# Vermont Energy Investment Corporation (VEIC) Case Study: OpenStudio Calculations for Commercial Retrofit and New Construction

Introduction and Overview

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.
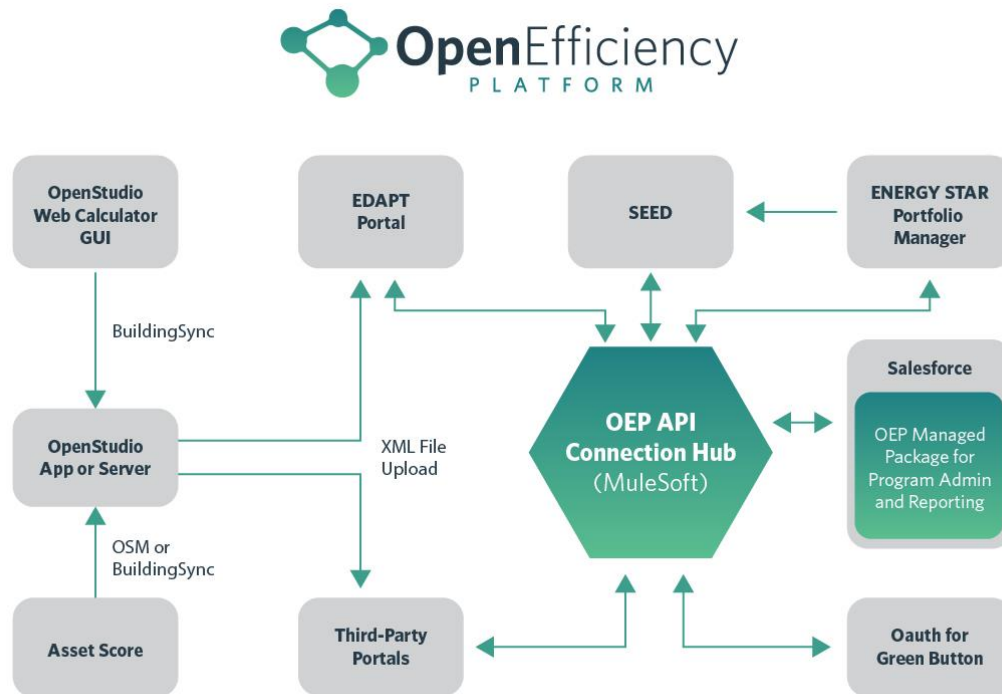
Demonstration of the OEP occurred through pilots conducted by energy-efficiency program administrators (PAs) who designed each pilot to use relevant components of the OEP. Each pilot was evaluated as a case study based on interviews with key stakeholders and a review of pilot data. This case study of the pilot conducted by Vermont Energy Investment Corporation (VEIC) was prepared by Cadmus.[1]

The overall purpose of each case study was to evaluate the specific application of the OEP. Being each project was a unique pilot and the number of pilots was limited, the case study approach was the most appropriate research methodology. For each pilot, the case study provided information on the issues OEP was implemented to address, how effective it was, what actions were least effective, lessons learned, and insights about other opportunities for applying OEP.

Pilot Description

VEIC worked with PSD as part of an effort to improve the performance of energy efficiency program operations using DOE tools. This pilot did not focus on a specific program. Instead, it was intended to leverage components of OEP in ways that would benefit energy-efficiency programs by decreasing program costs and improving operations by reducing costs of modeling more complex energy-efficient systems.

VEIC operates Efficiency Vermont (EVT), an energy efficiency utility that provides Vermonters with technical services and financial support and trains and partners with local providers of efficient goods and services. VEIC also operates the District of Columbia Sustainable Energy Utility (DCSEU) and owns Commons Energy, an energy service company (ESCO). Commons Energy and EVT utilize different databases and systems, but they share many of the same staff. VEIC also develops savings methods for measures incorporated in Technical Reference Manuals (TRMs). In the past, VEIC has relied on eQUEST software and spreadsheets to estimate energy savings from measures in commercial buildings. Their staff are skilled in using these tools and recently VEIC has interacted more and more with the National Renewable Energy Laboratory (NREL), DOE, and the larger community of building modelers, and they intend to expand their engagement with these groups to enhance their modeling knowledge and skills.

