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Commercial Building Operational Assessment

Market Research

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EXECUTIVE SUMMARY

The U.S. Department of Energy (DOE) has recently created an Asset Scoring tool that assists in the evaluation of physical characteristics of buildings, independent of building operation and occupant behavior. This tool acts as a complement to ENERGY STAR Portfolio Manager (ESPM) which benchmarks the actual energy use of buildings with respect to other existing buildings. Using these two resources, building owners and operators are able to evaluate their current level of energy consumption as well as receive suggestions regarding upgrades to building envelope and equipment.

The missing piece for building owners is a method of evaluating the efficiency with which their buildings are operated. This aspect of building energy use is not directly addressed by Energy Star Portfolio Manager or Asset Score, due to inherent challenges in separating structural efficiency from operational efficiency using utility bills only. The DOE is considering developing an additional set of capabilities for the Asset Scoring tool that would address this area. Through literature review and in-depth interviews, this study investigates the market demand for a complimentary Operational Assessment (OA) tool that would provide users with feedback on how efficiently their buildings are operated.

Approximately 30 geographically-distributed building industry stakeholders contributed their expertise for this project. These stakeholders represented eight different groups: 1) Large Building Owners; 2) Large Building Operators; 3) Small Building Owners and Operators; 4) Energy Service Providers (e.g., retro-commissioning agents); 5) Efficiency Program Administrators; 6) Municipal Agencies; 7) State Governments; and 8) Federal Agencies. Portfolio sizes of owners and operators ranged from a single building to upwards of 1,400 buildings.

The most common participant responses were ubiquitous across stakeholder categories, clearly highlighting essential market needs regarding building operational assessment. Central themes included the following:

- Participants prefer a tool that is flexible with respect to the amount of input information required. Suggestions include constructing a tool with more than one discrete mode of operation, providing default parameters, and including brief in-line quizzes designed to help estimate difficult inputs (e.g., plug loads, hot water use).

- Participants emphasized the challenges inherent in obtaining tenant-specific inputs (e.g., plug loads), as well as encouraging operational changes at a tenant level.

- While interviewees clearly indicated that an Operational Assessment tool could make an important contribution to the marketplace, participants noted the need for reliable, building-specific, actionable results and suggestions.

- Three scores (ESPM, AS, and OA) are generally viewed as overwhelming and unnecessary. While interviewees appreciated separate AS/OA savings estimates and ESPM score improvement, they were largely in favor of using a simple operational efficiency percentage in lieu of an actual OA score.

- Though some stakeholders could identify benefits to a completely independent scoring system, nearly all participants requested some kind of context or reference point to assist in interpretation of AS/OA scores. Suggestions included providing EUI as a concrete reference, or indicating the AS of a similar building designed to code (e.g., ASHRAE 90.1-2007).

- The most frequent suggestions for market use of the tool included: 1) providing benchmarked buildings with actionable next steps toward energy efficiency; 2) using OA to identify which buildings in a portfolio would benefit most from additional attention; 3) employing OA as a first step in an energy audit or retro-commissioning plan; 4) providing encouragement for owners to take action; and 5) helping to drive energy conservation in the marketplace via added publicity for efficient buildings.

Based on these findings, the following considerations for development of an Operational Assessment tool can help ensure that it meets stakeholder needs. First, it is helpful to provide at least two discreet levels of complexity regarding user input requirements, or offer simple input calculation tools and default values for harder-to-obtain input information. Second, recommendations should focus on operational items that are building-specific and actionable. Third, many stakeholders find that operational results conveyed as an efficiency percentage are more accessible than an operational score. Fourth, the design of the Asset Score scale can assist with score interpretation. This can be done by adding an absolute context to the scale (e.g., EUI) or a comparative context (e.g., baseline score of a code-compliant building). Finally, the tool can assist facility owners and managers by providing functionality to compare Asset Scores and operational efficiencies across entire portfolios.

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1.0 INTRODUCTION

1.1 BACKGROUND AND MOTIVATION

Energy conservation efforts targeting the built environment have been in place for decades. During that time technologies have been developed to reduce envelope heat transfer, recover energy from exhaust air, utilize the sun's lighting and heating capabilities, and turn lights on and off automatically. When implemented concurrently, these technologies have allowed us to design, operate, and occupy highly efficient buildings – sometimes so efficient that, with on-site renewable energy generation, they boast a net annual energy use of zero.

The development of highly efficient building technologies, however, is only part of the story. The remainder is motivating people to adopt not only energy saving technologies, but energy saving habits and operating procedures as well. One of the most effective ways to engage people in energy efficiency efforts is to educate them, via performance feedback, on their energy use (Darby, 2006).

Peer benchmarking tools, such as ENERGY STAR Portfolio Manager, have gone a long way towards meeting this goal. Maximizing energy savings requires an assessment of the potential for improvement and the efficiency measures that could be implemented in each individual building.

The U.S. Department of Energy (DOE) has recently released a commercial building energy Asset Scoring Tool intended to enable building owners and operators to evaluate the energy use of their systems independently of building operation and occupant behavior. This tool provides building owners and operators with information regarding potential savings from envelope and equipment upgrades, an important complement to the information provided by ENERGY STAR Portfolio Manager.

Technologies alone are not enough to ensure significant energy savings. Advanced building technologies must be operated and maintained by people. Not all building systems are operated efficiently or, in the case of advanced building technologies, correctly. There is an opportunity for an estimated 20 percent energy savings through improved operations in commercial buildings (MIT CoLab, 2012; Mills, 2011), potentially saving $40 billion per year across the U.S. (Office of Energy Efficiency and Renewable Energy, 2012). Therefore, assessment of the operations of buildings is the linchpin for achieving the full potential of energy efficiency initiatives.

In light of these concerns, DOE is investigating the market need to develop operational assessment (OA) capabilities linked to the existing Asset Scoring Tool. The study

"*Development of an Online Toolkit for Measuring Commercial Building Energy Efficiency Performance"* (Pacific Northwest National Laboratory, 2013) suggests the potential for providing an operational score (OS) consistent with the methodology used by the existing Asset Scoring Tool. Operational characteristics such as plug loads, occupant schedule, the number of occupants, lighting schedules, temperature set-points, and heating, ventilation, and air conditioning (HVAC) schedules could be assessed in this manner.

DOE's interest is to provide a linked federal toolkit that can provide standardized assessments of building energy efficiency, including:

- Efficiency of building equipment (Asset Scoring Tool)
- Efficiency of building operations (Operational Assessment Tool)
- Peer benchmarking of energy use (ENERGY STAR Portfolio Manager provided by EPA)

Both the Asset Scoring Tool and an Operational Assessment Tool are intended to help building owners and operators understand, evaluate, and improve their building's energy performance. Integrated Asset Score and Operational Assessment Tools can diagnose both building infrastructure and operations and maintenance (O&M) practices to identify potential opportunities for cost effective energy savings.

1.2 RESEARCH GOALS

Sustainable Engineering Group, LLC (SEG) conducted an in-depth analysis for the U.S. DOE Office of Energy Efficiency and Renewable Energy (EERE) of building industry needs and stakeholder responses to potential designs for a commercial building Operational Assessment Tool.

The main objective of this study was to address the following questions regarding operational (non-capital) measures:

- What information is most useful for building owners, operators, and tenants to improve their building energy performance?
- What are the main technical and policy issues that the building owners and operators are facing when improving their building energy performance?
- What methods do building operators currently use to assess their building operation? What data are being collected? What is their current workflow and how might that change with the availability of a low-cost operational assessment tool? What differences exist between large buildings and small buildings?
- Where are the gaps? What features do building owners and operators expect to see in an operational assessment?

To answer these questions, work consisted of a review of existing and emergent operational assessment tools, interviews with building industry stakeholders, and an evaluation of their responses. This report documents analysis methodology, findings, and recommendations. Its intent is to support and inform the DOE Office of Energy Efficiency and Renewable Energy on the market uses and potential impacts of the Operational Assessment Tool to encourage energy reduction in existing commercial buildings.

1.2 APPROACH OVERVIEW

This investigation consisted of two main tasks: a literature review of existing resources for commercial building operational assessment, and stakeholder research conducted via in-depth interviews. Key stakeholder groups were identified as: 1) Large Building Owners; 2) Large Building Operators; 3) Small Building Owners and Operators; 4) Energy Service Providers (e.g., retro-commissioning agents); 5) Efficiency Program Administrators; 6) Municipal Agencies; 7) State Governments; and 8) Federal Agencies.

An initial list of 68 potential participants was created to adequately sample each stakeholder group and insure a broad geographical distribution. Portfolio sizes of owners and operators ranged from a single building to upwards of 1,400 buildings. Stakeholders were enlisted via phone and email outreach, achieving a participation rate of approximately 40%. One quarter of interviewed stakeholders had previously participated in the Asset Score pilot, and were therefore familiar with basic tool configuration and interface.

Operational Assessment Tool mock-ups were provided by Pacific Northwest National Laboratory (PNNL) as supplementary interview materials (Appendix A). The interview discussion guide was developed by SEG in collaboration with PNNL and DOE, and resulted in conversations with stakeholders that lasted approximately 45 minutes. The discussion was broadly organized into three sections: 1) Operational assessment general practices; 2) OA tool configurations (Inputs/Outputs); and 3) Presentation of summary information.

Overall, approximately thirty participants were interviewed. In most instances, discussions were conducted individually; however, in some cases participants requested the inclusion of additional colleagues. Interviewees' comments and responses were assigned anonymous labels indicating only their general stakeholder category, and common themes were identified.

