective and efficient whole-building programs and ways to overcome those barriers*.

Recognizing the consequences of this research gap, the U.S. Department of Energy (DOE) funded Performance Systems Development of New York, LLC (PSD) to develop an integrated open source platform under the Open Efficiency Initiative (OEI), and to evaluate it through a series of whole-building energy efficiency program pilots.

The Open Efficiency Platform (OEP) aims to integrate a suite of DOE and U.S. Environmental Protection Agency (EPA) tools and to expand their use in energy efficiency programs. The OEI's overall goal is to increase the range and depth of energy savings available from commercial whole-building energy efficiency programs through reducing program administrative costs and better aligning program operations with private-sector market experience. Ultimately, OEI seeks to make regulated, commercial, whole-building energy efficiency programs easier to implement and more cost-effective for administrators, with simplified and automated processes for practitioners and building owners.

PSD contracted with Cadmus to inform and evaluate the OEI. This report provides groundwork for research and evaluation by identifying barriers to the design, implementation, and evaluation of whole-building energy efficiency programs. It then examines tools that can help address these barriers, focusing specifically on tools incorporated in the OEP, and explores how integrating the functionality of these tools using a platform—such as the OEP—can enhance these tools' effectiveness in overcoming barriers.

Commercial whole-building energy efficiency programs seek to reduce energy consumption by treating a commercial building as a whole rather than as the sum of its parts. The Consortium for Energy Efficiency (CEE) has defined whole-building programs as follows:

> "While traditional energy efficiency programs offer incentives for more energy efficient components or products, there is growing recognition that deeper savings can be achieved by treating buildings as integrated systems and helping owners and operators embed energy considerations in ongoing building management, operations, and maintenance…." (CEE 2012)

In the United States, utility and other program administrators of energy efficiency programs promote whole-building energy efficiency as part of larger, energy efficiency portfolio requirements under regulatory or policy mandates. Recognition continues to grow among regulators, energy efficiency program administrators, and the public that whole-building, deep energy savings are needed to meet federal or statewide emission reduction goals, especially for commercial energy efficiency programs.

For example, California's Energy Efficiency Strategic Plan (California Public Utilities Commission [CPUC] 2011) and Existing Buildings Energy Efficiency Action Plan (California Energy Commission [CEC] 2016) both extensively reference the need for deep energy savings from comprehensive improvements, identified through benchmarking and building monitoring in new and existing buildings to achieve ambitious statewide emissions reduction goals (Itron 2016). Although commercial whole-building programs are becoming more widely adopted, additional research and pilot programs are required to define how to best implement the whole-building approach (Effinger et al. 2012).

Key steps in developing commercial, whole-building, energy efficiency program pilots include addressing barriers to their design, implementation, and evaluation, and understanding what tools and practices can be employed to overcome such barriers. This report presents a comprehensive literature review of common barriers facing commercial whole-building programs, in concert with Cadmus' assessment of the roles that can be played by federal and non-federal tools serving as OEP components. To perform the literature review and assessment, Cadmus researched a wide range of studies and products involving commercial, whole-building, energy efficiency program design, implementation, and evaluation as well as various Technical Reference Manuals (TRMs) and other relevant products. TRMs provide a set of standard methodologies and inputs for calculating the savings impacts and cost-effectiveness of energy conservation measures. The US Department of Energy has supported standardization across state and regional TRMs with the Uniform Methods Project (UMP).[1]

[1] For more information see https://www.energy.gov/eere/about-us/ump-home

Whole-Building Commercial Energy Efficiency Programs in the United States

Various types of commercial whole-building energy efficiency programs are available across the United States. In 2016, CEE (CEE 2016) published results that indicated at least 266 commercial whole-building programs were offered in the United States and Canada that year.[2] About one-quarter of these commercial whole-building programs (63 of 266) supported whole-building energy efficiency in new construction or major renovations (as shown in Table 1). Fifty-eight programs provided incentives for energy audits or assessments in existing buildings, which might subsequently lead to participation in other programs (or subprograms) supporting building commissioning and/or metered data-driven tuning and fault detection.

Table 1. Commercial Whole-Building Energy Efficiency Program Types Offered by CEE Members in the United States and Canada

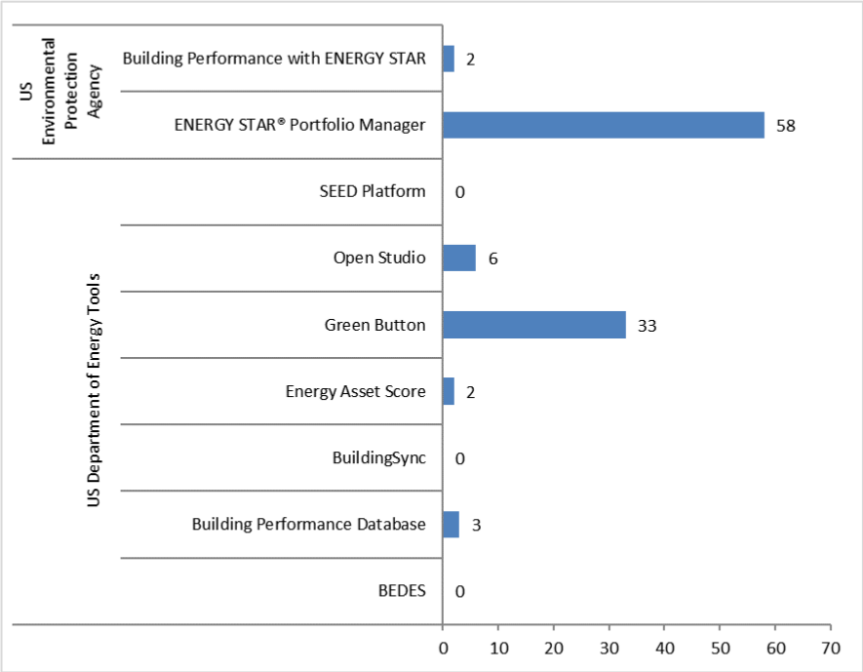
Whole-Building Program Type	Number of Programs
New Construction or Major Renovations	63
Energy Audit or Assessment	58
Commissioning (e.g., recommissioning, retrocommissioning, monitoring-based commissioning)	43
Financing	33
Meters, Energy Management Information Systems, or Other Tools	28
Other Program Types	17
Strategic Energy Management	16
Feasibility Study	8
Total	**266**

Source: CEE 2016.

Sixty-three CEE members use federal tools developed by the DOE or EPA for the commercial whole-building programs they offer. As shown in Figure 1, EPA's ENERGY STAR® Portfolio Manager is the most commonly used of these tools (58 members), followed by DOE's Green Button (33 members). The data indicate that some federal tools (e.g., the Standard Energy Efficiency Data [SEED] platform and the Building Energy Data Exchange Specification [BEDES]), have not realized the same uptake level so far.

2 CEE calculated this number based on information from its members—electric and natural gas efficiency program administrators that joined forces to support strategic energy efficiency initiatives in the United States and Canada. At the time of this literature review, CEE's website (www.cee1.org) listed 103 energy efficiency program administrator members operating in 45 states and seven provinces.

Figure 1. Number of CEE Members Using Various Federal Tools



Source: CEE 2016.

Overview of Barriers, Best Practices, and the Open Efficiency Platform

Any program administrator understands the importance of anticipating and overcoming barriers that can impede the successful design and delivery of energy efficiency programs; surmounting such obstacles ensures administrators achieve their energy savings goals effectively and efficiently. Considering uncertain energy efficiency program budgets, expanding utility savings goals, and complicated operational structures, such goals are becoming harder and riskier to achieve.

These challenges have become more pronounced for commercial, whole-building, energy efficiency programs than other program types, in that they typically require more complex and highly interactive energy conservation measure packages, which may include hard-to-quantify savings. While opportunities exist for implementing deep, whole-building, energy efficiency programs, a variety of barriers stand in the way.

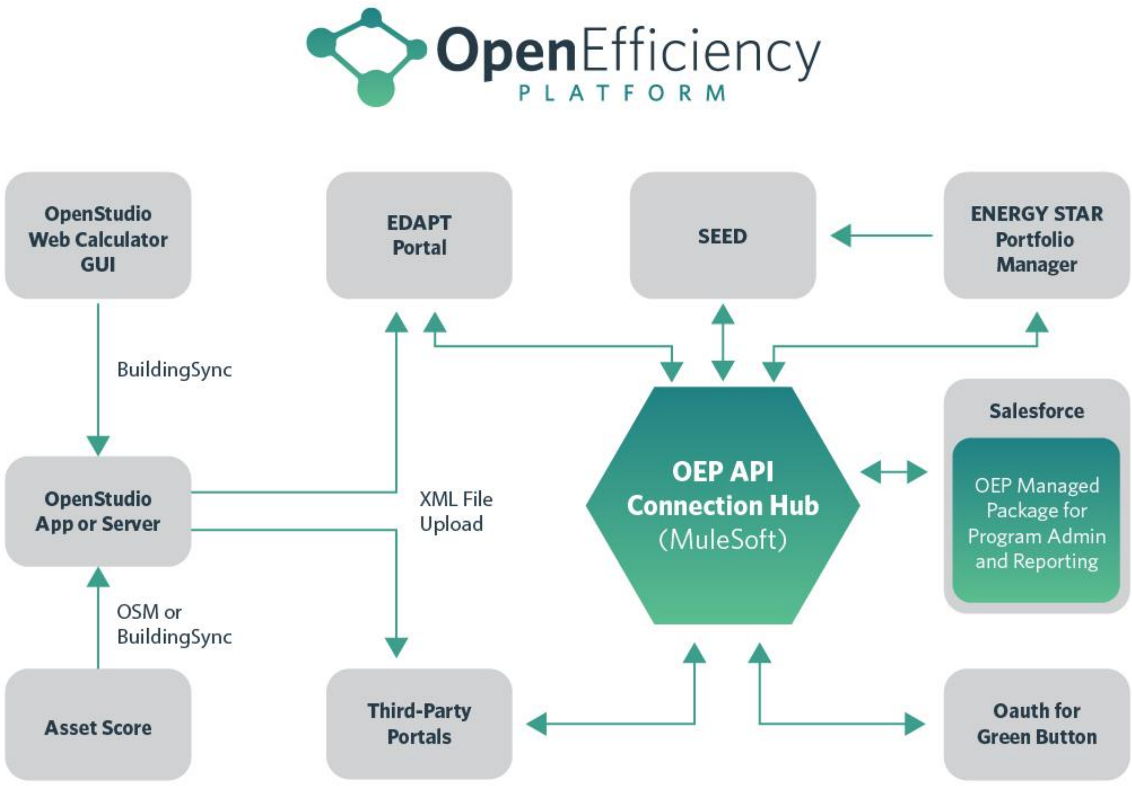
Cadmus' literature review verified this in identifying a large set of barriers encountered by commercial whole-building programs. For discussion purposes, we have organized them into four key barrier categories barriers that must be addressed to increase the range and depth of energy savings cost-effectively:

1. Lack of confidence in estimated savings
2. Lack of integrated and streamlined data management
3. Program costs
4. Lack of standardization in savings methodologies

The literature review sought to identify proposed or implemented solutions to overcome each barrier type. Given the limited research to date in this area, Cadmus found far less information on approaches proposed or used to resolve the barriers.