This pilot project aimed to leverage the capabilities of the OpenStudio simulation tool in ways that could be integrated into VEIC's provision of services, particularly by reducing the costs associated with simulations relating to the operations of EVT and the definition of savings calculations in TRMs. VEIC had

reached a point with EVT where the program had harvested the low hanging fruit, and producing more

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[1] VEIC is a non-profit energy services organization.

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savings was becoming very challenging. VEIC felt that OpenStudio would allow them to do more large-scale parametric analyses and use building prototypes to explore new measures cost-effectively. VEIC noted especially how analyses and cost barriers posed additional challenges to increasing program participation and savings in smaller commercial buildings.

To tackle these goals, VEIC specifically wanted to reduce the cost of providing incentives to emerging technologies such as Variable Refrigerant Flow (VRF) heating and cooling systems. These are very complex, but potentially very efficient, systems as shown in the following graphic example.
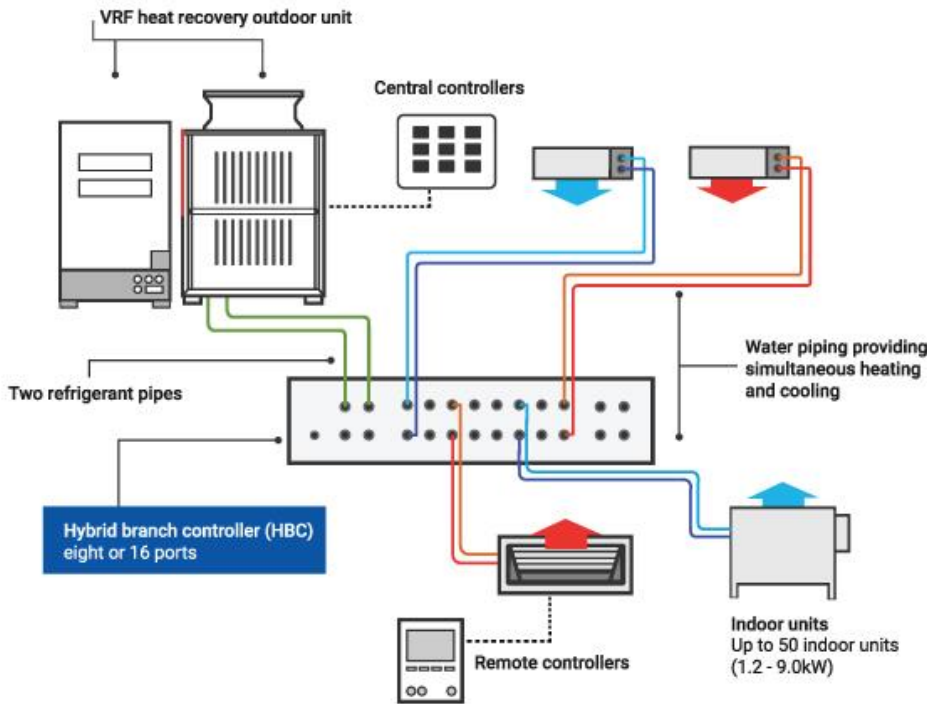
They found there had been a high cost to model energy savings accurately for some emerging technologies, such as VRF systems. The high cost of energy modeling increased the overhead cost per transaction for each incentive application reviewed. These high costs drained program resources and reduces participation of smaller buildings where the savings per project did not justify incentives large enough to offset the analysis costs.
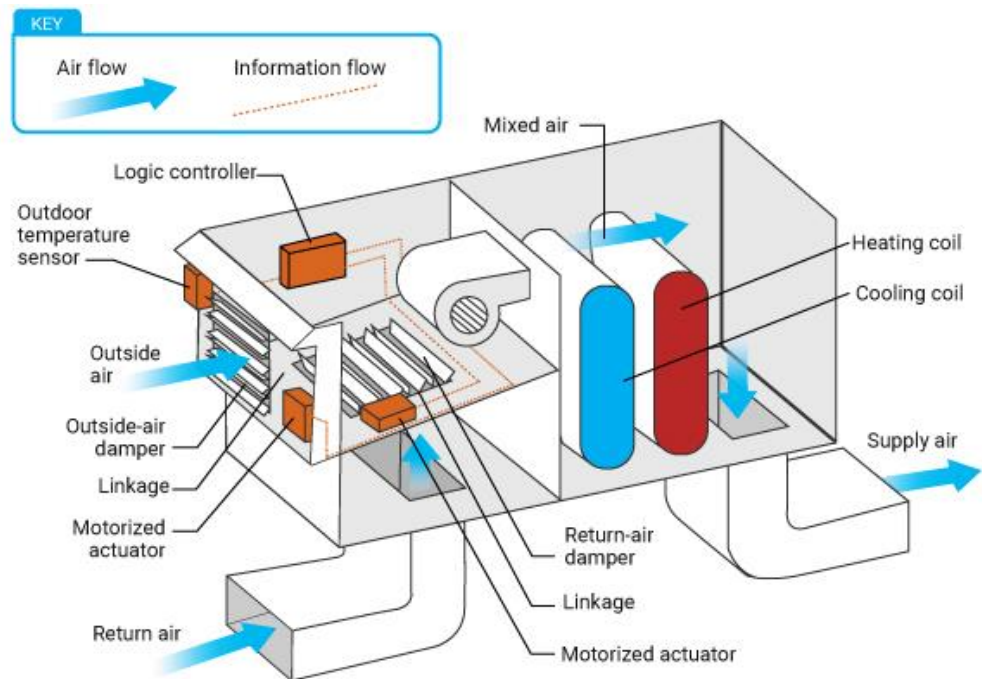
VEIC viewed the pilot as an opportunity to reduce the modeling costs and improve accuracy of savings estimates for emerging or complex technologies in their commercial building programs. They believed that by reducing modeling costs, the partial automation of an energy modeling calculation using OpenStudio had the potential to increase the number of buildings and expand the coverage of smaller buildings served with these technologies. They anticipated that standardized data produced in conjunction with this approach also could be used in program reporting. VEIC also sought a tool that could pull data from existing databases and communicate with other tools, such as Portfolio Manager and Salesforce.

