Improving Building Operating Decisions: A Tool to Help Make Smart Decisions

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Abstract
As the concepts high performance, sustainable and smart buildings continue to penetrate the facility management community, processes and tools to move from reactive to proactive energy and maintenance management are becoming even more important. A large amount of data is available from smart, high performance buildings. Thus, many new tools and processes will be needed to analyze this data for decision making. After defining what a smart, high performance building is, this paper describes a *Decision Support System* software prototype developed through the PhD research *A Framework for Improving Building Operating Decisions*. The *Decision Support System* developed is a question driven software as a service tool to help facility managers, facility management consultants and other professionals prioritize energy, maintenance and human factors practices for a specific building or campus of buildings to help transform existing buildings into smart, high performance buildings. Use of the tool can help facility managers to make better decisions of how utilize limited funding, staff and other resources to reduce environmental impacts and meet sustainability goals. The paper concludes practical tips for three groups, facility managers and facility management consultants, architects and engineers, and building owners, about how to transform existing buildings into smart, high performance buildings.

1 What is a Smart, High Performance Building?

A smart building integrates different systems within the building, such as enterprise systems, building systems (HVAC and electrical) and facility management software (GSA 2009). A high performance building is *"A building that integrates and optimizes on a lifecycle basis all major high performance attributes, including energy [and water] conservation, environment, safety, security, durability, accessibility, cost-benefit, productivity, sustainability, functionality, and operational considerations"* (U.S. Energy Independence and Security Act 2007 401 PL 110-140). Thus, a smart, high performance building is the sum of the definitions of a smart building and a high performance building.

In order to operate and maintain smart, high performance buildings, facility managers must seek to balance people, process and technology. This is a core focus of facility management, as IFMA defines facility management as "a profession that encompasses multiple disciplines to ensure functionality of the built environment by integrating people, process and technology" (IFMA 2011). However, often the construction of new buildings and renovation of existing buildings to be smart, high performance buildings focuses mainly on technology, not people and process. To reach energy efficiency and sustainability goals set for smart, high performance buildings, there is a need for proactive energy and maintenance management best practices to be used within the management and operations of a larger percentage of commercial and institutional buildings. Although some commercial and institutional buildings exhibit world class operations and maintenance management practices, many buildings rely mostly on reactive energy and maintenance management practices (Lewis, et al. 2010a). Making the transition from reactive to proactive management practices is challenging because there are many opportunities for improvement and it can be challenging to prioritize. Additionally, proactive processes are data driven. Instead of reacting to a problem when it occurs, a proactive process uses data to decide what should be done and when, putting the facility manager in control of the decision making process. Determining what data will be needed for decision making, what data format is most useful, who will have access to the data and how and where the data will be stored can be challenging to determine. The value of the data, including the cost of collecting, processing and storing of the data must also be considered. To best utilize available staff time and funds, when making these decisions is important to start with clearly defined and prioritized goals. Once clearly defined goals are set and embraced, a plan can be developed and implemented.

2 A Framework for Improving Building Operating Decisions, the *Decision Support System*

Within many facility management organizations, there seems to never be enough time, money or staff to accomplish all of the necessary projects. Thus, it can be challenging to determine what to prioritize. A *Decision Support System* prototype software tool was developed as part of the PhD research *A Framework for Improving Building Operating Decisions* to help facility managers, facility management consultants and other professionals within the built environment create a prioritized plan to help transform buildings into smart, high performance buildings.

2.1 Methodology and Research Methods

The *Decision Support System* software prototype was developed using a multimethodology, mixed methods approach. A multimethodological approach was needed to support the proposition testing to develop the decision support rules, using a positivist epistemology. However, to form the initial ideas for the prototype, it was necessary to gain understanding why certain events occurred or did not occur, as seen through the eyes of many individuals, each with their own social reality. Thus, it was also necessary to use a phenomenal epistemology to collect initial data. The researcher viewed the nature of reality through an objectivist lens. A mixed methods approach was used because the observations from three case studies (Lewis et. al 2011a) where used to write ten research propositions which were tested through a questionnaire (Lewis et al. 2010). The results of the proposition testing through analysis of the questionnaire findings were then used to write the rules for the *Decision Support System* processing algorithms. Further discussion of the methodology and research methods can be found in Lewis et al. 2011b.

2.2 The *Decision Support System*

The *Decision Support System* is a question-driven tool structured as a software as a service (Saas) prototype, to help prioritize energy, maintenance and human factors management practices to help facility managers determine how to move towards more proactive energy and maintenance management practices used within a specific building or campus of buildings. Within the prototype, human factors are defined to include the interactions of humans with energy and maintenance management systems and processes, which include, but are not limited to strategic planning, training, goal setting and effective communication.