Finally, Cadmus examined the OEI platform's components (i.e., the OEP) and how they—individually and through the integrated framework—could potentially address whole-building program barriers. Figure 2 illustrates the OEP and its components, followed by brief discussions of each component.

Figure 2. OEI Platform Components



- DOE developed OpenStudio as an open-source "operating system" for building energy modeling (BEM). This robust, full-featured software development kit automates many functions associated with creating energy models, modifying existing energy models to create design alternatives, running energy simulations, and collating, analyzing, and visualizing results from energy modeling experiments. A cross-platform collection of software tools, OpenStudio supports whole BEM using EnergyPlus and supports advanced daylight analysis using Radiance. OpenStudio is available as an application with a graphical user interface and Command Line Interface (CLI) application suitable for deployment on a server. OpenStudio can also export an XML file containing results of multiple simulation runs.
- The EPA's ENERGY STAR Portfolio Manager tracks energy and water usage as well as greenhouse gas emissions using billing data, and provides a score based percentage ranking relative to the performance of other similar buildings. s. Primarily, Portfolio Manager provides information on overall building performance over time.
- DOE's Building Energy Asset Score (Asset Score) provides a nationally standardized tool for assessing the physical and structural energy efficiency of commercial and multifamily residential buildings. Built on the OpenStudio framework, Asset Score uses EnergyPlus simulations to generate simple energy efficiency ratings that enable comparisons among buildings, and identifies investment opportunities through energy efficiency upgrades. Primarily, Asset Score

informs whether a building will benefit from capital investments. DOE makes it available for voluntary use, free of charge. The Asset Score can export an OpenStudio file which can be opened in the OpenStudio Application.

- The Audit Template feature of the web based Building Energy Asset Score tool can be used to collect, store and report building energy audit data as needed. Users are able to generate an audit data report in PDF, CSV, or XML* file formats after entering building audit data into the tool, which lists all of the data entered and calculated tables and charts outlining the building energy use by energy type and end use, and the cost and payback of energy saving opportunities.
- The Green Button initiative reflects an industry-led effort to provide utility customers with easy and secure access to their energy usage information through a consumer-friendly, computer-friendly format. Customers can securely download their own detailed energy usage using a simple click of a literal “Green Button” on electric utilities' websites.
- The SEED Platform™ is an open source software application that helps organizations easily manage data on the energy performance of large groups of buildings. It provides users with a standardized, flexible, enterprise data platform to manage portfolio-scale building performance data from multiple sources. Its development was driven by the need to support administration of city benchmarking mandates.
- Building Energy Data Exchange Specification (BEDES) provides a dictionary of terms, definitions, and field formats to facilitate sharing of building characteristics and energy-use data.

In addition to providing a platform for integrating the functionality of DOE and EPA tools, OEP’s design provides a platform linking DOE and EPA tools with at least two other key tools:

- Energy Design Assistance Project Tracker (EDAPT) is a web-based program management tool that allows tracking and management of individual projects, from applications through final measurement and verification (M&V) and tracking of portfolio performance. Developed initially by Xcel Energy, DOE has worked to disseminate it and deliver it as a service. EDAPT imports the XML created by OpenStudio to manage the reporting of incentives for commercial new construction programs.
- Salesforce is a commercial software tool widely used by utilities for customer relationship management (CRM). Salesforce can be customized to support the management of programs and benchmarking or audit ordinances. The OEI Managed Package is a plug in that inserts a standardized data module for program reporting into Salesforce. This plug supports the secure transfer of information to and from Salesforce. The data taxonomy used in the Managed Package was developed using the BEDES standardized taxonomy.

This report provides insights into how the OEP components, through integration provided by their platforms, could resolve some barriers encountered by whole-building programs. While the document addresses all of these tools, it focuses most on use of OpenStudio, EDAPT, and Salesforce in support of whole-buildings programs. Pilots conducted through OEI will provide the basis for testing and evaluating OEP with different program types and scenarios.

Barrier 1: Lack of Confidence in Estimated Savings from Building Energy Simulations

Description of Confidence Barrier

For most utility energy efficiency programs, it is important that projects and the program deliver savings estimated prior to implementation as these estimates usually tie to incentives and energy planning. Energy and demand savings estimated prior to implementation are called claimed, reported, or *ex ante* savings, while achieved savings are called evaluated or *ex post* savings. The ratio of evaluated savings to claimed savings provides the realization rate; if the realization rate approaches or exceeds 100% , the program and projects deliver the expected energy savings. The realization rate serves as a key performance indicator for utility program designers, implementers, and evaluators.

As incentives often tie to modeled or calculated claimed savings in commercial whole-building programs (rather than actual savings), realization rates significantly less than (or even greater than) 100% can be particularly troubling and pose risks for these programs. A 100% realization rate means expected savings neither overstate nor understate actual achievements, reducing the need for future program planning adjustments. Given a program’s success depends on achieved total energy savings, providing the most accurate claimed savings estimate possible plays a vital role, as does aligning program delivery with evaluation requirements during the design stage.

The *International Performance Measurement and Verification Protocol* (IPMVP) defines four M&V options to quantify savings from energy conservation measures and to verify results of energy efficiency projects (Efficiency Valuation Organization [EVO] 2012):

- ***Option A. Partially Measured Retrofit Isolation:*** An engineering calculation of baseline and reporting-period energy, drawn from estimated values and short-term or continuous measurements of key operating parameters
- ***Option B. Retrofit Isolation:*** Short-term or continuous measurements of baseline and reporting-period energy and/or engineering computations using measurements of proxies for energy use
- ***Option C. Whole Facility:*** Analysis of whole-facility baseline and reporting-period (i.e., utility) meter data
- ***Option D. Calibrated Simulation:*** Energy-use simulation, calibrated with hourly or monthly utility billing data (with energy end-use metering possibly used to help refine input data)

Utility energy efficiency programs involving installations of specific energy efficiency measures usually estimate claimed savings using deemed savings or TRM calculations. When evaluating these programs, savings are typically assessed using Option A or B at the measure level by performing engineering calculations or by installing meters on the affected equipment or measure, and taking direct energy-consumption measurements. As these methods do not usually apply to whole-building programs, this section focuses on barriers related to M&V methods suitable for whole-building programs, particularly building simulations.

At the whole-building level, Option C typically provides a good method for interactive, multiple-measure retrofits or renovation projects with whole-building pre-implementation (baseline) consumption data available. Analysts typically prefer Option D for new construction projects with multiple interactive measures, particularly when baseline energy consumption proves unavailable.

Option C and Option D are internationally accepted methodologies used to calculate evaluated savings for whole-building energy efficiency programs. Many widely used and authoritative evaluation protocols and manuals (such as those shown in Table 2 [Cadmus and NMR 2016]) reference these two methodologies.

Table 2. Overview of Evaluation Protocol Sources

Guideline or Protocol (Source)	Whole-Building Methodologies Addressed	
	Billing Analysis	Building Simulation
International Performance Measurement and Verification Protocol (EVO 2012)	X	X
Uniform Methods Project (National Renewable Energy Laboratory 2013)	X	–
Roadmap for Assessment of Energy Efficiency Measures (Regional Technical Forum 2014)	X	–
Energy Efficiency Program Impact Evaluation Guide (SEE Action 2012)	X	X
California Energy Efficiency Evaluation Protocols (CPUC 2006)	X	X

Analysis of whole-facility utility meter data through IPMVP Option C compares records of participants' energy usage before and after program participation—typically through analysis of their utility bills—to estimate savings attributable to program activities. Utility meter data analysis can be used to derive whole-building savings, and reflect both participants' behavioral adjustments and measure-driven consumption changes. IPMVP considers utility-meter data 100% accurate for determining savings, although adjustments may be necessary for a number of factors (EVO 2012).

Calibrated building energy simulations through Option D rely on advanced engineering analysis via qualified simulation software to determine energy impacts of weather-sensitive measures where significant interactive effects occur between multiple energy conservation measures. Using building energy simulations, a modeler typically develops a simulation model based on conditions observed in the individual buildings analyzed or develops one or more prototypes representative of the energy efficiency program's population.

Methods for applying simulations depend on whether the analysis estimates claimed savings or evaluated savings, and whether the program addresses new or existing buildings. Improving the accuracy of claimed and evaluated savings usually requires using metered data (when available) to calibrate simulation models. Table 3 shows the relationships between metered (typically utility consumption) data and whole-building simulations.

Table 3. Use of Metered Data in Whole-Building Simulations*

Use of Metered Data	Existing Buildings		New Buildings	
	Claimed Savings	Evaluated Savings	Claimed Savings	Evaluated Savings
Calibrate with pre-metered data	Yes	Yes	No	No
Calibrate with post-metered data	No	Yes	No	Yes

*Use of metered data depends on availability.

Determining savings through building energy simulations can prove very complex, and, in certain cases, might result in a low confidence level, given the quality of building energy simulation results depend on multiple parameters, as shown in Table 4 (Cadmus and NMR 2016).

