Carver County Government Center Exterior Lighting Improvement

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Prepared on Behalf of
Carver County

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CARVER COUNTY

Resilient Communities Project

UNIVERSITY OF MINNESOTA
Driven to Discover℠

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This publication may be available in alternate formats upon request.

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Introduction

Carver County was selected as the winner of the Resilient Communities Project, the county is trying to initiate different projects to develop various areas from housing opportunities to alternative transportation and community engagement.

Using renewable energy to provide electricity reduces non-renewable energy consumption and can significantly lower the energy costs of operating the Carver County government building. The project is about identifying key aspects of the design and implementation of solar lighting or not, and the feasibility of installing that at the Carver County government building for a cost that will be determined along the project.

Project scope

This project involves a collaboration between Carver County and our group of five students with the ultimate goal of switching all exterior lights at the Carver County government building and try to utilize solar radiation as a form of energy to provide light for the parking lots and entryways.

We considered three different approaches for this project

- The first approach is about switching the current metal halide light bulbs to LED bulbs. This option will probably be the cheapest since no modification on the current infrastructure is required.

Solar photovoltaic panels can be applied in this project to produce electricity for the exterior lighting. We will study and compare different kinds of solar panels in order to choose the most efficient method of applying renewable energy which brings us to the two other options:

- The second approach we are considering is adding to the first approach solar PV panels to produce energy. This option is going to be pricier and its feasibility depends on the area and roof space available in the buildings.
- The third approach that will be considered involves the first and the second approach in addition to the the removal of the current light fixtures in favor of updating to energy efficient LED bulbs. Although this plan may have even more initial costs than the second option, the LED bulbs can last for a much longer period of time than normal fixtures as well as consume about a third of the energy.

All costs will be studied in the project to show the efficiency of LED bulbs and using the solar panels from both energy and cost perspectives.

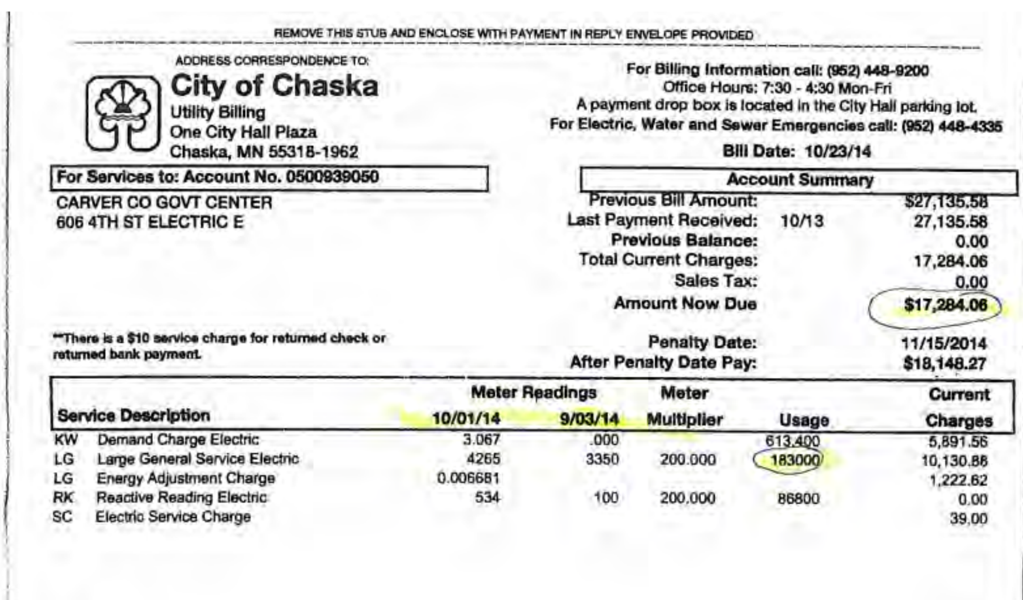
Project objectives

One of our main objectives is to investigate closely the different options we are considering for updating the outdoor lighting in the parking lots at the Chaska Government Center

As shown in our options, our top priority is using LED bulbs and utilizing solar energy to save energy and money.

Insight at the utility bills cost

Annually, the government building spends thousands of dollars on energy bills, so any offset of costs via renewable energy will lead to a relatively quick return on investment. We anticipate that developing a solar-powered exterior lighting system will be a much better alternative to the current and outdated lights.


