Involving Stakeholders at Early Stage of the Design Process to Improve Credit Points Allocation

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ABSTRACT

Several sustainable buildings (existing or new construction) that seek Leadership in Energy and Environmental Design (LEED) credentials tend to lack proactive plans at a very early stage of the project. stakeholders and decision-makers typically wait until the design phase begins to discuss LEED's categories (i.e. credit point allocations), which drains out the budget with a limited number of resources. This conventional method has a higher probability of reducing production and collaboration and also limits creativity and innovation. Therefore, this research is intended to evaluate the early preparation of eco-friendly buildings (e.g. the Technology Building at Colorado State University (CSU-P) as a case study) and examine practical applications to seek a LEED certification.

A collaborative iterative process approach was utilized by researching and evaluating ideas and conducting interviews with stakeholders and decision-makers. This process is undertaken to identify the most useful materials, items, ideas, and then weigh them against their pay-back periods. The purpose of this research was to integrate the iterative process into a high level of integrative process approach at an early stage of the project (Feasibility and Programming stage). The aim was to concentrate on the LEED categories that contribute more to the project in terms of point allocations without draining the project's budget at a very early stage of the project.

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2.0.0. Introduction

Since LEED (BD+C) rating system consists of seven categories according to the scorecard of New Construction and Major Renovation, this paper proposes the utilization of new ideas and materials that could be used for commercial buildings (e.g. educational building). These new ideas and materials help to accomplish synergy between credit category, system, and components that can be realized through the integrative process to achieve high levels of building performance, human well-being, and environmental benefits. Each LEED credit is assigned points based on its contribution toward addressing one or more of the LEED impact categories. The credit categories are composed of required and optional green building strategies. Required strategies are referred to as "pre-requisites." Optional strategies are referred to as "credits." To receive certification, projects must achieve all prerequisites and a minimum of 40 out of the available 110 points. Higher levels of certification are achieved by earning more points: LEED Certified is 40-49 points, LEED Silver is 50-59 points, LEED Gold 60-79 points, and LEED Platinum is 80 or more points. Proactive project teams typically target 3-4 more points than the minimum number of points necessary to achieve the targeted certification level. This is an effective risk management strategy since it is possible that a few credits may no longer be feasibly pursued during the design and construction phases of a project or that credits will be denied during the Green Business Certification Inc (GBCI) review.

Typically, educational buildings are built or renovated using conventional materials (e.g. concrete and steel), which are not useful in terms of minimizing the embodied energy and other impacts associated with the extraction, processing, transport, maintenance, and disposal of building materials (Alshareef 2018). Therefore, this paper shifts the focus toward more eco-friendly materials that are not typically utilized in commercial buildings. Not only these materials are feasible, efficient, and have a less negative impact on the environment, but also they achieve all prerequisites and credit points. As a result, stakeholders and decision-makers' participation at a very early stage of the project are highly recommended.

3.0.0. Methodology

The purpose of this case study is to explore different approaches to improve the efficiency of potentially newly renovated buildings (i.e. Technology Building at CSU-P). The paper collaborators began with a general observation of the Technology Building's needs with the LEED point system in mind. This approach is used because it produces generalized concepts and decisions based on a small number of observations. This is happened by iteratively meeting daily, weekly, and monthly to refine the objectives and goals and to find sustainable solutions. Also, several personal interviews were conducted with stakeholders and owner representatives to integrate their ideas and visions into this research and refine the overall processes. Furthermore, a high level of an integrative process was conducted through three phases of evaluations such as Discovery, Implementation, and Occupancy phases. For this research, data was collected mostly by interviewing construction faculty members, owner representatives, designers, general contractors, and the paper contributor personal observations. Afterward, all the collaborative approaches are examined against the LEED category sections concerning the prerequisites and credit conditions.