Table 4. Building Simulation Quality Dependencies that Affect Confidence in Analysis

Dependency	Detail
Quality of the chosen simulation software	• Supported software (the developer publishes regular updates) • Consistent results, given similar inputs
User's understanding of the software	• Users receive proper training on simulation software and building science • Users understand each input and its effect on results
Quality and quantity of data available	• Measured data points (model inputs) are more accurate than assumed values • Every data point (model input) is measured (ideally)
Assumptions used by the modeler	• Greater accuracy in specific assumptions may be needed, depending on the measures and/or effects being tested • Assumptions on heating and cooling efficiency create considerable uncertainty in results
Modeler's approach to calibration using energy consumption data	• Aggregate calibration • Weather-normalized calibration

Currently, the market offers numerous building energy simulation tools and software to address different user needs. Commonly used simulation software for commercial building energy analysis include the Quick Energy Simulation Tool[3] (eQUEST; DOE2 based software), EnergyPlus[4], Trane Trace™ 700[5], Carrier Hourly Analysis Program (HAP)[6], Design Builder[7], and Integrated Environmental Solutions' IESVE[8]. Use continues to expand for DOE's latest whole-building simulation tool, EnergyPlus. As DOE's

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3 http://www.doe2.com/equest/

4 https://energyplus.net/

5 http://www.trane.com/commercial/north-america/us/en/products-systems/design-and-analysis-tools/analysis-tools/trace-700.html

6 https://www.carrier.com/commercial/en/us/software/hvac-system-design/hourly-analysis-program/

7 https://www.designbuilder.com/

8 https://www.iesve.com/software/ve-for-engineers

free open-source, whole-BEM engine (and the successor to DOE-2.1E), the tool is used as a physics engine by other software (i.e., the Asset Score tool). Under development since 1997, EnergyPlus embodies state-of-the-art BEM knowledge through a comprehensive, robust engine that is continuously maintained, thoroughly documented, and fully supported. DOE releases major updates to EnergyPlus twice annually.

A chosen building energy analysis tool's capabilities should have a direct impact on the quality of analysis results and on the confidence of estimated savings. Working around the limitations of building energy analysis tools requires advanced understanding of the capabilities and limitations of tools and modeling skills required, which introduce uncertainties in providing accurate results. Therefore, the quality of building energy simulations also depends on the user's understanding of the software.

High-quality building energy simulation tools utilize another important feature: continuous support from the developer, including regular updates. Most available building energy analysis tools and software are updated regularly, with their component and measure libraries expanded to include most recent energy technologies. However, unsupported software and tools and those not updated regularly might cause serious issues and force users to rely on inaccurate assumptions and approximations.

Developing a building energy model using a simulation tool often requires a significant amount of input data. The amount of data required depends on the simulation tool used for analysis and the scope of the analysis. Models typically require physical characteristics of the modeled building, its occupant data, and weather data. Uncertainties regarding these data points (especially related to building occupancy characteristics) can cause inconsistencies in savings estimated through building energy simulations. Recent research indicates that imperfect information on the performance and energy savings from different equipment, technologies, buildings, and systems poses one of the biggest market barriers to energy efficiency analyses (Vaidyanathan et al. 2013).

Depending on the simulation type desired and on the quality and quantity of available input data, the modeler may need to rely on numerous assumptions and approximations that ultimately impact the results' quality. Many simulation tools offer reasonable default assumptions regarding details such as internal gains due to lighting and appliances; other, however, require users to specify these as inputs, either measured or assumed based on a secondary source. In some cases, relying on secondary data may not be very accurate, but obtaining real-time occupant data via surveys with facility managers or building occupants can be costly and time consuming. Therefore, difficulties with finding high-quality data, especially on occupant behaviors and operating parameters, can present a prominent barrier to accurately estimating savings via building energy simulations.

As suggested in Table 3, calibration offers a key way to reduce potential uncertainties in building energy simulations, as required by the IPMVP. Still, the modeler's calibration approach affects the work's quality. Coakley et al. (2014) identifies seven key barriers to building energy simulation model calibration, as outlined in Table 5. These seven key calibration barriers might impact the quality of building energy simulations, hence reducing the confidence level of claimed and evaluated savings estimates.

Table 5. Building Energy Simulation Models Calibration Issues

Key Barrier	Reasons
Standards	Current calibration criteria provide a reasonable standard for goodness-of-fit assessments, but do not address all uncertainties; current guidelines specify acceptable error ranges for yearly whole-building simulations, but do not account for input uncertainty, submetering calibration, or zone-level environmental discrepancies.
Expense	Expense and time are associated with obtaining required hourly submetered data, which are usually not available.
Simplification	Calibration presents an over-specified, underdetermined problem: among thousands of model inputs, relatively few measurable outputs are available with which to assess model accuracy, unless performing extensive submetering and increased sampling.
Inputs	A lack of high-quality input data required for detailed models.
Uncertainty	Currently, few studies account for uncertainty in model inputs and predictions, leading to a lack of confidence in building energy system outputs.
Identification	Problems can emerge in identifying the underlying causes of discrepancies between model predictions and measured data.
Automation	A limited number of integrated tools and automated methods are available to assist calibration, although the tools available have expanded in recent years.

Source: Coakley et al. 2014.

Cadmus' literature review on building commercial energy efficiency programs observed many issues leading to lack of confidence in estimated savings through building energy simulations:

- A recent analysis for the Bonneville Power Administration shows a large variance in project performance for commercial energy efficiency programs implemented via Energy Savings Performance Contracting, depending on the M&V methodology (Urbatsch and Boyer 2016). According to the study, projects evaluated via Option D achieved an average realization rate of 160%, but average realization rates for projects evaluated via Option C were very low, at 56%. Although verification via Option C is not considered to include measurement error as it uses actual utility meter data, non-routine events (e.g., changes in occupancy) might not be accounted for in the analysis, and could bias the savings estimates. Though the study did not provide enough information to determine the causes of typical differences from the two methods, but the information underlines that the optimal operation projected by Option D's theoretical simulations may diverge significantly from actual building operations, resulting in unrealistic realization rates.
- An existing buildings/new buildings program evaluation for Energy Trust of Oregon (Cadmus 2015b and Cadmus 2015c) revealed that building simulation models for several sites did not accurately reflect as-built conditions or operating parameters. When engineers updated the models with observed conditions and calibrated them to actual utility data, evaluated savings were less than claimed savings; hence, realization rates were less than 100% for the custom program participants.
- A business new construction program evaluation for the City of Palo Alto Utilities (Cadmus 2015a) revealed that building simulation models did not accurately reflect operating parameters

(e.g., hours of use, schedule). Although Cadmus found that reported baseline measures were correctly modeled as code compliant by the eQUEST compliance analysis module, the baseline models used default operating schedules, which could not be modified or overwritten in the compliance module to account for actual building operations. To evaluate savings properly, it is necessary to use the actual operating schedule in the baseline as well as in the as-built models. Therefore, these limitations of energy simulation software and its module prevented the study team from appropriately estimating energy savings.

Best Practices to Alleviate Confidence Barrier

To summarize the above findings, limited confidence in savings evaluations via calibrated building energy simulations present a common barrier faced by commercial whole-building energy efficiency programs, given results from model limitations and uncertainties in input data. The following best practices from the literature and Cadmus' internal review can minimize such potential uncertainties and potential errors, and increase confidence in results produced by such models:

- Use the latest published version of software that is regularly and systematically updated. Updates often fix bugs identified and reported from regular users. Notably, very rapid development cycles might create a barrier for market adoption and sow confusion among users. Therefore, the software's development cycles and quality/ease of use should be balanced with education provided regularly for new versions.
- Use a group of very experienced building energy modelers to develop simulation models, minimizing the learning curve and anticipating and resolving potential problems in a timely manner.
- Create internal workbooks to standardize the data input process, enhance quality control, and track model adjustments and revisions.
- Use prototype models to shorten simulation development times and to enhance quality control.
- Calibrate simulation models to a set of participant billing data; so inputs and assumptions can be adapted to provide a relatively accurate representation of participants or populations under consideration.

Currently, a flexible and adaptable standard set of best practices does not exist to reduce uncertainties in simulation modeling; so most professionals involved with design, implementation, and evaluation of commercial whole-building energy efficiency programs develop and use their own analysis' best practices. Commercial whole-building energy programs would benefit from developing a standard set of best practices related to building simulations and using the following characteristics:

- Supports high-quality simulation software, with an adaptive open-source equipment library and a glossary of default values and methodologies for energy calculations, using various options that minimize user assumptions and approximations
- Supports comprehensive data sources that streamline the data input process
- Uses a smart user interface that balances simplicity and flexibility for the user
- Streamlines the manual calibration process

Role of Open Efficiency Platforms in Increasing Confidence

Table 6 summarizes how various OEP components can assist in increasing confidence in commercial, whole-building program, simulation model results by reducing barriers that limit confidence in the results' accuracy. It further highlights how the OEP can provide linkages needed among different components to enhance confidence.

Table 6. Role of Open Efficiency Platform Open Efficiency Platform Components in Increasing Confidence in Modeling Results

OEP Component	Access to Software Enhancements and Updates	Model QC and Project/Program Tracking	Calibration	Input Data Quality and Efficiency
OpenStudio	• EnergyPlus engine is updated regularly by DOE • Component library is updated regularly • Users can add to the Building Component Library	• Automated baseline model possible • Can support uncertainty analysis • QC measures can help automate building-specific QA	• Automatic parametric runs expedite calibration • Manual calibration options	• Input interface easy to use • Built-in measures library enhances consistency and efficiency
EDAPT	• Central SaaS** provided by National Renewable Energy Laboratory • Private market equivalents	• Simplifies project tracking	• N/A	• Part of the QA automation process
Asset Score	• Free SaaS with DOE support for enhancements	• N/A	• N/A	• Reduced input model expands access to modeling and reduces input error; exports OpenStudio model
Audit Template	• Free SaaS with DOE support for enhancements • Mandated use by cities for reporting audits	• Audit submission simplified, tracking of required submissions	• Standardized source of data on building systems, allowing for aggregate analysis	• Aggregation of standardized data supports automated QA of audit data

OEP Component	Access to Software Enhancements and Updates	Model QC and Project/Program Tracking	Calibration	Input Data Quality and Efficiency
ENERGY STAR Portfolio Manager	• Data definitions are part of BEDES taxonomy • Large user base and support • Mandated use by cities and states	• Provides directional information on performance over time	• PM contains information on operational conditions in the building	• Export of standardized data supports automated QA beyond internal PM QA
Green Button	• National standard	• N/A	• Usage analysis results inform calibration	• Allows customers and other companies to access standardized data easily
SEED	• DOE supported • Open source and available for download	• Supports QC with accessible, standardized data	• Potential to connect audit data to usage data in Portfolio Manager	• SEED supports QA on buildings between data from different sources
BEDES/BuildingSync	• Data standardization supports interoperability and tool choice	• Standardized outputs support automated review	• N/A	• Streamlines data input
Salesforce	• SaaS gets updated regularly as part of license agreement • OEI Reporting Package distributed via Salesforce distribution mechanism	• CRM tracking and data reporting platform used by utilities	• N/A	• Streamlines data input
OEP Integration	• Open source platform supports sharing of updates as application program interface connections change over time, reducing platform costs over time • Mule mappings distribution to be determined	• Link and coordinate data transfer • Supports Salesforce-managed reporting packages	• Improved access to data to support calibration	• Automation of data transfer reduces error and enhances the frequency of access to data

** Software as a Service

Integrating OEP components can increase confidence in estimated savings in many ways, as each component has unique features, and integration of these components can reveal many other opportunities. Adoption of OpenStudio can play a large role in increasing confidence in estimated savings for commercial, whole-building programs. OpenStudio and its supporting tools are regularly updated by DOE, unlike many other counterparts in the market. An up-to-date component library provides users with an advantage to easily apply emerging technologies into their energy models. This feature can prove especially beneficial for modeling high-performance building designs that include cutting-edge technologies (e.g., zero-net energy [ZNE] buildings). More up-to-date component libraries also can reduce users' potential to depend on unreliable assumptions in their energy models.

