Using Asset Management to Unlock Sustainability Potential

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Abstract
The US Department of Energy's (DOE) National Nuclear Security Administration (NNSA) ensures the nation's nuclear security. Comprised of eight science and manufacturing campuses covering 36 million square feet of facilities, NNSA is the heart of the United States nuclear deterrence and non-proliferation missions.
NNSA must invest in its workforce and specialized functions, while repairing and replacing old facilities--54% of facilities are over 40 years old. The expanded Asset Management Program (AMP) uses a systems-engineering approach to invest in infrastructure to include roofs and cooling and heating equipment. The Roof Asset Management Program (RAMP) and the Cooling and Heating Asset Management Program (CHAMP) actively integrate sustainability into its core processes.
This paper determines how asset management and sustainability frameworks can be used together when applied to infrastructure investment programs. Asset management can provide definitions and process, and sustainability can provide a decision-making framework. This combination of frameworks addresses the challenge of translating sustainability concepts into action, as well as establishes a decision-making paradigm for infrastructure asset management processes.

Background

What is NNSA?

The US Department of Energy's (DOE) National Nuclear Security Administration (NNSA) ensures the nation's nuclear security. Comprised of eight science and manufacturing campuses covering 36 million square feet of facilities, NNSA is the heart of the United States nuclear deterrence and non-proliferation missions. Its unique capabilities, from supercomputing to laser science, and workforce of upwards of 40,000, together consume 9.1 trillion BTU's per year. A snapshot of NNSA is provided in Figure 1.

