Evaluating LED Lighting Options for Duke Athletics

By

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Executive Summary

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Duke Athletics spends $222,000 for 3,000MWh[1] of electricity annually in 20 athletic venues. As a means to reduce energy costs, Duke Athletics could retrofit the lamps in all 20 venues from HID[2] to LED[3] for a projected annual cost of $105,000 for 1,400MWH of electricity – the initial capital to do this would be approximately $2MM. Duke Athletics is not advised to retrofit all venues, but instead evaluate the NPV[4] associated with the entire portfolio along three warranty periods: 10, 18, and 25 years to negotiate the most optimal warranty with lighting vendors. After finalizing a warranty period, examining the NPV/kWh savingd will help Duke Athletics make a priority list of individual venues.

LED and HID

The 20 athletic venues in this analysis use HID as a means of primary lighting. This is a legacy technology that is able to produce intense amount of light at a high wattage, which correlates to high costs. LED lamps are emerging as alternatives by emitting high intensity light at reduced wattages. Unlike HID lamps, LED lamps can quickly cycle on/off, and instantly produce optimal light at full brightness.

Savings in Wattage

An LED lamp is capable of high efficacy, emitting the same lighting density as an HID at a reduced wattage. Because electricity costs are most sensitive to the hours a lamp is on, the differential in wattage can lead to tremendous savings with venues that have considerable lighting usage hours.

Savings in Maintenance

Currently, Duke Athletics needs to service and replace HID lamps as they burn out. Approximately 10% of HID lamps on any given array will need to be replaced annually due to failures at a rate of $300/bulb. If Duke Athletics were to retrofit to LED, a manufacturer would offer a warranty period for the LED

[1] MWh = megawatt-hour; 1 MWh = 1000 kWh
[2] High Intensity Discharge Lamp
[3] Light Emitting Diode
[4] Net Present Value

fixtures in place. This would essentially make the maintenance costs of LED near $0 annually along the warranty period offered. Duke Athletics would benefit from avoided maintenance savings. For example, if there was an array with 100 HID lamps, Duke Athletics would expect to pay approximately $3,000 ($300 × 100 × 10%) in replacement bulbs per year. A 10-year warranty would save Duke $30,000 ($3,000 × 10) by never having to maintenance the former HID lamps.

Assessing the Portfolio

Once each venue was benchmarked for current costs and energy usage, a retrofit salutation was developed to determine new bulb counts and reduced wattage to determine new costs and energy usage. Then, a cash flow model was created to assess the NPV of three different warranty scenarios:

- (10/10): 10-Year Interior & 10-Year Exterior Warranties
- (10/18): 10-Year Interior & 18-Year Exterior Warranties
- (10/25): 10-Year Interior & 25-Year Exterior Warranties

These three models show that the most significant savings associated with a retrofit are associated with avoided maintenance savings, not the reduced wattage on the system. The models hold the interior warranty length constant at 10 years. This presents only 6 NPV positive interior venues. The models vary the exterior warranty periods. We observed zero NPV positive exterior projects in 10 years, one NPV positive exterior project in 18 years, and four NPV positive exterior projects in 25 years. The longer the warranty, the longer Duke Athletics can realize savings associated with avoided maintenance costs.

Once Duke Athletics finalizes a warranty period from a vendor, they would then be advised to target the highest NPV/kWh venues. This means venues which have the largest NPV per kWh reduced. A marginal abatement curve (such as those found in this report) will allow Duke Athletics to target venues which have the highest NPV to maximize their investment, and highest potential savings from reduced wattage and operating costs due to the retrofit.

Contents

Duke's Climate Commitment:

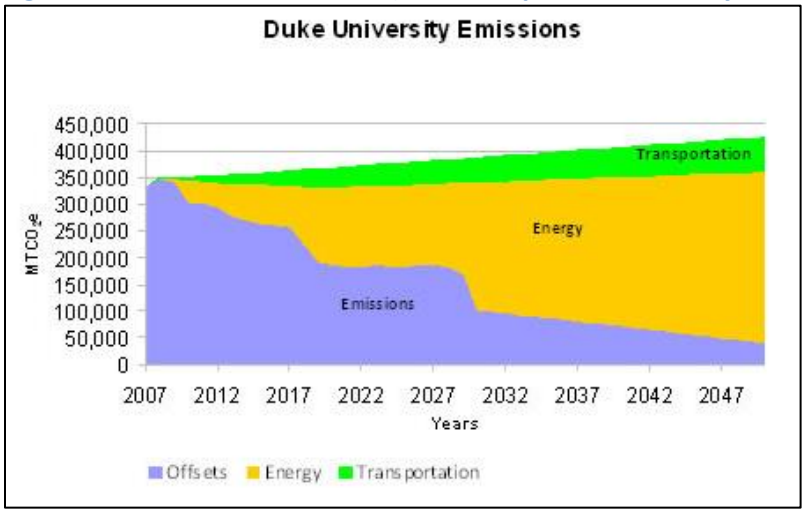
In 2007, Richard H. Brodhead, President of Duke University, signed the American College & University Presidents' Climate Commitment (ACUPCC) (Office of News & Communications, 2009). The ACUPCC is a consortium of colleges and universities aiming to take industry leadership by facilitating the pursuit of reduced global warming emissions.

Since then, Duke has made a goal of becoming climate-neutral by 2024; coinciding with the 100th anniversary of James B. Duke's establishment of Duke University (Office of News & Communications, 2009).

Duke has since established the need for a Climate Action Plan (CAP) to be spearheaded by the Dean of the Nicholas School of the Environment and the Executive Vice President as they co-chair a Campus Sustainability Committee (CSC) with representation of a committee of students, faculty, and staff. The CSC's objective is to identify dates for carbon neutrality, target deadlines, strategies, and mitigation recommendations to achieve the 2024 goal (Duke Campus Sustainability Committee).

In 2007, the CSC benchmarked and inventoried the university's 332,972 $MTCO_2e$[5] by sources (mostly from transportation and energy), and made projections through 2050. Recommendations to reduce projected emissions were developed as part of the CAP. The CSC also noted that their targets only apply to the university component, a separate entity separate from the larger Duke (which includes the Health system throughout Durham, NC) (Campus Sustainability Committee, 2009).

Figure 1: AP Recommendations (Duke Campus Sustainability Committee)



[5] Megatons of Carbon Dioxide Equivalent

As a means of reducing the 2050 projected 426,466 $MTCO_2e$, the CAP calls for a plan based on the orange and green wedges in Figure 1 to demonstrate the possible reductions due to implantation of transportation and energy measures such as moving away from coal, photovoltaic (PV) systems, and financial incentives, and alternative options for transportation. Duke then founded the Carbon Offsets Initiative to discover potential offset projects for wedges in purple. Offset projects such as methane capture systems from animal husbandry / livestock farms can serve as a way to abate carbon spent by the university. These offsets would be able to be purchased by the university on an annual basis (Duke Campus Sustainability Committee).

The university has made strides by use of LEED standards and practices for all new buildings as of 2003, the re-opening of the natural gas converted East Campus Steam Plant in 2009, and a partnership with Loyd Ray Farms to capture methane from a swine farm in Yadkin County, North Carolina (Duke University Sustainability).

Duke generates steam and chilled water for heating, ventilation and air conditioning (HVAC) systems on campus. This allows for control of source fuel for these industrial processes, and the ability for the university to use cleaner fuels such as natural gas in place of coal at the steam plants. However, Duke does not generate electricity on campus, and uses Duke Energy (no relationship to Duke University) as a supplier for electricity throughout the university (Campus Sustainability Committee, 2009).

Because building energy represents 79% of Duke's emissions, reduction of electricity demand can be an expedited way of achieving target milestones, and the overall 2024 goal for climate neutrality (Duke Campus Sustainability Committee). See Figure 2 and Figure 3 for disaggregated usage of Duke's energy profile.

Figure 2: Duke Emissions Projected to 2050 (BAU – Business As Usual) (Campus Sustainability Committee, 2009)

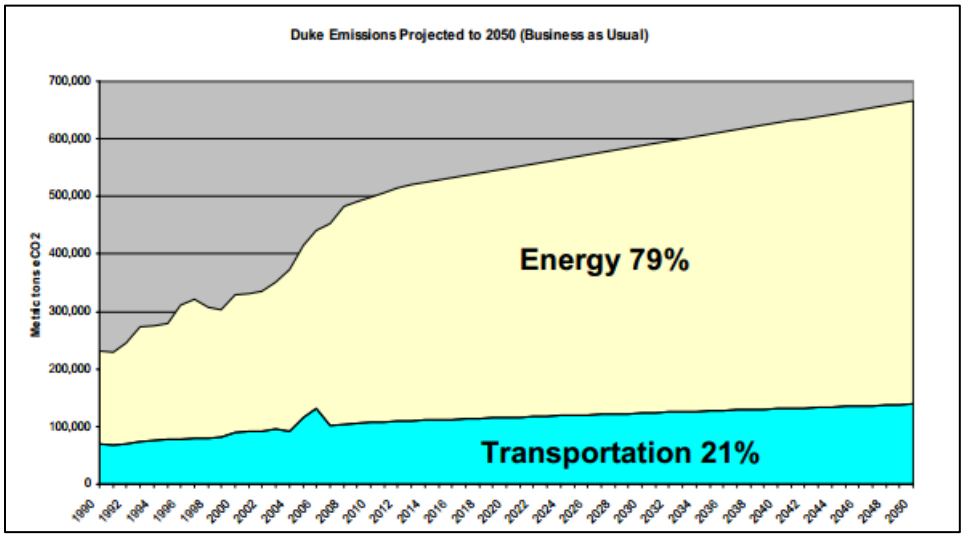
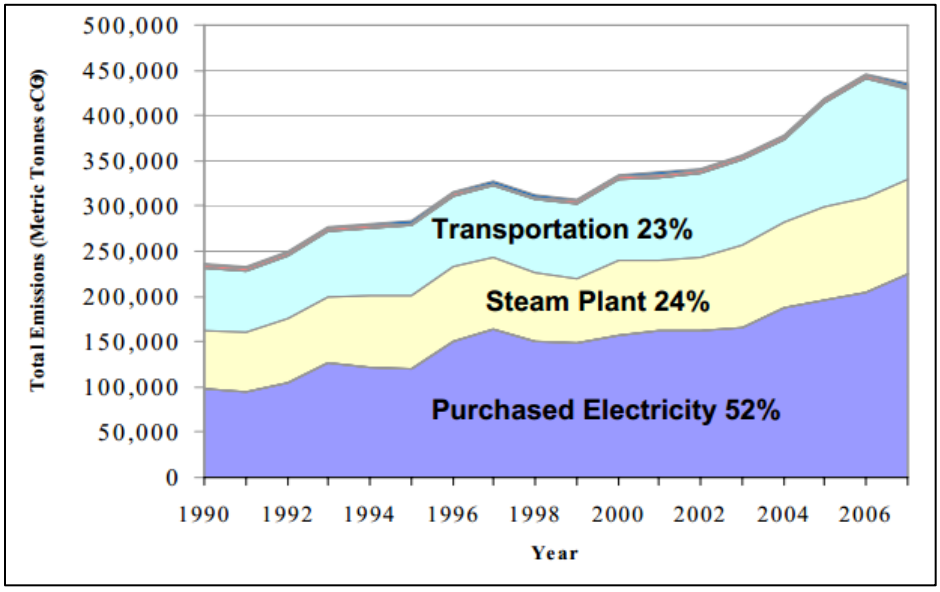


Figure 3: Historic Emissions per Source and Sector (Campus Sustainability Committee, 2009)



Introduction to Lighting:

High Intensity Discharge (HID) Lamps:

HID lamps are often used in indoor and outdoor sports facilities due to their high light output levels. HID lamps generate light by discharging electricity through a mixture of inert gasses in a bulb. HID lamps use a compact arc tube which houses these gases under high temperature and pressure. When electricity is transferred though, a vast amount of light is created. General uses also include street lighting, parking garages, commercial and industrial areas, high ceiling spaces, and warehouses. HID lamps are rarely used in residential planning due to excessively high light output, and high initial capital costs. There are three primary types of HID lamps: HPS (High Pressure Sodium), MH (Metal Halide), and MV (Mercury Vapor). HID lamps take several minutes to warm up before optimal light is being outputted, and cannot be rapidly switched back on; once turned off, the lamp must cool down before it is turned back on (Whelan & DeLair, 2010) (Atkinson, Denver, McMahon, & Clear, 2008).

Metal halide lamps are the dominant technology among current HID variants, and solely make up Duke Athletics' lighting profile. MH systems can last from 5,000 – 20,000 hours, produce a white light, have an efficacy of 45-100LPW, and have CRI values of 65-90. These features have caused MH to become a cost-effective solution to industrial and commercial lighting needs (Atkinson, Denver, McMahon, & Clear, 2008).

Figure 4: HID Lamp (Whelan & DeLair, 2010)

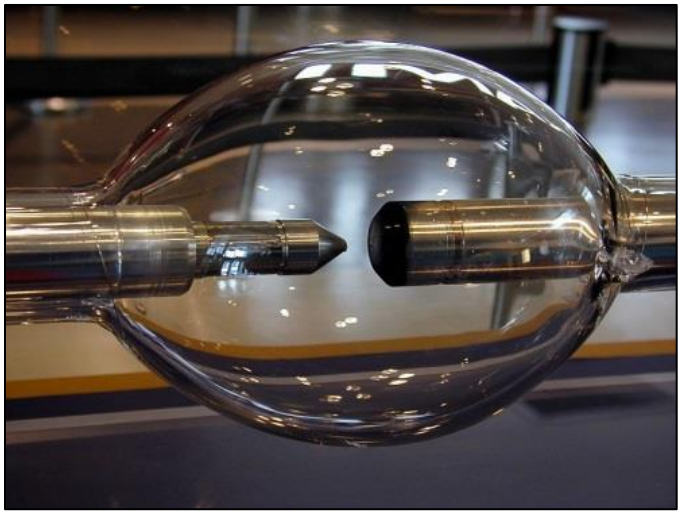


Figure 5: HID Fixture (GE Lighting)

Figure 6: HID Fixture Array (Altoona Curve - Stadium Lighting, 2007)

Light Emitting Diode (LED) Lamps:

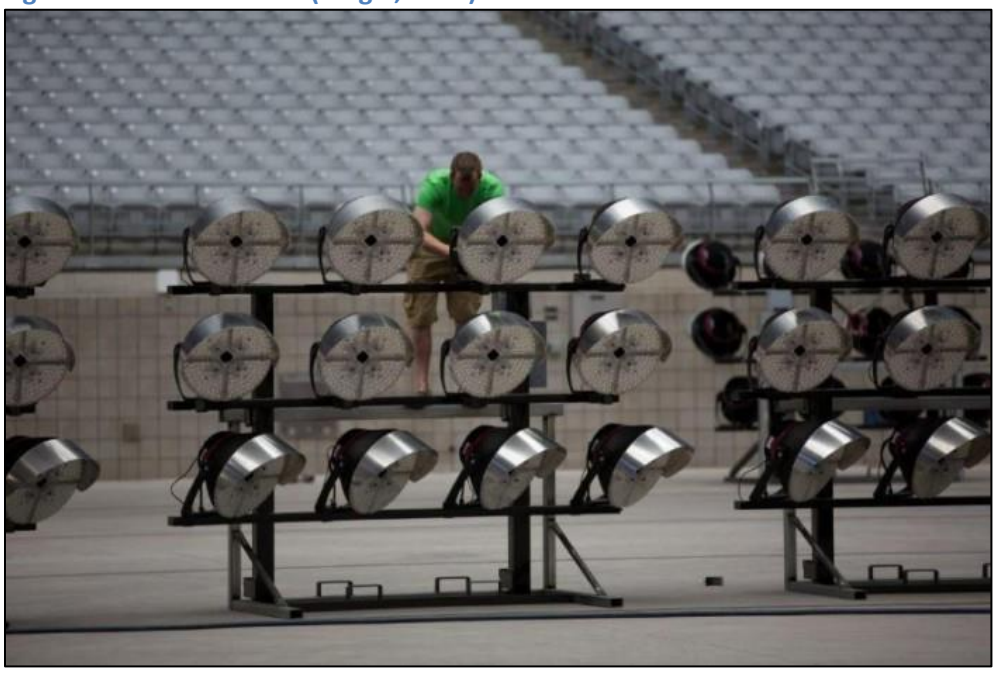
HID systems required an electronic ballast to regulate and stabilize the current into the fixture. LED lamps offer a digital solution with semiconductor-based components that emit light when current is applied. LED lamps are offered in a variety of temperature colors (3,200-12,000K), have higher efficacies for white colored lamps (and greater for other colors), and carry CRI values of 60 to >90. LED solutions offer much smaller wattage per unit, but often are available at much higher costs than their comparable HID equivalents, and especially than their incandescent equivalents. With some fixtures demonstrating a lamp life of nearly 2250,000 hours (Ephesus Lighting, 2014) along with increased durability, and use of no toxic elements, LED lamps are quickly becoming a dominant and reliable alternative technology (Atkinson, Denver, McMahon, & Clear, 2008).

Transitioning to LED lamps also has a tremendous effect on the operating costs associated with powering a lamp. Appendix A: Comparative Lighting Standards demonstrates that an LED bulb of 100W is capable of providing the same illuminance in terms of lumens/square foot (known as Foot Candles) as a 175W metal halide lamp. For facilities operating many hours per day annually, this 75W differential multiplied by hours on and the $/kWh rate can result in thousands of dollars saved by switching to LED.

Maintenance savings should also not be overlooked. LED retrofits come with warranty periods ranging from 10-25 years, thus guaranteeing $0 annually in maintenance costs during this period. Generally, 10% of MH lamps will require replacements annually; expenses not only include the bulbs, but also hiring a crew and trucks to replace MH lamps. When comparing the LED and HID solutions across the same financial period, the HID option quickly adds up to significantly more costs, especially because of the warranty accompanying the LED solution.

Figure 7: LED Lamp (McFarland, 2004)

Figure 8: LED Installation (Ringle, 2015)



Back of the Envelope Calculation for Operations:

In the case of an interior Duke Athletics facility, we found that a 240W LED fixture would be able to provide the same illuminance as a 443W HID fixture (400W lamp + 43W ballast). Using this information, and assuming a sample run time of 100 hours and an example rate of 10¢/kWh we found that the LED is the cheaper option in terms of operating activities:

Figure 9: HID vs LED Energy and Cost Comparison

Lamp Type:	HID	LED
Wattage:	443W (HID)	240W (LED)
Relative Wattage:	Higher Wattage	Lower Wattage
Relative Energy Consumption:	More Energy Consumed	Less Energy Consumed
	@100 Hours & 10¢/kWh	
Cost:	$4.43	$2.40

Current Development / ESPN and ACC Standards in Lighting:

Lighting costs represent significant operating costs for Duke University Athletics. Knowledge by Athletic Directors prompted interest in LED-lit stadiums and the development of the following LED retrofit phase schedule of all facilities in the Athletics portfolio. The list consists of each facility, its target specification, and proposed phase with Williams Field at Jack Katz Stadium to become the pilot stadium for LED lighting.

Figure 10: Duke Athletics Original Priority List

FACILITY	ANTICIPATED USAGE	PHASE	TARGET INSTALL DATE	MINIMUM LIGHTING LEVELS
WILLIAMS FIELD	VARSITY FIELD HOCKEY/RECREATION	PRE	Sep-2014	FIELD HOCKEY FEDERATION REGIONAL BROADCAST LEVEL
CAMERON INDOOR STADIUM	VARSITY BASKETBALL/VOLLEYBALL	1	Jul-2015	BASKETBALL - NATIONAL CHAMPIONSHIP SITE REQUIREMENTS W/INCREASED FC LEVELS SIMILAR TO NBA
K CENTER PRACTICE COURTS	VARSITY BASKETBALL	1	Jul-2015	BASKETBALL - NATIONAL CHAMPIONSHIP SITE REQUIREMENTS W/INCREASED FC LEVELS SIMILAR TO NBA
TAISHOFF AQUATIC CENTER	VARSITY SWIM/DIVE, RECREATION	1	Jul-2015	SWIMMING - REGIONAL BROADCAST W/INDIRECT LIGHT
BRODIE GYM POOL	RECREATION	1	Jul-2015	SWIMMING - INTERCOLLEGIATE PLAY W/INDIRECT LIGHT
AMBLER TENNIS STADIUM	VARSITY TENNIS	1	Jul-2015	REGIONAL BROADCAST - TENNIS
WALLACE WADE STADIUM	VARSITY FOOTBALL	1	Jul-2015	FOOTBALL NATIONAL CHAMPIONSHIP SITE REQUIREMENTS W/INCREASED FC LEVELS SIMILAR TO NFL
EAST CAMPUS TENNIS COURTS	RECREATION	1	Jul-2015	INTERCOLLEGIATE PLAY - TENNIS
CARD GYM BASKETBALL COURTS	RECREATION	2	Jul-2016	INTERCOLLEGIATE PLAY - BASKETBALL
WILSON CENTER BASKETBALL COURTS	RECREATION	2	Jul-2016	INTERCOLLEGIATE PLAY - BASKETBALL
BRODIE GYM BASKETBALL COURTS	RECREATION	2	Jul-2016	INTERCOLLEGIATE PLAY - BASKETBALL
YOH BUILDING SPEED & AGILITY ROOM	VARSITY FOOTBALL	2	Jul-2016	INTERCOLLEGIATE PLAY - FOOTBALL
IM BUILDING	VARSITY TRACK, SWIM/DIVE	2	Jul-2016	INTERCOLLEGIATE PLAY - BASKETBALL
BROOKS PRACTICE FIELD	VARSITY FOOTBALL	2	Jul-2016	FOOTBALL NATIONAL BROADCAST
HAYNES FIELD	RECREATION	2	Jul-2016	INTERCOLLEGIATE PLAY - SOCCER
751 PRACTICE FIELDS	VARSITY SOCCER/LACROSSE	2	Jul-2016	REGIONAL BROADCAST - SOCCER
SOFTBALL STADIUM	VARSITY SOFTBALL	3	Jul-2017	REGIONAL BROADCAST - SOFTBALL
SHEFFIELD INDOOR TENNIS CENTER	VARSITY TENNIS	3	Jul-2018	REGIONAL BROADCAST - TENNIS
PASCAL FIELD HOUSE	VARSITY FOOTBALL/RECREATION	3	Jul-2022	FOOTBALL NATIONAL BROADCAST
JACK COOMBS FIELD	VARSITY BASEBALL	3	Jul-2022	NATIONAL CHAMPIONSHIP W/UPLIGHTING FOR FLY BALLS
BASSETT DRIVE PRACTICE FIELDS	VARSITY SOCCER/LACROSSE/RECREATION	3	Jul-2023	REGIONAL BROADCAST - LACROSSE
WILLIAMS TRACK AND FIELD	VARSITY TRACK/FIELD/RECREATION	3	Jul-2024	REGIONAL BROADCAST - TRACK & FIELD
KOSKINEN STADIUM	VARSITY SOCCER/LACROSSE	3	Jul-2024	NATIONAL BROADCAST - LACROSSE

In the summer of 2014, Williams Field at Jack Katz Stadium, located on Duke's East campus and host to women's field hockey, became home to the first NCAA (National Collegiate Athletic Association) Division I outdoor venue lit with LED lamps as the primary lighting fixtures.

The stadium was initially illuminated with 88-1,000W metal halide HID lamps. This provided 9 foot-candles of light, significantly less than the NCAA recommended 75 foot-candle for this type of venue and sport. Duke had two options, add an additional 50 HID lamps which may have also required additional poles, or retrofit with 56 1,000W LED fixtures using the existing poles.

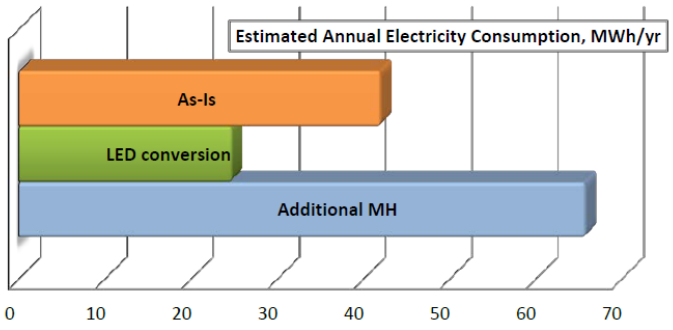
Duke Facilities Management provided the following estimated Cost-Benefit Analysis of the project:

Figure 11: Duke FMD Energy Analysis

Project Options Snapshot	LED Conversion	Add Metal Halide	"As-is"
Estimated Implementation Cost:	$ 162,300	$55,000[2]	$0
Cost *Savings* from "As-is"" Option			
Annual Estimated Energy Cost Savings:	$1,315	($1,811)	N/A
Annual Operational Savings:	$6,440	($3,659)	N/A
Net Annual Savings:	$7,755	($5,470)	N/A
Simple Payback (Yrs):	20.9	N/A	N/A
25 Year Life Cycle Cost:	$243,000	$605,000	$351,000
Net Present Value of 25-yr Operating Costs:	$191,800	$310,300	$164,600
Internal Rate of Return (25-year):	2%	N/A	N/A

Energy & Greenhouse Gas Impact:

Carbon Savings		
Greenhouse Gas calculation	LED	Add MH
Metric Tons CO2e/yr	6.5	-8.9
Pounds CO2e/yr	14300	-19700



Considering game time only, as-is, the stadium was consuming 42 MWh per year. An LED solution would have reduced consumption to 25 MWh per year while additional metal halide lamps would increase consumption to 66 MWh yearly.

The carbon savings associated with LED replacements corresponded with 6.5 Metric tons (14,300 pounds) CO_2e per year avoided. Additional metal halide resulted in an increased 8.9 metric tons (19,700 pounds) of CO_2e per year.

Adding 50 extra HID lamps onto the system would account for additional energy costs of $1,811 and increased operations and maintenance costs of $3,659 for an annual increase of $5,470. Duke pushed forward the LED option to save $1,315 annually in energy costs, and $6,440 in avoided operations and maintenance costs for a grand total of $7,755 in annual savings.