Moreover, OpenStudio allows use of automated model calibration through the Parametric Analysis Tool (PAT) Framework, which uses pre-configured sets of OpenStudio measures for calibration. These results were developed by the National Renewable Energy Laboratory (NREL) and are referred to as the Building Component Library (BCL).[9] The open-source PAT application and framework provides users with an automated method that can be applied against a "calibrated" model to further evaluate input parameter uncertainty analysis, generating output parameter uncertainty distributions that can be quantitatively and qualitatively assessed. These assessments can provide inputs into risk assessments frameworks and uncertainty analysis, both for individual and portfolio level investments.

Model calibration using standardized OpenStudio measures provides both a method for increased productivity and a method for generating transparent documentation of calibrated results. This feature enhances the confidence in estimated savings thanks to transparent documentation of parameter settings used to achieve calibration and to the ability to apply automated input parameters and output results. Utilities might prefer developing and using of custom calculator tools, powered by complete OpenStudio models, to conduct simplified engineering analysis for estimating program savings; however, such an approach might constrain users, as they would have limited input capabilities.

Adoption of EDAPT, another OEP component, can help program administrators simplify their project tracking and management. Compatible with OpenStudio, EDAPT allows use of both tools' capabilities for more complicated applications. EDAPT can perform automated quality checks of energy model designs and can generate project documentation and reports for commercial buildings.

Adoption of Asset Score can simplify the process of modeling a commercial building's energy use and of identifying opportunities for improving energy efficiency. Built on OpenStudio and EnergyPlus, Asset Score can export an OpenStudio file. As it requires fewer inputs, Asset Score reduces input error. The Audit Template (the audit data reporting application companion to the Asset Score) supports the standardized submission of audit data for municipal audit ordinances. Standardization of data supports the development of data analytics and improved targeting of opportunities. The Audit Template data is stored using the BEDES data taxonomy and can be exported as a BuildingSync standardized file.

[9] For more information see https://bcl.nrel.gov/

These features of EDAPT and Asset Score simplify the overall process, and adoption of the SEED Platform and BEDES/BuildingSync help standardize data management and tracking. Adoption of SEED also can help program administrators in curating standardized data sets. An easy-to-use, flexible, and cost-effective tool to improve the quality and availability of data, SEED can be leveraged to clean, validate, and analyze data, assess compliance, and disclose results per public transparency requirements. The improvements that program administrators can achieve in transparency and standardization through adopting these tools can reduce potential errors in parameters used to estimate program savings and, hence, increase confidence levels regarding program achievements.

Utilization of OEP Integration by combining these tools can fundamentally increase confidence in commercial whole-building programs as the process links and coordinates data transfer among tools, and data transfer automation reduces errors and improves data quality, all supporting increased confidence in calculated savings. Further documenting the processes and potential benefits of using these tools through the OEP platform will help identify whether their use can increase confidence in commercial whole-building program energy savings estimates.

Barrier 2: Lack of Integrated and Streamlined Data Management

Description of Data Management Barrier

Current industry practices and tools for utility energy efficiency program design, implementation, and evaluation are typically not well-integrated or very efficient. Data transfers between stakeholders in utility energy efficiency programs (including program administrators, implementers, trade allies, evaluators, and program participants) typically utilize a manual data transfer process: slow, causing issues in terms of operational efficiency, and prone to errors, this usually requires multiple steps to cope with data format changes and quality control. Data security and protection of program participants' personally identifiable information add another complexity level to manual operation processes.

During program implementation and evaluation, inadequate project documentation (due to fragmented data management practices) often creates issues and slows down the process, sometimes leading to quality control issues that impact realization rates of energy efficiency programs. Current rigid and complicated data management methodologies also limit the repeatability, reproducibility, and scalability of utility energy efficiency program design, implementation, and evaluation. Issues surfacing due to fragmented data management practices also add complexity to program management and, therefore, potentially impact program administration costs.

Fragmented data management becomes more prevalent for commercial, whole-building, energy efficiency programs, as program operations and processes for estimating and validating energy savings are relatively more complex. The following list sums up findings from Cadmus' literature review regarding data management issues for commercial, whole-building, energy efficiency programs:

- Commonwealth Edison Energy's (ComEd) Energy Usage Data System allows customers to aggregate energy usage data from commercial buildings, automatically upload the data to ENERGY STAR Portfolio Manager, and benchmark buildings. ComEd's Energy Insights Online is an energy information system that allows customers to monitor electricity consumption, and then translate the data into easy-to-understand graphs and reports, accessible online. This enables customers to understand what drives electricity consumption at their facilities. The study identified two issues regarding these systems:
  - The difficulty in accessing customer data, as ComEd data are housed in the utility billing system
  - The need to transform ComEd's billing system information into understandable, actionable information through the user interface (CEE 2012)
- The New Buildings Program evaluation for Energy Trust of Oregon revealed that project documentation used for performing analysis with energy simulation software were inconsistent from one project to the next, presenting difficulties in determining appropriate savings and relevant material to support energy savings (Cadmus 2015c).
- National Grid offers its Pay for Performance Program to commercial and industrial customers. Program participants, including those with a best-case scenario (e.g., newer building, open-source control system, sophisticated and engaged facilities engineer, quality controls vendor),

experienced issues with data accessibility, both in terms of uploading customer data and in viewing data through a dashboard. The program's future plans include developing a whole-building level option for medium-sized customers (CEE 2012).

- Through the Continuous Energy Improvement Program, Southern California Edison (SCE) and Southern California Gas Company provide consulting services to commercial customers to achieve the following:
  - Identify and launch projects that reduce energy waste
  - Leverage existing incentive programs for electricity and natural gas
  - Pursue branding and certification programs (e.g., ENERGY STAR and LEED for existing buildings).

  Challenging coordination with consultants, documentation of progress, and reporting were identified as issues encountered by the program (CEE 2012).
- New Jersey makes its Clean Energy Program Benchmarking Program available to specific commercial and industrial market segments. Participation requires completing and submitting a Building Data Collection Form, which provides key information for the modeling process, including 12 months of consecutive fuel data. Barriers identified for this program include participant time required to fill out the paperwork, participants' understanding of the value offered by the report's data and information, and participants' understanding of how to use the report for guidance and justification in pursuing energy efficiency projects.

The effort and cost of managing of the data associated with the administration of municipal and state benchmarking and audit ordinances has also been a barrier. Municipal and state governments have limited resources to support and enforce these programs.

- Data on buildings from government records such as property tax records needs to be matched with data independently reported on benchmarking and audit activity.
- The government needs to determine those buildings out of compliance and then track the interactions to stimulate compliance, including the enforcement of penalties.
- New data on benchmarking and audits is submitted daily, resulting in data management tasks being performed repeatedly during the time periods surrounding compliance dates.

Best Practices to Alleviate Data Management Barrier

Automating processes offers a step toward overcoming fragmented and complicated data management issues. Whole-building programs target complex, often interactive measure sets, which, in addition to conventional technologies, may include measures with hard-to-quantify savings (including operational improvements, enabling technologies such as monitoring systems, or building occupant behavior changes).

As whole-building programs have become more prevalent, interest has grown in determining energy savings using methods based on actual metered energy use, which may be compatible with automated data collection processes. Recently, the industry has become increasingly interested in hybrid methods for estimating energy savings; these combine meter- and software-based analyses for whole-building M&V. Often referred to as M&V 2.0, proponents claim these methods provide results more quickly, at lower costs, and with comparable or improved accuracy by tapping into interval advanced metering infrastructure (AMI) data (Granderson et al. 2016b). By their very nature, these methods lend themselves to a degree of automation. Granderson's 2016 study shows that such models and automated comparisons of metered data hold great promise for expanding adoption of whole-building M&V and streamlining the process.

Another study emphasized that DOE's OpenStudio platform can address some of these issues by automating large-scale analysis for deemed energy conservation measures or custom projects and for existing building model calibration, while improving transparency, especially through DOE's OpenStudio Measures system (Roth et al. 2016). This capability may prove especially beneficial for commercial whole-building analysis, given the numerous types of buildings likely to participate in such programs.

Operating transparent and flexible data tracking systems that compile key information and clearly document all changes, adjustments, and decisions offers another step to overcome when faced with fragmented and complicated data management. Data types that must be tracked might differ for each commercial whole-building program:

- For example, the CEE report notes that tracking demographic data can help target efforts to increase program effectiveness in New Jersey's Clean Energy Program Benchmarking (CEE 2012).
- Another study conducted for the Public Service Commission of Wisconsin revealed that a process to simplify obtaining approvals and signatures from customers and other paperwork could improve overall operations for program participants (Cadmus et al. 2016).

Several additional best practices can minimize issues with data management for commercial, whole-building, energy efficiency programs:

- Maintaining strict and transparent version control of analysis documents and building energy simulation files that list any changes made to analysis documents and/or simulation models, and that document the reasons for those changes
- Creating a transparent, well-framed communication protocol that involves all program stakeholders
- Creating reporting guidelines that define the need for timely reporting with appropriate detail levels
- Considering cloud-based database solutions, which can be easily used by all stakeholders
- Creating guidelines and a framework for data transfer and data security

Role of Open Efficiency Platform in Improving Data Management

Table 7 summarizes how various OEP components can help improve data management in various stages of commercial whole-building programs, while minimizing barriers created by data management limitations. OEP integration's role proves especially important in addressing this barrier as data flow among tools and databases is essential for whole-building programs.