REMOVE THIS STUB AND ENCLOSE WITH PAYMENT IN REPLY ENVELOPE PROVIDED

ADDRESS CORRESPONDENCE TO:
City of Chaska
Utility Billing
One City Hall Plaza
Chaska, MN 55318-1962

For Billing Information call: (952) 448-9200
Office Hours: 7:30 - 4:30 Mon-Fri
A payment drop box is located in the City Hall parking lot.
For Electric, Water and Sewer Emergencies call: (952) 448-4335
Bill Date: 10/23/14

For Services to: Account No. 0500939050
CARVER CO GOVT CENTER
606 4TH ST ELECTRIC E

Account Summary

Previous Bill Amount:		$27,135.58
Last Payment Received:	10/13	27,135.58
Previous Balance:		0.00
Total Current Charges:		17,284.06
Sales Tax:		0.00
Amount Now Due		$17,284.06
Penalty Date:		11/15/2014
After Penalty Date Pay:		$18,148.27

**There is a $10 service charge for returned check or returned bank payment.

Service Description		Meter Readings 10/01/14	9/03/14	Meter Multiplier	Usage	Current Charges
KW	Demand Charge Electric	3.067	.000		613.400	5,891.56
LG	Large General Service Electric	4265	3350	200.000	183000	10,130.88
LG	Energy Adjustment Charge	0.006681				1,222.62
RK	Reactive Reading Electric	534	100	200.000	86800	0.00
SC	Electric Service Charge					39.00

Operating schedule times

Since the number of hours when the lights are on depend on the seasons besides the sunrise and sunset times vary according to the day and based on the data provided we decided to average when the lights are on using a month numbers from each season.

Winter season: December
Number of hours: 15

12/6/2015	7:36	16:32	2	7:38	16:32	8:53	15:07
12/7/2015	7:37	16:32	2	7:39	16:32	8:52	15:08
12/8/2015	7:38	16:32	2	7:40	16:32	8:51	15:09
12/9/2015	7:39	16:32	2	7:41	16:32	8:50	15:10
12/10/2015	7:40	16:32	2	7:42	16:32	8:49	15:11
12/11/2015	7:41	16:32	2	7:43	16:32	8:48	15:12
12/12/2015	7:42	16:32	2	7:44	16:32	8:48	15:12
12/13/2015	7:42	16:32	2	7:44	16:32	8:47	15:13
12/14/2015	7:43	16:32	2	7:45	16:32	8:46	15:14
12/15/2015	7:44	16:32	2	7:46	16:32	8:45	15:15
12/16/2015	7:45	16:32	2	7:47	16:32	8:45	15:15
12/17/2015	7:45	16:32	2	7:47	16:32	8:44	15:16
12/18/2015	7:46	16:33	2	7:48	16:33	8:44	15:16
12/19/2015	7:47	16:33	2	7:49	16:33	8:44	15:16
12/20/2015	7:47	16:33	2	7:49	16:33	8:43	15:17
12/21/2015	7:48	16:34	2	7:50	16:34	8:44	15:16
12/22/2015	7:48	16:34	2	7:50	16:34	8:43	15:17
12/23/2015	7:49	16:35	2	7:51	16:35	8:44	15:16
12/24/2015	7:49	16:35	2	7:51	16:35	8:43	15:17
12/25/2015	7:50	16:36	2	7:52	16:36	8:44	15:16
12/26/2015	7:50	16:37	2	7:52	16:37	8:45	15:15
12/27/2015	7:50	16:37	2	7:52	16:37	8:44	15:16
12/28/2015	7:51	16:38	2	7:53	16:38	8:45	15:15
12/29/2015	7:51	16:39	2	7:53	16:39	8:46	15:14
12/30/2015	7:51	16:39	2	7:53	16:39	8:46	15:14
12/31/2015	7:51	16:40	2	7:53	16:40		
						Average time on	15:12

Summer season: June
Number of hours: 8

6/6/2015	5:28	20:56	2	5:30	20:56	15:27	8:33
6/7/2015	5:27	20:56	2	5:29	20:56	15:27	8:33
6/8/2015	5:27	20:57	2	5:29	20:57	15:28	8:32
6/9/2015	5:27	20:58	2	5:29	20:58	15:29	8:31
6/10/2015	5:27	20:58	2	5:29	20:58	15:30	8:30
6/11/2015	5:26	20:59	2	5:28	20:59	15:31	8:29
6/12/2015	5:26	21:00	2	5:28	21:00	15:32	8:28
6/13/2015	5:26	21:00	2	5:28	21:00	15:32	8:28
6/14/2015	5:26	21:01	2	5:28	21:01	15:33	8:27
6/15/2015	5:26	21:01	2	5:28	21:01	15:33	8:27
6/16/2015	5:26	21:02	2	5:28	21:02	15:34	8:26
6/17/2015	5:26	21:02	2	5:28	21:02	15:34	8:26
6/18/2015	5:26	21:02	2	5:28	21:02	15:34	8:26
6/19/2015	5:26	21:03	2	5:28	21:03	15:35	8:25
6/20/2015	5:26	21:03	2	5:28	21:03	15:35	8:25
6/21/2015	5:26	21:03	2	5:28	21:03	15:34	8:26
6/22/2015	5:27	21:04	2	5:29	21:04	15:35	8:25
6/23/2015	5:27	21:04	2	5:29	21:04	15:35	8:25
6/24/2015	5:27	21:04	2	5:29	21:04	15:35	8:25
6/25/2015	5:27	21:04	2	5:29	21:04	15:34	8:26
6/26/2015	5:28	21:04	2	5:30	21:04	15:34	8:26
6/27/2015	5:28	21:04	2	5:30	21:04	15:33	8:27
6/28/2015	5:29	21:04	2	5:31	21:04	15:33	8:27
6/29/2015	5:29	21:04	2	5:31	21:04	15:32	8:28
6/30/2015	5:30	21:04	2	5:32	21:04		
						Average time on	8:29

