MINISTRY OF LANDS, HOUSING AND URBAN DEVELOPMENT

2024 | UGANDA SUPPORT TO MUNICIPAL INFRASTRUCTURE DEVELOPMENT, ADDITIONAL FINANCING (USMID-AF) PROGRAM

TITLE OF THE PROJECT

TECHNICAL STUDY ON ENERGY EFFICIENT PUBLIC LIGHTING IN USMID-AF IMPLEMENTING CITIES/MUNICIPALITIES

CONTRACT NUMBER

MLHUD/USMID-AF/CONS/22-23/00010

PERIOD UNDERTAKEN

25th March – 28th November 2024

TITLE OF THE REPORT

FINAL REPORT

DATE OF SUBMISSION

November 28, 2024

NAME OF COMPANY

WSS SERVICES (U) LTD
P.O Box 27755,
Kampala - Uganda

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List of Contributors/Authors

Name	Designation	Signature
1. Dr. Denis Byamukama	Contract Manager	.....
2. Eng. Philip Malaba	Team leader	.....
3. Eng. Jeffrey K. Kato	Solar Installations Engineer	.....
4. Eng. Maate Etiene	Municipal Services Engineer	.....
5. Mr. Raymond Mulondo	Technician	.....

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ACRONYMS AND ABBREVIATIONS

AC	Alternating Current
Ah	Ampere Hour
cd	Candela
DC	Direct Current
ERB	Engineers' Registration Board
IEC	International Electrotechnical Commission
KCCA	Kampala Capital City Authority
LG	Local Government
Lm	Lumens
Lux	Measurement for illumination
m	Metre
MEMD	Ministry of Energy and Mineral Development
MoLG	Ministry of Local Government
MoLHUD	Ministry of Lands, Housing and Urban Development
MoPS	Ministry of Public Service
MoWT	Ministry of Works and Transport
NYAP	National Youth Action Plan
NYP	National Youth Policy
O&M	Operation and Maintenance
PPDA	Public Procurement and Disposal of Public Assets
PTC	Program Technical Committee
PST	Program Support Team
UIPE	Uganda Institution of Professional Engineers
UNABSEC	Uganda National Association of Builders, Suppliers Engineering Contractors
UNBS	Uganda National Bureau of Standards
URDM	Urban Roads Design Manual, 2023
USEA	Uganda Solar Energy Association
USMID1	Uganda Support to Municipal Infrastructure Development Program (Phase One – 2013 to 2018)
USMID-AF	Uganda Support to Municipal Infrastructure Development – Additional Funding (Phase Two – 2019 to 2024)
Wp	Watt Peak
WSS	WSS Services (U) Limited
V	Voltage

EXECUTIVE SUMMARY

In response to the national concern of failing streetlighting systems installed along road infrastructure, a technical study on energy efficient public lighting was undertaken under the USMID program. This Study was funded by the World Bank through the Ministry of Lands, Housing and Urban Development (MoLHUD), and undertaken by M/s WSS Services (U) Limited.

The Consultant carried out technical field assessment of the performance of the installed streetlights in all the twenty-two beneficiary cities and municipalities. This was crowned with the Program Technical Committee (PTC) meeting at Hoima on 6th and 7th June 2024, that brought together the World bank, Central government and the implementing cities and municipalities for deliberations. The Consultant also carried out a peer-to-peer technical study visit to Kigali City Rwanda. Finally, one-on-one stakeholder engagement meetings occurred between the Consultant and MoWT, UNRA, Ministry of Local Government, UNBS, KCCA, UIPE/ERB, UNABSEC, USEA, and leading service providers like Davis and Shirtliff International Ltd and Chloride Exide Uganda Ltd.

Baseline data was captured from technical assessment of a sample space comprising of 2,406 and 6,694 streetlights under USMID1 and USMID-AF respectively. Below are key facts revealed.

i) There were material specification improvements along the evolution from USMID1 to USMID-AF programs especially with regards the solar panels, batteries, LED lamps and anti-vandalism mechanisms.
ii) As per the standards laid out in the MoWT Urban Roads Design Manual 2023, all USMID1 lights were found to perform below the standards mostly due to materials degradation, and only 54.7% of those installed in USMID-AF phase were performing within acceptable standards.
iii) There was inadequate funding at the Local Governments that hinders adequate maintenance of the streetlights. Local revenue and the Road Fund contributions do not have dedicated budgetary lines for maintenance of public lighting systems.
iv) All the streetlights designed in the entire USMID program used the traditional Lumen Method which only emphasizes amount of luminance emitted from LED bulb, unlike modern methods which in addition to luminance, also factor in lighting uniformity on the road surface, elimination of shadows in between poles, and the effects of glares on road users.

v) Vandalism and theft of the street lighting materials due to poor quality anti-vandalism shields, and failure to sensitize communities.

This study developed a 10-year lifecycle costs for solar-powered, grid-powered and hybrid streetlighting systems. This will serve as a guidance for authorities to formulate detailed operation and maintenance plans and budgets for the sustainable operation of the streetlighting assets.

The Study articulates that UGX 100,000 is required for basic quarterly maintenance per light with little or no spare parts. The cost breakdown covers basic maintenance requirements, such as regular cleaning materials, hire of the Lorry crane and the day allowance. The cost of spare parts is additional.

In conclusion, participating municipalities and cities have greatly been impacted by the USMID streetlighting systems. However, the challenge is their inability to properly maintain and operate the systems due to inadequate funding, low revenue sources, and the lack of trained and dedicated staff to implement O&M activities. Also, though the USMID program preferred solar-powered streetlights, lifecycle cost analysis carried out in this study shows that grid-powered streetlights are cheaper to establish, give higher and consistent road luminance levels, have lower lifecycle maintenance costs, are more suitable for urban settings, and easily to adapt to energy efficient technology.

The Study recommends the following key actions:

1) **Technical Capacity:** Consultants, contractors, and project managers on streetlighting projects should be thoroughly verified by the procurement bodies in conjunction with regulatory entities like ERA and UIPE for competence to produce better designs, perform quality check, installation as well as conduct effective operations and maintenance.
2) **Standardization of Technical Specifications:** The URDM 2023 version should be updated to explicitly clarify on the various lighting designs and standards required for various road classification.
3) **Computer-Aided Designs:** Designs should be aided and generated by computer software to minimize errors. All design reports should be checked by the Project managers for compliance to national and international standards.
4) **Quality Assurance**: Organizations like UNBS should be empowered to carry out quality checks on public lighting equipment in the country. Pre-shipment quality checks should also be done to reduce the likelihood of procuring substandard streetlighting equipment.

5) **Cost of Operation and Maintenance**: The cost for the operation and maintenance of street lighting should be paid by the public through revision of the power tariff structure. Finally, streetlighting projects should include a scope of maintenance for at least three years to include end-user training, replacement of faulty parts and technology transfer.
6) **O&M Equipment and Personnel**: Government needs to procure lorry cranes with hoists for work at height. This should be done at regional level. There is need to hire skilled Electrical Engineers and Technicians for O&M activities.
7) **Improved technologies**: Government should consider investing in modern public street lighting initiatives such as Hybrid and Smart Street lighting technologies which have superior advantages and are proven to be energy efficient.
8) **Separation of Streetlighting Contracts from Civil Works.** Streetlighting contracts should be executed separately from road construction designs and works. They should also have an enforceable defects liability period of at least two years, to cater for technology transfer and replacement of defective components.
9) **Salvaging of the USMID1 Streetlights**. The Local Governments to set aside funds to replace or thoroughly maintain (with latest technologies) the USMID1 streetlights to redeem the investment.

1 INTRODUCTION

The Government of Uganda represented by the Ministry of Lands, Housing and Urban Development (MLHUD) signed a consultancy contract with M/s WSS Services (U) Limited, P. O. Box 27755 Kampala, Uganda (also here thereafter referred to as "WSS") on November 30, 2023, to conduct a "Technical Study on Energy Efficient Public Lighting in USMID-AF Implementing Cities and Municipalities.

1.1 **Background to the Assignment**

The Uganda Support to Municipal Infrastructure Development Program (USMID) Program executed by the Ministry of Lands, Housing and Urban Development (MLHUD) and financed by the World Bank set out to "enhance the institutional performance of the selected municipal Local Governments to improve urban service delivery". The Program was implemented in two phases.

Phase one was financed by a US$ 150 million from the World Bank. A government contribution of US$ 10 million dollars is made directly to local governments as development grants. The program became effective on 4th September 2013 and ended in December 2018 [1]. The Program scope at that time were Municipalities include: Arua, Gulu, Lira, Soroti, Moroto, Mbale, Tororo, Jinja, Entebbe, Masaka, Mbarara, Kabale, Fort Portal and Hoima.

Phase two was financed by US$ 360 million from the World Bank/IDA and the Program (USMID Additional Financing-USMID-AF) was introduced after successful achievements were registered in Phase one. USMID-AF ran for 5 years starting in fiscal year 2018/19 and ending in June 2024. The geographical coverage of the Program extended to eight additional municipal local governments of Kitgum, Kamuli, Mubende, Kasese, Busia, Ntungamo, Apac and Lugazi and introduced support to 8 refugee host districts of Adjumani, Moyo, Yumbe, Arua, Isingiro, Kiryandongo, Kamwenge and Lamwo [2].

Among the achievements, the USMID Program has impacted 10 Cities, 12 Municipalities and 11 Refugees Hosting Districts, building approximately 130km of urban roads and installing thousands of solar streetlights boosting security and visibility in the benefiting areas [3].

However, in the execution of the USMID Program, the solar streetlights installed began failing due to mainly poor maintenance or underperforming due to design and/or installation short comings. Each urban area installed different

streetlights fixtures with various makes, designs, and specifications. This has contributed to public concern about the types of lighting units installed, their effectiveness, durability, functionality, and maintainability [4].

This Report, therefore, is an outcome of a technical study commissioned by MLHUD to understand the above underlying factors and present energy efficient solutions and recommendations to avert the crisis.

1.2 **Overall Objective**

The Overall Objective was to assess potential in street lighting in the USMID implementing cities and municipalities and to identify potential energy efficiency investments which may cover the rehabilitation and optimization of the urban roads and street lighting system, including lighting equipment replacement, and associated infrastructure to enhance energy efficiency primarily in the implementing Cities and Municipalities.

1.3 Specific Objectives

More specifically the objectives are to:

i) Review whether the USMID installed Solar Street Light designs and specifications meet approved specifications and whether the specifications could be reviewed given recent technology advances.
ii) Carry out site visits to all USMID-AF implementing cities and municipalities for benchmarking purposes.
iii) Verify the quantities of installed lamps, designs and installations, document experiences of the experts and consultants in the various Clusters and come up with draft standards and guidelines.
iv) Ascertain that installed Solar Street Lighting specifications are consistent with the contract documents and the standards applicable.
v) Check that Solar Street Lighting Units are installed correctly according to design (Numbers, location, lamp types, vertical and horizontal distances).
vi) Make observations and take sample measurements of key values such as Lux.
vii) Check whether the Solar Street Light equipment have sufficient protection against vandalism, lightning, internal voltage, and short circuits.
viii) Conduct energy efficiency assessments and undertake other studies of different lighting technology suitable for urban areas and most recent tests of the suitability of LED lighting for a developing nation like Uganda.
ix) Review best practices and lessons learned from other cities that have

implemented energy efficient street lighting programs, including LED lighting.

x) Describe the potential procurement methods that could be used by the Cities and Municipalities in general and the likely technical requirements to support tender processes.

xi) Meet and hold discussions with contractors, consultants, clients, solar light equipment manufacturers and suppliers and road users.

xii) Advise on detailed planning for the installation of the streetlights.

xiii) Write and submit final report highlighting recommendations to USMID-AF including guidelines and draft long-term service agreements and/or warranties with suppliers and vendors prior to permitting installation of the infrastructure.

xiv) Advise on long-term service agreements and guarantees with suppliers, vendors and contractors and maintenance requirements (including operation and maintenance work plans and budgets).

1.4 Streetlighting – An Overview

1.4.1 Basic Definitions

A better understanding of street lighting technical definitions will facilitate one's perception and appreciation of this Report. And here are some key definitions (as used in the assessment), highlighted below [11]:

a) **Road illuminance** is the amount of light (lumens) incident on per unit area of road surface. Units are Lux (lm/m^2)

b) **Lumen output** is the amount of light emitted by a light source. Unit is Lumens.

c) **Uniformity** - it is a measure of how evenly distributed the light on the road is. It is expressed as either Overall uniformity or Longitudinal uniformity. Higher uniformity increases visibility and reduces accidents on the road

d) **Glare** - it is the blinding sensation when the brightness of the light exceeds the adaptation level of the human eye to light. It produces discomfort and reduces road visibility. It is measured in Threshold Increment (TI) which is the percentage increase in required luminance to compensate the effect of glare.

e) **Surround Ratio (SR)** – it is the visibility of the road's periphery relative to

that of the main road. Road lighting should light up not only the road but also the adjacent areas so motorists can see objects in the periphery and anticipate potential road obstructions e.g., a pedestrian crossing the road.

Figure 1: Surround Ration Definition

f) **Maintenance Factor (MF**) is a measure of how much light output, or lumens, reduces over time. The maintenance factor is important in lighting design as it helps ensure that the lighting system can provide the required level of illumination throughout its lifespan [48].

1.4.2 Major components

Public lighting in Uganda is implemented by either using grid-powered or solar-powered streetlights. The streetlighting system elements are characterised as follows:

a) Solar Photovoltaic Panel (PV Panel) is the energy generating component responsible for harvesting energy from the sun and converting it to a usable form of electric energy.

b) Battery is the energy storage and supply component of the system. It converts stored chemical energy into electrical energy. The battery in a solar lighting system is rechargeable and designed to supply energy to the lighting system for up to three consecutive days and should have about 3 days for rainy or non-sunny days (autonomy days).

c) Charge Controller is considered the "heart of the system' It harvests the current to charge the battery during the daytime and discharges the battery during the night to power the LED lamp as efficiently as possible. It also regulates the flow of electric current to and from the battery and prevents over-charging, over discharging or over voltage, all of which may reduce battery performance or lifespan, and may pose a safety risk. [2].

d) **Luminaire** this is the lamp module that transforms electric energy to light energy. Currently high-quality LED type lamps are preferred to their excellent properties (energy saving, long lifetime, safe for environment, better colour rendering properties) than the other lamp types.

e) **Street Pole** supports all components of the lighting system including internal wiring and protection devices that connects all components together. The pole must stand firm against unfriendly weather forces.

1.4.3 The Need for Streetlighting

Road traffic crashes are a major cause of death and injury, especially in low and middle-income countries. Worldwide, over a million people are killed and some ten million people are permanently disabled in road traffic crashes, annually. Since 2020, road traffic injuries are now third in world disease burden rankings, accounting for 2.3 million deaths each year globally. Street lighting has been suggested as a relatively low-cost intervention with the potential to prevent traffic crashes [5].

Street lighting improves safety and security in communities. Street lighting is a critical component of road furniture increasing visibility and better road use at night. It improves aesthetics and rises property rates of the surroundings areas. Improved levels of socio-economic transformation, societal welfare and cohesion are registered due to higher income levels from longer hours of business operations. Street lighting enables increased revenue collections in Urban Councils from growth in trading, transport, tourism, and entertainment.

1.4.4 Justification for Streetlighting

The Study has shown enormous potential benefits for the Government to embrace street lighting initiatives. Some of these include:

i. **Crime Reduction**: Proper streetlighting can reduce crime rates, making streets feel safer. The study by Brandon Welsh and David Farrington, 2008 showed that street lighting interventions are associated with a significant desirable effect on total crime (14% reduction in treatment areas compared with comparable control areas); furthermore, street lighting significantly reduces property crimes, but not in violent crimes [6].

ii) **Traffic Safety:** Africa has the highest rate of fatalities from road traffic injuries in the world. Visibility is a key factor in reducing risk especially

for pedestrians in most urban centres in Africa [7]. Street lighting plays a critical role in enhancing traffic safety. Properly illuminated streets help drivers navigate more safely, reducing the likelihood of accidents, particularly at intersections and pedestrian crossings. Pedestrians and cyclists also benefit from increased visibility, which is crucial for their safety, especially during night hours [8].

iii) **Fostering Social Cohesion:** Street lighting encourages social interaction by making outdoor spaces more accessible and appealing. Well-lit parks, plazas, and streets become venues for social activities such as evening walks, jogging, community events, and local markets. These interactions strengthen community bonds with all persons, including as the disabled and the elderly, and fostering a sense of belonging, healthy living, inclusivity, and reduction in isolation among residents [8].

vi) **Economic Benefits**: Street lighting allows informal vendors and traders to operate for longer hours, boosting local economies. The surge in night economy creates more job opportunities and it is estimated that if street lighting is distributed nationally, 14,000 new job opportunities will be created. [7]. Street lighting is part of the improved road infrastructure installed at the Local Governments and these investments in are some of the key ingredients spurring Uganda's GDP growth from 3.9% in 2013 to 5.8% in 2022 [9]. Infrastructure development stimulates economic activity by facilitating trade, commerce, and industrial growth. Improved infrastructure supports businesses by providing better logistics, reducing operational costs, and opening new markets [10]

vii) **Property Values:** Well-lit neighborhoods are perceived as safer and more attractive, which can increase property values. Homebuyers and renters are willing to pay a premium for residences in well-lit areas, reflecting the desirability of these locations. This increase in property values can lead to greater tax revenues for local governments, which can then be reinvested in community services and infrastructure [8].

viii) **Tourism:** Tourist attractions and landmarks benefit significantly from effective lighting. Iconic structures and cultural sites, when illuminated appropriately, become more appealing to visitors, thereby boosting tourism revenues. Night-time tourism can be a substantial economic driver, drawing visitors to events such as light festivals and evening tours [8].

ix) **Promoting Environmental Sustainability and Energy Efficiency:** Modern streetlight control systems prioritize energy efficiency, utilizing technologies such as high-quality LED technologies and smart lighting systems that incorporate sensors, wireless communication, and data analytics to optimize lighting performance. These systems minimize light pollution which disrupts ecosystems and affects human health and can adjust lighting levels (dimming) based on real-time data on traffic flow, weather, and time of day reducing energy consumption and lowering carbon footprints. The integration of Internet-of-Things (IoT) in street lighting allows for centralized control and monitoring which ensures rapid response to issues such as malfunctions or outages, ensuring continuous and reliable lighting [8].

x) **Solar-Powered Lights:** Solar-powered streetlights represent a sustainable alternative to traditional grid-powered lighting. These systems harness solar energy during the day and store it in batteries for use at night. Solar streetlights are particularly beneficial in areas with limited access to electricity, providing a reliable and eco-friendly lighting solution [8].

1.5 **Study Area**

The assignment is to be undertaken in the USMID-AF participating Cities of Arua, Gulu, Lira, Soroti, Mbale, Jinja, Masaka, Mbarara, Hoima and Fort Portal as well as in the USMID-AF participating Municipalities of Arua, Kitgum, Apac, Moroto, Lugazi, Tororo, Busia, Kamuli, Entebbe, Mubende, Ntungamo, Kabale and Kasese.

1.6 **Project Deliverables**

The project deliverables for the Technical Study are contained in Table 1 shown below.

Table 1: Project Deliverables

No.	Project Deliverable	Status	Dates
1	Inception Report	Submitted	April 19, 2024.
2	Field Verification Report	Submitted	July 24, 2024
3	Draft Report	Submitted	October 11, 2024
4	Final Report	Submitted	November 28, 2024

1.7 **Report Structure**

This Report presents the activities executed in the reporting period between March 25, 2024, to November 28, 2024, and is structured in Chapters shown in Table 2 below:

Table 2: Final Report Structure

Chapter	Content
Start	Forward and Executive Summary
Chapter 1	Introduction (Consultant's Engagement, Objectives, Study Area, Deliverables and Report Structure)
	•
Chapter 2:	Baseline Assessment • Baseline study and findings; Gaps identified, and Appropriate interventions suggested • Measure of impact of streetlighting under USMID • Suggestion of revamping all the USMID1 lights
Chapter 3	Analysis of Public Lighting Technologies
Chapter 4	Stakeholder Engagement • Selected Government Ministries and Entities • 17th Program Technical Committee Meeting held at Hoima. • Study visit conducted at Kigali, Rwanda
Chapter 5	Environmental and Social Concerns and Recommendations
Chapter 6	Proposed Technical Designs and Specifications • Design Considerations, Software, Materials Specifications, and Installation Guidelines
Chapter 7	Cost of Technology and Benefits Analysis • Key Assumptions, Lifecycle costs, Regulatory framework, and Implementation Plan
Chapter 8	Feasibility to Implement
Chapter 9	Proposed Operation and Maintenance Framework
Chapter 10	Conclusions
Chapter 11	Recommendations
Others	References and Appendices

2 BASELINE ASSESSMENT

2.1 Introduction

The data collected during the study serves as a reference point against which progress can be measured and evaluated throughout the project cycle. The baseline study provides a clear understanding of the current situation, identifies the gaps, and provides valuable insights that guide the development of appropriate interventions and the establishment of indicators to track progress towards achieving desired outcomes [..].

2.2 Methodology

The target closure of the USMID-AF Program was June 2024. This Baseline Assessment was deployed to monitor and evaluate the streetlighting technologies used and propose design improvements and performance indicators to close gaps to improve the effectiveness of rehabilitated or future street lighting systems. The diagram below provides the methodology employed:

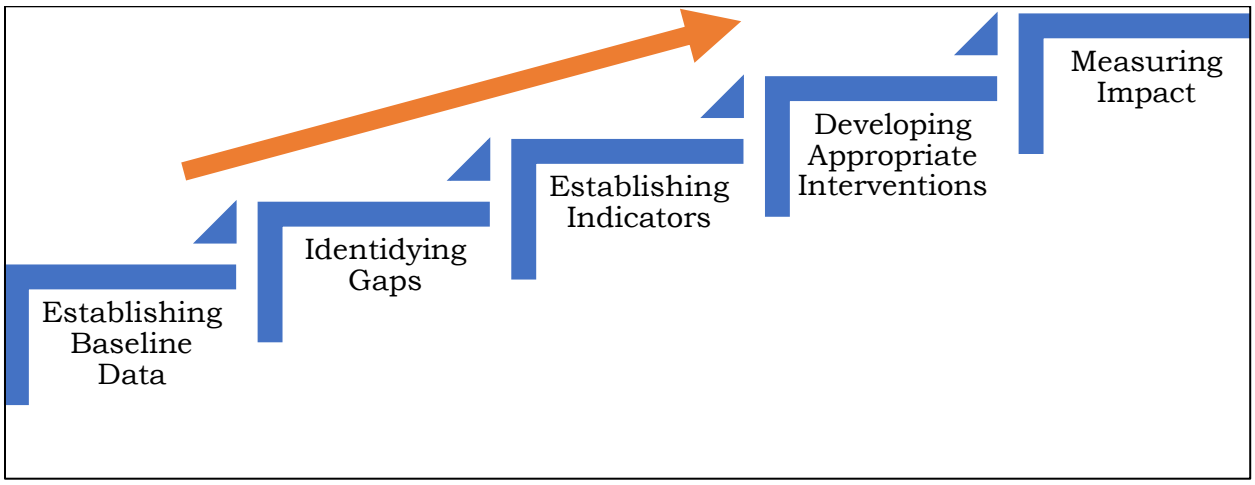

Figure 2: Methodology for the Baseline Assessment

2.3 Baseline Study and Findings

Site visits were undertaken in twenty-two Local Governments implementing the USMID-AF Program. Baseline data was collected from: a) document reviews received (USMID1 and USMID-AF road contracts, design review studies, payment invoices, completion reports/records etc..); b) field inspections/studies as well as from c) measurements of street lighting performance parameters in the period of March to May 2024. Most of this data is presented and analysed in

the Study's Field Verification Report [13]. However, a summary of the highlights is presented in Table 3 below. A couple of guiding notes are equally presented hereunder.

Table 3: Baseline Data M&E of the USMID Program

Item / Specification	USMID1	USMID-AF
Number of road projects reviewed in the Study	21	44
Number of streetlights reviewed in the Study	2,406	6,694
Height of Pole; Anti-vandalism	9m, no spikes	9m, with spikes
Solar Panel, Lifetime	2no. 90W/17V; 25 years	2no 100W/17.5V; 25 years
Charge Controller	20A, 12/24VDC	20/30A, 12/24VDC
Battery; Lifetime	1no. 250W Gel-type underground; > 5years	2no. 100AH/12V Lithium-ion (on Pole); > 5years
LED Lamp; Lifetime	LED 40W/4500lm; > 50000 hrs	LED 60/80W; > 50,000 hrs
Average maintained illumination	> 0.5cd/m² or 6.25lux (Based on UNRA)	> 0.75cd/m² or 9.42lux (Quoting BS EN 13201)
Compliant (average illumination 9lux of greater)	0%	54.7%
Contracts with Streetlights - Omitted	0	2
Contracts with Streetlights - Pending Installation	0	8
Contracts with average illumination less than 6lux.	14	6

Guiding Notes and Findings:

i) USMID1 refers to First Phase of USMID Program between 2013 to 2018.
ii) USMID-AF refers to the second phase of the USMID Program between 2019 to 2024.
iii) Currently, designing street lighting projects in Uganda follow the Road Design Manual, Volume VI, Urban Roads Part 1: Design Manual and Appendices. issued in July 2023 by the Ministry of Works and Transport (MoWT) [15].
iv) Under USMID1, streetlighting designs were found to have been based on UNRA guidelines, whereas in USMID-AF attempts were seen following international standards.
v) Most of the USMID urban roads were classified between M2 - M4. However, the survey findings noted that lighting class for M4 (or Class 4) of

0.75cd/m² (9.42lux) was prescribed for most of the designed roads of M2 – M4 (or road classes 2 – 4).