PSD staff trained VEIC's energy modeling staff on using the OpenStudio framework for manipulating the EnergyPlus simulation engine. This training included content on the development of OpenStudio "measures" or scripts written to automate model generation, quality assurance, and reporting. In

addition to writing measures for them, PSD trained VEIC staff on how to create measures in a more automated way. Much of PSD's assistance was around the work flow and how to make it as efficient and rapid as possible. VEIC also wanted to have outputs that tied into all the reports in OpenStudio and custom reports with data ready to go into other systems for claiming savings.

VEIC contracted with PSD to define and automate a standardized saving calculation for VRF systems using OpenStudio measures. This OpenStudio measure was intended to replace a spreadsheet calculator. PSD developed a specification for the modeling process jointly with VEIC and then PSD wrote the OpenStudio measures, which modeled both VRFs and Dedicated Outdoor Air Systems (DOAS). DOAS provide intelligent control of input of outside air to the heating/cooling system (see example in the illustration below). Although the approach was not for whole-building efficiency programs, it did account for interactions between the VRF and DOAS.

VEIC staff used the automated modeling to support the delivery of programs for EVT and to support the eventual inclusion of OpenStudio in development of the TRM that VEIC maintains for the State of Illinois. VEIC reviewed how results of the OpenStudio analyses for the TRM compared with the results from eQUEST analyses used previously.

The pilot also included investigation of the requirements for an open schema to support a managed package for program reporting in Salesforce[2] and Mule[3] connectivity to this package, including load shapes.

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[2] Salesforce is a customer relationship management software tool widely used by utilities.
[3] Mule is a lightweight enterprise service bus (ESB) and integration framework provided by MuleSoft.

Assessment of the Pilot

Methodology

Cadmus conducted interviews with the VEIC project manager to assess the VEIC pilot application of the OEP.[4] We conducted one interview prior to the pilot and one after it was completed. The interviews followed detailed interview guides. The guide used to conduct the final interview addressed the following topics:

- What barriers the OEP and related federal tools helped the pilot project overcome
- What difficulties the pilot project had implementing the OEP and related federal tools
- What benefits OEP and related federal tools offered compared to the conventional approach to implement the pilot project
- What lessons can be learned from this pilot to help improve the OEP and support adoption of federal tools, such as the program's best applications and usefulness (including those for small buildings)
- Other potential OEP applications

In addition to the information we collected from the interview, the PSD project manager provided insights based on working with the VEIC team on the project. We integrated this information with findings from the pilot participant interviews.