Following the success of William's Field, Duke Athletics proposed a financial analysis for all venues in the athletics portfolio to recalibrate their initial rollout schedule, and identify venues with the largest positive NPV per kilowatt-hour and prioritize them, based on the internal rate of return.

Scope of Work / Methods:

Usage data (in hours) was obtained from Bob Weiseman, Assistant Director of Athletics/Athletic Facilities: Game Operations and Championships, using the Duke Athletics' EMS Professional software (Appendix B: Room Statistics:). Bob and I examined the report to correct any discrepancies between what was reported, and what the expected annual hours should be estimated at (Appendix C: Verified Time Usage). Data, including fixture counts and wattage per fixture, was obtained (Appendix D: Fixture Specifications at all Facilities) from Casey Collins of Duke Facilities Management Department. Using this dataset, annual kWh per year numbers were calculated along with operating costs based on the university's contracted electricity rates from Duke Energy. Four venues were omitted:

- **751 Practice Field** - Schematics of field are unknown.
- **Pascal Field House** - Has a 20 year service agreement with Musco (a lighting vendor) for lighting replacements, not worth the retrofit.
- **Sheffield Indoor Tennis Center** - Currently using high output linear fluorescent bulbs when a retrofit was complete in 2013.
- **Williams Field** - Has recently undergone retrofit.

Using this information, a more complete list was developed and combined with fixture specification data such as wattage per fixture, and quantity of fixtures for each facility for a complete benchmark of annual electrical usage of 2,973,445 kWh per year equating to an annual electricity bill of $221,522.

Type of Retrofit:

Retrofits were classified into two different categories based on the following:

- Category 1: Environment
    - Interior or Exterior
- Category 2: Retrofit Type
    - 1-for-1 or Recalibration
- 1for1:
    - Typically, indoor facilities are a 1-for-1 retrofit using LED fixtures that are lower in wattage than their HID counterpart. If an indoor facility was lamped with LED fixtures of comparable HID wattage the facility would be excessively bright. 1-for-1 in interior setting does not require photo-metrics to recalibrate playing fields; using lower bulbs wattage in the same amount of points in the ceiling, issues with shadows are eliminated.

    - Use LED fixtures that are lower in wattage than HID counterpart; same amount of fixtures.
- Recalibration:
    - Exterior facilities are typically a recalibration retrofit. In these instances, LED fixtures of similar wattage are used for their HID counterparts. However, at comparable wattage, these LED fixtures will emit might higher lighting density than the HID lamps, which results in fewer fixtures needed. This eliminates the need for additional poles.
    - Use LED fixtures with same wattage to their HID counterpart; fewer amount of fixtures
- Ambler Tennis Stadium is the only Exterior venue with a 1-for-1 retrofit. Due to the nature of tennis stadiums, this structure must have uniform lighting density; using LED would require photo-metrics incompatible with tennis venues.
- Basketball facilities are the only indoor venues with recalibration retrofits because these facilities will be using fixtures with wattages comparable to HID counterparts. Because of the high wattage and foot candles from these fixtures, a reduced quantity is needed.

LED: MH Ratio:

To evaluate LED recalibration retrofits, a ratio of Metal Halide to LED had to be developed to understand how many Metal Halide bulbs equate to one LED. This was calculated by using a proposal from Ephesus stating that 138-1000W CMH field lamps provide the lighting density equal to 56-Ephesus Stadium 1000, 5600K CCT LED lamps. This ratio of 2.46 MH: LED (138/56) was used forward.

Bulb Equivalent:

To evaluate 1 for 1 recalibration types, the following table provides original HD bulb wattage with corresponding LED bulb wattage

Figure 12: LED Replacement Wattages for HID

HID (Lamp + Ballast)	Corresponding LED
284 W	**160 W**
380 W	**240 W**
443 W	**240 W**
480 W	**240 W**
1,080 W	**1,000 W**
1,625 W	**1,000 W**

Labor Costs & Bulb Cost:

Based on estimates for lamp replacement, and previous maintenance costs, labor cost associated with 1 bulb was calculated at $295.73. Fixtures costs were calculated as follows, using contractor data:

Figure 13: Fixture Costs Comparison

Exterior Fixtures		Interior Fixtures	
LED Lamp (W)	Fixture Cost	**LED Lamp (W)**	Fixture Cost
60	$328.25	**60**	$233.33
140	$375.14	**140**	$266.67
240	$562.71	**240**	$400.00
380	$890.96	**380**	$633.33
1,000	$2,344.64	**1,000**	$1,666.67
1,580	$3,704.54	**1,580**	$2,633.33

Electricity Rates:

2014-15: $0.07450

2015-16: $0.07420

For 2016 onward, projections were made at a 1% annual increase to account for potential rate increases.

Benchmarked vs Proposed Retrofit Costs:

Equations:

To calculate the baseline and retrofit for each venue, the following calculation was used:

- $\boldsymbol{Total\ kWh\ per\ year} = \frac{Watts}{Fixture} \times \frac{\#\ Fixtures}{Venue} \times hours\ of\ usage \times \frac{1kWh}{1000W}$
- $\boldsymbol{Total\ Cost\ per\ year} = \frac{Watts}{Fixture} \times \frac{\#\ Fixtures}{Venue} \times hours\ of\ usage \times \frac{1kWh}{1000W} \times \frac{\$}{kWh}$
- $\boldsymbol{Fixture\ Costs} = \#\ Fixtures \times \frac{\$X}{Fixture}$
    - See Figure 13: Fixture Costs
- $\boldsymbol{Labor\ Costs} = \#\ Fixtures \times \frac{\$295.73}{Fixture}$
    - See Figure 14: List of Assumptions
- $\boldsymbol{Initial\ Capital} = [(Labor\ Cost + Fixture\ Cost) \times (1 + 4\%)] \times (1 + 5\%)$
    - This escalated 4% for Project Management and 5% for Contingency
- **LED: MH Ratio**: A ratio of 2.46 was used to calculate how many MH bulbs equate to one LED bulb. Based on photometric designs and previous proposals, 138 MH bulbs are able to produce the same amount of light 56 LED bulbs produce. This value was used to calculate the anticipated LED bulbs, for example, Basset Drive has 176 MH bulbs, dividing that by 2.46 and rounding up results in 72 expected LED bulbs.
- ***Net Present Value*** *= Sum of the present values along the warranty period*

$$Initial\ Capital + \sum_{t=1}^{t=end\ of\ warranty} \frac{Cash\ flows\ at\ Year\ 1}{1 + r^n}$$

- $\boldsymbol{Payback\ Period} = (Cost\ of\ Project)\ /\ (Annual\ Cash\ Inflows)$
- $\boldsymbol{Internal\ Rate\ of\ Return} =$
  $Discount\ rate\ which\ makes\ the\ Net\ Present\ Value\ equal\ zero$
- $\boldsymbol{Annual\ Savings} = (Old\ Energy\ \$ - New\ Energy\ \$) + Avoided\ Maintance\ Costs$

Results:

Initial Benchmark:

	Old Lighting System			
Facility	**Lamps Per Field / Court**	**Watts Per Fixture**	**Total KWH Per Year**	**Total Cost Per Year**
Ambler Tennis Stadium	48	1,080	70,425	$ 5,247
Bassett Drive Practice Fields	176	1,080	38,016	$ 2,832
Brodie Gym Basketball Courts	64	443	184,288	$ 13,729
Brodie Gym Pool	18	284	24,722	$ 1,842
Brooks Practice Field	32	1,080	16,105	$ 1,200
Cameron Indoor Stadium	127	1,080	600,761	$ 44,757
Card Gym Basketball Courts	31	480	92,330	$ 6,879
Card Gymnasium (track lvl lights)	26	284	45,818	$ 3,413
Haynes Field	16	1,080	6,912	$ 515
IM Building	64	443	89,548	$ 6,671
Jack Coombs Field	161	1,080	146,871	$ 10,942
K-Center Practice Courts 1 (Emergency Only)	9	380	29,959	$ 2,232
K-Center Practice Courts 2	86	1,080	289,786	$ 21,589
Koskinen Stadium	132	1,080	127,186	$ 9,475
Morris Williams Track	168	1,080	331,128	$ 24,669
Softball Stadium	150	1,080	137,700	$ 10,259
Taishoff Aquatic Center	65	1,080	307,476	$ 22,907
Wallace Wade Stadium	256	1,625	202,176	$ 15,062
Wilson Center Basketball Courts	64	443	175,924	$ 13,106
YOH Building Speed & Agility Room	52	380	56,316	$ 4,196
Total		**Total kWh**	**2,973,445**	**$ 221,522**
Total		**Total MWH**	**2,973**	

Proposed Retrofit:

	New Lighting System				DETAILS		FINAL SPECIFICATIONS					4%	5%	
Facility	**If Retrofit, Lamps required -**	**Watts Per Fixture**	**Total KWH Per Year**	**Total Cost Per Year**	**Venue Type**	**Retrofit Type**	**New Fixtures**	**New Per Fixture Costs**	**New Total Fixture Costs**	**Labor Costs**	**Total Cost**	**Internal Duke PM Costs**	**Contingency**	**Grand Total**
Ambler Tennis Stadium	20	1,000	65,208	$ 4,838	Exterior	1 for 1	48	$ 2,345	$ 112,543	$ 14,195	$ 126,738	$ 5,070	$ 6,337	$ 138,144
Bassett Drive Practice Fields	72	1,000	14,400	$ 1,068	Exterior	Recalib	72	$ 2,345	$ 168,814	$ 21,293	$ 190,107	$ 7,604	$ 9,505	$ 207,217
Brodie Gym Basketball Courts	26	240	99,840	$ 7,408	Interior	1 for 1	64	$ 400	$ 25,600	$ 18,927	$ 44,527	$ 1,781	$ 2,226	$ 48,534
Brodie Gym Pool	8	160	13,928	$ 1,033	Interior	1 for 1	18	$ 267	$ 4,800	$ 5,323	$ 10,123	$ 405	$ 506	$ 11,034
Brooks Practice Field	13	1,000	6,058	$ 450	Exterior	Recalib	13	$ 2,345	$ 30,480	$ 3,845	$ 34,325	$ 1,373	$ 1,716	$ 37,414
Cameron Indoor Stadium	52	1,000	227,760	$ 16,900	Interior	Recalib	52	$ 1,667	$ 86,667	$ 15,378	$ 102,045	$ 4,082	$ 5,102	$ 111,229
Card Gym Basketball Courts	13	240	46,165	$ 3,425	Interior	1 for 1	31	$ 400	$ 12,400	$ 9,168	$ 21,568	$ 863	$ 1,078	$ 23,509
Card Gymnasium (track lvl lights)	11	160	25,813	$ 1,915	Interior	1 for 1	26	$ 267	$ 6,933	$ 7,689	$ 14,622	$ 585	$ 731	$ 15,938
Haynes Field	7	1,000	2,800	$ 208	Exterior	Recalib	7	$ 2,345	$ 16,413	$ 2,070	$ 18,483	$ 739	$ 924	$ 20,146
IM Building	26	240	48,513	$ 3,600	Interior	1 for 1	64	$ 400	$ 25,600	$ 18,927	$ 44,527	$ 1,781	$ 2,226	$ 48,534
Jack Coombs Field	66	1,000	55,748	$ 4,137	Exterior	Recalib	66	$ 2,345	$ 154,746	$ 19,518	$ 174,265	$ 6,971	$ 8,713	$ 189,949
K-Center Practice Courts 1 (Emergency Only)	4	240	8,410	$ 624	Interior	Recalib	4	$ 400	$ 1,600	$ 1,183	$ 2,783	$ 111	$ 139	$ 3,033
K-Center Practice Courts 2	35	1,000	109,200	$ 8,103	Interior	Recalib	35	$ 1,667	$ 58,333	$ 10,351	$ 68,684	$ 2,747	$ 3,434	$ 74,866
Koskinen Stadium	54	1,000	48,176	$ 3,575	Exterior	Recalib	54	$ 2,345	$ 126,611	$ 15,970	$ 142,580	$ 5,703	$ 7,129	$ 155,413
Morris Williams Track	69	1,000	125,925	$ 9,344	Exterior	Recalib	69	$ 2,345	$ 161,780	$ 20,406	$ 182,186	$ 7,287	$ 9,109	$ 198,583
Softball Stadium	61	1,000	51,850	$ 3,847	Exterior	Recalib	61	$ 2,345	$ 143,023	$ 18,040	$ 161,063	$ 6,443	$ 8,053	$ 175,559
Taishoff Aquatic Center	27	1,000	284,700	$ 21,125	Interior	1 for 1	65	$ 1,667	$ 108,333	$ 19,223	$ 127,556	$ 5,102	$ 6,378	$ 139,036
Wallace Wade Stadium	104	1,000	50,544	$ 3,750	Exterior	Recalib	104	$ 2,345	$ 243,843	$ 30,756	$ 274,599	$ 10,984	$ 13,730	$ 299,313
Wilson Center Basketball Courts	26	240	95,309	$ 7,072	Interior	1 for 1	64	$ 400	$ 25,600	$ 18,927	$ 44,527	$ 1,781	$ 2,226	$ 48,534
YOH Building Speed & Agility Room	22	240	35,568	$ 2,639	Interior	1 for 1	52	$ 400	$ 20,800	$ 15,378	$ 36,178	$ 1,447	$ 1,809	$ 39,434
Total		**Total kWh**	**1,415,915**	**$ 105,061**							**$ 1,821,486**			**$ 1,985,420**
Total		**Total MWH**	**1,416**											

For detailed versions, see Appendix E: Existing Equipment and Proposed Retrofit

An initial usage calculations show that instantaneously converting all lamps in athletics facilities to LED will results in:

- Total reduced energy usage of 1,557,000 kWh (1,557 MWh) annually
    - Current energy usage: 2,973,000 kWh
    - Expected retrofit energy usage: 1,416,000 kWh
- Total reduced energy costs of $117,000 annually

- Current annual energy costs: $222,000
- Expected annual retrofit energy costs: $105,000

- Initial capital costs of $1,986,000 (one time, includes 4% for Project Management cost and 5% for a contingency plan)
- According the original schedule, Duke would be projected to spend the following along the three phases of the entire portfolio retrofit rollout:
  -

Phase	Old Capital Budget ($)	
Phase 1	$	776,000
Phase 2	$	283,000
Phase 3	$	927,000
Total	$	1,986,000

- Recall that Annual Savings = (Old Energy $-New Energy $)+Avoided Maintenance Costs
  - The above analysis only covers an instantaneous retrofit
  - The next section will address the savings associated with avoided maintenance costs of not having to replace HID lamps. A length of time needs to be established to evaluate potential savings due to 10% of HID lamps expecting replacement annually.

Maintenance Scenarios:

To evaluate potential savings, three warranty periods had to be first established:

1. (10/10): 10-Year Interior & Exterior Warranties
2. (10/18): 10-Year Interior & 18-Year Exterior Warranties
3. (10/25): 10-Year Interior & 25-Year Exterior Warranties

Then, each facility had to be individually analyzed by calculating the respective net present value (NPV). The NPV was chosen as an appropriate financial indicator because it considers future cash flows at a discounted rate to account for the time value of money along a time period. The cumulative cash flows along a period of time (usually the length of the investment, in this case, the warranty period) is calculated as the NPV. Investments with positive NPVs represent a positive return on investment. Conversely, a negative NPV represents a negative return on investment, or a loss (Hamel).

Discounted Cash Flow:

A discounted cash flow model was produced to calculate the NPV using the following assumptions:

Figure 14: List of Assumptions

Variable:	Value / Rate:
Discount Rate:	5%
Maintenance cost increase (annual):	1%
Annual increase in electricity price (annual):	1%
Maintenance cost per lamp (Interior):	$100 ~ approved by Duke FMD
Maintenance cost per lamp (Exterior):	$322 ~ approved by Duke FMD
% of HID light failures per year:	10%
Length of Investment / Warranty (Years):	• 10/10: (10-Year Interior / 10-Year Exterior) • 10/18: (10-Year Interior / 18-Year Exterior) • 10/25: (10-Year Interior / 25-Year Exterior)
Project management escalation:	4%
Contingency escalation:	5%

The NPV for both interior and exterior facilities were calculated separately due to differences associated with fixture costs, both applied a 5% discount rate, with interior projects representing 10 years, and exterior projects reflecting either 10, 18, or 25 years.

Maintenance costs were calculated by multiplying a 10% failure rate by the quantity of lights and the corresponding maintenance cost per bulb. This value was then increased 1% annually to account for increased rates.

Initial energy savings were calculated by subtracting old and new modeled energy costs for year 1, savings were increased by 1% annually to account for an increased cost in electricity.

The following tables display the savings (in terms of energy and costs), usage rank (in terms of hours), simple payback period, and the NPV of each facility:

(10/10): 10-Year Interior & 10-Year Exterior Warranties:

Under the 10/10 scenario, we observed 6 NPV positive venues totaling $199,000 and 14 NPV negative venues totaling -$890,000. It is important to note that none of the exterior venues are NPV positive under this scenario; only indoor facilities represent positive investments during these warranty periods.

Figure 15: 10/10 Warranty Scenario:

NPV Rank	Facility	Type	Savings ($)	Savings (kWh)	Initial Capital ($)	Payback (Years)	Time	NPV ($)
18	Ambler Tennis Stadium	E	$ -	5,000	$138,000	70.0	10	$(122,000)
20	Bassett Drive Practice Fields	E	$ 2,000	24,000	$207,000	27.6	10	$(147,000)
4	Brodie Gym Basketball Courts	I	$ 6,000	84,000	$ 49,000	6.9	10	$ 8,000
8	Brodie Gym Pool	I	$ 1,000	11,000	$ 11,000	11.1	10	$ (3,000)
12	Brooks Practice Field	E	$ 1,000	10,000	$ 37,000	20.8	10	$ (23,000)
1	Cameron Indoor Stadium	I	$28,000	373,000	$111,000	3.8	10	$ 125,000
5	Card Gym Basketball Courts	I	$ 3,000	46,000	$ 24,000	6.2	10	$ 7,000
7	Card Gymnasium (track lvl lights)	I	$ 1,000	20,000	$ 16,000	9.0	10	$ (2,000)
9	Haynes Field	E	$ -	4,000	$ 20,000	24.3	10	$ (13,000)
10	IM Building	I	$ 3,000	41,000	$ 49,000	12.9	10	$ (18,000)
16	Jack Coombs Field	E	$ 7,000	91,000	$190,000	15.7	10	$ (93,000)
3	K-Center Practice Courts 1 (Emergency Only)	I	$ 2,000	22,000	$ 3,000	1.8	10	$ 11,000
2	K-Center Practice Courts 2	I	$13,000	181,000	$ 75,000	5.2	10	$ 42,000
14	Koskinen Stadium	E	$ 6,000	79,000	$155,000	15.2	10	$ (73,000)
13	Morris Williams Track	E	$15,000	205,000	$199,000	9.5	10	$ (30,000)
15	Softball Stadium	E	$ 6,000	86,000	$176,000	15.5	10	$ (84,000)
17	Taishoff Aquatic Center	I	$ 2,000	23,000	$139,000	56.6	10	$(119,000)
19	Wallace Wade Stadium	E	$11,000	152,000	$299,000	15.2	10	$(140,000)
6	Wilson Center Basketball Courts	I	$ 6,000	81,000	$ 49,000	7.2	10	$ 6,000
11	YOH Building Speed & Agility Room	I	$ 2,000	21,000	$ 39,000	18.8	10	$ (23,000)

(10/18): 10-Year Interior & 18-Year Exterior Warranties:

Under the 10/18 scenario, we observed 7 NPV positive venues totaling $264,000 and 13 NPV negative venues totaling -$564,000. All 6 venues from the 10/10 Model carry over into the 10/18 Model along with the same NPV values because the warranty period does not change for interior facilities in this model. Morris Williams Track emerges as the #2 NPV positive venue, and only exterior facility NPV positive because the length of investment increases for exterior facilities. This means that exterior facilities are able to realize an additional 8 years of maintenance savings compared to the 10/10 Model.

Figure 16: 10/18 Warranty Scenario:

NPV Rank	Facility	Type	Savings ($)	Savings (kWh)	Initial Capital ($)	Payback (Years)	Time	NPV ($)
19	Ambler Tennis Stadium	E	$ -	5,000	$138,000	70.0	25	$ (113,000)
18	Bassett Drive Practice Fields	E	$ 2,000	24,000	$207,000	27.6	25	$ (113,000)
5	Brodie Gym Basketball Courts	I	$ 6,000	84,000	$ 49,000	6.9	10	$ 8,000
9	Brodie Gym Pool	I	$ 1,000	11,000	$ 11,000	11.1	10	$ (3,000)
11	Brooks Practice Field	E	$ 1,000	10,000	$ 37,000	20.8	25	$ (15,000)
1	Cameron Indoor Stadium	I	$28,000	373,000	$111,000	3.8	10	$ 125,000
6	Card Gym Basketball Courts	I	$ 3,000	46,000	$ 24,000	6.2	10	$ 7,000
8	Card Gymnasium (track lvl lights)	I	$ 1,000	20,000	$ 16,000	9.0	10	$ (2,000)
10	Haynes Field	E	$ -	4,000	$ 20,000	24.3	25	$ (10,000)
12	IM Building	I	$ 3,000	41,000	$ 49,000	12.9	10	$ (18,000)
16	Jack Coombs Field	E	$ 7,000	91,000	$190,000	15.7	25	$ (38,000)
4	K-Center Practice Courts 1 (Emergency Only)	I	$ 2,000	22,000	$ 3,000	1.8	10	$ 11,000
3	K-Center Practice Courts 2	I	$13,000	181,000	$ 75,000	5.2	10	$ 42,000
14	Koskinen Stadium	E	$ 6,000	79,000	$155,000	15.2	25	$ (26,000)
2	Morris Williams Track	E	$15,000	205,000	$199,000	9.5	25	$ 65,000
15	Softball Stadium	E	$ 6,000	86,000	$176,000	15.5	25	$ (33,000)
20	Taishoff Aquatic Center	I	$ 2,000	23,000	$139,000	56.6	10	$ (119,000)
17	Wallace Wade Stadium	E	$11,000	152,000	$299,000	15.2	25	$ (51,000)
7	Wilson Center Basketball Courts	I	$ 6,000	81,000	$ 49,000	7.2	10	$ 6,000
13	YOH Building Speed & Agility Room	I	$ 2,000	21,000	$ 39,000	18.8	10	$ (23,000)

(10/25): 10-Year Interior & 25-Year Exterior Warranties:

Under the 10/25 scenario, we observed more exterior facilities becoming NPV positive with a total of 10 NPV positive venues among interior and exterior totaling $388,000 and 10 NPV negative venues totaling -$381,000. This model provides an additional 7 years in realized maintenance savings compared to the 10/18 Model. Because longer warranties are associated with more potential savings for exterior facilities, the 10/25 Model provides the most available avoided maintenance savings.

Figure 17: 10/25 Warranty Scenario

NPV Rank	Facility	Type	Savings ($)	Savings (kWh)	Initial Capital ($)	Payback (Years)	Time	NPV ($)
19	Ambler Tennis Stadium	E	$ -	5,000	$138,000	70.0	25	$(107,000)
18	Bassett Drive Practice Fields	E	$ 2,000	24,000	$207,000	27.6	25	$ (91,000)
5	Brodie Gym Basketball Courts	I	$ 6,000	84,000	$ 49,000	6.9	10	$ 8,000
13	Brodie Gym Pool	I	$ 1,000	11,000	$ 11,000	11.1	10	$ (3,000)
15	Brooks Practice Field	E	$ 1,000	10,000	$ 37,000	20.8	25	$ (9,000)
2	Cameron Indoor Stadium	I	$28,000	373,000	$111,000	3.8	10	$ 125,000
7	Card Gym Basketball Courts	I	$ 3,000	46,000	$ 24,000	6.2	10	$ 7,000
11	Card Gymnasium (track lvl lights)	I	$ 1,000	20,000	$ 16,000	9.0	10	$ (2,000)
14	Haynes Field	E	$ -	4,000	$ 20,000	24.3	25	$ (7,000)
16	IM Building	I	$ 3,000	41,000	$ 49,000	12.9	10	$ (18,000)
12	Jack Coombs Field	E	$ 7,000	91,000	$190,000	15.7	25	$ (2,000)
4	K-Center Practice Courts 1 (Emergency Only)	I	$ 2,000	22,000	$ 3,000	1.8	10	$ 11,000
3	K-Center Practice Courts 2	I	$13,000	181,000	$ 75,000	5.2	10	$ 42,000
9	Koskinen Stadium	E	$ 6,000	79,000	$155,000	15.2	25	$ 4,000
1	Morris Williams Track	E	$15,000	205,000	$199,000	9.5	25	$ 127,000
10	Softball Stadium	E	$ 6,000	86,000	$176,000	15.5	25	$ 1,000
20	Taishoff Aquatic Center	I	$ 2,000	23,000	$139,000	56.6	10	$(119,000)
6	Wallace Wade Stadium	E	$11,000	152,000	$299,000	15.2	25	$ 7,000
8	Wilson Center Basketball Courts	I	$ 6,000	81,000	$ 49,000	7.2	10	$ 6,000
17	YOH Building Speed & Agility Room	I	$ 2,000	21,000	$ 39,000	18.8	10	$ (23,000)

Detailed Cash Flows can be found for the 10/25 warranty Scenario in Appendix F: Cash Flows

All figures a represented in the Appendix I: Final Calculations

Marginal Cost Abatement Curves:

NPV & Energy Savings Abatement Curve:

Using the NPV from the discounted cash flows and the first year savings in MWh, a marginal cost abatement curve was created to help Duke Athletics identify venues which have the highest NPV along with largest savings potential (in MWh). The following visual demonstrates the economic strength or weakness associated with all venues by plotting the NPV in dollars on the y-axis, and savings in MWh on the x-axis. Each venue is represented by a rectangle: the height represents the NPV potential, and width represents the energy savings potential.

For projects above the x-axis, venues (rectangles) with the largest widths and heights denote favorable projects that have both great financial returns and energy savings (Type 1). Venues with larger widths and small heights represent good investments with low energy savings (Type 2). Venues with smaller heights and low widths represent a smaller but positive NPV associated with high potential energy savings. Throughout all the models, Cameron Indoor Stadium, K-Center Practice courts, and Morris William's Track fall on the far right of their respective abatement curves. Once Duke Athletics has finalized the negotiating the warranty length, results similar to Figure 19: NPV/kWh will translate into a priority list for the schedule.