4.0.0. Case Study -Technology Building at CSU-Pueblo

4.1.0. Materials and Resources

4.1.1. Trash and Recycling Bins

This project will need an adequate number of dumpsters and recycling units to hold the amount of trash and any other type of material that is being removed while this building is under construction. For this project, the dumpster that should be used for the job is a 40-yard construction dumpster. A 40-yard dumpster typically includes a 5-6 tons or 10,000-12,000 pound weight limit, though weight limits vary by location and type of disposed of material. For the size of the building, there should be 4 dumpsters that are required to hold all the material that is to be removed. The size and number of dumpsters are prerequisites under the Materials and Resources category and no points are collected. A suitable location to store and sort all the materials that are being installed or being removed to reuse later on is a significant step in the construction process, which contributes to the prerequisites of the Construction and Demolition Waste Management Planning category. The best location to stage everything is going to be in the parking areas behind the Technology Building, parking lot S-1(Shown in Figure 1). This is the ideal location because it is large enough to store all of the building materials that are needed and it is convenient for trucks or equipment to enter and exit the job site. The authors recommend that the best location have everything staged for this project to be in the S-1 parking lot behind the Technology building. This gives the best location to have materials delivered and to have the dumpster placed in a good location that will make it easy to dispose of the waste that is being taken out of the building. And by making this location the designated area for staging, the Storage and Collection of Recyclables prerequisits can be achieved.

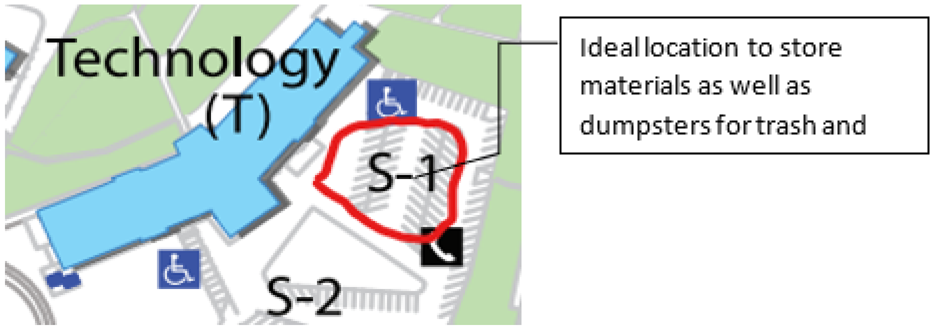

Figure 1: South S-1 Parking Lot, CSU-Pueblo Map

4.1.2. Exteriors

4.1.2.1. Exterior Insulation Finishing System (EIFS)

EIFS as an exterior provides insulation of an R-value of up to R20. It improves the energy efficiency of the building envelope and is environmentally friendly. EIFS helps to achieve partially Optimize Energy Performance credit (16 points). Unlike wood, siding, stucco and other siding materials, EIFS rarely need painting and are highly durable year-round, and they are even capable of withstanding powerful hurricanes. To move 25,000 square feet of material, EIFS requires 16 times fewer tractor trucks than bricks and 6 times less than stucco (Wasmi 2016). EIFS also support sustainable design practices such as achieving LEED Building Certifications. This material does great with managing air and moisture infiltration as well as condensation. EIFS has been proven to produce the smallest carbon footprint of all other claddings according to the National Institute of Standards and Technology (Shown in 2).

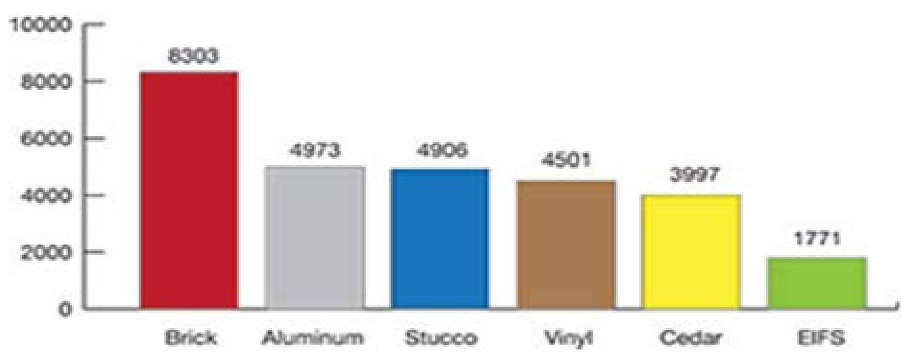

Figure 2: EIFS has a significantly smaller carbon footprint when compared to other materials.