Fall season:
Number of hours: 13

10/3/2015	7:15:46	18:50:13	11:33:13	12:26:47
10/4/2015	7:17:00	18:48:21	11:30:07	12:29:53
10/5/2015	7:18:14	18:46:29	11:27:01	12:32:59
10/6/2015	7:19:28	18:44:38	11:23:56	12:36:04
10/7/2015	7:20:42	18:42:48	11:20:51	12:39:09
10/8/2015	7:21:57	18:40:58	11:17:46	12:42:14
10/9/2015	7:23:12	18:39:09	11:14:42	12:45:18
10/10/2015	7:24:27	18:37:21	11:11:39	12:48:21
10/11/2015	7:25:42	18:35:34	11:08:36	12:51:24
10/12/2015	7:26:58	18:33:47	11:05:33	12:54:27
10/13/2015	7:28:14	18:32:01	11:02:31	12:57:29
10/14/2015	7:29:30	18:30:16	10:59:29	13:00:31
10/15/2015	7:30:47	18:28:32	10:56:28	13:03:32
10/16/2015	7:32:04	18:26:49	10:53:28	13:06:32
10/17/2015	7:33:21	18:25:08	10:50:30	13:09:30
10/18/2015	7:34:38	18:23:27	10:47:31	13:12:29
10/19/2015	7:35:56	18:21:47	10:44:33	13:15:27
10/20/2015	7:37:14	18:20:08	10:41:36	13:18:24
10/21/2015	7:38:32	18:18:30	10:38:39	13:21:21
10/22/2015	7:39:51	18:16:54	10:35:45	13:24:15
10/23/2015	7:41:09	18:15:18	10:32:50	13:27:10
10/24/2015	7:42:28	18:13:44	10:29:56	13:30:04
10/25/2015	7:43:48	18:12:12	10:27:05	13:32:55
10/26/2015	7:45:07	18:10:40		
			Average time on	12:52:38

Package One

When the Chaska Government Center asked about the possibility of adding solar panels to their parking lots to control their exterior lighting and cut down on their energy consumption, a three-part project was developed to investigate how individual aspects of their request could be broken down into different option packages that could show how energy savings at the Government Center could be achieved with any budget.

The first phase of the three-part package was to convert all of the light bulbs that are currently used in the exterior fixtures into LED. The thinking behind this option package is mainly cost-oriented: it would cost a lot less to replace light bulbs than to install solar panels and connect them to possible brand new light fixtures on the exterior. Also, the data collected from this option package would be applicable to the other packages where the savings calculated from light bulb conversions would drop into the calculations regarding the energy requirements of the solar panels and cost analyses.

The lighting currently in use on the exterior of the Chaska Government Center consists of high pressure sodium (HPS) and metal halide (MH) bulbs. These bulbs were the staple used in the 1990s and 1980s for parking lot lights because they were capable of high-lumen output within a bulb that was very inexpensive. However, the technology is very dated, and the benefits from both energy and longevity standpoints of using LED bulbs clearly outweigh the inexpensive upfront cost of MH and HPS bulbs.

Through the conversion of all light bulbs to LED technology, this package showed initially that the lifespan of the bulbs would double in the case of HPS and triple in the case of MH bulbs. This equates to significantly less waste of bulbs, and the conversion to LED would also eliminate the need to recycle mercury as in the case of the current bulbs. Furthermore, LED technology doesn't lead to the "lumen fade" effect, the term coined for the gradual decrease in light brightness as the bulb is illuminated over time. M[1]H and HPS bulbs experience severe lumen fade within less than half of their lifespan, as shown in Figure 1 below.