Program Barriers

In research based on an extensive literature review, Cadmus identified the following four categories of barriers that usually confront commercial building energy-efficiency programs:

- Uncertainties in energy savings estimates
- Lack of standardized methods for performing energy savings calculations
- Lack of methods to streamline data management
- Costs, especially those associated with estimating energy savings

In this and the other pilot project case studies, we used this taxonomy to structure our investigation of barriers that the project proponents sought to overcome by implementing the OEP.

As the low-hanging energy-efficiency fruit are harvested in Vermont commercial building programs, VEIC has faced the barrier of trying to estimate energy savings from more complex technologies. Historically, VEIC has relied on spreadsheet-based engineering tools to estimate savings, but they have not found these tools to be very suited for analyzing controls and other complex technologies, such as heat pumps. In the case of heat pumps, savings calculations need to take into account their operation at low temperatures (such as -20°F) and typical engineering analyses are not adequate to do so. The VEIC

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[4] Cadmus also interviewed this project manager for another pilot project conducted by Commons Energy, a subsidiary of VEIC.

interview respondent said that they found that OpenStudio allowed them to analyze measures such as these quickly and in standardized ways.

The VEIC respondent also observed that any systems that affect peak energy use have been challenging for spreadsheet or eQUEST analyses because peaks are very sensitive to other conditions and easily shift. They found that the ability to explore many scenarios in OpenStudio and its transparency have made it easier to understand and manage that sensitivity.

The VEIC respondent said that they wanted to get to a point where someone who does not know much about modeling can quickly put in the inputs and get consistent outputs; he said, "we are almost there after the pilot."

Standardization allowed VEIC to design protocols that specified the order in which measures are analyzed, thus attributing energy savings consistently. Standardization also allowed VEIC to reduce the time and resources required in program design by producing an initial calculation format that could then be adapted to different buildings or measure types.

OpenStudio helped manage data, increase consistency, and reduce costs by bridging program design and measurement and verification (M&V) activities. VEIC believes that OpenStudio will allow them to run scenarios quickly to quantify and calibrate savings.

VEIC also states that OpenStudio will support program design in another way. The flexibility and ability to perform scenario analysis efficiently with OpenStudio will assist with program design by allowing different designs to be examined and assessed quickly and cost-effectively.

Image: NREL

OpenStudio and other tools can reduce some of the barriers encountered during program implementation. Barriers implementing complex projects include uncertainty about energy savings, lack of standardization in savings calculations, lack of streamlined data management, and costs. In their experience, VEIC found OpenStudio and the OEP have helped overcome these barriers by permitting faster, more accurate savings quantification and providing interactivity that allows internal monitoring and will likely facilitate
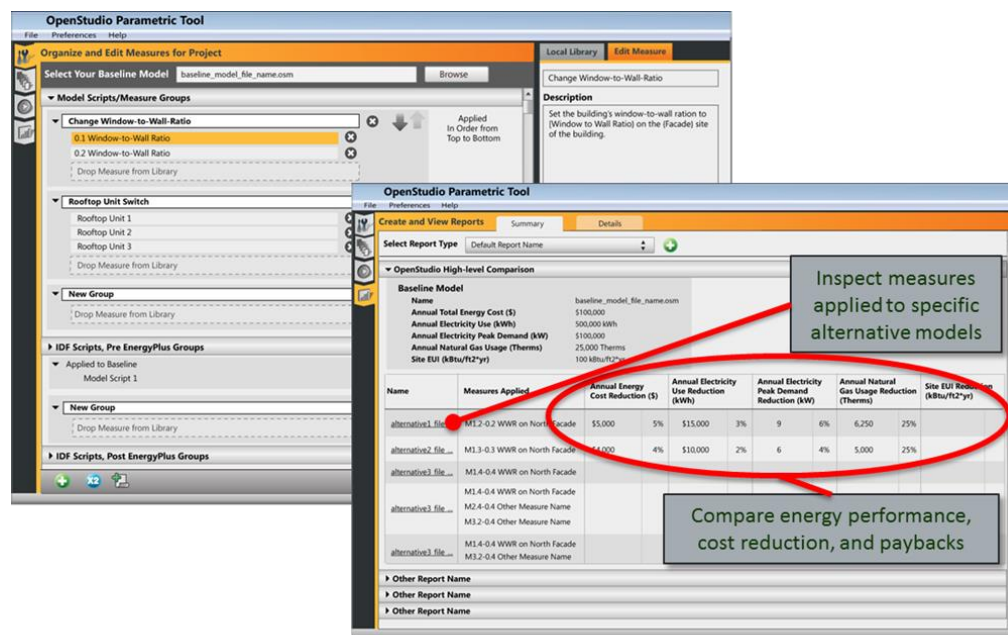
third-party review. Because none of the project are far enough long, VEIC has not been able to verify the last benefit yet but expects that it will emerge when they get to the program evaluation stage.

