Implementation of Energy and Water Saving Measures On An Office Building

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INTRODUCTION

The transportation sector is often blamed for its large contribution to global warming and other environmental issues, though the construction sector also has contributed plenty in the past few decades. There are assortments of methods to get the footprint down, they are often not enforced because of the extra costs which get deemed unnecessary as many projects already have very tight budgets. The Construction sector comprises establishments engaged in constructing, renovating, and demolishing buildings and other engineering structures. The sector includes contractors in commercial, residential, highway, and heavy industrial (e.g., tunnels, airports, and dams) and municipal utility construction (e.g., wastewater treatment plants) [1]. This accounts for about 76% of electricity use and 40% of all U.S. primary energy use and associated greenhouse gas emissions [2], making it essential to reduce energy consumption in buildings to meet national energy and environmental challenges. Specifically, office buildings often do not take advantage of opportunities to generate energy onsite with a national average of 1% [3].

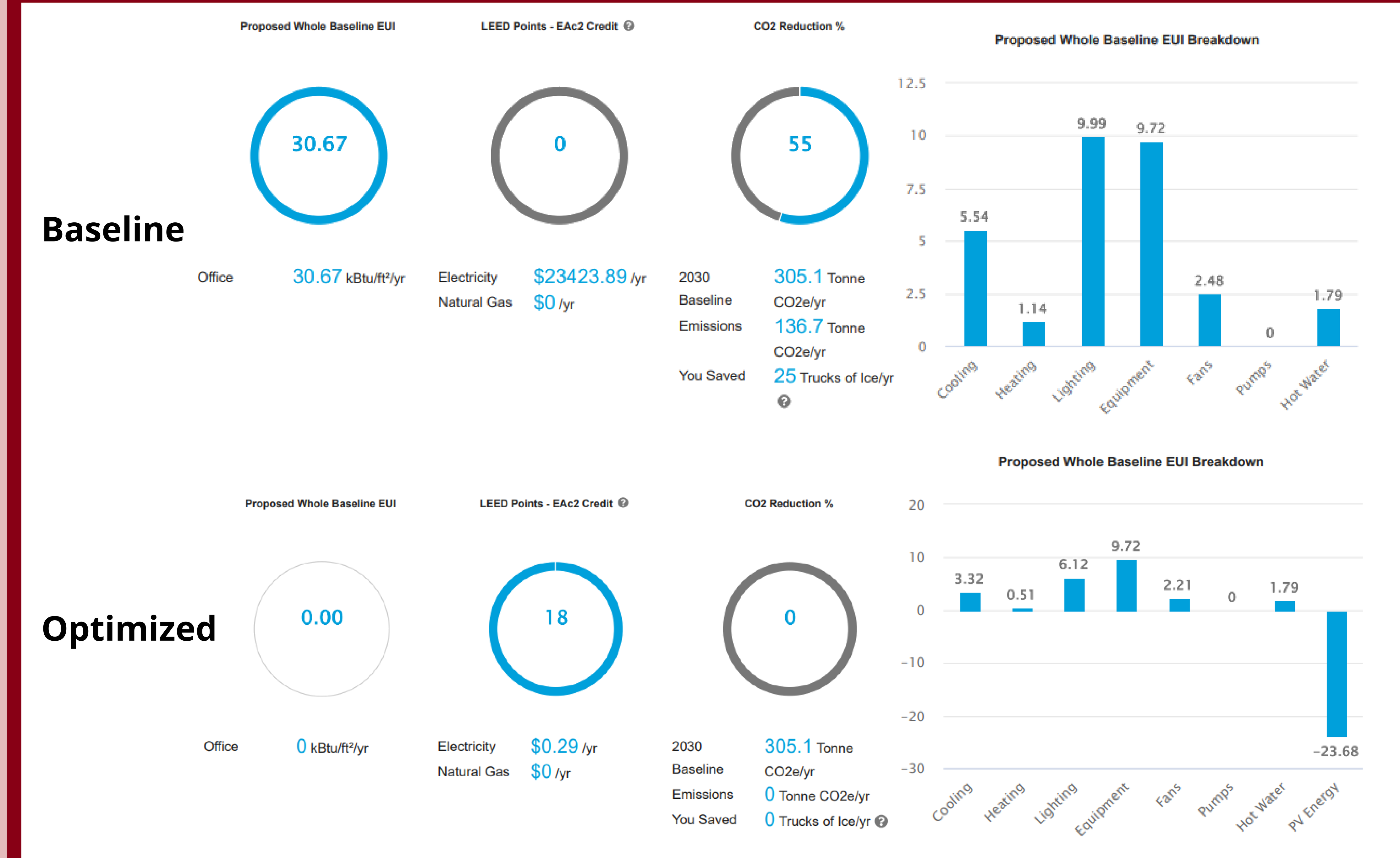
SUMMARY

This research was being conducted to display the potential effects of different methods of saving and reclaiming energy and water on the operation costs of buildings and the effects on the environment. The original data collected during this study uses software known as cove.tool to create realistic predictions on the original footprint of a building and the effect of sustainable changes made to the building based on a building's location, climate, age, and current construction properties such as envelope and the HVAC systems in place. The software will further offer estimates on the costs to carry out these changes. The software is limited, however. Water Calculations were done by hand as cove.tool could not do them.

METHODOLOGY

