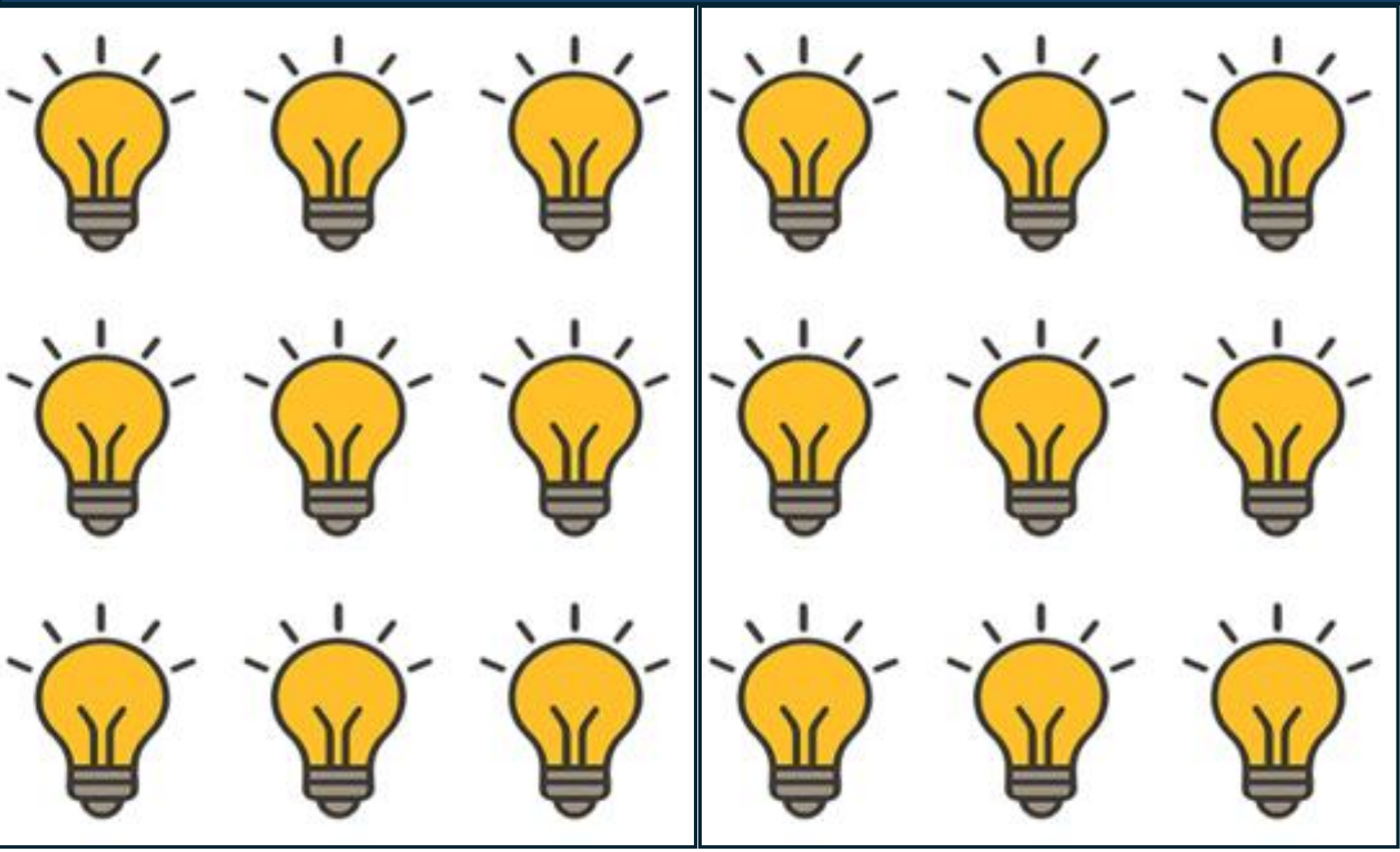
Energy Efficiency Techno-Economic Analysis on Lighting Appliances



DISCLAIMER

The information contained within this document ranging from analysis to data collection are based on my professional experience from performing Measurement and Verification(M&V), energy audits, energy analysis and energy modelling projects. To protect client confidentiality, all data has been adjusted and no proprietary or commercially sensitive information has been disclosed.