All EIFS panels include a fluid-applied water-resistive barrier coating that is applied to the exterior face of the structure, and exterior insulation is adhesively attached using a notched trowel to provide vertical paths for water drainage. Next, a base coat, either acrylic or polymer-based cement material is applied to the top of the insulation then reinforced with glass fiber reinforcement mesh. The reinforcement mesh is embedded in the base coat material. The finish is a textured coat that's decorative and protective shown in Figure 3.

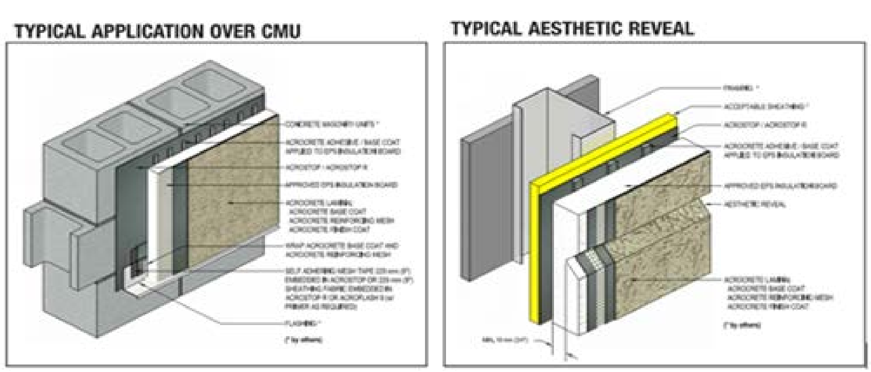

Figure 3: Two most common EIFS application on exteriors.

The main drawbacks with EIFS (Lstiburek 2007) are they need to be recoated every 10 years to maintain the system, and if not properly installed it can create problems that result in leakage. However, these installation problems can easily be avoided. A proper EIFS installation will shed water and be sealed at the windows and other wall penetrations so that leakage doesn't occur. Given the facts and information presented on EIFS, the authors recommend that the Technology Building chooses to use this highly efficient exterior system to achieve LEED certification for the Technology Building. With this suggestion, there is a rough estimate of the EIFS material cost (Canova 2013) compared to other commonly used materials (Shown in Table 1).

Exterior Options	Total Building Square Footage (ft²)	Material Cost Per Footage ($)	Total Estimated Cost of Material ($)
EIFS	24,900	$16	$398,400
Stucco	24,900	$20	$498,000
Brick	24,900	$22	$547,800

Table 1: Total estimated cost of material using different exterior applications

By running takeoffs using Blue Beam (See Figure 4) the authors' were able to calculate the total area of the exterior which was then multiplied by the cost of material per square foot, which then gave the proposed total of $398,000 to use EIFS on the entire Technology Building. This price includes material transportation and labor costs.

Figure 4: Takeoffs of the exterior on Technology Building using BlueBeam

4.1.3. Windows

Smart Glass Technology is a glass or glazed window whose light transmission properties are altered when voltage, light, or heat is applied. When a small electrical current is applied to the ceramic layers coated on the glass, it causes lithium ions to change layers which causes the class to tint. Reversing this polarity causes the glass to clear. Simply turn a dial to apply a small amount of electricity to the glass, and it will absorb infrared light. Turn another dial, and the glass will go dark. (Shown in Figure 5 and Figure 6). The effects are substantial when using electrochromic (Lee 2007) windows. Being that the Technology Building is sitting on top of a hill overlooking Pueblo, it is the authors' recommendation to use such technology because of the long hours of sunlight the college receives throughout the year, especially during the long hot summers. While significant energy savings is a big reason to consider smart glass for the Technology building, it isn't the only benefit. Smart glass gives building occupants a connection to the natural outdoor environment by providing quality views without having to sacrifice any scenery. The openness the smart glass creates in an office environment promotes happiness, creativity, and communication, which are important aspects of good design and sustainable building. Other advantages of electrochromic windows are that it brings the heat load of the building down (Somani 2002). According to scientists at the US Department of Energy's National Renewable Energy Laboratory (NREL), windows like this could save up to 8 percent of a building's total energy consumption. These windows use only tiny amounts of electricity to switch from dark to light which translates to huge net savings overall. With that said, HVAC systems can also be smaller, reducing overall capital expenses. Improved thermal comfort and a reduction of glare for the building occupants can be achieved.