Table 4: Lighting Classes for Various Traffic Roads

LIGHTING CLASS	dry			wet *	TI in %	SR
	L_{av} in cd/m²	U_o	U_l	U_o		
M1	2.0	0.40	0.70	0.15	10	0.5
M2	1.5	0.40	0.70	0.15	10	0.5
M3	1.0	0.40	0.60	0.15	10	0.5
M4	0.75	0.40	0.60	0.15	15	0.5
M5	0.50	0.35	0.40	0.15	15	0.5
M6	0.30	0.35	0.40	0.15	20	0.5

Note: M1 road lighting class refers to high driving speed roads like expressways, whereas M6 is for residential roads

vi) In this Study, the cutoff average illumination mark for compliance was 0.75cd/m² or 9 lux which was the minimum to ensure vehicular and pedestrian visibility [16]. Therefore, all lighting measurements at the road projects that were 9 lux and above were "compliant" and those that were below 9 lux were considered "non-compliant".

vii) By the end of May 2024, some streetlighting works were still ongoing for some contracts under USMID-AF, with physical progress at 80.5%.

viii) Among the few functional USMID1 lights, none was found to meet the 9-lux minimum performance standard. Nearly all USMID1 streetlights were found in poor state of operation coupled with old technologies. Apart from the street light pole (except where missing), replacement of these streetlights with new materials will require approximately UGX 20.546 billion for the works.

ix) Nearly half of the street lighting projects in USMID-AF are non-compliant to the minimum lighting Class M4 of 9.42 lux or 9 lux at the minimum. Street lighting compliance in USMID-AF with the URDM 2023 stands at 54.76% of the road projects assessed, which is a concern.

x) The component of streetlighting was omitted from two contracts in Masaka and Mubende due to cost variations arising from design changes.

2.4 Identifying the Gaps

There are several factors that may explain the performance gaps noted in the findings from the baseline data, field work and related studies. Most of these were cross cutting and affect public street lighting in the USMID Program as a sector. Some of gaps identified include:

2.4.1 Inadequate Funding

Local Government (LG) budget revenue is an aggregate of all financing inflows from (i) central government grant transfers (ii) locally raised revenues (OSRs) and (iii) direct grants, donations, and transfers from development partners. Own Source Revenues (OSR) are important sources of financing for local governments but account for about only 5% of total budget revenues across LGs. The rest of the 95% of LG budgets are financed by Central budgets and other direct donor funding and are usually tied to planned and approved priorities at the LGs [17]. OSRs connect taxpayers and service delivery, in a relationship that enhances accountability and local service efficiency. However, the low level of own source revenues limits this connection, weakens the local democratic processes and efficient service management which includes maintenance of infrastructure assets such as streetlights. Poor performance in local revenue is linked largely to (i) gaps in policy and legal framework, (ii) weak capacity in administration and institutions for the management of OSR, and (iii) slow adoption of automation across OSR processes. In the East African setting, local government OSR in Uganda is still low; it is at 0.2% of GDP compared to Kenya 0.5%, Tanzania 0.4% and Rwanda 0.9% of GDP.

In the Technical Study undertaken to understand the factors influencing sustainability of public street light development projects in Nairobi City County, Kenya by Mark Irungu Ndirangu and Prof. Maitho Timothy Elias, 2020; both authors agreed that financing/funding greatly influences sustainability of public streetlights development projects in Nairobi County [18]. In their Study, a unit change in financing/funding would realise a 72.8% increase in the sustainability of public street light development projects in Nairobi County if all other factors remained constant. They reported that insufficient funds, lack of training, low support of community development officials and lack of community involvement, poor management and lack of coordination were some of the reasons put forward why community-based street lighting projects that were started later failed and others struggle to survive in Nairobi County. Some of these projects were streetlights along Kangundo Road, Githurai Ward, Kangemi, Kawangware Roads,

Nile Road to name but a few. Many of the vices mentioned above equally represent the situation analysis at the LGs especially in failure to operate and maintain street lighting assets as noted in USMID1.

2.4.2 Unavailability of Maintenance Equipment and Spare Parts Store

A lorry crane is primarily a key piece of equipment required for street light installation and maintenance. During installation the bucket is replaced with a pulley for hoisting the pole for easy installation. No LG was noted to own their own lorry crane.

LGs do not have stores to keep frequently used spare parts such as LED lights, cables, PV panels, batteries, street poles, etc... that are required to facilitate quick maintenance procedures.

Figure 3: Lorry Crane for Street Light Maintenance

Lack of operation and maintenance equipment, tools, relevant measurement instruments and spare parts for the sector relegates the LGs to procure and contract external providers to carry out their maintenance activities. This process is not only expensive in the long run but withdraws technical training, internal institutional capacity development and offers no response to quick emergency maintenance works at the LGs.

2.4.3 Lack of Skilled Electrical Engineers/Electricians

LG staffing establishments (structure, employment) are determined centrally by the Public Service Commission under the Ministry of Public Service. District councils appoint local administrative staff except for the accounting officers who are appointed centrally [17]. Survey findings noted that nearly all USMID implementing LGs did not have inhouse skilled Engineers / Electricians as shown in the case of Soroti District LG below [19].

Table 5: Administrative Staffing Structure for Soroti District LG

1 District Engineer 1 2 Senior Engineer 1 3 Civil Engineer [water]-DWO 1 4 Senior Assistant Engineering Officer 1 5 Assistant Engineering Officer 1 6 Roads Inspector 1 7 Engineering Assistant- Civil 1	8 Engineering Assistant (Mechanical) 1 9 Engineering Assistant (Borehole Maintenance Tech) 1 10 Road overseers 2 11 Plant Operators 1 12 Machine Operators 1 13 Drivers 6 14 Plant Machine Attendants 6

Absence of Electrical Engineers / Electricians at the LGs constrain due diligence and quality supervision during implementation of electrical infrastructure development projects and later execution of operation and maintenance plans, budgets, and activities.

2.4.4 Vandalism and Theft

There were incidences of vandalism and theft of the streetlighting equipment. A few reasons for the rise of this crime are given here below.

A. High Poverty Rate

Poverty is one of the driving factors to vandalism and theft of public street lighting assets nationally. Reports show that increase in the population of the urban poor has led to crime especially theft and vandalism in search for metal scrap. [20]

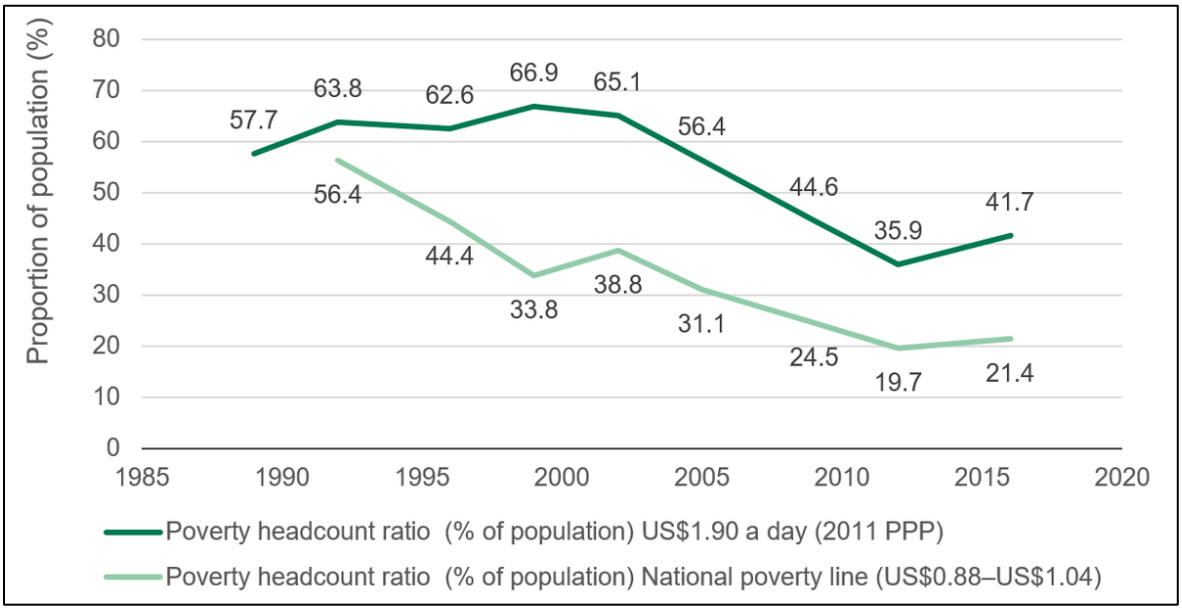

Figure 4: Poverty Headcounts in the Population

A multidimensional poverty approach shows that if deprivation in terms of education, health, welfare, and empowerment is considered, 42.1% of Ugandans are poor [21].

B. Youth Unemployment

Over the past decade, Uganda has registered a considerable increase in the youth unemployment rate. In 2021, the Uganda Bureau of Statistics (UBOS) revealed that youth unemployment (for persons between 18-30 years) increased from 12.7 per cent in 2012/13 to 13.0 per cent in 2019/20.

Youth unemployment has a significant impact on criminal activities, often contributing to higher crime rates. Unemployed youth may experience feelings of frustration, hopelessness, and social exclusion, which can drive them towards illegal activities as a means of coping or survival.

The photos noted below of vandalism and theft were taken during fieldwork at Lira City.

Streetlight vandalised and the solar panels and battery stolen at Lira City at the roundabout of Obote Avenue, Kyoga Road and Soroti Road.

C. Low Community Vigilance

Mark Irungu Ndirangu et all, 2020 agrees that community vigilance and participation influences sustainability of public street light development projects in Nairobi. Their Study revealed that conducting a feasibility report, enhancing community capacity building through majorly local employment, and establishing a management committee that engages the community greatly

influences sustainability of public street light development projects in Nairobi [18]. There is no evidence that communities were sensitized about the need to safeguard streetlighting installations by reporting any attempted vandalism to the relevant authorities like the Police and Local Defense Units. Therefore, vandalism and theft of streetlighting accessories occur undeterred. LG authorities equally take long to restore vandalized public assets and the laissez-faire attitude for all actors become the norm in such communities leading to failure or ineffective "well-intentioned" community infrastructure projects. Finally, and most importantly many of the installed pole spikes in USMID1 and USMID-AF were not fit for purpose [13].

Note: Some of the not-fit-for-purpose spikes installed are shown in the photos below

	
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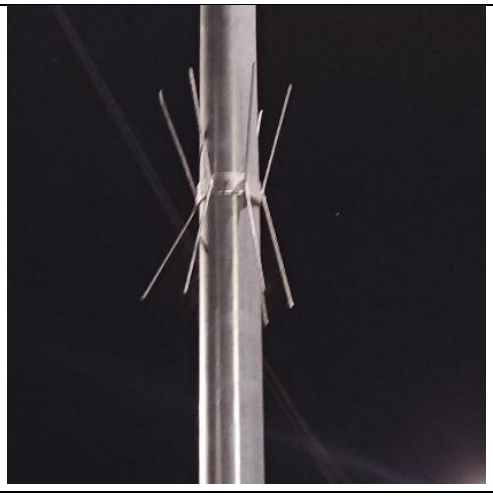
	
Techno Three – Kasese	China Wu Yi – Masaka

As reported in The Source online publication by Obed Kankiriho on November 7, 2023, Kabale Municipal Council invested ten million shillings to restore ten vandalized streetlights along major roads [36].

2.4.5 Inadequate Design Methods and Material Specifications

Road infrastructure design and implementation in Uganda is guided by the Ministry of Works and Transport Road Design Manual, 2023. Designing of streetlighting is discussed in Volume VI, Urban Roads, Part 1: Design Manual and Appendices (also referred as Urban Road Design Manual (URDM)) released in 2023 [15[. Internationally, street lighting designs follow the British Standards BS EN 13201:2015 [27].

In the Field Verification Report [13], we observed that no road project in USMID1 and twenty-three out of forty-four road projects (52.3%) in USMID-AF were compliant with 9 lux and above. 9 lux was the minimum lighting class for USMID-AF roads and this position (9 – 10 lux) is further emphasised in the "Research Report: Street Lighting for Pedestrian Safety by Travis Terry et al, December 2020 [16]. The low compliance performance was partly attributed to the use of inadequate design methods and material specifications, like the use of the traditional Lumen method in USMID-AF.

The street lighting materials and technologies used in USMID1 are now obsolete when compared to current technologies and may need to be replaced to facilitate easy maintenance and compliance to the road standards moving forward.

Additionally, there were no evidence that Factory Acceptance Tests (FATs) had been conducted at source for the streetlighting materials used in USMID road projects nor quality tests at UNBS for compliance with design specifications. Whereas availed documentation noted that technical specifications literature for the submitted public street lighting materials were approved by the road project Consultants in USMID-AF, the performance lighting measurements at commissioning were not undertaken. Therefore, there exists a possibility that the some of the installed street lighting materials were of low specifications thus not meeting the performance standard criteria.

2.4.6 Limitations of the MoWT URDM 2023 Guidelines

The Urban Road Design Manual 2023 discusses the design requirements for streetlights depending on the designed road classes. However, the Manual is silent with regards to the following sections:

i) Funding arrangements for streetlighting developments and maintenance.
ii) Standard design drawings with different pole sizes.

iii) Design criteria for street pole arrangements to different road geometries
iv) Installation guidelines
v) Testing and commissioning procedures for street lighting projects.
vi) Operation and Maintenance procedures for different public street lighting technologies
vii) Waste disposal for undesired public street lighting materials.

2.4.7 Inadequate Legal Framework (URF)

The Uganda Road Fund (URF) is a government agency mandated to finance routine and periodic maintenance of public roads in Uganda. Established by an Act of Parliament in 2008, the Fund has continued facilitating road safety activities on both national and Kampala city roads with over **UGX15 billion annually**. The activities include street lighting, road signage, marking of roads, demarcation of road reserves, protection of road reserves on national roads, and signalization of junctions and maintenance as reported by the Uganda Update online publication of July 14, 2024 [28].

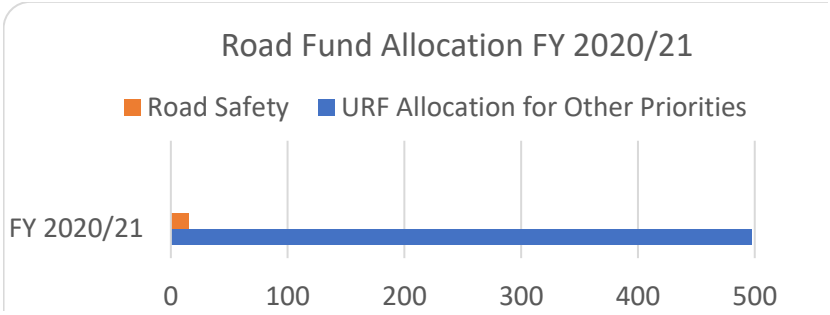


Figure 5: Road Fund Allocations FY 2020/21

However, the Uganda Road Fund in their Budgeting & Operational Guidelines for Designated Agencies in FY 2020/21 when distributing UGX 512.175 billion for FY 2020/21, mentioned that while the central allocation done by URF was to provide planning ceilings to various categories of Designated Agencies, the internal allocations to individual programs for road schemes were done by the agencies themselves. Designated Agencies include two authorities namely UNRA, KCCA and 134 Districts, 7 new cities and 34 municipalities while Sub Agencies include 227 Town Councils and 1185 Sub Counties that shall benefit from the URF [29].

Therefore, the Study noted that:

a) there were no specific regulations in the URF guidelines to govern the funding for operation and maintenance (O&M) activities of street lighting,
b) the share of cost for streetlighting of the UGX 15 billion was inadequate to cover the national scope given the fact that this budget was shared amongst funding other priorities. Let's take about 10,000 streetlights installed in the USMID1 and USMID-AF Programs; replacement of only the existing batteries with Lithium Iron Phosphate 100Ah batteries to all these lights after a 5-year period will consume about UGX 40 billion indicating that the above budget is very inadequate even though this replacement cost of batteries and other maintenance costs are phased through 3 to 4 years.
c) the were no detailed O&M plans and budgets at the LGs to attract fair assessment of funding from the URF allocations.

Therefore, Government should create a more robust regulatory framework to grow and manage domestic solar markets and public streetlighting in general. Ensuring a wide range of stakeholders – including local communities – are involved in planning and implementing such projects will help to maximise social impact and economic returns. In sub-Saharan African where, without proper regulations and standards in place, 'technology dumping' may lead to old and/or new but inefficient equipment being installed by manufacturers who cannot find a market for their products in other countries where these rules are in place [7].

2.5 Establishing Indicators

The baseline study establishes the following indicators to track progress towards achieving desired outcomes. The indicators help to measure the effectiveness of the intervention, and these are discussed under the following project reporting stages and outcomes in the table below:

a) Design, Installation and Commissioning
b) Defect Liability Period
c) Periodic Operation and Maintenance

Table 6: Establishing Technical Performance Indicators in M&E Reports

No	Project Intervention	Monitoring & Evaluation Report	Technical Performance Indicators for Inspection and Measurement	Project Outcomes
1	Design, Installation, Testing and Commissioning Processes	i) Project Design Reports (Material Specifications and Installation Drawings). ii) Project Site Inspection and Monthly Meeting Reports. iii) Payment Certificates iv) Commissioning or Practical Completion Report	i) Compliance to design specifications and drawings through physical inspection and verification. ii) Nature of workmanship through use of qualified and experienced contracting staff. iii) Certification of street lighting test reports and sample installations by certified Electrical Engineer on project. iv) Adherence to lighting class standards for that specific road class through conducting lighting measurements. v) Level of plumbness of the street pole vi) Certification of the Pole base by certified Civil/Structural Engineer on project and having an upstand of at least 150 - 200mm above the finished existing level. vii) Approved wiring and earthing systems for protection of lightning strikes and/or low voltage fault currents.	a) Project Acceptance and Take-over b) Issuance of the Practical Completion Certificate c) Payment at Practical Completion d) Receipt of accurate "As-Built" Drawings and Equipment Manuals e) Receipt of Street Light applicable material warranties. f) Issuance of snag lists for defects rectification

No	Project Intervention	Monitoring & Evaluation Report	Technical Performance Indicators for Inspection and Measurement	Project Outcomes
2	Defects Liability Period Processes	i) Snag Reports ii) Final Report	a) Mid-term snagging inspection and quality assurance reports b) Verification of completion of all snags through a final site inspection and reports. c) Remeasurements for sample lighting parameters to check compliance with the design requirements	a) End-of-Defects Liability Period Certificate b) Final Report c) Final Account
3	Periodic Operation and Maintenance Processes	i) Approved annual operation and maintenance plan and budget (To ensure availability of funding) ii) Quarterly Operation and Maintenance (O & M) Reports	a) Availability of skilled Electricians to undertake scheduled / corrective O & M operations. b) Availability of Training plan for technical staff (to ensure institutional capacity growth). c) Plumbness and the general state of the street pole, spikes, and barriers (whichever is present) d) Impact of surrounding vegetation to the street light output. e) Normal functionality of the street light accessories (LED lamp, battery, PV panel, electrical wiring, and controls systems. f) Sample earthing measurements for compliance with the Regulations.	a) Periodic Maintenance Reports Key contents: i) Activities undertaken ii) Spare parts documentation iii) Name of key Technicians who performed the works. iv) Proposals for improvement

2.6 Developing Appropriate Interventions

During USMID1 and USMID-AF, only solar-powered public street lighting systems were rolled out in the LGs. We have noted the gaps in the two USMID Programs and have laid out some recommendations and appropriate interventions for the sustainability of the social and economic benefits that arise from streetlighting in *Chapter 11* of this report.

2.7 Measuring Impact of the USMID Streetlighting

In this study, the baseline data recorded from the fieldwork is displayed and analyzed. The data findings identified some missing gaps to be addressed as well as highlighted indicators to track compliance, quality and completion relating to street lighting design, implementation, and post contract management. In attempting to address the missing gaps described above, the Study proposed appropriate interventions for Client consideration. Therefore, herein we discuss the beneficial impacts that the installed street lighting has produced on the LG communities.

i) Improved Urban Services

Street lighting installations are part of the improved road infrastructure that USMID1 and USMID-AF has installed in participating LGs. The improved road infrastructure has improved urban services in 10 cities, 12 municipalities, and 11 refugee-hosting districts [43]. The streetlights installed along the road networks have lowered road accidents, provided safety, and reduced on gender-based violence and crime that may crop up in the urban centres [44].

ii) Economic Growth

Provision of street lighting has facilitated long hours of work for the traders and persons in employment therefore boosting revenues and strengthening the night-time economy. Nationally, this would add 14,000 full time jobs benefiting local communities [...]. In 2013, Uganda's economy experienced a real GDP growth rate of approximately 3.9%. This period was marked by recovery from previous economic slowdowns, with growth driven by sectors such as agriculture, industry, and services. Uganda's economy recorded an average growth rate of 4.4% in the decade leading up to 2022, above the average 3.0% for Sub-Saharan Africa. By 2022, when USMID-AF was operational, Uganda's economic growth had improved significantly, with a real GDP growth rate of 5.8%. This growth

was supported by increased investments, particularly in infrastructure and oil-related projects, as well as a rebound in tourism and other key sectors [45]. Increases in trade volumes especially enhanced by the night economy deliver improvements in Municipal revenues and service delivery.

iii) Enhanced Living Conditions

The improved urban infrastructure having improved drains, sidewalks and streetlights improved the livelihoods of the surrounding communities. Pedestrian road safety is improved by using the sidewalks, jogging and health walks are facilitated, road sanitation, air quality and beauty are enhanced using installed garbage bins and greening, among and others. Socio-economic cohesion and linkages are increased through evening entertainment. "It was also evident, that outputs resulting from USMID support in the different municipalities have a direct contribution to changes in the income and welfare of beneficiaries i.e., improving incomes of service providers, traders, transporters, including producers of local building materials. Overall, it was observed that the beneficiary satisfaction level with outputs resulting from USMID support was very high at 93.7 percent" by USMID Beneficiary Satisfaction Survey – March 2021 [32].

iv) Growth in Real Estate

Having well-lit and improved road networks improves the real estate valve in the affected communities. This is actualized through improved accessibility and connectivity. Areas that previous that were difficulty to reach and unattractive now became accessible and are easily connected by the improved road infrastructure. This creates a surge in property rates because such real estate now becomes attractive and valuable. This reality is further elaborated in "Talk to the Nation" by NTV – Saturday June 29, 2024, by the USMID Program Coordinator [43].

2.8 Rehabilitation of USMID1 Solar Street Lighting

The Study assessed performance of 2,406 streetlights installed in USMID1 program. However, most of these lights are defective due to poor maintenance and obsolete as the installed technology is now out of date. If these lights are overhauled with new materials with exception of the street pole, Government would require about **UGX 25 billion for maintenance** in the twenty-two (22no.) participating LGs. This cost could be clustered out to several Contractors for fast execution, to be completed within one year.

3 ANALYSIS OF PUBLIC LIGHTING TECHNOLOGIES

Public street lighting under the USMID1 and USMID-AF programs are all solar-powered while in most of the main roads under the jurisdiction of the Uganda National Road Authority, grid-powered streetlights are installed. Both technologies have merits and demerits. However, there are other alternative public street lighting systems that are new concepts and may provide worthwhile benefits. These interventions are proposed below:

3.1 Solar powered Streetlighting

In the USMID Program, about 130km of paved urban road infrastructure were constructed within the implementing Cities and Municipalities and incorporated solar-powered street lighting. This form of streetlighting was preferred since no energy bills accrued, there were no disruptions due to power cuts and is an excellent off-grid solution. However, the costly battery replacements have proven a daunting task for the LGs to sustain.

3.2 Grid powered Streetlighting

Grid-powered Streetlighting produces sufficient merits such as: sustained high road luminance over its lifetime, it is the preferred technology for smart street lighting and limits vandalism due to fear of electric shocks. However, there is need for stable power networks for sustainable use of grid-powered public lighting systems. The transition from grid power supply to solar power supply for public street lighting was to avoid the costly electricity bills and debt servicing that exerted financial stress to City/Municipal budgets like in the case of Kampala and Jinja [7].
Prior to USMID1, public streetlighting was mainly powered by the national grid. This is still the case for selected national roads that are under the jurisdiction of Uganda National Roads Authority.