This content solely demonstrates my technical expertise in energy efficiency, energy analysis and monitoring and does not represent nor is considered as an official report or representation of any past employer or client. This report only warrants for reading purposes.

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Acronyms/Abbreviation

Variable Frequency Drives	**VFD**
Carbon Dioxide	**CO_2**
Watt	**W**
Kilowatt	**kW**
Air Conditioner	**AC**
Tonnage	**Tons**
Degrees Celsius	**^0C**
Kilowatt hour	**kWh**
Kenya Shilling	**Ksh**
Light Emitting Diode	**LED**
Feet	**FT**

EXECUTIVE SUMMARY

In the rising need for clean energy access across Africa and globally, energy efficiency is a key factor. Efficient appliances are a necessity and improve energy efficiency at high percentage. This applies across all energy consumers, from small house-hold to large industrial consumers. Energy-efficient appliances can be incorporated in our day to day lives.

Key Findings

- Energy-efficient practices range from behavioral factors (no-cost) to advanced cost intensive measures.
- To attain the clean energy access goal in Africa incorporation of energy-efficient lighting appliances is key.
- Energy-efficient measures in lighting play a huge role in CO_2 reduction.
- Data collection, analysis offers a proper economic analysis offering better stakeholder engagement and decision making.
- Energy-efficient lighting appliances have a productive use of finances.

Recommendations

- Light retrofit from inefficient lighting appliances to efficient lighting appliances.
- Lighting control incentives.

This analysis shows that with proper data collection and analysis, there is not only an environmental impact but an economical one as well. Even as we drive for clean energy access, energy-efficient lighting appliances can be incorporated seamlessly.

1. Energy Efficiency – Lighting Retrofit

Retrofitting of Sodium vapor, CFL and fluorescent bulbs with LED fixtures offers significant energy conservation benefits. There are four significant advantages to LED lighting:

1. LEDs have a longer lifespan (typically 50,000 hours) and require less frequent replacement, reducing overall energy use.

2. LEDs are extremely energy efficient relative to every other commercially available lighting technology. There are several reasons including they waste very little energy in the form of infrared radiation (much different than most conventional lights to include fluorescent lights), and they emit light directionally (over 180 degrees versus 360 degrees which means there are far fewer losses from the need to redirect or reflect light).

3. Comparatively high light quality.

4. Low maintenance costs and hassle.

Note: LED lights are relatively expensive. The up-front costs of an LED lighting project are typically higher than most of the alternatives. This part is by far the most significant downside that needs consideration. That said, the price of LEDs is rapidly decreasing, and as adoption increases in masses, the audit team expects a drop-in price.

Facility's Current Situation

Facility X

The facility relies on CFL and fluorescent lamps for the building lighting. It was observed as follows within the facility:

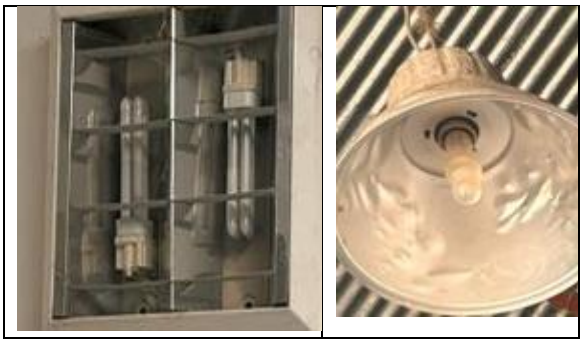

Figure 1: Types of Lighting Fixture at Facility X

See Annex 2 for calculations.

Table 1: Facility X Lighting energy consumption

Type of Lamp	Watt Rating	Quantity	Annual Energy Consumed
8ft Fluorescent	36 W	33	10,406.9 kWh
(4) 4ft Fluorescent	18 W	74	11,668.32 kWh
CFL Lamps	18 W	40	6,307.2 kWh

Facility Y

The facility relies on Halogen, Filament, Sodium vapor and fluorescent lamps for lighting. The following was noted in the facility:

Figure 2: Halogen light fixture at Facility Y

See Annex 2 for calculations.