Using DBR's database of past projects, a building was chosenI chose a building after filtering for specific conditions such as age and if it was possible to access a full set of drawings for the building. Other factors taken into consideration included the type of building, its size, and occupancy. The next step was to decide what changes would be reasonable considering the building's properties and determine the feasibility of those adjustments. The changes considered reasonable for this project were implementing low flow rate pipes and rain water reclamation for water savings, and optimizing the building's envelope (walls/roof/window), picking out a high-efficiency HVAC system, and updating the lighting system in place in the building for Energy savings. Then the next step would be to run two energy models. The first would collect the baseline data from the building before these changes and the second would implement these changes and compare the results. Because the software could not calculate the water savings, they were done by hand. By first calculating the yearly total of water that the building would use, it gave us an estimate of the original water usage. Then the calculations were repeated, taking into consideration low flow fixtures. Then one last calculation was done for the rainfall harvesting. After all the data was compiled, then it was possible to compare all the data and determine whether these changes were feasible or if another path should have been taken.

ENERGY SAVINGS



WATER SAVINGS

BASELINE FIXTURES FOR WATER SAVINGS

FIXTURE	USAGE RATE	TIME PER USE (SECONDS)	USES PER DAY PER OCCUPANT MALE	USES PER DAY PER OCCUPANT FEMALE	NUMBER OF OCCUPANTS MALE	NUMBER OF OCCUPANTS FEMALE	DAILY USE PER FIXTURE (GALLONS) MALE	DAILY USE PER FIXTURE (GALLONS) FEMALE	DAILY USE PER FIXTURE (GALLONS) COMBINED
WATER CLOSET	1.60	--	1.00	5.00	268.50	268.50	429.60	2,148.00	2,577.60
URINAL	1.00	--	4.00	--	268.50	268.50	1,074.00	-	1,074.00
LAVATORY	0.50	20	5.00	5.00	268.50	268.50	223.75	223.75	447.50

TOTAL DAILY USE 4,099.10 GALLONS
DAYS PER YEAR 365
YEARLY TOTAL 1,496,171.50 GALLONS

LOW FLOW FIXTURES

FIXTURE	USAGE RATE	TIME PER USE	USES PER DAY PER OCCUPANT MALE	USES PER DAY PER OCCUPANT FEMALE	NUMBER OF OCCUPANTS MALE	NUMBER OF OCCUPANTS FEMALE	DAILY USE PER FIXTURE (GALLONS) MALE	DAILY USE PER FIXTURE (GALLONS) FEMALE	DAILY USE PER FIXTURE (GALLONS) COMBINED
WATER CLOSET	1.1	--	1.00	5.00	268.50	268.50	295.35	1,476.75	1,772.10
URINAL	0.125	--	4.00	--	268.50	268.50	134.25	-	134.25
LAVATORY	0.25	20.00	5.00	5.00	268.50	268.50	111.88	111.88	223.75