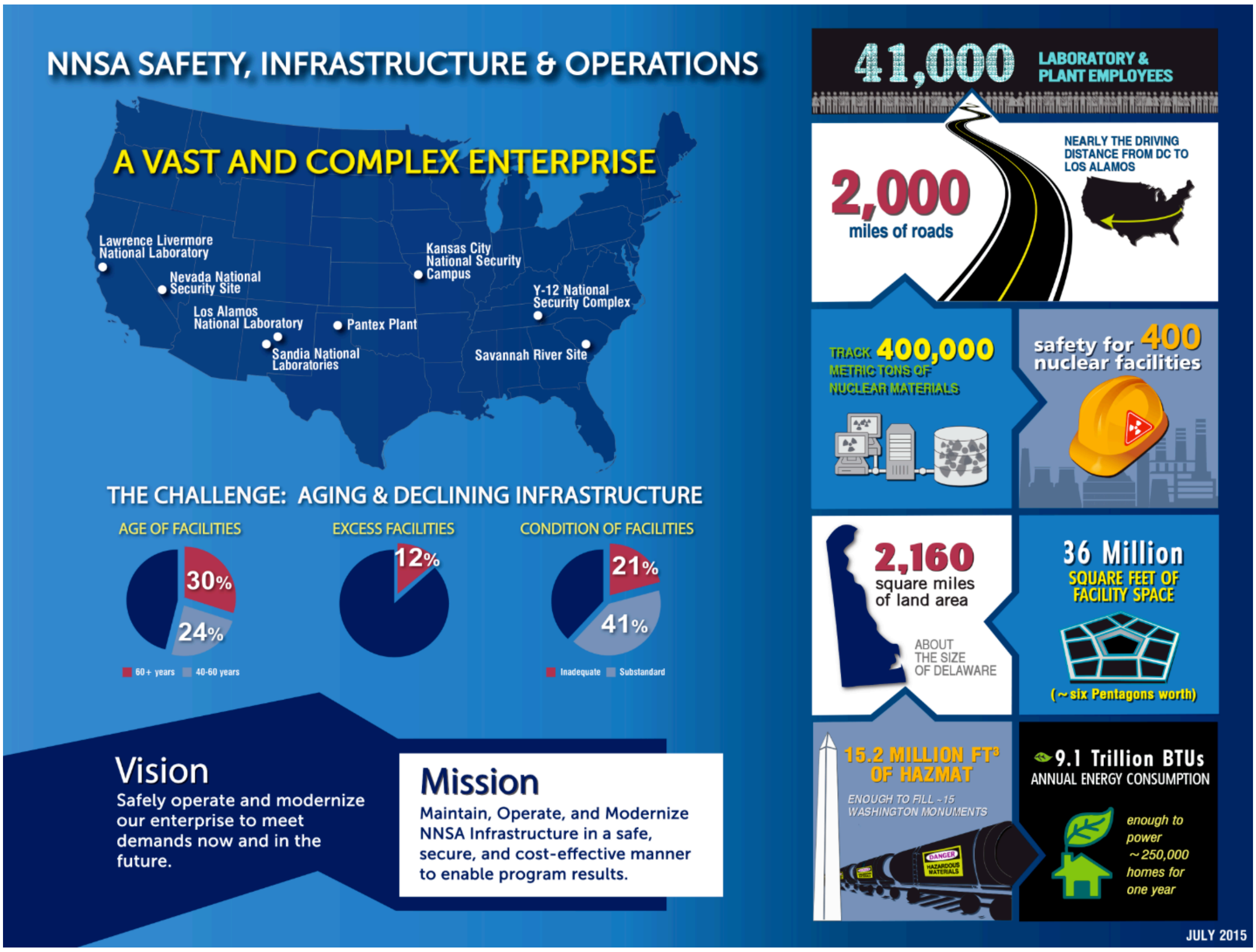

Figure 1. Snapshot of NNSA Infrastructure

What is the NNSA Asset Management Program?

Given the complex, nuclear work of NNSA, the organization aligns with similar industries who manage processes down to a low level of detail. One industry, off-shore oil drilling, for example, could benefit from the comprehensive, holistic approach of asset management (Markeset, 2012). Some have suggested that failure in effective asset management had catastrophic consequences for this industry as demonstrated by the British Petroleum 2010 oil spill in the Gulf of Mexico (Ratnayake, 2013, p. 198).

The Roof Asset Management Program (RAMP) was started in 2003 and established the Asset Management Program (AMP) concept used by NNSA today. RAMP's goal set aside funding for failed and leaking roofs affecting personnel and equipment. The program employed a national company that specialized in roof design and construction.

Starting in January 2015, NNSA started to expand AMP in hopes of applying the program methodology to other infrastructure systems. NNSA decided to focus on heating, ventilation, and cooling systems (HVAC) ranging from building-level thermostats to large cooling towers because of the broad impact HVAC. HVAC affects mission operations, workplace comfort, safety, and sustainability. NNSA HVAC relies on components that no longer have replacement parts, are non-functioning, and are not configured to support the current building uses. The Cooling and Heating AMP (CHAMP) is expecting contract award in early 2017.

NNSA's sites are operated by Management and Operating (M&O) contractors. The work of RAMP and CHAMP both made possible by contracts held by Management and Operating (M&O) contractors. The RAMP contract is held by the National Security Campus, Honeywell's contractor for NNSA's Kansas City Operations, and the CHAMP contract will be held by the Lawrence Livermore National Security, LLC, the operator of Lawrence Livermore National Laboratory.

Both programs operate with the M&O hiring a contractor who is an expert in assessing, designing, and leading the construction for the infrastructure system. Annual work packages at a site are $1M to $5M. Working with an industry sub-contractor expert gives NNSA and sites access to cutting-edge, industry-tested technologies and implementation strategies.

What is the Challenge?

NNSA must invest in its workforce and specialized functions, while repairing and replacing old facilities--54% of facilities are over 40 years old. The expanded Asset Management Program (AMP), which on average is funded at $20-30M per year, uses a systems-engineering approach to invest in infrastructure to include roofs and cooling and heating equipment.

By using asset management, an organization can flexibly define and target performance goals, including sustainability. RAMP, in place for more than a decade, has implemented a white roof, high insulation roof standard pre-dating mandatory codes. CHAMP integrates sustainability primarily in the design phase.

Purpose

The purpose of this paper is to determine how asset management and sustainability frameworks can be used together when applied to infrastructure investment programs. It also provides some tools and approaches, "for tailoring the rehabilitation technique selected for a given asset and context," (Marlow, Beale, & Burn, 2010, p. 1254). While some are challenged with how to make sustainability "practically feasible" to their business operations (Jamali, 2006, p. 813), the analysis contained herein supports the claim that performance of physical assets in the terms of sustainability can provide benefits to the asset owners (Markeset, 2012, p. 145). Asset management provides definitions and process, and sustainability provides a decision-making framework, allowing for prioritization. Combining these frameworks addresses the challenge of translating sustainability concepts into action, as well as establishes a decision-making paradigm for infrastructure asset management.

Procedure

To combine these two management systems, this paper employs analysis of two existing infrastructure investment programs, the roof asset management program (RAMP) and cooling and heating asset management program (CHAMP). Different analyses are created to, 1) define asset management and sustainability approaches for these programs, and 2) analyze program preferences, trends, and outcomes to determine how the two frameworks can be combined.