2.0 ENERGY ASSESSMENT TOOLS AND OPERATIONAL ASSESSMENT

Technological advances coupled with an increasing awareness of the cost-saving opportunities inherent in building energy use reduction have contributed to a rapid emergence of Energy Management and Information Systems (EMIS) tools in the marketplace (e.g., Granderson et al. 2009; Kramer et al., 2013; Wang, 2013). These technologies include benchmarking and utility tracking tools, energy information systems (EIS), and tools with a system-level focus (e.g., fault detection and diagnostics, and automated system optimization).

Benchmarking and utility bill analysis tools are designed to assist building owners and operators in assessing building energy performance. These tools utilize comparisons between building energy consumption and standardized reference points such as other buildings (peer benchmarking), previous energy use measurements (longitudinal benchmarking), or existing rating systems. Portfolio Manger's ENERGY STAR score, for example, is a peer-based rating system that assigns each building a score relative to other buildings. Benchmarking tools are generally unable to distinguish between asset-derived and operationally-derived contributions to energy consumption.

Energy Information Systems have been developed to assist building owners and operators in reducing energy consumption by identifying specific opportunities for improvement. The amount of input required by these tools varies widely, but at a minimum requires monthly utility data. Typically the tools that require more detailed information also provide more specific, actionable recommendations. Most of these tools focus primarily on asset-based building improvements.

System-level analytic tools interact directly with building automation systems (BAS) to provide equipment level fault detection/diagnostics and automated system optimization. These programs utilize both physical data (e.g., utility data, building characteristics) and real-time operational data to provide recommendations related to energy efficiency and occupant comfort. The direct connection between the tool and the building results in detailed and specific operation-based feedback to the owner.

In contrast to existing EMIS tools, a DOE Operational Assessment tool would likely utilize EnergyPlus building energy models. The models would incorporate both physical and operational building characteristics, ensuring that results were building-specific. As an example, such a tool could contrast modeled energy use under ideal operating conditions with modeled energy use under actual operating conditions, providing an immediate indication of available operation-based energy savings.

Of the EMIS tools discussed here, only system-level analytic tools focus primarily on operational improvements. Although there is undoubtedly some overlap between the operational parameters addressed by system-level analytic tools and those that would potentially be addressed by an Operational Assessment tool, they do have different approaches and applications. System-level analytic tools cannot be applied to buildings without building automation systems; a potential Operational Assessment tool could be utilized by buildings that do not have BAS. Also in contrast to existing resources, the Operational Assessment tool could compare a building's current operation to its own ideal operation, enabling an integrated, building-centric, standardized estimate of current operational efficiency.

3.0 STAKEHOLDER FEEDBACK

The purpose of this study is to evaluate the feasibility of adding an operational assessment capability to the existing DOE Commercial Building Energy Asset Score. The motivation for adding this capability would be to help building owners and operators understand how efficiently their building is operating as well as suggest steps they could take to operate more efficiently. Aspects of building operation that might be addressed include temperature set-point adjustments, scheduling and setback, and plug load management, (among others).

Many aspects of a building's operation can be optimized with little or no cost to the building owner (e.g., temperature set-points). The challenge for building owners and operators lies in identifying the aspects of their building operation that have significant potential for improvement. A DOE operational assessment tool could meet this need by providing users with initial recommendations regarding what could be done to improve operational efficiency in their building(s).

To determine the market need for such a tool, approximately thirty stakeholder interviews were conducted regarding building operational assessment. Results include feedback from a diverse set of stakeholder groups and geographical locations. Interview questions were designed to cover a consistent breadth of subject matter, but were adjusted slightly for each participant to investigate their specific perspective.

Conversations with participants lasted approximately 45 minutes. The discussion was broadly organized into three sections: 1) Operational assessment general practices; 2) OA tool configurations (i.e., inputs/outputs); and 3) Presentation of summary information. Mock-ups were provided by Pacific Northwest National Laboratory (PNNL) as supplementary interview materials (Appendix A).

Interviewees' comments and responses were assigned anonymous labels indicating only their general stakeholder category. Common themes were identified among the responses, and are summarized in the following sections.

3.1 CURRENT APPROACHES TO OPERATIONAL ASSESSMENT

Nearly every participant interviewed indicated that they assess their building's operational performance in some manner. Participants were asked to describe what motivates them to make operational adjustments, what procedures they follow to assess building operation, and what challenges they face in addressing operational issues.

3.1.1 MOTIVATION

> *Building managers are taught to keep their occupants comfortable. It's all about taking care of the hot and cold calls and making adjustments where needed.*
>
> –Federal Agency

Participants cited a variety of reasons for making changes to building operation. Approximately half of these were somehow related to energy efficiency. In order of prevalence, motives that were mentioned included: occupant comfort; marketing and publicity; financial and energy savings; addressing malfunctioning equipment; space-use adjustments; and fulfilling benchmarking requirements or federal energy reduction goals.

The most common catalyst for modifying operational parameters was occupant comfort. Providing a comfortable space for occupants can involve adjustments to parameters such as air temperature, radiant temperature, humidity, air speed, ventilation, sound levels, and/or lighting. Study participants typically viewed comfort issues as independent of energy use considerations; however, in some cases comfort concerns were seen as a potential hindrance to enacting energy saving operational adjustments.

The fact that in many cases building managers are evaluated based on minimizing occupant complaints led to statements by a number of participants that energy considerations did not frequently factor into operational adjustments at that level. Opinions were similar regarding motivating factors such as malfunctioning equipment and reassignment of spaces; on a day-to-day level operational adjustments are made to keep the building up and running and ensure the satisfaction of its occupants.

Another commonly cited motivation for adjusting building operation was marketing and publicity. This impetus is tied to energy use to the extent that exhibiting energy efficiency is largely viewed as good press. A broad set of stakeholder groups was cited as being motivated by marketing and publicity, including building owners/operators that served the public, those in areas with active disclosure ordinances, and real estate stakeholders for whom energy efficiency in buildings is associated with increased market value.

Reducing energy use for the purpose of utility cost savings was another major influence among participants. This motivation was often cited by large building owners and operators, particularly those with large portfolios. Similarly, although driven more by energy reduction goals than financial incentives, federal agencies with large portfolios were largely motivated by energy savings as well.

3.1.2 METHODOLOGY

> *I get my team together every two weeks…We take a few minutes to discuss what the latest numbers are, to let us actually know that we're doing the job we think we're doing, and if we're finding opportunities.*
>
> - Large Building Operator

Methods employed to assess operational performance in buildings range from simple and passive (e.g., wait until someone complains) to active and complex (real time EMIS evaluation of building systems and equipment). Likewise the frequency of operational assessment varies widely, with some participants reporting reviews that occur every 5 years and others sending daily reports to building operators that include operational suggestions and reminders.

Energy service providers and efficiency program administrators indicated that, in their experience, the majority of individual building owners and operators use the more passive, occupant comfort-driven approach to operational assessment. Those that exhibit more interest in energy efficiency, however, were reported to typically make use of monthly utility bills, ENERGY STAR Portfolio Manager, and/or an occasional professional audit.

Participants who managed a large number of buildings were more likely to have an active, standardized protocol for assessing building performance. They also utilized building automation system EMIS tools more frequently than other types of stakeholders. One of the major motivating factors for instituting these practices was to allow owners/operators to identify which of the buildings in their portfolio could benefit most from added attention. This was a recurring theme among these types of participants.

The more complex operational assessment methodologies described by participants involved elements such as: evaluation of sub-metered (by end-use and/or reduced time interval) data; daily adjustments to temperature set-points, window blind positions, etc. based on weather forecasts; routine professional audits; and ongoing utilization of EMIS tools. There was general consensus among participants that energy use data was the most critical input to obtain, and that sub-metered utility data provided the most leverage in identifying potential operational improvements.

3.1.3 CHALLENGES

> *You have all these different building types, and in some buildings you have people who are full time, totally into this stuff, and are really good at it. But in a lot of cases, even in the building I'm sitting in, it's just a fighting fire, band aid type approach.*
>
> - Efficiency Program Administrator

Participants exhibited general consensus with regard to the most common challenges faced in assessing building operational efficiency. Frequently mentioned obstacles included practical issues such as difficulty obtaining energy use data or a lack of human resources, as well as behavioral challenges such as motivating and engaging owners, tenants, staff, and building managers to assist in conservation efforts.

Obtaining energy use data was cited frequently as one of the main challenges to assessing building operational performance. Even in the case of owner-occupied buildings utility bills are often sent to an accounts payable department, and are therefore sometimes never seen by building operators or maintenance staff. This obstacle was also cited by energy service professionals who regularly provide energy audit or retro-commissioning services to commercial buildings.

Another major obstacle to operational assessment is that many buildings don't have the resources to invest large amounts of time into energy efficiency. Building managers and maintenance staff were often described by participants as overtasked with regard to their work loads. Addressing issues such as routine maintenance, occupant comfort, and equipment repair/replacement leaves little time for energy efficiency analysis.

On the motivational side, participant discussions revealed a number of challenging disconnects between those who stand to benefit from energy efficiency and those who are responsible for carrying out conservation measures. A classic example of this is the split incentive scenario in which tenants are responsible for their own utility bills, and building owners are left with little motivation to invest in building energy efficiency.

Some building owners and operators brought up the opposite example as well, stating that they had interest in energy efficiency but felt constrained by a lack of influence over the energy consumption habits of their tenants. A similar challenge expressed by participants involved difficulties in motivating their own occupants to enact energy saving behaviors.

> *It's a conundrum for us because we're a landlord and have multiple tenants in a building, and so we can't tell them, "Turn off your printers." They ultimately pay for their power; we don't pay for their power. If they want to keep their copy machine turned on all night, that's their prerogative.*
>
> - Large Building Operator

With respect to enacting overall building system (e.g., HVAC) operational efficiency measures, the most crucial players are building managers and maintenance staff. According to study participants, their willing engagement in energy efficiency can be challenging to obtain. Not only are building managers often faced with a lack of time and resources (as discussed above) but they also tend to be evaluated on the satisfaction of occupants more than efforts toward

energy savings. The combination of these factors can render conservation efforts a very low priority.