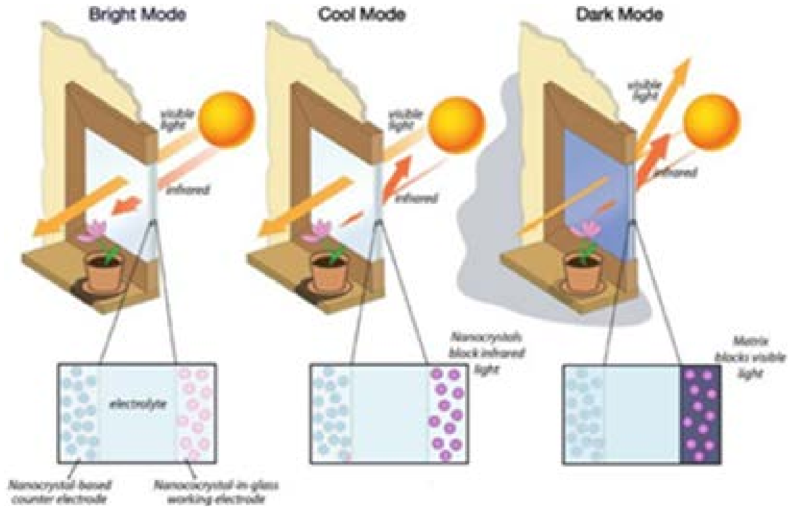

Figure 5: Smart Glass Technology effects on windows when the light transmission is altered

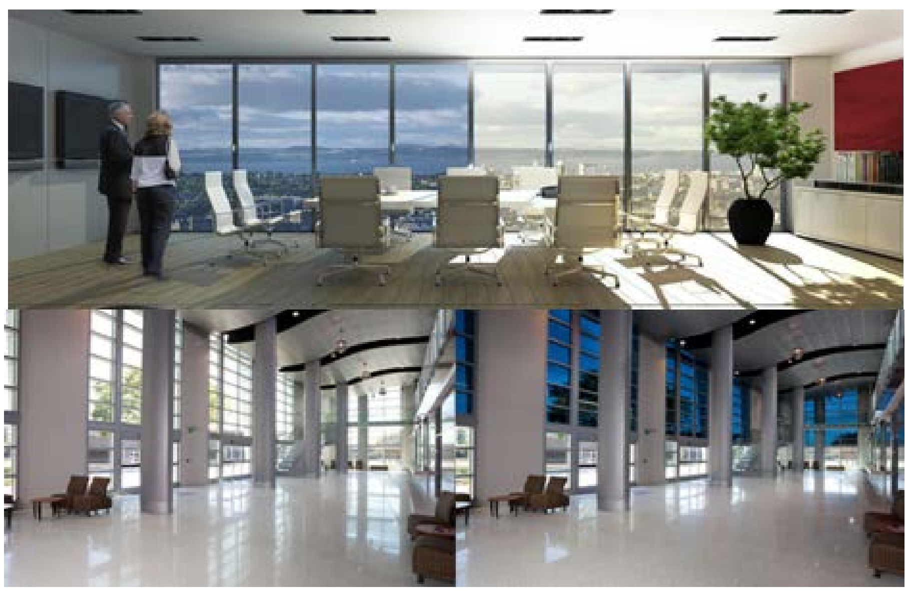

Figure 6: Before and after examples of Electrochromic Smart Glass in use

Smart glass was designed to maximize the use of natural daylight in buildings to improve the well-being of the people within. The use of smart glass on such a commercial project can help CSU-Pueblo achieve up to 37 LEED Certification Credits (Chart is shown in Figure 7). Part of those credits being one for innovative technology. By incorporating this design strategy that enhances daylight penetration with the use of smart windows, designers can additionally increase the number of occupants with exterior views. Adding smart windows and sidelights to openings built with this technology can help assist this project move forward in achieving this LEED Certification.

