LEED Process Assessments and Efficiency Improvements for Renovated Buildings

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ABSTRACT

The Library and Academic Resources Center (LARC) at Colorado State University – Pueblo (CSU-P) was renovated in 2011. During this time, the building was awarded Leadership in Energy and Environmental Design (LEED) Platinum. This is the highest award for a sustainable building granted by the United States Green Building Council (USGBC). This building was evaluated under the LEED version 2.2 Building and New Construction standard. The LARC building is studied and evaluated in this research as a case study. All three LEED phases were evaluated during this case study: discovery, implementation, and occupancy. The purpose of this case study is to assess the LEED process used during the first evaluation and propose any necessary improvements to increase the efficiency of the building. The secondary purpose was to determine if the building could achieve a lower LEED award without compromising efficiency. This study was conducted by interviewing campus LEED professionals, observing LEED literature in the LARC building, and utilizing publicly available information. Our analysis results in a proposal that increases the LEED score to 57 out of 69 points for an award of LEED Platinum. The infrastructure proposed in this paper could lead to an increased LEED score for all buildings on campus.

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1.0 Introduction

This report provides a comprehensive study and analysis of the Colorado State University - Pueblo LARC building. The study focuses on the way in which the building was certified as a LEED Platinum project. Aspects in the LEED process range from the physical materials used during the project, to environmental quality during construction and during the occupancy of the building after completion (Wasmi 2016). LEED certification also looks at the interior and exterior of the structure, such as indoor environmental quality, energy and atmosphere, and water efficiency; all of these topics where investigated throughout the duration of the case study. After the initial findings, it was found that the LARC building - even with a Platinum rating - could attain a handful of other LEED credits by using different methods and/or materials to increase the sustainability and efficiency of the building.

2.0 Methodology

This case study followed a three stage or phase methodology that tried to emulate the actual process in which a LEED project is developed and implemented. The first phase of our investigative methodology is the discovery phase. At this time in the study, the investigative team does not yet know what different means the builders used to achieve certification in LEED. In the discovery phase, the investigative team's goal was to begin to understand the project as a whole and then slowly break the scope of the project up into smaller components. These smaller components then became focal points for the rest of the case study. After understanding the focal points of the project, the discovery began to analyze the way in which the project achieved their LEED Platinum certification. Due to the fact that this case study is based around an existing building, the different systems, means, and methods used to reach said certification were relatively easy to find and understand. The last part of the discovery phase was to locate certain LEED credits that were not awards to the LARC building and possible reasons why they were not achieved. It was also in this part of the discovery phase in which the investigators could begin to plan for the next part of the phasing, the implementation phase. During the implementation phase of the study, the investigators were to use the information found in the discovery phase and find areas that the LARC building could improve on and possibly earn more credits toward their certification. Such areas include sustainable sites, water efficiency, energy and atmosphere, materials and resources, and indoor environmental quality. Each LEED accredited area was investigated in depth during the implementation phase in order to produce a better solution to the problems that the LARC could face based on their existing certification. This phase of the case study helped immensely due to the fact that it narrowed the focus of the investigation down to a few key concepts that could be improved on. It also allowed the investigators the chance to further research the different methods used to mitigate certain problems that other LEED projects had faced. The last phase of the methodology was the occupancy phase. This phase took the different methods recommended in the implementation phase and discussed whether or not these methods would be beneficial to the LARC building. This phase looked at the cost of each introduced method, what each method requires, both positive and negative aspects of each, and the rate of return on investment if there is any at all. This final phase provided the best results for recommendations to be made at the end of the case study.

3.0 Case Study - LARC Building at CSU-Pueblo

The LARC project achieved LEED Platinum certification with version 2.2 The renovation was considered a major renovation because the building's acoustics, exterior aesthetics, day lighting and overall Mechanical, Electrical, and Plumbing systems (MEP) were improved. The H.W. Houston was the general contractor for the renovation of the Library and Academic Resource Center (LARC) project. The architect firm was Bennett Wagner and Grody. The total square footage of the building was 125,800.

There are many alternatives to the LEED building design that do exist according to the Harvard Energy and Facilities committee. Throughout this research, it was discovered that it is no secret that creating an energy efficient building is quite a desirable goal. Building green saves on energy and waste costs and limits the negative impact on the environment (Alshareef 2018). There are a lot of alternatives that are available and would need to be considered before committing to an endeavor such as this.