Table 7. Role of Open Efficiency Platform Components in Improving Data Management

OEP Component	Data Transfer, Entry Speed, Efficiency	Data Transfer Accuracy	Data Security	Data Access and Transparency
OpenStudio	• Easy, efficient data inputs using Building Component Library • Export and Import of BuildingSync XML	• Accurate transfer of design data • XML exports	• Local to user or program hosted calculator	• Use of measure scripts via Building Component Library • Graphical User Interface (GUI) allows evaluators to inspect models • Import and Export of BuildingSync and custom XML
EDAPT	• Easy upload of energy and program data • Current import of PAT XML from OpenStudio or other tool source	• Accurate upload of modeling results	• Provides project/program data security	• Provides centralized, accessible, transparent project and program data • Automatic output of understandable results
Asset Score	• Inputs optimized	• Uses BuildingSync	• The Pacific Northwest National Laboratory (PNNL) hosted	• Provides easy-to-understand design performance rating
Audit Template	• Standardized data collection for audit mandates	• Uses BuildingSync	• PNNL hosted	• Access to data for cities with mandates
ENERGY STAR Portfolio Manager	• Two-way web services available	• Two-way web services available	• Utility data transferred to customer PM account for management by the customer	• Provides easy-to-understand whole-building performance ratings
Green Button	• Standard for transfer of interval data • Green Button Connect supports recurring access	• Accurate data transfer based on Energy Services Provider Interface (ESPI) standard	• Green Button Connect uses secure connection and customer authentication	• Provides easy-to-understand standard and transparent energy usage data

OEP Component	Data Transfer, Entry Speed, Efficiency	Data Transfer Accuracy	Data Security	Data Access and Transparency
SEED	• Accepting BuildingSync-based file upload • Portfolio Manager connection	• Alignment of records from different sources supports data aggregation and compliance record keeping	• User hosted	• Provides centralized, accessible, transparent portfolio scale building performance data
BEDES/BuildingSync XML	• Provides efficient data transfer among tools	• Provides accurate data transfer among tools	• N/A	• Enhances transparency by providing a dictionary of terms, definitions, and field formats
Salesforce	• OEI Salesforce managed reporting package simplifies secure acceptance of federal tools data into Salesforce	• Provides accurate data transfer	• Robust security; system used by large corporations	• Provides centralized, accessible, transparent project and program data
OEP Integration	• Easy billing data transfer to Portfolio Manager • Provides linkage among multiple tools	• Facilitates accurate data transfer	• Robust security; open source version of system used by large corporations	• Facilitates data accessibility and transparency among other OEP components

Adopting OEP components potentially offers program administrators ways improve data management for commercial whole-building programs. Adoption of OpenStudio can simplify data transfer and increase the efficiency and entry speed of data. NREL's BCL can provide a controllable, accessible resource for storing standardized model components and scripts for describing specific model articulations for OpenStudio measures, including provenance and versioning. Workflow designs that incorporate components and measures can make it easier to design and deploy standardized modeling processes. Adoption of EDAPT provides centralized, accessible, and transparent program database that could enhance program data security and allow accurate upload of modeling results.[10]

Adoption of the SEED Platform would allow for curation of standardized data sets. SEED provides a freely available, open-source tool set to program administrators, which can be leveraged to clean, validate, and analyze data, assess compliance, and disclose results per public transparency requirements. Data exported from SEED for post-processing in other tools can be configured to meet standard taxonomies via BEDES/BuildingSync, which would increase confidence in accuracy thanks to data QA/QC policies administered within SEED. SEED is a multi-tenant application, allowing a single instance of SEED to support multiple cities or programs.

BEDES adoption can help stakeholders make energy investment decisions, track building performance, and implement energy-efficient policies and programs. BEDES software would efficiently and accurately facilitate information exchanges among tools regarding building characteristics and energy use. Use of BEDES would allow program administrators to adopt standardized data dictionaries, providing agreements on taxonomy definitions.

A commonly used CRM software, Salesforce allows storing and managing prospect and customer information (e.g., contact info, accounts, leads, sales opportunities) in one central location. Its robust security features can handle large accounts. Adoption of other tools (e.g., Green Button) can help program administrators standardize transfers of interval data if used in combination with the other OEP components. Further, integration of the abovementioned components through OEP can reveal many other opportunities for program administrators.

Overall, OEP adoption to provide linkage among these tools and to facilitate data transfer offers methods to simplify and manage large data quantities critical to operating successful commercial whole-building programs.

[10] Developed by PSD, the COMPASS software can provide similar features to program administrators.

Barrier 3: Cost of Commercial Whole-Building Programs

Description of Cost Barriers

Often, commercial whole-building programs are relatively costly to design, implement, and evaluate. This occurs for several reasons, with the methodologies used to analyze savings as a contributing factor. As discussed, savings for whole-building, commercial, energy efficiency programs are typically verified through IPMVP Option C (analysis of whole-facility utility meter data) or Option D (using calibrated building energy simulation).

Data collection tasks and data analysis usually do not serve as major drivers of whole-building savings analyses costs that rely on Option C. Billing data analysis costs for whole-building programs tend to be much less than costs of utilizing building energy simulations. In some programs, however, particularly for commercial new building construction programs, use of billing data analysis does not prove practical or feasible due to absent pre-program or appropriate comparison data to use in estimating. Consequently, building energy simulations are used. Unlike billing data analysis, data collection and analysis steps in building energy simulations tend to be relatively expensive.

Typically, collecting input data for energy simulations is a very tedious and costly process. To increase the results' accuracy, billing data can be used to calibrate the models. This additional step, however, usually is implemented manually and is time-intensive and costly. When conducting building energy simulations without billing data calibration, even more input data are needed to develop a sufficiently precise building energy simulation that produces accurate results. Consequently, this approach can lead to significant cost increases at each project stage—design, implementation, and evaluation—where simulations are performed.

When necessary, building energy simulations represent significant costs for all whole-building programs, from the design through evaluation phases, but they present a more significant participation barrier for smaller buildings. As simulations entail fixed costs and other costs less-than-directly proportional to building sizes, they represent a larger percentage of costs for small building projects than larger ones, and prove more attractive for larger buildings.

Small commercial buildings, however, categorized as having less than 50,000 square feet, represent a significant share of building stock—90% of the total number of commercial buildings and 50% of the square footage in the United States (U.S. Energy Information Administration (EIA) 2015). Consequently, participation barriers in whole-building programs can lead to substantial, foregone energy savings. In addition to modeling costs, multiple factors limit participation of smaller buildings in whole-building programs (Granderson et al. 2016a, Langner et al. 2013):

- High transaction and administrative costs
- Relatively low energy expenditures
- Tight margins for return on investments
- A wide variety of building types that make developing streamlined approaches difficult
- Limited capital

- Lack of time for researching and implementing energy efficiency solutions
- Split-incentive obstacles
- Lack of available sector-specific resources and technologies

Researchers at the Lawrence Berkeley National Laboratory interviewed HVAC contractors and contractor association representatives, collecting information on achieving energy efficiency in small commercial buildings. This study ultimately determined that, to expand the small commercial building energy efficiency market, program administrators need to identify ways to lower transactional costs associated with data access and analysis (Granderson et al. 2016a).

Cadmus' comprehensive literature review on commercial building energy efficiency programs documented studies that reported cost barriers:

- A process evaluation conducted for the Public Service Commission of Wisconsin revealed that BEM upfront costs presented a main barrier for building owners participating in Focus on Energy's Design Assistance Program, which provides incentives to participating customers and their design teams for designing and constructing new buildings or completing substantial renovations. Building owners reported that the new construction program's design process proved quite lengthy. Interviews with trade allies also revealed excessive waiting times for approval. All these lengthy steps throughout the process typically increased program administrator costs and overall costs (Cadmus et al. 2016).
- A process evaluation conducted for Salt River Project in Arizona revealed that a main barrier for the program has been program administrators' costs when dealing with smaller customers' participation. Though their energy savings are much less, they require the same amount of support from the utility (CEE 2012).
- Puget Sound Energy offers the Resource Conservation Manager Program for small-to-large commercial buildings. The program faces a primary barrier in not being able to cost-effectively offer the program to smaller customers, again due to achieving fewer savings but requiring the same amount of support (CEE 2012).
- Efficiency Vermont's Monitoring Based Commissioning Pilot Program saves energy by improving whole-building controls. The report notes that M&V can prove challenging if building usage fluctuates after the project begins, requiring more staff hires or maintaining longer operations hours, which negative affects program costs (CEE 2012).
- For its SmartBuilding Advantage Program, Duke Energy employs a whole-building, integrated approach, designed to use energy-usage information, on-site assessments, and custom incentives to realize maximum energy efficiency for customers' facilities. Per feedback collected by CEE in 2012, the program has been labor intensive and expensive. The report also notes that the complexity of large commercial buildings requires adopting a systems approach, and owners have a difficult time assembling resources to conduct such work.
- BC Hydro's offers its holistic Continuous Optimization Program for commercial buildings. The program's main risk arises from capturing estimated savings cost-effectively (CEE 2012).

Given the issues described above, the cost of whole-building commercial energy efficiency programs constitutes one of the main barriers to program design, implementation, and evaluation.

Best Practices to Reduce Cost Barriers

The main cost drivers for whole-building programs arise from estimating energy savings, whether through metered consumption data (Option C) or whole-building simulations (Option D). Tools for managing customer, project, and energy data efficiently and transparently can reduce the costs of metered energy consumption analyses. Simulations also require significant quantities of data that can be costly to collect and manage.

An integrated and streamlined data management strategy can simplify data management steps, shorten the program development and review processes, and, therefore, create opportunities for reducing costs of commercial whole-building energy efficiency programs. Automating data management processes also plays a crucial role at all stages of whole-building programs for maximizing efficiency and transparency and for reducing costs.

As complex analyses, simulations require extensive building data inputs, error checking, calibration, adjustments, and model iterations. Best practices for lowering modeling costs include use of the following:

- Protocols and tools for easy and accurate data transfer
- Tools for reducing data amounts required for model inputs
- Techniques for simplifying calibrations
- Tools that automate standard procedures

Automation provides another opportunity for reducing costs by minimizing the effort required and, consequently, errors introduced, and increasing the efficiency and transparency of the data transfer process. Using such practices to reduce modeling costs can prove especially beneficial for programs seeking to recruit participation of smaller building projects.