Defining asset management. Asset management programs for NNSA have the following key features:

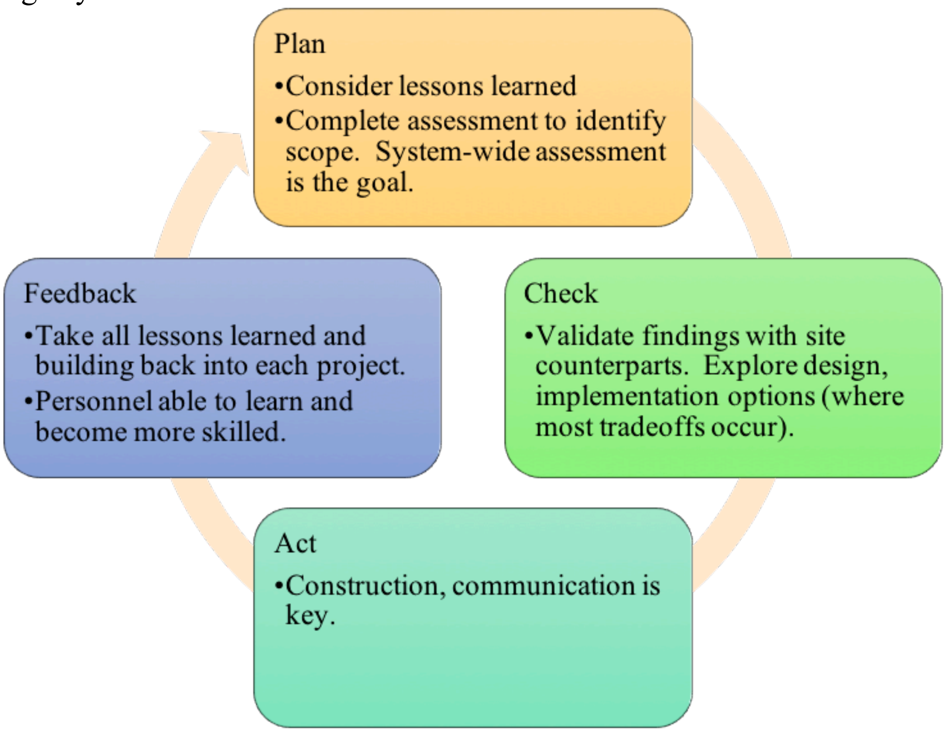

Figure 2. NNSA Asset Management Framework

Figure 2 shows an adaptation of the typical plan-do-check-act cycle that underlies asset management (The Economist, 2009). For the adapted model, the steps before "act" are expanded. The "act" step corresponds with construction, so little can be changed during this change without severe impacts to project performance. More focus must be placed on steps prior to "act" to reduce cost and safety risk.

Table 1 presents the desired outcome for each step in the asset management cycle and how each program can meet that goal. Roof and heating and cooling systems will meet asset management outcomes in different ways. For example, under the "plan" step, an identified goal is to "complete a system-wide assessment." For roofs, portfolio-wide assessment is achievable, as it is non-intrusive, inexpensively executed via aerial photography, and returns consistent results. Conversely, cooling and heating system assessment is more costly. It is more intrusive, as it involves going into buildings with design engineers to determine options for repair, replacement, and reconfiguration.

Table 1. *Comparison of Asset System Type to Asset Management Goals*

Asset Management Goal	Why this matters	Ability to Attain Goal	
Plan		**Roof**	**Cooling and Heating**
Complete system-wide assessment, cost-effectively	Enables fact-based condition assessment and prioritization. Assessment cost should be low compared to construction.	High – Roof conditions can be determined through aerial photography and spot inspection. Low assessment to construction cost ratio.	Low – Cooling and heating systems vary greatly by configuration and system components. High assessment to construction cost ratio.
Various technologies available	Provide more tailored solutions to specific issues.	Low – Few roof designs and options.	High – Many configurations and equipment types can be used.
Technical lessons learned can be used	Reduce assessment and design effort, increasing construction value.	High – Fewer options for roof-system types allow for more system-wide applicability.	Medium – Share and implement technology lessons learned, but variances limit applicability.
Plan		**Roof**	**Cooling and Heating**
Operational lessons learned can be used	Reduces cost and time to implement. Creates consistency which improves performance.	High –Although locations are spread across the country, requirements between locations are comparable.	High –Although locations are spread across the country, requirements between locations are comparable.
Check			
Validate findings with site and explore options.	Enables better design and constructability solutions for the project and repair life-cycle.	High - RAMP algorithm generates a roof construction priorities, which is validated with site and walk-thru. Cool roof standard implemented. Non-compliance is rare.	High – Conceptual designs developed. Alternatives address technology, cost, and installation. Strong sustainability preference ensures robust options. Employ triple-bottom-line analysis here.
Act			
Establish strong communication before construction start.	Stronger communication results in fewer construction issues.	High – Strong site oversight model results in check and balance during construction.	High – Strong site oversight model results in check and balance during construction.