Table 2: Facility Y Lighting energy consumption

Type of Lamp	Watt Rating	Quantity	Annual Energy Consumed
T8 LED fixture	36 W	342	1,617,797
Sodium Vapor	70 W	39	358,722
Filament Bulb	40 W	13	68,328
Halogen	70 W	225	2,069,550

Recommended Efficient Lighting Appliance

These are retrofit options identified for replacement of inefficient lighting appliances.

Table 3, shows sample of retrofit options available.

Table 3: Comparison of efficient and inefficient Lighting Appliances

Lumens (Brightness)	Incandescent Watts	CFL Watts	LED Watts (Viribright)
400 – 500	40W	8 – 12W	6 – 7W
650 – 850	60W	13 – 18W	7 – 10W
1000 – 1400	75W	18 – 22W	12 – 13W
1450-1700+	100W	23 – 30W	14 – 20W
2700+	150W	30 – 55W	25 – 28W

Sodium Light Bulb Wattage	LED Equivalent W
250 Watt	100 Watt
150 Watt	60 Watt
70 Watt	30 Watt

Fluorescent Tube Light Wattage	LED Equivalent Wa
70 Watt	24 Watt
58 Watt	22 Watt
35 Watt	18 Watt
20 Watt	9 Watt

Halogen Light Bulb Wattage	LED Equivalent
100 Watt	12 Watt
75 Watt	11 Watt
60 Watt	8 Watt
50 Watt	6 Watt
30 Watt	4 Watt

Incandescent Light Bulb Wattage	LED Equivalent
100 Watt	10 Watt
75 Watt	7.5 Watt
60 Watt	6 Watt
50 Watt	5 Watt
30 Watt	3 Watt

Energy, CO_2 and Economic Energy-Efficient Lighting Retrofit Analysis

Facility X Lighting Retrofit Analysis

The recommended energy-efficient lighting appliances for facility X is as follows:

Table 4: Facility X individual Lighting appliance recommendation

Type of Lamp	Watt Rating	Quantity	Type of LED Lamp	Watt Rating	Quantity

8ft Fluorescent	36 W	33	T8 LED fixture	18 W	33
4ft Fluorescent	18 W	74	4ft LED fixture	18 W	37
CFL Lamps	18 W	40	LED bulb	12 W	40

Find Energy Savings calculation at Annex 2.

Table 5: Facility X Annual Energy Savings

Type of LED Lamp	**Watt Rating**	**Quantity**	**Annual Energy consumed**	**Annual Energy saved**
T8 LED fixture	18 W	33	5,203.44 kWh	5,193 kWh
4ft LED fixture	18 W	37	5,834.16 kWh	5,833 kWh
LED bulb	12 W	40	4,204.8 kWh	2,103 kWh
Total Energy Saved				13,129 kWh