3.3 Hybrid Streetlighting System

Hybrid street lighting system comprises:

i) a farm of solar PV panels that harvest the solar energy and transforms it into electricity for use.
ii) Storage batteries that store the generated electricity or provides electricity on demand.

iii) Charge controller that is the logic equipment to controls the system and
iv) Inverter that converts the stored electricity from the batteries into alternating current which is supplied to the automatic change-over panel switch.
v) Automatic changeover switch for automatic selection of power supply depending on which one is preferred and available.
vi) Interconnecting cables for the system

The hybrid system, therefore, maintains the outdoor farm of solar PV panels and a power room that houses the storage batteries, charge controller and inverter system and other relevant accessories. The entire compound is fenced off and manned by security for safety. The merits for the hybrid system are:

i) The primary source of energy is the sun that is free energy.
ii) A well configured system shall include days of autonomy which emphases that the grid power backup will rarely be used.
iii) The hybrid establishment is well guarded having advanced security systems which nearly eliminates vandalism and theft.
iv) The public streetlights appear to resemble grid-powered streetlights with no solar panels and batteries. The streetlights will function always and never be load shaded nor affected by weather.
v) Maintenance is affordable since it is easily implemented at one point.

The downside of the hybrid system is the high cost of land acquisition. Land for setting up is usually preferred within urban centres which is pricy.

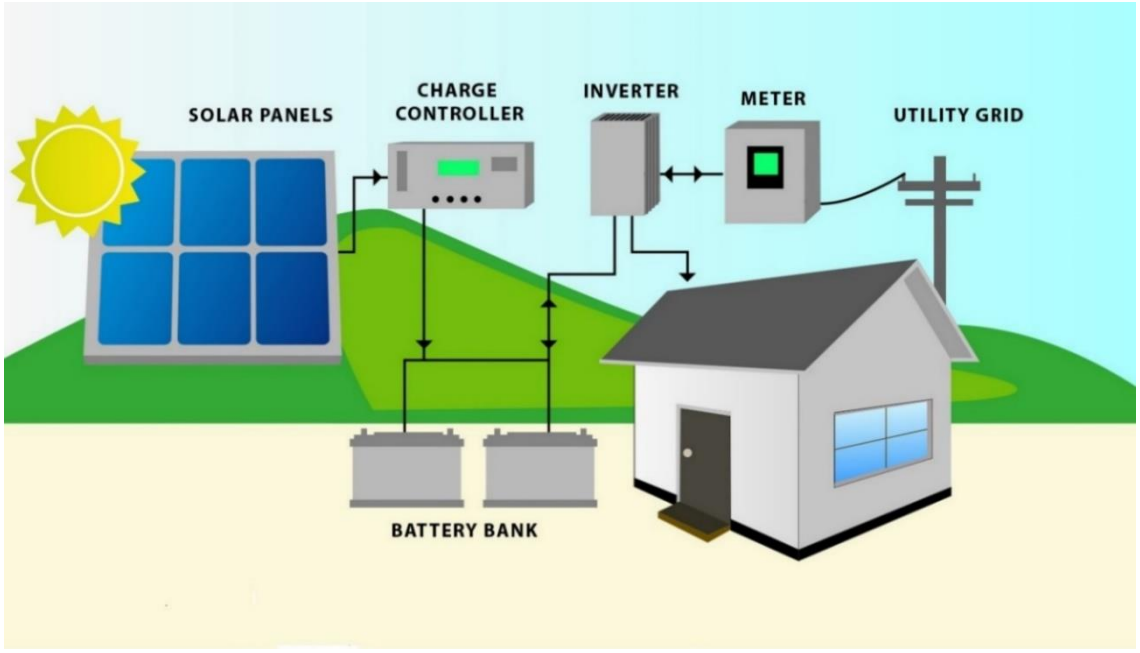


Figure 6: Illustration of the Hybrid AC/DC Power System

3.4 Smart Streetlighting System

A smart street lighting system is an advanced network of streetlights that integrates various technologies to enable intelligent control and management of outdoor lighting. [41]. This was the observation received from our Study visit to Rwanda. Pictorials from the Rwanda visit are attached in the Photo Gallery. Here are some key features and benefits of smart street lighting system:

Key Features:

i) Sensors and Connectivity: Smart Street lights are equipped with sensors and wireless connectivity, allowing them to detect movement and adjust lighting levels accordingly. This was acknowledged

ii) Energy Efficiency: By using LED technology and adaptive lighting, these systems can significantly reduce energy consumption, often by more than 50% [42].

iii) Remote Monitoring and Control: These lights can be monitored and controlled remotely in a secure Command Control Centre, enabling quick responses to outages and maintenance needs.

iv) Environmental Impact: Reduced energy consumption leads to lower greenhouse gas emissions, contributing to environmental sustainability [42].

Benefits:

i) Cost Savings: Lower energy usage and maintenance costs can result in significant savings for municipalities.

ii) Improved Safety: Enhanced lighting improves visibility for pedestrians, cyclists, and drivers, reducing accidents and increasing safety. This increases the quality of life making the cities more attractive.

iii) Reduced Light Pollution: Directional lighting minimizes light pollution, preserving the night sky and reducing disturbances to residents.

iv) Data Collection: These systems with additional equipment installed can collect valuable data on traffic patterns, camera surveillance, weather conditions, and air quality, etc. that help city planners make informed decisions.

v) Services Offered: With added improvements, Wi-Fi internet services, digital advertisement, digital time services, electronic vehicle charging, among others could be provided at cost boosting local revenues for the LGs.

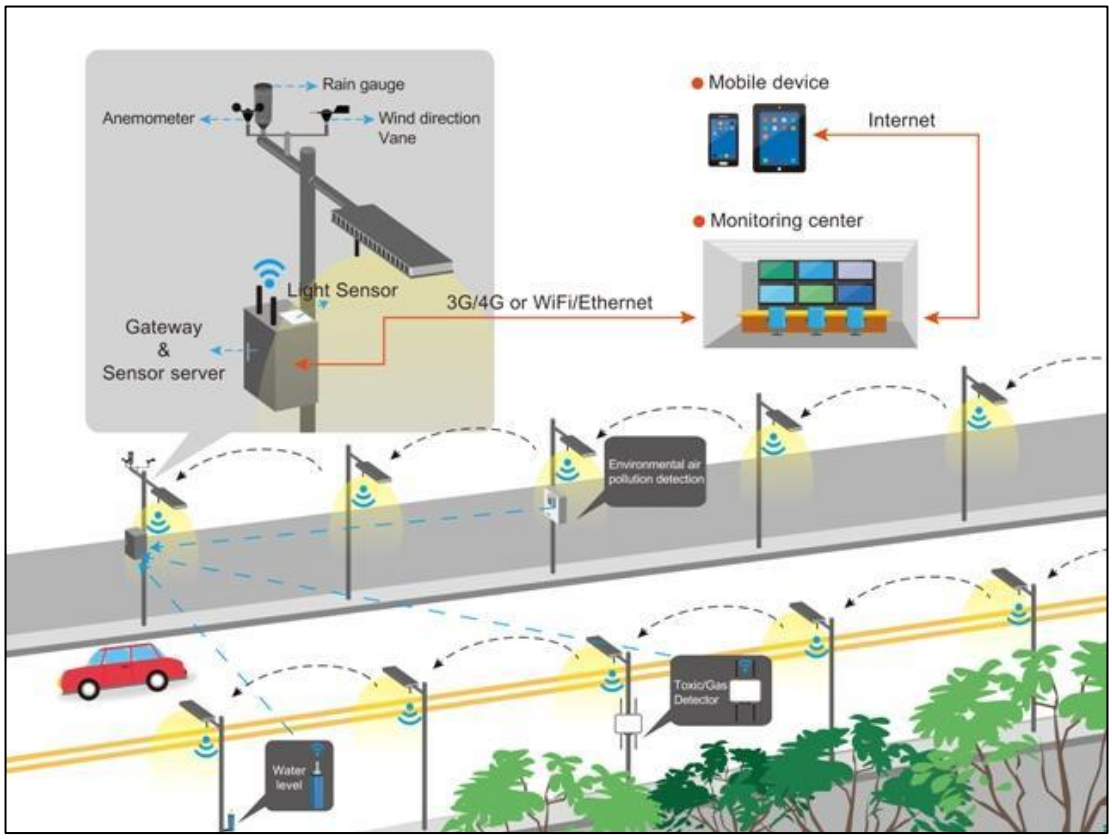


Figure 7: Smart Street Lighting System

Smart street lighting is a crucial component of smart cities, aiming to create safer, more efficient, sustainable, and environmentally friendly urban environments for which Uganda should adopt. As noted from our Study visit to Rwanda, smart street lighting system works optimally when the urban centers have reliable power supply, internet capabilities, government will and citizen participation, no vandalism and theft, robust and effective urban security, and law enforcement. The Command Centre functions twenty hours to control, implement and maintain the system efficiently and effectively.

Note: The Smartec® smart lighting system installed in Rwanda saves energy to 70%, reduces pollution by 70%, lowers maintenance to 50% and public expenditure to 50%.

4 STAKEHOLDER ENGAGEMENT

During the site visits, Local Government leaders, Engineering Department staff, Consultants, Contractors, Police, and road users were consulted in respect to the Study and findings. Details of the discussions, which were generally cross cutting and were enclosed in the Study's Field Verification Report [13].

From 6th to 7th June 2024, the Study team attended the Program Technical Committee (PTC) Meeting in Hoima and presented a preliminary Draft Report. Some of the feedback received from the PTC meeting are enclosed in the tables below. Additional Client instructions were received to conduct further stakeholder consultations with Government Ministries and relevant Entities to enrich the Study (*Refer to Appendix 2 for Schedule of Persons Consulted*). The feedback received is equally presented in the *Table 7* below.

Table 7: Minutes from Stakeholder Engagements

No.	Stakeholder	Remarks from the Stakeholder Engagement
1	Ministry of Works and Transport (MoWT) Meeting with Eng. Rutaagi Joseph. The principal Engineer at MoWT.	i) Local capacity still lacking in terms of proper design, quality checks, installation, and maintenance of public lighting systems, especially solar. ii) Public lighting contracts should include a scope of maintenance for at least three years. This should entail end-user training, replacement of faulty parts and technology transfer. iii) In the country, road designs and implementation are governed by the new Urban Roads Design Manual. What is yet to be seen is whether consultants and contractors will adhere to the URDM 2023. The URDM 2023 provides key basic design parameters in respect to public street lighting. iv) All urban councils should explore news ways to boost local revenues like advertising partnerships on the lights to cater for their maintenance costs. v) MoWT acknowledges that the Road Fund is not sufficient to meet streetlighting maintenance requirements and that more funding strategies are needed to improve the situation. vi) Hybrid street lighting should be considered for implementation in future projects. vii) Noticed that most contractors do not have competent electrical staff to supervise / implement standard public lighting installations viii) There is need for more advocacy to subsidize tariffs associated with streetlighting since it is a public good. ix) Urges Ministry of Energy to push for unconditional tax exemptions on solar products. This will increase usage and boost the sector
2	Kampala Capital City Authority	i) Their preference is grid-powered against solar-powered street lights. Some of the reasons include:

	Meeting with Eng Abdullah Ssenyonjo and Sankara James (Maintenance Department)	• Minimizes vandalism • Lower lifecycle cost per km. • High reliability and better road luminance levels ii) Solar designs have not factored in effective anti-vandalism measures till now, especially in urban areas. In this regard, KCCA is looking at having commercial partnerships with security vendors to curb this vice iii) The other measure is to incorporate an insurance policy to mitigate the risk of vandalism of public street lighting installations iv) There are budget constraints regarding the high cost of O&M activities. However, they acknowledge that O&M for grid is more achievable than solar. v) From experience, grid powered public lights, if well maintained, have a longer lifespan and fewer cases of vandalism. Focus currently is being put on creation of proper service ducts and well-designed cable trenches. vi) A major challenge with grid is the mode of switching of lights. Where if the system is faulty and maintenance is delayed, there will result power losses and high energy bills. vii) That UNBS is not with capacity to curb influx of substandard electrical products. They are unable to carry out acceptable factory inspection tests and pre-shipment checks. viii) That ERA should encourage more grid consumption in the population by reducing tariffs and given the fact that Uganda produces more power than is being utilised. ix) The cost of investment in solar systems should also be reduced through government policy b way of tax emption or heavily lowering the taxation rates. This will encourage more penetration and usage of the sector.

		x) The Government should start implementing smart street lighting technologies, as they prove to make public utilities more reliable. xi) Finally, there are joint efforts between KCCA, UNRA and MoWT in developing latest public solar street lighting specifications that would be appropriate for the Ugandan market. (The Study received these specifications from UNRA and are attached as *Appendix 8*).
3	Ministry of Local Government Meeting with Commissioner Charles Magumba	i) Acknowledges that the costs of ownership of both solar and UMEME powered public lighting is almost the same. ii) That grid is more reliable than solar which is intermittent depending on weather patterns and reliable maintenance. iii) There is no special tariff rate for public street lighting. This poses a cost challenge for local authorities who have low revenue collections. iv) Mr. Magumba prefers solar streetlights, on condition that a strict maintenance regime is in place. Why? Because its environmentally friendly, fits in the global green agenda. v) The downside of solar systems reported are outdated designs and lack of guarantees on the safety of equipment due to vandalism. vi) LGs to use existing laws and ordinances and strength urban security and law enforcement to fight abuse and misuse of public goods. vii) Way forward: Local authorities MUST budget for O&M, including hiring equipment like overhead cranes and purchase of service parts. viii) Government could look at the issue of purchasing lorry cranes for LGs to facilitate maintenance of streetlights. ix) Regarding funding challenges; it has been noted that revenues for municipalities and cities keep increasing every year, ever since automation of collection process was introduced, street lighting O&M priorities should no longer be ignored. Other measures to increase LG revenues should be explored such as: • Introduction of tax expansion strategies • Elimination of revenue leakages

		• Public Private Partnerships in revenue generation activities, and • Use of municipal bonds to generate income
4	Uganda Solar Energy Association Meeting with CEO Mrs. Robinah K. Nanyunja.	i) Hydroelectricity has frequent load power cuts thus is not good for sustainable street lighting unless heavy improvements are made to the hydro power systems. ii) Solar street lighting is worse for urban roads due to poor maintenance. No one takes full responsibility for their unreliability. iii) There is need to check the quality of street light materials at installation; The competency of installing supervisors seems lacking as cheap and poor-quality streetlights are flooding the Ugandan market. UNBS is not up to task. iv) URA has also not built capacity to know what solar products are exempted; or understand fake quality imports which should be barred from entry into the Country.
5	Uganda National Roads Authority Meeting with Eng. Kaddu Kenneth, Manager Electrical Department	i) Their preference is grid-powered against solar-powered streetlights. Some of the reasons include: • Minimizes vandalism • Lower lifecycle cost per km from their experience. • Sustained higher reliability and better road luminance levels are achieved. ii) KCCA is willing to have enhanced technical collaborations with USMID and other future programs, to share experiences and mitigation strategies for the sustainability of public lighting infrastructure. iii) That specifications of public lighting should lay emphasis on lumens than watts. This will force contractors/consultants to do thorough designs that are more compliant to specifications. The Study accessed some of the relevant UNRA specifications which are attached as *Appendix 8* to this Report.

		iv) As UNRA, they are currently overhauling existing solar public lights to grid notably every three years. This is informed by the experiences they have had with solar streetlights and the proven advantages of grid powered streetlights. An example was in Kabale Municipal Council where 274 million was spent to change solar streetlights along High Street with grid streetlights due to insufficient sunlight to charge the batteries [14].
6	Uganda National Bureau of Standards Meeting with Mr. Benard Mukwaya, Senior Electrical Engineer	i) That UNBS has a measure in place, called Pre-Export Verification of Conformity (PVOC), that aims at checking quality before items are shipped to Uganda. ii) Without PVOC, all import samples must be delivered to UNBS for certification before traders or suppliers can roll them to the market. However, this is not the case for all inbound goods without PVOC. iii) However, the organization still has gaps in four areas: • Lack of structured laboratories (premises) • Lack of specialised equipment • Lack of sufficient skilled technical staff • Not all Standard Specifications can be tested. • Staff training programs to be improved to build sufficient human resource capacity. iv) They are grateful for donor funded projects, which often include mandatory procurement of critical testing equipment and user training for UNBS technicians. v) Capacity to test LED lights, batteries and solar PV panels is in place. The test duration to confirm lifespans of the test objects take too long which remains a challenge. vi) Standard levy of 0.2% be charged on all locally and imported manufactured goods and given to UNBS for capacity building programs as is done in Kenya.

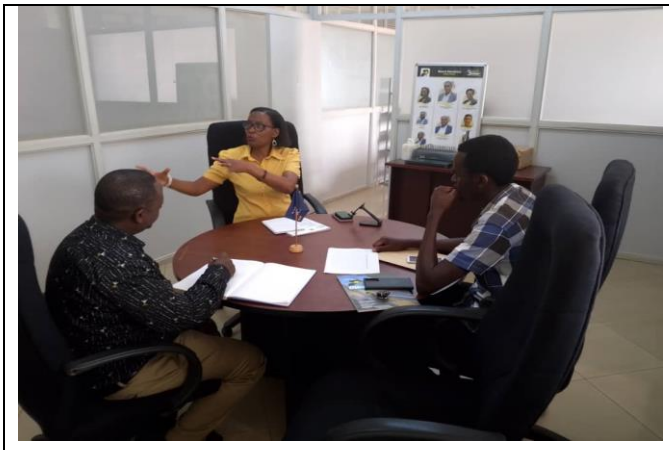
7	Uganda Institution of Professional Engineers (UIPE)/ Engineers' Registration Board (ERB). Meeting with Eng. Sam Ssentongo	i) Grid powered streetlights are recommended especially for urban settings. ii) Advocates for smart street lighting as the future of street lighting in cities for the numerous benefits that it delivers. iii) Blames vandalism to poor public attitude to public goods as well as widespread poverty. Implementing more CCTV cameras and using grid streetlights may deter crime. iv) Poor implementation of public streetlights projects is often caused by the lack of full participation of qualified and accredited Electrical Engineers in the Design and Supervision processes. v) Lack of Electrical Engineers / Technicians at the LGs equally lead to poor implementation of O&M for public streetlights at those locations.
8	Chloride Exide. Meeting with Mr. Tenywa Henry the Solar Sales Engineer.	i) Both solar and grid powered streetlights have their unique merits and demerits, but the recommendation could be hybrid streetlight system which offers a better reliability, more efficient and reduces vandalism. ii) Provides street light materials and consists of a dedicated team for O & M support when called upon. iii) Each product is supplied with a warranty statement against factory defects. However, inadequate designs and poor workmanship often invalidate this.
9	Davis and Shirtliff International Ltd Meeting with Ms. Milly Kure. Commercial Department Manager	i) Provide street lighting materials (solar PV panels, charge controllers, batteries, LED lamps) with a lead time of less than a month to reach Kampala. ii) Each product is supplied with a warranty statement. iii) Lithium Iron Phosphate batteries are available as observed in the 2024 Product Manual.

10	Uganda National Association of Builders, Suppliers and Engineering Contractors (UNABSEC) Meeting With Ag. Executive Director Ms. Mariam Namiya.	i) From the cost benefit analysis of solar, grid and hybrid street light system; hybrid would be the best option if supported by Government. ii) Comparison between the two existing systems, solar street light system is an excellent off-grid solution, environmentally friendly since it harnesses free solar energy for service. On the other hand, grid streetlights are preferred for cities and towns given stable power supply is guaranteed and energy tariffs reduced (by Government) to enable affordable bill payments. iii) Solar street light systems often fail due to poor municipal funding for maintenance budgets and activities, lack of O & M planning, lack of skilled technicians and vandalism. iv) Whereas municipal revenues could be raised internally, and are supported by Government and Donors, corruption tendencies at the LGs stifle public service delivery. v) The Engineering fraternity shy away from Politics and yet they may have better solutions for infrastructure improvements and funding to LGs, among others. vi) Vandalism can be minimized through community engagement during and after project implementation. The people will be the first guardians of the public goods and law enforcement will be supported.
11	Study visit to Kigali City Council, Rwanda	i) Grid Powered Street Lights. LED (80-160W) and High-Pressure Sodium lamps were used. ii) Uniform pole spacing was generally adhered to. 25 to 35m. Pole heights range from 10 – 12m. They all don't have spikes. iii) Latest designs for street lighting for any given road project were done using lighting software based on British Standards. iv) Street lighting maintenance cost is paid within the tariff structure of the utility bills by the population.

		v) Kigali city maintenance teams inspect all streetlights within Kigali and the surrounding divisions every night. Thereafter, online inspection reports were issued by the In-charge City Electrical Engineer who instructs all responsible subcontractors to carry out the required maintenance repairs. The repairs should be done within a period of 48 hours. vi) There were no prevailing national standards and guidelines for street lighting designs and management. It was reported that these are currently being undertaken. vii) Vandalism or vehicular damage to street light fittings hardly occur due to the tight urban security, high discipline exhibited by road users and positive national awareness/attitude. viii) Smart street lighting was mainly deployed at some street sections in Kigali. It is modern technology that controls lighting using antennas, gateway switches, the cloud and a 24-hour maintained Command Control Centre.
12	Program Technical Committee (PTC) Meeting, Hoima	**Lira TC** i) The choice between Grid or Solar powered street lighting should be agreed with the LG at project feasibility stage before it is too late at project implementation where nothing can be changed. ii) LG should plan for battery replacement for solar streetlights early before they fail to avoid a huge bill at the end of battery life. **Deputy TC/Masaka** i) They request for Central Government intervention like procurement of lorry cranes for LGs to ease maintenance of streetlights. ii) To standardize the anti-vandalism spikes nationally for all streetlights.

		Arua & Mubende TCs i) The Study should present minimum standards for solar streetlights. **Moroto Mayor** i) Reported that many LGs grapple with inadequate local revenues to meet O & M costs for the streetlights and other priority areas and requested more support by revising the Road Fund to cater for the gaps. **World Bank** i) Road Fund to be revised to adequately handle O & M activities for street lighting systems ii) Relevant policies and regulations to be revised to allow everybody pay for street lighting O&M as it is in the case of Rwanda (from the Study). iii) Public street light designs to be implemented with latest technologies as guided by the Study. This equally applies to usage of top-quality materials (batteries, lamps, etc.) for better reliability and ease of maintenance. iv) Testing of samples to be thoroughly done and due diligence to be achieved to prevent usage of substandard materials. v) Non-compliant streetlights should not be paid.

Below is a photo gallery from the stakeholder engagement meetings.

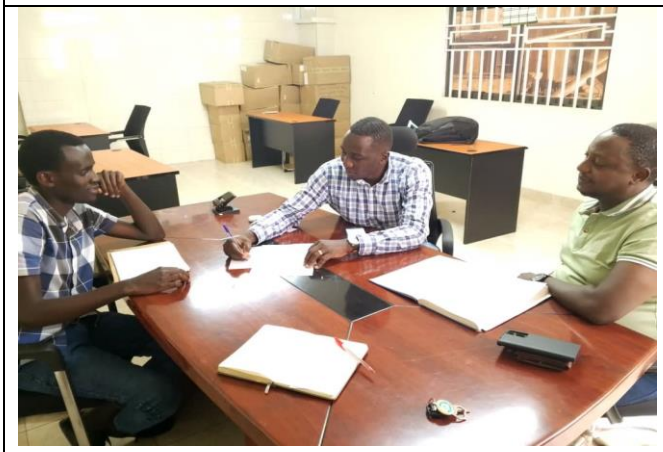


A meeting with Ms. Nanyunja K. Robinah the CEO of the Uganda Solar Energy Association (USEA).

A consultation with Tenywa Henry the solar sales engineer at Chloride Exide Uganda Ltd.

A meeting with Eng. Sam Ssentongo on behalf of UIPE and ERB.

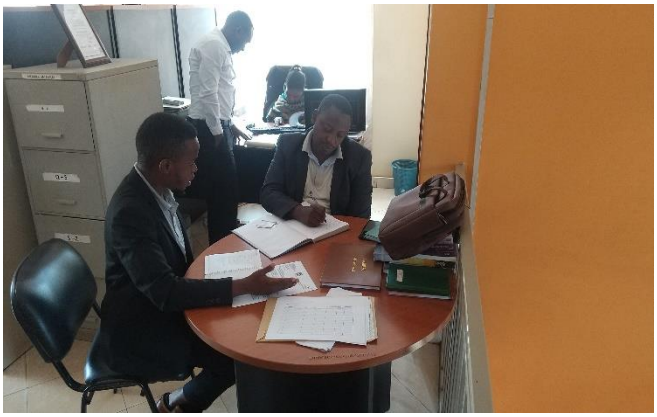
A meeting with Eng. Rutaagi Joseph the Principal Engineer at Ministry of Works and Transport.