Feedback		**Roof**	**Cooling and Heating**
Effective collection and use of lessons learned.	Strong lessons learned process ensures that failures are not made twice and successes are built upon.	High – As a mature program, lessons learned are easily implemented. Variances are obvious. Lessons learned focuses on construction.	Medium – New program, so few lessons learned. With more complexity, it can be more difficult to determine how to replicate results.
Personnel able to learn and become more skilled.	People's expertise enables them to quickly recognize potential failures and opportunities to maximize system effectiveness.	High – Program employs specialized contractor, using latest industry standards and trends. Expertise enables effective oversight of the construction process.	High – Program employs specialized contractor, using latest industry standards and trends. Expertise enables effective oversight of the construction process.

Defining Sustainability

Although a fairly recent concept, the triple-bottom-line is the cornerstone of sustainability decision-making. "The Economist" (2009) explains the history and definition of the TBL:

> The phrase "the triple bottom line" was first coined in 1994 by John Elkington, the founder of a British consultancy called SustainAbility. His argument was that companies should be preparing three different (and quite separate) bottom lines. One is the traditional measure of corporate profit—the "bottom line" of the profit and loss account. The second is the bottom line of a company's "people account"—a measure in some shape or form of how socially responsible an organisation has been throughout its operations. The third is the bottom line of the company's "planet" account—a measure of how environmentally responsible it has been. The triple bottom line (TBL) thus consists of three Ps: profit, people and planet. It aims to measure the financial, social and environmental performance of the corporation over a period of time. Only a company that produces a TBL is taking account of the full cost involved in doing business.

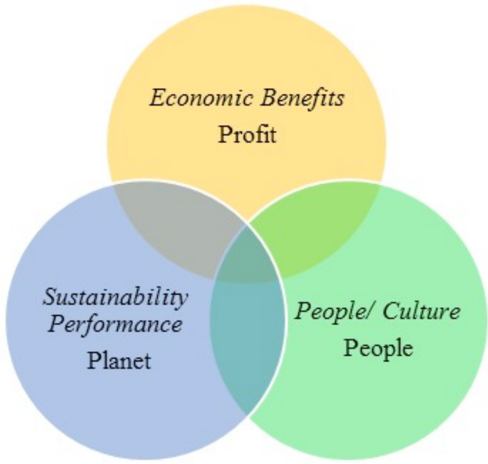

Figure 3. Triple Bottom Line (TBL) Model. In italics is the NNSA's AMP adaptation of the TBL. Overlapping sections represent decisions or projects that are beneficial for multiple reasons.

Despite the wide acceptance of the TBL, many argue that turning the concept into reality can be a challenge. As stated by Jamali, "the problem still facing organizations is the absence of a comprehensive management framework that would address, balance and integrate triple bottom line (TBL) considerations," (2006, p. 809). Therefore, it was important to map the model to concepts that fit better with a government program.

As a government program "profit" would seem to be a difficult idea to apply. However, by re-thinking profit as financial benefit, the concept is applicable.
The "planet" aspect of TBL is well-integrated into the culture of NNSA. As a government organization that handles nuclear materials, responsibility for ensuring the planet is reinforced by several federal, state, local, and NNSA requirements.

The "people" element of the TBL asks users to consider how a product was produced—how is the workforce and local community affected by the work needed to create this product or service. Jamali expands on this concept, and defines this aspect of the TBL as including, "issues of public health, community issues, public controversies, skills and education, social justice, workplace safety, working conditions, human rights, equal opportunity, and labor rights," (2006, p. 812). For NNSA, the elements that asset management programs affect directly is workplace safety, working conditions, equal opportunity, and labor rights, and goes one step further. As an organization responsible for scientific, industrial, and nuclear operations, the workforce must be engaged and highly skilled to discover and correct safety issues.

Defining the triple bottom line for NNSA AMP's. To extend the concept of the triple bottom line (TBL) to NNSA's asset management programs, one must identify what is considered a desirable and undesirable result for each TBL. Desirable results for the optimal air-handler unit is: installing an air-handling unit that meets the most recent green building standard is good for sustainability performance, equipment and installation cost that is cheaper than an conventional unit is good for economic benefit, and equipment installation times are shorter and easier to maintain is good for people, tenants of a building and for maintenance personnel. Table 2 summarizes potential desired and undesired TBL aspects.