Role of the Open Efficiency Platform in Reducing Cost Barriers

Table 8 illustrates how OEP components can help control various factors related to whole-building program cost barriers. Due to the range of issues involving building energy simulations, most effects involve simulations rather than metered data analyses.

Table 8. Role of Open Efficiency Platform Components in Reducing Cost Barrier

OEP Component	Data Transfer, Entry Speed, Efficiency	Quantity of Data Required	Calibration and Verification	Automation of Processes	Open Efficiency Platform Component Cost
OpenStudio	• Simplifies building characteristics data entry • Supports multiple analyses from a single mode; exports import results from other engines like the Radiance	• Medium	• Manual calibration options	• Automatic parametric runs • Automated baseline models	• Free
EDAPT	• Easy incorporation of everyday workflows	• Medium	• N/A	• Automated quality checks of energy model designs	• Free
Asset Score	• Allows efficient first-order modeling	• Low (Relies on defaults to reduce quantity of data required)	• N/A	• Simplifies initial analysis	• Free
Audit Template	• Simplifies and expedites energy audit data collection	• Low-High	• N/A	• Automated generation of a standard audit data report in PDF, CSV, or XML* file formats	• Free
ENERGY STAR Portfolio Manager	• User-friendly interface to enter energy and water consumption	• Low	• Allows benchmarking	• Export of standardized data supports automated QA	• Free
Green Button	• Easy and fast	• Low	• Usage analysis results inform calibration verification	• N/A	• Free

OEP Component	Data Transfer, Entry Speed, Efficiency	Quantity of Data Required	Calibration and Verification	Automation of Processes	Open Efficiency Platform Component Cost
SEED	• Simplified approach to manage large data sets • Allows data import from other tools such as Green button, Asset Score, etc.	• Low-High	• Potential to connect audit data to usage data in Portfolio Manager	• N/A	• Free
BEDES/BuildingSync XML	• N/A	• Low	• N/A	• Standardized model outputs support automated review	• Free
Salesforce	• Provides extensive data for metering analysis	• Low-High	• N/A	• Automation of report generation	• Medium-High
OEP Integration	• Provides linkage among multiple tools to enhance speed and efficiency of data transfer	• Low-High	• Improved access to data to support calibration and verification	• Automation of data transfer	• N/A

Integrating these tools and components through OEP can help program administrators overcome cost barriers. Adoption of OpenStudio and PAT Applications provide frameworks for lowering modeling costs by applying standardized automation of routine tasks (e.g., model articulation, quality assurance/quality control). PAT has been engineered to produce results as BuildingSync adherent XML exports. Software tools supported by utility programs usually can be extended to produce the same XML file exports, which can help program administrators handle large transaction volumes and to standardize collection and aggregation of program savings data from different energy modeling tools into a single reporting platform, thus lowering data handling costs. Given the open-source nature of these tools, required calculation transparency can be achieved easily, producing positively affecting a calculation review's overall costs.

Adoption of an OpenStudio Command Line Interface would allow users to create light skins with reduced input interactions that hide the detailed complexity of underlying, full-blown OpenStudio/ EnergyPlus models. This can lower the expertise level required, eliminating the need for expert energy modelers in certain cases. Small building owners can find the reduce need for such energy modeling expertise especially beneficial, thus enhancing participation in whole-building programs by smaller buildings through reduced participation costs. Similarly, adoption of the NREL's BCL can support use of standardized, transparent, repeatable, and reproducible automation, lowering utilities' review costs.

Adoption of Asset Score can provide similar benefits. Asset Score offers users a freely available simulation tool, capable of generating custom building geometry based on a few necessary input parameters. In turn, it allows users to export a fully functional, representative Asset Score building model, which can be further post-processed using OpenStudio. Programs utilizing Asset Score will likely realize program participation by small buildings, given reduced energy model generation costs through Asset Score's workflow (including post-processing efforts using controlled OpenStudio measures), rather than the much larger costs of creating custom energy models. Asset Score offers a standardized early stage assessment of the potential for savings in a building, relative to other buildings. This reduces the cost of targeting resources towards buildings with greater opportunity, allowing more and smaller buildings to be cost effectively screened.

Adoption of EDAPT (or similarly PSD Compass) can reduce review costs and time delays associated with utility reviews. These program workflow management tools can help program administrators to develop cost-control best practice guidance that key industry users (e.g., building owners, architects, designers, energy champions) can incorporate into their everyday workflows.

Use of BEDES allows program administrators to adopt standardized data dictionaries, providing agreement on taxonomy definitions. Use of these taxonomies can lower the costs of data interoperability between multiple applications, lowering the transaction costs for cross applications. Using OEP Integration to combine the abovementioned tools can very effectively reduce commercial, whole-building program costs.

Finally, OEP's integration capability can reveal synergistic opportunities between available tools. For example, combining standard outputs from Portfolio Manager and Asset Score in a quadrant analysis can expedite program administrators' or city officials' building portfolio assessment processes, simplifying decision-making processes regarding capital improvement projects or targeted tenant behavioral programs via standardized reporting and targeting visuals. The Salesforce OEI Managed Package contains information from both Asset Score and Portfolio Manager, allowing the creation of such a report.

Barrier 4: Lack of Standardization in Savings Methodologies

Description of Lack of Standardization Barrier

The savings methodologies required by different jurisdictions for commercial, whole-building energy efficiency programs generally remain inconsistent or—in some cases—unspecified. Developing guidelines and requirements for standardizing savings methodologies represents an important first step in reducing learning curves and the effects of limited analysis experience, especially when introducing conceptually new programs to the market (Rozanova et al. 2012).

Currently, methodologies for claimed and evaluated savings differ substantially across states and TRMs. In 2017, Cadmus reviewed 21 TRMs, resource management plans, and clean energy program protocols to identify specifically what each of these needed (or recommended) regarding use of calibrated simulation methodologies and tools for commercial building programs requiring whole-building analysis. Table 9 presents these findings (including for custom and new construction programs).

Table 9. Building Simulation Methodologies in TRMs and Other Similar Protocols

State	Year	Measures Recommended for Building Energy Simulations	Program Types	Specific Whole-Building Simulation Tools Recommended
AR	2015	Weather-sensitive deemed measures, commercial new construction and custom measures	New Construction/ Custom/Deemed	eQUEST, EnergyGauge
CA	2014	Complex and dynamic custom measures	Custom	N/A
CO	2016	Commercial new construction measures	New Construction	N/A
CT	2016	Commercial whole-building measures	Whole-Building	NA
DE	2012	Whole-building program measures planned or implemented	Whole-Building	N/A
HI	2014	Custom projects	Custom	N/A
MA	2015	Custom projects	Custom	N/A
MD/DC	2015	Whole-building program measures planned or implemented	Whole-Building	N/A
ME	2016	Custom projects	Custom	N/A
NJ	2014	Pay-for-Performance Program measures	Required for large energy users (100 kW) with exceptions	eQUEST, Trane Trace, Carrier HAP, DOE-2, EnergyPlus
NY	2016	Custom projects, commercial new construction	Custom	N/A
OH	2010	New construction custom measures	Custom	eQUEST and DOE-2

In summary, the review identified the following:

- Eight documents considered building energy simulation as a valid methodology for analyzing savings in custom or new construction programs

- Very few documents specified building energy simulation software recommended or required
- Nine additional TRMs[11] (not shown in the table) did not provide information about approaches for whole-building programs or building energy simulation tools

A few documents, such as the Mid-Atlantic TRM (used in Maryland and Washington, DC) and the New Jersey Clean Energy Program Protocol, specified that whole-building program designs should use building energy simulations, but they did not provide detailed specifications:

- Mid-Atlantic TRM Version 5 specifies that simulation modeling may be required to estimate savings for whole-building program projects being planned or implemented. Though the program did not document baseline specifications for whole-building efficiency measures, it recommended these for inclusion in a future TRM version.
- New Jersey's Clean Energy Program Protocol requires whole-building simulations for its Pay for Performance Program and specifies ASHRAE Guideline 14 as the primary source for developing such simulations.

Cadmus reviewed the TRMs in three states—Colorado, Vermont, and California[12]—and the UMP to compare their savings calculation approaches with simulation-based analyses. In Colorado, Xcel produces a demand-side management plan that contains its own TRM. The TRM does not identify an approach for commercial whole-building analysis, but does describe a deemed savings method for custom efficiency projects. However, this method does not specify requirements for building simulations and refers to standard engineering methodologies. In Vermont, the TRM is produced by Efficiency Vermont and presents methods, formulas, and default assumptions for estimating energy impacts for various end-uses and measures. It does not present a method for whole-building analysis or simulations. For some measures, the TRM algorithms include the effects of the measure on other end-uses or measures, i.e., the interactive effects. The TRM defines a procedure for calculating savings for prescriptive, custom, and combinations of measures. The California TRM, the Database for Energy Efficient Resources (DEER), provides deemed energy savings for a large number of efficiency measures. It does not provide a methodology to be used for whole-building savings analyses or specify a procedure for conducting building simulations. However, like the Vermont TRM, it provides pre-calculated interactive factors to account for the effects of one efficiency measure on the energy use of other end-uses.

The UMP[13] chapter on commercial building new construction projects describes a whole-building analysis approach using calibrated simulation models based on IPMVP Option D. The chapter provides details on where the protocol would apply, appropriate simulation software characteristics, definition of

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11 Technical Reference Manuals for Illinois, Indiana, Minnesota, Pennsylvania, Rhode Island, Texas, Vermont, Washington, and Wisconsin.

12 These states are the ones where the OEI pilots, discussed later, were conducted.

13 See Chapter 15 at https://www.nrel.gov/docs/fy18osti/70472.pdf

baseline conditions, data for calibration, savings calculations, and uncertainties. Key elements of the approach include these:

- Onsite verification and review of as-built drawings and commissioning reports (as available) should be performed to verify which energy saving features were actually installed and are functioning
- Ex-ante savings calculations should be based in a whole-building simulation model of the building or of a building that is representative of the actual facility
- Results should be compared with billing data (when available), engineering rules of thumb, and/or secondary literature to review reasonability.

The UMP chapter on retrocommissioning also recommends using a similar approach for projects expected to produce large energy savings.