A meeting with the Eng. Kaddu Kenneth an Electrical engineer at the UNRA.

Consultation with Mr. Magumba Charles the Commissioner at Ministry of Local Government.

A consultation meeting with Ms. Namiya Miriam the CEO at UNABSEC.



Further consultation with Mr. Golooba Vincent one of the staff at UNABSEC.

The team consulting Eng. Ssenyonjo Abdallah on behalf of KCCA.

A consultation meeting with the Mr. Mukwaya Benard senior Electrical Engineer at the UNBS.

Study visit to Kigali City Council in Rwanda.

PTC meeting with various stake holders at H.B Hotel in Hoima City.

5 ENVIRONMENTAL AND SOCIAL CONCERNS, AND RECOMMENDATIONS

5.1 Background and Field Findings

During the field visits for technical assessments and verifications, issues of environmental and social concerns in relation to the management of streetlighting systems were captured and are hereby highlighted in the report. Recommendations have been made regarding the better industry practices and statutory requirements of the management and addressing the observed environmental issues.

The Study noted compliance to the Environment, Social, Health and Safety (ESHS) aspects during implementation of sample road projects assessed. Most of the projects incorporated ESHS experts within in their Consultancy matrix to address the associated concerns and anticipated risks to enable smooth execution of the projects. For example, project ESHS concerns such as wayleaves and compensation, dust control, traffic control, sanitation, drainage control, workers' compensation, and medical requirements, among others were addressed within the confines of the road contracts.

During the site visits at the LGs, we were unable to find detailed and specific disposal plans for decommissioned streetlighting material and waste. In some of the LGs, streetlight material waste was seen stored at the Works Departments while others which were vandalized or hit by vehicles (street poles) were observed at the roads.

5.2 Proposed Mitigation and Disposal Strategies

It is upon this background that the Study has proposed the following schedule for guidance to the LGs to generate workable anticipated risks/concerns followed with mitigation remedies in respect to Environmental and Social aspects related to street light material waste disposal.

Finally, the cost of disposal of old, decommissioned, and obsolete major components of the public lighting system has been captured under Chapter 7, Section 7.2.

Table 8: Environmental and Social concerns and Mitigation Measures

Street Light Material	Area of Concern	Impact	Mitigation
Solar Panels	Environment	• Installation of solar panels has some ecological impact as it requires clearing of vegetation like trees which are habitation for wildlife. • There is the potential for environmental contamination if they are improperly disposed upon decommissioning.	• Road designs should be adjusted to ensure vegetation like trees are spared when installing lights • Tree planting to be implemented to replace cut down trees. • Disposal should be done by certified experts and at designated facilities • Government led initiate to establish regional e-waste facilities to handle proper disposal
	Social and Safety	• Like all electrical generating facilities, solar facilities may generate electric shocks if damaged during foul weather. • Possibility of falling debris onto traffic and pedestrians especially during windy weather if not secured firmly on the frame	• All installations should have proper earthing done to counter electric shocks • Ensure proper fastening of panels onto the structure by competent personnel during installation and periodic maintenance.
Solar Batteries	Environment	• Batteries are made using rare earth metals and other materials (for example Lead, Lithium, Iron, Phosphate, Plastics etc..) that will contaminate the environment when: i) Leakages occur during operation ii) Improperly disposed upon decommissioning.	• Use of improved battery technologies that: i) Have no Lead metals. ii) Are recyclable for reuse. iii) Last longer and are thermally stable (Use of Lithium Iron Phosphate) • Disposal should be done by certified experts and at designated facilities • Regular maintenance to be done to solar lighting systems to reclaim faulty

		iii) Underground batteries are intentionally ignored and forgotten – another form of improper disposal.	batteries from service for proper disposal.
Solar Batteries	Safety	• In several USMID streetlights, Lithium-type batteries are placed on the street pole thus being exposed to adverse weather elements. High temperatures may cause overheating leading to explosions and fire outbreaks. • Poor insulation of battery terminals can cause short circuit and fire when in operation.	• Use of high-quality corrosion-free battery terminal insulations • Install batteries suitable for specific site temperature conditions. • Battery cages should have proper aeration for heat exchange. • Installation should be done only by certified personnel.
LED Luminaires	Environment	• Poorly installed LED lamps may result into light pollution. • LED lighting affects movement of nocturnal creatures attracting them close to human settlements who will eventually harm them as they are looked at as pests. • Faulty LED lamps as poorly disposed harming the environment	• Use of high-quality LED lamps reduces greenhouse gas emissions. • Design and installation should be done only by certified personnel. • Disposal should be done by certified experts and at designated facilities.
	Safety	• Low quality or poor design and installation procedures may lead to uncomfortable glares to road uses increasing the risk of road traffic accidents. • Poor handling may lead to electric shocks	• LED luminaires that comply with calculated glare parameters to be used only in street lighting. • Damaged bulbs should be immediately replaced to prevent short circuits
Electrical Cables	Environment	• Burning of electric cables lets out toxic gases that contaminate the immediate environment.	• Worn out cables to be recycled for reuse.

		• The insulation of cables does not decompose; improper disposal of electrical cables will contaminate the soils.	• Proper designed cable sizes to be used during installation. • Periodic maintenance to be carried out by only certified personnel to avoid poor wiring and damaged cables in use.
	Safety	• Poor wiring, use of undersized power cables or use of damaged cables will all eventually lead overheating and burning if not checked. The burning may be catastrophic leading to loss of life and/or property.	
Street Poles	Environment	• Vegetation must be cleared to pave way for road construction and pole erection.	• Cut down trees to be replaced with tree planting initiatives to rejuvenate the environment.
	Safety	• Damaged poles arising from vehicular accidents, theft or improper installation pose safety risks to road uses in that locality. • Presence of electric shocks arising from faulty earthing may be harmful to anyone touching the pole.	• Use of concrete barriers to prevent vehicular accidents. • Poles should be installed at safe distances away from carriage ways. • Installation and periodic maintenance should be done only by certified personnel. • All street poles to be earthed.
General Entire Street lighting not functional (USMID1)	Social and Safety	• Poor road visibility • High levels of crime • Increased road traffic accidents • Reduced community activities at night • Low economic returns for the traders and the Local Governments	• Obsolete streetlights under USMID1 to be rehabilitated or replaced.

Pictorials of Street Lighting Materials for Disposal or Recycling

		
Damaged pole in Lira posing a safety risk to the nearby traffic close to the street pole	Decommissioned solar panels at Lugazi yet to be disposed off	Knocked pole barrier in Mbale; road island width is too narrow – safety risk to motorists
		
USMID1 Street Lights at Awange Mola Road in Lira were all non-functional	Blown of solar panel by wind in Kitgum; a safety risk to road users.	Street pole brought down, and all components stolen at Lira

6 PROPOSED TECHNICAL DESIGN AND SPECIFICATIONS

6.1 General Design Considerations

To embark on an appropriate design for streetlights, the following aspects are important technical factors to considers for best results.

6.1.1 Road Lighting Requirements

Appropriate streetlighting designs should first consider the nature of the road where the project is to be implemented and the required lighting levels. Key factors include:

i) Class and geometry of the designed road
ii) Maximum traffic volume during darkness (in the Manual)
iii) Design motorized speed
iv) Minimum road luminance, overall uniformity, longitudinal uniformity, threshold increment, glare and surround ratio as guided by applicable standards (national / international)

6.1.2 Pole foundation and structure

Pole stability is key in the operation of the street light. Therefore, the foundation of the pole should consider the weight and height of the pole and should withstand mechanical loading of the attached components (luminaire, batteries, solar panels, brackets), and adverse weather conditions. It should be of appropriate height in relation to the road width and properly spaced to achieve optimal lighting. The metallic pole must be bonded to the streetlight circuit bonding conductor to avoid short-circuits.

6.1.3 Brackets

This is the handle for the luminaire and care should be taken to select the right type for the application.

i) Length of the bracket is based on pole location in relation to the curbs or roadways. This also determines the reach required to position the luminaire.
ii) Should be strong enough to support weight of the luminaire and intermittent wind loads.
iii) It should be installed with enough clearance from overhead utility poles and wires.

6.1.4 Electrical components

The electrical system design should comply with energy-saving and safety standards. The controller, as the core component, should have over-charging

protection, over-discharging protection, and light control functions to ensure battery life and system safety.

6.1.5 Power and signal cables

These connect the luminaire to the energy source and are also used for communication between the control systems and the luminaires. These must be of appropriate size to avoid power and signal losses.

6.1.6 Smart control technology

Smart control systems ensure instantaneous monitoring and control of the streetlighting systems. The operator can automatically adjust the level of lighting depending on the surrounding conditions and troubleshoot any malfunctions in real-time. Therefore, there is need to install streetlighting infrastructure that can adopt to this technology so that future upgrades are possible.

6.1.7 Energy Efficiency Considerations

Energy efficiency is providing the same or better service using less energy [37]. Energy services are all the benefits we derive from energy use, such as illumination, thermal comfort, cooking, transport etc… Increasing end-use energy efficiency is often the least expensive and one of the most effective ways to meet demand for energy services while reducing energy consumption and the associated climate and environmental impacts.

The following interventions are required to further promote energy efficient street lighting systems:

a) Well-designed and executed streetlighting projects meeting the established standards and using of high-quality LED lamps having low energy use, better color rendering index (CRI >70%) and consistency, high lumen efficacy (>140m/W), efficient heat dissipation and longer lifetime than other lamp types such as High-Pressure-Sodium Lamp shown below

Figure 8: Street lighting with HPS Lamps Vs LED lamps

LED lights can reduce our carbon footprint. Given that in approximately 5% of global carbon dioxide emissions and 20% of total electricity consumption was due to lighting powered by electricity, and not to mention, around 3% of global oil demand is to power lights. It's estimated that 80% of lights used in 2030 will be LEDs and that doing so could cut back on power consumption associated with lighting by 40%. That reduction would lower CO2 emissions from power plants by more than 160 million metric tons**.** In 2017, it was found that using LED lights in outdoor spaces and buildings cut down carbon dioxide emissions associated with lighting by approximately 570 million tons [38].

b) Directionality and reduction in light pollution. Quality street light designs should define the direction and focus of LED lamp for consistency (good optics) to maximize road luminance and thus reducing light (energy) wastage [11]. Levels of light wastage (highest, high, acceptable, and optimum) are shown in the Figure below.

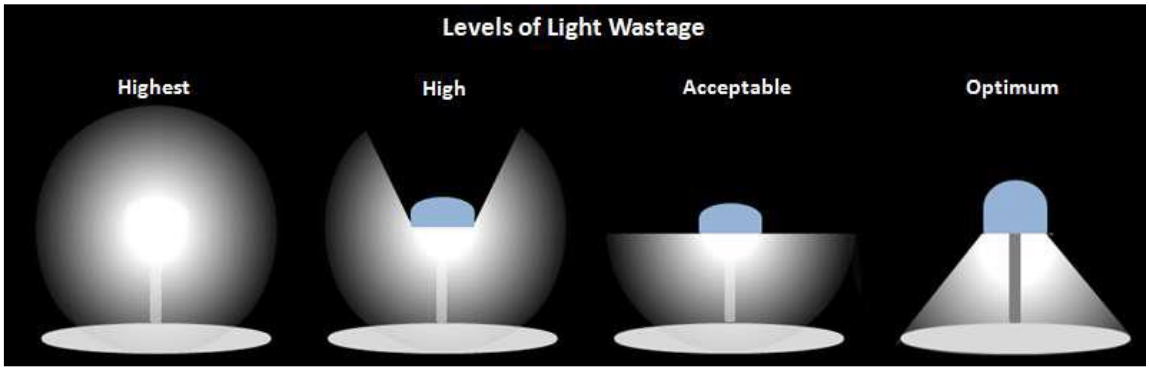


Figure 9: Directional lighting and reduction of light pollution [6]

c) Use of improved Lithium Iron Phosphate batteries rather than Lithium-Ion batteries due to their long cycle life, high safety, better thermal stability, and low maintenance as shown in Table 11 below [39]. They can also be fully discharged to 0% (i.e., 100% Depth of Discharge) without being harmed. The only effect is that the lifespan is limited to 2000 cycles say about 3 years. And finally, when the design operation limits discharge between 20% – 70% of remaining charge (i.e., DOD 80% to 30%) the lifespan is increased between 5,000 to 9,000 cycles (or about 8 years to 15 years - other factors remaining constant). This characteristic of long lifespan lowers lifecycle cost.

Table 9: Lithium-ion and Lithium Iron Phosphate batteries

Battery Type	**Lithium Ion**	**Lithium Iron Phosphate**
Energy Density (store energy in a given space)	Higher	Lower
Cycle life (Recharge / Discharged)	300 – 500 times (shorter)	3000 (latest technology is up to 7000 [15])
Depth of Discharge (Draining the Battery)	80 – 95 %	Up to 100%
Self-Discharge Rate (Slower the better)	5 %	3 %
Cost […]	Lithium Iron Phosphate battery has a higher initial cost value due to its advanced technology but a lower overall lifecycle cost value due to its longer lifespan than the same lithium battery.	
Weight per Wh […]	150 to 200 Wh/kg,	90 to 120 Wh/kg,
Sensitive to Heat and Cold	Yes (Damaged by heat and cold temperatures)	Better thermal stability
Environment concerns	Release toxic gases in hot temperatures	None

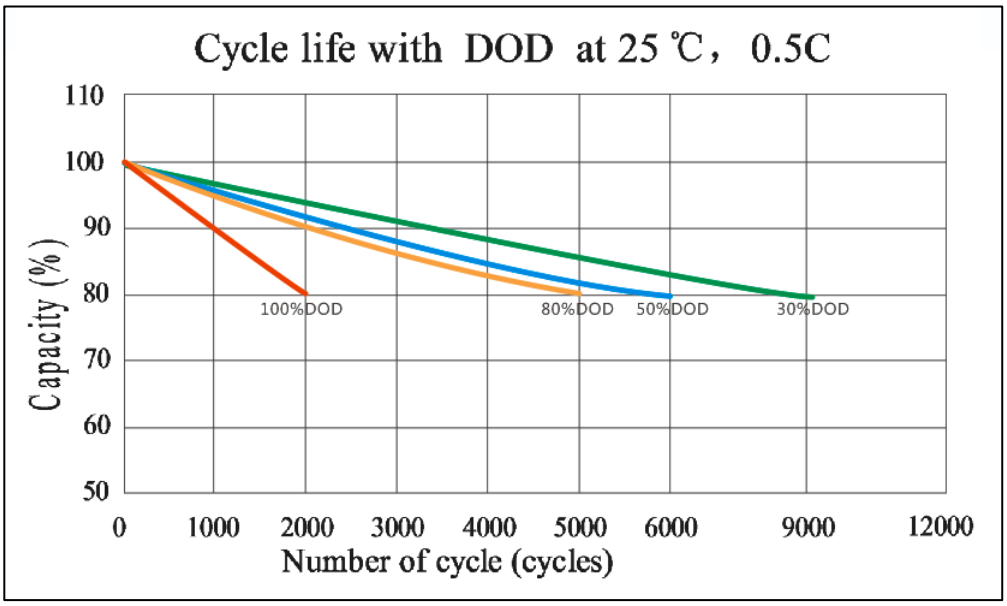


Figure 10: Long charge cycles - Lithium Iron Phosphate Battery [40]

6.2 DIALux Software Design Procedures

Latest design software such as DIALux by Phillips are currently used in the design and supervision to deliver an effective and energy efficient street lighting systems that are compliant to national and international regulations.
Below is a summary of procedures used by the DIALux software to produce a streetlighting design.

i) Identify the lighting standard (requirement) depending on the road class.
ii) Create street profiles like width, length, lanes, walkways, islands etc
iii) Select the desired street lighting materials/equipment specifications to be installed, pole height, spacing etc
iv) Adjust the street light arrangement (proper placement of pole and light)
v) Calculate the lighting parameters and adjust the design as required
vi) Export DIALux lighting design report

6.3 DIALux Software Design Output

For this study, a sample design was done, and as observed in the report graphics and Table below that the Designed results achieve compliance with the Standard requirements of the street lighting project [12].

The software design partial report is presented in *Figure 11* below

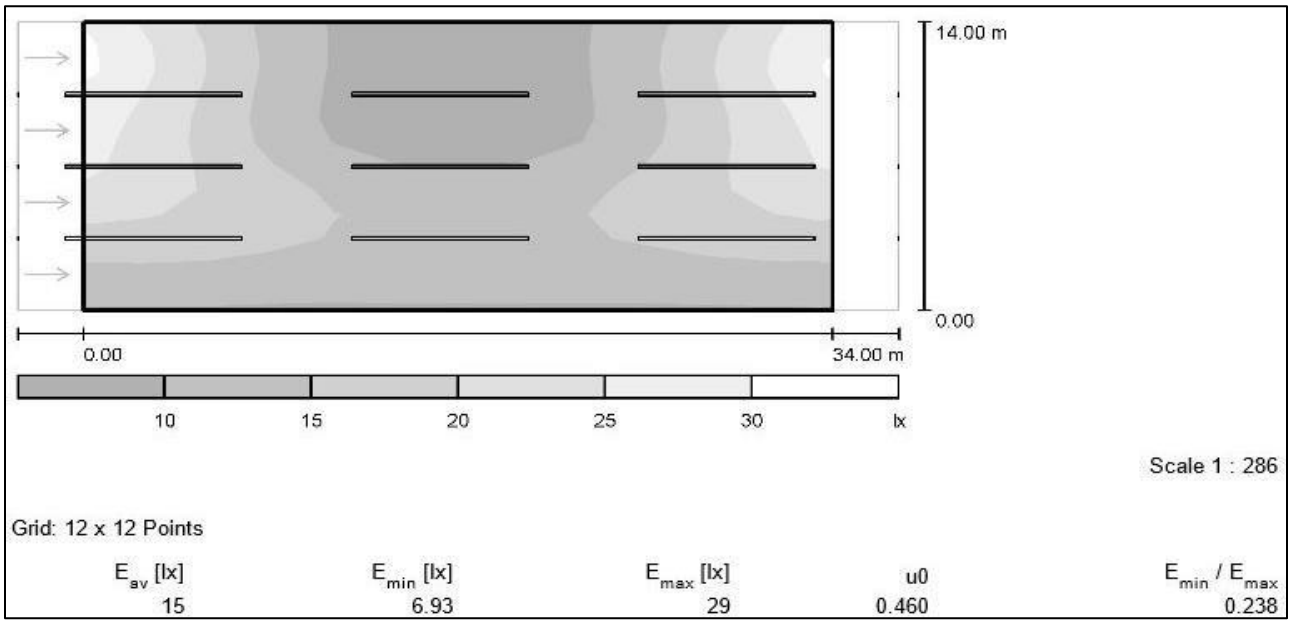


Figure 11: Software design: Surface illuminance map

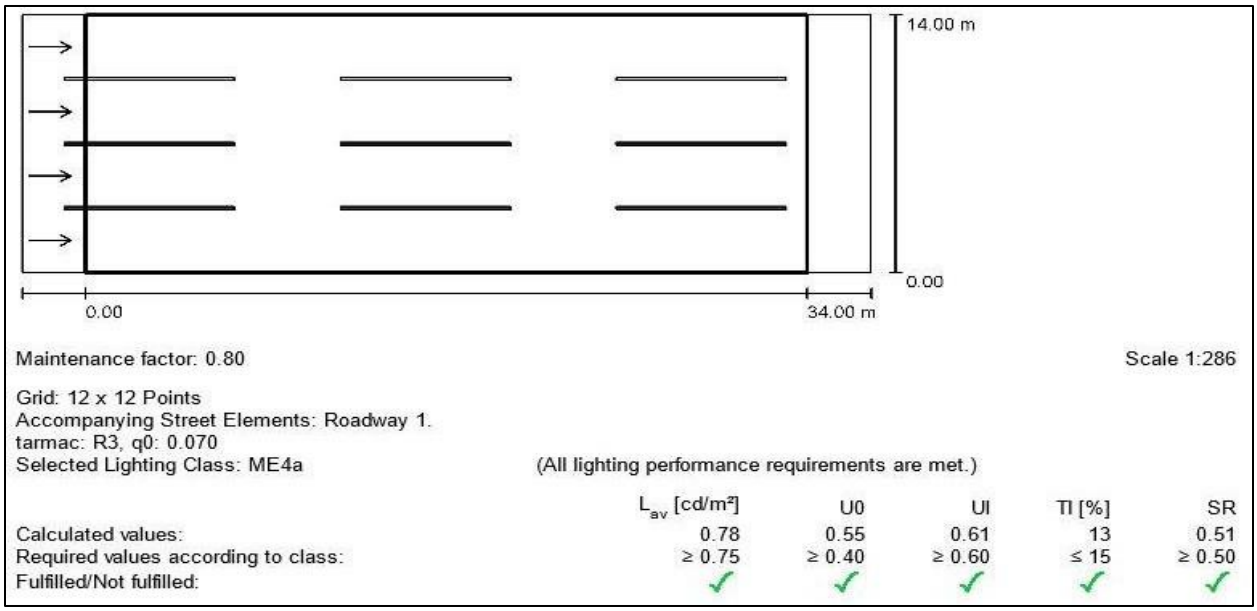


Figure 12: Design compliance report

Table 10: Designed Results in Compliance with Standard Requirements

Parameters	Standard Requirements	Designed Results
Road Width	14m	14m
Class of Road	ME4a	ME4a
Average Luminance (Lav)	0.75 cd/m²	0.78 cd/m²
Overall Uniformity (Uo)	≥ 0.4	0.55
Longitudinal Uniformity (Ul)	≥ 0.6	0.61
Threshold Increment (TI)	≤ 15	13
Surround Ratio (SR)	≥ 0.50	0.51
Maintenance Factor	0.8	0.8

6.4 Proposed Materials Specifications

Minimum material specifications are enclosed in the table below. These are suitable for Road Class 2 and above with a separation distance, pole height and LED lamp wattage specifications determined from the design calculations.

Table 11: Minimum Street Lighting Material Specifications

No.	Street Light Materials	Specifications:
1	LED lamp.	IP66; CRI > 70; 4000K – 6500K; 130lm/W or better; 80 – 120W, surge protection embedded and with standard dimming controls. Lifetime 50,000 (10 years)
2	Batteries	Lithium Iron Phosphate Batteries of 100Ahs or better. Lifespan 6,000 cycles or better. (10years or better).
3	PV Panels	Monocrystalline (N-type) high performance solar PV panels with 22% efficiency of better.
4	Charge Controller	MPPT type, 20/30A per LED lamp
5	Galvanized steel pole	Galvanized steel pole without any midwelds 9-12 Meters with 1700mm planting depth and base; thickness of 4mm.

It is important to note that these material specifications may be altered depending on the actual street light design calculations based on the actual civil road designs. Factory Acceptance Tests (FATs) and installation of sample lights prior to bulk purchase are very important to confirm quality and compliance to contractual specifications as well as workmanship.

6.5 Installation Guidelines

In addition to the design considerations stated in Section 6.1 above, here are some standard guidelines for the installation of streetlights.

6.5.1 Site selection and layout

The Installer should ensure that the chosen spot is free from shading obstruction and can receive sunlight throughout the day for effective performance of the solar panels. It should not be near heat sources and away from overhead entanglements like utility cables.

6.5.2 Safety precautions

The installer should formulate safety measures to minimise hazards during installation generally, and from the use of power and hand tools. Emergency plans for first aid and evacuation should also be in place.

6.5.3 Tools and equipment needed

It is critical to have the apt tools and equipment in place to facilitate the installation process. Tools are needed for hand works, electrical tests and calibrations, dimensional measurements, and spot markings, hoisting and safety enforcements

6.5.4 Foundation and base

Generally, the pole foundation should be at least 1.5 meters deep, and reinforced with concrete. The foundation should be on a solid level round, and the appropriate anchor bolts and nuts should be used to secure the pole onto it.

6.5.5 Solar panel

The solar panel is fixed on its bracket/stand. It should point to the equator for maximum sun exposure, however the northern hemisphere should face south, while the southern hemisphere should face north. The tilt angle will have to be adjusted according to one's latitude to aid self-cleansing of the panel during rainfall.

6.5.6 Battery and controller

The battery should be fitted in a weatherproof box, near the charge controller. The enclosure should have good aeration and wiring therein should be carefully done to ensure no live contact between the terminal and the box body.

6.5.7 The LED Lamp

The lamp should be positioned onto the fixture at the appropriate arm length and angle to focus of the target area of illumination. Wiring should be done according to the instructions in the wiring diagram and manual.

6.5.8 Cable conduits and ducting

Conduits are used to provide mechanical protection of the cables and ease of retrieval for future replacement. Conduits should be made from non-metallic materials like PVC and HDPE and should conform to National Electrical Manufacturers Association (NEMA) standards. Ducts should be continuous in that they run the full cable length to avoid exposure and risk of vandalism.