TOTAL DAILY USE 2,130.10 GALLONS
DAYS PER YEAR 365.00
YEARLY TOTAL 777,486.50 GALLONS

WATER SAVINGS 718,685.00 GALLONS
51.97% REDUCTION

RAINWATER HARVESTING

TOTAL ROOF AREA (SQFT)	RAINFALL (IN/YR)	RAINY DAYS PER YEAR
28,950.00	44.70	81.00

RAINFALL HARVESTED PER YEAR

ROOF AREA	RAINFALLY/YEAR (FT)	CONVERSION (CBFT TO GAL)	TOTAL (GAL)
28,950.00	3.73	7.50	808,790.63

USING HARVESTED RAINWATER FOR TOILET/URINAL FLUSHING, THE ONLY MUNICIPAL WATER WE WOULD REQUIRE IS FOR LAVATORIES.

YEARLY LOW FLOW LAVATORY USE 81,668.75 GAL

TOTAL WATER SAVINGS WITH RAINWATER HARVESTING 1,414,502.75 GALLONS
94.54% REDUCTION

FINDINGS

WATER SAVINGS

The initial water use was calculated to be 1,496,171.50 gallons per year, with an annual cost of $12,337.50. With the low flow rate fixture, the annual water usage decreased to 777,486.50 gallons per year, with an annual cost of $5,926.28. Then, after taking into consideration the water collected from rain water harvesting, that number decreased down to 81,668.75 gallons per year, with an annual cost of $673.44 yearly. This was an overall saving of $11,663.99. The only money being spent was to get water to supply the Lavatories, as it was not possible to distill water on the site. The payback was around 5 to 6 years, which is considered exceptionally efficient.

ENERGY SAVINGS

From the cove.tool predictions, the annual electricity cost of the building was $23,423.89 using 30.6 kBtu/ft2/year. with annual emissions of 136.7 tonnes of CO2. The building after the envelope and HVAC system were made more efficient and the solar panel array was added had significant changes. The office used 0 kBtu/ft2/year from the grid and paid only $0.29 every year on electricity. It also had no emissions and is net zero. The payback was around 10 years, which is efficient for this type of renovation.

DISCUSSION

This study only focussed on a single office building in one region of the world. It was also a relatively small building so the changes being made to it were not as taxing as some larger buildings. For example, a research center or a lab of some sort would have had different limitations that might have prevented some changes from being made. It also did not explore all the options that could have been implemented but only the ones that were most effective for this office building. A more in depth analysis of all possible options would have been an ideal but it was not possible at this stage. The research also attempted to get energy usage and water reclamation as high as possible which might not always be optimal when considering price limitations.

IMPLEMENTATION PAYBACK

Water savings:
The final cost for implementing the water savings plan is an estimate of $67,200.00. This consists of about $11,200.00 for new piping at $27.92 per foot, $38,000.00 for a cistern to hold rainwater, and $18,00.00 for filter equipment and a pump. Though this seems costly at first considering the savings of $11,663.99 each, this has a payback period of only 5.76 years which is extremely efficient.

Energy Savings:
The final cost for implementing the energy savings and envelope changes is an estimate of $572,394.91. This is compromised of the following. Upgrading walls from R-11.9 to R-19.4 would cost $59,845.00 and pay itself off in about 22 years. Upgrading windows from U-0.57 and SHGC 0.25 to U-0.22 and SHGC 0.26 would cost $8,676.00 and pay itself off in about 35 years. Upgrading the system from baseline (VAV) to a DOAS/VRF combo would cost $27,923.91 and pay itself off in about 22 years. Upgrading lights from 1.11 W/sqft to 0.56 W/sqft with all LED would cost $64,200.00 and pay itself off in about 19 years. Lastly, photovoltaics are always costly, at $411,750.00 for 164.70 kW which has a pay back of around 9 to 10 years which is still pretty efficient.

REFERENCES

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