INTUS WINDOWS

LEED v4 SCORECHART

LEED Category	LEED Credit	Points
Energy & Atmosphere	Optimize Energy Performance	18
Materials & Resources	Building Product Disclosure & Optimization - Product Declaration	2
	Building Product Disclosure & Optimization - Material Ingredients	2
Indoor Environmental Quality	Enhanced Indoor Air Quality Strategies	3
	Indoor Air Quality Assessment	2
	Daylight	3
	Quality Views	1
	Acoustic Performance	1
Innovation	Innovation	5
Grand Total		Up to 37

* max LEED points available

Figure 7: LEED v4 Score Chart showing a total of 37 points applicable to the use of SmartGlass Technology.

4.2.0. Water Efficiency

4.2.1. Indoor Water Usage

The Technology building has four restrooms, two men and two women. In each woman's bathroom, there are four sinks and five toilets. In each men's bathroom, there are 4 sinks, 3 toilets and 3 urinals. There is a total of 16 sinks, 16 toilets, and 6 urinals. All plumbing fixtures should be WaterSense labeled or similar because WaterSense label is an EPA standard for water efficiency. The U.S. Green Building Council (USGBC), states the most often used fixtures are high-efficiency toilets and non-water urinals. If there are lower reduction needs of 20% to 30%, dual flush and high-efficiency urinals were most often selected. The fixtures to evaluate were selected out of the 2019 Wholesalers List Price Book. The toilet, urinal and faucet models selected are WETS-2002.1201 with Sloan ECOS 8111, WEUS-1000.1201 with SOLIS 8186, and EBF 615 respectively. The EBF 615 is a battery-operated model and is to be assessed with an electric hardwired model, ETF-80.

4.2.2. Outdoor Water Usage

Outdoor water reduction was considered with the methods of xeriscaping and little or no irrigation. Xeriscaping is an approach that includes efficient irrigation and native plant species to reduce outdoor water usage. Native plant species reduce outdoor water use because the species is already adapted to the climate, therefore there is no need to water the plants. Irrigation was approached by comparing drip irrigation with the conventional sprinkling system. Drip irrigation was considered because the system targets the roots of the vegetation directly and reduces the amount of runoff because over-spraying is avoided and it uses far less water than conventional sprinkler systems. A diagram of a drip irrigation system is shown in Figure 8 provided by WP Law (2016).

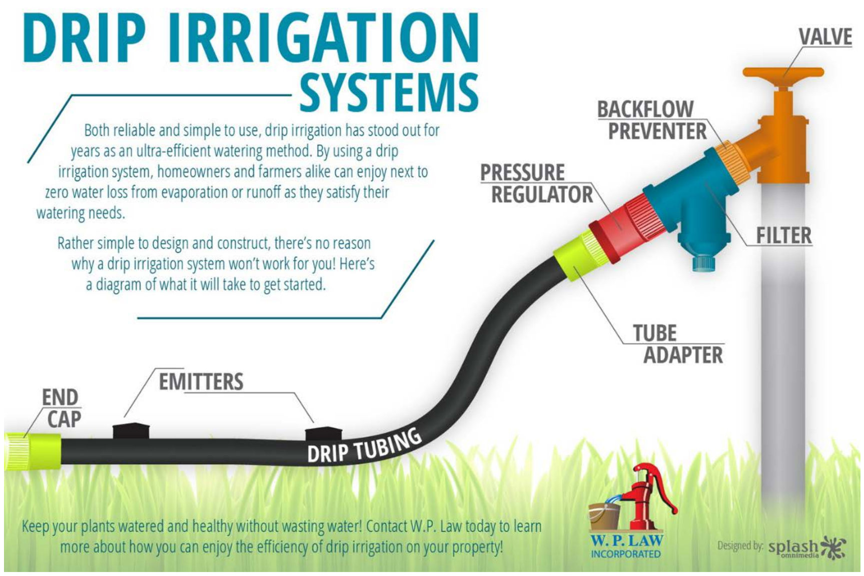

Figure 8: Drip Irrigation Systems, Diagram by WP Law, 2016

4.2.3. Water Usage

To reduce the amount of potable water, wastewater can be reused. The Technology Building does not have a system in place to reuse water. Treated wastewater can be used for toilet and urinal flushing. This will reduce the amount of potable water being used for purposes other than drinking. A type of wastewater treatment that was considered is the Living Machine. A living machine, according to Parsons Engineering Science (2001), will treat all wastewater so it can be used to flush toilets and urinals. If toilets and urinals are using reclaimed water to be flushed, that reduces the amount of water being used for purposes other than drinking. A diagram on Port of Portland's Living Machine is shown below in Figure 9, showing the indoor and outdoor cells.