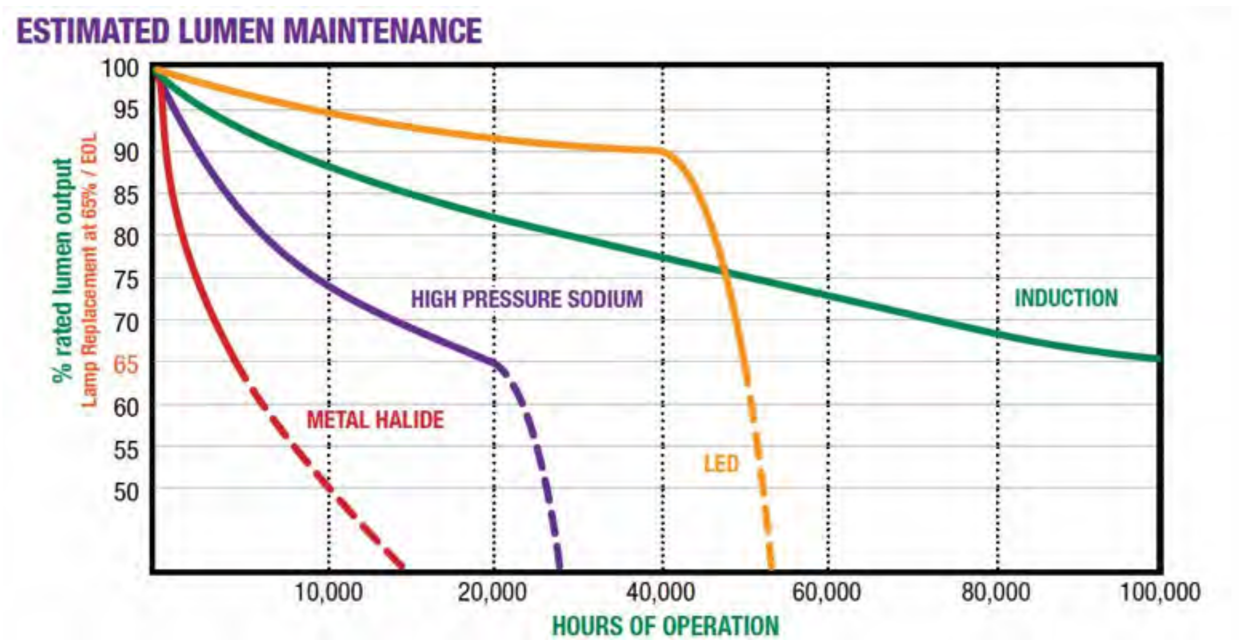


Figure 1: Graph[1] showing the dramatic decrease in lumen output of various bulb types over time.

The dotted line portion of each lifespan above shows the point at which the brightness is significantly degraded to a point that would not allow for adequate operation; it is at this point where 65% of the light output is remaining, and many consumers replace the bulbs assuming they were close to being at the end of their life. With LED bulbs, 90% of the lumen availability is retained well into the last 10,000 hours of life, meaning that there will be no substantial premature degradation of light output.

As mentioned earlier, there is a large savings in energy when utilizing LED bulbs in place of MH and HPS bulbs. To calculate the savings in energy, it is first important to determine the amount

[1] Induction Lighting: The Go-To Solution for Maintenance-Free Energy-Efficient Lighting." - *Current Information and Articles about Renewable Energy and LEED from Your Advocates at BCX Energy*. Chris Reich, 4 Apr. 2011. Web. 28 Nov. 2015.

of time the bulbs remain illuminated during one year's time. Once these average illumination times have been determined (see the *Introduction* for details), a series of calculations follow that take into account the off-peak summer price per kWh of \$0.06181/kWh[2] and the off-peak price of \$0.05666/kWh[2] for the rest of the year (lights are on at night, hence the assumption of off-peak energy usage). Using the data provided by the City of Chaska of the wattage of each light and the quantity of each light, it is possible to determine the total kWh used by just the exterior lights over one year's time with the current light bulbs: 84,536.27 kWh. The cost of these bulbs is extraordinarily inexpensive; taking into consideration the cos t of each individual bulb and the amount of time they can be illuminated before they require replacement, the total cost for these bulbs on a per-year basis totals \$10.03.[3] Factoring the varied electric cost for the seasons and the \$10 bulb cost, the total cost to run these lights for a year totals \$4,914.75.

Similarly, the amount of energy used by the proposed LED bulbs can be calculated using the same assumptions as described above. The energy savings, as expected, is about a fourth of the MH and HPS system currently in use; the total cost to operate a system completely run off of LED bulbs would total \$1,345.51/year plus an additional \$312.13[4] for the bulbs[2] (based off of their longevity and the amount of time they are illuminated). Comparing these two types of systems, converting the bulbs to LEDs would pay for itself within 5 years and the bulbs would only need to be replaced about once every 12 years.

While the economic implications have been discussed in previous sections, environmental impacts of converting to LED would lead to a lot less waste since the bulbs wouldn't need to be replaced as often as the MH and HPS bulbs. Furthermore, LED bulbs do not have any mercury (unlike MH and HPS bulbs), so the costs of recycling LED bulbs would require less processing and no hazardous material recycling. Social impacts of MH and HPS light bulbs include the dramatic lessening of waste due to the longevity of the bulbs as well as the lower requirement of energy in order to operate the outdoor lights. Otherwise the public viewpoint of the Chaska Government Center will be improved with the installation of more energy-efficient bulbs and the decrease of their carbon footprint.

Package Two

As it's mentioned in previous parts Chaska government annually pays a huge amount of money for their electricity bills, which also means the tremendous amount of energy they consume just for providing electricity. In package one, we worked on possibilities in order to decrease the energy use and costs. But even after switching all bulbs to LED bulbs, the site is still dependent on nonrenewable energy sources. In this package, we've proposed that not only reducing energy usage and cost are important, but also it should be considered that we don't have endless amount of fuel energy. We need to save more and more, as well as providing energy for our demands, and actually for the next generations, from the renewable energy sources like sun, wind, biofuels, etc. The source of energy that city of Chaska and we as a group

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[2] Light Efficient Design. *LED for HID Retrofit*. Cary: Light Efficient Design, 2013. Print.

picked is solar energy as a renewable, clean, and reliable source. Although PV panels have some issues like changing the weather and pollution rate can affect the efficiency, it seems it's still the most practical option for this project. Another issue that people can't neglect is initial costs for installing panels. In this part it's shown that even from cost perspective, the renewable sources bring health, productivity, and efficiency to the project.