3.2 OPERATIONAL ASSESSMENT TOOL CONFIGURATIONS

PNNL mock-ups illustrating the three Operational Assessment approaches under investigation were presented during study interview sessions. Participants provided feedback on the effort required to collect tool inputs, the value of resulting output information, and which scenario represented the best balance between effort and benefit. Slides for this portion of the interview may be found in Appendix A.

3.2.1 EFFORT REQUIREMENTS

> *The more time that you ask for them to invest in it, the smaller the number of people who will participate in it. But that's not to say there aren't people who would find this valuable.*
>
> - Efficiency Program Administrator

Input parameters for the three Operational Assessment scenarios investigated (Options A, B, and C) are listed in Table 1. These parameters are grouped by the tools with which they are primarily associated (i.e., Operational Assessment Option A could be performed using Green Button access and ESPM inputs). AS and OA Levels 1 and 2 correspond to basic and complex tool configurations, respectively. Checkmarks indicate which information is required for a given option. Participants discussed the relative amount of effort they felt each option would require, and described challenges they anticipated in obtaining the associated information.

In general, participants felt that the scenario with the least amount of required input information (Option A) would attract the most users. This option was viewed as involving little to no effort, based on two assumptions: 1) that most users would already be tracking their buildings via Portfolio Manager; and 2) that the OA tool would interface seamlessly with ESPM (i.e., would not require data re-entry). There was a certain amount of skepticism, however, regarding the accuracy of results obtained in this scenario.

Despite a recurring sentiment that the tool would lose a number of users at each transition to a higher level of complexity, participants tended to prefer Option C over Option B. This preference was due in part to the associated output of these options, which is discussed in the following section. In addition, however, some participants felt that if a user was already collecting input information for Option B, it would be worthwhile to obtain the additional Option C inputs as well.

Table 1. Operational Assessment Tool Input Options

Level	Input Data	Option A	Option B	Option C
ENERGY STAR Portfolio Manager				
-	Monthly Utility Bills	✓	✓	✓
	Building Area (sqft)	✓	✓	✓
	Number of Occupants & Computers	✓	✓	✓
	Weekly Operating Hours	✓	✓	✓
Green Button				
-	Hourly Energy Use Data	✓	-	-
Asset Score				
LEVEL 1	Floor Area, Number of Floors	-	✓	✓
	Window Orientation	-	✓	✓
	Envelope Type	-	✓	-
	Lighting Type	-	✓	-
	Heating/Cooling Equipment Types	-	✓	-
LEVEL 2	Footprint Dimensions	-	-	✓
	Window-to-Wall Ratio	-	-	✓
	Envelope Construction	-	-	✓
	Lighting Fixture Details	-	-	✓
	Heating/Cooling Equipment Types and Efficiencies	-	-	✓
Operational Assessment				
LEVEL 1	Number of Occupants	-	✓	✓
	Temperature Setpoints	-	✓	-
	Operating Schedules	-	✓	✓
	Plug Loads	-	✓	✓
LEVEL 2	HVAC System Setpoints	-	-	✓
	Peak Demand	-	-	✓
	Annual Schedule for Heating/Cooling	-	-	✓
	Envelope and Equipment Maintenance Routine	-	-	✓
	Service Hot Water Temperature Setpoint	-	-	✓
	Gallons of Hot Water Use	-	-	✓

The highly specific nature of the required Option C input information did give participants some pause. A number of times it was expressed that Option C inputs would be best addressed by experienced energy services providers, as use of the tool would be faster and entered information more reliable with professional assistance. In addition, Energy Service Providers that were working with a building would already have access to most of the required information.

The most cited overall obstacle to obtaining input information was the number of people that would need to be involved in the process. Utility information may come from accounts payable; asset information would primarily be obtained from building plans; and operational

parameters would likely require the involvement of building managers and/or tenants. Because some older buildings may not have up-to-date plans available, operational inputs were generally regarded as easier to obtain than asset inputs.

Specific asset inputs that were frequently cited by participants as difficult to gather included lighting fixture details and window-to-wall ratio. On the operational side, participants reported that the most problematic information to access would be hot water use and plug loads, unless they were already being sub-metered. Concerns were also raised about the difficulty of obtaining tenant data, and the complexities inherent in accurately representing buildings that were multi-use and had different operating hours for different floors/spaces.

> *We have different state departments, and three can be assigned to one building. So you'd have to go to each department in that building and say "How many occupants? How many computers?"*
>
> - State Government

Despite the challenges present in obtaining detailed building data, participants felt that in certain cases Option C would be worth pursuing. In particular, if the collected data could be exported and/or utilized in other capacities, it might be seen as a way to document and organize building information. It was pointed out by a few participants that most of the initial information would only need to be collected and entered once to continue to receive the benefits of the OA tool indefinitely.

3.2.2 OUTPUT OPTIONS

> *If I throw 20 generic recommendations at someone they will do nothing because they won't know how to prioritize in most cases, or will be afraid to prioritize because there is not much detail. What are the three things you should do in the next month specifically? That is what I have seen gets the best response.*
>
> - Municipal Agency

Available output information for the three OA configuration options considered in this study is listed in Table 2. Checkmarks indicate which information would be possible to obtain in each of the three scenarios. During this portion of the interview, participants evaluated the usefulness of this information as related to optimizing building operational efficiency, using their own personal experience as a context.

The dominant viewpoint expressed by participants was that regardless of the specific option chosen, results and/or recommendations need to be accurate, building-specific, and actionable to be of value. Some participants also underscored the importance of prioritizing operational efficiency recommendations to ensure that users would not be overwhelmed by choices, and would implement the highest-impact measures first. A customizable report that

could be manually adjusted to remove any inapplicable measures prior to sharing with building owners was also viewed as desirable.

Table 2. Operational Assessment Tool Output Options

Output Information	Option A	Option B	Option C
Scheduling and Setback	✓	✓	✓
Demand Management	✓	-	✓
Plug-load Management	✓	✓	✓
Savings Estimates ($)	✓	✓	✓
Set-point Adjustments	-	✓	✓
Operational Score	-	✓	✓
Operational Efficiency	-	✓	✓
Asset Score	-	-	✓
Oversized HVAC	-	-	✓
Leakage	-	-	✓
Over/Under Heated/Cooled	-	-	✓
Equipment Degradation	-	-	✓

With respect to the specific list of possible output information, participants frequently expressed a desire for a more concrete definition of "asset" relative to "operation". A natural delineation that arose during interviews was to divide results by capital investments versus operational investments. For example, Oversized HVAC, Leakage, and Equipment Degradation outputs were generally seen as asset-related rather than operational.

> *The wording of them should be clear. With Asset Score we are talking about physical change, and with Operational Assessment we are talking about operational change. In a manner that says, "The best you can do with what you've got", and "What we think you could do with the best".*
>
> - Municipal Agency

Scheduling and setback recommendations were generally regarded by participants as both useful and easy to implement. Plug load feedback received great interest from participants, as many of them do not currently assess plug loads in their buildings, but they recognize significant potential in addressing them. There was some question among study participants, however, as to how they would implement plug load recommendations in tenant occupied spaces. A suggestion to separate recommendations into two categories, those under the landlord's control and those under tenant control, was presented in response to this concern.

Regarding the implementation of recommended measures, participants were unanimous in the conviction that cost savings was an essential output for inspiring action among building owners and operators. Study participants cautioned, however, that operational recommendations should be presented in a manner that would reassure building managers

that overall occupant comfort would be maintained. In addition, participants emphasized that the language of operational suggestions should be easily understandable by building operators and managers spanning a range of skill levels.

3.2.3 OPTIMAL BALANCE

> *If I'm a service provider I may elect to go to Option C, because I know buildings and I want the greatest output. If I'm a building operator or owner I'm going to go with Option A because the other stuff is overwhelming.*
>
> - Municipal Agency

When asked to identify the option with the best balance between level of effort and output information, most study participants chose Option A. Of the remaining participants, slightly more were in favor of Option C than Option B, citing that it provided more benefits to building owners and operators that are serious about energy efficiency. There was general consensus among participants, however, that identifying the best option largely depended on who the target user was.

Option A was described by participants as being useful to small building owners and operators who might not have significant resources to invest in operational assessment. It was also felt that this option would be useful to stakeholders with large portfolios, as a cursory method of identifying which buildings would immediately benefit from increased attention.

The popularity of Option B suffered from the addition of significant effort on the input side resulting in little added value on the output side. Many participants were skeptical, however, regarding the quality of recommendations that could be derived from Option A. Therefore to some extent, Option B was viewed as a more reliable version of the tool that would be best applied to the same use-cases as Option A.

Participants exhibited a restrained sense of enthusiasm for Option C. There was clear consensus that, if reliable, the output information from this option would prove very valuable to building owners and operators. However, if results were not accurate, building-specific, and actionable, this option would not be worth the significant amount of additional effort required.

Participants with large portfolios indicated that they may test Option C on a few buildings first to determine if it would be worth investing in a subsequent portfolio-wide rollout. Despite their restraint, it was generally agreed upon by study participants that Option C would be an appropriate choice for building owners and operators who were strongly committed to

energy efficiency, as well as energy service providers intending to use the tool to inform audits or retro-commissioning.

3.3 SUMMARY INFORMATION AND SCORING APPROACH

> *I think the question in most scoring systems is, "What does the score mean to me?" Does it mean that I'm good or bad? Is 100 achievable or is that not achievable? If 100 is a net zero energy use building that's different than if 100 is the most efficient building that my building can be.*
>
> - Municipal Agency

In this portion of the interview participants viewed four possible configurations of Operational Assessment tool scoring summaries. They described their responses to the information presented as well as assessed its usefulness with regard to potential tool users. Each configuration (Options 1 – 4) involved a different permutation of output scores, described in Table 4 below.