The initial investment in becoming LEED certified can be quite significant. It was discovered that this needs to be kept in consideration. Becoming LEED certified is not only a complicated process, it's expensive. There is a flat registration fee ranging from $1,200 for the basic certification to $3,250 for silver, gold, and platinum certification, which is just for the precertification review. There are also additional costs, depending on the size of the building, and these costs can reach up to $27,500 for buildings with more than 500,000 square feet. Moreover, the things that must be changed in an existing structure to achieve the certification can cost hundreds of thousands of dollars. It was discovered that there is not only a large monetary investment involved, but that there is also a significant time investment to achieve LEED certification. Further, and upon becoming LEED certified, there is an investment in maintenance as well.

3.1 Water Efficiency

There are two alternatives that CSU-P should consider in order to increase water efficiency on campus: non-potable water usage or xeriscaping. These two ideas are not mutually exclusive; however, the cost to integrate a non-potable water irrigation system would be very high. Therefore, xeriscaping should be reduced if a non-potable system is installed.

Federal Energy Management program defines Xeriscaping as a landscape design practice that reduces or eliminates the need for irrigation. This is done by drastically reducing the surface area of the vegetative landscape. Often rocks or mulch are used, along with drought-tolerant plants. The main advantages to xeriscaping are that it greatly reduces water consumption, and it reduces maintenance and usage costs. However, grass is iconic on a college campus because it provides an environment in which students can come together. Therefore, a campus with a rock and mulch landscape may not be appealing to students.

Non-potable water is water that is not safe for human consumption, but it can still be used for other purposes. Non-potable water is highly effective for irrigation because it is cheaper than potable water, and vegetation can survive on it. There are three main ways of receiving non-potable water on campus: reclaimed water from a waste treatment facility, pumping the water directly from a water source, or collecting the water from a runoff on campus.

The James R. Dilorio Water Reclamation Facility treats waste water in the city of Pueblo. After the water is treated, it is pumped directly into the Arkansas River. This water could be used more efficiently if it was used for irrigation. Unfortunately, the waste treatment facility is nearly 3.5 miles from the CSU-P campus, as seen in Figure 1, and it would be very expensive to construct the pipe necessary to transport the water. Additionally, many businesses and residents would be impacted from the construction process.

Fountain Creek is approximately one mile from campus, and 1.25 miles from the LARC building, shown in Figure 2. Non-potable water could be pumped directly from Fountain creek; however, water rights would need to be obtained in order to do this. Although, it would be cheaper to construct the infrastructure necessary to pump water from Fountain Creek than from the water reclamation facility. A third option would be to construct a basin on the CSU-P campus that collects runoff. However, since CSU-P is on a hill, the basin would only get runoff from the campus itself. It is unlikely that the runoff from campus would be able to supply the entire campus's irrigation needs.

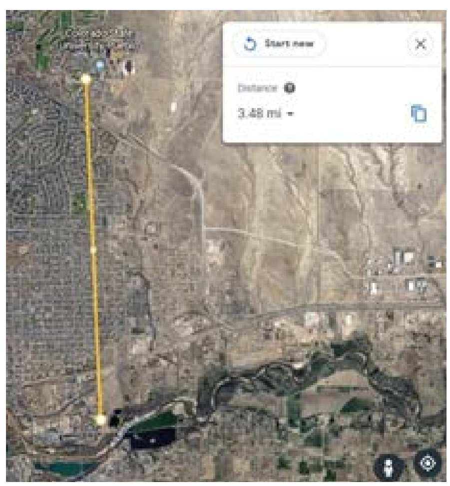

Figure 1 – Distance from Water Reclamation facility to CSU-P

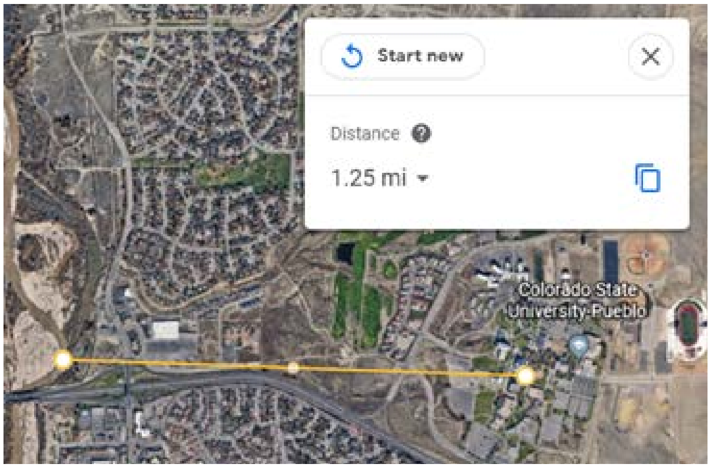

Figure 2 – Distance from Fountain Creek to CSU-P

3.2 Energy & Atmosphere

The LARC received 1 credit for optimizing energy performance. This credit was achieved through the use of high-performance lighting, T5HO lamps, LED accent lighting, a combination of arches and light-colored ceilings, high performance glazing, daylight harvesting controls, active beams, passive beams, modern HVAC technologies, and highly efficient condensing boilers.