Facility X Economic Analysis

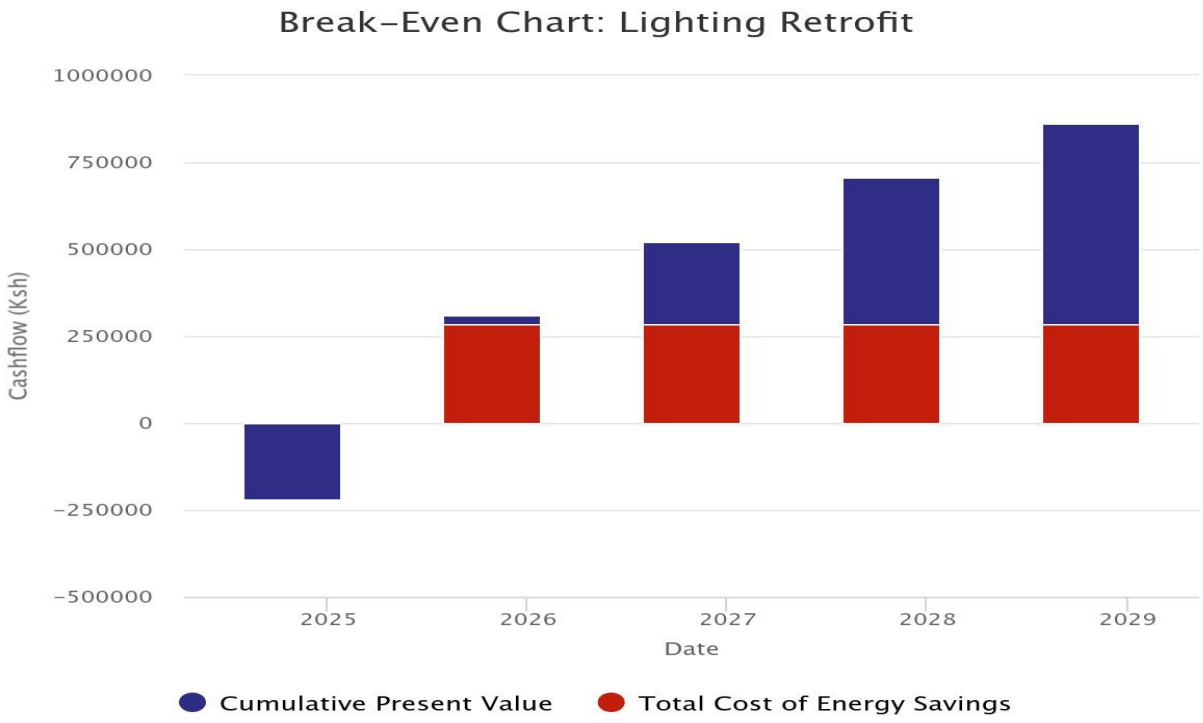

Figure 3: Facility X Efficient Lighting Cash Flow Analysis

Table 6: Facility X Economic, Energy CO_2 and Economic

Investment Analysis	
Purchase of Equipment	Ksh 220,000.00
Savings Summary	
Annual CO_2 Emission Reduction	4.33 Tons
Annual Energy Saving (kWh)	13,129.00 kWh
Annual Cost of Savings (Ksh) at 20 Ksh/kWh	Ksh 262,580
Simple Payback Period (Years)	0.77 Years
Financial Summary	
Discounting Factor	16.00%
Net Present Value (4 Years, 16.00 % interest)	Ksh 577,934.45
Profitability Index	3.67

Facility Y Lighting Retrofit Analysis

The recommended energy-efficient lighting appliances for facility Y is as follows:

Table 7: Facility Y individual Lighting appliance recommendation

Type of Lamp	**Watt Rating**	**Quantity**	**Type of LED Lamp**	**Watt Rating**	**Quantity**
T8 LED fixture	36 W	342	T8 LED fixture	18 W	342
Sodium Vapor	70 W	39	LED fixture	30 W	39
Filament Bulb	40 W	13	LED bulb	5 W	13
Halogen	70 W	225	LED Floodlight	11 W	225

Find Energy Savings calculation at Annex 2.

Table 8: Facility Y Annual Energy Savings

Type of LED Lamp	**Watt Rating**	**Quantity**	**Annual Energy consumed (kWh)**	**Annual Energy saved(kWh)**
T8 LED fixture	18 W	342	1,617,797	808,898
Sodium Vapor	30 W	39	358,722	153,738
Filament Bulb	5 W	13	68,328	8,541
Halogen	11 W	225	2,069,550	325,215
Total Energy Saved				2,818,005 kWh