Table 3. Scoring Summaries

	Scores Referenced
Option 1	OA
Option 2	OA, ESPM
Option 3	OA, AS
Option 4	OA, AS, ESPM

Definitions: OS = Operational Assessment Score; ESPM = ENERGY STAR Portfolio Manager Score; AS = Asset Score

Figure 1 illustrates the most complex option investigated (Option 4), and includes each of the possible scoring components. This was the option selected by the majority of participants as providing the most useful information, despite the associated challenges detailed below. For examples of the other three options, please see the interview slide deck presented in Appendix A.

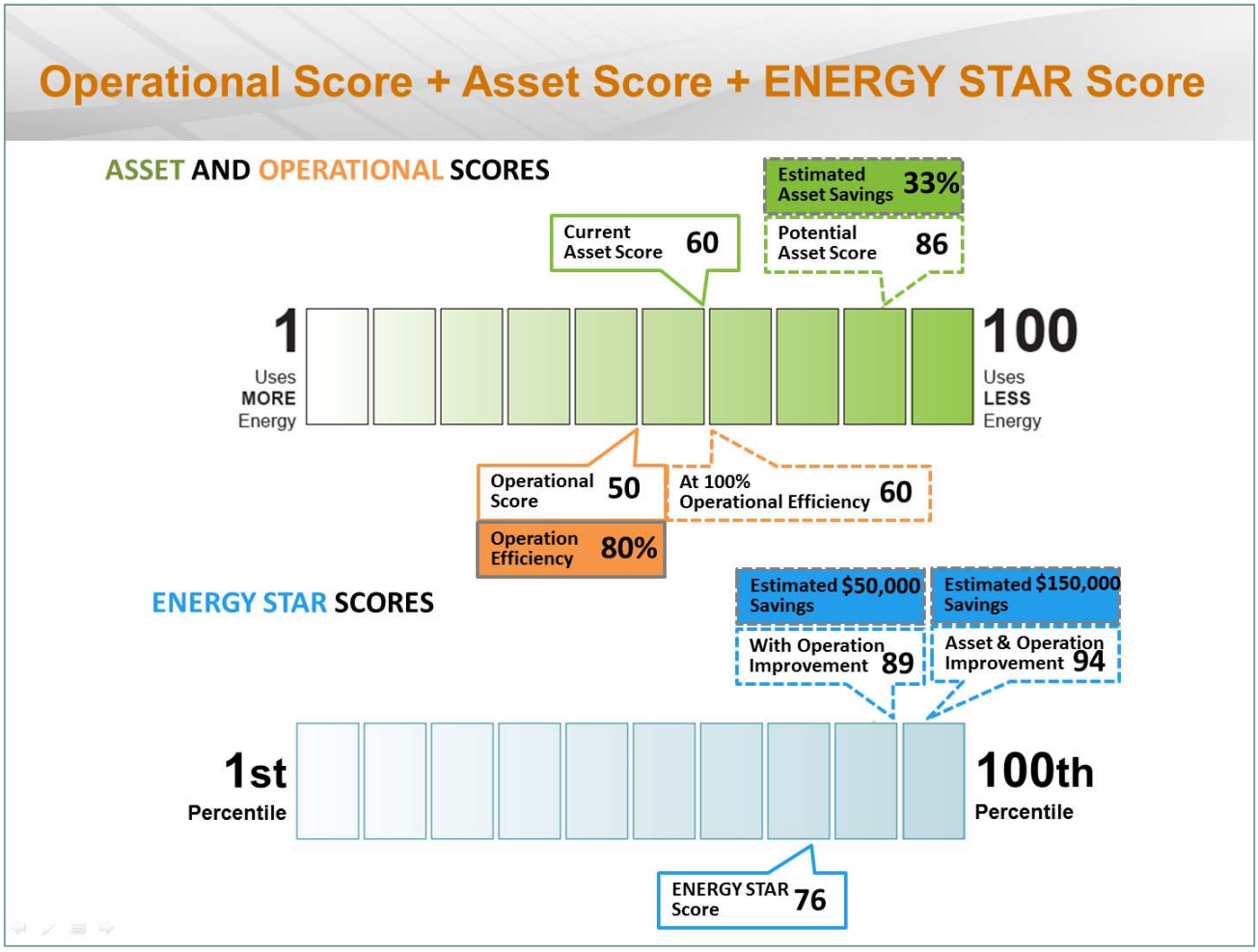

Figure 1. Scoring Summary Option 4.

The most ubiquitous opinion among participants was that the Asset Score scale needed some absolute reference point to give scores meaning and context. Possible solutions suggested by participants included indicating the Energy Use Intensities (EUI) corresponding to scores 1 and 100, or providing a reference point somewhere on the scale that represented a building constructed to a measureable code standard (such as ASHRAE 90.1-2007).

Participants generally exhibited consternation regarding the association between Asset Score and Operational Score. This tended to be expressed via confusion over why a building with 100% operational efficiency could attain a score of only 60. While participants were in favor of receiving independent asset and operational savings estimates and effects on ESPM scores, they felt that a separate Operational Score was unnecessary, and that a simple operational efficiency percentage would provide sufficient indication of current operational efficiency.

There was also an appreciable amount of confusion on the part of participants regarding the combination of the differing Asset Score and ENERGY STAR scales. Despite this initially

confounding barrier, participants indicated that there was significant value in seeing how the implementation of recommended asset and operational improvements would affect their ENERGY STAR Score. The primary suggestion here was to physically separate the two scoring scales (possibly on two different pages of a report, for example) to allow users to more easily differentiate between them mentally.

One element of the scoring summaries that was particularly appreciated by participants was indications of how the building is currently performing versus how it could be performing (in both asset and operation). Another very popular element was the financial savings information, with some participants predicting that users would be more interested in savings than scores in general. A few users suggested that monetary savings information would be more useful if it were associated with the Asset Score scale rather than the ESPM scale, and nearly every participant indicated that they would like to see some units associated with estimated savings (e.g., per month or per year). Figure 2 shows a mock-up incorporating a number of participant suggestions regarding summary scoring information.

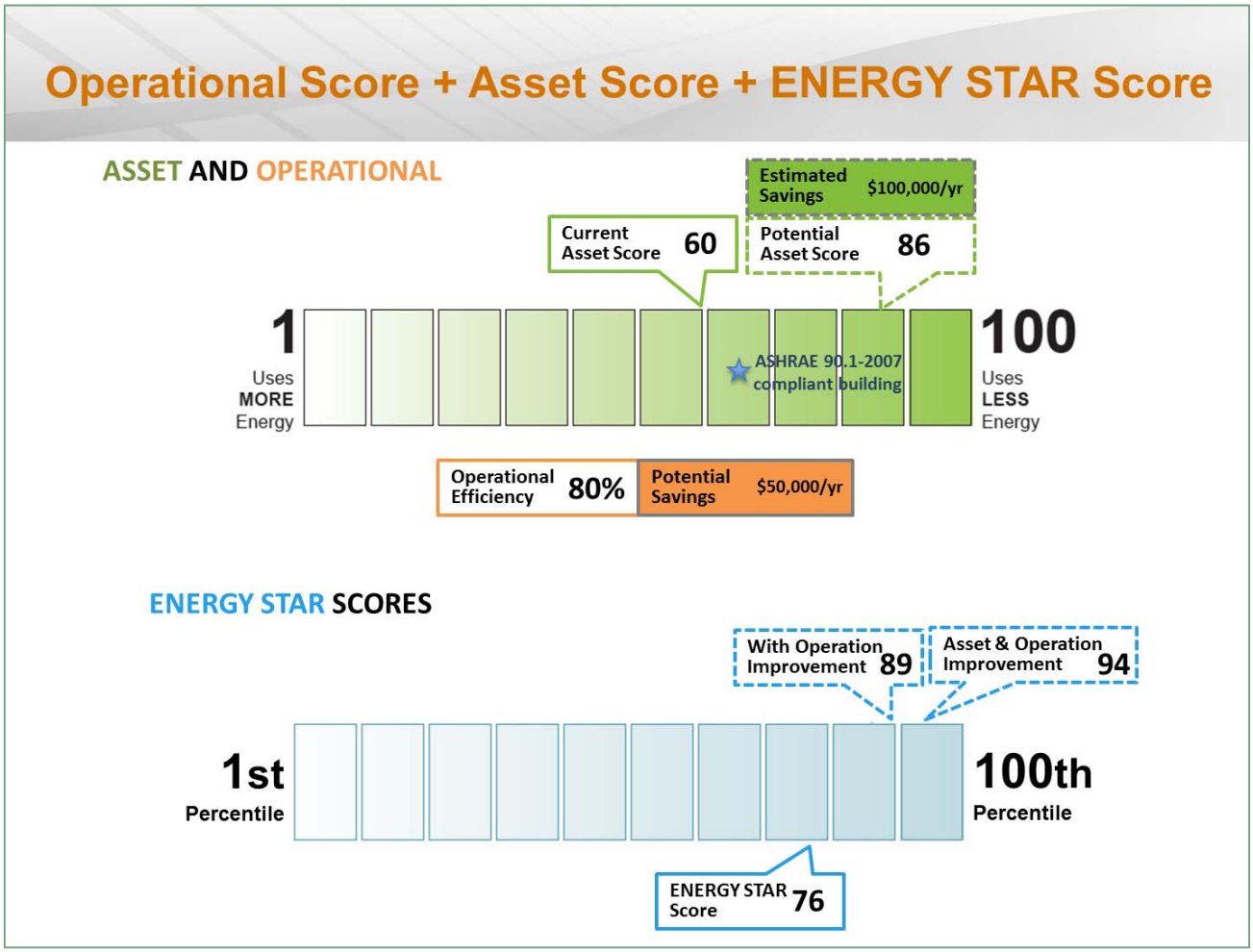

Figure 2. Scoring Summary Incorporating Participant Suggestions

3.4 OPERATIONAL ASSESSMENT USES AND BARRIERS

To assist the DOE in understanding the most promising market uses of an Operational Assessment tool as well as the main challenges that will be faced in the execution of this tool, participants shared their views regarding overall applications and obstacles.