High-performance lighting provided warm and comfortable lighting very efficiently. The primary overhead lighting utilized T5HO lamps. The combination of arches and light-colored ceilings, with the type of lighting fixtures that shines the light up as well as down, provided evenly dispersed, diffused lighting that furnish less glare for computer screens. LED accent lighting provided new shapes of lighting. High performance glazing allowed for larger areas of glass, while preventing unwanted heat from entering or desired heat from escaping from the building. Daylight harvesting controls used photocells to monitor the amount of ambient light and dim the lighting to appropriate levels when sufficient daylight exists. The active beams used high velocity air to induce warm room air to move through chilled coils. Passive beams rely on the natural flow of warm air rising and cool air falling to silently cool the space. The modern HVAC technologies achieved 43.5% energy savings. This was achieved through the use of chilled beams, radiant heated slabs, and the displacement of air systems. The highly efficient condensing boilers produced hot water more efficiently than traditional boilers.

3.3 Indoor Environmental Quality

The LARC building achieved a score of 10 out of 15 possible credits (reference Table 1) in Indoor Environmental Quality. The credits that the project did not receive were air delivery monitoring, controllability of systems for both heating and lighting, and daylight and views. An initial alternative was to allow the controllability of heating and lighting throughout the layout of the building. This was proven to have more of a negative impact on the efficiency of the building due to the function of the building. The LARC building operates as a classroom and learning environment, a study area, and a lounge or social area. Giving controllability of climate and lighting systems would provide no financial benefit, and giving control to the occupants in the building is not cost effective due to the fact that the occupants do not reside in the building on a regular basis, meaning climate and lighting systems would be left in operation without the need for either; consequently affecting the efficiency of the building. Air delivery monitoring is a credit that is easily achievable on almost any project in today's industry, it is a matter of whether it is going to be necessary or not depending on the functions and location of the building. Air delivery monitoring can provide feedback to the climate system inside of a building. This in turn can improve the efficiency of the HVAC system in the building so that the system is not in use when it does not need to be. With daylight and views, the LARC building is an area where this use of natural lighting could be extremely useful, both for economic reasons and social reasons. This is one aspect of the project where the investigation is deciding to make improvements and attempt to achieve the two credits associated with daylight and views. Some positive points to make about daylight and views are as follows:

- Lower energy costs (HVAC)
- When controlled, natural lighting generates hardly any heat at all
- Overall energy savings can range from 15 to 40 percent
- Can have a positive impact on productivity and satisfaction of occupants

Negative points of daylight and views:

- Significant initial investment

- If not planned properly, using natural lighting can result in undesirable heat gains in the building
- Direct sunlight penetration in classrooms and offices often produce unpleasant glares

If planned and designed properly, a new daylight and views system could be beneficial to the LARC building, as well as providing two more credits to the overall LEED score applied to the building.

Table 1 Indoor Environmental Quality LEED Credits (scorecard of LARC building)

Indoor Environmental Quality				
		Max	Obtained	Proposed
Prereq 1	**Minimum IAQ Performance**	Required	Required	Required
Prereq 2	**Environmental Tobacco Smoke** (ETS) **Control**	Required	Required	Required
Credit 1	**Outdoor Air Delivery Monitoring**	1	0	1
Credit 2	**Increased Ventilation**	1	1	1
Credit 3.1	**Construction IAQ Management Plan**, During Construction	1	1	1
Credit 3.2	**Construction IAQ Management Plan**, Before Occupancy	1	1	1
Credit 4.1	**Low-Emitting Materials**, Adhesives & Sealants	1	1	1
Credit 4.2	**Low-Emitting Materials**, Paints & Coatings	1	1	1
Credit 4.3	**Low-Emitting Materials**, Carpet Systems	1	1	1
Credit 4.4	**Low-Emitting Materials**, Composite Wood & Agrifiber Products	1	1	1
Credit 5	**Indoor Chemical & Pollutant Source Control**	1	1	1
Credit 6.1	**Controllability of Systems**, Lighting	1	0	0
Credit 6.2	**Controllability of Systems**, Thermal Comfort	1	0	0
Credit 7.1	**Thermal Comfort**, Design	1	1	1
Credit 7.2	**Thermal Comfort**, Verification	1	1	1
Credit 8.1	**Daylight & Views**, Daylight 75% of Spaces	1	0	1
Credit 8.2	**Daylight & Views**, Views for 90% of Spaces	1	0	1
		15	10	13