Design Process of Solar PV Panels:

According to the results of package one, annual energy use to provide electricity for exterior **LED bulbs is 23,143 Kwh**. We've already achieved the great reduction compared to the energy use of **existing bulbs which is 84, 536 Kwh,** but the next step is combination of using LED bulbs and solar PV panels. Design process of installing PV panels tells us that for providing this much energy, **the area that is needed is about 2200 sqft.** The huge amount of roof area of different buildings in the site is available to apply PV panels. However, in terms of efficiency, distance between panels and exterior lightings is important. So, we chose those parts of the roofs which are closer to our parking lots and exterior lightings because energy in long distance transmission will be lost.

Selected Roofs of City of Chaska government center

Next important step is selecting the most applicable and efficient type of solar panel. Based on all research studies done in the group, the following options are selected:

- Monocrystalline Silicon (Single Silicon)

Right now, these are the most efficient types of solar panels In other words, when sunlight hits these panels, more of it turns into electricity than the other types below. As a result of their high silicon content, they're also more expensive, but you need fewer of them. That's why they're ideal for roofs. You can tell if you have a monocrystalline solar panel by its square-ish cells[1]

- Polycrystalline Silicon (Multi-silicon)

"Poly" panels have lower silicon levels than "mono" panels. In general, that makes them less expensive to produce, but they're also slightly less efficient. The good news is that their overall construction design can often make up for the efficiency loss, so they're also good for roofs. You can tell polysilicon panels by their groovy mélange of silicon woven through thin rectangular conduit wires. Thin film (amorphous silicon, cadmium telluride, copper indium gallium (di)selenide). Everyone talks about "thin film" because they're really inexpensive to make and they don't mind the heat, which is all cool.Except right now, they're very inefficient, which means you'll see them in big solar farm projects with a lot of land, but not on your roof.[2]

- BIPV (Building Integrated Photovoltaics)

BIPV can look like real roofing tiles (solar shingles are an example). That's nice, but good looks do cost a lot more. Second, they're way less efficient than conventional PV, which means you need a sunny spacious roof to make a dent in your electric bill. Finally, they may not last as long as regular panels.[2]

Power	85W/90W/95W/100W
Dimension	1190×550×30mm
Weight	8kg
Tolerance	±3%

http://www.okorder.com/p/mono-silicon-solar-panel_103758.html

Material :	Polycrystalline Silicon	Max. Power :	80w
Size :	836*670*30mm	Transform efficiency :	17%~19%
QC warranty :	25 years module output wa	Jnction box :	diode IP65 rated

http://www.ec21.com/product-details/80W-Polycrystalline-Silicon-Pv-Solar--6513581.html

Model	Ten-BIPV85M-36	Ten-BIPV120M-54	Ten-BIPV170M-72
Size	1365*640*17MM	1365*640*17MM	1365*640*17MM

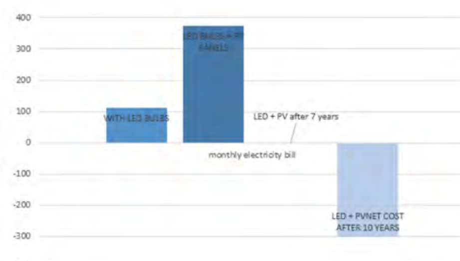
http://www.alibaba.com/product-detail/BIPV-SOLAR-PANEL_861638155.html

It seems that the best option is Monocrystalline Silicon (Single Silicon) which gives us the highest amount of energy and efficiency. These panels should be located in south facing position and with 30 degree tilt angle in summer and 60 degree in winter. Also solar rating in this area is 4.7Kwh/sqm/day which is comparatively good and 22.18 Kw of peak power is required for the solar system capacity.

PV panels placement on the selected roofs of City of Chaska government center

This picture demonstrates how PV panels will be placed on 2200 sqft of the roof area, and provides 100% of energy needed for exterior LED lighting

One of the drawbacks of solar panels is initial costs. Currently they pay almost $17,500 for their monthly electricity bills. Installing all these PV panels needs about $77,630 including government taxes. It may seem a huge amount of money, but it is already being paid for their 6 months bills. The difference between these amounts of money is pay back process which is important to be aware that the amount of money they spend every month for their electricity bills, as well as energy used, is never returned. PV panels help them to produce energy that never ends. So, not only our non- renewable source won't be depleted, but also energy is produced by that, which makes the site completely independent of other energy sources and equipment. Calculations and assumptions show us that if they pay around $370 per month for the electricity bills, after 5 years they have pay back, and even after 10 years the City of Chaska government can save money, because energy will be produced free, clean, onsite, and constantly. The problem is people prefer not paying the huge amount of money in the beginning of their process. But if they notice all economic, social, and environmental benefits, and pay back times, they will be eager to pay and save energy, money, and life.