6.5.9 System grounding and bonding

Grounding requires that the installer to make an intentional and permanent electrical connection between the electrical system of the streetlight and the earth. Bonding refers to the joining of all non-current carrying metallic

components of the streetlighting system to each other to form a permanent electrically conductive path. Therefore, grounding, and bonding conductors must have a sufficient electrical rating to be able to handle power surges. The grounding system should be of low resistance and low impedance. IEC 62305-3 standard require soil resistivity values to be less than 10 ohms.

6.5.10 Lightning Protection

Given the fact that streetlighting installations are usually at a height above the ground, they become the shortest path of lightning discharge from the clouds to the ground. Installers should fact in the following guidelines to mitigate risk of electronic damage due to lightning strikes.

i) All electronics in the streetlighting system should have surge protection capability to prevent power circuits from damage.
ii) The pole should be fitted with a single needle lightning rod to redirect lightning electricity to the ground.
iii) There should be well sized conductor cables, imbedded in the pole, to carry current from the lightning arrestor to the copper-clad ground rod, buried at least 600 mm in the earth.
iv) The lightning protection system should be inspected regularly for compliancy.

6.5.11 Performance Guarantee Tests

Upon completion of works, the installer should carry out performance tests majorly on automation of the switching function of the lights, amount of lumen output by the luminaire, duration of performance and the effectiveness of the grounding system, using relevant measurement tools to confirm that the entire system operates properly.

7 COST OF TECHNOLOGY AND BENEFITS ANALYSIS

In this section, we discuss; assumptions and factors that must be held constant for the implementation of energy efficient systems, lifecycle costs of technology, maintenance, and disposal of equipment for the different options of public street lighting systems and their benefits analysis. This is to guide policy makers, funders and implementing partners in achieving the desired energy efficient public lighting systems.

7.1 Assumptions

The buildup of costs shown in the tables below includes the following assumptions:

i) Only high-quality materials specifications have been considered to achieve superior performance.
ii) The cost of equipment used here are from reputable distributors and importers. We assume that Contractors will mark up these costs between 20 % to 50% as selling prices to cater for profits and inflation.
iii) The quarterly professional fee for periodic maintenance of each streetlight is UGX 100,000, that is, UGX 50,000 for labor, UGX 30,000 contribution to crane hire, and UGX 20,000 for sundries, with no spare part replacement. *Note: The costs of hiring a lorry crane are offset if twenty or more streetlights are to be maintained at a go.*
iv) Costs of transportation of the equipment to their various destinations are not included in our analysis.
v) Certified service providers are mandated to manage the streetlights' material waste for disposal after accumulation.
vi) Grid powered lights are turned off and on automatically. If the switching systems get faulty then energy bills get out-of-hand.
vii) The energy bills are paid on demand and no interest payments are considered.
viii) Costs associated to vandalism and theft are equally not considered.

7.2 Life Cycle Cost Analysis

The data presents that in ten years, the lifecycle cost for grid-powered lights is less expensive compared to the costs associated with solar or hybrid street lighting systems and need to be prioritised in urban settings.

Table 12: Cost of Ownership

COST OF OWNERSHIP		Grid			Solar			Hybrid - 500 metres coverage		
Item Description	**UoM**	**Qty**	**Unit, UGX**	**Total, UGX**	**Qty**	**Unit, UGX**	**Total, UGX**	**Qty**	**Unit, UGX**	**Total, UGX**
Lamp 90W LED 50,000 hours - DC	pc			-	1	600,000	600,000			-
Lamp 90W LED 50,000 hours - AC	pc	1	600,000	600,000			-	18	600,000	10,800,000
Solar panel 285W	pc			-	2	250,000	500,000			-
MPPT Charge controller 20A 12/24 DC Auto	pc			-	1	590,000	590,000			-
LiFePO4 battery 100Ah 24V	pc			-	1	3,330,000	3,330,000			-
Solar panel 575W	pc			-			-	12	435,000	5,220,000
Solar panel structure	Ls							12	402,500	4,830,000
LiFePO4 battery 100Ah 48V	pc			-			-	5	4,275,000	21,375,000
Battery management unit (BMU)	pc			-			-	1	896,800	896,800
Inverter - Charger 6kVA	pc			-			-	1	4,375,000	4,375,000
Battery rack	Ls			-			-	1	1,250,000	1,250,000
Solar array structure	Ls			-			-	1	5,175,000	5,175,000
Lamp post w/ fixtures - 9 metres	pc	1	1,700,000	1,700,000	1	1,700,000	1,700,000	18	1,700,000	30,600,000
Mounting base for pole	Ls	1	300,000	300,000	1	300,000	300,000	1	300,000	300,000
Cable 2.5mm - on pole	m	12	8,000	96,000	6	8,000	48,000	216	8,000	1,728,000
Cable 6mm - distribution	m	30	25,000	750,000			-	540	25,000	13,500,000
Electrical distribution unit	Ls	1	1,500,000	1,500,000			-	1	3,500,000	3,500,000
Electrical insulation and protection	Ls	1	100,000	100,000			-	1	1,500,000	1,500,000
Control room - 3x3x3 metres	Ls			-			-	1	12,000,000	12,000,000
Land acquisition, fencing and development	Ls			-			-	1	80,000,000	80,000,000
Inspection and connection fees	Ls	1	500,000	500,000						
Installation costs of streetlight	Ls	1	700,000	700,000	1	250,000	250,000	18	700,000	12,600,000
Total Cost, UGX				**6,246,000**			**7,318,000**			**209,649,800**
Cost of ownership per street light, UGX				**6,246,000**			**7,318,000**			**11,647,211**

Table 13: Cost of Operation, Maintenance and Waste Disposal

OPERATION AND MAINTENANCE - 10 YEARS		Grid			Solar			Hybrid		
a) OPERATIONAL COSTS (ROUTINE)	**UoM**	**Qty**	**Unit, UGX**	**Total, UGX**	**Qty**	**Unit, UGX**	**Total, UGX**	**Qty**	**Unit, UGX**	**Total, UGX**
Quarterly preventive maintenance	no.	4	100,000	400,000	4	100,000	400,000	4	1,800,000	7,200,000
Energy cost per year/ kWh	kWh	440	370	162,800	-		-	-		-
Security costs - monthly	Ls	-			-			12	300,000	3,600,000
Total Annual Operational Cost				**562,800**			**400,000**			**10,800,000**
Av. Annual Operational cost per light	**A**			**562,800**			**400,000**			**600,000**
b) REPLACEMENT COSTS (10 years)	**UoM**	**Qty**	**Unit, UGX**	**Total, UGX**	**Qty**	**Unit, UGX**	**Total, UGX**	**Qty**	**Unit, UGX**	**Total, UGX**
LED lamp replacement	pc	2	660,000	1,320,000	1	660,000	660,000	18	660,000	11,880,000
Solar battery replacement	pc	-		-	1	3,663,000	3,663,000	5	4,702,500	23,512,500
Replacement - charge controller	pc	-		-	1	649,000	649,000	-		-
Labour Cost	Ls	2	200,000	400,000	1	300,000	300,000	1.00	5,308,875	5,308,875
Total Replacement Cost - Up to 10th Year				**1,720,000**			**5,272,000**			**40,701,375**
Av. Annual Replacement Cost Per Light	**B**			**172,000**			**527,200**			**226,119**
Av. Annual O&M Cost per light (A+B)				734,800			927,200			826,119

COST OF WASTE DISPOSAL - 20 years		Grid			Solar			Hybrid		
Item Description	**UoM**	**Qty**	**Unit, UGX**	**Total, UGX**	**Qty**	**Unit, UGX**	**Total, UGX**	**Qty**	**Unit, UGX**	**Total, UGX**
Disposal of LED lamp	Ls	4	5,000	20,000	2	5,000	10,000	36	5,000	180,000
Disposal of Lithium Solar Battery -100Ah	Ls	-		-	2	5,000	10,000	-		-
Disposal of Lithium Solar Battery - 200Ah	Ls	-		-	-		-	10	10,000	100,000
Disposal of Electrical Equipment	Ls	-		-			-	1	10,000	10,000
Disposal of Solar panel - 100W	Ls	-		-	2	5,000	10,000	-		-
Disposal of Solar panel - 575W	Ls	-		-	-		-	12	5,000	60,000
Total Disposal Cost, UGX				**20,000**			**30,000**			**350,000**
Disposal cost per street light, UGX				20,000			30,000			19,444

7.3 Benefit Analysis

In addition to the costs of different technologies discussed above, a summary of the benefits analysis is shown in the table below.

Table 14: Cost of Technology and Benefit Analysis

Requirements	**Grid-Lights**	**Solar Lights**	**Hybrid (Research)**
Energy Source	Grid	Solar (Panels)	Solar / Grid
Distribution cable/works	Yes	No	Yes
Street Pole and Lamp	Yes	Yes	Yes
Power Storage (Batteries)	No	Yes	Yes
Monthly Security Cost	No	No	Minimal
Land and Development	No	No	Yes (Costly)
Energy Bills	Yes	No	Minimal
Affected by Power Cut	Yes	No	No
Affected by Weather	No	Yes	No
Ownership Cost per unit	6,246,000	7,318,000	11,647,211
O&M Cost per unit after up to 10 years	734,800	927,200	826,119
Total Cost per Unit after 10 years	6,980,800	8,245,200	12,473,330
Recommended usage	Public and Private Estates	Public and Private Estates. Not suitable for Class 1 Roads	Public and Private Estates

From the above Table, the following are the remarks:

i) Grid-powered Street lighting systems are least expensive to operate compared to solar and hybrid street lighting systems in ten years.
ii) Solar and Hybrid Street lighting systems are not affected by power cuts.
iii) Lithium Iron Phosphate batteries last for 10 years or more.
iv) All street lighting systems need monthly preventive inspection and maintenance for continuous reliability and sustainability.
v) Whereas the road luminance from grid powered streetlights is brighter, the monthly energy bills generated are a deterrent because they are not planned and budgeted for. Government subsidising the cost of energy for public street lighting will be a big boost for affordability and roll-out.
vi) Hybrid street lighting systems guarantees better security (of equipment, batteries, and PV Panels) and more reliable power supply to the streetlights. However, several hybrid systems need to be set up to cover street lighting for an entire urban centre. The LGs should consider

donating land or heavily subsidizing the land cost for this system to turn viable for adoption. Further feasibility studies shall be required for actual designing, piloting, simulation, testing, and adoption.

vii) Solar-powered Street lighting is not recommended for Class 1 roads such as national highways due to design and budget complexities and need for sustained high road luminance levels in compliance to Standards.

8 FEASIBILITY TO IMPLEMENT

Upon determining the viability of the streetlighting design and its associated costs, project implementation is the next step. This involves procurement, supply and installation, integration to existing infrastructure (if available) and programming of the smart control systems (if necessary). Additional, post installation activities such as monitoring, and evaluation (M&E) and O&M are critical to the success of street lighting project. The following could act as guidelines in achieving the above assertion.

8.1 Regulatory Considerations

The URDM manual guidelines should be updated and fully enforced to compel all road construction consultants and contractors to adhere to the road lighting specifications for various classes. Secondly, there is need to develop national policies promoting energy efficiency, renewable energy, and urban development. Procurement entities need to include energy efficient specifications in tender documents and award based on strict compliance to the same.

To maintain strict adherence to acceptable standards of supplies and works, regulatory agencies such as ERA, and professional watchdogs like UIPE must be involved in approving designs and personnel in these installation works.

8.2 Procurement of Equipment and Service Providers

The solar and LED market continues to attract many reputable local and foreign players that can supply and install streetlighting systems as per design and quality standards. The local distributors have proven to have stock holding capacity for all the key components to be able to service large projects.

The procurement process should be able to set the right specifications as per design. The supplier should have proven project experience, have a strong financial capacity, their offer should meet performance standards at the lowest initial cost and cost of ownership.

8.3 Implementation Plan

Streetlighting projects that involve latest technology and have high costs of installation can be implemented through pilot projects in selected beneficiary urban areas. This will test the effectiveness of the new lighting systems before full scale roll out to other areas. Once the pilot is successful, the rest of the project can be implemented in phases, based on results and lessons learnt from the pilot project, and to minimise budgetary pressure on government and its partners.

8.4 Monitoring and Evaluation

This is an important aspect that the project funder and other stakeholders can use to ensure compliancy and measure the effectiveness of the installed streetlighting infrastructure in relation to the objectives of the project. Effective M&E will ensure there is evidence in improvement of lighting levels, energy savings in terms of usage and cost, and reduction in carbon emissions. Finally, this allows benchmarking and documentation of key lessons learnt for the success of future streetlighting projects.

9 PROPOSED OPERATION AND MAINTENANCE FRAMEWORK

9.1 Definitions

Operations and Maintenance (O&M) involves a broad set of activities aimed at ensuring that physical assets and infrastructure within an entity operate efficiently, continuously, and safely [46]. Here are some key aspects:

i) **Routine Tasks**: This includes regular inspections, cleaning, minor repairs, lubrication to prevent significant issues before they arise.

ii) **Preventive Maintenance**: O&M focuses on proactive or preventive measures to reduce unexpected equipment failures and downtime [46]. This is usually minor maintenance and care of assets that do not require in-depth technical knowledge of how that asset functions. Work that requires a highly skilled engineer or technician with specific knowledge of the equipment's inner workings and design would fall under corrective or reactive maintenance [47]. In this case the repairs are costly with increased downtime.

iii) **Management and Training**: Effective O&M programs involve training, management, budgeting, and business practices that work together to ensure smooth operations.

9.2 Operation and Maintenance Goals

The presentation below summaries the O & M goals for consideration [47]:

Figure 13: Operation and Maintenance Goals

i) Protect Investments

Government has made a significant investment by implementing public street lighting at number of urban roads in USMID1 and USMID-AF programs and performing routine maintenance on them is a key element of keeping them in operating order.

Preventive maintenance also extends the life span of equipment and assets, ensuring they last longer and give you the best Return-on-Investment. Keeping a very close eye on the state of your equipment will also help prepare you to budget for asset replacement when it does reach the end of its life span, protecting you from huge unplanned expenses and improving forecasting capabilities. O&M activities are considered low- or no-cost as they are performed in addition to technicians' other tasks, so it is also a cost-effective method for ensuring reliability, asset uptime and safety.

ii) Optimize Labour Efficiency

District or Municipal Engineers should create annual detailed routine maintenance plans with proper schedules in the calendar in a tangible way, reducing the chances they will forgotten. Planning these preventive tasks along a reasonable timeline well in advance also prevents technicians from becoming overwhelmed with unexpected repairs at the last minute.

iii) Enhance Asset Performance

Keeping a streetlight from breaking down is one thing, but routine maintenance also keeps it operating better when it's operational. Preventive maintenance tasks help keep assets running at peak performance and in peak condition, making them more efficient and profitable.

iv) Promote Awareness and Accountability

A huge benefit of increased visibility into maintenance workflows will be increased awareness and accountability throughout the Works / Engineering Department. By enforcing standards of frequent maintenance and inspections, Engineers promote greater familiarity with and awareness of assets. By assigning tasks to specific technicians (rather than supplying a general pool of work that needs to be completed), Engineers create an atmosphere of accountability. If certain technicians consistently fall behind on scheduled tasks, Engineers can assess performance factors and adjust ensure standards are realistic.

v) Reduce Downtime and Failures

Routine preventive maintenance is key to preventing unexpected street light downtime or catastrophic failure which are costly.

vi) Increase Planned-to-Unplanned Maintenance Ratio

Planned maintenance percentage is a maintenance metric that a District Engineer can use to quantitatively measure technician team performance. It refers to the percentage of planned vs. unplanned maintenance performed. Tracking this metric helps management understand how much maintenance performed on an individual asset is preventive vs. reactive, which can help identify upkeep costs and determine when an asset has reached the end of its life span. This aids early planning and budgeting for sustainability of service.

To calculate this metric, the formula: Planned Percentage = (scheduled maintenance time / total maintenance hours) x 100 is used. In an ideal system, 90% of maintenance is planned in time, and 10% occurs in response to an unexpected breakdown.

vii) Improve Safety

A successful O&M plans promotes better site safety. All streetlights contain power supply within their systems. Broken lines may cause electric shocks directly when touched or indirectly through touching the steel pole that is energized. Routine O & M takes care of such leaks and offers protection to technicians, the public and animals.

It is therefore prudent that all O&M activities are carried out by technicians donning full personal protective equipment wear shown in the figure above.

9.3 Building Institutional Capacity

It is the intention of the Technical Study that Local Governments develop inhouse technical and financial capacity to handle most O & M tasks related to the management of streetlights than relying of external suppliers, vendors and

contractors who are expensive in the long run. Several steps could be taken at building institutional capacity to internally execute O&M activities.

i) Employment of skilled Electrical Engineers / Technicians
ii) Technology transfer and training through collaborations with Road Consultants during project feasibility, tender process, implementation till commissioning stages. In these stages, several processes and documentation will be accessed such as construction drawings, sample approvals, testing and measurements, valuations, As-Built drawings, O&M manuals and guiding procedures, warranty statements and completion reports.
iii) Effective O & M planning and budgeting for annual and quarterly maintenance activities. All requirements, including funding, for O&M tasks should be acquired in time to facilitate seamless execution.
iv) Reporting. All work requests, work approvals and work completion reports including spare parts interventions should be generated and maintained safely within the Works / Engineering Departments for future reference.

9.4 Basic Maintenance for Street Lighting System

The Study highlights basic maintenance procedures that should be undertaken by the Local Governments in Table 15 below. Key parts of the street lighting system for O & M include:

i) Solar PV Panel
ii) Solar Batteries
iii) LED Lamp
iv) Charge Controller
v) Street Pole
vi) Electrical Distribution Board, Wiring and Earthing Requirements
vii) General sanitation around the Street Light.

9.5 Risks Associated with Disposal of Streetlights

Solar streetlighting comprise of PV panels, batteries, charge regulators, LED lamps and other electronic components, each requiring specific disposal and recycling methods to prevent hazardous waste. According to the International

Solar Renewable Energy Agency, solar waste will make up 78 million metric tons of waste by 2050 [49].

Therefore, there is a need for sustainable disposal and recycling of solar streetlighting components for environmental conservation and stewardship.

Below are some risks associated with disposal of solar streetlights.

i) Solar panels are primarily made of silicon, glass, and aluminium. Whereas these materials are recyclable, the process of recycling panels is complex and requires specialised facilities.
ii) Batteries contain heavy metals and toxic chemicals such as lead-acid and lithium-ion. These can leach into the soil and water causing harm to mankind and wildlife.
iii) LED bulbs contain small amounts of gallium and indium, which can be recovered and reused.

In conclusion, sustainable disposal, and recycling practices for solar streetlighting components is enhanced by collaboration with manufacturers to produce easily recyclable equipment with clear guidelines, and good policies that raise public awareness and encourage collection of waste to appropriate facilities

Table 15: Operation and Maintenance Activities for Street Lights

Item	Operation and Maintenance Activities	Resource(s)	Frequency
Solar Panel	Inspect and wipe the panel with water and bar soap to remove dust, leaves and bird droppings using Polyvinyl cloth, bucket, and water Check for sagging cables and fasten them; then cracks on modules that could be visible and report for replacement.	Crane with bucket. Casual labour	Quarterly
Solar Battery	Check for corrosion around the terminals Check status of the terminal adaptors against loose connection Check for voltage readings to conform with standards Inspect body to ensure no leakage of fluids Check temperature for conformity. Replace the battery if the measurements are below acceptable standards.	Crane with bucket. Skilled Electrician	Quarterly
LED lamp	Inspect wires against loose connections. Check and test motion sensors – if present. Adjust to the correct sensitivity level if required. Replace the LED lamp if worn out. Inspect body against cracks and leakages Night measurements for compliance luminance levels	Crane with bucket; Skilled technician	Quarterly
Charge controller	Inspect against loose wiring connection Check electric input and output parameters for conformity Inspect body for any damages due to vandalism or decay	Crane with bucket; Skilled Electrician	Quarterly
Pole /Array support structure	Spot check rusting on the mounting frame in case it needs surface repainting. Inspect and tighten any loose screw, nuts and bolts. Ensure the pole and lamp frame are stable and firm. Ensure earthing continuity cable is attached to the pole structure.	Crane with bucket; Skilled technician	Biannually
Inverter (Hybrid System)	Inspect any pending failures due to burning contacts, loose connections and openings/ holes in the inverter box and report these to the electrician for correction.	Skilled Electrician	Biannually

	Check for alarm lights (red LEDs) for 'FAULT' Check if there are any error notifications in the inverter's display. Clean the inverter by wiping off dust and cobwebs that have accumulated. Check for holes and close them up to avoid rodents and reptiles from entering the inverter box. Check earthing values and ensure it is compliant as per regulations. Check and log the power output on the solar inverters display to monitor the state of health of the entire system. Service the inverter as well as the main junction box and circuit breakers using an electric air blower.		
Electrical wiring	Carry out spot checks on the wiring system and ground connections to ensure compliance. Fix and tide up all loose sagging wires. Check that cables and connections are intact with no loose connections or exposed conductors.	Crane with bucket; Skilled Electrician	Quarterly
Power Distribution board	Check for loose connections Check for damages due to rodents and cuts Measure input and output electrical parameters against specifications	Skilled Electrician	Biannually
General sanitation	Ensure that the streetlight is clean. Clean the surrounding every time you step on site. Maintain low vegetation by clearing tall grass, trimming of trees to avoid shading of solar arrays and breeding of rodents and reptiles.	Crane with bucket; Casual labour	Quarterly

10 CONCLUSIONS

The implementing municipalities and cities have greatly benefited from this capital investment in the short and medium term, with positive impacts like improvement of the night economy, security, and urbanization. However, they clearly lack technical and financial capacity to carry out effective O&M activities, that are critical for the sustainability of the streetlighting systems.

Furthermore, it was noted that all beneficiary municipalities and cities are yet to develop specific disposal plans for vandalized and obsolete streetlighting equipment. This is also made worse by the absence of specialized e-waste disposal service providers and facilities in the country.

This study also confirms that, whereas the lights installed under USMID program meet the specifications stated in the contracts, their shortcoming is in comparison to the established national and international standards. The MoWT roads design manual of 2023 is not explicit enough on design standards in relation to road classifications in the national context. In studying the USMID streetlighting design, it was assumed that all roads to be constructed were of the same classification and design. This has implications on performance of streetlights.

There are loopholes in enforcing material quality. UNBS is incapacitated, not well equipped and involved in assessing source of materials for compliance. During the study, we did not find evidence that there was verification of imported equipment in relation to the designs and standards. This explains why some lights performed better than others even when they are of the same specifications.

The procurement processes being used to select Contractors and Consultants seem not able to evaluate the actual performance of the proposed streetlighting systems. Moreso, there is no evidence that the consultants are using appropriate tools to analyze performance of the installed lights before approval of payment certificates. These risks creating a combination of substandard designs, works and installations.

There is a clear lack of consistency in designs, materials and installation standards by the different contractors and consultants. This makes it difficult to achieve the desired performance of streetlights across the entire project

spectrum. An appropriate design would be able to consider the road classification, surrounding conditions and amount of expected traffic. This explains the inconsistency in designs of anti-vandalism spikes and presence of concrete barriers.

From the cost benefit analysis done, both solar and grid-powered lighting systems have equally strong merits based on the various circumstances like weather patterns, traffic intensity, security situation, and availability of funds among others.

It is also confirmed that both solar and grid-powered lighting models can be converted to smart lighting technology, though it will require upgrade of existing infrastructure with communication gateways, interconnecting signal cables, upgrade of the LED lamps and dedicated control centers for monitoring by competent O&M personnel.

The component of energy efficiency in the current streetlighting installations is very marginal because the designs are almost obsolete due to the everchanging technology in the LED and solar systems, and most importantly the fixed price contracts that do not encourage significant design variations and improvements once contracts have been signed.

Notwithstanding the socio-economic benefits that streetlighting under USMID program has brought to the urban centers, this technical study identified some underlying gaps that need to be addressed by the relevant authorities. These include.

a) A national legal framework and policy for public lighting systems,
b) Harmonization of design, specifications, and installation by different stakeholders
c) Quality safeguards against substandard materials
d) Funding for operation and maintenance activities
e) Appropriate tools and equipment, and competent staff for O&M activities.
f) Warranty cover against non-conforming installations, while in defects liability period.
g) Establishment of e-waste disposal plans and facilities in the country.
h) Community ownership for project sustainability.

11 RECOMMENDATIONS

The Study presents the following recommendation for consideration.