Typical barriers during program evaluation include uncertainty about original claimed savings and evaluated savings, consistency in savings estimation methods, and data management. The VEIC respondent noted that when there are disagreements between the claimed and evaluated savings, "you need the ability to show the evaluator clearly what you did and what the assumptions were." He stated both parties need to understand what the other did so consensus can be reached. Although none of the projects had gone through the evaluation process yet, he felt that the OEP provides tools that would better prepare VEIC for the evaluation, in part by allowing them to perform rapid sensitivity analyses, and it would help overcome some of the evaluation barriers by demonstrating what approach was used and providing transparency.

Difficulties Implementing OEP

VEIC had little difficulty using OpenStudio because their staff had good building simulation experience. Their recent interactions with NREL and involvement with several building performance organizations also helped them adapt OpenStudio to their program and TRM needs.

Although VEIC found it relatively easy to start using OpenStudio, they encountered some difficulties expanding the building types they could analyze. They started with certain prototype buildings and had challenges extending their analyses to other building types. The VEIC respondent believed that some building types would continue to be problematic to analyze with OpenStudio.

VEIC saw many advantages in moving to OpenStudio from eQUEST for their EVT programs and TRM development, but made the transition cautiously. They found OpenStudio more transparent and customizable, and trusted its results more, but the VEIC representative indicated that the transition needed to be made carefully so "it did not create too many waves." The VEIC respondent said that they needed to make everyone comfortable as they made the transition and he predicted it would take another two years to fully transition.

Although VEIC is convinced of the advantages of OpenStudio, the VEIC respondent believed that the lack of familiarity with it in the evaluation community was a potential hurdle to its use.

VEIC also explored the possibility of using Salesforce as a program reporting platform, but decided it was more cost-effective and feasible to invest in enhancing their existing system.

Other OEP Benefits

Overall, the VEIC representative believed participating in the pilot enhanced their staff's building analyses expertise. In particular, participation increased their capabilities using OpenStudio, bringing all the benefits of that tool, and improved their understanding of how to leverage the tool better, integrate external data, and connect to other tools.[5]

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[5] The VEIC staff who used OpenStudio for the EVT programs also supported Commons Energy and these benefits also applied to the ESCO services provided by Commons Energy.

The VEIC respondent identified the flexibility of OpenStudio as a positive feature that helped overcome various program barriers, as noted above. The flexibility allowed them to run various scenarios and perform sensitivity analyses that provided insights into the effects of various efficiency measures, added credibility to savings estimates, and generated other qualitative benefits.

Their experience using OpenStudio to analyze specific measures enhanced their capabilities in projects outside Vermont. It is assisting them in their measure development for the Illinois TRM. They are leveraging their experience to develop a TRM for Iowa. Additionally, they are using what they have learned in their role operating the DCSEU. They anticipate this will have a large impact because buildings in DC are more similar so some of the complexities of analyzing diverse buildings will be reduced.

VEIC's interest in integrating other tools with OpenStudio also had other benefits. They said that one result of their investigation of this was that it "opened up some of the holes in some of their data tracking in the way it existed, so they've had to update EVT data tracking." They found the data being stored did not deal with the building as an entity but was associated with a project instead. They are now in the process of revising their tracking system so the building is treated as an entity regardless of the project or who owns it. According to the VEIC respondent, "That will allow better connectivity between modeling and other data systems."