Facility Y Economic Analysis

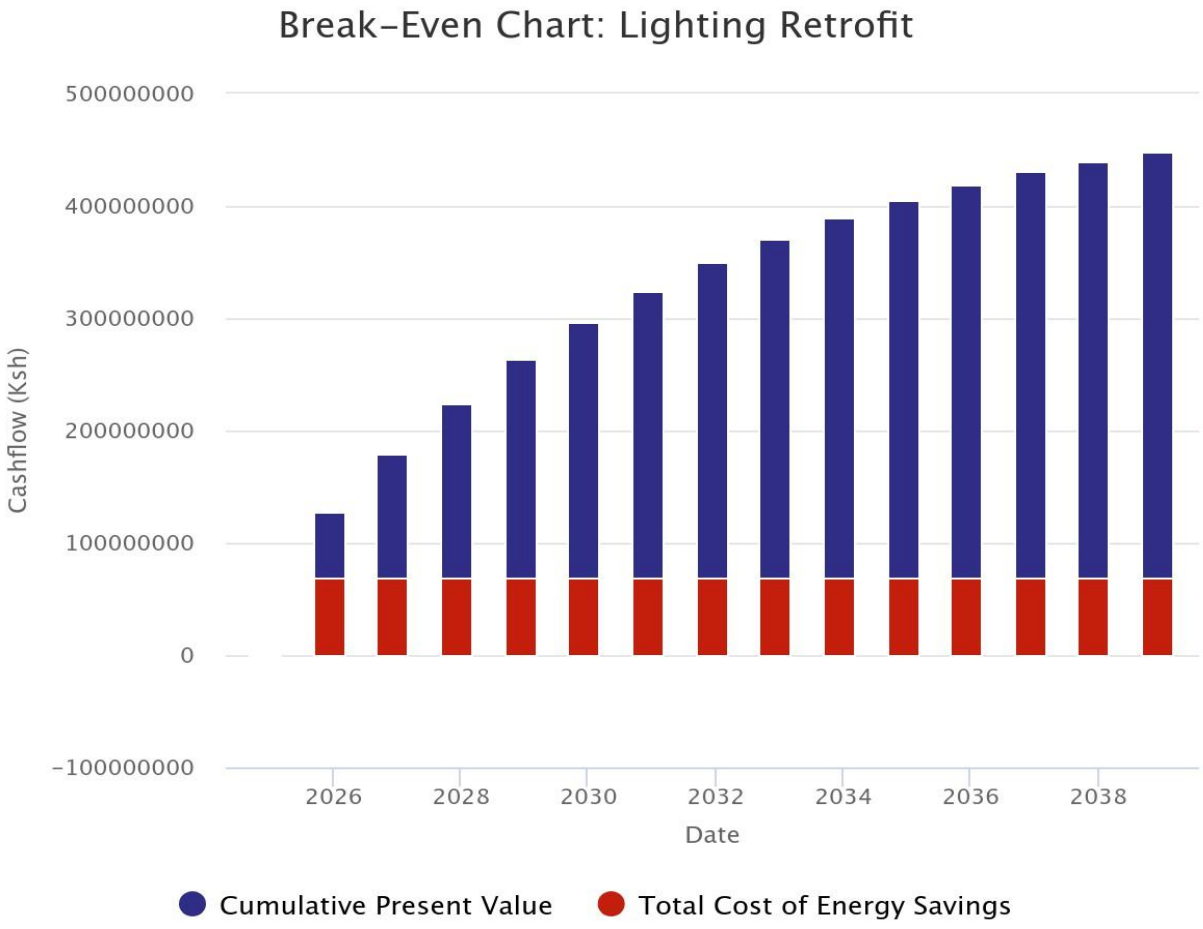

Figure 4: Facility X Efficient Lighting Cash Flow Analysis

Table 9: Facility X Economic, Energy CO_2 and Economic

Investment Analysis	
Purchase of Equipment	Ksh 1,316,800.00
Savings Summary	
Annual CO_2 Emission Reduction	929.94 Tons
Annual Energy Saving (kWh)	2,818,000.00 kWh
Annual Cost of Savings (Ksh) at 20 Ksh/kWh	Ksh 56,360,000
Simple Payback Period (Years)	0.02 Years

Financial Summary	
Discounting Factor	16.00%
Net Present Value (14 Years, 16.00 % interest)	Ksh 379,402,454.35
Profitability Index	289.13

2. Energy Efficiency – Lighting Control (Use of Modern Technology and Behavioral Change)

Light control is essential in conserving energy and light fixture life span. A lighting control can be as follows:

1. Use of timers to set when the light goes on or off.
2. Use of infrared sensors
3. Use of motion sensors
4. Manually turning off light fixtures.

Facility Z's Current Situation

Figure 5, shows the lighting demand profile for facility Z. Across the facility; majority of the lighting fixtures were observed to be on during the day and at night.