http://estimator.solar-estimate.org/

Comparing this package to package one, we believe that this package, however needs more time to grow and work, but it will work pretty well and efficient from cost and energy perspectives, as well as saving and producing both money and energy, which in package one although it seems more cost efficient and faster than this package, and it provides saving energy and money, but earning money and producing energy is not completely possible. We are almost at the end of the fuel sources, and we should do something in order to save energy as fast as we can for the next generations. Even if one strategy is not cost efficient but energy efficient, that the start point to save the earth and life for people in the future. Depleting all sources will make so many troubles and pollutants for the future. So, it’s time to start applying clean and non-renewable sources.

Package Three

Considering the impact of each other package, package 3 allows for all packages to take effect while additionally changing every light fixture, hoping for the largest energy savings. This package will transform the entire government center allowing for new LED light bulbs, a new solar PV array, and finally the complete replacement of existing light fixtures with new updated energy efficient light fixtures. Overall, all each package has its own initial investment to make an update. Whether, it be for the light bulb replacement, solar pv panels or replacing the fixtures. In turn this will increase with each initial investment. For package 3, the initial investment boasts a large sum, $50,000+ dollars. This amounts from the 95 fixtures in existence currently in the parking lots, building parameter, and fixtures attached to the complex. Though the initial investment is a hefty sum, $50,000+ dollars added to the other two packages; we were allotted enough time to determine the feasibility both economically and sustainably.

Potential design scheme

In-order for the new fixtures to be a viable option we had to refer to and abide by specific regulations, due to the facility itself. Being a government building attached to a jail there were certain restrictions that limited our selection of fixtures bringing rise to a specific design. We needed to adjust for the specific lumens, which is the level of brightness within the bulb. Then we had to account for the lifespan of the bulb with correct lumen output. Additionally, the prices per fixture. The wattage output and the percent of wattage saved after replacing each fixture. (besides the fixture these features were accompanied by package 1). Finally, we had to procure a proper set up where the PV array that would be best suited to generate power to all fixtures. Therefore, all fixtures; post lights, wall packs, recessed lighting, flood lights, and flag pole lights had to establish policy precedent. The layout was specific and the choice of fixtures were intentionally sought after. Each specified fixture replaced followed the Chaska municipalities board on building design, making sure each chosen fixture replaced the designated current fixture.

Figure 2: The blue dots represent the location of all 95 fixtures needing to be replaced. They are association to the policy and regulations
https://carver.maps.arcgis.com/apps/webappviewer/index.html

Energy input and output

The current facilities kilowatt usage per year from the government complex's bills, came to being assumed that approximately 84,536.27 kW/yr. were needed to be considered when providing an energy solution. **This wattage accrued a cost of $4,914.75 per year.** Once we decided on the proper fixtures we determined that an average of 70% efficiency towards the overall wattage used, from replacing all fixtures would occur. This would generate a savings of 40% of your monthly energy bills simply from replacing all fixtures. While this savings is happening, the life span and the lumens of the bulb in the fixtures would account for additional energy savings due to the cohesion with the fixtures. These fixtures with the correct bulbs create the 70% efficiency. Allowing for less kilowatt usage per day, month, and year for the entire span of the fixture which was upwards of 50000 hours of usage.

Figure 3: The specific fixtures used and gather from http://www.usaveled.com/applications/

Advantages and disadvantages

The advantages of package 3 are seen from the inclusion of package two and one. The initial phase of replacing bulbs accounts for major savings in energy. The continuance of package two brings the ability to supplement the energy usage by replacing it with solar radiation. Making it possible to generate all electricity needed for the fixtures bulbs. Creating the capability to produce without expenditure over the lifespan of the panels. Finally, the fixtures allow for additional savings from energy efficiency, while giving a newly update aesthetic.

The disadvantages all stem from one main issue. That would be the allotted budget for package 3. Considering that the package = 1+2+3 = $110000+ dollars, the initial investment would be very large and in-order to see eventually return, it would take many years. Another, disadvantage to package 3 is due to the warranty and lifespan of the solar panels. The solar panels themselves predict replacement before seeing the return come to fruition. This would again create a financial burden, having to replace solar panels before seeing the return from the initial investment, assuming another sum of 30-50 thousand additional dollars.

Social impact

Package 3 includes all previous packages that being said, lumens become a major key point within this package. Solely, the lumens account for the largest social impact. Bearing in mind that the facility conjoins to a jail bright areas surrounding the complex are very important. If there were a facility break down, there would need to be sufficient bright areas as to not lose potential threats to the surrounding community from the criminals in the jail. Another social impact would be the aesthetic of the building. The surrounding community would be able to visibly see that their municipality is actively striving for modernization and advanced technology to supplement the energy usage. Show they are giving back to the community with simply efforts such as these. While, putting taxpayer dollars to good use.