Figure 18: Description of Venue Rectangle Sizes provides a quick overview of rectangle size properties. Spending capital to reduce energy savings with no financial reward is not desirable. For this reason, rectangles under the x-axis should not be favored as the NPV is negative for all these projects. Venues with the largest "bang-per-buck" are represented on the far right of the abatement curves. These venues would be first to target due to the ratio of NPV/MWh. This means that for every MWh saved, more than $1 NPV is yielded in returns. Figure 19: NPV/kWh details the potential among each facility for the 10/25 Model.

Throughout all the models, Cameron Indoor Stadium, K-Center Practice courts, and Morris William's Track fall on the far right of their respective abatement curves. Once Duke Athletics has finalized the negotiating the warranty length, results similar to Figure 19: NPV/kWh will translate into a priority list for the schedule.

Figure 18: Description of Venue Rectangle Sizes

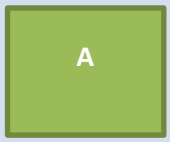
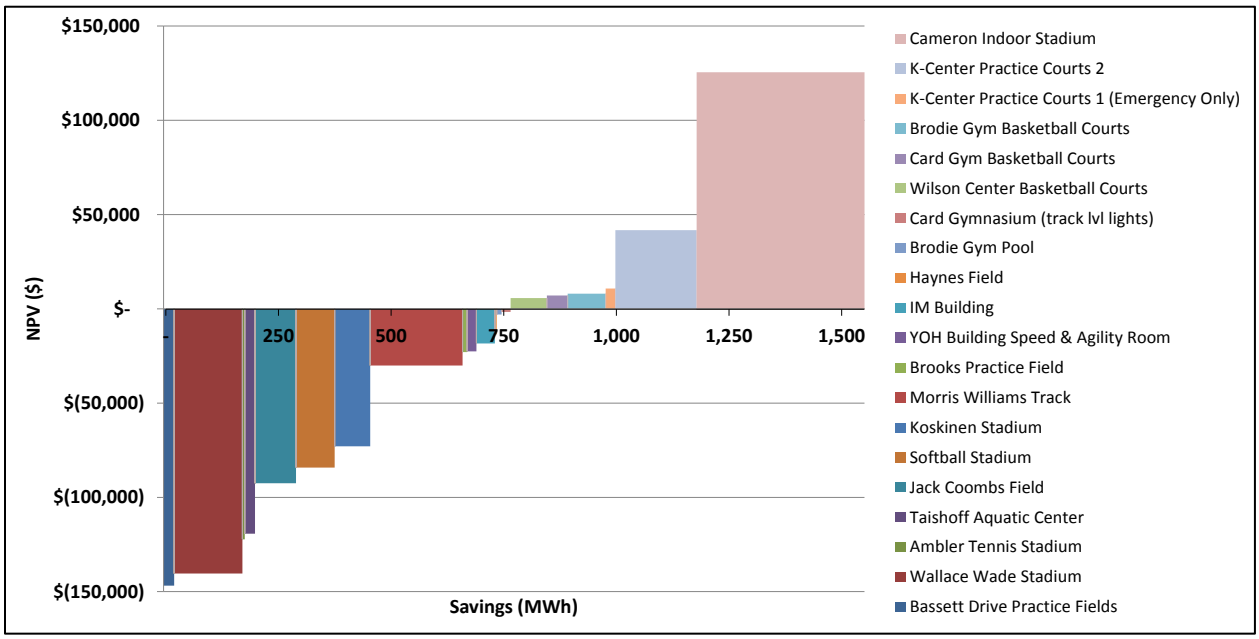
Type	Qualities if above x-axis	Qualities if below x-axis
	• High Positive NPV – Good Investment • High Energy Savings	• High Negative NPV – Bad Investment • High Energy Savings
	• High Positive NPV– Good Investment • Low Energy Savings	• High Negative NPV – Bad Investment • Low Energy Savings
	• Low Positive NPV– Decent Investment • High Energy Savings	• Low Negative NPV – Bad Investment • High Energy Savings

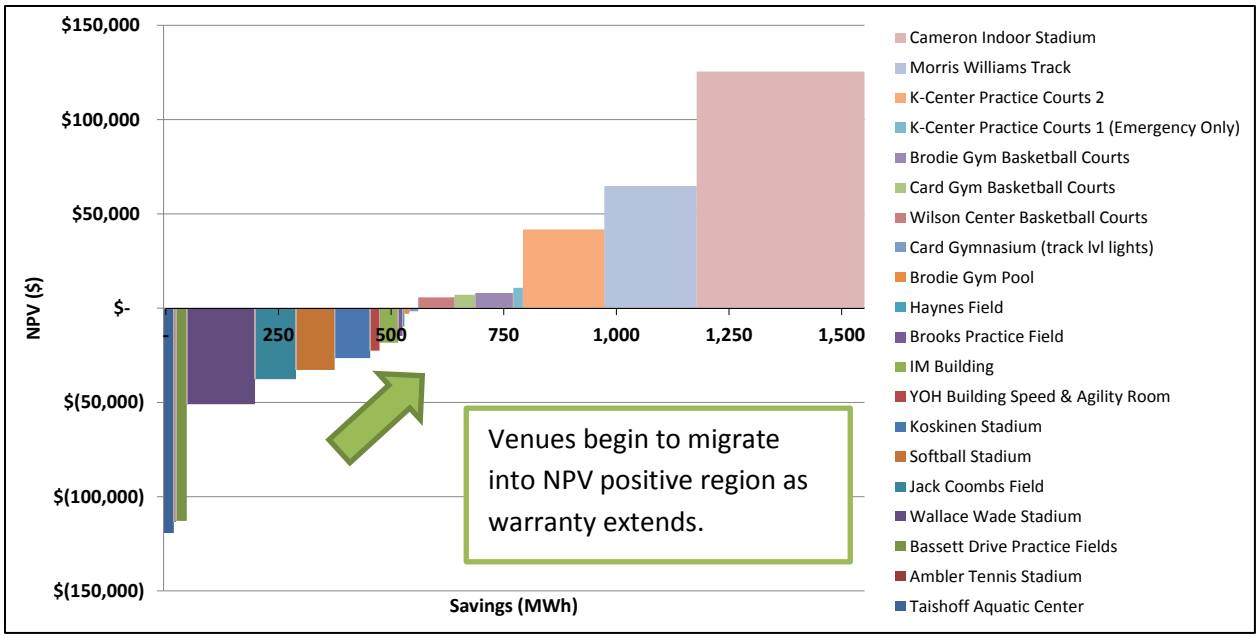
Figure 19: NPV/kWh Saved

Facility (10/25 Model)	Hour Rank	NPV/kWh
Morris Williams Track	1	$ 617
K-Center Practice Courts 1 (Emergency Only)	4	$ 500
Cameron Indoor Stadium	2	$ 336
K-Center Practice Courts 2	3	$ 231
Card Gym Basketball Courts	7	$ 153
Brodie Gym Basketball Courts	5	$ 95
Wilson Center Basketball Courts	8	$ 71
Wallace Wade Stadium	6	$ 49
Koskinen Stadium	9	$ 49
Softball Stadium	10	$ 9
Jack Coombs Field	12	$ (20)
Card Gymnasium (track lvl lights)	11	$ (83)
Brodie Gym Pool	13	$ (278)
IM Building	16	$ (448)
Brooks Practice Field	15	$ (943)
YOH Building Speed & Agility Room	17	$ (1,087)
Haynes Field	14	$ (1,762)
Bassett Drive Practice Fields	18	$ (3,838)
Taishoff Aquatic Center	20	$ (5,237)
Ambler Tennis Stadium	19	$ (20,606)

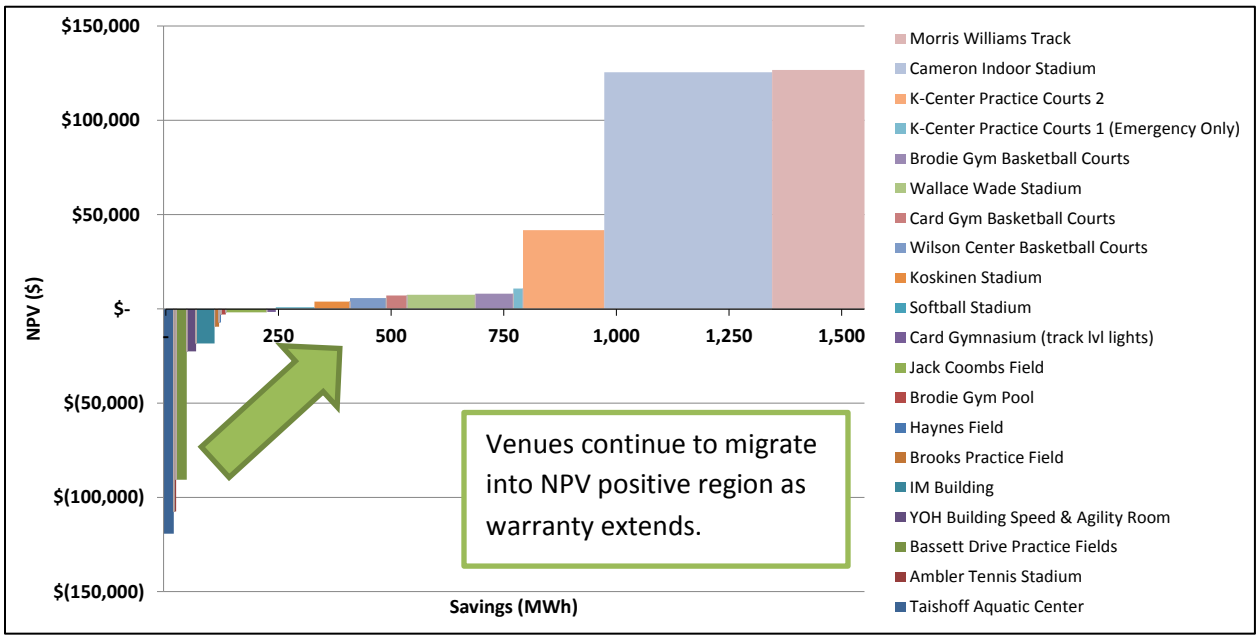
(10/10): 10-Year Interior & 10-Year Exterior Warranties NPV/MWh:



(10/18): 10-Year Interior & 18-Year Exterior Warranties NPV/MWh:



(10/25): 10-Year Interior & 25-Year Exterior Warranties NPV/MWh:

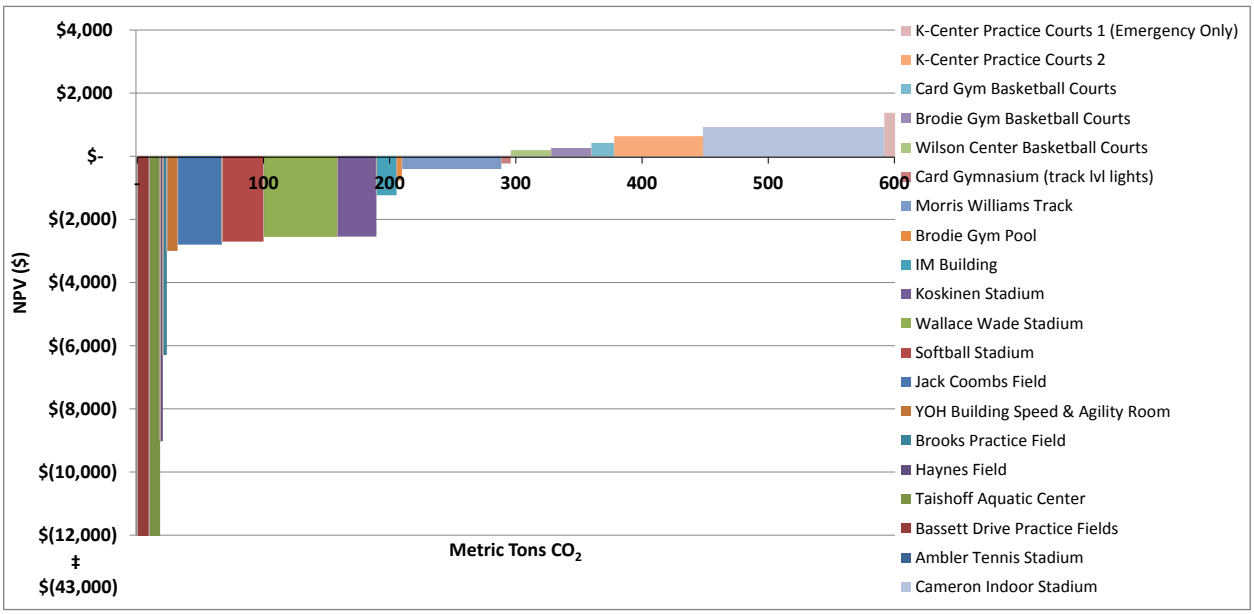


NPV & CO_2 Savings Abatement Curve:

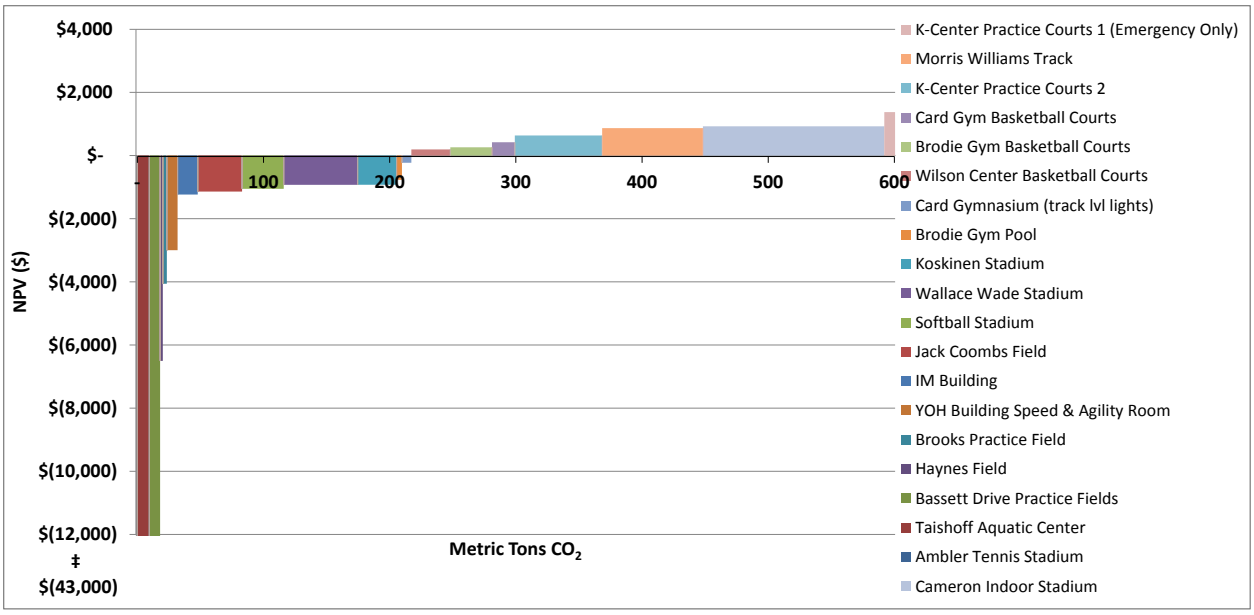
The same procedure was applied to examine how much CO_2 would be abated per dollar. To calculate the CO_2 savings, the energy savings for each venue were multiplied by *0.80* CO_2 pounds per net kWh, a value provided by Duke Energy (Duke Energy, 2015). This value is a composite value that Duke Energy has calculated based on their entire energy portfolio which may consist of nuclear, coal, solar and natural gas plants. Duke Energy is stating that 0.80 pounds of CO_2 are created in the generation of 1 kWh. These calculations were in line with the initial Williams Field proposal from Duke FMD to Duke Athletics. These values were also escalated 1% for 40 years as seen in Figure 20: CO_2 Savings under the 10/25 Model.

Unfortunately, the reduced $MTCO_2e$ per these projects does not represent significant impacts to the annual 426,466 $MTCO_2e$ identified by the CAP. It is worth observing that all NPV positive projects under the 10/25 model equate to 474.7 $MTCO_2$ in 2015 (and 706.7 $MTCO_2$ in 2055 projections at a 1% increase annually since 2015). While this represents less than 1% of the 426,466 $MTCO_2e$, it is worth mentioning that lighting within Duke Athletics is minuscule compared to the entire university. Many departments on campus likely leave lights on many more hours than a typical game at a facility managed by Duke Athletics. It is not wise to discount the CO_2 savings associated with lighting retrofits; it is advised to examine which departments on campus are excessive users of electricity for lighting, and cross-examining equipment in those respective buildings. Additionally, there are other sources of energy reduction that should be examined such as HVAC (heating ventilation air conditioning) systems that potentially use significantly more energy than lighting systems.

(10/10): 10-Year Interior & Exterior Warranties NPV/MTCO$_2$:



(10/25): 10-Year Interior & 18-Year Exterior Warranties NPV/MTCO$_2$:



(10/25): 10-Year Interior & 25-Year Exterior Warranties NPV/MTCO$_2$:

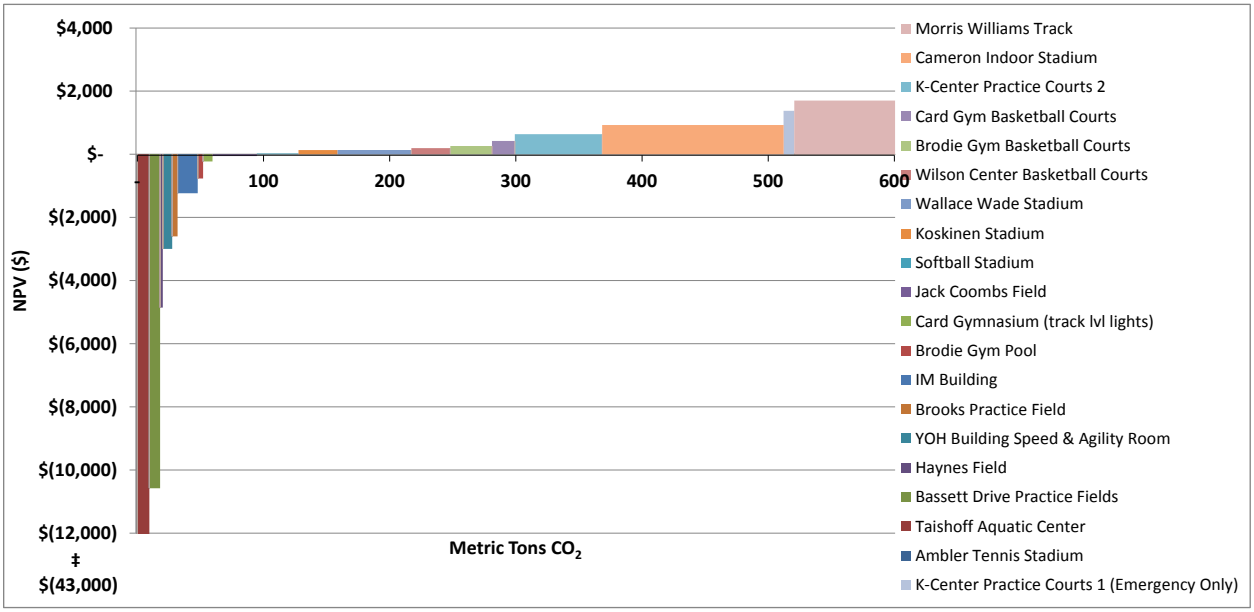


Figure 20: CO_2 Savings under the 10/25 Model

NPV Rank	Facility	Present CO2 Abated (MT)	40 Year Future CO2 Abated (MT)	NPV ($/MT)	NPV ($)
1	Morris Williams Track	74.5	110.9	$ 1,702	$ 126,701
2	Cameron Indoor Stadium	135.4	201.5	$ 927	$ 125,483
3	K-Center Practice Courts 2	65.5	97.6	$ 637	$ 41,726
4	K-Center Practice Courts 1 (Emergency Only)	7.8	11.6	$ 1,377	$ 10,766
5	Brodie Gym Basketball Courts	30.6	45.6	$ 262	$ 8,040
6	Wallace Wade Stadium	55.0	81.9	$ 136	$ 7,459
7	Card Gym Basketball Courts	16.8	24.9	$ 422	$ 7,074
8	Wilson Center Basketball Courts	29.3	43.6	$ 195	$ 5,708
9	Koskinen Stadium	28.7	42.7	$ 134	$ 3,834
10	Softball Stadium	31.2	46.4	$ 25	$ 793
11	Card Gymnasium (track lvl lights)	7.3	10.8	$ (227)	$ (1,650)
12	Jack Coombs Field	33.1	49.2	$ (56)	$ (1,860)
13	Brodie Gym Pool	3.9	5.8	$ (766)	$ (3,002)
14	Haynes Field	1.5	2.2	$ (4,855)	$ (7,245)
15	Brooks Practice Field	3.6	5.4	$ (2,600)	$ (9,479)
16	IM Building	14.9	22.2	$ (1,234)	$ (18,371)
17	YOH Building Speed & Agility Room	7.5	11.2	$ (2,996)	$ (22,559)
18	Bassett Drive Practice Fields	8.6	12.8	$ (10,577)	$ (90,643)
19	Ambler Tennis Stadium	1.9	2.8	$ (56,785)	$ (107,494)
20	Taishoff Aquatic Center	8.3	12.3	$ (14,431)	$ (119,270)

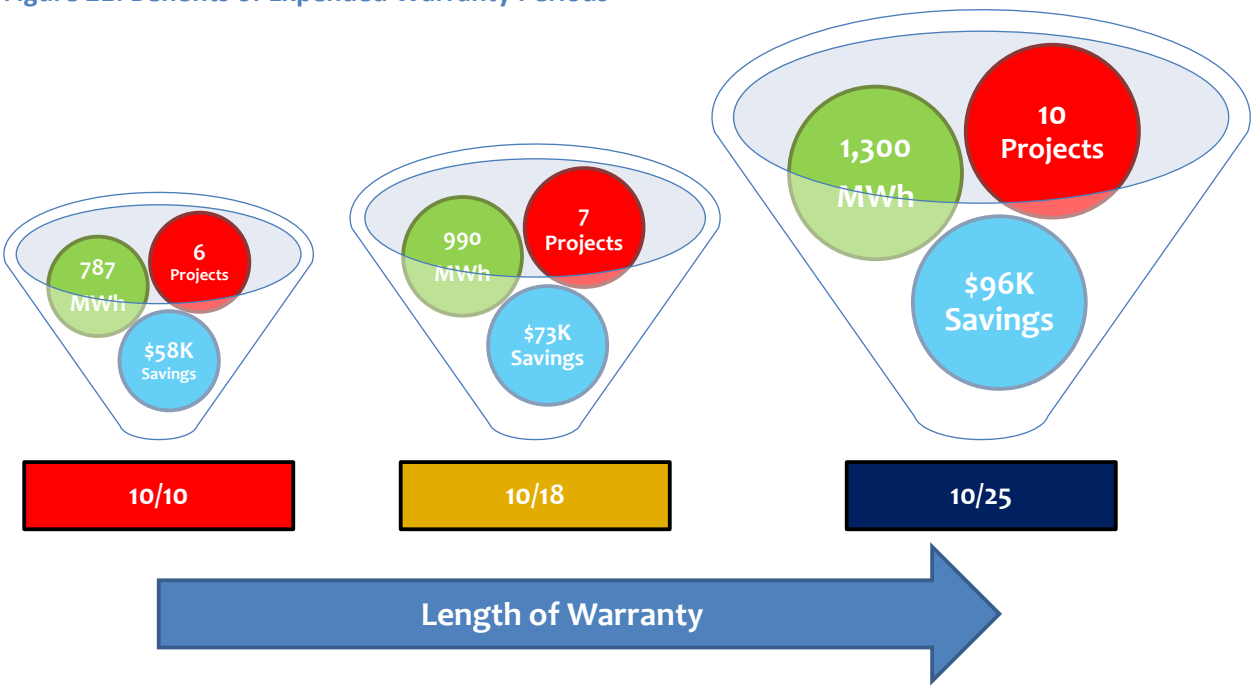
Recommendations:

The NPV of these facilities is a comparison of the initial capital required to the total value of future cash flows of savings in today's dollars while taking into account the time value of money. This will help Duke Athletics determine whether a project is financially viable while making an optimal financial decision. Under the 10/10 Model we observed the following:

Model	10/10	10/18	10/25
NPV Positive Projects	6	7	10
NPV of Positive Projects	$199,000	$264,000	$338,000
Potential Reduction in Energy Consumption:	787 MWh	990 MWh	1,300 MWh
Potential Reduction in Annual Energy Costs	$58,000	$73,000	$96,000
Initial Capital Required	$311,000	$510,000	$1,140,000

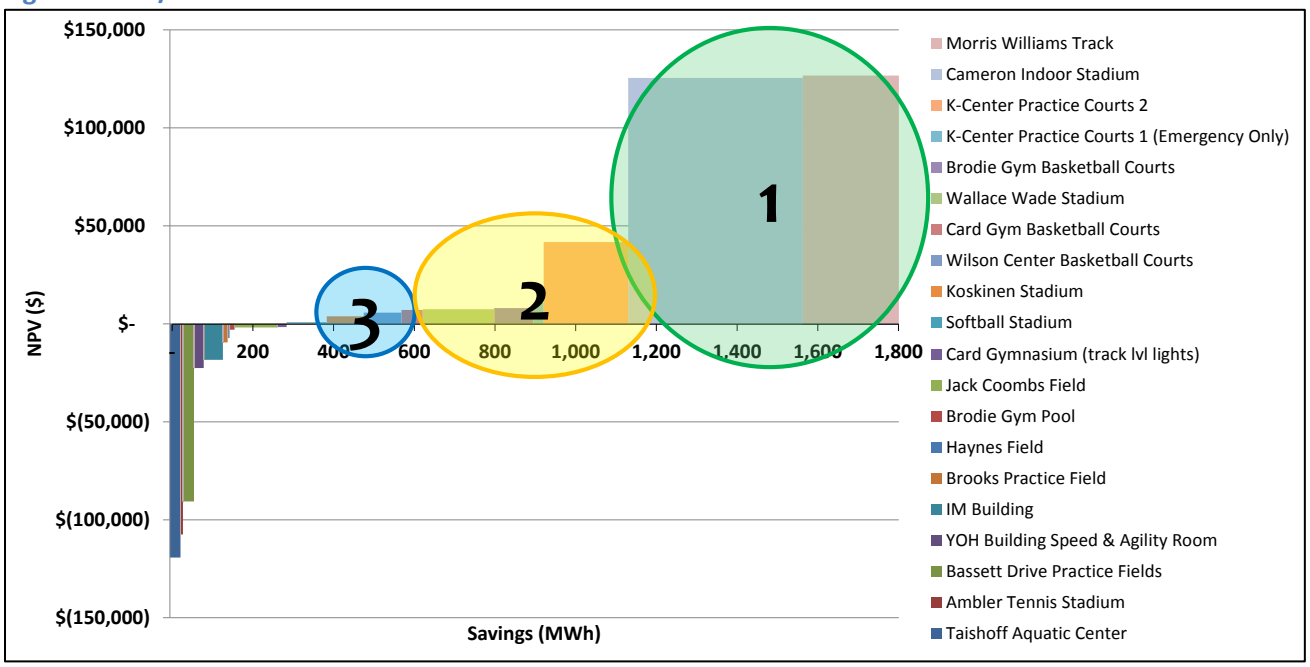
Extending the warranty period of the investment is a critical pathway in determining which venues Duke Athletics will target first in its retrofit phases. We have observed that typically, contractors offer 10-year warranties on interior projects. The 10/10 model provides 6 NPV projects for Duke Athletics to implement – all of which are interior facilities. Because the 10/10 Model offers no exterior venues, we identified the need to assess a longer warranty period, and at an 18-year warranty, we only observe 1 exterior facility becoming NPV positive. After extending the warranty evaluation again to 25 years, we finally observe a considerable amount of NPV exterior projects, see: Figure 21: Benefits of Expended Warranty Periods.