As shown in Figure 1, by answering a set of multiple choice questions, the user receives a *Recommendations Report*. Answering the set of questions helps the user to define the problem and determine a solution: A prioritized plan to begin implementing energy, maintenance and/or human factors best practices. The solution is determined through a series of algorithms and rules that are processed on a server. The final result, a *Recommendations Report,* contains a list of three prioritized *Best Practice Recommendation Sheets* and a *Proactive/Reactive Score* of how reactive or proactive the facility or campus management practices are. A *Best Practice Recommendation Sheet* a one page, often graphical, summary of an energy, maintenance or human factors best practice. The one page description of the best practices allows the user to further assess if and how the best practices recommended within the *Recommendations Report* will meet the needs of the facility. The *Proactive/Reactive Score* is a quantitative value from negative five to positive five of how reactive (negative) or proactive (positive) the energy, maintenance and human factors practices are at the facility the question set was answered for. As shown in lower right corner of Figure 1, the scores are displayed as a color coded bar graph, where green indicates proactive and red indicates reactive. To access the *Recommendations Report*, the user logs on to a password protected website.

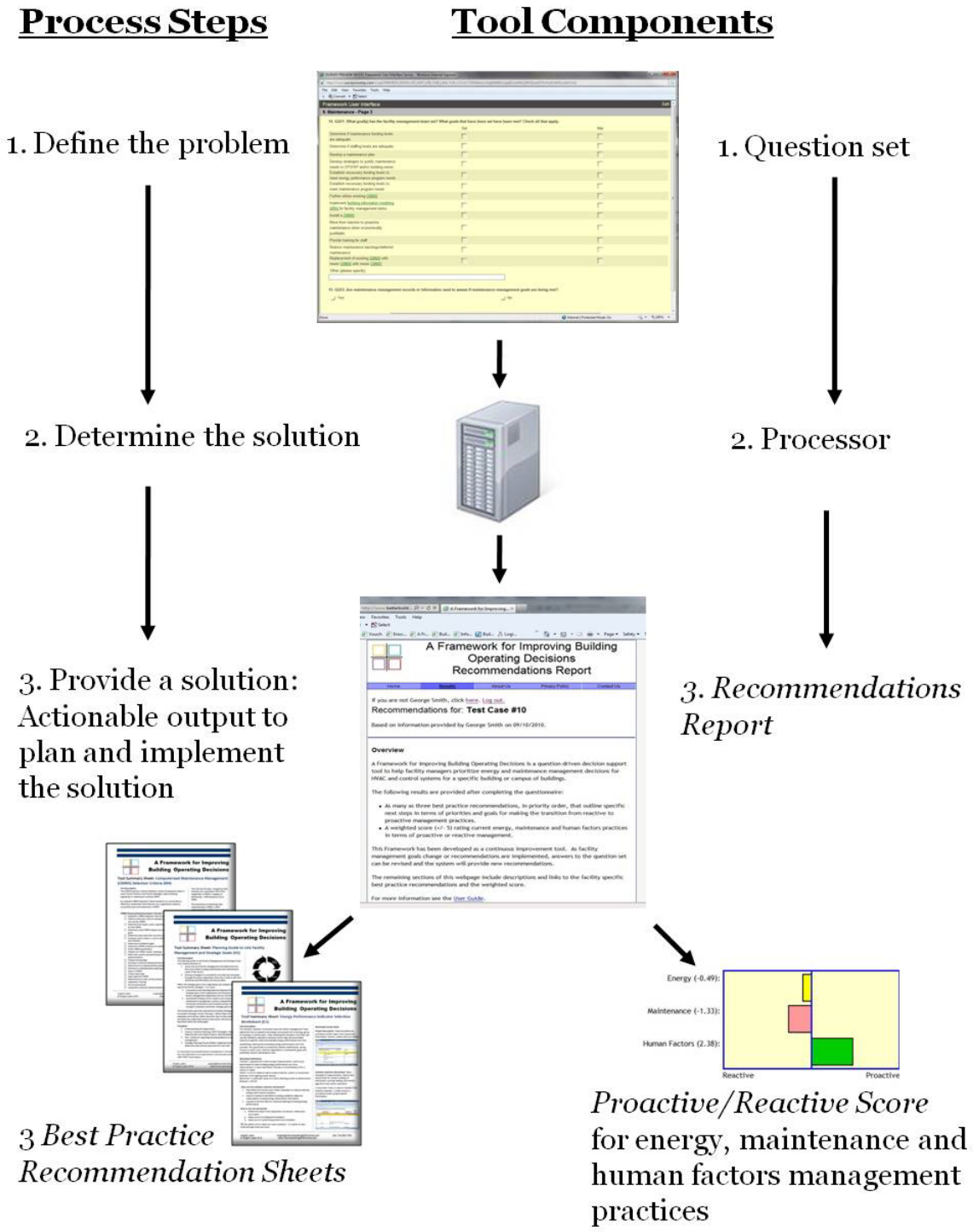

Figure 1: Components of the *Decision Support System*

2.3 Users of the *Decision Support System*

The *Decision Support System* was developed primarily for facility managers and facility management consultants. However, energy managers, energy engineers, large maintenance service providers and commissioning agents may also benefit from using it. During the prototype testing, it took an average of one hour and 21 minutes to complete the question set. However, it is very likely that multiple test participants were working on other tasks while completing the question set and the total time to complete

the question set is actually less. Thus, the prototype provides a relatively quick process to determine and prioritize energy and maintenance management goals.

2.4 Testing of the *Decision Support System*

To determine the potential value of the prototype *Decision Support System* to practicing facility managers, consultants and other professionals, the prototype was tested by 56 industry participants. After completing the question set and receiving the *Recommendations Report*, test participants were asked to complete an evaluation about how helpful and useful the prototype was.

The evaluation consisted of 30 questions. Some of the questions used a five-point scale where five indicated extremely useful or extremely helpful and one indicated not at all helpful or not at all useful. The overall findings of the evaluation were that the *Decision Support System* was helpful to very helpful and useful to very useful. Overall, over 60 percent of respondents found the prototype to be helpful or very helpful, while 14 percent found it extremely helpful. Over 90 percent of respondents found the *Decision Support System* to be helpful or very helpful to make energy and maintenance management decisions within the same decision process. The remaining 10 percent of participants found the combined energy and maintenance management decision making process to be extremely helpful. Therefore, for the test population, combining energy and maintenance management decisions within the same process is of value to facility management professionals.

The evaluation revealed that the *Decision Support System* was rated as either somewhat easy or easy to use by the test population. As most new things people learn have a learning curve, it is not surprising that few respondents selected that the *Decision Support System* was “very easy to use.”