No.	Recommendation	Responsibility
1	A feasibility study should be carried out to determine which streetlighting technology (either grid, solar or hybrid) is suitable for a particular municipality or city, based on local needs, financial and technical ability to sustain their long-term functionality.	• Ministry of Local Government (MoLG) • MoLHUD / USMID Secretariat • Consultants • City / Municipal Engineers • City / Municipal Clerks
2	The Urban Roads Design Manual should be updated to highlight acceptable lighting levels for different road classes and develop standard materials specification s to guide streetlighting designs.	• Ministry of Works and Transport (MoWT) • Input from key stakeholders like MoLHUD/USMID, KCCA, UNRA, UNBS, Electricity Regulatory Authority (ERA) and UIPE among others
3	There should be unconditional tax exemptions on solar products to boost investment in renewable technology and accessibility to modern streetlighting technologies that are sustainable to operate and maintain.	• Ministry of Energy and Mineral Development (MEMD) • ERA • Uganda Revenue Authority (URA) • Uganda Solar Energy Association (USEA)
4	UNBS should be apt to enforce quality standards of streetlighting equipment. There is need to capacity building through staff training, acquisition of modern testing facilities and pre-shipment certifications.	• Ministry of Trade, Industry and Cooperatives (MTIC) • MEMD

5	Need for advanced research and development into latest street lighting technologies such as hybrid and smart street lighting systems in a bid to achieve proven merits of energy efficiency, low maintenance, environmentally friendly, high reliability attributes among others	• MoWT • MoLHUD / USMID Secretariat
6	Public streetlighting contracts should have an enforceable maintenance and defects liability period of at least two years, to cater for technology transfer and replacement of defective components. This will ensure that contractors adhere to high standards of designs and project materials that meet contractual specifications	• MoLHUD / USMID Secretariat • City / Municipal Engineers
7	There is need for further research, design review and upgrade of the anti-vandalism mechanisms to enhance protection of streetlighting equipment. There is need for better spikes, introduction of alarm systems.	• MoLHUD / USMID Secretariat • MoWT
8	There should be development of appropriate mitigation plans to counter risks associated with e-waste that is accumulated over the lifespan of streetlighting systems	• MoLHUD / USMID Secretariat • City / Municipal Engineers • City / Municipal Clerks
9	Streetlighting contracts be awarded separately from civil road designs and works to improve technical scrutiny of designs and performance, attract qualified professional providers, and enable enforcement of warranty and guarantees.	• MoLHUD / USMID Secretariat
10	Streetlighting designs should be computer generated to take into consideration all design considerations along with updated national and international standards	• Consultants • Project Managers
11	Purchase and installation of streetlights should be only upon approval of designs and material samples.	• City / Municipal Clerks • MoLHUD / USMID Secretariat
12	Payment for works should be done upon confirmation of compliance to design and specifications, and issuance of performance guarantee reports	• City / Municipal Engineers • City / Municipal Clerks • Consultants • MoLHUD

13	Measures should be put in place to strengthen community ownership of streetlighting installations to improve security, surveillance, and vigilance against vandalism	• City / Municipal Clerks • Security organs • Local councils
14	Public streetlighting contracts should have an enforceable maintenance and defects liability period of at least two years, to cater for technology transfer and replacement of defective components. This will ensure contractors adhere to high standards of designs and project materials that meet contractual specifications	• MoLHUD / USMID Secretariat • City / Municipal Clerks
15	As part of the funding requirements, the cost for the operation and maintenance of street lighting should be paid by the population through revision of the power tariff structure since it is a public good	• MEMD • ERA
16	The staff schedule of local governments includes accredited and certified Electrical Engineers and Technicians for sustainability of public lighting infrastructure.	• Ministry of Public Service • MoLG • KCCA
17	These staff should also have access to continuous training and be equipped with appropriate tools for O&M.	• MoLHUD / USMID Secretariat • Local governments • UIPE
18	Local authorities should be facilitated to acquire specialized trucks with the ability to handle work at height for O&M activities	• MoLHUD / USMID Secretariat
19	Local governments should take strategic steps to increase revenue generation to fund O&M needs	• Ministry of Local Government • Municipal / City Clerks • Municipal / City Mayors
20	Strategic annual maintenance plans and budgets should be developed, validated, and implemented at the local level.	• Municipal / City Clerks • Municipal / City Engineers
21	The Road Fund allocations should be enhanced with a clear and specific vote towards funding of operation and maintenance activities of public street lighting systems.	• MoWT / The Road Fund • Municipal / City Clerks

22	All implementing cities under USMID1 should seek technical expertise and appropriate funding to revamp all vandalized and dilapidated streetlighting facilities	• MoLHUD / USMID Secretariat • Municipal / City Clerks

REFERENCES

Number	Reference
1	*USMID 1 Program Details* https://mlhud.go.ug/wp-content/uploads/2015/10/Summary-USMID-Program-brief-to-MPs-in-Jinja-meeting-slated-for-10-Feb-2017.pdf
2	*USMID-AF Program Details* https://mlhud.go.ug/projects/usmid-program/usmid-af/
3	*USMID Program Achievements* https://www.youtube.com/watch?v=sR0yNPCBb8g
4	https://www.parliament.go.ug/news/5504/lands-ministry-spot-over-street-lighting
5	*Improved Street Lighting as a measure to counter Road Accidents* Street lighting for preventing road traffic crashes and injuries | Cochrane
6	*Effects of improved street lighting on crime* *Welsh BP, Farrington DC. Effects of improved street lighting on crime. Campbell Systematic Reviews 2008:13* The impact and policy relevance of street lighting for crime prevention: A systematic review based on a half-century of evaluation research - Welsh - 2022 - Criminology & Public Policy - Wiley Online Library
7	*Lessons on solar-powered street lights from Kampala and Jinja, Uganda.* Gillard R, Oates L, Kasaija P, Sudmant A, Gouldson A. 2019. Sustainable urban infrastructure for all: Lessons on solar-powered street lights from Kampala and Jinja, Uganda. Coalition for Urban Transitions. London and Washington, DC. http://newclimateeconomy.net/content/cities-working-papers
8	*Street Lighting Enhancing Multiple Benefits* Brightening Communities: The Social Impact of Street Light Control - My Blog (insgoshable.com)
9	*Uganda GDP Growth Trend* GDP growth (annual %) - Uganda | Data (worldbank.org)
10	*Infrastructure Development stimulates Economic Benefits* The Impact of Infrastructure Development on Real Estate Investment in Uganda - ROPA SPACES
11	*Definitions of Lighting Concepts* LED Road Lighting Design Manual by Philips, 2014 Microsoft Word - PDM_Nov2014 (dfintl.com)
12	*Street Light Guidebook, Theory and Practice by Demonstration Projects Support Team, a project funded by the European Union* guidebook_sl_en.pdf (com-dep.eu)
13	*Stakeholder Engagement*

	Technical Study on Energy Efficient Public Lighting In USMID-AF Implementing Cities/Municipalities – Field Verification Report by Eng. Philip Malaba, Eng. Etienne Maale et al, 2024
14	*UNRA changes Solar Street Lights to Grid Street Lights* UNRA replaces solar lights with hydro-electric ones in Kabale | Monitor
15	Road Design Manual, Volume IV, Urban Roads issued on July 2023 by Ministry of Works and Transport
16	Research Report: Street Lighting for Pedestrian Safety by Travis Terry et al, December 2020 https://safety.fhwa.dot.gov/roadway_dept/night_visib/docs/StreetLightingPedestrianSafety.pdf
17	*Inadequate Funding in Local Governments* *Consultancy Services to Review the Legal, Policy and Administrative Framework for Local Government Revenue Management and Design a Local Government Own Source Revenue Mobilization Strategy, January 2020 by Oficon Consulting* LG-Own-Source-Revenue-Mobilisation-Strategy_Draft-v01.pdf (ldpg.or.ug)
18	*Inadequate Funding in Local Governments* *Ndirangu, M. I. & Maitho, T. E. (2020). Factors influencing sustainability of public street light development projects in Nairobi City County, Kenya. International Academic Journal of Information Sciences and Project Management, 3(6), 245-260* iajispm_v3_i6_245_260.pdf (iajournals.org)
19	Soroti Staffing Structure WORKS AND TECHNICAL SERVICES | Soroti District
20	*Definition of Poverty* Poverty_in_Uganda_-_National_and_regional_data_and_trends.pdf (ams3.cdn.digitaloceanspaces.com)
21	*Uganda Bureau of Statistics – Multidimensional Poverty Index Report, 2022* ubos.org/wp-content/uploads/publications/08_2022Multi_Poverty_Dimensional_Index_Report_2022.pdf
22	*Preliminary National Census Results 2024* NPHC 2024 – Preliminary Results (ubos.org)
23	*Youth Population* Uganda's population hits 46 million (nilepost.co.ug)
24	*Youth Unemployment in Uganda: A Worsening Plight by Philemon Okillong, ACODE* issue15_A3.pdf (acode-u.org)
25	*What is the impact of youth unemployment on criminal activities? Response by Rohit Kumar, Panjab University, June 13, 2024* Cite this answer (researchgate.net)

26	*Benefits of Community Participation in Public Infrastructure Spending* Benefits of Community Participation in Public Infrastructure Spending | ThoughtExchange
27	*BS EN 13201-2:2015 Road Lighting Part 2: Performance Requirements, Published by the BSI Standards Limited 2016* https://www.mklights.com/data/upload/ueditor/20220126/61f0dcf443744.pdf
28	*Uganda Road Fund – More than a Decade of Financing Road Maintenance* Uganda Road Fund – More Than A Decade Of Financing Road Maintenance - Uganda Update News
29	URF Road Maintenance Budgeting and Operational Guidelines for FY 2020/21 Your ref: (roadfund.ug)
30	*Stakeholder Theory – R. Edward Freeman, 1984* About | Stakeholder Theory
31	*Stakeholder Engagement* Stakeholder Engagement: What It Means & Why It Matters (simplystakeholders.com)
32	*USMID Beneficiary Satisfaction Survey, March 2021 by Strategic Friends International Limited.* THE-USMID-PROGRAM-BENEFICIARY-SATISFACTION-SURVEY-REPORT.pdf (mlhud.go.ug)
33	*Uganda's National Youth Policy and Job Creation for Youth by Rita Makumbi online publication in the IDS Bulletin, Vol. 49 No. 5 (2018)* Uganda's National Youth Policy and Job Creation for Youth | IDS Bulletin
34	*Empowering Youth Through Data and Community Development (EYDCD) program* Uganda's youth to benefit from expanded empowerment program, creating 250,000 jobs by 2028 - New Vision Official
35	*National Youth Action Plan Theme: "Unlocking Youth Potential for Sustainable Wealth Creation and Development." Ministry Of Gender, Labour and Social Development, September 29, 2016* National-Youth-Action-Plans-2016.pdf (mglsd.go.ug)
36	*Kabale Municipality Council restores vandalized street lights.* Street Light Vandalism Sparks Concerns Over Public Safety in Kabale Municipality | The Source Reports
37	*Definition of Energy Efficiency* Energy Efficiency | Understand Energy Learning Hub (stanford.edu)
38	*Use of LED lamps outdoor to cut carbon emissions* Are LED Lights Bad for the Environment? 6 Quick Facts (citizensustainable.com)
39	*Lithium and Lithium Iron Phosphate Batteries: Key Differences and Advantages.*

	LiFePO4 vs. Lithium-Ion: Key Differences and Advantages (renewablesadvice.com) LiFePo4 vs. Lithium-Ion Batteries - How to Decide Which One You Need | Eco Tree Lithium
40	*Lithium Iron Phosphate Charging Cycles* Lithium Iron Phosphate (LFP or LiFePO4) | BSLBATT® (lithium-battery-factory.com)
41	*Smart Street Lighting System* FAQs about Smart Streetlights | Performance Services
42	*(Energy efficiency of Smart Street Lighting System to 50%)* DC Smart Street Lights
43	*Impact of Street Lighting in improving Urban Services* How World Bank's USMID project has developed over the years | TALK OF THE NATION - NTV Uganda Sat Jun 29, 2024
44	*Registered Achievements of the USMID Program* USMID Program – Ministry of Lands, Housing & Urban Development (mlhud.go.ug)
45	*Uganda GDP Growth Trends* GDP growth (annual %) - Uganda | Data (worldbank.org)
46	*Definition of Operation and Maintenance (O & M)* What Is Operations and Maintenance (O&M)? | Limble (limblecmms.com)
47	*O & M is mainly Preventive Maintenance* What is Operations and Maintenance? 2024 Ultimate Guide (selecthub.com)
48	*Definition of Maintenance Factor* A Guide to Understanding Lighting Maintenance Factor - AGC Lighting (agcled.com)
49	*Concerns about Solar Waste* *https://www.streetlights-solar.com/solar-waste-problem-recycle.html*

APPENDICES

Appendix 1 Terms of Reference

THE REPUBLIC OF UGANDA

Ministry of Lands, Housing and Urban Development

UGANDA SUPPORT TO MUNICIPAL INFRASTRUCTURE DEVELOPMENT- ADDITIONAL FUNDING (USMID-AF) PROGRAM

TERMS OF REFERENCE

FOR

TECHNICAL STUDY ON ENERGY EFFICIENT PUBLIC LIGHTING IN USMID-AF IMPLEMENTING CITIES/MUNICIPALITIES

September 2022

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1. BACKGROUND

The Government of Uganda represented by the Ministry of Lands, Housing and Urban Development (MLHUD) has over the last 9 years been implementing the Uganda Support to Municipal Infrastructure Development (USMID) Program with Financing from the World Bank (IDA).

The Program Development Objective was to enhance the institutional performance of the initial USMID participating 14 Municipal Local Governments of Arua, Gulu, Lira, Soroti, Moroto, Mbale, Tororo, Jinja, Entebbe, Masaka, Mbarara, Kabale, Hoima and Fort Portal to improve urban service delivery. That Phase closed on 31st December 2018.

Both Government and the World Bank had identified urban infrastructure as a priority problem because the investments in urban infrastructure and services had not kept pace with the rapidly increasing demographic and economic importance of urban centers, resulting in, inter alia, the seriously deteriorating condition of municipal infrastructure, inadequate basic urban services, and deteriorating urban environments.

The capacity gaps identified across the then participating Municipal Governments fell into three broad categories, namely, gaps in number of key positions filled, operation skills to backup the academic qualifications and inadequate tools and equipment.

The urban infrastructure services targeted for development and improvement under the USMID Program were:

1. Urban Roads and Streets;
2. Storm Water Drainage;
3. Street Lighting;
4. Sewerage;
5. Water and Solid Waste Management; and
6. Economic Investments (establishment of industrial parks, markets, bus parks, lorry stands), urban landscaping and planting of trees on the verge of roads.

Each participating City/Municipal Local Government prepares a prioritised list of their sub-projects from the above menu for financing under the Program, based on specific local needs and reflected in its Development Plan. Each entity is responsible for implementing civil works including procurement of service providers, however overall technical oversight lies with the Program Support Team (PST) in the Ministry of Lands, Housing and Urban Development.

However overall technical oversight lies with the Program Support Team (PST) in the Ministry of Lands, Housing and Urban Development.

Following successful implementation of the initial Phase of the Program, the Government of Uganda received Additional Financing Loan from the World Bank to roll-over a new USMID-Additional Financing (USMID-AF) Program with a similar development objective for another

five years from FY2018/19 to FY2022/23. This is intended specifically to consolidate and expand the previous achievements and lessons learnt.

USMID-AF Program scope was expanded to include additional 8 Municipal Local Governments of Apac, Kitgum, Busia, Kamuli, Kitgum, Kasese and Mubende and 8 District Local Governments of Adjumani, Moyo, Obongi, Yumbe, Arua, Madi-Okollo, Lamwo, Terego, Isingiro, Kiryandongo and Kamwenge and their selected urban centers, hosting large numbers of refugees.

The Cities/Municipalities are grouped in 7 Clusters (listed below) with each Cluster having its own Contractor and Consultants.

Table 1 USMID-AF Municipal Council Implementation Clusters

Cluster	Municipal Councils
Cluster 1	Arua Gulu, Kitgum
Cluster 2	Apac, Lira and Moroto
Cluster 3	Soroti, Mbale and Tororo, Busia
Cluster 4	Jinja, Kamuli and Lugazi
Cluster 5	Entebbe, Masaka and Mubende
Cluster 6	Mbarara, Kabale and Ntungamo
Cluster 7	Fort Portal , Hoima and Kasese

2 Challenges in Street, Road and Public Lighting

Solar Street Lighting is the most cost effective measure the world over. In Uganda, it is suitable for street/road lighting in cities, the municipalities and for other urban areas.

All USMID Program Engineering Design Reports and Bid Documents on Solar Street Lighting provide for conformity with General Technical Specifications are based on FIDIC requirements and in particular are drawn from "General Specifications for Roads and Bridges Works, January 2002" published by the then Ministry of Works, Housing and Communications in January 2005. (Section 5800 of the General Specification applies to Road Lighting).

USMID Program has invested in rehabilitation of over 100 km of urban roads and streets of over 4,000 Solar Street Lights installed. At least 2500 Solar Street Light columns at total an estimated total investment cost of $15m solar street lighting which must be sustained and protected.

However studies have shown that installed Solar Light elements are of various makes and specifications mainly because Design Engineers, listening to various stakeholders, have often ignored official Specifications issued to them leading to differing installations, installation materials, and equipment and lighting levels. Some participating Cities / Municipalities have independently commissioned own Solar Street Lighting projects with other funds without either reference to the MLHUD to ensure consistency with the official

MoWT Specifications. Some of the installations are not only poorly installed but pose electrocution risks to the public.

This has contributed to public concern about the types of lighting units installed, their effectiveness durability and functionality. There is therefore national challenge to avert large discrepancies in Solar Street Light installations and to ensure that the specifications are adhered to.

Additionally, most Solar Street Lighting at night is inadequate. The few systems in place are in need of repair and are poorly functioning. Each urban area has various designs and installations.

The Program plans to support the participating entities to minimize the ad-hoc approach to public street lighting in pursuit of modernising and efficiently supervising the urbanization process so that as many urban streets, roads and public places are well lit from dusk to dawn for safety and security purposes.

The Ministry of Lands, Housing and Urban Development therefore intends to use part of the proceeds of the USMID-AF Loan from the World Bank for the consultancy study assignment described in these Terms of References.

2. OBJECTIVES OF THE TECHNICAL STUDY ASSIGNMENT

The Overall Objective is to assess potential in street lighting in the USMID implementing cities and municipalities and to identify potential energy efficiency investments which may cover the rehabilitation and optimization of the urban roads and street lighting system, including lighting equipment replacement, and associated infrastructure to enhance energy efficiency primarily in the implementing Cities and Municipalities.

The outcome of the Study should provide the technical and engineering specifications recommendations required to implement the Program, the rnain technical challenges and their potential solutions and the overall savings potential for the Program.

The assignment is to be undertaken in the USMID-AF participating Cities of Arua, Gulu, Lira, Soroti, , Mbale, Jinja, Masaka, Mbarara, Hoima and Fort Portal as well as in the USMID-AF participating Municipalities of Arua, Kitgum, Moroto, Busia, Kamuli, Entebbe, Mubende, Ntungamo, Kabale and Kasese

More specifically the Objectives are to:

1. Review whether the USMID installed Solar Street Light designs and specifications meet approved specifications and whether the specifications could be reviewed given recent technology advances;

2. Carry out site visits to all USMID-AF implementing cities and municipalities for benchmarking purposes;
3. Verify the quantities of installed lamps, designs and installations, document experiences of the experts and consultants in the various Clusters, and come up with draft standards and guidelines;
4. Ascertain that installed Solar Street Lighting specifications are consistent with the contract documents and the standards applicable;
5. Check that Solar Street Lighting Units are installed correctly according to design (Numbers, location, lamp types, vertical and horizontal distances);
6. Make observations and take sample measurements of key values such as Lux;
7. Check whether the Solar Street Light equipment have sufficient protection against vandalism, lightning, internal voltage and short circuits;
8. Conduct energy efficiency assessments conducted by the team and undertake other studies of different lighting technology suitable for urban areas and most recent tests of the suitability of LED lighting for a developing nation like Uganda;
9. Review best practices and lessons learned from other cities that have implemented energy efficient street lighting programs, including LED lighting;
10. Describe the potential procurement methods that could be used by the Cities and Municipalities in general and the likely technical requirements to support tender processes;
11. Meet and hold discussions with contractors, consultants, clients, solar light equipment manufacturers and suppliers and road users;
12. Advise on detailed planning for the installation of the streetlights; and
13. Write and submit final report highlighting recommendations to USMID-AF including guidelines and draft long-term service agreements and/or warranties with suppliers and vendors prior to permitting installation of the infrastructure.
14. Advise on long-term service agreements and guarantees with suppliers, vendors and contractors and maintenance requirements (including operation and maintenance work plans and budgets).

3. SCOPE OF WORK AND TIME INPUT

The detailed Study assignment includes data collection, measurements of the systems, analysis of the historical and measured data, and detailed energy savings as well as financial and economic calculations for already installed and suggested street lighting projects.

The detailed energy surveys not only involve the analyses of the performance of individual equipment, but the evaluation of the complete system.

The assignment includes the following key steps:

1. Calculation and establishment of the energy consumption baseline;
2. Assessment of potential energy efficiency options and the identification and costing of recommended measures for reducing energy costs and improve energy efficiency in street lighting; and

3. monitoring and verification framework also covering the following elements:- (i) lighting fixtures; (ii) poles; (iii) arms; (iv) electrical wiring; and (v) management and control systems for street lighting

The assignment will be carried out under the broad areas listed below

Technical Studies

Establish the Baseline

Building on information already collected through recent studies, conduct an energy audit of public lighting in the urban areas. Verify the performance of installed Street Lights against presented specifications and energy saving estimates and international standards.

Advise on the suitability of the warranty offered to the implementing Cities/Municipalities by contractors

The Results should constitute a preliminary energy audit with technical data usable for potential procurement by the Cities/Municipalities. This needs to include types of lighting points, number of the lighting points, electricity consumption by type of bulb and balance of plant, average hours of use per type of bulb, location of bulbs (residential area, tourist area, commercial area, other urban settlements, etc.)

Report on the cost and benefits of using various efficient public lighting technologies including LED, dimmers, timers, photo sensors, public lighting management systems as specific to a particular city or municipality.

Technology Specifications and Risk for LEDs

Report on the need to standardize the technical specifications of LEDs and how this could affect the timing to implement a LED Street Lighting installation;

Report on the most updated information regarding LED technology risk in the country and make a recommendations for the key issues that need to be resolved before a LED program for public Street Lighting can be implemented.

These include metering

.Propose Recommended Technical Design

Based on results of the analysis described above, recommend the optimal solution for energy efficient Street Lighting. This should take into account technology risk, institutional setup, the impact of the local climate, the cost and availability of the technology and any other relevant factors;

Discuss outcomes of site inspections, necessary upgrades to existing infrastructure (e.g. the metering system) and changes to the balance of plant, if the optimal solutions were to be implemented.

Conduct Environmental and Social Impact Assessment Studies

Identify, assess and mitigate the potential environmental and social impacts that might result from the proposed infrastructure investments in Program Cities/Municipalities under USMID-AF Program.

Specific Objectives of the ESIA are to:

1. Identify and assess potential adverse environmental and social effects of the planned infrastructure sub-projects;
2. Make recommendations that can be used for mitigating adverse effects resulting from project implementation;
3. Identify stakeholders and undertake stakeholder mapping including their information needs throughout the project cycle;
4. prepare Environmental and Social Management Plans (ESMP) for each sub-project that can assist in implementing mitigation measures recommended; and
5. Ensure that Program Solar Street Lighting activities conform to the Environment and Social Management Framework in the Program Operational Manual (POM) and the national social and environment standards, policies, legal, regulatory and institutional frameworks.

Cost of Technology and Benefits

Provide an estimated range of the **"all-in"** cost of LEDs in Uganda and in the region including the cost of equipment and cost of installation, maintenance and management of the system;

Quantify the benefits from LED lighting in terms of more precise energy, financial and savings.

Assist USMID-AF in customizing Bid Documents for the acquisition of Solar Street Lights using the PPDA approved template and the technical specifications as revised and approved.

Prepare an Evaluation Matrix

Provide a testing framework and recommend test specifications for the sample lights usually required early for Client monitoring before bulk orders are approved.

Feasibility to Implement

Report on the market capability to implement City/Municipality-wide Street Lighting program using the recommended technology (LED), including availability of companies to install and maintain lamps across, availability of domestic and international companies to manufacture and supply lamps

Capital

The Consultant shall at all times work closely and make adequate consultations with key stakeholders, notably PST, City/ City/Municipal Town Clerks, City Municipal Engineers, Environment Officers, Physical Planner's and other Technical Staff, City/Municipal Development Fora (C/MDF), utility service providers, etc., Uganda National Roads Authority (UNRA), Ministry of Works and Transport (MoWT), Kampala Capital City Authority (KCCA) and others.

The Program Coordinator-AF in charge of the Program Support Team (PST) in MLHUD shall be responsible for technical oversight and approval of all work done by the Consultant during the Study assignments The final designs, layouts and key features of infrastructure sub-projects must be agreeable to and approved by the relevant City/Municipal Local Government Councils and appropriate organs of the Councils.