Figure 21: Benefits of Expended Warranty Periods



Ideally, Duke Athletics should target the 10/25 Model with contractors, and after finalizing this warranty period length, Duke Athletics would then turn to analyzing the largest NPV/kWh venues to determine a schedule. A table similar to Figure 19: NPV/kWh would be used to prioritize the NPV per kWh reduced to maximize the investment and benefits. Figure 22 presents the 10/25 Model Abatement Curve with prioritization based on the NPV/kWh. Venues with large NPV/kWh represented with large rectangles are targeted first, followed by mid-sized venues, and smaller venues last. At this point in the future, technology might be better in providing energy saving measures.

Figure 22: 10/25 Model with Prioritized Phases



Duke Athletics' initial schedule was changed to the below recommended schedule is based on selecting projects with the highest NPV/kWh in the following table:

Figure 23: Re-Worked Schedule

NPV Rank	Facility	Old Phase	New Phase
1	**Morris Williams Track**	**3**	**1**
2	**Cameron Indoor Stadium**	**1**	
3	**K-Center Practice Courts 2**	**1**	**2**
4	**K-Center Practice Courts 1 (Emergency Only)**	**1**	
5	**Brodie Gym Basketball Courts**	**2**	
6	**Wallace Wade Stadium**	**1**	
7	**Card Gym Basketball Courts**	**2**	**3**
8	**Wilson Center Basketball Courts**	**2**	
9	**Koskinen Stadium**	**3**	
10	**Softball Stadium**	**3**	
11	Card Gymnasium (track lvl lights)	2	
12	Jack Coombs Field	3	
13	Brodie Gym Pool	1	
14	Haynes Field	2	
15	Brooks Practice Field	2	
16	IM Building	2	
17	YOH Building Speed & Agility Room	2	
18	Bassett Drive Practice Fields	3	
19	Ambler Tennis Stadium	1	
20	Taishoff Aquatic Center	1	

Summary Table of Analysis:

Figure 23: Re-Worked Schedule is extremely powerful in demonstrating the need to reprioritize the initial retrofit deployment schedule to Duke Athletics. For example, Morris Williams Track was initially prioritized in phase 3; however, after examining the NPV/kWh, Morris Williams Track actually represents a significant investment opportunity (with the largest NPV) and substantial energy savings. Conversely, venues like Taishoff Aquatic center, Ambler Tennis Stadium, and Brodie Gym were prioritized first, but after analysis were identified to have negative NPVs and should not be scheduled for retrofit. This re-worked schedule also allows for a re-worked budget (Figure 24: Re-Worked Budget) which is able to provide a more even distribution of cash flow during phases. Examine that under the old capital budget, spend fluctuates tremendously between Phases 1 to 2 and 2 to 3. This is less drastic under the reworked schedule.

Figure 24: Re-Worked Budget

Phase	Old Capital Budget ($)	(NPV +)Capital Budget ($)
Phase 1	$ 776,000	$ 310,000
Phase 2	$ 283,000	$ 426,000
Phase 3	$ 927,000	$ 404,000
Total	$ 1,986,000	$ 1,140,000

As Duke Athletics negotiates final warranty lengths they should be mindful of the impact the length of time can have on the priority list as venues will shift due to extreme sensitivity to time. A final analysis table of Duke Athletics' maximum potential savings in terms of kWh and dollars can be found in Figure 25: Final Analysis Under 10/25 Model:

Figure 25: Final Analysis Under 10/25 Model:

NPV Rank	Facility	Hour Rank	Old Phase	New Phase	Type	Savings ($)	Savings (kWh)	Future CO2 Abated (MT)	Initial Capital ($)	IRR	Payback (Years)	NPV ($)
1	Morris Williams Track	12	1	1	Exterior	$ 15,325	205,203	110.9	$ 198,583	10%	9.5	$ 126,701
2	Cameron Indoor Stadium	7	1	1	Interior	$ 27,857	373,001	201.5	$ 111,229	24%	3.8	$ 125,483
3	K-Center Practice Courts 2	10	2	2	Interior	$ 13,486	180,586	97.6	$ 74,866	15%	5.2	$ 41,726
4	K-Center Practice Courts 1 (Emergency Only)	1	2	2	Interior	$ 1,608	21,550	11.6	$ 3,033	57%	1.8	$ 10,766
5	Brodie Gym Basketball Courts	2	2	2	Interior	$ 6,321	84,448	45.6	$ 48,534	8%	6.9	$ 8,040
6	Wallace Wade Stadium	17	1	2	Exterior	$ 11,312	151,632	81.9	$ 299,313	5%	15.2	$ 7,459
7	Card Gym Basketball Courts	3	2	3	Interior	$ 3,453	46,165	24.9	$ 23,509	11%	6.2	$ 7,074
8	Wilson Center Basketball Courts	3	2	3	Interior	$ 6,034	80,615	43.6	$ 48,534	7%	7.2	$ 5,708
9	Koskinen Stadium	14	1	3	Exterior	$ 5,901	79,009	42.7	$ 155,413	5%	15.2	$ 3,834
10	Softball Stadium	15	2	3	Exterior	$ 6,411	85,850	46.4	$ 175,559	5%	15.5	$ 793
11	Card Gymnasium (track lvl lights)	3	2	-	Interior	$ 1,498	20,005	10.8	$ 15,938	3%	9.0	$ (1,650)
12	Jack Coombs Field	16	3	-	Exterior	$ 6,805	91,123	49.2	$ 189,949	5%	15.7	$ (1,860)
13	Brodie Gym Pool	6	2	-	Interior	$ 808	10,794	5.8	$ 11,034	-1%	11.1	$ (3,002)
14	Haynes Field	19	3	-	Exterior	$ 307	4,112	2.2	$ 20,146	1%	24.3	$ (7,245)
15	Brooks Practice Field	18	3	-	Exterior	$ 750	10,047	5.4	$ 37,414	2%	20.8	$ (9,479)
16	IM Building	9	3	-	Interior	$ 3,072	41,034	22.2	$ 48,534	-4%	12.9	$ (18,371)
17	YOH Building Speed & Agility Room	11	1	-	Interior	$ 1,556	20,748	11.2	$ 39,434	-9%	18.8	$ (22,559)
18	Bassett Drive Practice Fields	20	1	-	Exterior	$ 1,764	23,616	12.8	$ 207,217	0%	27.6	$ (90,643)
19	Ambler Tennis Stadium	13	1	-	Exterior	$ 408	5,217	2.8	$ 138,144	-6%	70.0	$ (107,494)
20	Taishoff Aquatic Center	7	3	-	Interior	$ 1,782	22,776	12.3	$ 139,036	-23%	56.6	$ (119,270)

Appendix

Appendix A: Comparative Lighting Standards:

Table 2
Comparative Lighting Calculations

Room Dimensions:	60 ft by 300 ft
Ceiling Height:	9.75 ft
Mounting Height:	8.75 ft
Ceiling Reflectance:	35%
Wall Reflectance:	35%
Floor Reflectance:	20%
Lateral Spacing, ft:	30 ft

	Average Horizontal Illuminance on Floor, FC			Average Vertical Illuminance @ 5 feet on side wall, FC			Minimum Horizontal Illuminance on Floor, FC			Minimum Vertical Illuminance @ 5 feet on side wall, FC			Lighting Power Density		
Longitudinal Spacing, ft	20	30	40	20	30	40	20	30	40	20	30	40	20	30	40
Beta LED 60	4.8	3.2	2.5	1.7	1.1	0.7	1.7	1.0	0.8	0.7	0.4	0.4	0.12	0.08	0.06
Beta LED 80	6.3	4.3	3.4	2.3	1.5	0.9	2.3	1.3	1.0	1.0	0.5	0.5	0.16	0.10	0.08
Beta LED 100	7.9	5.1	4.2	2.8	1.5	1.1	2.9	1.5	1.3	1.2	0.5	0.6	0.19	0.14	0.10
Widelight LED 100	6.4	4.5	3.5	3.5	1.5	1.2	2.7	1.0	1.0	1.1	0.7	0.9	0.22	0.15	0.12
Kim PGL71W	2.9	1.9	1.5	2.5	1.9	0.9	1.3	0.8	0.8	1.3	0.8	0.8	0.13	0.08	0.07
Gardco 85W Induction	3.7	2.5	1.9	2.1	1.4	1.2	1.3	0.8	0.7	0.9	0.5	0.6	0.15	0.10	0.08
KIM 85W Induction	4.0	2.7	2.1	2.7	1.8	1.5	1.3	0.8	0.8	1.3	0.7	0.9	0.15	0.10	0.08
Maris 80W Induction	3.3	2.2	1.8	2.4	1.5	1.1	1.0	0.7	0.6	1.2	0.7	0.9	0.14	0.09	0.07
Lithonia 4T8 STD	10.4	7.2	5.7	7.3	3.5	2.7	3.0	1.8	1.7	3.5	1.8	2.2	0.19	0.12	0.10
Columbia 4T8	9.8	6.8	5.3	6.9	3.4	2.6	3.9	1.7	1.7	2.3	1.7	2.2	0.19	0.12	0.10
Renova 3T8 std	6.5	4.2	3.3	3.6	3.6	2.8	1.8	1.1	1.0	2.0	1.4	1.6	0.16	0.11	0.09
Lithonia 2T5HO	9.6	6.6	5.2	6.8	3.5	2.7	2.9	1.7	1.6	3.3	1.8	2.2	0.20	0.13	0.11
KIM PGL1 150W HPS	11.2	7.5	5.9	8.3	5.6	4.1	3.9	2.9	3.2	3.6	1.6	1.6	0.31	0.21	0.13
KIM PGL1 175W MH	8.6	5.1	4.2	4.9	2.9	2.2	2.9	1.8	2.0	1.9	0.8	1.0	0.35	0.23	0.16

Note: Yellow highlighted illuminance is below industry standards.

(Monahan, 2010)

Appendix B: Room Statistics:

Duke University, Athletics

Room Statistics

Reporting Period: 8/1/2013 thru 8/1/2014

Building	Room	Bookings	Reserved Hours	Event Hours	Estimated Attendance	Actual Attendance
751 Practice Field						
	751 Practice Field	280	2,021.58	2,021.58	135	0
	Total	280	2,021.58	2,021.58	135	0
Ambler Tennis Stadium						
	Ambler Game Courts	94	858.25	850.25	144	0
	Ambler Practice Courts	58	136.75	136.75	99	0
	Court 1	29	71.25	71.25	0	0
	Court 2	27	68.25	68.25	0	0
	Court 3	29	71.25	71.25	0	0
	Court 4	10	30.75	30.75	0	0
	Court 5	12	33.75	33.75	0	0
	Court 6	10	30.75	30.75	0	0
	Practice Court 1	6	11.50	11.50	4	0
	Practice Court 2	4	7.50	7.50	0	0
	Practice Court 3	4	7.50	7.50	0	0
	Practice Court 4	5	11.00	11.00	2	0
	Practice Court 5	4	10.00	10.00	0	0
	Practice Court 6	4	10.00	10.00	0	0
	Total	296	1,358.50	1,350.50	249	0
Brodie Center						
	Brodie Classroom	218	516.25	516.25	102	0
	Brodie Pool	103	171.33	170.33	11	0
	East Tennis Court #1 (Lit)	0	0.00	0.00	0	0
	East Tennis Court. #2 (Lit)	0	0.00	0.00	0	0
	Lane 1	0	0.00	0.00	0	0
	Lane 1 Deep	0	0.00	0.00	0	0
	Lane 1 Shallow	0	0.00	0.00	0	0
	Lane 2	0	0.00	0.00	0	0
	Lane 2 Deep	0	0.00	0.00	0	0
	Lane 2 Shallow	0	0.00	0.00	0	0
	Lane 3	0	0.00	0.00	0	0
	Lane 3 Deep	0	0.00	0.00	0	0

Reporting Period: 8/1/2013 thru 8/1/2014

Building	Room	Bookings	Reserved Hours	Event Hours	Estimated Attendance	Actual Attendance
	Lane 3 Shallow	0	0.00	0.00	0	0
	Lane 4	0	0.00	0.00	0	0
	Lane 4 Deep	0	0.00	0.00	0	0
	Lane 4 Shallow	0	0.00	0.00	0	0
	Lanes 1&2	2	19.00	19.00	0	0
	Lanes 1, 2 & 3	5	23.50	23.50	0	0
	Lanes 2&3	4	30.75	30.75	0	0
	Lanes 3&4	0	0.00	0.00	0	0
	Lower Court 1	12	82.00	46.50	1,330	0
	Lower Court 2	0	0.00	0.00	0	0
	Lower Courts	241	1,657.00	847.00	160	0
	Multi-purpose Room	1,071	1,725.67	1,725.67	379	0
	Racquetball Court A	0	0.00	0.00	0	0
	Racquetball Court B	0	0.00	0.00	0	0
	Upper Court 1	22	127.00	43.00	285	0
	Upper Court 2	4	35.00	19.00	70	0
	Upper Courts	75	412.92	144.92	2,128	0
	Total	1,757	4,800.42	3,585.92	4,465	0
Brooks Football Building						
	Brooks Practice Field	17	320.00	320.00	0	0
	Media Room	8	188.00	188.00	0	0
	Team Room	8	188.00	188.00	0	0
	Total	33	696.00	696.00	0	0
Cameron Indoor Stadium						
	Bill Brill Media Room	85	607.47	600.47	258	0
	Cameron Indoor Stadium Concourse	79	678.72	664.72	4,000	0
	Coach K Court	359	2,298.60	2,094.10	22,154	0
	K-Ville	107	1,416.25	1,416.25	2,000	0
	Legacy Room	167	1,609.08	1,599.08	0	0
	Morton Plaza	57	491.00	491.00	0	0
	Total	854	7,101.12	6,865.62	28,412	0

Reporting Period: 8/1/2013 thru 8/1/2014

Building	Room		Bookings	Reserved Hours	Event Hours	Estimated Attendance	Actual Attendance
Card Gymnasium							
	Badminton Court 1		0	0.00	0.00	0	0
	Badminton Court 2		0	0.00	0.00	0	0
	Badminton Court 3		2	4.00	4.00	20	0
	Badminton Court 4		1	2.00	2.00	10	0
	Card Gym Court 1		61	219.50	219.50	667	0
	Card Gym Court 2		14	24.75	24.75	230	0
	Card Gym Courts		583	1,838.50	1,838.50	3,602	0
		Total	661	2,088.75	2,088.75	4,529	0
Central Campus Aquatics Center							
	Entire Center		2	7.50	5.50	60	0
	Lane 1		0	0.00	0.00	0	0
	Lane 1 & 2		0	0.00	0.00	0	0
	Lane 2		0	0.00	0.00	0	0
	Lane 3		0	0.00	0.00	0	0
	Lane 4		0	0.00	0.00	0	0
	Lane 5		0	0.00	0.00	0	0
	Lane 5 & 6		0	0.00	0.00	0	0
	Lane 6		0	0.00	0.00	0	0
	Lanes 3 & 4		0	0.00	0.00	0	0
	Open Swim		26	312.00	312.00	0	0
		Total	28	319.50	317.50	60	0
Hanes Field							
	Practice Field		184	1,151.00	1,151.00	0	0
		Total	184	1,151.00	1,151.00	0	0
IM Building							
	Dry Land Diving		0	0.00	0.00	0	0
	Squash Court A		116	432.47	432.47	67	0
	Squash Court B		266	409.47	409.47	418	0
	Track		438	2,316.48	2,316.48	5,227	0

Reporting Period: 8/1/2013 thru 8/1/2014

Building	Room	Bookings	Reserved Hours	Event Hours	Estimated Attendance	Actual Attendance
	Total	820	3,158.42	3,158.42	5,712	0
Jack Coombs Stadium						
	Batting Cages	105	660.50	473.50	0	0
	Game Field	192	1,139.25	944.25	130	0
	Grandstand	107	734.25	547.25	50	0
	Total	404	2,534.00	1,965.00	180	0
Kennedy Tower						
	Hospitality Suite	0	0.00	0.00	0	0
	Media Room	0	0.00	0.00	0	0
	Total	0	0.00	0.00	0	0
Koskinen Stadium						
	Home Team Locker Room	53	659.70	497.60	133	0
	Koskinen Game Field	174	2,676.47	2,524.37	1,120	0
	Officials Locker Room	50	644.70	482.60	3	0
	Skandalaris Pavilion	54	659.70	503.60	183	0
	Visiting Team Locker Room	52	651.70	495.60	83	0
	Total	383	5,292.27	4,503.77	1,522	0
Krzyzewski Center						
	Basketball Practice Court	10	27.00	27.00	0	0
	Basketball Practice Court	4	7.00	7.00	0	0
	Classroom	219	611.58	611.58	1,472	0
	Conference Room	337	750.80	733.50	1,466	0
	Duke Basketball Practice Courts	155	856.50	856.50	0	0
	Duke Basketball Theater	9	105.00	101.00	0	0
	Scharf Hall	156	1,692.25	1,401.75	4,767	330
	Scharf Hall A	174	847.75	502.25	407	0
	Scharf Hall B	164	854.75	498.75	3,546	1,050
	Tutoring Room	0	0.00	0.00	0	0
	Tutoring Room	0	0.00	0.00	0	0
	Tutoring Room	0	0.00	0.00	0	0

Reporting Period: 8/1/2013 thru 8/1/2014

Building	Room	Bookings	Reserved Hours	Event Hours	Estimated Attendance	Actual Attendance
	Tutoring Room	0	0.00	0.00	0	0
	Tutoring Room	0	0.00	0.00	0	0
	Total	1,228	5,752.63	4,739.33	11,658	1,380
Morris Williams Track						
	Grass Field	0	0.00	0.00	0	0
	Track	0	0.00	0.00	0	0
	Total	0	0.00	0.00	0	0
Murray Building						
	Conference Room	4	4.50	4.50	11	0
	Team Meeting Room	35	189.00	189.00	965	0
	Total	39	193.50	193.50	976	0
Pascal Field House						
	Practice Field	115	820.00	820.00	0	0
	Total	115	820.00	820.00	0	0
Schwartz-Butters Athletic Building						
	Duke Athletics Hall of Fame	64	533.50	520.50	0	0
	Duke Athletics Hall of Honor	100	770.00	757.00	1,410	0
	Duke Basketball Museum	59	480.00	473.00	0	0
	Total	223	1,783.50	1,750.50	1,410	0
Sheffield Tennis Center						
	Bonk Room	7	144.00	144.00	14	0
	Indoor Tennis Courts	218	1,841.00	1,837.00	15,618	0
	Practice Court 1	63	682.00	682.00	0	0
	Practice Court 2	54	594.00	594.00	0	0
	Practice Court 3	63	682.00	682.00	0	0
	Practice Court 4	51	586.50	586.50	0	0
	Practice Court 5	60	674.50	674.50	0	0

Reporting Period: 8/1/2013 thru 8/1/2014

Building	Room	Bookings	Reserved Hours	Event Hours	Estimated Attendance	Actual Attendance
	Practice Court 6	52	588.00	588.00	2	0
	Total	568	5,792.00	5,788.00	15,634	0
Taishoff Aquatic Center						
	Athletics Camp Space, Lane 7&8 and Dive Well	17	47.30	40.50	530	0
	Dive Well	276	891.82	891.42	70	0
	Entire Aquatic Facility	4	23.50	23.50	0	0
	Lane 1	0	0.00	0.00	0	0
	Lane 1 Deep	0	0.00	0.00	0	0
	Lane 1 Shallow	0	0.00	0.00	0	0
	Lane 2	0	0.00	0.00	0	0
	Lane 2 Deep	0	0.00	0.00	0	0
	Lane 2 Shallow	0	0.00	0.00	0	0
	Lane 3	0	0.00	0.00	0	0
	Lane 3 Deep	0	0.00	0.00	0	0
	Lane 3 Shallow	0	0.00	0.00	0	0
	Lane 4	0	0.00	0.00	0	0
	Lane 4 Deep	0	0.00	0.00	0	0
	Lane 4 Shallow	0	0.00	0.00	0	0
	Lane 5	0	0.00	0.00	0	0
	Lane 5 Deep	0	0.00	0.00	0	0
	Lane 5 Shallow	0	0.00	0.00	0	0
	Lane 6	0	0.00	0.00	0	0
	Lane 6 Deep	0	0.00	0.00	0	0
	Lane 6 Shallow	0	0.00	0.00	0	0
	Lane 7	0	0.00	0.00	0	0
	Lane 7 Deep	0	0.00	0.00	0	0
	Lane 7 Shallow	0	0.00	0.00	0	0
	Lane 8	0	0.00	0.00	0	0
	Lane 8 Deep	0	0.00	0.00	0	0
	Lane 8 Shallow	0	0.00	0.00	0	0
	Lap Pool	237	613.17	613.17	0	0
	Lap Swim	8	35.00	35.00	0	0

Reporting Period: 8/1/2013 thru 8/1/2014

Building	Room	Bookings	Reserved Hours	Event Hours	Estimated Attendance	Actual Attendance
	Left Side Low	0	0.00	0.00	0	0
	Right Side High	0	0.00	0.00	0	0
	Taishoff Lane 1 & 2	18	24.10	18.50	970	0
	Taishoff Lane 1-4	53	107.00	107.00	0	0
	Taishoff Lane 3 & 4	0	0.00	0.00	0	0
	Taishoff Lane 5 & 6	0	0.00	0.00	0	0
	Taishoff Lane 5-8	0	0.00	0.00	0	0
	Taishoff Lane 7 & 8	1	1.50	1.50	0	0
	Taishoff Pool Deck	0	0.00	0.00	0	0
	Taishoff Welcome Center	0	0.00	0.00	0	0
	Total	614	1,743.38	1,730.58	1,570	0
Wallace Wade Stadium						
	Alumni Box	8	188.00	188.00	0	0
	Game Field	75	1,585.33	1,545.33	160,000	0
	President's Box	15	286.00	286.00	0	0
	Total	98	2,059.33	2,019.33	160,000	0
Wannamaker Field						
	Sand Volleyball	0	0.00	0.00	0	0
	Track & Field Practice Area	0	0.00	0.00	0	0
	Total	0	0.00	0.00	0	0
West Practice Complex						
	Turf Fields	158	1,402.10	1,313.00	2,045	0
	West Grass Field 4	296	1,355.33	1,355.33	1,030	0
	West Turf Field 1	373	877.25	877.25	1,299	0
	West Turf Field 2	349	1,001.75	985.75	832	0
	West Turf Field 3	93	589.00	589.00	1,007	0
	Total	1,269	5,225.43	5,120.33	6,213	0
Williams Field at Jack Katz Stadium						

Reporting Period: 8/1/2013 thru 8/1/2014

Building	Room	Bookings	Reserved Hours	Event Hours	Estimated Attendance	Actual Attendance
	Visiting Team Locker Room	56	306.00	306.00	105	0
	Williams Field	351	1,458.50	1,440.50	555	0
	Williams Field House	45	202.00	202.00	12	0
	Total	452	1,966.50	1,948.50	672	0
Wilson Center						
	Basketball Court 1	115	599.50	599.00	670	0
	Basketball Court 2	181	740.00	740.00	48	0
	Basketball Court 3	129	307.25	307.25	900	0
	Indoor Track	1	1.00	1.00	0	0
	Multi-purpose Room 110A	1,400	2,288.58	2,288.58	1,055	0
	Multi-purpose Room 125B	1,446	2,281.50	2,260.50	541	0
	Racquetball Court A	145	250.00	250.00	121	0
	Racquetball Court B	114	183.00	183.00	158	0
	Spin Room	0	0.00	0.00	0	0
	Wilson Classroom 018	356	728.00	728.00	278	0
	Wilson Classroom 020	605	1,076.25	1,074.25	1,095	0
	Wilson Courts	199	1,761.35	1,761.35	16,822	0
	Total	4,691	10,216.43	10,192.93	21,688	0
Yoh Football Complex						
	Team Meal Area	2	4.50	4.50	45	0
	Total	2	4.50	4.50	45	0
	Total	14,999	66,078.77	62,011.57	265,130	1,380

Appendix C: Verified Time Usage:

Facility	Notes	New Estimate (Yearly Hours)
Ambler Tennis Stadium	Based off booking	**1,358.50**
Bassett Drive Practice Fields		**200.00**
Brodie Gym Basketball Courts	Assuming open 15 hrs for students, another 4 for maintenance (M-F), S&S open 11 hrs + 3, 52 weeks per year	**6,500.00**
Brodie Gym Pool	Checked weekly schedule, added extra 4 daily	**4,836.00**
Brooks Practice Field	Field: 5 months *6 days *3 hrs	**466.00**
Cameron Indoor Stadium	7AM - 7PM x 365	**4,380.00**
Card Gym Basketball Courts	7AM - 12AM x 365	**6,205.00**
Card Gymnasium (track lvl lights)		**6,205.00**
Haynes Field	300 - 500 per year of light use	**400.00**
IM Building	Verified with Bob from data pull	**3,158.42**
Jack Coombs Field	Verified with Bob from data pull	**844.67**
K-Center Practice Courts 1 (Emergency Only)	7AM - 7PM x 365; 8 hrs used daily on the low end	**8,760.00**
K-Center Practice Courts 2		**3,120.00**
Koskinen Stadium	Verified with Bob from data pull	**892.16**
Morris Williams Track	Lights on 5 hrs per day	**1,825.00**
Softball Stadium		**850.00**
Taishoff Aquatic Center	7AM - 7PM x 365 days	**4,380.00**
Wallace Wade Stadium	14 days lights are on 24 hours	**486.00**
Wilson Center Basketball Courts	7AM - 12AM x 365; same hours as Card	**6,205.00**
YOH Building Speed & Agility Room	10 hrs x 365 days	**2,850.00**

Appendix D: Fixture Specifications at all Facilities:

Ind	Facility	Building Number	Drawings Compiled?	Room Number (if applicable)	Primary Usage	Secondary Usage	Target Lighting Conversion Date	Lighting Level Standard category	Lighting Level sport	# lamps for field/ court illumination	Primary Lighting Technology	lamp wattage	ballast wattage	per fixture Wattage	Installed lighting demand, kW
18	751 Practice Field	7856	Yes		Varsity Soccer/Lacrosse	Recreation	7/1/2016	Regional Broadcast	Soccer		HID	1000	80	1080	0
10	Ambler Tennis Stadium	7769	Yes		Varsity Tennis	NA	7/1/2015	Regional Broadcast	Tennis	48	HID	1000	80	1080	51.8
24	Bassett Drive Practice Fields		Yes		Varsity Soccer/Lacrosse	Recreation	7/1/2023	Regional Broadcast	Lacrosse	176	HID	1000	80	1080	190.1
19	Brodie Gym Basketball Courts	7726	Yes		Recreation	NA	7/1/2016	Intercollegiate Play	Basketball	64	HID	400	43	443	28.4
4	Brodie Gym Pool	7226	Yes		Recreation	NA	7/1/2015	Intercollegiate Play	Swimming (in	18	HID	250	34	284	5.1
16	Brooks Practice Field	7773	Yes		Varsity Football	NA	7/1/2016	National Broadcast	Football	32	HID	1000	80	1080	34.6
3	Cameron Indoor Stadium	7743	Yes		Varsity Basketball	NA	7/1/2015	National Championship	Basketball	127	HID	1000	80	1080	137.2
12	Card Gym Basketball Courts	7717	Yes		Recreation	NA	7/1/2016	Intercollegiate Play	Basketball	31	HID	400	80	480	14.9
	Card Gymnasium (track lvl lights)	7717			Track level lighting	NA	7/1/2016	Intercollegiate Play	NA	26	HID	250	34	284	7.4
17	Haynes Field	7273			Recreation	NA	7/1/2016	Intercollegiate Play	Soccer	16	HID	1000	80	1080	0
15	IM Building	7775	Yes		Varsity Track & Field	Recreation	7/1/2016	Intercollegiate Play	Basketball	64	HID	400	43	443	28.4
22	Jack Coombs Field	7790	Yes		Varsity Baseball	NA	7/1/2022	National Championship	Baseball w/ U	161	HID	1000	80	1080	173.9
	K-Center Practice Courts 1 (Emerg	7733	Yes		Emergency Lighting	NA	7/1/2015	NA	NA	9	HID	320	60	380	3.4
11	K-Center Practice Courts 2	7733	Yes		Varsity Basketball	NA	7/1/2015	National Championship	Basketball	86	HID	1000	80	1080	92.9
	K-Center Practice Courts 3	7733	Yes		Varsity Basketball	NA	7/1/2015	National Championship	Basketball	95	HID	misc	misc	misc	96.3
25	Koskinen Stadium	7850	Yes		Varsity Soccer/Lacrosse	NA	7/1/2024	National Broadcast	Lacrosse	132	HID	1000	80	1080	142.6
23	Pascal Field House	7849	Yes		Varsity Football	Recreation	7/1/2022	National Broadcast	Football	72	HID	1500	80	1580	113.8
21	Sheffield Indoor Tennis Center	7778	Yes		Varsity Tennis	NA	7/1/2018	Regional Broadcast	Tennis	960	T5HO	49	1	50	48
20	Softball Stadium				Varsity Softball	NA	7/1/2017	Regional Broadcast	Softball	150	HID	1000	80	1080	162
5	Taishoff Aquatic Center	7799	Yes		Varsity Aquatic	Recration	7/1/2015	Regional Broadcast	Swimming (in	65	HID	1000	80	1080	70.2
2	Wallace Wade Stadium	7718	Yes		Varsity Football	NA	7/1/2015	National Championship	Football	256	HID	1500	125	1625	416
1	Williams Field	7272	Yes		Varsity Lacrosse	Recreation	9/1/2014	Regional Broadcast	Field Hockey	88	HID	1000	83	1083	95.3
26	Morris Williams Track		Yes		Varsity Track & Field	Recreation	7/1/2024	Regional Broadcast	Track & Field	168	HID	1000	80	1080	181.4
13	Wilson Center Basketball Courts	7777	Yes		Recreation	NA	7/1/2016	Intercollegiate Play	Basketball	64	HID	400	43	443	28.4
9	Wilson Rec Exercise Area	7777	Not is Scope of Work for Ephesus				7/1/2015	NA		30	HID	var.	var.	942	9.4
14	YOH Building Speed & Agility Roo	7779	Yes		Varsity Football	NA	7/1/2016	Intercollegiate Play	Football	52	HID	320	60	380	19.8

Appendix E: Existing Equipment and Proposed Retrofit:

	Old Lighting System				New Lighting System				DETAILS		FINAL SPECIFICATIONS					4%	5%	
Facility	Lamps Per Field / Court	Watts Per Fixture	Total KWH Per Year	Total Cost Per Year	If Retrofit, Lamps required -	Watts Per Fixture	Total KWH Per Year	Total Cost Per Year	Venue Type	Retrofit Type	New Fixtures	New Per Fixture Costs	New Total Fixture Costs	Labor Costs	Total Cost	Internal Duke PM Costs	Contingency	Grand Total
Ambler Tennis Stadium	48	1,080	70,425	$ 5,247	20	1,000	65,208	$ 4,838	Exterior	1 for 1	48	$ 2,345	$ 112,543	$ 14,195	$ 126,738	$ 5,070	$ 6,337	$ 138,144
Bassett Drive Practice Fields	176	1,080	38,016	$ 2,832	72	1,000	14,400	$ 1,068	Exterior	Recalib	72	$ 2,345	$ 168,814	$ 21,293	$ 190,107	$ 7,604	$ 9,505	$ 207,217
Brodie Gym Basketball Courts	64	443	184,288	$ 13,729	26	240	99,840	$ 7,408	Interior	1 for 1	64	$ 400	$ 25,600	$ 18,927	$ 44,527	$ 1,781	$ 2,226	$ 48,534
Brodie Gym Pool	18	284	24,722	$ 1,842	8	160	13,928	$ 1,033	Interior	1 for 1	18	$ 267	$ 4,800	$ 5,323	$ 10,123	$ 405	$ 506	$ 11,034
Brooks Practice Field	32	1,080	16,105	$ 1,200	13	1,000	6,058	$ 450	Exterior	Recalib	13	$ 2,345	$ 30,480	$ 3,845	$ 34,325	$ 1,373	$ 1,716	$ 37,414
Cameron Indoor Stadium	127	1,080	600,761	$ 44,757	52	1,000	227,760	$ 16,900	Interior	Recalib	52	$ 1,667	$ 86,667	$ 15,378	$ 102,045	$ 4,082	$ 5,102	$ 111,229
Card Gym Basketball Courts	31	480	92,330	$ 6,879	13	240	46,165	$ 3,425	Interior	1 for 1	31	$ 400	$ 12,400	$ 9,168	$ 21,568	$ 863	$ 1,078	$ 23,509
Card Gymnasium (track lvl lights)	26	284	45,818	$ 3,413	11	160	25,813	$ 1,915	Interior	1 for 1	26	$ 267	$ 6,933	$ 7,689	$ 14,622	$ 585	$ 731	$ 15,938
Haynes Field	16	1,080	6,912	$ 515	7	1,000	2,800	$ 208	Exterior	Recalib	7	$ 2,345	$ 16,413	$ 2,070	$ 18,483	$ 739	$ 924	$ 20,146
IM Building	64	443	89,548	$ 6,671	26	240	48,513	$ 3,600	Interior	1 for 1	64	$ 400	$ 25,600	$ 18,927	$ 44,527	$ 1,781	$ 2,226	$ 48,534
Jack Coombs Field	161	1,080	146,871	$ 10,942	66	1,000	55,748	$ 4,137	Exterior	Recalib	66	$ 2,345	$ 154,746	$ 19,518	$ 174,265	$ 6,971	$ 8,713	$ 189,949
K-Center Practice Courts 1 (Emergency Only)	9	380	29,959	$ 2,232	4	240	8,410	$ 624	Interior	Recalib	4	$ 400	$ 1,600	$ 1,183	$ 2,783	$ 111	$ 139	$ 3,033
K-Center Practice Courts 2	86	1,080	289,786	$ 21,589	35	1,000	109,200	$ 8,103	Interior	Recalib	35	$ 1,667	$ 58,333	$ 10,351	$ 68,684	$ 2,747	$ 3,434	$ 74,866
Koskinen Stadium	132	1,080	127,186	$ 9,475	54	1,000	48,176	$ 3,575	Exterior	Recalib	54	$ 2,345	$ 126,611	$ 15,970	$ 142,580	$ 5,703	$ 7,129	$ 155,413
Morris Williams Track	168	1,080	331,128	$ 24,669	69	1,000	125,925	$ 9,344	Exterior	Recalib	69	$ 2,345	$ 161,780	$ 20,406	$ 182,186	$ 7,287	$ 9,109	$ 198,583
Softball Stadium	150	1,080	137,700	$ 10,259	61	1,000	51,850	$ 3,847	Exterior	Recalib	61	$ 2,345	$ 143,023	$ 18,040	$ 161,063	$ 6,443	$ 8,053	$ 175,559
Taishoff Aquatic Center	65	1,080	307,476	$ 22,907	27	1,000	284,700	$ 21,125	Interior	1 for 1	65	$ 1,667	$ 108,333	$ 19,223	$ 127,556	$ 5,102	$ 6,378	$ 139,036
Wallace Wade Stadium	256	1,625	202,176	$ 15,062	104	1,000	50,544	$ 3,750	Exterior	Recalib	104	$ 2,345	$ 243,843	$ 30,756	$ 274,599	$ 10,984	$ 13,730	$ 299,313
Wilson Center Basketball Courts	64	443	175,924	$ 13,106	26	240	95,309	$ 7,072	Interior	1 for 1	64	$ 400	$ 25,600	$ 18,927	$ 44,527	$ 1,781	$ 2,226	$ 48,534
YOH Building Speed & Agility Room	52	380	56,316	$ 4,196	22	240	35,568	$ 2,639	Interior	1 for 1	52	$ 400	$ 20,800	$ 15,378	$ 36,178	$ 1,447	$ 1,809	$ 39,434
Total		**Total kWh**	**2,973,445**	**$ 221,522**		**Total kWh**	**1,415,915**	**$ 105,061**							**$ 1,821,486**			**$ 1,985,420**
Total		**Total MWH**	**2,973**			**Total MWH**	**1,416**											
Rounded Figures		**Total kWh**	**2,973,000**	**$ 222,000**		**Total kWh**	**1,416,000**	**$ 105,000**							**$ 1,821,000**			**$ 1,986,000**

Appendix F: Cash Flows:

Ambler Tennis Stadium	Exterior		Cash Flow	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Old Bulbs	48																												
New Bulbs	48																												
Old Yearly Electricity Cost		$	5,247	$ 5,247	$ 5,299	$ 5,352	$ 5,406	$ 5,460	$ 5,514	$ 5,569	$ 5,625	$ 5,681	$ 5,738	$ 5,796	$ 5,854	$ 5,912	$ 5,971	$ 6,031	$ 6,091	$ 6,152	$ 6,214	$ 6,276	$ 6,339	$ 6,402	$ 6,466	$ 6,531	$ 6,596	$ 6,662	$ 6,728
New Yearly Electricity Cost		$	4,838	$ 4,838	$ 4,887	$ 4,936	$ 4,985	$ 5,035	$ 5,085	$ 5,136	$ 5,187	$ 5,239	$ 5,292	$ 5,345	$ 5,398	$ 5,452	$ 5,507	$ 5,562	$ 5,617	$ 5,673	$ 5,730	$ 5,787	$ 5,845	$ 5,904	$ 5,963	$ 6,022	$ 6,083	$ 6,144	$ 6,205
Savings		$	408	$	$ 412	$ 416	$ 421	$ 425	$ 429	$ 433	$ 438	$ 442	$ 446	$ 451	$ 455	$ 460	$ 465	$ 469	$ 474	$ 479	$ 483	$ 488	$ 493	$ 498	$ 503	$ 508	$ 513	$ 518	$ 523
Initial Capital		$	138,144	$ (138,144)																								
Mainteneance Savings		$	15,456	$	$ 1,561	$ 1,577	$ 1,592	$ 1,608	$ 1,624	$ 1,641	$ 1,657	$ 1,674	$ 1,690	$ 1,707	$ 1,724	$ 1,742	$ 1,759	$ 1,777	$ 1,794	$ 1,812	$ 1,830	$ 1,849	$ 1,867	$ 1,886	$ 1,905	$ 1,924	$ 1,943	$ 1,963	$ 1,982
Net Cash Flow				**$ (138,144)**	**$ 1,973**	**$ 1,993**	**$ 2,013**	**$ 2,033**	**$ 2,053**	**$ 2,074**	**$ 2,095**	**$ 2,116**	**$ 2,137**	**$ 2,158**	**$ 2,180**	**$ 2,202**	**$ 2,224**	**$ 2,246**	**$ 2,268**	**$ 2,291**	**$ 2,314**	**$ 2,337**	**$ 2,360**	**$ 2,384**	**$ 2,408**	**$ 2,432**	**$ 2,456**	**$ 2,481**	**$ 2,506**
NPV (Exterior):		**$**	**(107,494)**	$ (138,144)	$ 1,879	$ 1,808	$ 1,739	$ 1,673	$ 1,609	$ 1,548	$ 1,489	$ 1,432	$ 1,377	$ 1,325	$ 1,274	$ 1,226	$ 1,179	$ 1,134	$ 1,091	$ 1,050	$ 1,010	$ 971	$ 934	$ 899	$ 864	$ 831	$ 800	$ 769	$ 740
IRR			**-6%**																									
Payback (Years) [Using Avg Cash Flow Savings]			**70.01**																									

Bassett Drive Practice Fields	Exterior		Cash Flow	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Old Bulbs	176																												
New Bulbs	72																												
Old Yearly Electricity Cost		$	2,832	$ 2,832	$ 2,861	$ 2,889	$ 2,918	$ 2,947	$ 2,977	$ 3,006	$ 3,036	$ 3,067	$ 3,098	$ 3,129	$ 3,160	$ 3,191	$ 3,223	$ 3,256	$ 3,288	$ 3,321	$ 3,354	$ 3,388	$ 3,422	$ 3,456	$ 3,490	$ 3,525	$ 3,561	$ 3,596	$ 3,632
New Yearly Electricity Cost		$	1,068	$ 1,068	$ 1,079	$ 1,090	$ 1,101	$ 1,112	$ 1,123	$ 1,134	$ 1,146	$ 1,157	$ 1,169	$ 1,180	$ 1,192	$ 1,204	$ 1,216	$ 1,228	$ 1,240	$ 1,253	$ 1,265	$ 1,278	$ 1,291	$ 1,304	$ 1,317	$ 1,330	$ 1,343	$ 1,357	$ 1,370
Savings		$	1,764	$	$ 1,781	$ 1,799	$ 1,817	$ 1,835	$ 1,854	$ 1,872	$ 1,891	$ 1,910	$ 1,929	$ 1,948	$ 1,968	$ 1,987	$ 2,007	$ 2,027	$ 2,048	$ 2,068	$ 2,089	$ 2,110	$ 2,131	$ 2,152	$ 2,174	$ 2,195	$ 2,217	$ 2,239	$ 2,262
Initial Capital		$	207,217	$ (207,217)																								
Mainteneance Savings		$	56,672	$	$ 5,724	$ 5,781	$ 5,839	$ 5,897	$ 5,956	$ 6,016	$ 6,076	$ 6,137	$ 6,198	$ 6,260	$ 6,323	$ 6,386	$ 6,450	$ 6,514	$ 6,579	$ 6,645	$ 6,712	$ 6,779	$ 6,847	$ 6,915	$ 6,984	$ 7,054	$ 7,125	$ 7,196	$ 7,268
Net Cash Flow				**$ (207,217)**	**$ 7,505**	**$ 7,580**	**$ 7,656**	**$ 7,733**	**$ 7,810**	**$ 7,888**	**$ 7,967**	**$ 8,047**	**$ 8,127**	**$ 8,208**	**$ 8,290**	**$ 8,373**	**$ 8,457**	**$ 8,542**	**$ 8,627**	**$ 8,713**	**$ 8,800**	**$ 8,888**	**$ 8,977**	**$ 9,067**	**$ 9,158**	**$ 9,249**	**$ 9,342**	**$ 9,435**	**$ 9,530**
NPV (Exterior):		**$**	**(90,643)**	$ (207,217)	$ 7,148	$ 6,876	$ 6,614	$ 6,362	$ 6,119	$ 5,886	$ 5,662	$ 5,446	$ 5,239	$ 5,039	$ 4,847	$ 4,663	$ 4,485	$ 4,314	$ 4,150	$ 3,992	$ 3,840	$ 3,693	$ 3,553	$ 3,417	$ 3,287	$ 3,162	$ 3,041	$ 2,926	$ 2,814
IRR			**0%**																									
Payback (Years) [Using Avg Cash Flow Savings]			**27.61**																									

Brodie Gym Basketball Courts	Interior		Cash Flow	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Old Bulbs	64																												
New Bulbs	64																												
Old Yearly Electricity Cost		$	13,729	$ 13,729	$ 13,867	$ 14,005	$ 14,145	$ 14,287	$ 14,430	$ 14,574	$ 14,720	$ 14,867	$ 15,016	$ 15,166	$15,318	$15,471	$15,625	$15,782	$15,939	$16,099	$16,260	$16,422	$16,587	$16,753	$16,920	$17,089	$17,260	$17,433	$17,607
New Yearly Electricity Cost		$	7,408	$ 7,408	$ 7,482	$ 7,557	$ 7,633	$ 7,709	$ 7,786	$ 7,864	$ 7,943	$ 8,022	$ 8,102	$ 8,183	$ 8,265	$ 8,348	$ 8,431	$ 8,515	$ 8,601	$ 8,687	$ 8,773	$ 8,861	$ 8,950	$ 9,039	$ 9,130	$ 9,221	$ 9,313	$ 9,406	$ 9,500
Savings		$	6,321	$	$ 6,385	$ 6,448	$ 6,513	$ 6,578	$ 6,644	$ 6,710	$ 6,777	$ 6,845	$ 6,914	$ 6,983	$ 7,053	$ 7,123	$ 7,194	$ 7,266	$ 7,339	$ 7,412	$ 7,486	$ 7,561	$ 7,637	$ 7,713	$ 7,790	$ 7,868	$ 7,947	$ 8,026	$ 8,107
Initial Capital		$	48,534	$ (48,534)																								
Mainteneance Savings		$	6,400	$	$ 646	$ 653	$ 659	$ 666	$ 673	$ 679	$ 686	$ 693	$ 700	$ 707	$ 714	$ 721	$ 728	$ 736	$ 743	$ 750	$ 758	$ 766	$ 773	$ 781	$ 789	$ 797	$ 805	$ 813	$ 821
Net Cash Flow				**$ (48,534)**	**$ 7,031**	**$ 7,101**	**$ 7,172**	**$ 7,244**	**$ 7,316**	**$ 7,390**	**$ 7,463**	**$ 7,538**	**$ 7,614**	**$ 7,690**																
NPV (Interior):		**$**	**8,040**	$ (48,534)	$ 6,696	$ 6,441	$ 6,196	$ 5,960	$ 5,733	$ 5,514	$ 5,304	$ 5,102	$ 4,908	$ 4,721															
IRR			**8%**																									
Payback (Years) [Using Avg Cash Flow Savings]			**6.90**																									

Brodie Gym Pool	Interior		Cash Flow	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Old Bulbs	18																												
New Bulbs	18																												
Old Yearly Electricity Cost		$	1,842	$ 1,842	$ 1,860	$ 1,879	$ 1,898	$ 1,917	$ 1,936	$ 1,955	$ 1,975	$ 1,994	$ 2,014	$ 2,034	$ 2,055	$ 2,075	$ 2,096	$ 2,117	$ 2,138	$ 2,160	$ 2,181	$ 2,203	$ 2,225	$ 2,247	$ 2,270	$ 2,292	$ 2,315	$ 2,339	$ 2,362
New Yearly Electricity Cost		$	1,033	$ 1,033	$ 1,044	$ 1,054	$ 1,065	$ 1,075	$ 1,086	$ 1,097	$ 1,108	$ 1,119	$ 1,130	$ 1,142	$ 1,153	$ 1,164	$ 1,176	$ 1,188	$ 1,200	$ 1,212	$ 1,224	$ 1,236	$ 1,249	$ 1,261	$ 1,274	$ 1,286	$ 1,299	$ 1,312	$ 1,325
Savings		$	808	$	$ 816	$ 825	$ 833	$ 841	$ 850	$ 858	$ 867	$ 875	$ 884	$ 893	$ 902	$ 911	$ 920	$ 929	$ 938	$ 948	$ 957	$ 967	$ 977	$ 986	$ 996	$ 1,006	$ 1,016	$ 1,026	$ 1,037
Initial Capital		$	11,034	$ (11,034)																								
Mainteneance Savings		$	1,800	$	$ 182	$ 184	$ 185	$ 187	$ 189	$ 191	$ 193	$ 195	$ 197	$ 199	$ 201	$ 203	$ 205	$ 207	$ 209	$ 211	$ 213	$ 215	$ 217	$ 220	$ 222	$ 224	$ 226	$ 229	$ 231
Net Cash Flow				**$ (11,034)**	**$ 998**	**$ 1,008**	**$ 1,018**	**$ 1,028**	**$ 1,039**	**$ 1,049**	**$ 1,060**	**$ 1,070**	**$ 1,081**	**$ 1,092**																
NPV (Interior):		**$**	**(3,002)**	$ (11,034)	$ 951	$ 914	$ 880	$ 846	$ 814	$ 783	$ 753	$ 724	$ 697	$ 670															
IRR			**-1%**																									
Payback (Years) [Using Avg Cash Flow Savings]			**11.05**																									

Brooks Practice Field	Exterior		Cash Flow	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Old Bulbs	32																												
New Bulbs	13																												
Old Yearly Electricity Cost		$	1,200	$ 1,200	$ 1,212	$ 1,224	$ 1,236	$ 1,249	$ 1,261	$ 1,274	$ 1,286	$ 1,299	$ 1,312	$ 1,325	$ 1,339	$ 1,352	$ 1,366	$ 1,379	$ 1,393	$ 1,407	$ 1,421	$ 1,435	$ 1,450	$ 1,464	$ 1,479	$ 1,493	$ 1,508	$ 1,523	$ 1,539
New Yearly Electricity Cost		$	450	$ 450	$ 454	$ 459	$ 463	$ 468	$ 472	$ 477	$ 482	$ 487	$ 492	$ 497	$ 501	$ 507	$ 512	$ 517	$ 522	$ 527	$ 532	$ 538	$ 543	$ 548	$ 554	$ 560	$ 565	$ 571	$ 576
Savings		$	750	$	$ 758	$ 765	$ 773	$ 781	$ 789	$ 796	$ 804	$ 812	$ 821	$ 829	$ 837	$ 845	$ 854	$ 862	$ 871	$ 880	$ 889	$ 897	$ 906	$ 916	$ 925	$ 934	$ 943	$ 953	$ 962
Initial Capital		$	37,414	$ (37,414)																								
Mainteneance Savings		$	10,304	$	$ 1,041	$ 1,051	$ 1,062	$ 1,072	$ 1,083	$ 1,094	$ 1,105	$ 1,116	$ 1,127	$ 1,138	$ 1,150	$ 1,161	$ 1,173	$ 1,184	$ 1,196	$ 1,208	$ 1,220	$ 1,233	$ 1,245	$ 1,257	$ 1,270	$ 1,283	$ 1,295	$ 1,308	$ 1,321
Net Cash Flow				**$ (37,414)**	**$ 1,799**	**$ 1,817**	**$ 1,835**	**$ 1,853**	**$ 1,872**	**$ 1,890**	**$ 1,909**	**$ 1,928**	**$ 1,948**	**$ 1,967**	**$ 1,987**	**$ 2,007**	**$ 2,027**	**$ 2,047**	**$ 2,067**	**$ 2,088**	**$ 2,109**	**$ 2,130**	**$ 2,151**	**$ 2,173**	**$ 2,195**	**$ 2,216**	**$ 2,239**	**$ 2,261**	**$ 2,284**
NPV (Exterior):		**$**	**(9,479)**	$ (37,414)	$ 1,713	$ 1,648	$ 1,585	$ 1,524	$ 1,466	$ 1,411	$ 1,357	$ 1,305	$ 1,255	$ 1,208	$ 1,162	$ 1,117	$ 1,075	$ 1,034	$ 994	$ 957	$ 920	$ 885	$ 851	$ 819	$ 788	$ 758	$ 729	$ 701	$ 674
IRR			**2%**																									
Payback (Years) [Using Avg Cash Flow Savings]			**20.80**																									