As a result of these findings, it can be concluded that the *Decision Support System* can serve as a tool to help justify and raise awareness of energy, maintenance and human factors management needs across facility management organizations and the organizations which facility management teams support. The *Decision Support System* can also be used to identify new challenges the facility management team may not have been aware of. Further details of the testing can be found in the thesis, *A Framework for Improving Building Operating Decisions*.

3 Practical Tips to Transform Existing Buildings into Smart, High Performance Buildings

The results of the *Decision Support System* testing, as well as the results of the case studies and questionnaire, provide several practical tips for facility managers and facility management consultants, engineers and architects, and building owners. First, two tips relevant to all three stakeholder groups are provided.

First, it is important to determine energy and maintenance management goals at the start of a project. Currently, it is not standard practice to set energy or maintenance management goals during design, or to know if energy performance goals set during design were met. A survey by Lewis (2010) found that energy performance goals were set by 66 percent of survey respondents, but only 34 percent of respondents always or almost always knew if energy performance goals set during design were met within the first year of operation. The survey also revealed that maintenance goals were set 56 percent of the time during design, while only 22 percent of respondents always or almost always knew if the maintenance goals were met during the first year of operation. If the industry truly values transforming existing buildings into smart, high performance buildings, it is critical for all key members of project teams to know what the goals are and if the project goals are met. If this information is unknown, it is not possible to make necessary changes or for the team to learn important lessons learned from the project.

Second, after goals have been set, develop a plan to implement the goals by identifying small steps to move towards the goal. As the project progresses, be sure to maintain a clear understanding of the goal. A manageable goal could be to develop a maintenance plan, install or optimize the use of a computerized maintenance management system, create a parts inventory program, start benchmarking energy consumption or earn a building rating, all which are a examples of the best practices recommended by

the *Best Practice Recommendation Sheets*. Selecting one goal and achieving it can help to elevate the status of the facility management team and encourage future goals to be set.

3.1 Tips for Facility Managers and Facility Management Consultants

Facility managers and facility management consultants are faced with many opportunities when determining how to transform an existing building into a smart, high performance building. One often well understood, but overlooked opportunity is the interdependency between energy efficiency and maintenance: The most energy efficiency equipment can be installed, but if over time it is not maintained it will not remain energy efficient. Even equipment designed to be low maintenance will have components that wear or sensors that drift out of calibration. Therefore, as evidenced by the *Decision Support System* testing, it can be helpful to consider both energy and maintenance management practices within the same decision making process. To do this, especially in large facility management organizations, it may be necessary to expand lines of communication across energy management and maintenance management teams because these discussions and decisions are often within separate departments, with two separate budgets. If both departments are able to effectively communicate and collaborate, it may be possible that opportunities exist to further reduce operating costs.