The Consultant shall ensure that all approvals by relevant sections of government as required by law shall be done timely.

4. TECHNICAL ASPECTS, REPORTING REQUIREMENTS AND KEY DELIVERABLES

The following sub-sections summarize the technical requirements of the services and key deliverables to be provided by the Consultant. Study Assignments.

Transfer of Knowledge

MLHUD wishes to promote skills development, lesson learning and knowledge sharing across the consulting and contracting community in Uganda. Transfer of Knowledge is important especially in supporting MLHUD to enhance better delivery of urban development services.

The Consultant shall provide for a strategy articulating how a limited number of technical staff from MLHUD and the participating Cities and Municipalities shall benefit from the knowledge, skills and experiences of the Consultant. The knowledge and skills transfer should cover all aspects of planning, design, installation and maintenance management of Solar Lighting infrastructure in genera and shall incorporate the following:

The Consultant shall make provision for training 3 No. Graduate Trainees (2 No. Graduate Engineers and 1 No. Environment Trainee) that shall be identified by the PST and one each from the implementing Cities/Municipalities for the duration of the assignment in their urban locations.

A report detailing skills transfer to the trainees and staff development shall be prepared as part of the deliverables of the assignment.

1.1 Local Participation

The Consultant is encouraged to associate with local companies and to use Local Experts wherever possible and appropriate and encouraged to demonstrate commitment to developing the infrastructure and urban development sectors in the longer term, either themselves or through their local partners, and this includes in-house capacity building attachments.

The key Professional Staff input is expected to be 9 person-months for the entire Study assignment

The Consultant shall complete the Team Composition and Task Assignment in sufficient detail to ensure that all technical requirements fall under the responsibility of a named expert. The Consultant shall also submit signed CVs for all the Key Staff in their proposed Team with a confirmation from each staff that they shall be available for the assignment. All CVs must meet the minimum requirements to be considered compliant. The Consultant shall propose relevant support staff for the assignment to ensure the necessary support is provided during the entire period of the assignment.

5. STAFFING

Key Professional Staff: The Key Professional Staff to be provided by the Consultant shall be sufficient to cover the assignment in accordance with the technical requirements defined in these Terms of Reference. The timing and inputs of each professional staff member shall be in accordance with the agreed programme for delivery of the services and appropriate duration.

The Consultant's Team comprising 3 key Professional Staff will provide an estimated total of 9 professional person-months over a period of 3 calendar months.

The Consultant shall also provide the support staff, technical and non-technical that are needed for the duration of the assignment.

All personnel shall be fully fluent (in reading, writing and speaking) the contract language, English and shall be competent in the use of modern word processing and spreadsheet software as well as any technical software appropriate to their specialist areas.

Table 3: Minimum Key Professional Staff and Person Month Requirement

S/N	Position		
	KEY STAFF	**No**	**Man-Months**
1	Team Leader/Technical Expert	1	3
2	Electrical Engineer (Solar Installations)	1	3
3	Electrical Engineer (Municipal Services)	1	3
	Sub-Total (Key Staff) – Main Assignment		9
	SUPPORT STAFF		
1	Solar Lights Technicians	2	6

Table 4: Required Expertise of the Consultant

Position	Number of years of professional experience	Specific Experience
1. Team Leader/Technical Expert	15 years	1. Must be a Registered Professional or Chartered Engineer with at least Bachelor's Degree in Engineering in Renewable Energy or in Solar Lighting with 15 years' post graduate experience specific experience in LED Street Lighting as follows: 2. Minimum 8 years' recent experience with LED lighting projects of similar scope and size including experience in working in similar climatic conditions; 3. Minimum 8 years' recent experience in street lighting equipment, application and standardization 4. Minimum 5 years' recent experience in developing standards/criteria for monitoring the performance of electrical equipment in particular LED street lighting; 5. Minimum 3 years' recent experience in the evaluation of LED street lighting or other related initiatives. Fluency in written and spoken English is mandatory and ability to communicate ideas freely and easily is essential.
2. Electrical Engineer (Solar Installations)		Must be a Registered Professional or Chartered Engineer with at least Bachelor's degree in Engineering in Renewable Energy or in Solar Lighting with 15 years' post graduate experience specific experience in LED Street Lighting as follows:

Position	Number of years of professional experience	Specific Experience
	15 years	1. Minimum 5 years' recent experience in evaluation of previously installed solar systems to test performance. 2. Design and implementation of solar systems. with LED lighting projects of similar scope and size including experience in working in similar climatic conditions; 3. Minimum 5 years' recent experience in developing standards/criteria for monitoring performance of electrical equipment in particular LED street lighting; 4. Minimum 5 years' recent experience in the evaluation of LED street lighting or other related initiatives. relevant professional institution. responsible for carrying out electrical engineering services including preparation of necessary documentation for buildings, street lighting and related structure. . Fluency in written and spoken English is mandatory.
3. Electrical Engineer (Municipal Services)	10 years	1. Minimum 5 years' recent experience in evaluation of previously installed solar systems to test performance. 2. Minimum 5 years' recent experience in evaluation of previously installed solar systems to test performance. 3. Minimum 5 years' experience of Street lighting design and documentation 4. Minimum 5 years' recent experience in developing standards/criteria for monitoring performance of electrical equipment in particular LED street lighting; 5. Must show evidence of at least four electrical engineering consultancy services assignments provided to public sector clients Fluency in written and spoken English is mandatory.

Support Staff: The Consultant shall include in their Financial Proposal provision for all necessary support staff indicated in Table 3 above.

6. LOGISTICS AND TIMING

1. Timing: The approximate timing for the Study assignment assumes a start date of November 2022

2. The services to be provided shall be phased as shown in Table 5 below.

Table 5: Timing of the Services

Consultant to Provide Detailed Work Plan showing the timing of deliverables within the Maximum Duration of the assignment indicated below

Service / Activity	Duration (weeks)
Inception Report	
Inception Report	3
Field Verification Report of research survey on various installed Solar Street Light performance issues to improve the solar PV system efficiency	6
Draft Report: outline of all work undertaken, recommendations, lessons learnt and conclusions.	8
Final Repot: outline of all work undertaken, recommendations, lessons learnt and conclusions.	10
Maximum Duration of the Assignment	**12**

7. DATA, SERVICES AND FACILITIES TO BE PROVIDED BY THE CLIENT

Documents to be provided by Program Support Team (PST), USMID:

1. Contract Completion Reports
2. USMID-AF Program Appraisal Document (PAD);
3. USMID-AF Program Operational Manual (POM);
4. USMID-AF Disbursement Schedules and IPF limits; and
5. Customs and Tax Exemptions as detailed in Conditions of the Consultancy Agreement, etc.

PST shall also facilitate liaison with, and the cooperation of, Government Ministries and other organisations as necessary for the Consultant to perform the services and to follow protocols to ensure effective and efficient implementation of the services and subsequent works.

Documents to be provided by the City/Town Clerk

The Town Clerk will provide to the Consultant the following documents:

1. USMID Batch 1(a),1(b) & II Contract Completion Reports
2. Engineering Supervision Monthly Reports,
3. Infrastructure Inventory, etc
4. Current Municipal Development Plan, Municipal Land Use Plan and other data related to the assignment to the extent available in the Municipal office;
5. Cadastral sheets, topographic maps and any other required information from other Government Agencies considered essential for the proper and effective execution of the Study;
6. Recent rainfall information, existing drainage information, flood prone areas and urban drainage conditions; and
7. Available reports, as-built records, and Organisation & Maintenance practices, etc.

8. RESPONSIBILITIES OF THE CONSULTANT

6. The Consultant shall employ well qualified and competent professional staff (whose CVs have been approved by PST) at all times in the execution of the Study. Replacement or temporary substitution shall not be permitted unless in emergency, or under very exceptional circumstances.

7. The Consultant shall make all necessary arrangements for carrying out the assignment and supporting the staff assigned to the study. This shall include office and living accommodation, equipment, transport- (using the vehicles acquired under the Provisional Sums), telecommunications, office and other supplies etc.

8. The Consultant shall ensure that the Team Leader and Experts have the full authority, in country, to make any technical decisions necessary to complete the services as required.

9. The Consultant shall co-operate fully with the relevant Government Ministries and Departments. The City/Town Clerk will provide the Consultant with Data and Services outlined in Section 7 Paragraph 3 above.

10. The Consultant shall be solely responsible for the analysis and interpretation of all Data received and for the conclusions and recommendations based upon them.

1. MANAGEMENT AND ADMINISTRATION

Quality Management: The Consultant shall implement a Quality Management System for the assignment in accordance with ISO 9001 requirements, either within the framework of their own organisation's quality management systems or specifically for this assignment. In particular the Consultant shall prepare a Project Control Plan which shall define how they intended to ensure Key Deliverables are produced on time, within budget and to the technical standards defined in the TOR.

The Project Control Plan should include:

1. Work Schedule and timeliness controls;
2. Budget and cost controls (earned value analysis);
3. Technical verification, quality controls and quality records management;
4. Risk management controls;
5. Project Document Management; and
6. Project reviews and progress reporting requirements.

2. The Consultant shall submit the Project Control Plan to PST and the Town Clerk to review its adequacy. The Consultant shall include Quality Management issues in their Reports.

9. REPORTING REQUIREMENTS AND SCHEDULE OF DELIVERABLES

Progress Review Meetings with PST

The Consultant shall ensure that regular meetings and interfaces with the PST Team are held during the Study assignment. The Consultant shall be proactive in organizing such meetings to clarify on aspects of the assignment as and when required. This shall also include interfacing with Program implementing City/Municipal Local Governments and other stakeholders to the Program There shall be at least one Consultant-PST meeting every month. The Program Coordinator may also call on the Consultant for a meeting at any time during the assignment to provide clarification on any issues that may arise. During these monthly meetings the Consultant shall present progress of the assignment and seek approvals for key infrastructure design features.

Meetings of Consultant and Stakeholders or End Users

The Consultant shall ensure that the City/Municipality Local Government, the MDF and key Municipal stakeholders are kept informed of the progress of work and particularly on the key design features of the infrastructure. In case of upgrades or changes and alterations to the design features of existing infrastructure, there must be written agreement of consent by the Municipality leadership.

PST Specialists shall always be informed of the schedule for such meetings.

Particular Requirements for Reporting and Approvals

1. Form and Language of Reports: The Consultant shall submit written reports in the English Language, in addition to drawings and other pertinent technical illustrations, at the end of each stage. All Reports shall be submitted in hard copy and soft copy. Soft copies shall be submitted as PDF files and must have corresponding files in the original computer software format such as Microsoft Word, Microsoft Excel, Microsoft Power Point, AutoCAD, Arc GIS, etc.
2. The Consultant shall take into account all comments received from concerned parties and modify or cause to be modified the reports, drawings and documents accordingly.
3. All Data shall be in units of the metric systems and all prices shall be quoted in the in Uganda Shillings.
4. The general paper format for presentation of reports shall be Size A4 (210 x 297mm) with A4 multiples folded down to that size, except for drawings where appropriate paper sizes shall be used.
5. The Consultant shall bear the cost of printing and reproduction of all Reports and documents under this assignment as well as all associated cost of submissions and obtaining of approvals/comments as appropriate.
6. Reports shall be submitted both in soft copy (on a CD) as well as in hard copy form and the number of copies scheduled as in the Table 6 above.

Failure to comply with Reporting Schedule

Reports and documents to be submitted by the Consultant shall comply with the implementation schedule of the project. Failure on the part of the Consultant to meet submission deadlines will attract liquidated damages at rates to be provided for in the consultancy contract.

Contact Person

1. For purposes of managing the assignment and receiving communications/issuing notices, the USMID-AF Program Coordinator shall be the contact person who shall also be the Team Leader of the assignment. The Team Leader shall be responsible for the overall management of the assignment.
2. For day to day Contract Management the Consultant shall be supervised by a Team led by the USMID Municipal Infrastructure Development Specialist (MIDS) comprising of PST Specialists, MLHUD staff and City/Municipality Staff. This Team may co-opt members from other relevant government agencies such as MoWT.

Cost of making changes to Reports and documents

In the event that the Consultant's reports or designs and documents are found unacceptable at any stage of the project, the Consultant will resubmit revised reports or documents or designs at no additional cost. Any revisions required by the MLHUD or the City or Municipal

Local Government Council following submissions for approval will be completed by the Consultant within the Lump Sum cost of the consultancy fees and expenses.

1.1.1 Return of Documents, Soft Copies and Software to the Client

a) At the end of the assignment, the Consultant shall return to MLHUD and to each City/Municipal Local Government , as the case may be, documents, reports and all written communications originating from both parties and put at the disposal of the Consultant for the purpose of the project, together with an inventory;

b) At the end of the assignment, the Consultant shall submit in hard copy and soft copies all raw data and analysed date including but not limited to traffic counts, rainfall and weather data, storm water flow rates, cadastral survey data, soil test results, materials test results, interview/questionnaire forms, and any other data collected during the course of the assignment; and

c) Neither the Consultant nor any of their staff shall claim a right of authorship or design patent on the contents of any of the reports and documents submitted during the project.

ANNEXES

ANNEX 1: Example of Table for Indicators for pre and Post Installation Technology

Parameters	Pre-installation	Post-installation
Lighting Technology		
Wattage (W)		
Lumens (lm)		
Efficacy (lumen/Watt)		
Lifetime (years)		
Illuminance (lux)		
Colour Rendering Index (CRI)		
Street Name		
Number of light points*		
Street dimensions		
Operating hours (per year)		
Electricity consumption per year (kWh)		

*of the same technology located in the same street

10. ANNEX 2 – Example of parameters of new Lighting System

(a) Classification of the roads
(b) Specification for street lighting poles
(c) Recommended levels of illumination and Mounting Height of Luminaires
(d) Type of lamps
(e) Wattage of system (lamp + ballast)
(f) Illuminance (lux)
(g) Density of electric power for lighting (W/m2)

ANNEX 1 – EXAMPLE OF DATA TO BE COLLECTED TO DOCUMENT EXISTING CONDITION OF LIGHTING SYSTEM

- Physical condition of existing street lighting system
- Description of metering and control system (as relevant)
- Number and locations of sub-stations in the City/Municipality
- Details of power supplied for street lighting systems from each of the stations on a daily basis for the past 12 months
- Monthly electricity bills of the individual street lighting circuits for the past 12 months (as relevant)
- Number and type of lights changed over the past 3 years (as relevant)
- Number and locations of the street lighting transformers in the municipality
- Number of feeders and conductor sizes in each of the transformers
- Number and type of lights and fixtures in each of the feeder, including lux levels and color rendering index (CRI)
- Length of each feeder
- Height of poles
- Distance between poles
- Type of Lighting technology
- Potential power light points
- Operational hours
- Electricity cost (MXN/kWh) and tariff category
- Street Lighting Electricity cost per year (MXN/year)
- O&M Street Lighting Costs per year (MXN/year).

11. ANNEX 4 – STREET LIGHTING ENERGY EFFICIENCY INDICATORS

Note: energy indices or indicators of energy performance are a quantitative value or measure of the energy performance as defined by the company, industry or authority.

- Lighting power density [W/m²]
- Luminous efficacy [lm/W]
- Illumination level in luxes
- Avoided CO2 emissions per year [TCO2 / year]

Appendix 2 Schedule of People Consulted

No.	Name	Title	Organization
1	Mr. Mukwaya Benard	Senior Electrical Engineer	Uganda National Bureau of Standards
2	Mr. Magumba Charles	Commissioner	Ministry of Local Government
3	Eng. Rutaagi Joseph	Principal Engineer	Ministry of Works and Transport
4	Eng. Abdullah Ssenyonjo	Senior Electrical Engineer	Kampala Capital City Authority (KCCA)
5	Mr. Sankara James	Electrical Engineer	KCCA
6	Mrs. Robinah K. Nanyunja.	Chief Executive Officer	Uganda Solar Energy Association (USEA)
7	Mr. Bakengana Paddy	Senior Programs Associate	USEA
8	Eng. Kaddu Kenneth	Manager Electrical Department	Uganda National Roads Authority
9	Eng. Ssentongo Samuel	Engineer	Uganda Institution of Professional Engineers (UIPE), M&E Associates Ltd
10	Ms. Lydia Naisaza	Officer	UIPE
11	Mr. Tagane Joseph	Clients Relations Officer	Engineers Registration Board (ERB)
12	Mr. Tenywa Henry	Sales Engineer	Chloride Exide (U) Ltd
13	Mrs. Milly Kure	Sales Manager	Davis & Shirtliff International Ltd
14	Mrs. Mariam Namiya	Executive Director	Uganda National Association of Builders, Suppliers and Engineering Contractors (UNABSEC)
15	Mr. Golooba Vincent	Development Officer	UNABSEC

Appendix 3 Stakeholder Meeting Attendance List

TITLE: USEA MEETING WITH STAKE HOLDER CONSULTATIONS.

DATE: 14th/08/2024

S/N	NAME	DESIGNATION	ORGANISATION	TELEPHONE NUMBE	EMAIL	SIGNATURE	
1.	Rebirah K. Danyuka	CEO	USEA	0772508970	CEO@USEAUG.ORG		11:58am
2.	Bakengana Paddy	Senior Programs Associate	USEA	0772406681			
1.	Milly Kune	Sales Manager	Davis & Shirtliff	0761254637	ugenquiries@davisshirtliff.com	Milly	12:30pm.
1	Henry Tenywa	Solar sales Engineer	Chloride Exide	htenywa@davisshirtliff.com	0781538666		1:30pm.
1	Tagame Joseph	Clients Relations Officer	Engineers Technician Board	0788108220	info@enb.go.ug		5:10pm
1	Lydia Naisaza	Front Desk Officer.	UIPE.	0774422030	info@uipe.co.ug		3:35pm.
1.	Samuel Sentongo	Electrical Eng	RTE Research	0772746371	ssentongo@rtea.co.ug		
	Bernard Mukwaya		UNBS	0702721321	bernard.mukwaya@unbs.go.ug		
	Joseph Rutaagi	Principal Engineer	MEMD	0772415923	jrutaagi@gmail.com		
	Charles Magumba	CEA-Mong		0772521677	Charles.magumba@energy.go.ug		

TITLE: STAKE HOLDER CONSULTATION.

DATE: 20th/08/2024.

S/N	NAME	DESIGNATION	ORGANISATION	TELEPHONE NUMBE	EMAIL	SIGNATURE
01	Kenneth Kaddu	Electrical Eng.	UNRA	0782792204	Kenneth.Kaddu@unra.go.ug	
02	GOLOUBA VINCENT	Membership Services & Devt officer	UNABSEC	0705205803	membership@unabsec.co.ug	
03.	Mariam Namiya	Ag. ED	UNABSEC	0759653705	executive.director@unabsec.co.ug	
04	Sankara James	Electrical Eng	KCCA	0776643491	Jsankara@kcca.go.ug	
05	Eng. Abdallah. Ssenyonjo	Sup. Elect.	KCCA	0704545821	assenyonjo@gmail.com	

Appendix 4 Streetlight Testing Framework

COMPONENT	TEST REQUIREMENT	ASSESSMENT AND REMARKS
FOUNDATION / BASE	Contruction	
	Finishes	
	Plumbness	
POLE	Thermal protection	
	Proof - Load testing	
	Ultrasonic tests for joints	
	Resistance to dust and moisture	
	Anchoring and bolts	
	Insulation	
	Corrosion resistance	
BATTERY	Energy capacity	
	Rate of discharge	
	Thermal endurance	
	Wiring and terminals	
	Surge protection	
	Insulation and earthing	
SOLAR PANEL	I-V curve testing	
	Rated power (W)	
	Thermal endurance	
	Surge protection	
	Angle of inclination	
CHARGE CONTROLLER	Wiring and terminals	
	Reverse polarity protection	
	Continuity test	
	Voltage output	
	Ingress protection	
	Earthing	
	Thermal endurance	
LED Luminaire	Insulation against electric shock	
	Operating temperature	
	Light sensors or automatic switching	
	Luminaire efficacy (lm/W)	
	Color Rendering Index (CRI)	
	Rated luminous flux (Lm)	
	Luminous intensity distribution	
	Ingress protection	
	Reverse polarity protection	
	Earthing and grounding	
WIRING	Terminations and Loose connections	
	Leakages	
	Insulation	
	Continuity test	
	Wear and tear	
	Thermal resistance	

Appendix 5 Quotations and Datasheets for Proposed Specifications

DAVIS & SHIRTLIFF

know H_2Ow through experience

SALES QUOTE

Date	30 Sep 2024
Quote No	SQ0069165
Due Date	30 Sep 2024
Account No	**44948**

Jinja Road
Plot 43
Jinja Road, JINJA ROAD
Uganda
Tel: +256 323 346 200
jinjaroad@dayliff.com
TIN NO 1000028625
Certificate No.: EXMP-CERT-71877
Salesperson: DENIS SSEMPALA

PHILIP MALABA
Uganda

Subject: SUPPLY OF SOLAR EQUIPMENT

DESCRIPTION	QTY	VAT	UNIT PRICE	AMOUNT
DAYLIFF DLIP 100AH 48V LITHIUM ION BATTERY	1	0	4,230,000.00	4,230,000.00
STECA PRS20A CHARGE CONTROLLER	1	0	436,050.00	436,050.00
DAYLIFF DLIP 150AH 48V LITHIUM ION BATTERY	1	0	6,760,800.00	6,760,800.00
DAYLIFF 80W 3.2V INTEGRATED SOLAR STREET LIGHT	1	18	1,382,250.00	1,382,250.00
DAYLIFF 60W 3.2V INTEGRATED SOLAR STREET LIGHT	1	18	1,330,000.00	1,330,000.00
			Subtotal	14,139,100.00
			VAT	488,205.00
			Total USH	**14,627,305.00**

DELIVERY EX STOCK

VALIDITY SUBJECT TO CONFIRMATION AT DATE OF ORDER

PAYMENT IN FULL WITH ORDER, MTN *165*4*4# Merchant ID: DAVISUG, Airtel- *185*9# Merchant ID: 1112363

WARRANTY AS PER D&S TERMS OF WARRANTY

BANK DETAILS

ACCOUNT NAME	BANK	BANK BRANCH	CURRENCY	ACCOUNT No	BANK CODE

QUOTE CONFIRMATION

We are happy with the quote. Please proceed with the order.

Name _____ Date _____ Sign _____

Water Pumps · Boreholes · Swimming Pool · Water Treatment · Generators · Solar · Irrigation

Water & Energy Solutions for Africa

DAVIS & SHIRTLIFF

know H_2Ow through experience

SALES QUOTE

Date	30 Sep 2024
Quote No	SQ0069165
Due Date	30 Sep 2024
Account No	**44948**

Jinja Road
Plot 43
Jinja Road, JINJA ROAD
Uganda
Tel: +256 323 346 200
jinjaroad@dayliff.com
TIN NO 1000028625
Certificate No.: EXMP-CERT-71877
Salesperson: DENIS SSEMPALA

PHILIP MALABA
Uganda

We trust this is in order and look forward to receiving your instructions in due course.

Yours faithfully,

BANK DETAILS

ACCOUNT NAME	BANK	BANK BRANCH	CURRENCY	ACCOUNT No	BANK CODE

QUOTE CONFIRMATION

We are happy with the quote. Please proceed with the order.

Name _____ Date _____ Sign _____

Water Pumps | Boreholes | Swimming Pool | Water Treatment | Generators | Solar | Irrigation

Water & Energy Solutions for Africa

Proforma Invoice

Energy solutions -for all!

Bill-to Customer No.: CA1000

UGANDA CASH CUSTOMER
WSS SERVICES
KAMPALA
KAMPALA
KAMPALA, 00
UGANDA

Your Reference:
VAT Registration No.:
TIN No.:

CHLORIDE EXIDE UGANDA LTD
2nd Street Industrial Area, Plot 7/9

PO BOX 9463
KAMPALA UGANDA
0200 400 900

customerserviceug@chlorideexide.com
VAT No.: 477730-G
TIN No.: 1000072437

Quote No.	Document Date	SalesPerson	Payment Terms
PF-KLA524110	October 3, 2024	Tracy Ampwereire	

Description	Quantity	Unit Price	DISC %	VAT %	Amount
SOLAR LITHIUM 100AH EASTMAN 24V	1	3,330,000.00		0	3,330,000.00
285W MONO SOLAR PANEL 24V (SLD)	2	249,019.00		0	498,038.00
SMART SOLAR MPPT 100/20 (UPTO 48V)	1	590,000.00		0	590,000.00

Subtotal	**4,418,038.00**
Total UGSHS Incl. VAT	**4,418,038.00**

Bank Details

Account Name	Bank Name	Account No.	Bank Code	Bank Branch
CHLORIDE EXIDE UGANDA LTD	NCBA BANK	3000111251	35	RWENZORI TOWER
CHLORIDE EXIDE UGANDA LTD				

Mobile Money Details

Pay By	DIAL	Name	Merchant ID	Account No.
Airtel	*185*9#	CHLORIDE EXIDE UGANDA LTD	1163159	CA1000
MTN	*165*3#	CHLORIDE EXIDE UGANDA LTD	608725	CA1000

CONDITIONS:

1. Prices are subject to change anytime without prior notice.
2. This is only for quotation purpose and is NOT an invoice.