				Cash Flow	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Cameron Indoor Stadium	**Interior**																													
Old Bulbs	127																													
New Bulbs	52																													
Old Yearly Electricity Cost		$	44,757	$ 44,757	$ 45,204	$ 45,656	$ 46,113	$ 46,574	$ 47,040	$ 47,510	$ 47,985	$ 48,465	$ 48,950	$ 49,439	$49,934	$50,433	$50,937	$51,447	$51,961	$52,481	$53,006	$53,536	$54,071	$54,612	$55,158	$55,709	$56,266	$56,829	$57,397
New Yearly Electricity Cost		$	16,900	$ 16,900	$ 17,069	$ 17,239	$ 17,412	$ 17,586	$ 17,762	$ 17,939	$ 18,119	$ 18,300	$ 18,483	$ 18,668	$18,855	$19,043	$19,234	$19,426	$19,620	$19,816	$20,014	$20,215	$20,417	$20,621	$20,827	$21,035	$21,246	$21,458	$21,673
Savings		$	27,857		$ 28,135	$ 28,417	$ 28,701	$ 28,988	$ 29,278	$ 29,571	$ 29,866	$ 30,165	$ 30,467	$ 30,771	$31,079	$31,390	$31,704	$32,021	$32,341	$32,664	$32,991	$33,321	$33,654	$33,991	$34,331	$34,674	$35,021	$35,371	$35,725
Initial Capital		$	111,229	$ (111,229)																										
Mainteneance Savings		$	12,700		$ 1,283	$ 1,296	$ 1,308	$ 1,322	$ 1,335	$ 1,348	$ 1,362	$ 1,375	$ 1,389	$ 1,403	$ 1,417	$ 1,431	$ 1,445	$ 1,460	$ 1,474	$ 1,489	$ 1,504	$ 1,519	$ 1,534	$ 1,550	$ 1,565	$ 1,581	$ 1,597	$ 1,613	$ 1,629
Net Cash Flow				**$ (111,229)**	**$ 29,418**	**$ 29,712**	**$ 30,009**	**$ 30,310**	**$ 30,613**	**$ 30,919**	**$ 31,228**	**$ 31,540**	**$ 31,856**	**$ 32,174**																
	NPV (Interior):	**$**	**125,483**	$ (111,229)	$ 28,017	$ 26,950	$ 25,923	$ 24,936	$ 23,986	$ 23,072	$ 22,193	$ 21,348	$ 20,534	$ 19,752															
	IRR		**24%**																											
	Payback (Years) [Using Avg Cash Flow Savings]		**3.78**																											

				Cash Flow	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Card Gym Basketball Courts	**Interior**																													
Old Bulbs	31																													
New Bulbs	31																													
Old Yearly Electricity Cost		$	6,879	$ 6,879	$ 6,947	$ 7,017	$ 7,087	$ 7,158	$ 7,229	$ 7,302	$ 7,375	$ 7,449	$ 7,523	$ 7,598	$ 7,674	$ 7,751	$ 7,829	$ 7,907	$ 7,986	$ 8,066	$ 8,146	$ 8,228	$ 8,310	$ 8,393	$ 8,477	$ 8,562	$ 8,648	$ 8,734	$ 8,821
New Yearly Electricity Cost		$	3,425	$ 3,425	$ 3,460	$ 3,494	$ 3,529	$ 3,565	$ 3,600	$ 3,636	$ 3,673	$ 3,709	$ 3,746	$ 3,784	$ 3,822	$ 3,860	$ 3,898	$ 3,937	$ 3,977	$ 4,017	$ 4,057	$ 4,097	$ 4,138	$ 4,180	$ 4,222	$ 4,264	$ 4,306	$ 4,349	$ 4,393
Savings		$	3,453		$ 3,488	$ 3,523	$ 3,558	$ 3,593	$ 3,629	$ 3,666	$ 3,702	$ 3,739	$ 3,777	$ 3,814	$ 3,853	$ 3,891	$ 3,930	$ 3,969	$ 4,009	$ 4,049	$ 4,090	$ 4,130	$ 4,172	$ 4,214	$ 4,256	$ 4,298	$ 4,341	$ 4,385	$ 4,428
Initial Capital		$	23,509	$ (23,509)																										
Mainteneance Savings		$	3,100		$ 313	$ 316	$ 319	$ 323	$ 326	$ 329	$ 332	$ 336	$ 339	$ 342	$ 346	$ 349	$ 353	$ 356	$ 360	$ 363	$ 367	$ 371	$ 375	$ 378	$ 382	$ 386	$ 390	$ 394	$ 398	
Net Cash Flow				**$ (23,509)**	**$ 3,801**	**$ 3,839**	**$ 3,877**	**$ 3,916**	**$ 3,955**	**$ 3,995**	**$ 4,035**	**$ 4,075**	**$ 4,116**	**$ 4,157**																
	NPV (Interior):	**$**	**7,074**	$ (23,509)	$ 3,620	$ 3,482	$ 3,349	$ 3,222	$ 3,099	$ 2,981	$ 2,867	$ 2,758	$ 2,653	$ 2,552															
	IRR		**11%**																											
	Payback (Years) [Using Avg Cash Flow Savings]		**6.19**																											

				Cash Flow	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Card Gymnasium (track lvl lights)	**Interior**																													
Old Bulbs	26																													
New Bulbs	26																													
Old Yearly Electricity Cost		$	3,413	$ 3,413	$ 3,448	$ 3,482	$ 3,517	$ 3,552	$ 3,588	$ 3,623	$ 3,660	$ 3,696	$ 3,733	$ 3,771	$ 3,808	$ 3,846	$ 3,885	$ 3,924	$ 3,963	$ 4,003	$ 4,043	$ 4,083	$ 4,124	$ 4,165	$ 4,207	$ 4,249	$ 4,291	$ 4,334	$ 4,377
New Yearly Electricity Cost		$	1,915	$ 1,915	$ 1,934	$ 1,954	$ 1,973	$ 1,993	$ 2,013	$ 2,033	$ 2,053	$ 2,074	$ 2,095	$ 2,116	$ 2,137	$ 2,158	$ 2,180	$ 2,202	$ 2,224	$ 2,246	$ 2,268	$ 2,291	$ 2,314	$ 2,337	$ 2,360	$ 2,384	$ 2,408	$ 2,432	$ 2,456
Savings		$	1,498		$ 1,513	$ 1,528	$ 1,544	$ 1,559	$ 1,575	$ 1,590	$ 1,606	$ 1,622	$ 1,638	$ 1,655	$ 1,671	$ 1,688	$ 1,705	$ 1,722	$ 1,739	$ 1,757	$ 1,774	$ 1,792	$ 1,810	$ 1,828	$ 1,846	$ 1,865	$ 1,883	$ 1,902	$ 1,921
Initial Capital		$	15,938	$ (15,938)																										
Mainteneance Savings		$	2,600		$ 263	$ 265	$ 268	$ 271	$ 273	$ 276	$ 279	$ 282	$ 284	$ 287	$ 290	$ 293	$ 296	$ 299	$ 302	$ 305	$ 308	$ 311	$ 314	$ 317	$ 320	$ 324	$ 327	$ 330	$ 333	
Net Cash Flow				**$ (15,938)**	**$ 1,776**	**$ 1,793**	**$ 1,811**	**$ 1,829**	**$ 1,848**	**$ 1,866**	**$ 1,885**	**$ 1,904**	**$ 1,923**	**$ 1,942**																
	NPV (Interior):	**$**	**(1,650)**	$ (15,938)	$ 1,691	$ 1,627	$ 1,565	$ 1,505	$ 1,448	$ 1,393	$ 1,340	$ 1,289	$ 1,239	$ 1,192															
	IRR		**3%**																											
	Payback (Years) [Using Avg Cash Flow Savings]		**8.98**																											

				Cash Flow	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Haynes Field	**Exterior**																													
Old Bulbs	16																													
New Bulbs	7																													
Old Yearly Electricity Cost		$	515	$ 515	$ 520	$ 525	$ 531	$ 536	$ 541	$ 547	$ 552	$ 558	$ 563	$ 569	$ 575	$ 580	$ 586	$ 592	$ 598	$ 604	$ 610	$ 616	$ 622	$ 628	$ 635	$ 641	$ 647	$ 654	$ 660	
New Yearly Electricity Cost		$	208	$ 208	$ 210	$ 212	$ 214	$ 216	$ 218	$ 221	$ 223	$ 225	$ 227	$ 229	$ 232	$ 234	$ 236	$ 239	$ 241	$ 244	$ 246	$ 249	$ 251	$ 254	$ 256	$ 259	$ 261	$ 264	$ 266	
Savings		$	307		$ 310	$ 313	$ 316	$ 320	$ 323	$ 326	$ 329	$ 333	$ 336	$ 339	$ 343	$ 346	$ 350	$ 353	$ 357	$ 360	$ 364	$ 367	$ 371	$ 375	$ 379	$ 382	$ 386	$ 390	$ 394	
Initial Capital		$	20,146	$ (20,146)																										
Mainteneance Savings		$	5,152		$ 520	$ 526	$ 531	$ 536	$ 541	$ 547	$ 552	$ 558	$ 563	$ 569	$ 575	$ 581	$ 586	$ 592	$ 598	$ 604	$ 610	$ 616	$ 622	$ 629	$ 635	$ 641	$ 648	$ 654	$ 661	
Net Cash Flow				**$ (20,146)**	**$ 831**	**$ 839**	**$ 847**	**$ 856**	**$ 864**	**$ 873**	**$ 882**	**$ 891**	**$ 899**	**$ 908**	**$ 918**	**$ 927**	**$ 936**	**$ 945**	**$ 955**	**$ 964**	**$ 974**	**$ 984**	**$ 994**	**$ 1,003**	**$ 1,013**	**$ 1,024**	**$ 1,034**	**$ 1,044**	**$ 1,055**	
	NPV (Exterior):	**$**	**(7,245)**	$ (20,146)	$ 791	$ 761	$ 732	$ 704	$ 677	$ 651	$ 627	$ 603	$ 580	$ 558	$ 536	$ 516	$ 496	$ 477	$ 459	$ 442	$ 425	$ 409	$ 393	$ 378	$ 364	$ 350	$ 337	$ 324	$ 311	
	IRR		**1%**																											
	Payback (Years) [Using Avg Cash Flow Savings]		**24.25**																											

				Cash Flow	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
IM Building	**Interior**																													
Old Bulbs	64																													
New Bulbs	64																													
Old Yearly Electricity Cost		$	6,671	$ 6,671	$ 6,738	$ 6,805	$ 6,873	$ 6,942	$ 7,012	$ 7,082	$ 7,153	$ 7,224	$ 7,296	$ 7,369	$ 7,443	$ 7,517	$ 7,593	$ 7,668	$ 7,745	$ 7,823	$ 7,901	$ 7,980	$ 8,060	$ 8,140	$ 8,222	$ 8,304	$ 8,387	$ 8,471	$ 8,555
New Yearly Electricity Cost		$	3,600	$ 3,600	$ 3,636	$ 3,672	$ 3,709	$ 3,746	$ 3,783	$ 3,821	$ 3,859	$ 3,898	$ 3,937	$ 3,976	$ 4,016	$ 4,056	$ 4,097	$ 4,138	$ 4,179	$ 4,221	$ 4,263	$ 4,306	$ 4,349	$ 4,392	$ 4,436	$ 4,481	$ 4,525	$ 4,571	$ 4,616
Savings		$	3,072		$ 3,102	$ 3,133	$ 3,165	$ 3,196	$ 3,228	$ 3,261	$ 3,293	$ 3,326	$ 3,359	$ 3,393	$ 3,427	$ 3,461	$ 3,496	$ 3,531	$ 3,566	$ 3,602	$ 3,638	$ 3,674	$ 3,711	$ 3,748	$ 3,785	$ 3,823	$ 3,862	$ 3,900	$ 3,939
Initial Capital		$	48,534	$ (48,534)																										
Mainteneance Savings		$	6,400		$ 646	$ 653	$ 659	$ 666	$ 673	$ 679	$ 686	$ 693	$ 700	$ 707	$ 714	$ 721	$ 728	$ 736	$ 743	$ 750	$ 758	$ 766	$ 773	$ 781	$ 789	$ 797	$ 805	$ 813	$ 821	
Net Cash Flow				**$ (48,534)**	**$ 3,749**	**$ 3,786**	**$ 3,824**	**$ 3,862**	**$ 3,901**	**$ 3,940**	**$ 3,979**	**$ 4,019**	**$ 4,059**	**$ 4,100**																
	NPV (Interior):	**$**	**(18,371)**	$ (48,534)	$ 3,570	$ 3,434	$ 3,303	$ 3,178	$ 3,056	$ 2,940	$ 2,828	$ 2,720	$ 2,617	$ 2,517															
	IRR		**-4%**																											
	Payback (Years) [Using Avg Cash Flow Savings]		**12.95**																											

		Cash Flow	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Jack Coombs Field	**Exterior**																											
Old Bulbs	161																											
New Bulbs	66																											
Old Yearly Electricity Cost		$ 10,942	$ 10,942	$ 11,051	$ 11,162	$ 11,273	$ 11,386	$ 11,500	$ 11,615	$ 11,731	$ 11,848	$ 11,967	$ 12,087	$12,207	$12,330	$12,453	$12,577	$12,703	$12,830	$12,958	$13,088	$13,219	$13,351	$13,485	$13,620	$13,756	$13,893	$14,032
New Yearly Electricity Cost		$ 4,137	$ 4,137	$ 4,178	$ 4,220	$ 4,262	$ 4,304	$ 4,348	$ 4,391	$ 4,435	$ 4,479	$ 4,524	$ 4,569	$ 4,615	$ 4,661	$ 4,708	$ 4,755	$ 4,802	$ 4,850	$ 4,899	$ 4,948	$ 4,997	$ 5,047	$ 5,098	$ 5,149	$ 5,200	$ 5,252	$ 5,305
Savings		$ 6,805		$ 6,873	$ 6,942	$ 7,012	$ 7,082	$ 7,153	$ 7,224	$ 7,296	$ 7,369	$ 7,443	$ 7,517	$ 7,593	$ 7,668	$ 7,745	$ 7,823	$ 7,901	$ 7,980	$ 8,060	$ 8,140	$ 8,222	$ 8,304	$ 8,387	$ 8,471	$ 8,555	$ 8,641	$ 8,727
Initial Capital		$ 189,949	$ (189,949)																									
Mainteneance Savings		$ 51,842		$ 5,236	$ 5,288	$ 5,341	$ 5,395	$ 5,449	$ 5,503	$ 5,558	$ 5,614	$ 5,670	$ 5,727	$ 5,784	$ 5,842	$ 5,900	$ 5,959	$ 6,019	$ 6,079	$ 6,140	$ 6,201	$ 6,263	$ 6,326	$ 6,389	$ 6,453	$ 6,517	$ 6,583	$ 6,648
Net Cash Flow			**$ (189,949)**	**$ 12,109**	**$ 12,231**	**$ 12,353**	**$ 12,476**	**$ 12,601**	**$ 12,727**	**$ 12,854**	**$ 12,983**	**$ 13,113**	**$ 13,244**	**$13,376**	**$13,510**	**$13,645**	**$13,782**	**$13,920**	**$14,059**	**$14,199**	**$14,341**	**$14,485**	**$14,630**	**$14,776**	**$14,924**	**$15,073**	**$15,224**	**$15,376**
NPV (Exterior):		**$ (1,860)**	$ (189,949)	$ 11,533	$ 11,093	$ 10,671	$ 10,264	$ 9,873	$ 9,497	$ 9,135	$ 8,787	$ 8,453	$ 8,131	$ 7,821	$ 7,523	$ 7,236	$ 6,961	$ 6,696	$ 6,440	$ 6,195	$ 5,959	$ 5,732	$ 5,514	$ 5,304	$ 5,102	$ 4,907	$ 4,720	$ 4,541
IRR		**5%**																										
Payback (Years) [Using Avg Cash Flow Savings]		**15.69**																										

		Cash Flow	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
K-Center Practice Courts 1 (Emergency Only)	**Interior**																											
Old Bulbs	9																											
New Bulbs	4																											
Old Yearly Electricity Cost		$ 2,232	$ 2,232	$ 2,254	$ 2,277	$ 2,300	$ 2,323	$ 2,346	$ 2,369	$ 2,393	$ 2,417	$ 2,441	$ 2,465	$ 2,490	$ 2,515	$ 2,540	$ 2,566	$ 2,591	$ 2,617	$ 2,643	$ 2,670	$ 2,696	$ 2,723	$ 2,751	$ 2,778	$ 2,806	$ 2,834	$ 2,862
New Yearly Electricity Cost		$ 624	$ 624	$ 630	$ 637	$ 643	$ 649	$ 656	$ 662	$ 669	$ 676	$ 682	$ 689	$ 696	$ 703	$ 710	$ 717	$ 724	$ 732	$ 739	$ 746	$ 754	$ 761	$ 769	$ 777	$ 784	$ 792	$ 800
Savings		$ 1,608		$ 1,624	$ 1,640	$ 1,657	$ 1,673	$ 1,690	$ 1,707	$ 1,724	$ 1,741	$ 1,759	$ 1,776	$ 1,794	$ 1,812	$ 1,830	$ 1,848	$ 1,867	$ 1,885	$ 1,904	$ 1,923	$ 1,943	$ 1,962	$ 1,982	$ 2,001	$ 2,021	$ 2,042	$ 2,062
Initial Capital		$ 3,033	$ (3,033)																									
Mainteneance Savings		$ 900		$ 91	$ 92	$ 93	$ 94	$ 95	$ 96	$ 96	$ 97	$ 98	$ 99	$ 100	$ 101	$ 102	$ 103	$ 104	$ 106	$ 107	$ 108	$ 109	$ 110	$ 111	$ 112	$ 113	$ 114	$ 115
Net Cash Flow			**$ (3,033)**	**$ 1,715**	**$ 1,732**	**$ 1,749**	**$ 1,767**	**$ 1,785**	**$ 1,802**	**$ 1,820**	**$ 1,839**	**$ 1,857**	**$ 1,876**															
NPV (Interior):		**$ 10,766**	$ (3,033)	$ 1,633	$ 1,571	$ 1,511	$ 1,454	$ 1,398	$ 1,345	$ 1,294	$ 1,244	$ 1,197	$ 1,151															
IRR		**57%**																										
Payback (Years) [Using Avg Cash Flow Savings]		**1.77**																										

		Cash Flow	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
K-Center Practice Courts 2	**Interior**																											
Old Bulbs	86																											
New Bulbs	35																											
Old Yearly Electricity Cost		$ 21,589	$ 21,589	$ 21,805	$ 22,023	$ 22,243	$ 22,466	$ 22,690	$ 22,917	$ 23,146	$ 23,378	$ 23,612	$ 23,848	$24,086	$24,327	$24,570	$24,816	$25,064	$25,315	$25,568	$25,824	$26,082	$26,343	$26,606	$26,872	$27,141	$27,412	$27,686
New Yearly Electricity Cost		$ 8,103	$ 8,103	$ 8,184	$ 8,266	$ 8,348	$ 8,432	$ 8,516	$ 8,601	$ 8,687	$ 8,774	$ 8,862	$ 8,950	$ 9,040	$ 9,130	$ 9,222	$ 9,314	$ 9,407	$ 9,501	$ 9,596	$ 9,692	$ 9,789	$ 9,887	$ 9,986	$10,085	$10,186	$10,288	$10,391
Savings		$ 13,486		$ 13,621	$ 13,757	$ 13,895	$ 14,034	$ 14,174	$ 14,316	$ 14,459	$ 14,604	$ 14,750	$ 14,897	$15,046	$15,197	$15,349	$15,502	$15,657	$15,814	$15,972	$16,132	$16,293	$16,456	$16,621	$16,787	$16,955	$17,124	$17,295
Initial Capital		$ 74,866	$ (74,866)																									
Mainteneance Savings		$ 8,600		$ 869	$ 877	$ 886	$ 895	$ 904	$ 913	$ 922	$ 931	$ 941	$ 950	$ 959	$ 969	$ 979	$ 989	$ 998	$ 1,008	$ 1,019	$ 1,029	$ 1,039	$ 1,049	$ 1,060	$ 1,070	$ 1,081	$ 1,092	$ 1,103
Net Cash Flow			**$ (74,866)**	**$ 14,490**	**$ 14,635**	**$ 14,781**	**$ 14,929**	**$ 15,078**	**$ 15,229**	**$ 15,381**	**$ 15,535**	**$ 15,690**	**$ 15,847**															
NPV (Interior):		**$ 41,726**	$ (74,866)	$ 13,800	$ 13,274	$ 12,768	$ 12,282	$ 11,814	$ 11,364	$ 10,931	$ 10,515	$ 10,114	$ 9,729															
IRR		**15%**																										
Payback (Years) [Using Avg Cash Flow Savings]		**5.17**																										

		Cash Flow	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Koskinen Stadium	**Exterior**																											
Old Bulbs	132																											
New Bulbs	54																											
Old Yearly Electricity Cost		$ 9,475	$ 9,475	$ 9,570	$ 9,666	$ 9,762	$ 9,860	$ 9,959	$ 10,058	$ 10,159	$ 10,260	$ 10,363	$ 10,467	$10,571	$10,677	$10,784	$10,892	$11,001	$11,111	$11,222	$11,334	$11,447	$11,562	$11,677	$11,794	$11,912	$12,031	$12,151
New Yearly Electricity Cost		$ 3,575	$ 3,575	$ 3,610	$ 3,647	$ 3,683	$ 3,720	$ 3,757	$ 3,795	$ 3,833	$ 3,871	$ 3,910	$ 3,949	$ 3,988	$ 4,028	$ 4,068	$ 4,109	$ 4,150	$ 4,192	$ 4,234	$ 4,276	$ 4,319	$ 4,362	$ 4,405	$ 4,449	$ 4,494	$ 4,539	$ 4,584
Savings		$ 5,901		$ 5,960	$ 6,019	$ 6,079	$ 6,140	$ 6,202	$ 6,264	$ 6,326	$ 6,390	$ 6,453	$ 6,518	$ 6,583	$ 6,649	$ 6,715	$ 6,783	$ 6,850	$ 6,919	$ 6,988	$ 7,058	$ 7,129	$ 7,200	$ 7,272	$ 7,345	$ 7,418	$ 7,492	$ 7,567
Initial Capital		$ 155,413	$ (155,413)																									
Mainteneance Savings		$ 42,504		$ 4,293	$ 4,336	$ 4,379	$ 4,423	$ 4,467	$ 4,512	$ 4,557	$ 4,603	$ 4,649	$ 4,695	$ 4,742	$ 4,789	$ 4,837	$ 4,886	$ 4,935	$ 4,984	$ 5,034	$ 5,084	$ 5,135	$ 5,186	$ 5,238	$ 5,291	$ 5,343	$ 5,397	$ 5,451
Net Cash Flow			**$ (155,413)**	**$ 10,253**	**$ 10,355**	**$ 10,459**	**$ 10,563**	**$ 10,669**	**$ 10,776**	**$ 10,883**	**$ 10,992**	**$ 11,102**	**$ 11,213**	**$11,325**	**$11,438**	**$11,553**	**$11,668**	**$11,785**	**$11,903**	**$12,022**	**$12,142**	**$12,264**	**$12,386**	**$12,510**	**$12,635**	**$12,762**	**$12,889**	**$13,018**
NPV (Exterior):		**$ 3,833.91**	$ (155,412.56)	$ 9,764.35	$ 9,392.37	$ 9,034.57	$ 8,690.39	$ 8,359.33	$ 8,040.88	$ 7,734.56	$ 7,439.91	$ 7,156.48	$ 6,883.86	#######	#######	#######	#######	#######	#######	#######	#######	#######	#######	#######	#######	#######	#######	#######
IRR		**5%**																										
Payback (Years) [Using Avg Cash Flow Savings]		**15.16**																										

		Cash Flow	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Morris Williams Track	**Exterior**																											
Old Bulbs	168																											
New Bulbs	69																											
Old Yearly Electricity Cost		$ 24,669	$ 24,669	$ 24,916	$ 25,165	$ 25,417	$ 25,671	$ 25,927	$ 26,187	$ 26,449	$ 26,713	$ 26,980	$ 27,250	$27,522	$27,798	$28,076	$28,356	$28,640	$28,926	$29,216	$29,508	$29,803	$30,101	$30,402	$30,706	$31,013	$31,323	$31,636
New Yearly Electricity Cost		$ 9,344	$ 9,344	$ 9,437	$ 9,531	$ 9,627	$ 9,723	$ 9,820	$ 9,918	$ 10,018	$ 10,118	$ 10,219	$ 10,321	$10,424	$10,529	$10,634	$10,740	$10,848	$10,956	$11,066	$11,176	$11,288	$11,401	$11,515	$11,630	$11,746	$11,864	$11,983
Savings		$ 15,325		$ 15,479	$ 15,633	$ 15,790	$ 15,948	$ 16,107	$ 16,268	$ 16,431	$ 16,595	$ 16,761	$ 16,929	$17,098	$17,269	$17,442	$17,616	$17,792	$17,970	$18,150	$18,331	$18,515	$18,700	$18,887	$19,076	$19,267	$19,459	$19,654
Initial Capital		$ 198,583	$ (198,583)																									
Mainteneance Savings		$ 54,096		$ 5,464	$ 5,518	$ 5,574	$ 5,629	$ 5,686	$ 5,742	$ 5,800	$ 5,858	$ 5,916	$ 5,976	$ 6,035	$ 6,096	$ 6,157	$ 6,218	$ 6,280	$ 6,343	$ 6,407	$ 6,471	$ 6,535	$ 6,601	$ 6,667	$ 6,733	$ 6,801	$ 6,869	$ 6,937
Net Cash Flow			**$ (198,583)**	**$ 20,942**	**$ 21,152**	**$ 21,363**	**$ 21,577**	**$ 21,793**	**$ 22,011**	**$ 22,231**	**$ 22,453**	**$ 22,678**	**$ 22,904**	**$23,133**	**$23,365**	**$23,598**	**$23,834**	**$24,073**	**$24,313**	**$24,557**	**$24,802**	**$25,050**	**$25,301**	**$25,554**	**$25,809**	**$26,067**	**$26,328**	**$26,591**
NPV (Exterior):		**$ 126,701.36**	$ (198,582.71)	$ 19,945.10	$19,185.28	$18,454.42	$17,751.39	$17,075.15	$16,424.66	$15,798.96	$15,197.10	$14,618.16	$14,061.28	#######	#######	#######	#######	#######	#######	#######	#######	#######	#######	#######	#######	#######	#######	#######
IRR		**10%**																										
Payback (Years) [Using Avg Cash Flow Savings]		**9.48**																										