3.4.1 MARKET APPLICATIONS

> *This kind of information would help us better make portfolio wide decisions, like targeting buildings for retrofits.*
>
> - Federal Agency

In addition to providing a free resource to all commercial building owners and operators that can be used to assess their building operation, six principle market uses of an Operational Assessment tool surfaced during conversations with study participants. These uses included:

- A method of providing benchmarked buildings with actionable next steps toward energy efficiency
- A first step in guiding more detailed energy audits and retro-commissioning work
- A tool for comparing operational efficiency across large portfolios to identify buildings that would benefit from increased attention
- A standardized scoring system that could be referenced in the building management industry
- A method of encouraging owners to take action on recommended energy efficiency measures
- A way to drive energy efficiency in the marketplace via added publicity for energy efficient buildings

Benchmarking ordinances have been passed in nine cities, one county, and two states as of the writing of this document, and many more locations are in the process of evaluating the benefits of such policies. For those buildings that receive low benchmarking scores, it may be difficult for owners and operators to identify cost-effective opportunities to improve their energy efficiency. Study participants indicated that an Operational Assessment tool may provide a useful avenue for these users to obtain actionable next steps toward energy conservation.

Although it was clear to participants that this tool would not function as a replacement for detailed energy audits or building retro-commissioning, it was viewed as a potentially useful supplement to both of those processes. Running an Operational Assessment at the beginning and end of such work could help guide energy service providers in identifying the best opportunities and assist in the quantification of resulting energy savings. Additionally,

building owners and operators may run an initial Operational Assessment themselves to determine whether their buildings could benefit from a subsequent audit.

> *I think there is room for a simple tool to come up with ballpark opportunities, listing a couple of things which can really tell a building owner whether they should have an audit, and guide the auditor in identifying the best opportunities.*
>
> - Energy Service Provider

Similarly, building owners and operators with large portfolios could run the tool on their entire portfolio to determine which buildings would benefit the most from increased attention. To this purpose, stakeholders with large portfolios specifically requested functionality that would allow them to easily compare the scores of their entire portfolio within the tool itself. Among these types of stakeholders it was pointed out that the Operational Assessment tool would be more immediately useful than the Asset Score tool, since operational recommendations would be less likely to involve added capital.

Another potential application of the OA tool would be to use operational efficiency rating as a standardized measure in building management contracts and interactions. For example, a building owner might contractually require that their manager maintain an annual operational efficiency of at least 80%, or a building management firm could promote the fact that every building they manage has an operational efficiency of over 90%. This functionality would be achievable if the tool was built to focus on operational parameters that are solely under owner/manager control.

Overall, stakeholders were intrigued by this idea as it could provide an operational standard for the market that is not currently available with existing EMIS tools or ESPM. There were, however, a handful of concerns voiced around this concept. One was the idea that there would be no guarantee that an owner would support the efforts or investments required to meet minimum operational standards. Another issue raised by stakeholders involved trusting the property management staff's ability to perform at the levels required by contract.

Participants that had faced reticence from owners when approached with energy efficiency initiatives suggested that the OA tool could be used to provide credence to recommended measures, thereby encouraging owners to take action. Owners and operators could also benefit from the added publicity of having the energy efficiency of their buildings documented on a standardized scale. Through this publicity, participants envisioned a successfully integrated AS/OA tool being used to drive energy efficiency in the marketplace.

3.4.2 POTENTIAL OBSTACLES

> *If it's buildings we built that aren't that old that we can access the data, fine. But there are a lot of buildings we just don't have the exact records for. So that's a little more challenging than what we anticipated.*
>
> - Large Building Owner

The potential barriers to effective market deployment of an OA tool that were expressed by participants can be grouped into four main categories: 1) input-related; 2) effort-related; 3) recommendation enactment; and 4) ESPM confusion. Many of these topics were touched upon in previous sections; they are revisited here to provide a combined summary of obstacles that may be faced in market acceptance of an OA tool.

One input-related challenge that was previously mentioned involves the tendency for older buildings to either not have an available set of drawings, or not have a reliable set of drawings, making it difficult to robustly enter many of the Asset Score inputs. Also along those lines, additions are built onto some buildings (schools, for example) that have separate HVAC systems and different envelope constructions. Participants wondered whether the tool would be able to accurately model such systems, and/or whether entering information on such complex buildings would prove overly cumbersome.

Another input-related concern expressed by participants involves limitations on building type and/or function, and the ability of the tool to model certain types of systems (e.g., rooftop AC units). Finally, a number of stakeholders had doubts regarding the reliability of reporting on the input side, citing experiences with ESPM in which building owners, operators or managers had inadvertently entered the wrong data, rendering subsequent results unreliable. The more involved OA tool options require a higher number of entries than ESPM, proportionately increasing the odds that data will be misentered.

A possible solution to reliable reporting concerns would be to hire an energy service provider (ESP) to run the tool, however this coincides with one of the effort related concerns of participants. Not all buildings have the resources to hire an ESP, and some don't even have the internal resources to devote to a potentially time consuming assessment tool. The final and perhaps most challenging effort-related obstacle mentioned by participants is simply engaging people's time and attention in the pursuit of energy efficiency.

When it comes to putting recommended energy efficiency measures into action, participants cited a number of possible stumbling blocks. One obstacle involved having to go through a long chain of command to receive approval to enact suggested measures. Closely related to this was the idea that some buildings already have central policies in place that designate operational parameters such as temperature set-points, leaving little room for adjustment.

Another concern expressed by participants on the recommendation enactment front was a perceived difficulty in conveying required actions to maintenance staff, or conversely needing to hire an ESP to implement measures for the building. Finally, building owners and

operators with tenants may have a tough time engaging the assistance of occupants in carrying out applicable energy saving recommendations.

> *You can be as scientific and have as many facts as you want, but you can't overcome a person's opinion or emotion. If you tell them that they'd be setting a great example if they turned the lights off, it doesn't mean that they will. That's probably the biggest hurdle; if you have 100 people in the building you have 100 different ways of viewing that.*
>
> - Small Building Owner/Operator

Possibly the most formidable obstacle that an Operational Assessment tool would face in terms of market acceptance lies in cultivating a completely separate identity from ENERGY STAR Portfolio Manager. ESPM has obtained deep market penetration, and is the first tool that comes to participants' minds when asked about building energy efficiency. Its relative scoring scale has attained an impressive level of acceptance and familiarity among users.

Some participants intimated that they felt one could use ESPM to obtain a gross estimate of operational efficiency. Others faced difficulties in identifying the difference between the two tools, since ESPM takes in actual, in-operation energy use information and is therefore a measure of a building's operation. For example, in the absence of asset improvements, weather-corrected changes in a building's energy use over time could be viewed as indicative of variations in operational efficiency. As beneficial as ESPM has been to the cause of energy efficiency in this country, it is a truly formidable obstacle when it comes to marketing a new energy efficiency tool.

3.5 SUGGESTIONS AND SOLUTIONS

> *You may need a menu of options so you can bring in more building folks to participate. Even Option B scares some people away, so it would probably make sense that the people who don't want to invest as much time still have Option A to draw from.*
>
> - Energy Service Provider

In addition to pointing out potential obstacles, participants contributed a number of suggestions regarding improvements to the design of a potential OA tool. To address concerns related to data input requirements, participants suggested making default values available, as well as possibly including some simple in-line input-based calculations (e.g., input number of computers to estimate plug loads, or input number of restroom faucets to estimate hot water use).

To allow the OA tool to engage the greatest number of users, participants recommended a design that would provide multiple levels of complexity. For example, if the tool allowed users to choose between Option A and Option C, it would address a larger segment of the market than if it were constrained to a single level of effort investment.

In terms of market penetration, participants suggested a number of approaches. They felt that it would be worthwhile for DOE to produce and advertise case studies of actual buildings that had used the tool and could demonstrate measurable resulting energy savings. A related

recommendation was to track OA scores and corresponding property values, to enable future correlational investigations. Participants further suggested that efficiency program administrators could contribute by helping their clients use the tool and/or by providing OA training to local building owners, operators, and service providers. Finally, building an awareness of the tool in those with visibility and influence (e.g., policymakers, educators, property appraisers, brokers) was viewed as crucial to ensuring the success of an OA tool in the marketplace.

4.0 SUMMARY AND RECOMMENDATIONS

Current federally-provided energy efficiency tools address both building asset evaluation and energy use benchmarking. The only outstanding piece of the energy puzzle is assessment of building operations and occupant behavior. This aspect of energy use, while critical to perfecting energy efficiency in the built environment, is frequently overlooked or unaddressed due to its inherent complexities. The U.S. Department of Energy (DOE) is considering the creation of a building assessment tool that would fill the current market gap by providing owners with a method of evaluating operational efficiency. Through in-depth interviews, this study investigates the market demand for such an Operational Assessment (OA) tool.

Approximately 30 geographically-distributed building industry stakeholders were interviewed for this project. These stakeholders represented eight target groups: Large Building Owners; Large Building Operators; Small Building Owners and Operators; Energy Service Providers; Efficiency Program Administrators; Municipal Agencies; State Governments; and Federal Agencies. Portfolio sizes of owners and operators ranged from one to more than 1,400 buildings.