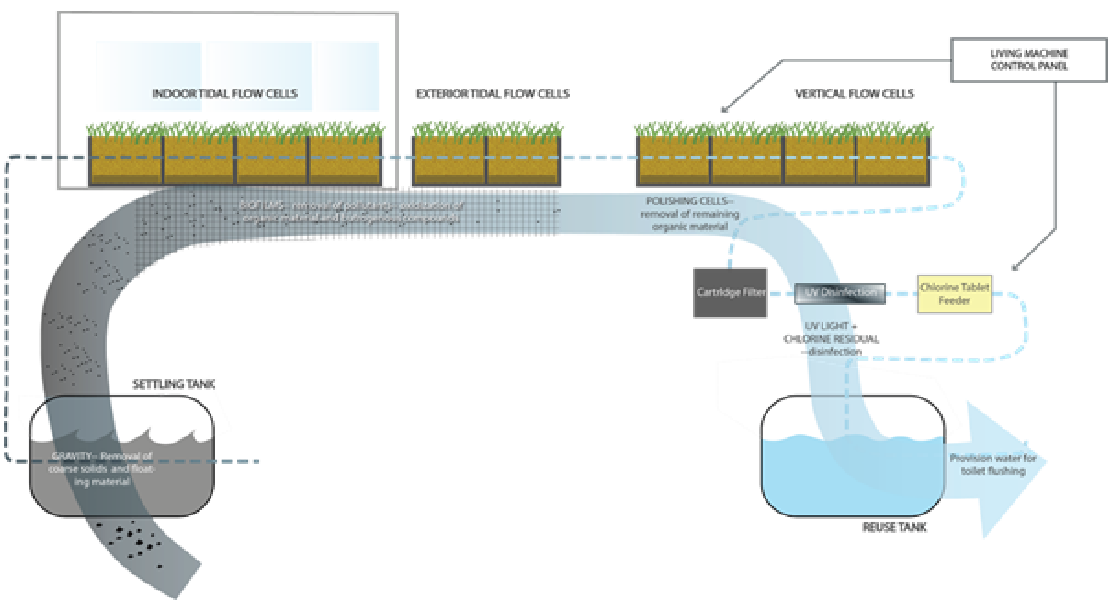

Figure 9: Port of Portland's Living Machine Diagram by Yidan, Tamara, and Pure, 2016

The U.S. EPA compared a living machine to a conventional wastewater system. The Present Worth Comparison Of "Living Machines" and Conventional Systems table shows the cost of living machines with and without a greenhouse to a conventional wastewater system depending on the gallons used per day. Table 2 shows the Living Machine without a greenhouse costs less than the Living Machine with a greenhouse and a Conventional system. The unit gpd is gallons per day. The table also shows the price of different gpd.

Process	40,000 gpd	80,000 gpd	1 million gpd
"Living Machine" with greenhouse	$1,077,777[1]	$1,710,280[1]	$10,457,542[2]
"Living Machine" without greenhouse	$985,391	$1,570,246	$9,232,257
Conventional System	$1,207,036[1]	$1,903,751[1]	$8,579,978[2]

(1) Cost difference is less than 20 percent
(2) Cost difference is greater than 20 percent

Source: U.S. EPA, 2001.

Table 2: Present Worth Comparison of "Living Machine" and Conventional Systems by U.S. EPA, 2001

The EPA states the Living Machine can treat wastewaters many needs to BOD5, TSS, and more. Also, the Living Machine is aesthetically pleasing. The Port of Portland Headquarters has a Living Machine which is indoors and outdoors. Figure 10 shows a living machine can be aesthetically pleasing indoor and outdoor. The EPA also states the disadvantages to having the Living Machine are it only removes about 50 percent of influent phosphorus and it requires a greenhouse for reliable operation in cold weather of more temperate climates.