				Cash Flow	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Softball Stadium	**Exterior**																													
Old Bulbs	150																													
New Bulbs	61																													
Old Yearly Electricity Cost		$	10,259	$ 10,259	$ 10,361	$ 10,465	$ 10,569	$ 10,675	$ 10,782	$ 10,890	$ 10,999	$ 11,109	$ 11,220	$ 11,332	$11,445	$11,560	$11,675	$11,792	$11,910	$12,029	$12,149	$12,271	$12,394	$12,518	$12,643	$12,769	$12,897	$13,026	$13,156
New Yearly Electricity Cost		$	3,847	$ 3,847	$ 3,886	$ 3,925	$ 3,964	$ 4,003	$ 4,044	$ 4,084	$ 4,125	$ 4,166	$ 4,208	$ 4,250	$ 4,292	$ 4,335	$ 4,379	$ 4,422	$ 4,467	$ 4,511	$ 4,556	$ 4,602	$ 4,648	$ 4,694	$ 4,741	$ 4,789	$ 4,837	$ 4,885	$ 4,934
Savings		$	6,411		$ 6,475	$ 6,540	$ 6,606	$ 6,672	$ 6,738	$ 6,806	$ 6,874	$ 6,943	$ 7,012	$ 7,082	$ 7,153	$ 7,225	$ 7,297	$ 7,370	$ 7,443	$ 7,518	$ 7,593	$ 7,669	$ 7,746	$ 7,823	$ 7,901	$ 7,980	$ 8,060	$ 8,141	$ 8,222
Initial Capital		$	175,559	$ (175,559)																										
Mainteneance Savings		$	48,300		$ 4,878	$ 4,927	$ 4,976	$ 5,026	$ 5,076	$ 5,127	$ 5,178	$ 5,230	$ 5,282	$ 5,335	$ 5,389	$ 5,443	$ 5,497	$ 5,552	$ 5,607	$ 5,664	$ 5,720	$ 5,777	$ 5,835	$ 5,894	$ 5,952	$ 6,012	$ 6,072	$ 6,133	$ 6,194
Net Cash Flow				**$ (175,559)**	**$ 11,354**	**$ 11,467**	**$ 11,582**	**$ 11,698**	**$ 11,815**	**$ 11,933**	**$ 12,052**	**$ 12,173**	**$ 12,295**	**$ 12,417**	**$12,542**	**$12,667**	**$12,794**	**$12,922**	**$13,051**	**$13,181**	**$13,313**	**$13,446**	**$13,581**	**$13,717**	**$13,854**	**$13,992**	**$14,132**	**$14,274**	**$14,416**
	NPV (Exterior):	**$**	**793**	$ (175,559)	$ 10,813	$ 10,401	$ 10,005	$ 9,624	$ 9,257	$ 8,905	$ 8,565	$ 8,239	$ 7,925	$ 7,623	$ 7,333	$ 7,053	$ 6,785	$ 6,526	$ 6,278	$ 6,039	$ 5,809	$ 5,587	$ 5,374	$ 5,170	$ 4,973	$ 4,783	$ 4,601	$ 4,426	$ 4,257
	IRR		**5%**																											
	Payback (Years) [Using Avg Cash Flow Savings]		**15.46**																											

				Cash Flow	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Taishoff Aquatic Center	**Interior**																													
Old Bulbs	65																													
New Bulbs	65																													
Old Yearly Electricity Cost		$	22,907	$ 22,907	$ 23,136	$ 23,367	$ 23,601	$ 23,837	$ 24,075	$ 24,316	$ 24,559	$ 24,805	$ 25,053	$ 25,304	$25,557	$25,812	$26,070	$26,331	$26,594	$26,860	$27,129	$27,400	$27,674	$27,951	$28,230	$28,513	$28,798	$29,086	$29,377
New Yearly Electricity Cost		$	21,125	$ 21,125	$ 21,336	$ 21,549	$ 21,765	$ 21,982	$ 22,202	$ 22,424	$ 22,649	$ 22,875	$ 23,104	$ 23,335	$23,568	$23,804	$24,042	$24,282	$24,525	$24,770	$25,018	$25,268	$25,521	$25,776	$26,034	$26,294	$26,557	$26,823	$27,091
Savings		$	1,782		$ 1,800	$ 1,818	$ 1,836	$ 1,855	$ 1,873	$ 1,892	$ 1,911	$ 1,930	$ 1,949	$ 1,969	$ 1,988	$ 2,008	$ 2,028	$ 2,049	$ 2,069	$ 2,090	$ 2,111	$ 2,132	$ 2,153	$ 2,175	$ 2,196	$ 2,218	$ 2,241	$ 2,263	$ 2,286
Initial Capital		$	139,036	$ (139,036)																										
Mainteneance Savings		$	6,500		$ 657	$ 663	$ 670	$ 676	$ 683	$ 690	$ 697	$ 704	$ 711	$ 718	$ 725	$ 732	$ 740	$ 747	$ 755	$ 762	$ 770	$ 777	$ 785	$ 793	$ 801	$ 809	$ 817	$ 825	$ 834	
Net Cash Flow				**$ (139,036)**	**$ 2,457**	**$ 2,481**	**$ 2,506**	**$ 2,531**	**$ 2,556**	**$ 2,582**	**$ 2,608**	**$ 2,634**	**$ 2,660**	**$ 2,687**																		
	NPV (Interior):	**$**	**(119,270)**	$ (139,036)	$ 2,340	$ 2,250	$ 2,165	$ 2,082	$ 2,003	$ 1,927	$ 1,853	$ 1,783	$ 1,715	$ 1,649																	
	IRR		**-23%**																											
	Payback (Years) [Using Avg Cash Flow Savings]		**56.60**																											

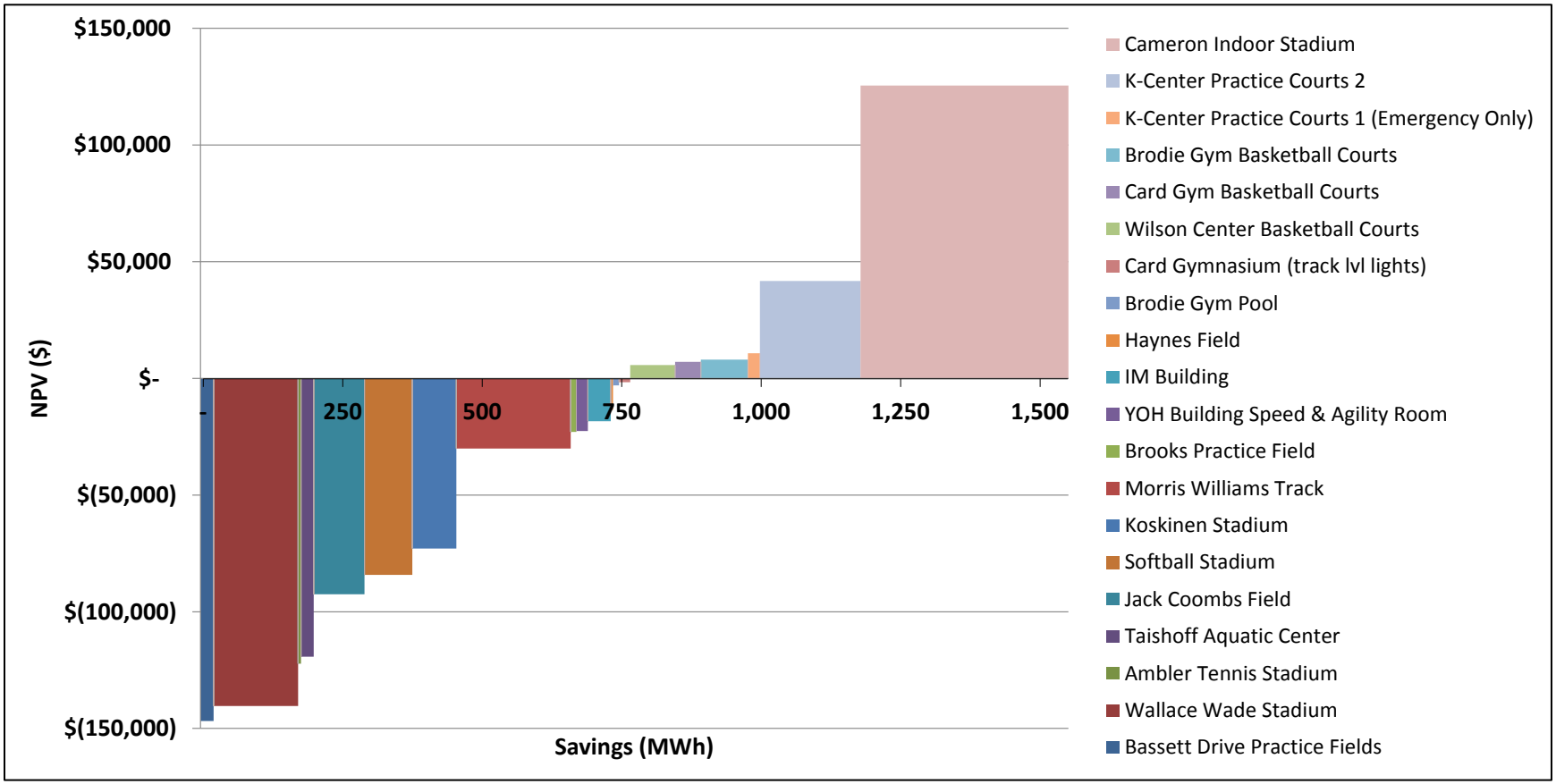
				Cash Flow	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Wallace Wade Stadium	**Exterior**																													
Old Bulbs	256																													
New Bulbs	104																													
Old Yearly Electricity Cost		$	15,062	$ 15,062	$ 15,213	$ 15,365	$ 15,519	$ 15,674	$ 15,830	$ 15,989	$ 16,149	$ 16,310	$ 16,473	$ 16,638	$16,804	$16,972	$17,142	$17,314	$17,487	$17,662	$17,838	$18,017	$18,197	$18,379	$18,562	$18,748	$18,936	$19,125	$19,316
New Yearly Electricity Cost		$	3,750	$ 3,750	$ 3,788	$ 3,826	$ 3,864	$ 3,903	$ 3,942	$ 3,981	$ 4,021	$ 4,061	$ 4,102	$ 4,143	$ 4,184	$ 4,226	$ 4,268	$ 4,311	$ 4,354	$ 4,398	$ 4,442	$ 4,486	$ 4,531	$ 4,576	$ 4,622	$ 4,668	$ 4,715	$ 4,762	$ 4,810
Savings		$	11,312		$ 11,425	$ 11,539	$ 11,655	$ 11,771	$ 11,889	$ 12,008	$ 12,128	$ 12,249	$ 12,371	$ 12,495	$12,620	$12,746	$12,874	$13,003	$13,133	$13,264	$13,397	$13,531	$13,666	$13,802	$13,941	$14,080	$14,221	$14,363	$14,507
Initial Capital		$	299,313	$ (299,313)																										
Mainteneance Savings		$	82,432		$ 8,326	$ 8,409	$ 8,493	$ 8,578	$ 8,664	$ 8,750	$ 8,838	$ 8,926	$ 9,015	$ 9,106	$ 9,197	$ 9,289	$ 9,382	$ 9,475	$ 9,570	$ 9,666	$ 9,762	$ 9,860	$ 9,959	$10,058	$10,159	$10,260	$10,363	$10,467	$10,571	
Net Cash Flow				**$ (299,313)**	**$ 19,750**	**$ 19,948**	**$ 20,147**	**$ 20,349**	**$ 20,552**	**$ 20,758**	**$ 20,966**	**$ 21,175**	**$ 21,387**	**$ 21,601**	**$21,817**	**$22,035**	**$22,255**	**$22,478**	**$22,703**	**$22,930**	**$23,159**	**$23,391**	**$23,625**	**$23,861**	**$24,099**	**$24,340**	**$24,584**	**$24,830**	**$25,078**
	NPV (Exterior):	**$**	**7,459**	$ (299,313)	$ 18,810	$ 18,093	$ 17,404	$ 16,741	$ 16,103	$ 15,490	$ 14,900	$ 14,332	$ 13,786	$ 13,261	$12,756	$12,270	$11,802	$11,353	$10,920	$10,504	$10,104	$ 9,719	$ 9,349	$ 8,993	$ 8,650	$ 8,321	$ 8,004	$ 7,699	$ 7,406
	IRR		**5%**																											
	Payback (Years) [Using Avg Cash Flow Savings]		**15.15**																											

				Cash Flow	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Wilson Center Basketball Courts	**Interior**																													
Old Bulbs	64																													
New Bulbs	64																													
Old Yearly Electricity Cost		$	13,106	$ 13,106	$ 13,237	$ 13,370	$ 13,503	$ 13,639	$ 13,775	$ 13,913	$ 14,052	$ 14,192	$ 14,334	$ 14,478	$14,622	$14,769	$14,916	$15,065	$15,216	$15,368	$15,522	$15,677	$15,834	$15,992	$16,152	$16,314	$16,477	$16,642	$16,808
New Yearly Electricity Cost		$	7,072	$ 7,072	$ 7,143	$ 7,214	$ 7,286	$ 7,359	$ 7,433	$ 7,507	$ 7,582	$ 7,658	$ 7,734	$ 7,812	$ 7,890	$ 7,969	$ 8,048	$ 8,129	$ 8,210	$ 8,292	$ 8,375	$ 8,459	$ 8,544	$ 8,629	$ 8,715	$ 8,803	$ 8,891	$ 8,979	$ 9,069
Savings		$	6,034		$ 6,095	$ 6,156	$ 6,217	$ 6,279	$ 6,342	$ 6,406	$ 6,470	$ 6,534	$ 6,600	$ 6,666	$ 6,732	$ 6,800	$ 6,868	$ 6,936	$ 7,006	$ 7,076	$ 7,147	$ 7,218	$ 7,290	$ 7,363	$ 7,437	$ 7,511	$ 7,586	$ 7,662	$ 7,739
Initial Capital		$	48,534	$ (48,534)																										
Mainteneance Savings		$	6,400		$ 646	$ 653	$ 659	$ 666	$ 673	$ 679	$ 686	$ 693	$ 700	$ 707	$ 714	$ 721	$ 728	$ 736	$ 743	$ 750	$ 758	$ 766	$ 773	$ 781	$ 789	$ 797	$ 805	$ 813	$ 821	
Net Cash Flow				**$ (48,534)**	**$ 6,741**	**$ 6,809**	**$ 6,877**	**$ 6,945**	**$ 7,015**	**$ 7,085**	**$ 7,156**	**$ 7,227**	**$ 7,300**	**$ 7,373**																
	NPV (Interior):	**$**	**5,708**	$ (48,534)	$ 6,420	$ 6,176	$ 5,940	$ 5,714	$ 5,496	$ 5,287	$ 5,086	$ 4,892	$ 4,705	$ 4,526																	
	IRR		**7%**																											
	Payback (Years) [Using Avg Cash Flow Savings]		**7.20**																											

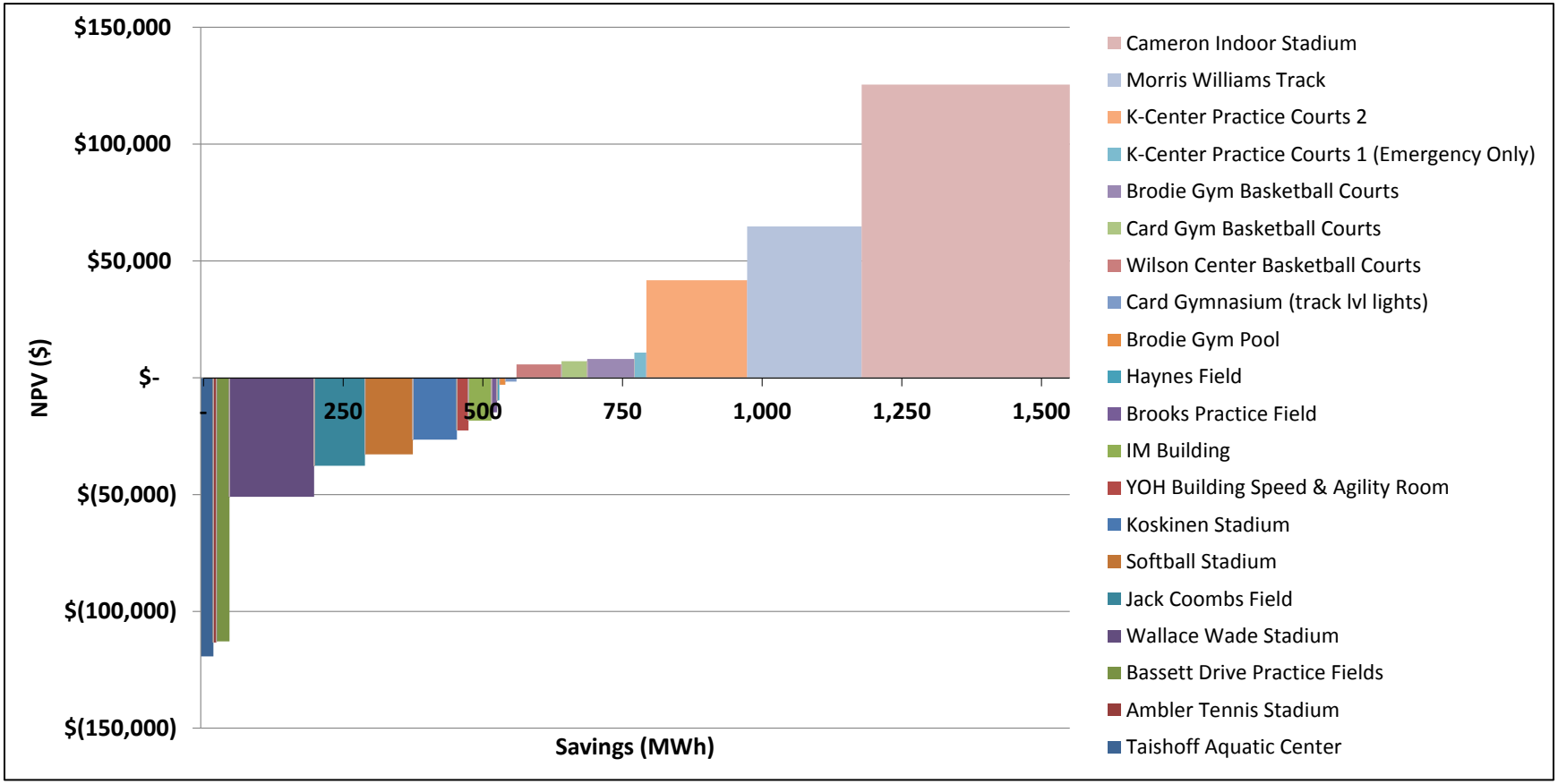
				Cash Flow	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
YOH Building Speed & Agility Room	**Interior**																													
Old Bulbs	52																													
New Bulbs	52																													
Old Yearly Electricity Cost		$	4,196	$ 4,196	$ 4,237	$ 4,280	$ 4,323	$ 4,366	$ 4,410	$ 4,454	$ 4,498	$ 4,543	$ 4,589	$ 4,634	$ 4,681	$ 4,728	$ 4,775	$ 4,823	$ 4,871	$ 4,920	$ 4,969	$ 5,018	$ 5,069	$ 5,119	$ 5,171	$ 5,222	$ 5,274	$ 5,327	$ 5,380
New Yearly Electricity Cost		$	2,639	$ 2,639	$ 2,666	$ 2,692	$ 2,719	$ 2,746	$ 2,774	$ 2,802	$ 2,830	$ 2,858	$ 2,886	$ 2,915	$ 2,944	$ 2,974	$ 3,004	$ 3,034	$ 3,064	$ 3,095	$ 3,126	$ 3,157	$ 3,188	$ 3,220	$ 3,252	$ 3,285	$ 3,318	$ 3,351	$ 3,385
Savings		$	1,556		$ 1,572	$ 1,588	$ 1,604	$ 1,620	$ 1,636	$ 1,652	$ 1,669	$ 1,685	$ 1,702	$ 1,719	$ 1,736	$ 1,754	$ 1,771	$ 1,789	$ 1,807	$ 1,825	$ 1,843	$ 1,862	$ 1,880	$ 1,899	$ 1,918	$ 1,937	$ 1,957	$ 1,976	$ 1,996
Initial Capital		$	39,434	$ (39,434)																										
Mainteneance Savings		$	5,200		$ 525	$ 530	$ 536	$ 541	$ 547	$ 552	$ 558	$ 563	$ 569	$ 574	$ 580	$ 586	$ 592	$ 598	$ 604	$ 610	$ 616	$ 622	$ 628	$ 634	$ 641	$ 647	$ 654	$ 660	$ 667	
Net Cash Flow				**$ (39,434)**	**$ 2,097**	**$ 2,118**	**$ 2,139**	**$ 2,161**	**$ 2,182**	**$ 2,204**	**$ 2,226**	**$ 2,248**	**$ 2,271**	**$ 2,294**																
	NPV (Interior):	**$**	**(22,559)**	$ (39,434)	$ 1,997	$ 1,921	$ 1,848	$ 1,778	$ 1,710	$ 1,645	$ 1,582	$ 1,522	$ 1,464	$ 1,408																	
	IRR		**-9%**																											
	Payback (Years) [Using Avg Cash Flow Savings]		**18.80**																											

Appendix G: Marginal Cost Abatement Curve (NPV and kWh):

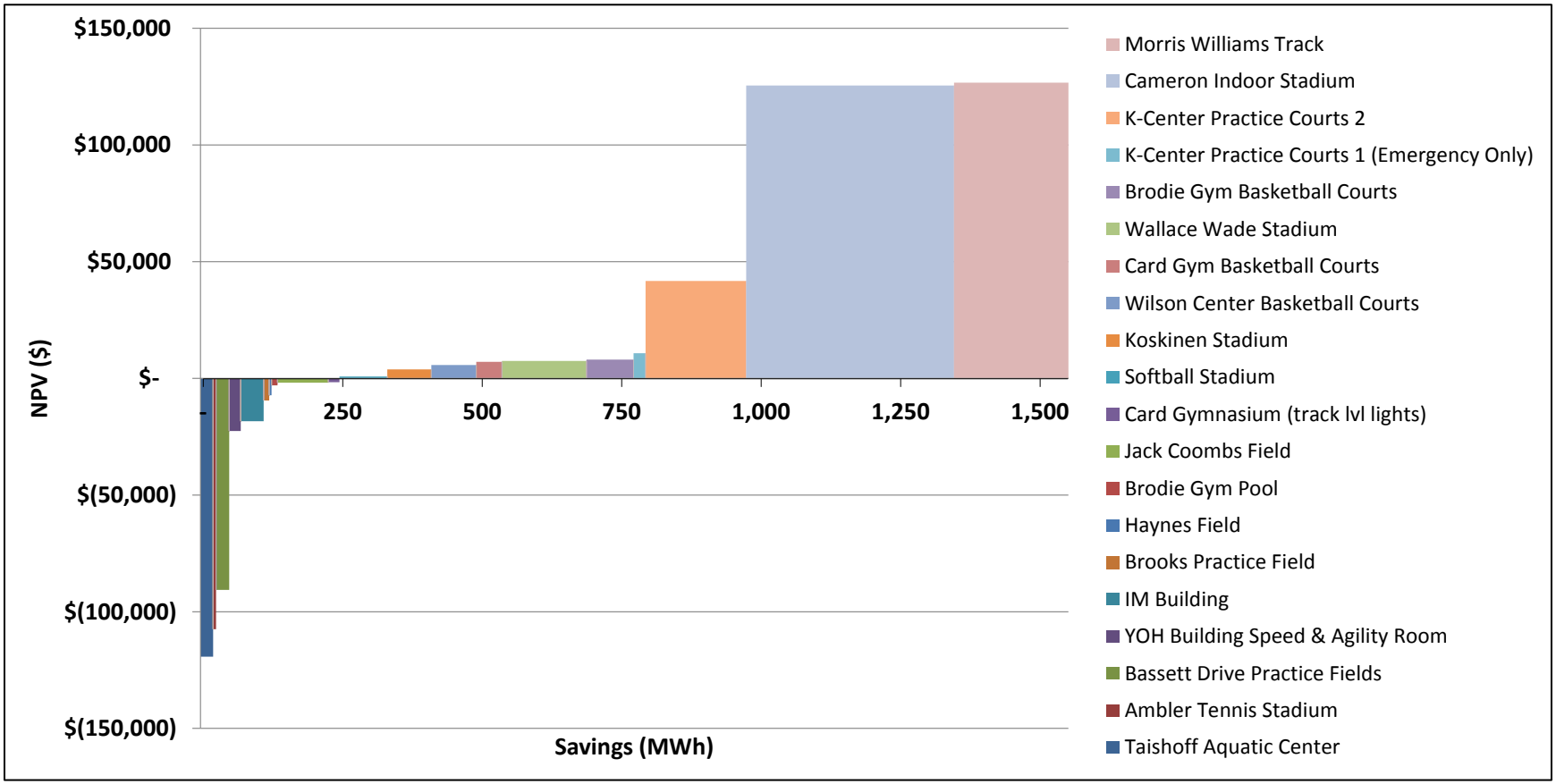
10-Year Interior & 10-Year Exterior Warranties:



10-Year Interior & 18-Year Exterior Warranties:

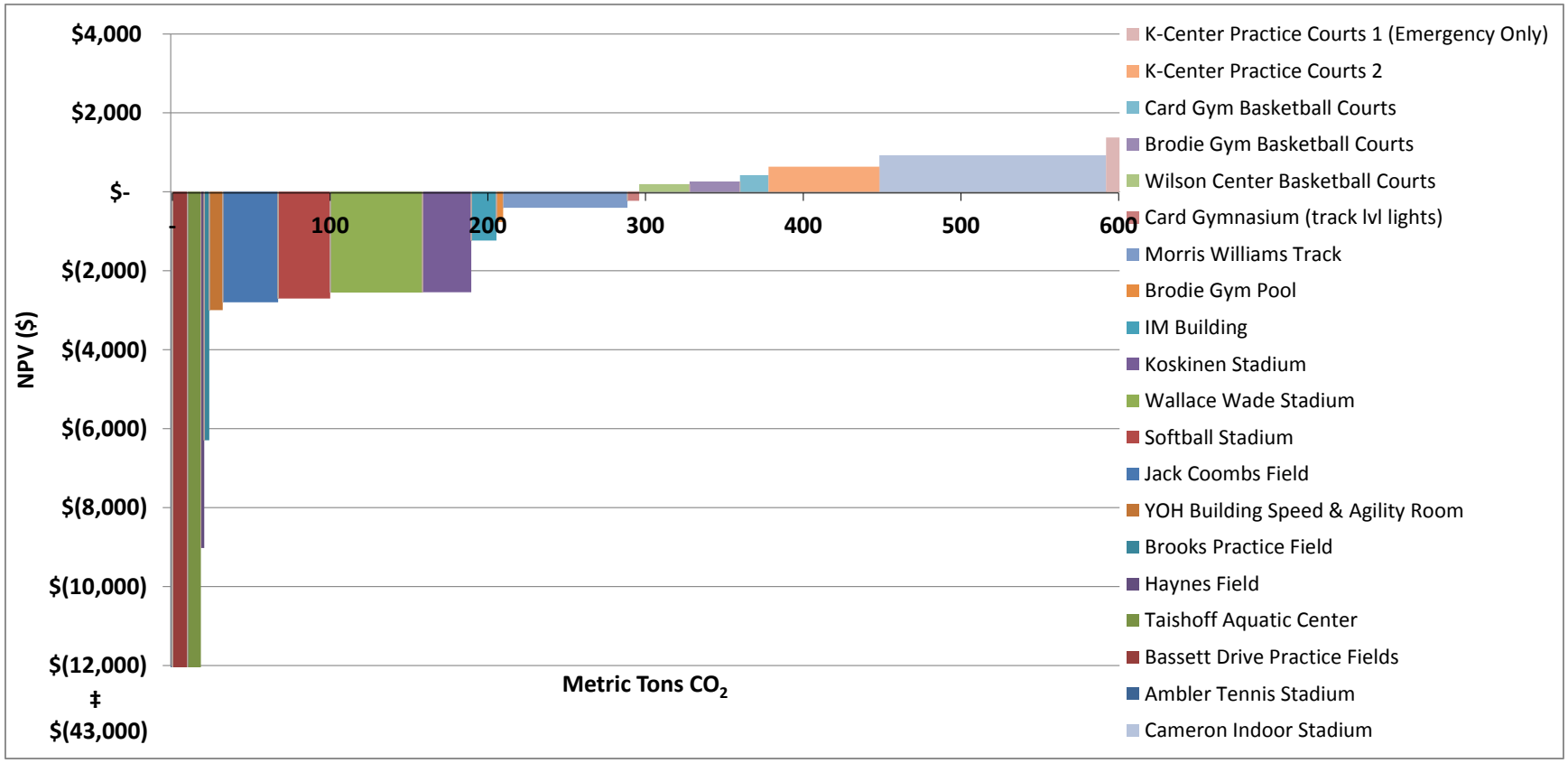


10-Year Interior & 25-Year Exterior Warranties:

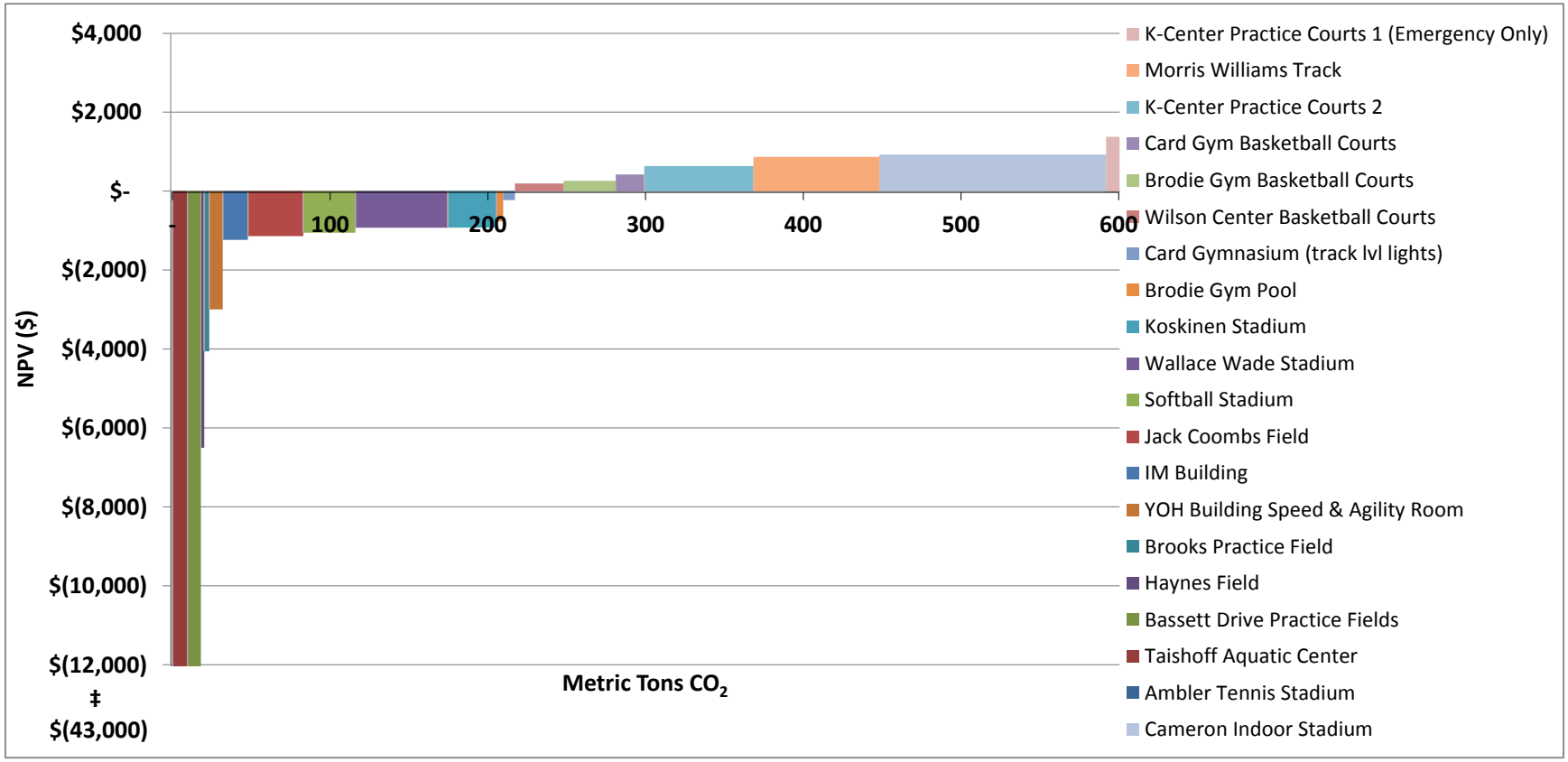


Appendix H: Marginal Cost Abatement Curve (NPV/MT CO_2):

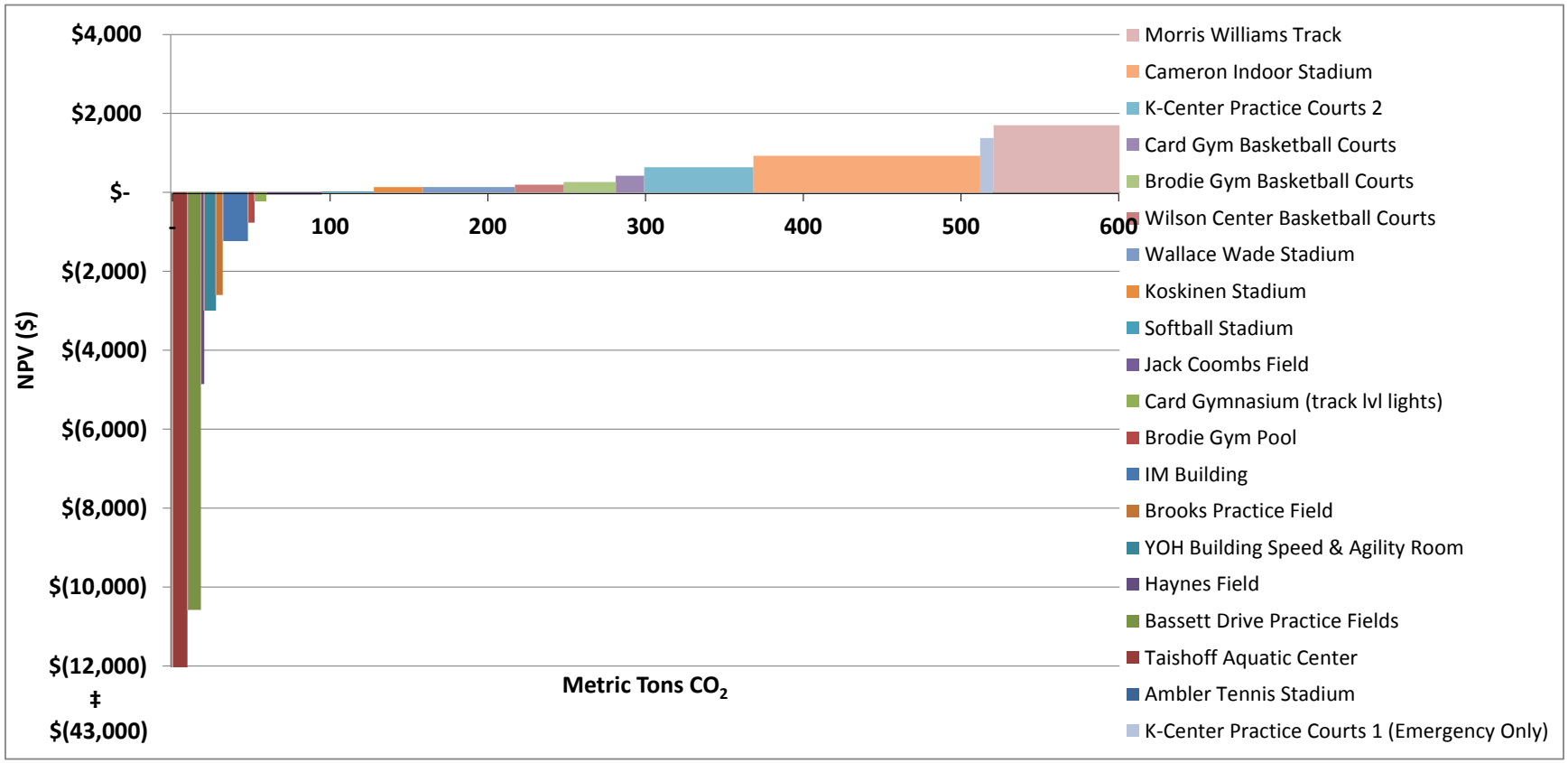
10-Year Interior & 10-Year Exterior Warranties:



10-Year Interior & 18-Year Exterior Warranties:



10-Year Interior & 25-Year Exterior Warranties:



Appendix I: Final Calculations

10-Year Interior & 10-Year Exterior Warranties:

NPV Rank	Facility	Hour Rank	Type	Old Yearly Electricity Cost ($)	New Yearly Electricity Cost ($)	Savings ($)	Old kWh / Yr	New kWh / Yr	Savings (kWh)	Present CO2 Abated (MT)	Future CO2 Abated (MT)	NPV ($/MT)	Initial Capital ($)	IRR	Payback (Years)	NPV (Years)	NPV ($)
1	Cameron Indoor Stadium	7	Interior	$ 44,757	$ 16,900	$ 27,857	600,761	227,760	373,001	135.4	201.5	$ 927	$ 111,229	24%	3.8	10	$ 125,483
2	K-Center Practice Courts 2	10	Interior	$ 21,589	$ 8,103	$ 13,486	289,786	109,200	180,586	65.5	97.6	$ 637	$ 74,866	15%	5.2	10	$ 41,726
3	K-Center Practice Courts 1 (Emergency Only)	1	Interior	$ 2,232	$ 624	$ 1,608	29,959	8,410	21,550	7.8	11.6	$ 1,377	$ 3,033	57%	1.8	10	$ 10,766
4	Brodie Gym Basketball Courts	2	Interior	$ 13,729	$ 7,408	$ 6,321	184,288	99,840	84,448	30.6	45.6	$ 262	$ 48,534	8%	6.9	10	$ 8,040
5	Card Gym Basketball Courts	3	Interior	$ 6,879	$ 3,425	$ 3,453	92,330	46,165	46,165	16.8	24.9	$ 422	$ 23,509	11%	6.2	10	$ 7,074
6	Wilson Center Basketball Courts	3	Interior	$ 13,106	$ 7,072	$ 6,034	175,924	95,309	80,615	29.3	43.6	$ 195	$ 48,534	7%	7.2	10	$ 5,708
7	Card Gymnasium (track lvl lights)	3	Interior	$ 3,413	$ 1,915	$ 1,498	45,818	25,813	20,005	7.3	10.8	$ (227)	$ 15,938	3%	9.0	10	$ (1,650)
8	Brodie Gym Pool	6	Interior	$ 1,842	$ 1,033	$ 808	24,722	13,928	10,794	3.9	5.8	$ (766)	$ 11,034	-1%	11.1	10	$ (3,002)
9	Haynes Field	19	Exterior	$ 515	$ 208	$ 307	6,912	2,800	4,112	1.5	2.2	$ (9,022)	$ 20,146	-13%	24.3	25	$ (13,463)
10	IM Building	9	Interior	$ 6,671	$ 3,600	$ 3,072	89,548	48,513	41,034	14.9	22.2	$ (1,234)	$ 48,534	-4%	12.9	10	$ (18,371)
11	YOH Building Speed & Agility Room	11	Interior	$ 4,196	$ 2,639	$ 1,556	56,316	35,568	20,748	7.5	11.2	$ (2,996)	$ 39,434	-9%	18.8	10	$ (22,559)
12	Brooks Practice Field	18	Exterior	$ 1,200	$ 450	$ 750	16,105	6,058	10,047	3.6	5.4	$ (6,293)	$ 37,414	-11%	20.8	25	$ (22,942)
13	Morris Williams Track	12	Exterior	$ 24,669	$ 9,344	$ 15,325	331,128	125,925	205,203	74.5	110.9	$ (404)	$ 198,583	2%	9.5	25	$ (30,071)
14	Koskinen Stadium	14	Exterior	$ 9,475	$ 3,575	$ 5,901	127,186	48,176	79,009	28.7	42.7	$ (2,543)	$ 155,413	-6%	15.2	25	$ (72,916)
15	Softball Stadium	15	Exterior	$ 10,259	$ 3,847	$ 6,411	137,700	51,850	85,850	31.2	46.4	$ (2,703)	$ 175,559	-6%	15.5	25	$ (84,201)
16	Jack Coombs Field	16	Exterior	$ 10,942	$ 4,137	$ 6,805	146,871	55,748	91,123	33.1	49.2	$ (2,798)	$ 189,949	-7%	15.7	25	$ (92,511)
17	Taishoff Aquatic Center	7	Interior	$ 22,907	$ 21,125	$ 1,782	307,476	284,700	22,776	8.3	12.3	$ (14,431)	$ 139,036	-23%	56.6	10	$ (119,270)
18	Ambler Tennis Stadium	13	Exterior	$ 5,247	$ 4,838	$ 408	70,425	65,208	5,217	1.9	2.8	$ (64,588)	$ 138,144	-25%	70.0	25	$ (122,266)
19	Wallace Wade Stadium	17	Exterior	$ 15,062	$ 3,750	$ 11,312	202,176	50,544	151,632	55.0	81.9	$ (2,551)	$ 299,313	-6%	15.2	25	$ (140,392)
20	Bassett Drive Practice Fields	20	Exterior	$ 2,832	$ 1,068	$ 1,764	38,016	14,400	23,616	8.6	12.8	$ (17,133)	$ 207,217	-14%	27.6	25	$ (146,826)

10-Year Interior & 18-Year Exterior Warranties:

NPV Rank	Facility	Hour Rank	Type	Old Yearly Electricity Cost ($)	New Yearly Electricity Cost ($)	Savings ($)	Old kWh / Yr	New kWh / Yr	Savings (kWh)	Present CO2 Abated (MT)	Future CO2 Abated (MT)	NPV ($/MT)	Initial Capital ($)	IRR	Payback (Years)	NPV (Years)	NPV ($)
1	Cameron Indoor Stadium	7	Interior	$ 44,757	$ 16,900	$ 27,857	600,761	227,760	373,001	135.4	201.5	$ 927	$ 111,229	24%	3.8	10	$ 125,483
2	Morris Williams Track	12	Exterior	$ 24,669	$ 9,344	$ 15,325	331,128	125,925	205,203	74.5	110.9	$ 870	$ 198,583	9%	9.5	25	$ 64,755
3	K-Center Practice Courts 2	10	Interior	$ 21,589	$ 8,103	$ 13,486	289,786	109,200	180,586	65.5	97.6	$ 637	$ 74,866	15%	5.2	10	$ 41,726
4	K-Center Practice Courts 1 (Emergency Only)	1	Interior	$ 2,232	$ 624	$ 1,608	29,959	8,410	21,550	7.8	11.6	$ 1,377	$ 3,033	57%	1.8	10	$ 10,766
5	Brodie Gym Basketball Courts	2	Interior	$ 13,729	$ 7,408	$ 6,321	184,288	99,840	84,448	30.6	45.6	$ 262	$ 48,534	8%	6.9	10	$ 8,040
6	Card Gym Basketball Courts	3	Interior	$ 6,879	$ 3,425	$ 3,453	92,330	46,165	46,165	16.8	24.9	$ 422	$ 23,509	11%	6.2	10	$ 7,074
7	Wilson Center Basketball Courts	3	Interior	$ 13,106	$ 7,072	$ 6,034	175,924	95,309	80,615	29.3	43.6	$ 195	$ 48,534	7%	7.2	10	$ 5,708
8	Card Gymnasium (track lvl lights)	3	Interior	$ 3,413	$ 1,915	$ 1,498	45,818	25,813	20,005	7.3	10.8	$ (227)	$ 15,938	3%	9.0	10	$ (1,650)
9	Brodie Gym Pool	6	Interior	$ 1,842	$ 1,033	$ 808	24,722	13,928	10,794	3.9	5.8	$ (766)	$ 11,034	-1%	11.1	10	$ (3,002)
10	Haynes Field	19	Exterior	$ 515	$ 208	$ 307	6,912	2,800	4,112	1.5	2.2	$ (6,502)	$ 20,146	-2%	24.3	25	$ (9,702)
11	Brooks Practice Field	18	Exterior	$ 1,200	$ 450	$ 750	16,105	6,058	10,047	3.6	5.4	$ (4,059)	$ 37,414	-1%	20.8	25	$ (14,799)
12	IM Building	9	Interior	$ 6,671	$ 3,600	$ 3,072	89,548	48,513	41,034	14.9	22.2	$ (1,234)	$ 48,534	-4%	12.9	10	$ (18,371)
13	YOH Building Speed & Agility Room	11	Interior	$ 4,196	$ 2,639	$ 1,556	56,316	35,568	20,748	7.5	11.2	$ (2,996)	$ 39,434	-9%	18.8	10	$ (22,559)
14	Koskinen Stadium	14	Exterior	$ 9,475	$ 3,575	$ 5,901	127,186	48,176	79,009	28.7	42.7	$ (924)	$ 155,413	3%	15.2	25	$ (26,493)
15	Softball Stadium	15	Exterior	$ 10,259	$ 3,847	$ 6,411	137,700	51,850	85,850	31.2	46.4	$ (1,053)	$ 175,559	3%	15.5	25	$ (32,791)
16	Jack Coombs Field	16	Exterior	$ 10,942	$ 4,137	$ 6,805	146,871	55,748	91,123	33.1	49.2	$ (1,140)	$ 189,949	2%	15.7	25	$ (37,680)
17	Wallace Wade Stadium	17	Exterior	$ 15,062	$ 3,750	$ 11,312	202,176	50,544	151,632	55.0	81.9	$ (926)	$ 299,313	3%	15.2	25	$ (50,962)
18	Bassett Drive Practice Fields	20	Exterior	$ 2,832	$ 1,068	$ 1,764	38,016	14,400	23,616	8.6	12.8	$ (13,168)	$ 207,217	-3%	27.6	25	$ (112,843)
19	Ambler Tennis Stadium	13	Exterior	$ 5,247	$ 4,838	$ 408	70,425	65,208	5,217	1.9	2.8	$ (59,868)	$ 138,144	-11%	70.0	25	$ (113,331)
20	Taishoff Aquatic Center	7	Interior	$ 22,907	$ 21,125	$ 1,782	307,476	284,700	22,776	8.3	12.3	$ (14,431)	$ 139,036	-23%	56.6	10	$ (119,270)

10-Year Interior & 25-Year Exterior Warranties:

NPV Rank	Facility	Hour Rank	Type	Old Yearly Electricity Cost ($)	New Yearly Electricity Cost ($)	Savings ($)	Old kWh / Yr	New kWh / Yr	Savings (kWh)	Present CO2 Abated (MT)	Future CO2 Abated (MT)	NPV ($/MT)	Initial Capital ($)	IRR	Payback (Years)	NPV (Years)	NPV ($)
1	Morris Williams Track	12	Exterior	$ 24,669	$ 9,344	$ 15,325	331,128	125,925	205,203	74.5	110.9	$ 1,702	$ 198,583	10%	9.5	25	$ 126,701
2	Cameron Indoor Stadium	7	Interior	$ 44,757	$ 16,900	$ 27,857	600,761	227,760	373,001	135.4	201.5	$ 927	$ 111,229	24%	3.8	10	$ 125,483
3	K-Center Practice Courts 2	10	Interior	$ 21,589	$ 8,103	$ 13,486	289,786	109,200	180,586	65.5	97.6	$ 637	$ 74,866	15%	5.2	10	$ 41,726
4	K-Center Practice Courts 1 (Emergency Only)	1	Interior	$ 2,232	$ 624	$ 1,608	29,959	8,410	21,550	7.8	11.6	$ 1,377	$ 3,033	57%	1.8	10	$ 10,766
5	Brodie Gym Basketball Courts	2	Interior	$ 13,729	$ 7,408	$ 6,321	184,288	99,840	84,448	30.6	45.6	$ 262	$ 48,534	8%	6.9	10	$ 8,040
6	Wallace Wade Stadium	17	Exterior	$ 15,062	$ 3,750	$ 11,312	202,176	50,544	151,632	55.0	81.9	$ 136	$ 299,313	5%	15.2	25	$ 7,459
7	Card Gym Basketball Courts	3	Interior	$ 6,879	$ 3,425	$ 3,453	92,330	46,165	46,165	16.8	24.9	$ 422	$ 23,509	11%	6.2	10	$ 7,074
8	Wilson Center Basketball Courts	3	Interior	$ 13,106	$ 7,072	$ 6,034	175,924	95,309	80,615	29.3	43.6	$ 195	$ 48,534	7%	7.2	10	$ 5,708
9	Koskinen Stadium	14	Exterior	$ 9,475	$ 3,575	$ 5,901	127,186	48,176	79,009	28.7	42.7	$ 134	$ 155,413	5%	15.2	25	$ 3,834
10	Softball Stadium	15	Exterior	$ 10,259	$ 3,847	$ 6,411	137,700	51,850	85,850	31.2	46.4	$ 25	$ 175,559	5%	15.5	25	$ 793
11	Card Gymnasium (track lvl lights)	3	Interior	$ 3,413	$ 1,915	$ 1,498	45,818	25,813	20,005	7.3	10.8	$ (227)	$ 15,938	3%	9.0	10	$ (1,650)
12	Jack Coombs Field	16	Exterior	$ 10,942	$ 4,137	$ 6,805	146,871	55,748	91,123	33.1	49.2	$ (56)	$ 189,949	5%	15.7	25	$ (1,860)
13	Brodie Gym Pool	6	Interior	$ 1,842	$ 1,033	$ 808	24,722	13,928	10,794	3.9	5.8	$ (766)	$ 11,034	-1%	11.1	10	$ (3,002)
14	Haynes Field	19	Exterior	$ 515	$ 208	$ 307	6,912	2,800	4,112	1.5	2.2	$ (4,855)	$ 20,146	1%	24.3	25	$ (7,245)
15	Brooks Practice Field	18	Exterior	$ 1,200	$ 450	$ 750	16,105	6,058	10,047	3.6	5.4	$ (2,600)	$ 37,414	2%	20.8	25	$ (9,479)
16	IM Building	9	Interior	$ 6,671	$ 3,600	$ 3,072	89,548	48,513	41,034	14.9	22.2	$ (1,234)	$ 48,534	-4%	12.9	10	$ (18,371)
17	YOH Building Speed & Agility Room	11	Interior	$ 4,196	$ 2,639	$ 1,556	56,316	35,568	20,748	7.5	11.2	$ (2,996)	$ 39,434	-9%	18.8	10	$ (22,559)
18	Bassett Drive Practice Fields	20	Exterior	$ 2,832	$ 1,068	$ 1,764	38,016	14,400	23,616	8.6	12.8	$ (10,577)	$ 207,217	0%	27.6	25	$ (90,643)
19	Ambler Tennis Stadium	13	Exterior	$ 5,247	$ 4,838	$ 408	70,425	65,208	5,217	1.9	2.8	$ (56,785)	$ 138,144	-6%	70.0	25	$ (107,494)
20	Taishoff Aquatic Center	7	Interior	$ 22,907	$ 21,125	$ 1,782	307,476	284,700	22,776	8.3	12.3	$ (14,431)	$ 139,036	-23%	56.6	10	$ (119,270)

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