The main results of these interviews can be organized into common themes that span the entire distribution of stakeholder types:

- Stakeholders prefer a tool that is flexible with respect to the amount of input information required. Suggestions include constructing a tool with more than one discrete mode of operation, providing default parameters, and including brief quizzes designed to help estimate difficult inputs (e.g., plug loads, hot water use).

- Participants emphasized the challenges inherent in obtaining tenant-specific inputs (e.g., plug loads), as well as encouraging operational changes at a tenant level.

- While interviewees clearly indicated that an Operational Assessment tool could make an important contribution to the marketplace, a great amount of concern was voiced regarding the production of reliable, building-specific, actionable results and suggestions. "Generic" recommendations were viewed as useless.

- Three scores (ESPM, AS, and OA) are generally viewed as overwhelming and unnecessary. While interviewees appreciated separate AS/OA savings estimates and ESPM score improvement, they were largely in favor of using a simple operational efficiency percentage in lieu of an actual OA score.

- Though some stakeholders could identify benefits to a completely independent scoring system, nearly all participants requested some kind of context or reference point to assist in interpretation of AS/OA scores. Suggestions included providing EUI as a concrete reference, or indicating AS for a similar building designed to code (e.g., ASHRAE 90.1-2007).

- The most frequent suggestions for market use of the tool included: 1) providing benchmarked buildings with actionable next steps toward energy efficiency; 2) using OA to identify which buildings in a portfolio would benefit most from additional attention; 3) employing OA as a first step in an energy audit or retro-commissioning plan; 4) providing encouragement for owners to take action; and 5) helping to drive energy conservation in the marketplace via added publicity for efficient buildings.

Based on a thorough integration of participant feedback, the following considerations for development of an Operational Assessment tool can help ensure that it meets stakeholder needs:

1) Design the OA tool to provide at least two discreet levels of complexity regarding user input requirements, or offer simple input calculation tools and default values for harder to obtain input information.
2) Restrict recommendations to operational items which are building-specific and actionable; allow for customization of results on user end.
3) Eliminate OA score completely - provide operational results as an efficiency percentage and continue to provide financial savings and ESPM score improvements associated with enacting OA recommendations.
4) Re-frame Asset Score scale by adding either an absolute context (e.g., EUI) or comparative context (e.g., baseline score of a code-compliant building).
5) Provide functionality to compare Asset Scores and operational efficiencies across entire portfolios.

Driving market adoption of both the Asset Score and Operational Assessment tools might use a variety of approaches, including:

- Obtain and advertise case studies that showcase concrete energy impacts achieved by using the tools
- Enlist municipalities and energy program administrators to support use by providing local training and education services
- Encourage energy service providers to integrate the tools with their current energy audit/retro-commissioning processes

- Provide AS/OA information on ESPM website

Stakeholders exhibited consensus regarding the idea that the market could significantly benefit from a tool that would enable energy-based assessments of building operation. Designed according to the needs of the building industry and coupled with existing complementary resources, such a tool could ultimately provide a powerful method of addressing one of the key hurdles to energy efficiency in the built environment.

5.0 ACKNOWLEDGEMENTS

This work was made possible by the contributions and assistance of many individuals and organizations. We are particularly grateful to the many stakeholders that generously shared their time and expertise with us. We would also like to give special thanks to our external reviewers, Martin Weiland, Rachel Sholly, Eliot Crowe, and Jessica Granderson, as well as Cody Taylor, Joan Glickman, Nora Wang, Matthew McMurtry, and Patty Kappaz for their fantastic support and contributions throughout.

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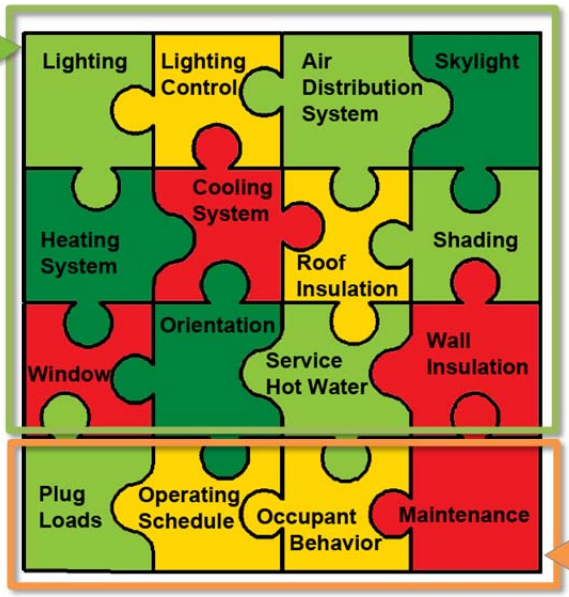
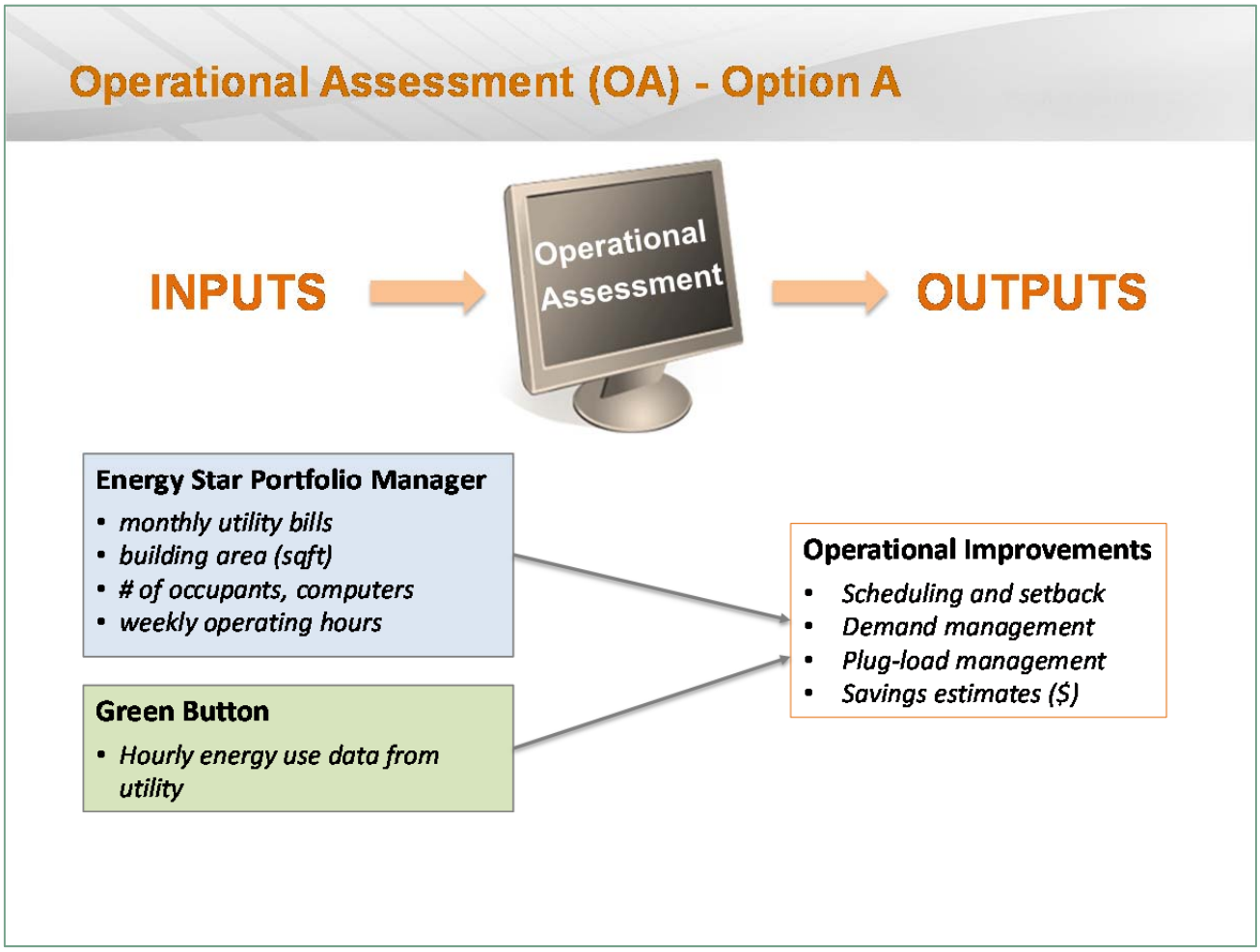
APPENDIX A: INTERVIEW SLIDE DECK