Figure 10: Exterior (Left) and Interior (Right) Flow Cells from Port of Portland Case Study, 2013

4.4.0. Indoor Environmental Quality

Intelligent controllers provide solutions for building automation as well as creating a healthy environment. BAS's also fulfill indoor environmental quality credits because the system design usually includes economizers to implement outdoor air supply. Because LEED is a certification above the bare minimum (in this case being ASHRAE standards), things such as timers and CO2 sensors can be tuned to keep air filtered, thereby eliminating the possibility of sick building syndrome. Lighting is another area of the building that contributes greatly to occupancy health, it also contributes greatly to power consumption. In fact, LEED cited lighting power as the largest electricity consumer in commercial buildings (LEED GA v4.1). Remedies to excessive power consumption in buildings result in addressable light controls, changes to color temperature, and regulated daylight.

5.0.0. Findings

5.1. Battery vs. Electric

Touchless faucets are useful for conserving water. Because the water shuts off automatically, this can dramatically cut down on water waste and reduce the risk of sink overflow caused by the faucet being left on. Some benefits to the electric hardwired faucet are that sensor taps would pour 10L to 15L per minute, while the other type would not use more than 6L. This practice can benefit the environment more if the power comes from a renewable source and if further restraints are made in the system to control the outflow of water. A disadvantage to the electric operation is that if the building loses power, it can cause the faucets to stop working. Battery-powered faucets are beneficial because both are the same as the electric in every way in saving water consumption and efficiency. Another disadvantage to the battery-powered is that batteries are replaceable often. The battery-powered is good because if the power happens to go out the faucets will continue to work. The most common one used for buildings like this is the electric type. The electric faucet is the most commonly used because both are easy to install and there is hardly any maintenance required. Even though each option is useful the electric faucet is the best option for the job. Therefore the EBF 615 battery powered is not considered, instead, the ETF-80 hardwired model will be considered.

5.2. Water Efficiency

5.2.1. Indoor Water

The Water Resource category will affect the overall use of potable water in the Technology Building. The authors' final decision on water efficiency for indoor use is to use efficient fixtures for the toilets, urinals, and faucets. The total number of fixtures are shown in *Table 3*. The total number of fixtures were found by counting each fixture and recorded in a spreadsheet.

	Men	Women	Total
Number of Bathrooms:	2	2	4
# of Sinks:	4	4	16
# of Toilets:	3	5	16
# of Urinals:	3	0	6

Table 3: Number of Fixtures, table made in Excel

The cost of the fixtures based on the list price is shown in Table 4. The total cost for all fixtures is found by multiplying the total amount of each fixture by the List Price found in the Wholesalers List Price Book.

Efficiency	Model	List Price:	Cost for all fixtures
1.6/1.1 gpf	WETS-2002.1201 w/ Sloan ECOS 8111	$817.15	$13,074.40
0.125 gpf	WEUS-1000.1201 w/SOLIS® 8186	$958.95	$5,753.70
0.35 GPM	ETF-80	$ 752.65	$12,042.40
		Total	$30,870.50

Table 4: List Cost of Fixtures made in Excel Spreadsheet

5.2.2. Outdoor Water

The decision on outdoor water use is to focus on more efficient irrigation and landscaping by using native plants, and drip-irrigation to avoid excessive use from runoff. The EPA has a study on the types of irrigation, which states that a conventional sprinkler system has an initial cost, low and high, of $1,540.00 and $2,240.00 respectively. The total annual costs over its low lifespan of 20 years and high lifespan of 12 years are $1,371.73 and $1,408.93 respectively. A sub-surface drip irrigation system has an initial cost, low and high, of $1,707.00 and $2,029.89 respectively. The total annual costs over its low lifespan of 25 years and high lifespan of 20 years are $445.95 and $504.77 respectively.