A similar outcome related to their investigation of the possibility of using the OEP to connect OpenStudio with Salesforce. Although they decided against doing that as part of the pilot, this activity led to further definition of the requirements for an open schema to support program reporting in Salesforce and developing Mule connectivity.

VEIC has continued to build upon their experience in the pilot. They have expanded their use of the OpenStudio platform and continue to work with PSD on the integration of OpenStudio into EVT program operations through measure writing. PSD has built a demonstration OpenStudio-based calculator dedicated to quickly evaluating energy savings for VRF systems. The calculator also generates a standard EDAPT XML[6] and will be extended to generate an OEI XML for expanded program reporting. VEIC is evaluating how this calculator demonstration can be used to further extend the use of OpenStudio in their programs. Expanded adoption would drive the need for the standardized data transfers that use the XML export feature of the calculator.

The VEIC respondent noted that there were broad benefits of the kind of connectivity the OEI was targeting. He stated that he was a "believer in having and achieving better and better connectivity between tools," and he believed that lessons learned from the OEI and further demonstrations of connectivity among more tools would be valuable to many organizations that rely on the tools. He recommended that future funding be dedicated to this effort.

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[6] EDAPT is the Energy Design Assistance Project Tracker, pioneered by Xcel Energy and partly funded by DOE. EDAPT connects project data with model outcomes to streamline reporting. XML stands for Extensible Markup Language, which is a markup language that defines a set of rules for encoding documents in a format that is both human-readable and machine-readable.

Other OEP Application Opportunities

When asked about other applications for the OEP and related federal tools, the VEIC representative focused on taking a perspective broader than energy savings. He noted the increased adoption of carbon reduction goals across states and thought that this platform and tools could be useful for planning purposes and be applied to organizations beyond utilities and that the interconnectivity of the tools facilitate these efforts.

Overall Conclusions and Recommendations

Although a single case study does not provide enough evidence to draw many generalizable conclusions, this pilot project highlighted observations that can be applied broadly to other situations and programs. Key conclusions from this case study include the following:

- The need for more sophisticated and complex tools to analyze energy savings is likely to grow as programs exhaust low-hanging fruit and incentivize more complex energy-efficiency measures.
- Widespread use of more capable energy analysis tools will depend on user interfaces that make it possible for analysts to use them to conduct robust analyses, including scenario and sensitivity analyses, with a moderate amount of training and standardization of inputs, outputs, and analysis protocols.
- OpenStudio can satisfy many of these requirements of an effective interface that allows analysts access to a powerful building analysis tool, EnergyPlus.
- It is important to be aware of the limitations of a tool such as OpenStudio, however, and anticipate how the limitations are likely to affect application to an energy-efficiency program.
- Although OpenStudio offers many benefits, transitioning to it can be disruptive if the process is done too quickly and without adequate staff coordination and training, especially if program staff have little familiarity with the tool.
- Despite the potential benefits of Salesforce as a reporting tool, converting to it in a relatively short timeframe may not be the most cost-effective approach.
- Adopting a new tool, such as OpenStudio, to support an energy-efficiency program is likely to reveal unexpected needs and opportunities in existing processes. In this pilot project, VEIC found inadequacies in their tracking system and helped identify a framework for reporting using Salesforce.

Based on our review of this pilot project we make the following recommendations:

- Commercial building program designers, implementers, and evaluators and TRM developers should investigate the use of OpenStudio to analyze energy and demand savings of complex energy-efficiency measures.
- Organizations considering adopting OpenStudio to analyze energy-efficiency measures should assess its limitations, as well as capabilities, and dedicate enough time and resources to the adoption process.

- An organization considering adopting OpenStudio should consider adopting it as part of the OEP and evaluate other tools in the OEP suite that could reduce costs, decrease savings uncertainties, improve consistency in savings calculations, and improve data management.
- In the process of adopting OpenStudio or other tools, an organization should anticipate that the adoption process might identify other needs and opportunities and be open to considering adoption of other complementary tools.
- DOE and program administrators should draw upon the lessons learned from the set of case studies prepared for the OEI pilot projects.