4.0 Findings

It was further discovered by the investigators that in order for this building to strive closer to becoming a zero-point energy building, there would be many additional costs involved to achieve this. Specifically, the investigators had looked closely at incorporating a green, living roof to the building. It was therefore discovered that this could and would very likely cut down on the costs to supply food for this building's occupants. However, there is a significant financial investment the investigators found to implement this. The investigators did find that the overall level of self-sustainability could be improved with additional financial investment toward this goal.

4.1 Sustainable Sites

This first category of LEED Certification prerequisites has to do with the specific location and piece of land that the project is to be built on. It was discovered that these credits specifically deal with protecting the natural habitat in the area, keeping the open spaces open, dealing with the rainwater the best way possible, and keeping the heat island effect and light pollution down to a minimum.

Site Assessment:

This credit is worth 1 point. In order to earn this credit, project teams must perform and document a site assessment of the project location, including the following topics: topography, hydrology, climate, vegetation, soils, human use, and human health effects. The assessment should discuss how the topics above influence the design, as well as any of the topics that were not addressed in the design.

Protect or Restore Habitat:

This credit is worth 1-2 points. The project must preserve and protect at least 40% of the greenfield (undeveloped) area on the project site, if such an area exists. In addition, the project must restore 30% of the site to natural habitat using native and adapted plant species (worth 2 credits) or provide financial support to an organization accredited by the Land Trust Alliance (worth 1 credit). The habitat restoration should include both soil and vegetation, and vegetated roofs can be counted in certain circumstances.

Open Space:

This credit is worth 1 point. The project must provide open space equal to 30% of the total site area. At least 25% of that open space must be vegetated or have overhead vegetation. Turf grass areas do not count as vegetated areas. Open spaces must be designed for one or more of the following uses: social gathering, gardening, physical activity, or natural habitat that includes elements for human interaction. Vegetated roofs can be counted in certain circumstances.

Rainwater Management:

This credit is worth 1-3 points. This credit asks the project team to design a rainwater management system that handles the water falling on the site in a way that is similar to the native state of the site. Depending on how much water the system is capable of handling, 1-3 points are possible. The capacity of the system is measured by what percentage of local or regional rain events could be handled by the system. If the system can handle 95% of the events, then it can earn 2 points, and 3 points for handling 98%. Or, as an alternate way of calculating the credit, if the system can handle 100% of the increase in runoff that occurs as the result of the development of the site from its natural state, then the project can earn 3 points.

Heat Island Reduction:

This credit is worth 1-2 points. Heat islands occur in areas where hardscape surfaces (such as parking lots and sidewalks) hold heat and reflect it back, raising the temperature of the surrounding environment. This change in temperature can affect weather patterns in the local area. To avoid this, projects receive credit for using roofing materials with a high solar reflectance, reducing the number of hard surfaces, shading project areas with trees and other foliage, placing parking lots under cover, and using open paver systems.

Light Pollution Reduction:

This credit is worth 1 point. Projects must reduce the amount of up-lighting used for exterior lighting, avoid pollution of light into adjoining sites, and control light levels outside the building to meet certain standards. This requires a photometric plan, which shows the level of light in all areas of the site. The design team must take measurements to confirm that the built condition meets the requirements for this credit.

4.2 Water Efficiency

Table 2, below, shows the points available in the water efficiency category. This table is a modified version of the 2013 LEED scorecard for the LARC. Five points can be obtained in this category, and CSU-P obtained three points. The research contributors believe that CSU-P should consider pursuing the "Water Efficient Landscaping" credit. In order to do this, a considerable investment would need to be made to bring non-potable water to the campus or removing irrigation altogether throughout the entire footprint of the LARC building.

Table 2 Water Efficiency LEED Credits (scorecard of LARC building)

Water Efficiency				
		Max	Obtained	Proposed
Credit 1.1	**Water Efficient Landscaping**, Reduce by 50%	1	1	1
Credit 1.2	**Water Efficient Landscaping**, No Potable Use or No Irrigation	1	0	1
Credit 2	**Innovative Wastewater Technologies**	1	0	0
Credit 3.1	**Water Use Reduction**, 20% Reduction	1	1	1
Credit 3.2	**Water Use Reduction**, 30% Reduction	1	1	1
		5	3	4

Xeriscaping has a much cheaper total cost than installing non-potable water, but studies show that a grass environment is more appealing to humans. A xeriscaped environment may be detrimental in the recruiting efforts of the university; therefore, it is the recommendation of the research contributors that CSU-P investigates the feasibility of bringing non-potable water to campus. Bringing non-potable water to campus would have a high upfront cost; however, the pipe network has a lifespan of 50-70 years. Once the infrastructure is in place it could be used for every facility on campus. This would give every structure on campus the water efficient landscaping credit. Additionally, it would considerably reduce irrigation costs and reduce the campuses potable water consumption.