The drip irrigation system may have a greater initial cost however over its lifetime there is a lowercost annual cost which makes the drip irrigation system's total cost cheaper than the conventional sprinkler system. The data and results are shown in Table 5. The Initial Cost, Annual Cost over Lifetime, and Life Time are from the EPA case study.

	Conventional Sprinkler System		Drip Irrigation System	
	Low	High	Low	High
Initial Cost	$1,540.00	$2,240.00	$1,707.00	$2,029.89
Annual Cost over lifetime	$1,371.73	$1,408.93	$445.95	$504.77
Life Time (year)	20	12	25	20
Total Cost	$28,974.60	$19,147.16	$12,855.75	$12,125.29

Table 5: Irrigation Comparison made in Excel Spreadsheet

5.2.3. Water Usage

The final decision for the Water Resource category is to use The Living Machine to reduce the amount of potable water consumption by using reclaimed wastewater for flushing toilets and urinals. Based on the Port of Portland Headquarters' case study on the Living Machine, the system capacity is 5,000 gpd of a 200,000 square foot headquarters building. The area of the Technology Building which is about 29,600 square foot was found by using the website Mapdevelopers' area finder (See Figure 16). By comparing the Port of Portland's system capacity and size of the building to the Technology Building, a living machine of similar criteria will support the size of the Technology building with ease. If the price of a 40,000 gpd system is $1,077,777, the worth of the Living Machine for the technology building could be less than the worth of a Living Machine with a greenhouse.

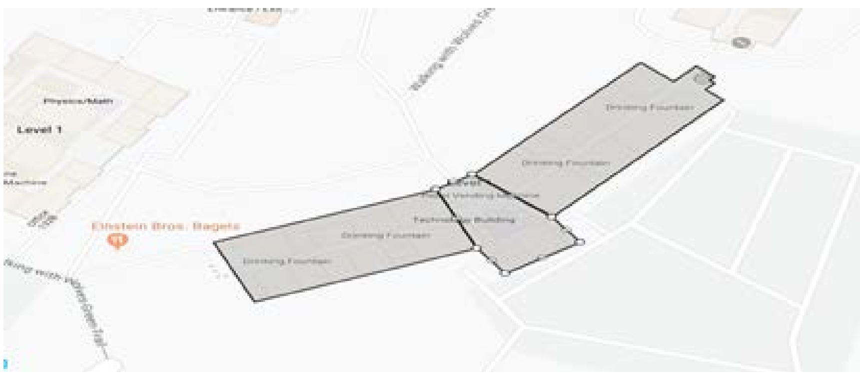

Figure 16: Technology outline from mapdevelopers.com

A Living Machine needs a greenhouse when the climate is too cold, which is why the Technology Building should install a Living Machine similar to the Port of Portland Headquarters interior and exterior Living Machine. Having the fragile part of the Living Machine inside of the building removes the need for a greenhouse.

6.0.0. Conclusion

This research considered synergy at a very early stage of projects (i.e. Feasibility and This research considered synergy at a very early stage of projects (i.e. Feasibility and Programming stage) to encourage stakeholders and decision-makers involvements to have a more collaborative environment with fewer budget constraints. Typically, changes at this stage are expected and have fewer impacts on the budget; more so, participants are more resilient to new ideas. Therefore, this research studied new ideas and materials that are rarely utilized in commercial buildings (i.e. educational buildings) to develop more eco-friendly and sustainable buildings. The effort will lead to transforming the way buildings and communities are designed, built, and operated, enabling an environmentally and socially responsible, healthy, and prosperous environment that improves the quality of life.

The research is used to gain a better insight into the possibilities for improvement of the Technology Building at CSU-Pueblo as an educational case study building. It was approached to produce generalized concepts and conclusions by gathering documents and reports for the most useful materials, items, and ideas to compare them to their pay-back periods. The LEED categories were the vehicle to drive the research study to evaluate the tradeoff of materials against credit points while considering the project's budget at an early stage. Furthermore, multiple iterative processes were incorporated into a high level of integrative process to refine the outcome and collaborate with subject matter experts. This approach helped to provide a more efficient methodology and eliminated unnecessary overlaps and inefficiency.

7.0.0. References

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