Based on our review of the TRMs, specific measure TRMs usually rely on engineering calculations in isolation from other measures. When the measure algorithms consider interactive effects of other measures, they partially replicate the function of simulations, but the interaction factors are usually generic so do not capture conditions in individual buildings. The whole-building simulation approach prescribed by the UMP is consistent with best practices so aligns with the protocols that would be required by the components of the OEP.

As Cadmus' review revealed, savings methodologies for commercial whole-building programs vary widely across states. Additionally, version control within each state's TRM can present challenges as program years might not match TRM effective dates.

As noted earlier, increased availability of AMI data has spurred interest in advanced M&V techniques utilizing automated analysis of metered energy data (M&V 2.0). As of August 2017, there were at least 30 different tools available for performing these analyses (NEEP 2017). Although this methodology offers the possibility to "…determine savings in near-real time to provide stakeholders with more timely and detailed information …[and]… inform ongoing building operations, provide early input on energy efficiency program design, or assess the impact of efficiency by location and time of day,"[14] the lack of consistency in methodologies and ways to demonstrate accuracy have limited applications of the methodology. However, stakeholder groups look to M&V 2.0 as a possible way to standardize savings calculations and make them available sooner (Franconi *et al.* 2017). DOE (Granderson 2018) and other organizations are supporting efforts to pilot test approaches, provide guidance for rigor and transparency, and develop techniques for handling issues such as non-routine events that bias estimates.

[14] Franconi *et al.*, p.5.

Best Practices for Enhancing Standardization

Benefits from standardizing savings methodologies includes consistency, clarity, and transparency for all stakeholders, thus minimizing misunderstandings. A more standardized approach for utilities, evaluators, and other stakeholders for estimating and verifying energy savings from commercial, whole-building energy efficiency programs can be achieved by developing standard, transparent, and applicable savings methodologies across the states, and by using standardized baseline selection methodologies and documentation, which can aid in scenario planning and model sensitivity testing.

Some studies underline the benefits from more standardized savings methodologies. Per a CEE study (2012), the comprehensive energy efficiency New Jersey Clean Energy Pay for Performance Program provides incentives toward whole-building energy improvements in large commercial and industrial buildings, noting that using federal tools and standards in the program allowed partners to participate more easily, especially if they had participated in past performance programs or those in neighboring states.

Role of Open Efficiency Platform for Enhancing Standardization

Table 10 shows how OEP components could affect various elements related to the lack of standardized requirements for whole-building simulations. Several tools utilize BCL, which supports standardization across tools and follows published application program interface requirements.

Table 10. Role of Open Efficiency Platform Components in Reducing Barriers Due to Lack of Standardization

OEP Component	Standardization of Input Parameters	Standardization of Outputs/Reports	Other Standardization Features
OpenStudio	• Provides common space types and configuration of systems • Standardized building components library • Provides data import from standard schemas like gbXML • Supports multiple analyses from a single mode	• Provides standardized summary of the analysis	• Automated and standardized baseline models
EDAPT	• Standardized upload of input files	• Provides auto-generated reports • Allows detailed portfolio tracking	• Allows use of OpenStudio's capabilities for complicated applications

OEP Component	Standardization of Input Parameters	Standardization of Outputs/Reports	Other Standardization Features
Asset Score	• Standardized and simplified input parameters including building components, types, and physical parameters	• Provides standardized summary of the analysis	• A national standardized tool assessing the physical and structural energy efficiency of commercial and multifamily buildings
Audit Template	• Standardized data inputs in simple format	• Standardized audit data report in different file formats	• N/A
ENERGY STAR Portfolio Manager	• Standardized and simplified data entry process through property and meter wizards or though Excel spreadsheets	• Standardized and simplified reports performance highlights	• A national standardized tool providing average building scores • Standardized building categories for benchmarking
Green Button	• Standardized input format • A data exchange protocol which allows for the automatic transfer of data from a utility to a third party based on customer authorization	• Standardized energy information provided in a consumer-friendly XML format	• A voluntary adoption of a industry standard by utilities based on the Energy Services Provider Interface (ESPI) data

OEP Component	Standardization of Input Parameters	Standardization of Outputs/Reports	Other Standardization Features
SEED	• Standardized and automated process of formatting, matching, cleaning, and validating input data • Allows data import from other tools such as Green Button, Asset Score, etc.	• Simplified reporting through application programming interface (API) that allows selected data to be shared directly with other software tools or public-facing dashboards.	• A standardized data platform to manage portfolio scale building performance data
BEDES/BuildingSync	• Standardized of input/export parameters including building components, types, and physical parameters and recommended energy conservation measures	• N/A	• Standardized dictionary of terms, definitions and field formats to help facilitate the exchange of information on building characteristics and energy use
Salesforce	• Standardized data inputs	• Standardized reporting	• N/A
OEP Integration	• Provides a standardized and integrated platform to utilize the data input features of DOE and other related tools	• Provides a standardized and integrated platform to utilize the data input features of DOE and other related tools	• Provides automated data exchange among different OEP components

Adopting these tools through OEP's integration capability can enhance standardization of savings methodologies for commercial whole-building programs, thus enhancing consistency and comparability across jurisdictions and reducing participation barriers. Wide adoption of OpenStudio can provide common infrastructure to all stakeholders in the industry, while allowing third-parties to introduce flexibility to the tool and to focus on adding their individual differentiating values for serving their clients.

OpenStudio offers a unique feature in Measures, based on Ruby scripts—a dynamic, open-source programming language—run on OpenStudio energy model and simulation results to automate modeling tasks (i.e., application of energy conservation measures, creating custom reports and visualizations, connecting EnergyPlus to other analysis tools [DOE 2016]). Measures can be downloaded from BCL and installed manually. Measures and other Ruby programs also are available as installation packages called Gems. Use of OpenStudio Standards Gem can expedite creation of custom prototype buildings and custom baseline buildings by following a standardized process. Wide adoption of the NREL's BCL can support use of standardized, repeatable, and reproducible automation for model creation.

Wide adoption of other tools (e.g., EDAPT, SEED Platform, BEDES/BuildingSync XML) can help standardize data management and program tracking processes for program administrators. Adopting

SEED can help program administrators curate standardized data sets, and data exported from SEED for post-processing in other tools can be configured to meet standard taxonomies (BEDES/BuildingSync), providing higher confidence in the accuracy in savings due to enhanced data QA/QC policies.

OEP can play an important role in the standardization process, providing a common infrastructure and language for communication between all of the discussed tools. While tool the standardization plays a major role in increased savings methodology consistency among commercial whole-building programs, market leaders would benefit from encouraging guidance document standardization across the United States. Widely adapting ASHRAE Standard 209P “Energy Simulation-Aided Design for Buildings” and achieving more consistency on algorithms and specifications for building energy simulations provided in numerous TRMs can further advance efforts for standardizing savings methodologies.

Conclusions and Next Steps

Whole-Building Programs and Barriers

Increasing the efficiency of commercial buildings at the whole-building scale potentially offers significant energy savings. Consequently, most utilities and other program administrators include commercial whole-building programs in their portfolios of energy efficiency programs. In 2016 alone, nearly 300 such programs operated in North America. These programs target new and existing commercial buildings and provide incentives and technical assistance for activities designed to increase energy efficiency, ranging from design phases through construction and performance measurement.

Despite the programs' widespread presence, a number of barriers can limit their reach and effectiveness. These barriers can affect multiple stakeholders, including program designers, implementers, participants, and evaluators. They can constrain the program design by limiting program features, such as types of qualifying buildings, data requirements, and flexibility. For participants, the barriers can limit their willingness to participate in the program, innovate, or achieve energy savings. For evaluators, these barriers can increase research costs and study times required while reducing accuracy. Unchecked barriers can produce undesirable impacts, such as the following:

- Difficulty recruiting participants
- Narrowed participation, leading to underrepresentation of some buildings (especially smaller facilities)
- Unanticipated program costs
- Increased risks and uncertainty
- Reduced realization rates
- Diminished cost-effectiveness

This report has investigated multiple key barriers that experience has demonstrated can reduce the effectiveness and benefits of commercial whole-building programs, and types can influence all program phases, from design, through implementation, and during evaluation:

1. Lack of confidence in savings estimates, especially those generated through building simulations.
2. Lack of integrated and streamlined data management.
3. Costs of commercial whole-building programs, particularly for smaller buildings.
4. Lack of standardization in savings methodologies.

The study's literature review and interviews revealed that these four, widespread barriers can have significant negative effects. Due to their significance, they can serve as a practical checklist for assessing the benefits of various approaches (such as OEP and its components) in mitigating program barriers.

Benefits of Open Efficiency Platform Components and Illustrative Scenarios

Table 11 summarizes information presented in this report regarding commercial whole-building program barriers and the ways in which OEP might help address the barriers. Energy efficiency program administrators and others engaged in whole-building analyses and programs can benefit from using the OEP's tools, taking advantage of integration provided by the OEP hub, and leveraging federal and other tools to overcome barriers that constrain program design, implementation, and evaluation. To illustrate how the OEP might support diverse, whole-building programs, Cadmus describes three program scenarios that illustrate the benefits from using OEP components to address program barriers.