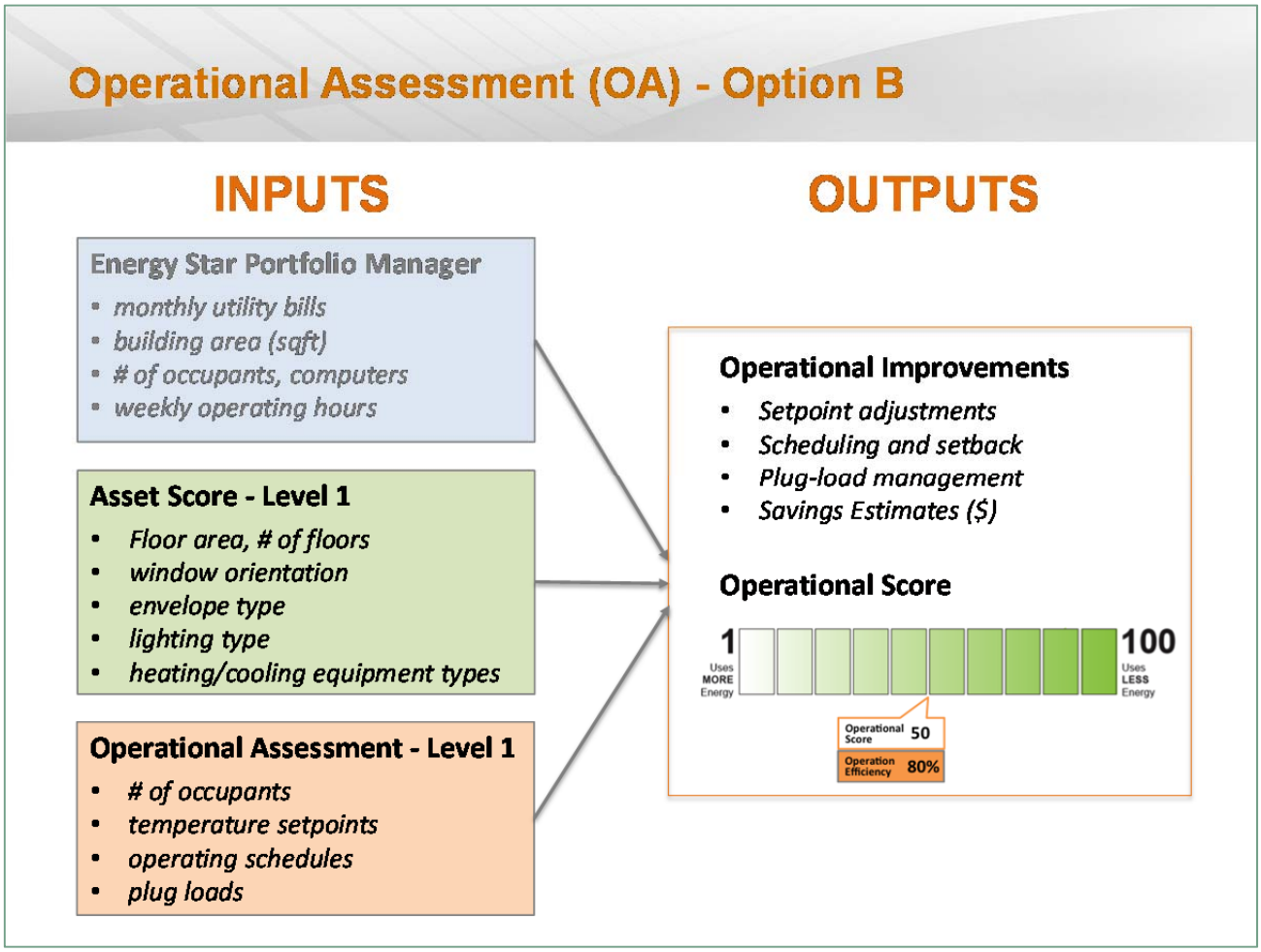
DOE Energy Assessment Tools

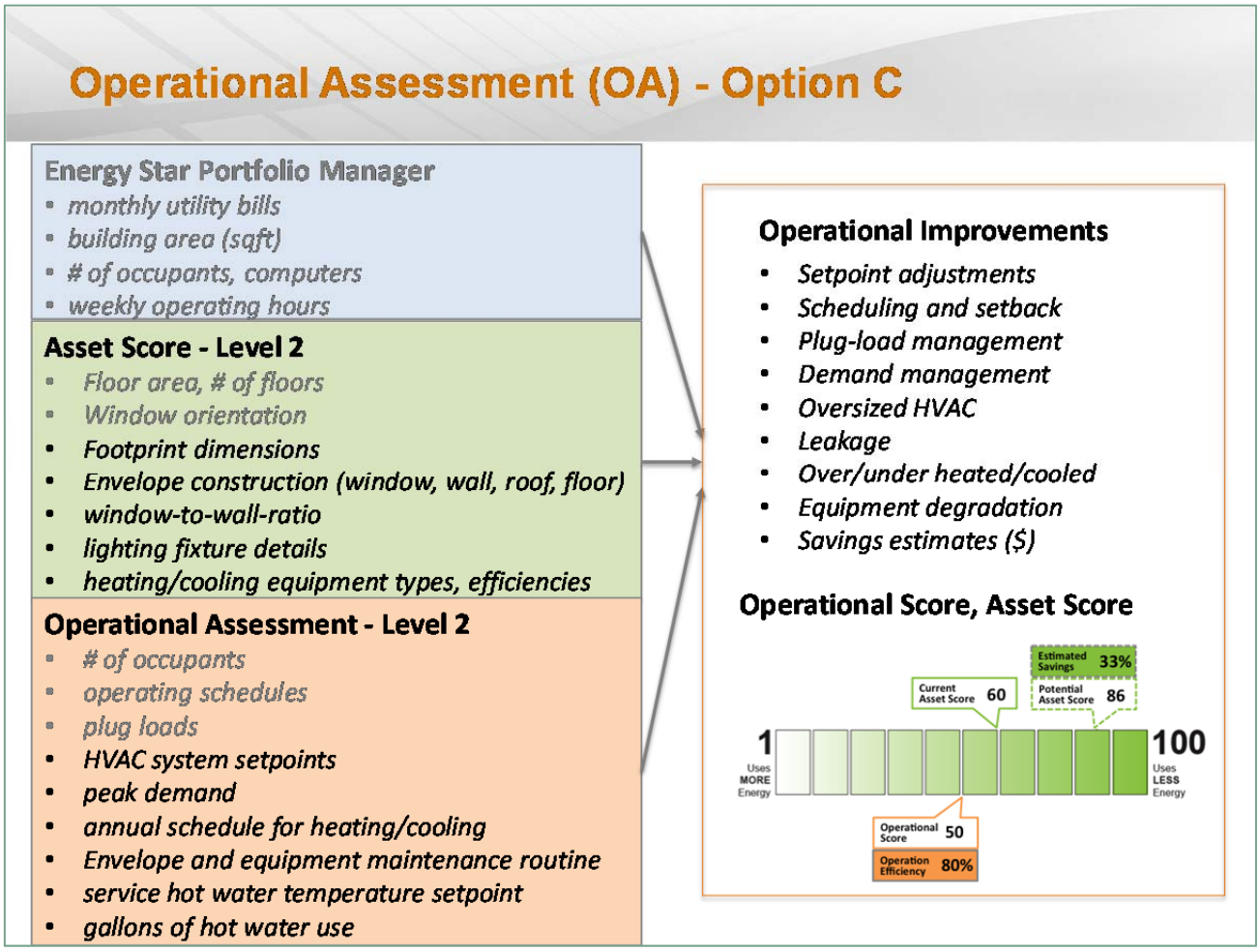
Asset Score: evaluates physical characteristics (envelope, HVAC, lighting)



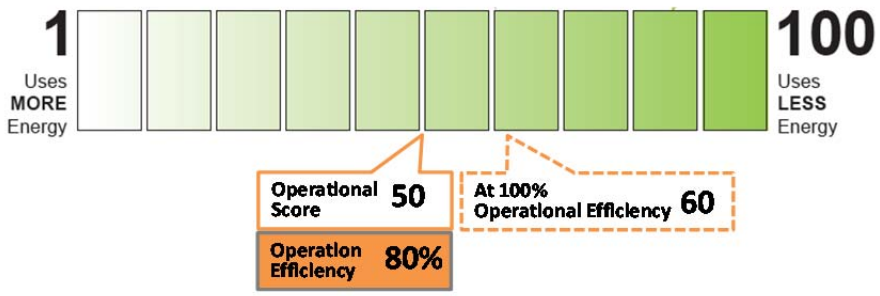
Operational Assessment: evaluates building operation and maintenance