Figure 5: Lights on during the day at Facility Z

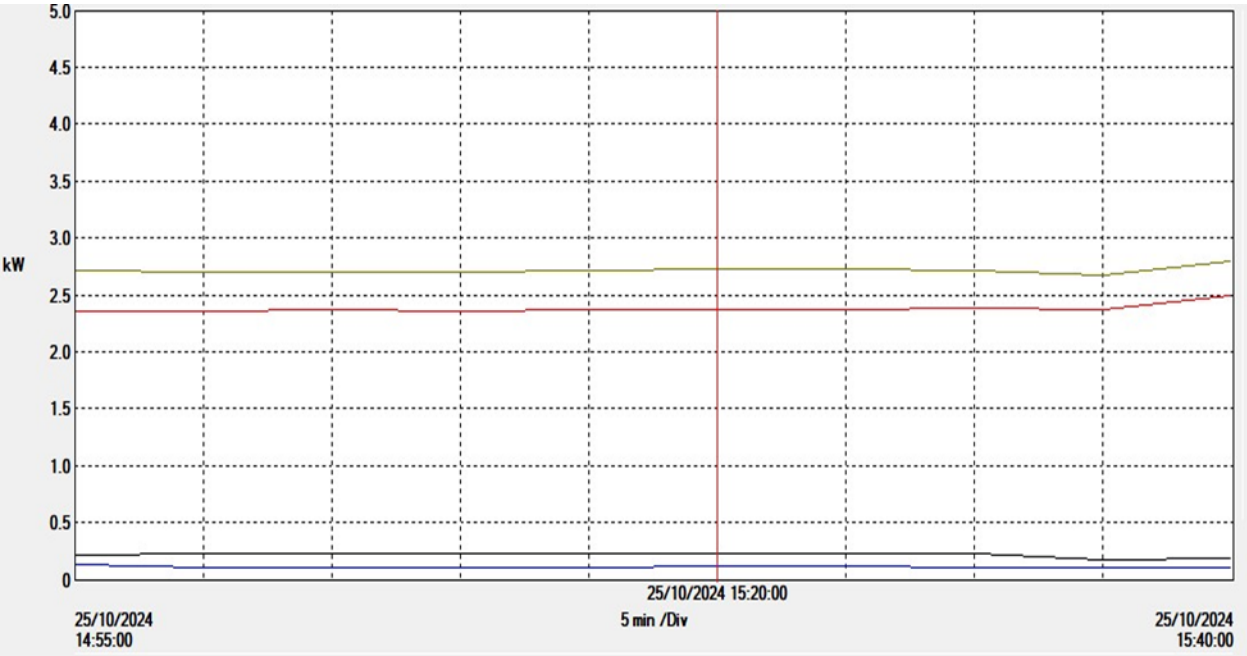

Figure 6: Facility Z's lighting demand profile

Table 10: Current Lighting Analysis

Current Hours of Operation	Current Annual Power consumption
24	596,030.4 kWh

Energy, CO_2 and Economic Energy-Efficient Lighting Control Analysis

Facility Z Proposed Lighting Analysis

Find energy savings analysis at Annex 2.

Figure 7: Lights off during the day

Table 11: Recommended Energy Savings

Recommended Hours of Operation	Proposed Annual Power consumption
12	298,015.2 kWh

Table 12: Facility Y's Economic, Energy CO_2 and Economic

Investment Analysis	
The proposed efficiency measure proposed being a behavioral one, no investment is required.	
Savings Summary	
Annual CO_2 Emission Reduction	98.34 Tons
Annual Energy Saving (kWh)	298,015.00 kWh
Annual Cost of Savings (Ksh) at 20 Ksh/kWh	Ksh 5,960,300
Simple Payback Period (Years)	No pay back period as there is no investment cost
Financial Summary	
No financial summary as there is no investment cost.	

ANNEX 1 – Methodology and Data Collection Tools

To identify energy-efficient measures for HVAC equipment, an accurate analysis of the individual performance and effectiveness of the equipment was paramount.
The following tools and technology were used in conjunction to software systems and applications for both data collection and analysis.

1. Power Energy Logger (PEL 103)
Used to log the actual load at distribution boards.
The PEL 103 software was used to perform a load profile analysis.
2. Clamp meter
Used to confirm accuracy of data logged.