3.2 Tips for Architects and Engineers

Transforming existing buildings through renovation projects and designing new buildings that will be operated and maintained to be smart, high performance buildings requires changes in project processes. As stated earlier, proactive processes are data driven. Thus, data about the facility created during design, construction, startup and commissioning must be handed over to the facility management team in the format it can be used. To meet this need, new data collection processes and tools are needed, as well as contract structures to support new processes. Current handover structures where electronic or paper documents are provided generally do not support efficient population of computerized maintenance management (CMMS) or integrated workplace management systems (IWMS).

Second, architects and engineers should consider how design and construction decisions impact energy and maintenance management decisions during the occupancy of the building. It is important to think about building design and construction activities as the creation of assets, not just as a project that starts with a basis of design and ends with the delivery of construction documents. This is important to consider because the length of time to design and construct a building is short, compared to the life of the building. Additionally, the cost to design and construct a building is much smaller, 5 to 10 percent of the life cycle cost, opposed to operations and maintenance which is 60 to 85 percent of the life cycle cost (Christian and Pandeya 1997).

3.3 Tips for Building Owners

Owning a smart, high performance building can help to make a strong statement about sustainability and energy efficiency. For some existing buildings, is can be challenging and expensive to transform a building into an energy efficient, high performance building. However, it is important to realize that the commitment to energy efficiency, high performance and smart do not stop with the end of the renovation project. It requires a diligent effort to keep a building performing at an optimal condition. Therefore, it is important for building operators, facility managers and building occupants to understand how the building works. For building operators and facility managers, this may require training about new systems and equipment and/or new data collection and analysis processes. For building occupants, consider a short presentation and discussion, or a method of written communication appropriate for the organization to help building occupants know how they have an impact on energy efficiency by leaving lights on, using space heaters and other energy inefficient habits.

To keep a facility operating at optimal conditions, it is important to be proactive. Being proactive requires being able to assess current operating conditions and know how to respond when conditions start to drift or indicate a small problem, before a larger problem occurs. This requires the use of data. To have the necessary data, it is important to allocate necessary levels of funding within the design and construction budget so the design and construction team can handover proper documentation to the facility management and operations team in a format it can be used. Additionally, funding must be provided to

purchase software and data storage capabilities so that the data handed over can be fully utilized. Currently, document handover to support the facility management team to have detailed records of assets is generally not standard practice.

Finally, owners have a large opportunity to drive change within the design, construction and facility management industry. The use of new contract structures and contracts could be used to require document handover to support more effective population of computerized maintenance management systems (CMMS) and integrated workplace management systems (IWMS). Bold owners may even consider design and construction contracts that require certain levels of energy efficiency after the building has been in operation for a period of time.

4 Conclusion

To transform existing buildings into smart, high performance buildings requires new tools to be created. As the number of tools available increases, it is important to be sure tools to help define and prioritize goals are available. This paper has briefly summarized the development and testing of a *Decision Support System*, question driven tool to identify and prioritize energy, maintenance and human factors management decisions. Through the testing of this prototype tool, it can be concluded that there is a need to consider the impacts and interactions of both energy and maintenance management practices when determining how to incorporate more proactive strategies within facility management organizations. Successfully implemented energy and maintenance management practices will support optimized performance of smart, high performance buildings.

For more information about the research, see www.improvebuildingperformance.com.

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References

Christian, J. and A. Pandeya (1997). "Cost predictions of facilities." Journal of Management in Engineering 13(1): 52-61.

Energy Independence and Security Act (2007). Section 401 PL 110-140. www.gpo.gov/fdsys/pkg/PLAW-110publ140/pdf/PLAW-110publ140.pdf . Accessed July 19, 2011.

GSA (2009). GSA Smart Buildings Report.

IFMA (2011). What is FM?, Definition of Facility Management. www.ifma.org/resources/what-is-fm.htm Accessed April 12, 2011.

Lewis, A., A. Elmualim, et al. (2011a). "Linking Energy and Maintenance Management for Sustainability Through Three American Case Studies." Facilities **29**(5/6): 243.

Lewis, A. and A. Elmualim (2011b). Use of a Mixed Methods Research Approach to Improve Building Operating Decisions. Architectural Engineering Institute, Architectural Engineering Conference, Oakland, CA, ASCE.

Lewis, A., A. Elmualim, et al. (2010). Development of a Framework for Improving Building Operating Decisions: Findings from the Questionnaire. International Conference on Innovation in Architectural Engineering and Construction, State College.

Lewis, A. (2010). "Designing for Energy-Efficient Operations and Maintenance." Engineered Systems(August): 30-40.