Economic impact

Since these fixtures will offer superior light quality, reduced energy usage and diminished maintenance costs compared with the original lighting on this facility, the financial savings will be steeply impacted if you allow for a sufficient amount time. The reduction of energy consumption by up to 70% will also contribute to the dramatic savings that would happen from introducing these new fixtures. The average kw usage for the past years have been 84,536.27 kw/yr. This accrued a cost of $4,914.75 per year, which would save approximately $3,500.00 each year. The expected return on investment from the initial replacement fixture cost, rounding down to about $50,000, would take approximately 30 years just from the saving per watt used. After doing the math, we have come up with figures for the next 50 years. Because only then would see significant gain in savings of close to $74,711.87. After those 50 years then package 3 seems to be worth the investment.

Environmental impact

This reduction in energy usage due to the change package 3 makes; is further compounded by the reduced burden that LEDs place on climate control solutions, meaning cooling costs are greatly reduced. According to the U.S. Department of Energy, "Widespread use of LED lighting has the greatest potential impact on energy savings in the United States. An additional positive environmental impact is that LEDs contain no mercury, unlike their counterparts, whose mercury-laden remnants can seep into our water supply and adversely affect sea life, and those who eat it. Having these new additives will help in rendering problems like this irrelevant. This adds up to considerable energy savings. [6] A U.S. Department of Energy study concluded that switching away from the before mentioned bulbs in package 1, reduces the environmental harm of lighting by three to 10 times. Furthering this proposed benefit is that LED lights contain no toxic elements. [6] All of these are continuing the environmental positive effects.

Cost over time:	4924.78	1 year	103420.39	21 year
	9849.56	2 year	108345.17	22 year
	14774.34	3 year	113269.95	23 year
	19699.12	4 year	118194.73	24 year
	24623.90	5 year	123119.51	25 year
	29548.68	6 year	128044.29	26 year
	34473.46	7 year	132969.07	27 year
	39398.24	8 year	137893.85	28 year
	44323.02	9 year	142818.63	29 year
	49247.80	10 year	147743.41	30 year
	54172.59	11 year	152668.19	31 year
	59097.37	12 year	157592.97	32 year
	64022.15	13 year	162517.76	33 year
	68946.93	14 year	167442.54	34 year
	73871.71	15 year	172367.32	35 year
	78796.49	16 year	177292.10	36 year
	83721.27	17 year	182216.88	37 year
	88646.05	18 year	187141.66	38 year
	93570.83	19 year	192066.44	39 year
	98495.61	20 year	196991.22	40 year

201916.00	41 year
206840.78	42 year
211765.56	43 year
216690.34	44 year
221615.12	45 year
226539.90	46 year
231464.68	47 year
236389.46	48 year
241314.24	49 year
246239.02	50 year

Savings after 50 years	74711.87

Figure 4: Illustrates the amount of time it will take to pay back the initial investment of package 3 at 30 years, then at 50 years subtracting the initial investment you will have saved $74,711.87

Summary

Package 1 (Bulb replacement to LEDs)

- ❖ Replacing all the current light bulbs with the most efficient LEDs bulbs.

Advantages

- ➢ The total cost to operate a system completely run off of **LED bulbs** would total **$1,345.51/year**, compared to the **current** total cost to run these lights would total **$4,914.75/year.**
- ➢ The LEDs bulbs are very efficient in consuming energy, which means less consumption of energy, and less carbon footprint. As a result less money can be spent on electrical bills.
- ➢ Package 1 is the least expensive in terms of the initial cost, which is about **$15,352.00,** and could be easily **paid off in 5 years,** so if you have a tight budget, this package would be your best choice.

- ➢ The LEDs bulbs have **double,** and in some cases **triple the life expectancy** of the current light bulbs.
- ➢ Package 1 would take the least amount of time to be applied to the ground.
- ➢ No need to recycle mercury at the end of the life span of the LED bulbs compared to the current bulbs.
- ➢ The LEDs bulbs have a consistent level of brightness over its lifespan compared to the the current light bulbs, which **lose 35% of its brightness** before the half of its life. As a result, consumers think that they are almost done and replace them with new ones.

Disadvantages

- ➢ The electrical systems will still depend on the the main grid to provide the required energy for the LED bulbs.

Package Two (LED BULBS + SOLAR PV PANELS)

- ❖ Replacing all the current light bulbs with the most efficient LEDs bulbs

and

- ❖ Placing a central, fixed solar PV panels on the roof.

<u>Advantages</u>

- The LEDs bulbs are very efficient in consuming energy, which means less consumption of energy, which as a result lead to less money spent electrical bills.
- The energy needed for the LEDs bulbs can be produced by the solar PV panels, which **will cost nothing to generate energy, after the initial cost is paid off.**
- The energy produced by the solar PV panels is clean, which could make the project a nominate for lots of clean energy rebates programs.
- The package is the 2nd least expensive in terms of the initial cost, which is about **$76,323.58**, and could be paid off in **10 years.**
- The solar panels can be maintained every **15-20 years.**

<u>Disadvantages</u>

- The upfront cost is expensive (**$15,352.00** +**$76,323.58**) **for the LEDs bulbs & the Solar PV.**
- **Therefore, it will take longer period of time to get the initial cost back(10 years) so this package requires patience on the initial investment.**
- The buildings will still be connected to the main electrical grid, in case of a cloudy day, which could lead to less sun energy to harvest.