Table 11. Summary of Ways that Open Efficiency Platform Could Reduce Program Barriers

OEP Component	Increase Confidence in Energy Simulations	Integrate and Streamline Data Management	Reduce Program Costs	Enhance Standardization of Savings Methodologies
OpenStudio	• Stays up to date • Easy to use • Supports calibration and baseline automation	• Easy to use • Provides efficient and accurate data transfer	• Free to use • Potential program cost savings through simplified data entry process and automation opportunities	• Provides common core infrastructure for BEM • Standardized inputs/outputs • Provides an automated process for baseline models
EDAPT	• Publicly available and supported • Simplifies tracking and QA	• Easy to use • Provides accurate and secure data transfer	• Free to use • Potential program cost savings through easy incorporation of everyday workflows and automated quality checks	• Standardized inputs/outputs • Allows detailed portfolio tracking
Asset Score	• Publicly available and supported • Easy to use and interfaces with OpenStudio	• Hosted securely • Provides easy-to-understand outputs	• Free to use • Potential program cost savings through simplified data entry and initial analysis	• Standardized inputs/outputs • A national standardized tool
Audit Template	• Publicly available and supported • Easy to use and standardized	• Hosted securely • Standardized data collection	• Free to use	• Standardized inputs/outputs
ENERGY STAR Portfolio Manager	• Large user base and supported • Standardized data	• Accurate and efficient data transfer • Provides easy-to-understand outputs	• Free to use • Potential program cost savings through standardized data, simplified benchmarking, automated quality assurance	• Standardized inputs/outputs • A national standardized tool

OEP Component	Increase Confidence in Energy Simulations	Integrate and Streamline Data Management	Reduce Program Costs	Enhance Standardization of Savings Methodologies
Green Button	• Informs calibration	• Provides efficient and secure data transfer	• Free to use • Potential program cost savings through simplified, efficient and fast implementation	• Standardized inputs/outputs • Allows for the automatic transfer of data
SEED	• Publicly available and supported • Supports QC	• Integrates records from other sources	• Free to use • Potential program cost savings through simplified approach that can handle large data sets and capability to connect with Portfolio Manager usage data	• Standardized inputs/outputs • Allows data import and data exchange directly with other tools
BEDES/BuildingSync XML	• Provides data standardization	• Provides efficient and accurate data transfer	• Free to use • Potential program cost savings through enhanced data consistency and automated review opportunity	• Provides standardized and consistent terms, definitions and field formats to facilitate the exchange of information on building characteristics and energy use
Salesforce	• Frequent updates • Widespread use	• Provides secure and efficient data transfer	• Potential program cost savings through automation of report generation	• Standardized inputs/outputs
OEP Integration	• Provides reliable, automated transfer among tools	• Provides efficient, accurate, and secure data transfer among OEP components	• Potential program cost savings through automation of data transfer among all OEP components	• Provides a standardized and integrated platform to utilize the features of DOE and other related tools

Scenario 1: Supporting City Zero-Net Energy Strategies

As pressures increase on local governments to reduce environmental impacts, many cities have started establishing ZNE targets and climate action plans. There typically require new and existing commercial buildings to reduce their energy usage sufficiently to meet energy needs through on-site renewable energy generation (e.g., photovoltaic panels). For city officials, accurately and efficiently assessing the energy performance of government buildings proves crucial in informing decision-making processes for capital improvements or investment projects to most economically and effectively achieve ZNE. Potential costs, however, can be prohibitive for conducting the analyses necessary to identify opportunities for achieving and verifying ZNE.

Through OEP and its ability to leverage federal tools, city officials may be able to reduce some costs and risks associated with achieving and demonstrating ZNE. With existing city buildings, cities can use the OEP hub to benchmark and audit their building portfolio to inform ZNE strategies and reduce costs of ZNE action planning.

For example, using ENERGY STAR's Portfolio Manager can provide valuable information that allows city officials to better understand the energy performance of their building portfolio. Utilizing DOE's Commercial Building Asset Score and OpenStudio, could create opportunities for city officials to easily execute both light and in-depth audits of their building portfolio, thus better identifying any potential improvement areas through energy efficiency retrofits, setting realistic goals, and measuring progress over time.

A staged application of these tools, combined with the OEP hub's integration capability, could reveal synergistic opportunities among available federal tools as well as accomplishing the following:

- Integrate key data into the audit process
- Simplify energy model input processes and streamline energy model generation
- Identify efficiency investments and ZNE opportunities quickly
- Improve overall data management

All of these improvements can help city officials ease and expedite the overall process, reducing costs and risks for ZNE action planning.

Scenario 2: Supporting Program Administrator Market Characterizations of New Commercial Office Buildings

As new, commercial, whole-building energy efficiency programs spread, it becomes evident that administrators must thoroughly understand the market to better inform the program design process for new programs and to identify improvement areas for existing programs. Market characterization studies can play a critical role in helping program administrators design and market programs more effectively, identifying proper program incentives and rebates, and supporting better-informed strategies overall. Market characterization studies, however, can be difficult to design and costly to conduct.

By using the federal tools and integration provided by the OEP hub, program administrators can streamline and expedite their market characterization studies, reducing the overall cost of the process. Characterizing the market typically requires reviewing large sets of secondary sources to provide the following:

- A profile of physical attributes of buildings in the market (e.g., type, number, location, square footage)
- The market's qualitative aspects (e.g., Building Owners and Managers Association classifications [Class A, Class B, Class C]) or sustainability levels (e.g., ENERGY STAR-rated or LEED certified)
- Annual sales of certain energy efficiency measures for particular building types among a subset of regional retailers

Program administrators could utilize the SEED platform to help easily collect data from a variety of available sources and to process and manage large data sets required to characterize the market thoroughly. Market characterization studies typically require that program administrators invest significant time and resources to develop customized processes and tools to collect, cleanse, validate, analyze, and manage such large data sets. Using the OEP hub's integration capability with multiple federal tools (e.g.,. Green Button, ENERGY STAR Portfolio Manager, Commercial Building Asset Score) and other publicly available databases to gather required data could provide benefits such as the following:

- Simplifying the overall process for gathering and distilling large data sets
- Streamlining and automating data management
- Standardizing the overall process for executing market characterization studies

All of these improvements can help program administrators expedite the overall process of better understanding building market trends and interests, and reducing costs and risks associated with market characterization studies.

Scenario 3: Reducing Administrative Costs for Early Design Assistance Programs of New and Existing Commercial Buildings

Carefully planning the design phase of new construction and retrofits proves especially important for projects seeking high-level energy efficiency targets (e.g., achieving LEED Platinum certification, deep energy retrofit, ZNE). Collaboration of all stakeholders in a project's early design phase is necessary to determine, in a timely manner, the best energy efficiency solutions that also prove technically feasible and cost-effective. Though utilities often develop and offer early design assistance programs that support project owners and designers in improving and reduce the design costs of high-efficiency commercial buildings, utilities and other program administrators have come under growing pressure to reduce the administrative costs associated with early design assistance programs.

Integrations of federal and non-federal tools through the OEP hub can help program administrators streamline project documentation management and reporting of programs, including early design assistance, expediting the overall process for providing real-time energy simulations and incentive opportunities to a project's owners and designers based on their design strategies. OEP's EDAPT component is a federal tool that can track and manage projects, generate project documentation and reports, and perform automated quality checks of energy model designs. OpenStudio, which can provide the capability for creating high-quality energy models to assist with energy-efficient design options, is compatible with EDAPT.

In estimating project budgets, project owners and designers need to better understand incentive opportunities for their design options. Salesforce, a popular, widely used, on-demand CRM tool can inform project owners and designers about incentive opportunities. As Salesforce is not compatible with EDAPT, utilization of OEP's integration capability can help program administrators overcome the need for manual data transfers between EDAPT and Salesforce. Using federal and non-federal tools through OEP in early design assistance programs could reveal new opportunities for program administrators to accomplish the following:

- Provide clients with easy, fast, high-quality data transfers
- Simplify and standardize project tracking and incentive applications for program administrators
- Streamline the decision-making process for project owners and designers, allowing them to better evaluate the performance and cost-effectiveness of their innovative design options
- Reduce administrative costs for early design assistance programs

Open Efficiency Initiative Pilot Projects and Next Steps

This report discusses significant barriers commonly faced by commercial, whole-building energy efficiency programs and how these barriers can be addressed using various tools, including federal and non-federal tools linked through the OEP. One OEI objective supports various whole-building pilots that employ OEP tools and components to demonstrate how OEP can help address many of these barriers.

The OEI has engaged several partners to design and conduct a variety of pilot projects using OEP and its tools; these are intended to provide helpful information on the usefulness of OEP and its components:

- **Xcel Energy, Energy Design Assistance (EDA) Program.** The pilot involves Xcel Energy connecting the EDAPT program management portal, which supports the Xcel EDA program to the Xcel Salesforce using the OEI Managed Reporting Package and Schema. This provides an extensible footprint for securely moving data from federal tools into Xcel tracking systems. This schema and Salesforce-managed package will provide a distributed outcome for the OEI project.
- **The Southern California Regional Energy Network, Energy Efficiency Assistance to Public Buildings.** The pilot tested use of Asset Score, Portfolio Manager, and the Audit Template to collect data and to generate audit reports on public facilities. The pilot developed four use cases, based on different effort levels in extending the OpenStudio model, generated by the Asset Score, and using the data from the other tools. The PSD Compass platform was used to integrate the data into a report for each building.
- **The Energy Coalition (TEC), Benchmarking and Tracking Public Facilities.** Cadmus obtained usage data for individual meters from SCE and turned these into a portfolio-wide benchmarking report for all meters for the participating individual municipalities. This report from the Compass platform was used to help drive municipal efficiency investments. Summary data on usage- and

project-related data were pushed to the TEC Salesforce using MuleSoft Anypoint. SCE's Green Button Connect data were connected to the system using the Anypoint hub and were used to support savings tracking for the projects. Integration of other federal tools remains in evaluation. A MuleSoft Anypoint configuration will serve as a deliverable outcome from the OEI project.

- **Vermont Energy Investment Corporation (VEIC), OpenStudio Calculations for Commercial Retrofit and New Construction.** PSD worked with VEIC to develop a set of OpenStudio-scripted transforms or "measures" to support standardized savings calculations from a Variable Refrigerant Flow HVAC system, in combination with a Direct Outside Air System for ventilation. PSD worked with NREL to develop a simplified, web-based interface for the calculations, greatly reducing the costs of procuring energy and demand impacts for this complex improvement.
- **Commons Energy, Federal Tool Support for Screening and Assessment of Energy Service Company Opportunities in Public and Subsidized Multifamily Housing.** PSD worked with Commons Energy, a public-purpose Energy Service Company and VEIC subsidiary, to apply the Asset Score and Portfolio Manager to its work flow for early assessments and sales.

The next steps in the overall OEI will be to evaluate each pilot, providing the following:

- Descriptions of the pilot, including its objectives, participants, relationships, and processes
- Documentation of the ways each pilot utilizes OEP components and integration provided through the OEP hub
- Qualitative assessments of each pilot's overall effectiveness and roles played by the OEP
- Estimates of quantitative OEP impacts that can be readily measured (e.g., cost or time savings)
- Identification of lessons learned from pilots, such as the program's best applications and usefulness (including those for small buildings)
- Discussions of other potential OEP applications

Due to the small numbers of pilots and each pilot's unique qualities, Cadmus will conduct these evaluations as case studies. Despite limiting the evaluation by its case study nature, the results will provide insights into OEP's effectiveness in managing commercial, whole-building energy efficiency programs' costs and risks, and will assist with future efforts in fine-tuning the OEP, targeting its application, and evaluating the platform more comprehensively.

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