Table 2. *Desirable and Undesirable Results for TBL Aspects*

Criteria	Desirable	Undesirable
Sustainability performance	• Technology that meets latest energy or green building codes • Metering and diagnostics • Redesign to maximize efficiency for components	• Like-for-like with old, inefficient equipment • Higher waste/less efficient equipment and operations • Less sustainable solutions to achieve other performance goals
Economic costs	• Cheaper capital/first costs • Cheaper operating costs • Fewer repair costs	• Long return on investment for technologies and installations that are life-cycle cost effective
People/culture	• Lower exposure to hazards • Simplified, easy to understand operations • Clear roles and responsibilities	• Too complex, requires attention, excessive maintenance • Complicated data interfaces • Creates confusion on who is doing what

The following sections analyze how the RAMP and CHAMP programs meet TBL criteria of sustainability performance, economic costs, and people/culture.

Sustainability Performance

RAMP. The roof program implements a white roof, high-insulation standard. Replacing or repairing a roof inherently benefits the energy efficiency of a building because holes and cracks in the roofing cause inefficiency in heating and cooling. RAMP has also adopted sustainable features to include: 1) thicker roof layers ("build up") to achieve target insulation thickness, currently R-30 for all roofs, and 2) a high reflectance requirement.

Occasionally, the additional roof thickness can create issues because it can change the elevation of the roof surface, requiring movement of other equipment on the roof. Roof repair work requires the temporary removal of equipment regardless, so this build up is usually easy to implement. High reflectance on the roof reduces the heat gained by the building, which minimizes heat island effects, as well as reduces how hard the HVAC system work.

CHAMP. CHAMP has several options when achieving sustainable performance. The availability of affordable, sustainable HVAC equipment and designs is ubiquitous. As a result, replacing any equipment in an older facility increases energy efficiency and sustainability performance simply by using common equipment.

However, with several options available for configuration and equipment, it is also easy to miss opportunities. Therefore, the assessment team must go into any project asking "how can we make the project as sustainable as possible?" as a like-for-like replacement is usually inappropriate, but avoids design costs.

One of the sustainability requirements of the program is sub-metering. When installing of large equipment, such as chillers and cooling towers, submetering better monitors equipment health, and therefore, helps target maintenance and energy efficiency improvements.

Economic Costs

RAMP. The sustainability improvements such as roof insulation and reflectance do not have significant cost compared to other standard practices. The cost for RAMP is optimized through the bidding process. Best practices include:

- More work at a site means lower cost per unit (economies of scale)
- Pre-bid processes in early/mid Fall notifies the market of our interest and identifies any fatal flaws for the program early enough for changes to be made
- Expand qualified subcontractor base in order to create competition and reduce prices.
- Perform work in the dry and warm/hot season. Roof material behaves better in these conditions. Extend construction season by phasing work across the country.

While these practices benefit RAMP economically, sustainability practices do not improve the economic outcomes. Therefore, there is not much overlap between economic benefit and sustainability benefit.

CHAMP. Most HVAC work must go far beyond simple design attributes to balance sustainability performance with cost. The potential variability of HVAC systems means economic trade-off analysis must be complete, but for small projects, trade-off analysis must also be inexpensive.

Sustainability was identified as a key requirement at the beginning of the project. During the pilot phase, the program stressed that projects must use modern energy codes and prioritize sustainability. However, the program did not specify the use of green building codes, such as ASHRAE 189.1, to see how HVAC designers would meet the challenge.

When the design team conducted their pre-conceptual design inspection, potential sustainability design elements were identified without considering cost. At the next stage, 75% design, major decisions were made, and trade-offs occurred. Design alternatives were refined and compared to meet all performance goals. Because of the small size of each project, decisions must be quick and inexpensive. Generally, there is bias towards the status quo because it has the most data available, and several of the pro's and con's are qualitative and cannot be costed. This echoes analysis on incorporating sustainability into asset management, stating that, "At present, there is a tendency to adopt like-for-like replacement for many assets, rather than consider if there is an opportunity to defer investment in a given asset and subsequently replace a group of assets with a different configuration or approach to service provision," (Marlow, Beale, & Burn, 2010, p. 1254).

The use of the TBL allowed the program to quickly determine best value. By using a TBL approach, the designer was able to select smaller, less costly equipment rather than assuming like-for-like replacement without extensive analysis. A life-cycle-cost analysis was also used for selection of major HVAC equipment, but as some of indicated, the significant costs associated with life-cycle-cost assessment made it infeasible to complete analysis for the entire project (Niekamp, Bharadwaj, Sadhukhan, & Chryssanthopoulos, 2015, p. 24). Furthermore, qualitative aspects of the project, like usability, expected maintenance behaviors, and tenant comfort remained difficult to incorporate, although obviously critical to decisions for the project team.