Package 3 (Fixture replacement with new ones + Package 2)

- Replacing all the current light bulbs with the most efficient LEDs bulbs

and

- Placing a central, fixed solar PV panels on the roof.

and

- Replacing all the current fixtures with new ones.

<u>Advantages</u>

- Installing new LEDs bulbs, solar pv panels, and new fixtures would make the parking lots and the buildings more fashionable, advanced, and more sustainable in general.
- Savings of **40% of the monthly energy bills** simply from just replacing all fixtures with new ones, which would benefit the life span and the lumen of the bulbs also.
- This reduction in energy usage due to the new fixtures in package 3 would eliminate even additional amounts of GHG emissions, and would be considered a great step towards a healthier community.

Disadvantages

- The upfront cost is very expensive (**$15,352.00** + **$76,323.58 +** $50,000.00**) for the LEDs bulbs & the Solar PV & the new fixtures.**
- **Therefore, it will take longer period of time to get the initial cost back (30 years)**
- limited selection of fixtures because of the sensitivity of the location as being adjacent to a jail, which requires specific level of brightness from each fixture selected.
- The **solar panels themselves** have to be replaced before the initial cost of the package is back to the investor, which will add about **$30,000.00 to $50,000.00** to the overall cost of the package.

Future investment

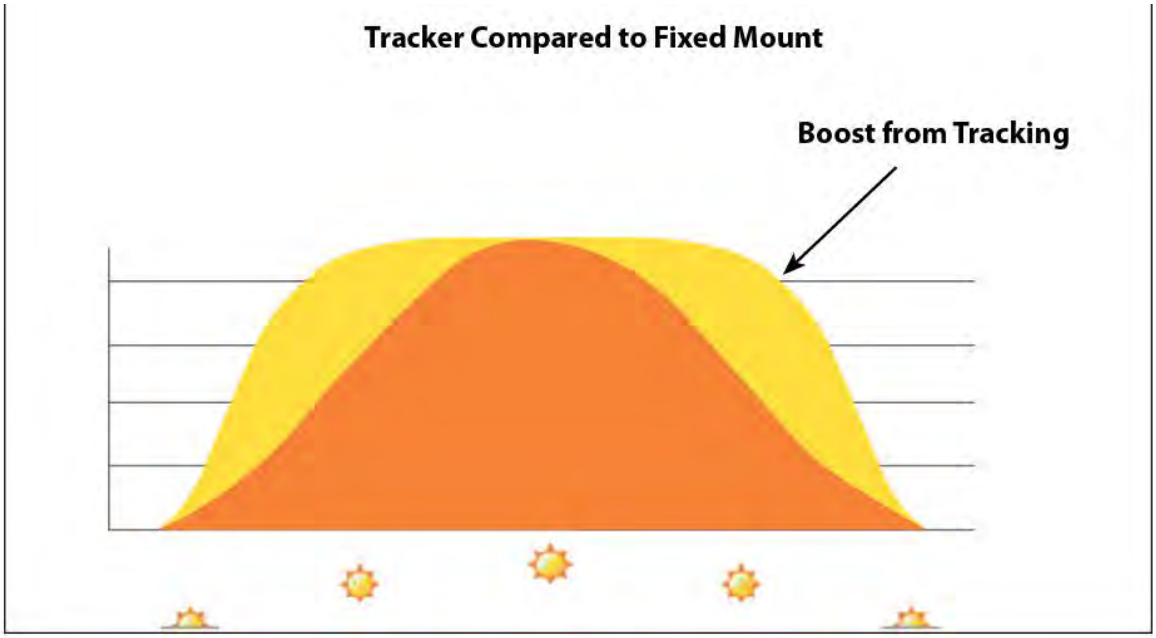
- Fixed Solar Panels:

For the most part our common everyday solar cells run at an efficiency of 18-20%1, meaning **they only convert 18-20% of the energy they receive from the sun into electricity.** While this is far better than the 3-6% efficiency that most green plants end up with2, it doesn't quite meet our power needs. To bring in enough power we either need to improve the efficiency of our panels or find ways of getting more from our current solar panels.

Every panel we see in your day to day life is in a fixed position, most likely facing south at a 45 degree angle3. While this approach is extremely simple and meets the needs of most small applications, it isn't producing as much energy as it could be. Therefore, a **new idea was proposed to track the sun and keep the specific angle, which the sun has to make with the solar panel, in order to get the best benefit of the sun's energy, and this idea was achieved by a solar tracking system.**

- Solar tracking system:

The single most simple way of getting more energy out of a solar panel is to have it track the sun, and it can does so by using sensors to find the brightest source of light at all times. **In fact solar panels that track the sun create around 30% more energy per day than a fixed panel.**4



Source: First Solar

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