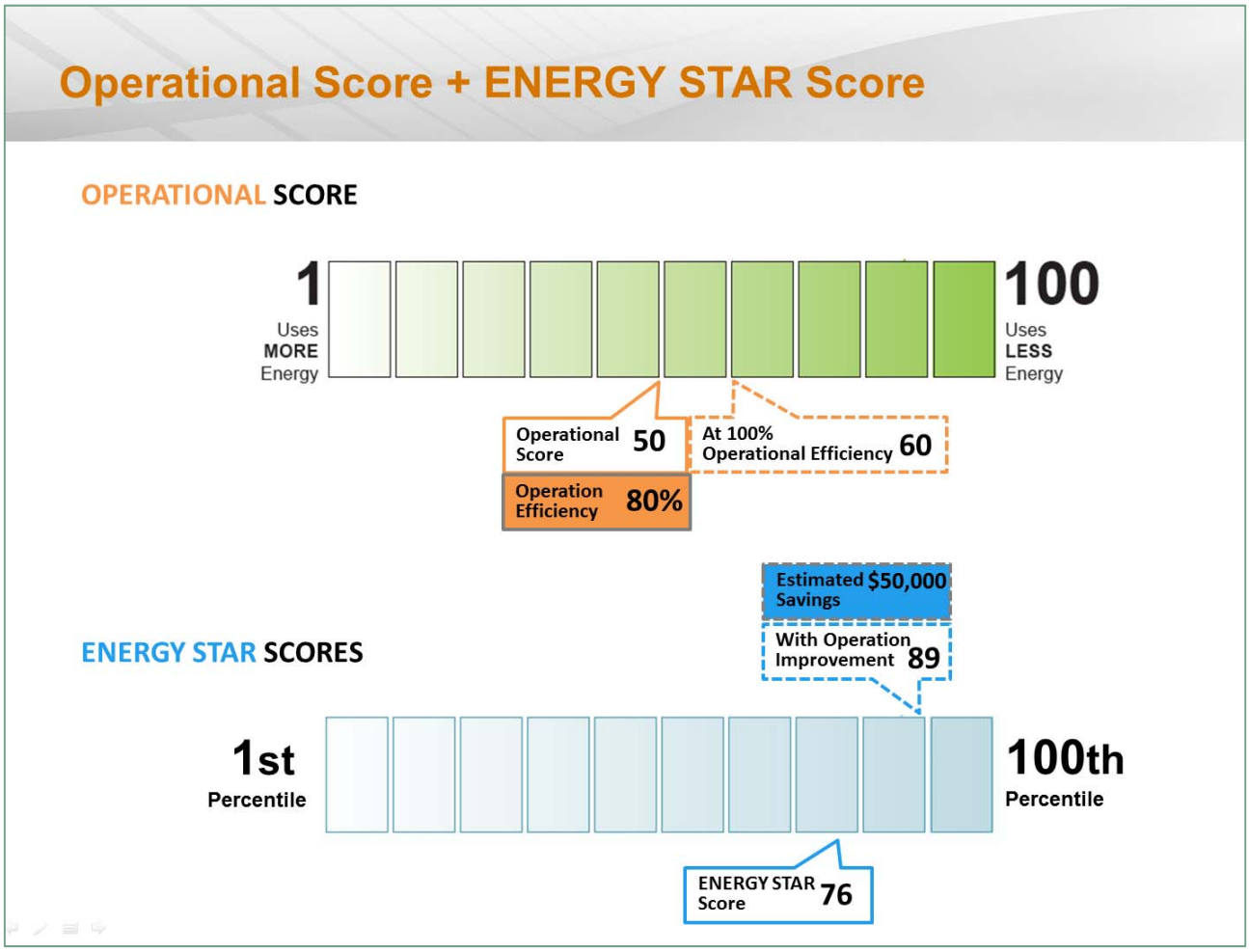

Operational Assessment (OA) - Option A
INPUTS
Operational Assessment
OUTPUTS
Energy Star Portfolio Manager
• monthly utility bills
• building area (sqft)
• # of occupants, computers
• weekly operating hours
Green Button
• Hourly energy use data from utility
Operational Improvements
• Scheduling and setback
• Demand management
• Plug-load management
• Savings estimates ($)


Operational Assessment (OA) - Option B
INPUTS
OUTPUTS
Energy Star Portfolio Manager
• monthly utility bills
• building area (sqft)
• # of occupants, computers
• weekly operating hours
Asset Score - Level 1
• Floor area, # of floors
• window orientation
• envelope type
• lighting type
• heating/cooling equipment types
Operational Assessment - Level 1
• # of occupants
• temperature setpoints
• operating schedules
• plug loads
Operational Improvements
• Setpoint adjustments
• Scheduling and setback
• Plug-load management
• Savings Estimates ($)
Operational Score
1
Uses MORE Energy
100
Uses LESS Energy
Operational Score 50
Operation Efficiency 80%

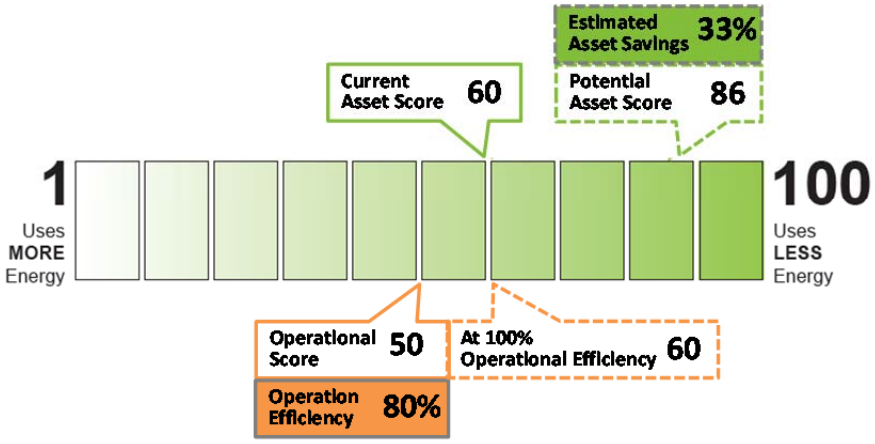

Operational Assessment (OA) - Option C
Energy Star Portfolio Manager
• monthly utility bills
• building area (sqft)
• # of occupants, computers
• weekly operating hours
Asset Score - Level 2
• Floor area, # of floors
• Window orientation
• Footprint dimensions
• Envelope construction (window, wall, roof, floor)
• window-to-wall-ratio
• lighting fixture details
• heating/cooling equipment types, efficiencies
Operational Assessment - Level 2
• # of occupants
• operating schedules
• plug loads
• HVAC system setpoints
• peak demand
• annual schedule for heating/cooling
• Envelope and equipment maintenance routine
• service hot water temperature setpoint
• gallons of hot water use
Operational Improvements
• Setpoint adjustments
• Scheduling and setback
• Plug-load management
• Demand management
• Oversized HVAC
• Leakage
• Over/under heated/cooled
• Equipment degradation
• Savings estimates ($)
Operational Score, Asset Score
Estimated Savings 33%
Current Asset Score 60
Potential Asset Score 86
1
Uses MORE Energy
100
Uses LESS Energy
Operational Score 50
Operation Efficiency 80%

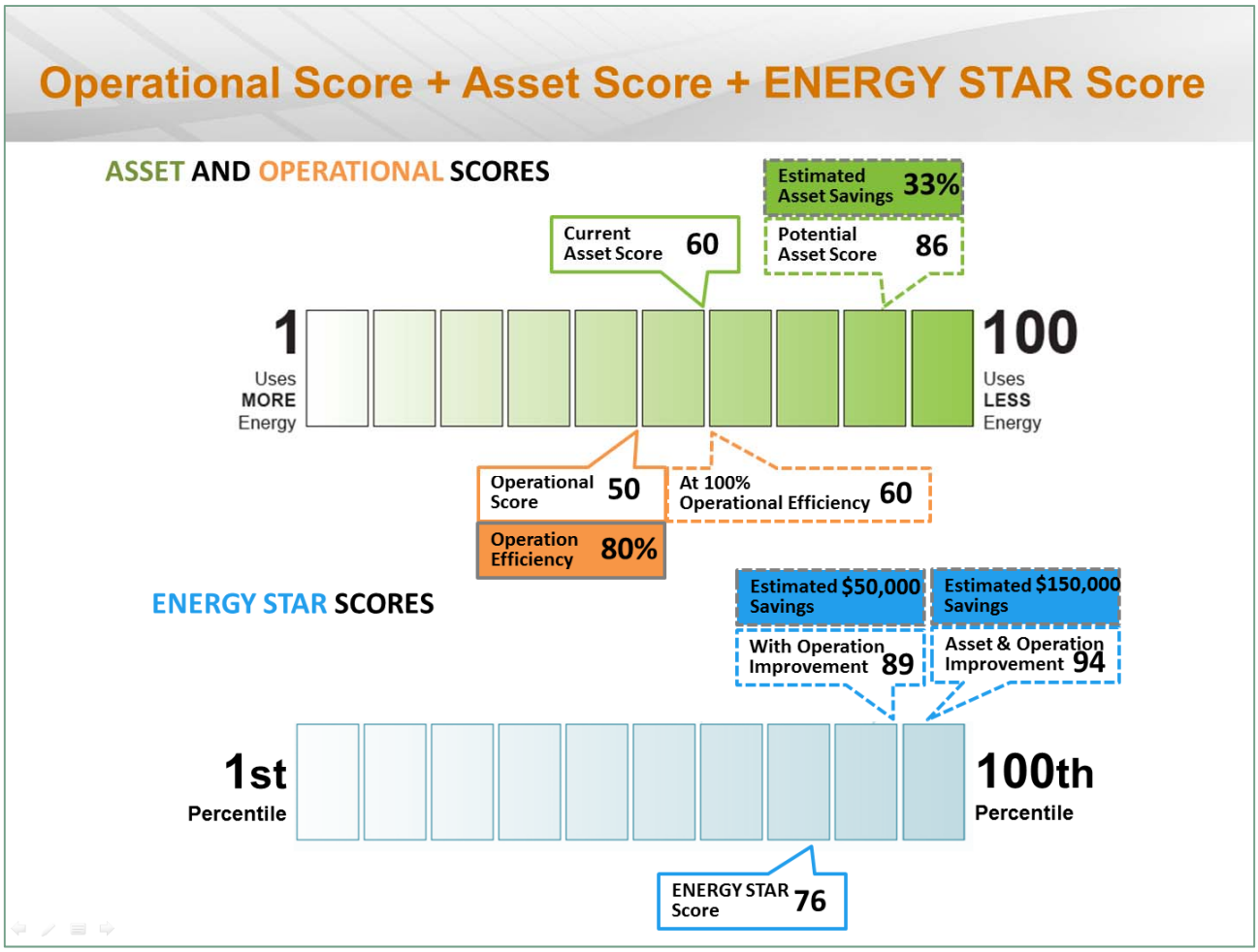
Operational Score




Operational Score + ENERGY STAR Score
OPERATIONAL SCORE
1
Uses MORE Energy
100
Uses LESS Energy
Operational Score 50
At 100% Operational Efficiency 60
Operation Efficiency 80%
Estimated $50,000 Savings
With Operation Improvement 89
ENERGY STAR SCORES
1st Percentile
100th Percentile
ENERGY STAR Score 76

Operational Score + Asset Score




Operational Score + Asset Score + ENERGY STAR Score
ASSET AND OPERATIONAL SCORES
Estimated Asset Savings 33%
Current Asset Score 60
Potential Asset Score 86
1
Uses MORE Energy
100
Uses LESS Energy
Operational Score 50
At 100% Operational Efficiency 60
Operation Efficiency 80%
ENERGY STAR SCORES
Estimated $50,000 Savings
Estimated $150,000 Savings
With Operation Improvement 89
Asset & Operation Improvement 94
1st Percentile
100th Percentile
ENERGY STAR Score 76

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