People/Culture

RAMP. Given the nuclear nature of its work, safety is a key concern of NNSA. For RAMP, safety risk is greatest during construction, and includes the risk of falling, exposure to chemicals and other hot industrial materials, limited ability to hear on a roof, and exposure to the weather, especially heat and lightning.

A key element to the safety of the program is the oversight by both a third-party and site representatives. By having a work being completed by a third-party with a vetted and competitively selected construction team, NNSA can select the best value team for its work. The program also works with the different sites that review and oversee safety and security documentation, as well as construction. Each site representative gains valuable hands-on experience and gains expertise in roof safety, materials and installation methods. As a result, NNSA has reinforced and increased roof expertise by requiring knowledge at each site be exercised continuously. This builds a basis for informed feedback to improve implementation each year.

CHAMP. CHAMP's close engagement with site representatives occurs early in the project. HVAC system improvement is typically more intrusive, so the program and site benefit from more interaction prior to and during the assessment process.

CHAMP's assessment process aims to collect as much pre-visit design and performance data available for a project. The program then conducts a walk-through to explore options for technologies, configuration and operation. When a site has a preference for what exactly needs to be done to complete a repair, the site ownership can be so strong, better solutions can be dismissed. However, if no solution is envisioned, it is difficult to complete a comprehensive and inexpensive assessment. Therefore, it is critical to understand how much work has already been done, so the program can know how to approach a project.

Because of the importance of the pre-design and design phases, this is where people are considered the most, and must be built in. In addition, the process itself includes the relationship building between the program, the sites, and the specialty design contractor. This relationship is long-term, so investing in communication and a healthy relationship is critical to both ensuring project result and program longevity.

Method for Combining Asset Management and TBL

The analysis presented in this paper demonstrates that asset management and sustainability concepts can be translated into distinct decisions and actions in an infrastructure project and program. The following figures expand on the analysis and show how mapping questions that correspond with TBL onto the asset management process can provide a decision-making tool. The project used to develop these questions was the replacement of an HVAC system for a 25,000 square foot mixed use office building that also has a cafeteria.