4.3 Energy & Atmosphere

The alternate energy that could be used in the LARC building is a geothermal system. The benefits of a geothermal system can be configured to accommodate the amount of property used. A geothermal system can be configured to a horizontal or vertical, open or closed loop system. Horizontal loop systems have lower installation cost, but they require a plot of land sufficient for 3-5 trenches: 130 to 160 feet long and 12 to 20 feet apart. Water or antifreeze circulated through the pipes collects heat for heating in the winter and dumps heat for air conditioning in warm months. A vertical loop system has a higher installation cost, about $1500.00 per 12,000 BTU's (British Thermal Units). This system is ideal for smaller properties. Vertical loop systems are where several holes are drilled, each between 50-400 feet deep, and several pipes are installed. Water is then circulated through the pipes that collect heat for heating in the winter and dumps heat for air conditioning in warm months. The other benefits of this system are that they have a quiet operation, resulting in less noise pollution. Geothermal systems are more efficient than ordinary heating and air conditioning units because the systems deliver more energy than they use. A geothermal system will offer a more precise distribution of cooled or heated air, year-round, so there would be less hot and cold spots in the building. Geothermal technology is more reliable than most air conditioning units and heat pumps, and they typically require less maintenance than other heating and cooling units.

Heat pump pipes even have warranties of between 25 and 50 years, while the pump can usually last for at least 20 years. This also requires less space for hardware as opposed to conventional systems. This system is more environmentally friendly because geothermal systems don't emit carbon dioxide or other greenhouse gases that are considered contributors to environmental air pollution. This system is highly efficient because geothermal heat pump systems use 25% to 50% less electricity than conventional systems for heating or cooling, and with their flexible design, they can be adjusted to different situations, requiring less space for hardware as opposed to conventional systems.

4.4 Material & Resources

The LARC received 16.4 credits in the material and resources category. These credits varied from building reuse, recycled content, low-emitting material, and for certified wood. The reason the LARC received 1.2 credits for building reuse was because it maintained 95% of the precast structure and cladding system. The exception was where panels were removed to allow for the expanded exterior glazing which added more natural lighting. The reason the LARC received 4.2 credits for recycled content was because 20% of the building content was re-used. These materials varied from carpet, countertops, solar shades, and ceiling tiles. The reason the LARC received 4 credits for low-emitting material was because materials that have low-VOC (volatile organic compounds) content were used. These materials were adhesives, sealant, paints, coatings, and carpet systems. Composite woods and Agri fiber were selected to contain no urea-formaldehyde. The reason the LARC received 7 credits for certified wood was because the wood that was selected were FSC (Forest Stewardship Council) certified.

4.5 Indoor Environmental Quality

This investigations recommendation for improved Indoor Environmental Quality is to enhance the daylight and views in the LARC building. This comes as a recommendation due to its ability to save on energy and improve the social dynamic inside the building. Both of these focal points become more important based on the overall use of the building. The LARC is utilized as a classroom building, study area, and social/gathering area all at the same time. When natural daylight can improve productivity and satisfaction in these types of environments, the reason for this change is justified with the social improvement that it can have. The energy savings is more complicated. In order for the improved daylighting and views to be cost effective, it would be this investigations recommendation to perform a design study before construction and/or improvements commenced. Such studies can be in the form of a Building Information Modeling (BIM) model, and when coupled with a specific location and time of year, the design team can resolve to the best solution possible.

5.0 Conclusion

Using the seven LEED (BD+C) rating system's categories, this report analyzed comprehensively the existing Platinum certification of an educational building (i.e. the LARC building at Colorado State University-Pueblo). This investigation was able to improve the overall score of the LEED accreditation by five points with respect to the budget. The intent of all explanations and recommendations is to ensure the betterment of the operation and sustainability of the LARC building, as well as to improve the building's LEED accreditation. The infrastructure proposed in this paper could lead to an increased LEED score for all buildings on campus (i.e. CSU-P), so this research serves as a vehicle for future investigation in this regard.

6.0 References

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