The data was collected for an entire week to obtain an entire profile of weekdays to weekends

ANNEX 2 – Data Analysis

Lighting Retrofit Analysis

Facility X

Table 13: Current Energy Consumed at Facility X

Type	36 W (T8 Fluorescent Tube)	18 W (4 FT Fluorescent Tube)	18 W (CFL Bulbs)
No. of Fixtures	33	74	40
Period	24 hrs	24 hrs	24 hrs
Energy			
Power Consumed	1, 188 W	1,332 W	720 W
Daily	28.512 kWh	31.968 kWh	17.280 kWh
Monthly	855.36 kWh	959.040 kWh	518.400 kWh
Annual	10,406.88 kWh	11,668.32 kWh	6,307.2 kWh

Table 14: Facility X Energy Consumption Daily, Monthly and Annually

Type	18 W (T8 LED Tube)	18 W (4FT LED Tube)	12W (LED bulb)
No. of Fixtures	33	37	40
Period	24 hrs	24 hrs	24 hrs
Energy			
Power Consumed	594 W	666 W	480 W
Daily	14.256 kWh	15.984 kWh	11.52 kWh
Monthly	427.680 kWh	479.520 kWh	345.600 kWh
Annual	5,203.44 kWh	5,834.16 kWh	4,204.8 kWh

Table 15: Facility X Annual Energy Savings

Type	18 W (T8 LED Tube)	18 W (4FT LED Tube)	12W (LED bulb)
No. of Fixtures	33	37	40
Period	24 hrs	24 hrs	24 hrs
Energy			
Current Annual Energy Consumed	10,406.88 kWh	11,668.32 kWh	6,307.2 kWh
Proposed Annual Energy Consumed	5,203.44 kWh	5,834.16 kWh	4,204.8 kWh
Annual Energy Savings	5,203.44 kWh	5,834.16 kWh	2,102,4 kWh

Facility Y

Table 16: Current Energy Consumed at Facility Y

Type	36 W T8 Fluorescent Tube	Sodium Vapor (70 W)	Filament Bulbs (40 W)	Halogen (70 W)
No. of Fixtures	342	39	13	225
Period	12 hrs	12hrs	12hrs	12 hrs
Energy				
Power Consumed	12,312 W	2,730 W	520 W	15,750 W
Daily	147.744 kWh	32.76 kWh	6.24 kWh	189 kWh
Monthly	4,432.32 kWh	982.8 kWh	187.2 kWh	5,670 kWh
Annual	1,617,796.8 kWh	358,722 kWh	68,328 kWh	2,069,550 kWh

Table 17: Facility X Energy Consumption Daily, Monthly and Annually

Type	18 W (T8 LED Tube)	LED (30 W)	LED (5 W)	LED (11 W)

No. of Fixtures	342	39	13	225
Period	12 hrs	12hrs	12hrs	12 hrs
Energy				
Power Consumed	6,156 W	1,170 W	65 W	2,475 W
Daily	73.87 kWh	14.04 kWh	0.78 kWh	29.7 kWh
Monthly	2,216.16 kWh	421.2 kWh	23.4 kWh	891 kWh
Annual	808,898kWh	153,738 kWh	8,541 kWh	325,215 kWh

Table 18: Facility X Annual Energy Savings

Type	**18 W (T8 Fluorescent Tube)**	**Sodium Vapour (30 W)**	**Filament Bulbs (5 W)**	**Halogen (11 W)**
No. of Fixtures	342	39	13	225
Period	12 hrs	12hrs	12hrs	12 hrs
Energy				
Current Annual Energy Consumed	1,617,796.8 kWh	358,722 kWh	68,328 kWh	2,069,550 kWh
Proposed Annual Energy Consumed	808,898kWh	153,738 kWh	8,541 kWh	325,215 kWh
Annual Energy Savings	808898.8 kWh	204,984 kWh	59,787 kWh	1,744,335 kWh

Lighting Control Analysis

Facility Z

Table 19: Lighting Control Energy Consumption at Facility Z

Current Energy Consumption	
Energy Consumed (24 hrs)	2.268 kWh

Daily	54. 432 kWh
Monthly	1,632.96 kWh
Annual	596,030.4 kWh

Table 20: Recommended Lighting Control Energy Consumption at Facility Z

Current Energy Consumption	
Energy Consumed (12 hrs)	2.268 kW
Daily	27.216 kWh
Monthly	816.48 kWh
Annual	298,015.2 kWh
Annual Energy Consumption	
Annual Energy Consumed (24 hrs)	596,030.4 kWh
Annual Energy Consumed (24 hrs)	298,015.2 kWh
Annual Energy Saved	298,015.2 kWh

Bibliography

[1] «Viribright,» [En ligne]. Available: https://viribright.com/blogs/insights/comparing-led-vs-cflvs-incandescent-light-bulbs. [Accès le 25 10 2024].