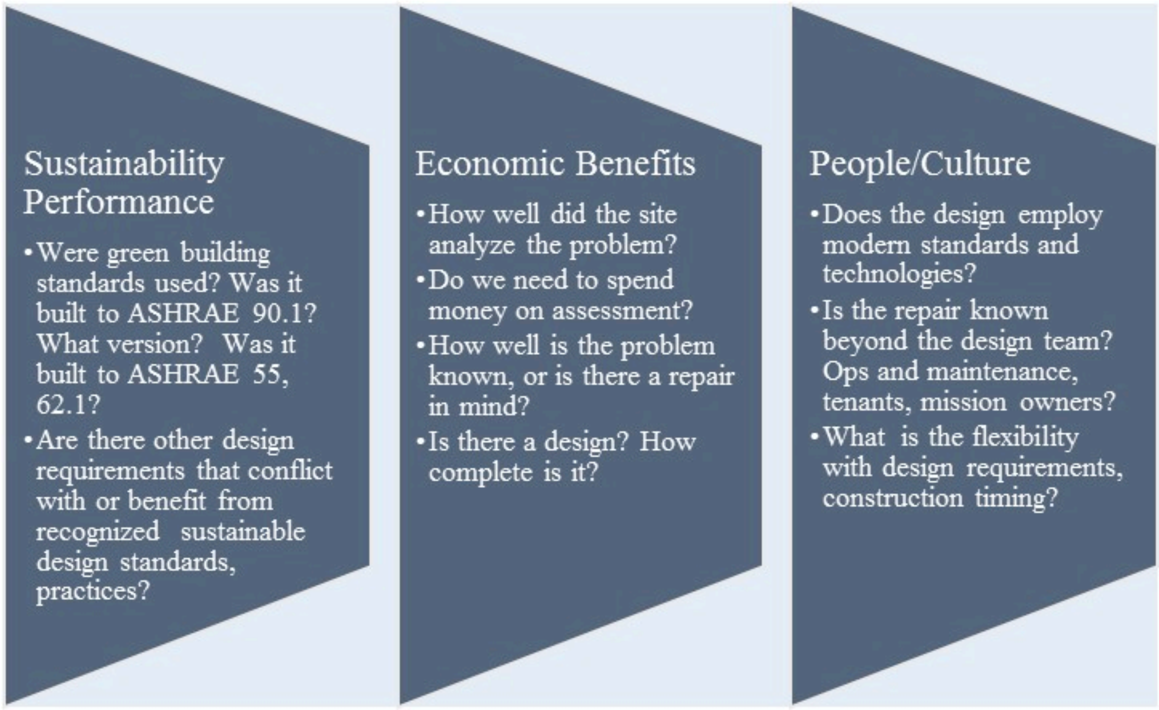

Figure 4. Plan

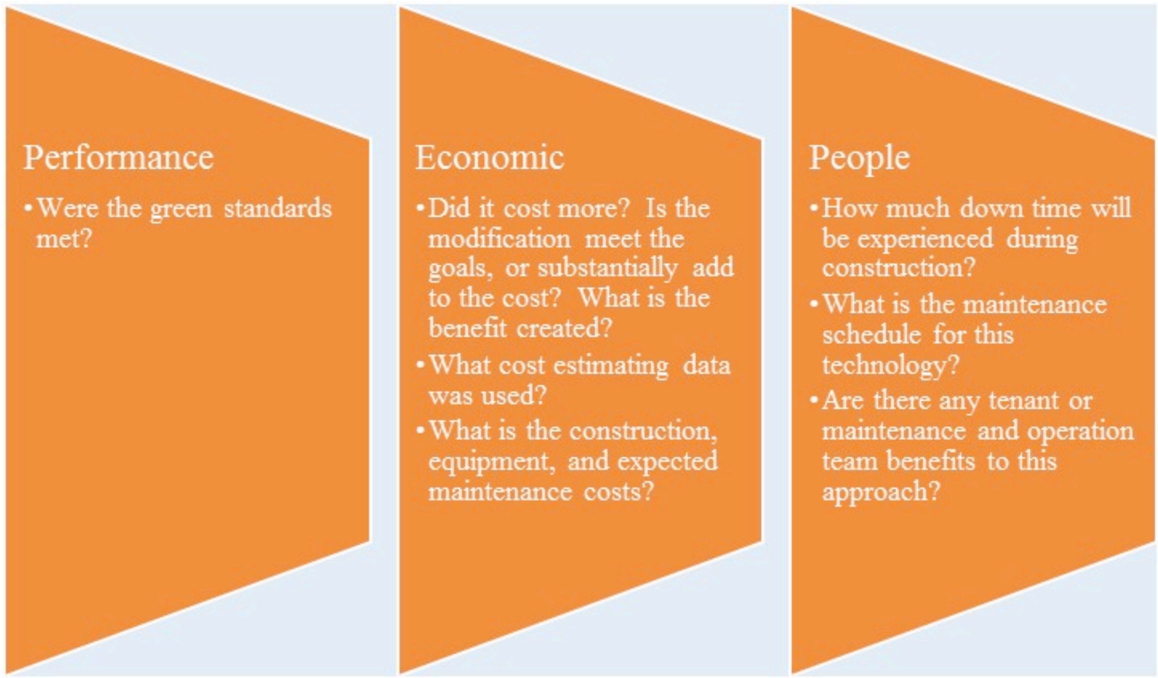

Figure 5. Check

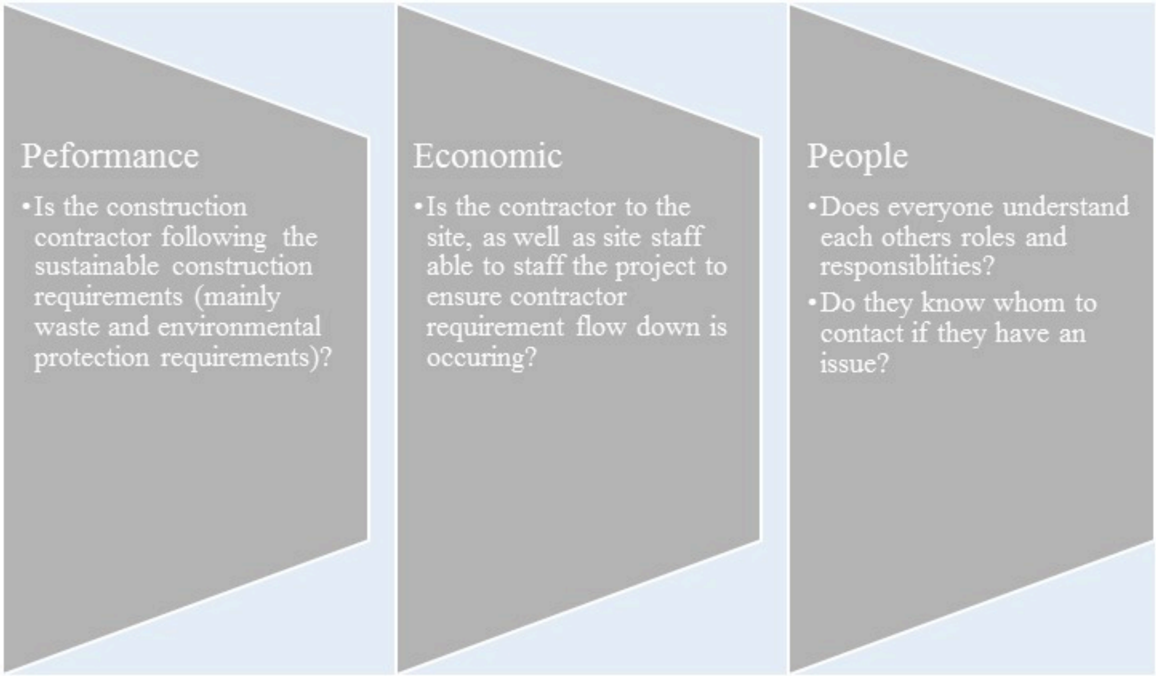

Figure 6. Act

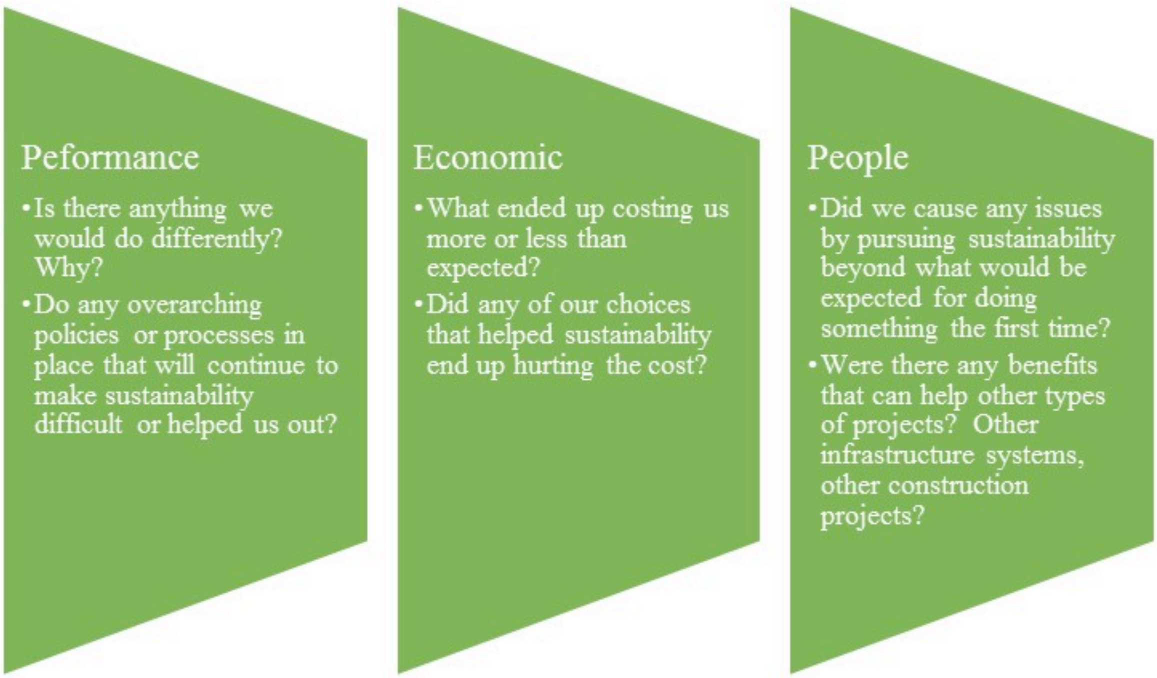

Figure 7. Feedback

Conclusions

Before a project begins, analyzing how asset management and sustainability applies to that infrastructure system is also important because infrastructure systems can differ in significant ways. This analysis shows that roof and HVAC systems can differ, changing what would be a good or a bad outcome. This paper shows that the two systems can be combined in a simple, repeatable way, as shown through the combined sustainability and asset management model presented.

An infrastructure asset management program can help focus attention on specific infrastructure issues. Following an asset management process also opens up the possibility of integrating other frameworks, such as sustainability and the triple-bottom-line in particular, in a systematic way. Sustainability also offers a decision-making framework that is simple and fast, which is a benefit for small projects.

Future Plans

While this paper shows that it is possible to combine these two frameworks for specific infrastructure investments, the next questions are, what is allowing these systems to be compatible, and what are the highest-value activities for both management systems. For example, human factors which would include feedback and the people/culture elements of asset management and sustainability respectively may be a critical factor. Ratanyke explains that “human performance is central to any kind of the asset intensive organization,” (2013, p. 205). The implications for infrastructure programs to determine its most influential aspect would then allow a program to invest in its most critical elements, obtaining the best value for its work.

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