Proforma Invoice

Energy solutions -for all!

Bill-to Customer No.: CA1000

UGANDA CASH CUSTOMER
WSS SERVICES
KAMPALA
KAMPALA
KAMPALA, 00
UGANDA

Your Reference:
VAT Registration No.:
TIN No.:

CHLORIDE EXIDE UGANDA LTD
2nd Street Industrial Area, Plot 7/9

PO BOX 9463
KAMPALA UGANDA
0200 400 900

customerserviceug@chlorideexide.com
VAT No.: 477730-G
TIN No.: 1000072437

Quote No.	Document Date	SalesPerson	Payment Terms
PF-KLA524111	October 3, 2024	Tracy Ampwereire	

Description	Quantity	Unit Price	DISC %	VAT %	Amount
580 WATTS PANEL (MONO)-JINKO	12	434,275.00		0	5,211,300.00
SOLAR RIIO SUN II 48/6KVA (TBB)	1	4,375,000.00		0	4,375,000.00

Subtotal	**9,586,300.00**
Total UGSHS Incl. VAT	**9,586,300.00**

Bank Details

Account Name	Bank Name	Account No.	Bank Code	Bank Branch
CHLORIDE EXIDE UGANDA LTD	NCBA BANK	3000111251	35	RWENZORI TOWER
CHLORIDE EXIDE UGANDA LTD				

Mobile Money Details

Pay By	DIAL	Name	Merchant ID	Account No.
Airtel	*185*9#	CHLORIDE EXIDE UGANDA LTD	1163159	CA1000
MTN	*165*3#	CHLORIDE EXIDE UGANDA LTD	608725	CA1000

CONDITIONS:

1. Prices are subject to change anytime without prior notice.
2. This is only for quotation purpose and is NOT an invoice.

KAMPALA ELECTRIC MART

ONE SOURCE TOTAL SOLUTION

6th Street Plot No. 147-153, Industrial Area Kampala, Uganda
+256 393 130 068
+256 393 130 666
info@chintuganda.com
www.chintuganda.com

CHINT 正泰 Switch to the best

PROFORMA INVOICE

Invoice To: **M/S. WSS SERVICES LTD LTD C/O USMID-AF PROGRAM KAMPALA, .**

TIN No.: **1009241778**
Invoice No.: **121438**
Issue Date: **27-09-2024**

No.	Description	QTY	Units	Rate	Amount
1	NEP-LD0615000052 150W LED STREET LAMP	**1**	PCS	**1,480,000**	1,480,000
2	LED STREET LIGHT ZDL1129 100W 6500K	**1**	PCS	**600,000**	600,000
3	ZDL1129 60W 6500K LED STREET LIGHT	**1**	PCS	**318,000**	318,000

SUB TOTAL	**UGX**	**2,398,000**
TOTAL	**UGX**	**2,398,000**

Terms and Conditions

- We reserve the right of price changes whenever necessary.
- Exchanges are allowable within 7days after purchase.(T&C apply)

Amount in words: Two Million, Three Hundred Ninety-Eight Thousand Uganda Shillings Only

PREPARED BY
KOBWEMI SAMUEL (0789635806)
For Kampala Electric Mart Ltd.

Mobile Money Details

MoMo from MTN (*165*3#) 146886

airtel Payments Bank (*185*9#) 1147978

FlexiPay (*291#) 238168

Thank you for trusting CHINT, the principal shirt sponsor of KCCA-FC

www.jinkosolar.com

TIGER Neo

72HL4-(V)

580-605 Watt

MONO-FACIAL MODULE

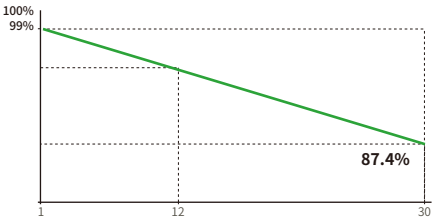
N-type

N-type Technology

N-type modules with Tunnel Oxide Passivating Contacts (TOPcon) technology offer lower LID/LeTID degradation and better low light performance.

HOT 3.0 Technology

N-type modules with JinkoSolar's HOT 3.0 technology offer better reliability and efficiency.



12Year Product Warranty | **30**Year Linear Power Warranty | **1**% First-year Degradation | **0.40**% Annual Degradation Over 30 Years

Durability Against Extreme Environment

High salt mist and ammonia resistance.

Mechanical Load Enhanced

Certified to withstand:
5400 Pa front side max static test load
2400 Pa rear side max static test load

- IEC61215:2021 / IEC61730:2023
- IEC61701 / IEC62716 / IEC60068 / IEC62804
- ISO9001:2015: Quality Management System
- ISO14001:2015: Environment Management System
- ISO45001:2018: Occupational health and safety management systems

SMBB Technology

Better light trapping and current collection to improve module power output and reliability.

Anti-PID guarantee

Minimizes the chance of degradation caused by PID phenomena through optimization of cell production technology and material control.

JKM580-605N-72HL4-(V)-F9-EN

72HL4-(V) 580-605 Watt

Mechanical Characteristics

Cell Type	N -type Mono-crystalline
No. of cells	144 (72×2)
Dimensions	2278×1134×30 mm
Weight	27.0 kg
Front Glass	3.2mm, Anti-reflection Coating, High Transmission, Low Iron, Tempered Glass
Frame	Anodized Aluminium Alloy
Junction Box	IP68 Rated
Protection Class	Class II
IEC Fire Type	Class C
Connector Type	JK03M/MC4/Others
Output Cables	4.0 mm^2 (+): 400 mm , (-): 200 mm or Customized Length

Packaging Configuration

Pallet Dimensions	2308×1140×1249 mm
Packing detail (Two pallets=One stack)	37 pcs/pallets, 74 pcs/stack, 740 pcs/ 40'HQ Container

Specifications (STC)

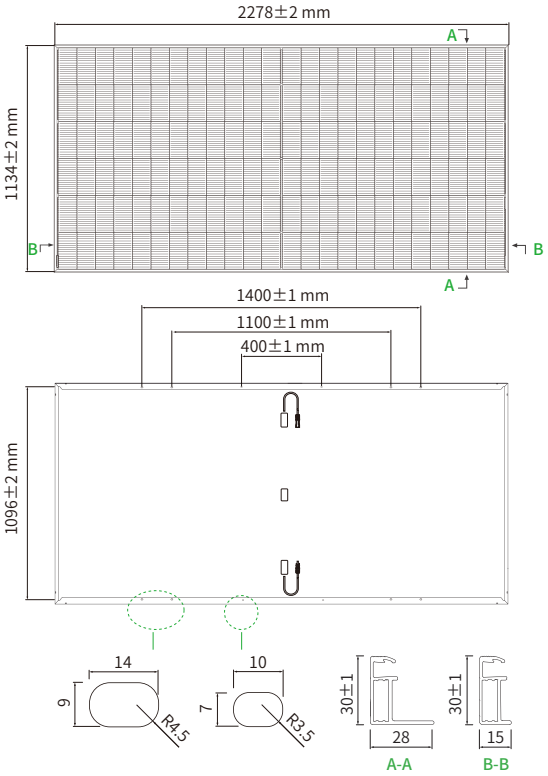
Maximum Power – Pmax [Wp]	580	585	590	595	600	605
Maximum Power Voltage – Vmp [V]	43.35	43.53	43.71	43.88	44.06	44.23
Maximum Power Current – Imp [A]	13.38	13.44	13.50	13.56	13.62	13.68
Open-circuit Voltage – Voc [V]	52.31	52.47	52.63	52.79	52.95	53.11
Short-circuit Current – Isc [A]	14.01	14.07	14.13	14.19	14.25	14.31
Module Efficiency STC [%]	22.45	22.65	22.84	23.03	23.23	23.42
Power Tolerance	0 ~ + 3 %					
Temperature Coefficients of Pmax	-0.29 %/°C					
Temperature Coefficients of Voc	-0.25 %/°C					
Temperature Coefficients of Isc	0.045 %/°C					

STC: Irradiance 1000W/m^2, Cell Temperature 25°C, AM=1.5

Application Conditions

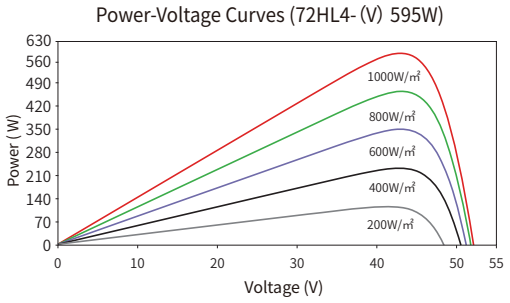
Operating Temperature	-40 °C ~ +70°C
Maximum System Voltage	1000/1500 VDC (IEC)
Maximum Series Fuse Rating	25 A

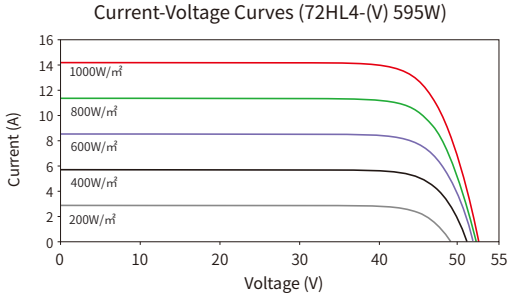
Engineering Drawings



*Note: For specific dimensions and tolerance ranges, please refer to the corresponding detailed module drawings.

Electrical Performance





Note: Please read the safety and installation manual before using the product. We reserve the right of final interpretation. The specifications in this datasheet are subject to change without notice.

www.jinkosolar.com

Jinko Solar
Building Your Trust in Solar

Eagle 60P
265-285 Watt

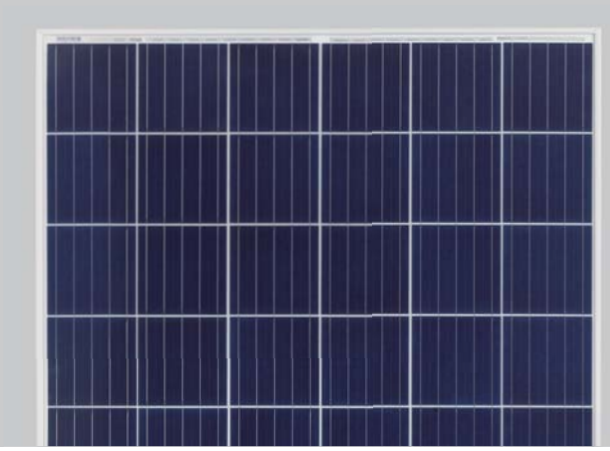
POLY CRYSTALLINE MODULE

Positive power tolerance of 0~+3%

ISO9001:2015、ISO14001:2015、OHSAS18001 certified factory.

IEC61215、IEC61730、UL1703 certified products.

(5BB)



KEY FEATURES

5 Busbar Solar Cell:

5 busbar solar cell adopts new technology to improve the efficiency of modules , offers a better aesthetic appearance, making it perfect for rooftop installation.

High Power Output:

Polycrystalline 60-cell module achieves a power output up to 285Wp.

PID RESISTANT:

Eagle modules pass PID test, limited power degradation by PID test is guaranteed for mass production.

Low-light Performance:

Advanced glass and surface texturing allow for excellent performance in low-light environments.

Severe Weather Resilience:

Certified to withstand: wind load (2400 Pascal) and snow load (5400 Pascal).

Durability against extreme environmental conditions:

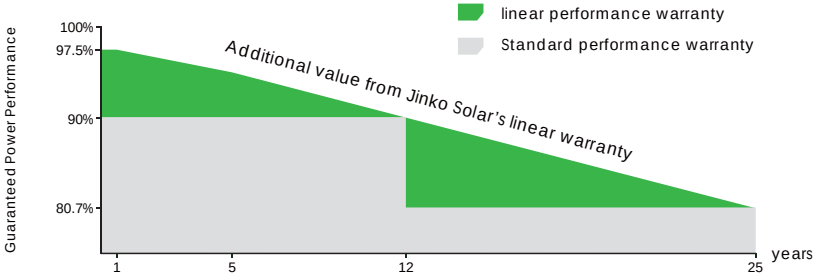
High salt mist and ammonia resistance certified by TUV NORD.

Temperature Coefficient:

Improved temperature coefficient decreases power loss during high temperatures.

LINEAR PERFORMANCE WARRANTY

12 Year Product Warranty • 25 Year Linear Power Warranty

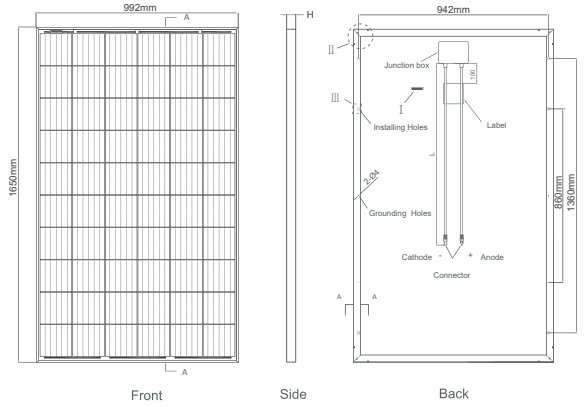


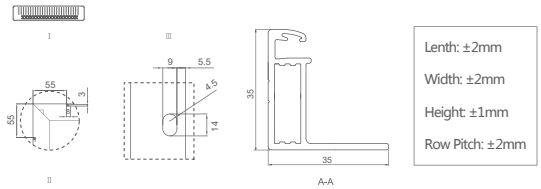
Nomenclature:

JKMxxxPP-60/72-V

Code	Cell	Code	Certification
null	Full	null	1000V
H	Half	V	1500V

Engineering Drawings





Lenth: ±2mm
Width: ±2mm
Height: ±1mm
Row Pitch: ±2mm

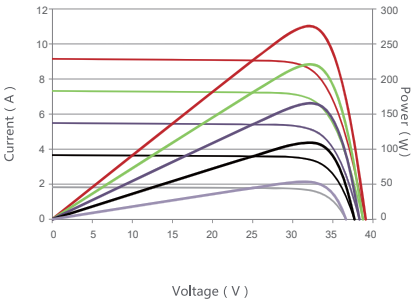
Packaging Configuration

(Two pallets=One stack)

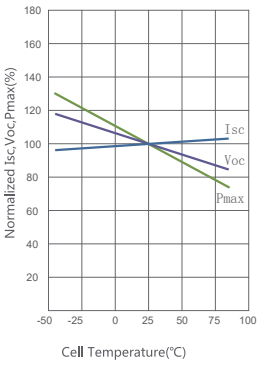
31pcs/pallet, 62pcs/stack, 868pcs/40'HQ Container

Electrical Performance & Temperature Dependence

Current-Voltage & Power-Voltage Curves (275W)



Temperature Dependence of Isc,Voc,Pmax



Mechanical Characteristics

Cell Type	Poly-crystalline 157×157mm (6 inch)
No.of cells	60 (6×10)
Dimensions	1650×992×35mm (65.00×39.05×1.37 inch)
Weight	19.0 kg (41.9 lbs)
Front Glass	3.2mm, Anti-Reflection Coating, High Transmission, Low Iron, Tempered Glass
Frame	Anodized Aluminium Alloy
Junction Box	IP67 Rated
Output Cables	TÜV 1×4.0mm^2, Length: 900mm or Customized Length

SPECIFICATIONS

Module Type	JKM265PP-60 JKM265PP-60-V		JKM270PP-60 JKM270PP-60-V		JKM275PP-60 JKM275PP-60-V		JKM280PP-60 JKM280PP-60-V		JKM285PP-60 JKM285PP-60-V	
	STC	NOCT	STC	NOCT	STC	NOCT	STC	NOCT	STC	NOCT
Maximum Power (Pmax)	265Wp	197Wp	270Wp	200Wp	275Wp	204Wp	280Wp	208Wp	285Wp	212Wp
Maximum Power Voltage (Vmp)	31.4V	29.0V	31.7V	29.4V	32.0V	29.8V	32.3V	30.1V	32.5V	30.4V
Maximum Power Current (Imp)	8.44A	6.78A	8.52A	6.80A	8.61A	6.85A	8.69A	6.91A	8.77A	6.97A
Open-circuit Voltage (Voc)	38.6V	35.3V	38.8V	35.4V	39.1V	35.4V	39.4V	35.6V	39.6V	35.7V
Short-circuit Current (Isc)	9.03A	7.36A	9.09A	7.38A	9.15A	7.44A	9.20A	7.99A	9.26A	8.05A
Module Efficiency STC (%)	16.19%		16.50%		16.80%		17.11%		17.41%	
Operating Temperature(℃)	-40℃~+85℃									
Maximum system voltage	1000/1500VDC (IEC)									
Maximum series fuse rating	20A									
Power tolerance	0~+3%									
Temperature coefficients of Pmax	-0.38%/℃									
Temperature coefficients of Voc	-0.31%/℃									
Temperature coefficients of Isc	0.06%/℃									
Nominal operating cell temperature (NOCT)	45±2℃									

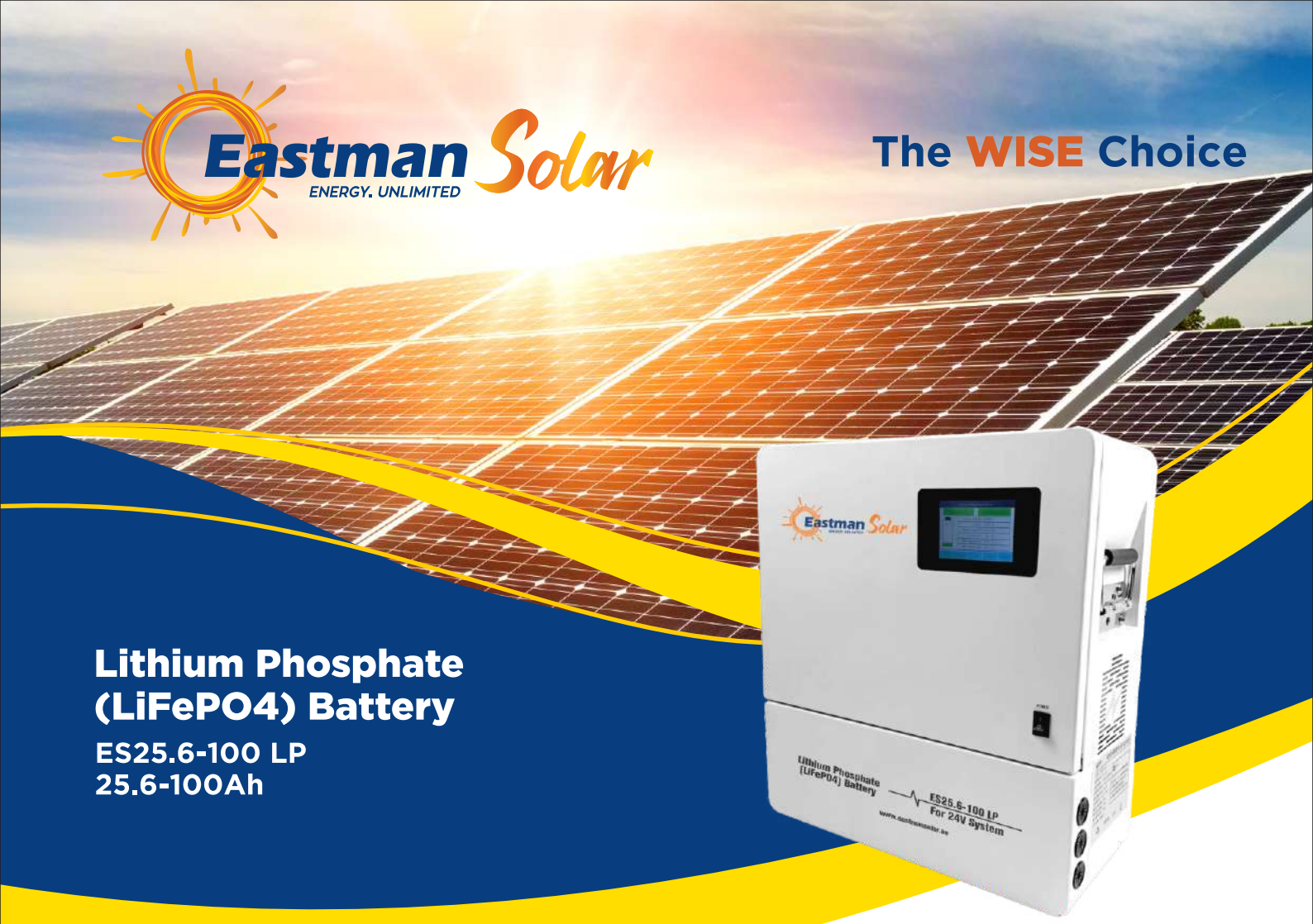
STC: Irradiance 1000W/m^2 Cell Temperature 25°C AM=1.5

NOCT: Irradiance 800W/m^2 Ambient Temperature 20°C AM=1.5 Wind Speed 1m/s

* Power measurement tolerance: ± 3%

Eastman Solar
ENERGY. UNLIMITED

The WISE Choice



Lithium Phosphate (LiFePO4) Battery

ES25.6-100 LP
25.6-100Ah

Features:

Longer Cycle Life: Offers up to 15 times longer cycle life and 5 times longer float/calendar life than lead acid battery.

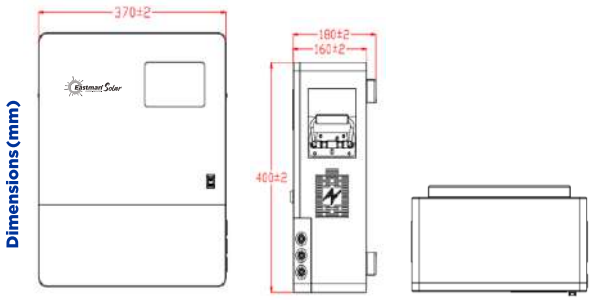
Lighter Weight: About 40% weight of a comparable lead acid battery, save up to 60% in weight.

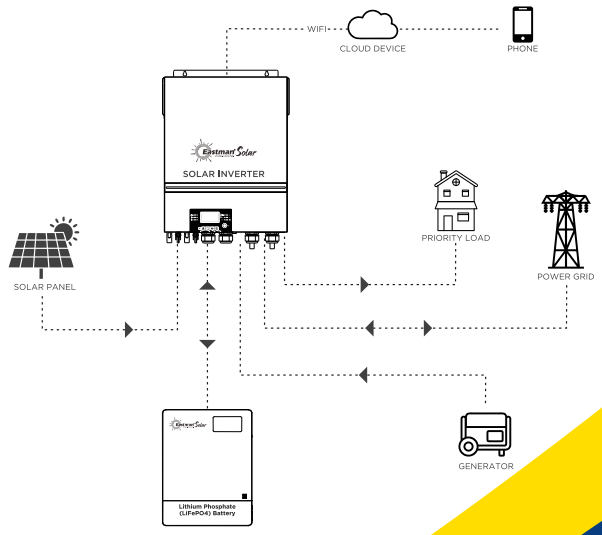
Fast Charge: Short charge time compared with lead acid battery.

Low Self-Discharge: Lower self-discharge compared with lead acid battery, longer storage time without recharging.

Superior Safety: Multi-protection methods built inside to protect the battery from overcharge, over discharge and short circuit situation

High Efficient: Higher round-trip energy efficiency of the average (92%) than lead acid battery 80% (discharge from 100% to 0% and back to 100% charged).





Lithium Phosphate (LiFePO4) Battery
ES25.6-100 LP | 25.6-100Ah

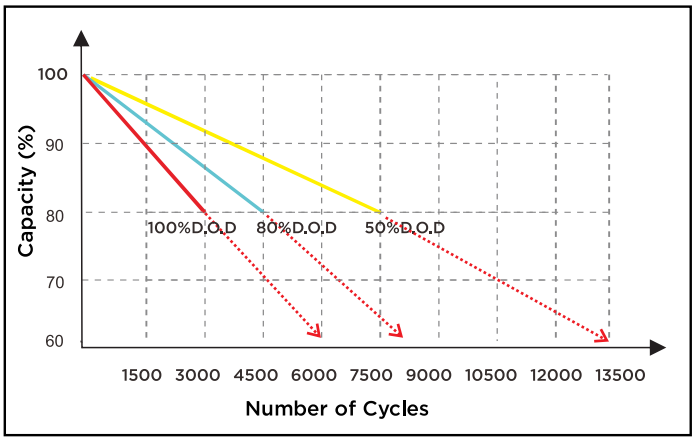
Specifications

Nominal voltage		24V
Nominal capacity		100Ah
Dimensions	Length	370±2mm (37 cm)
	Width	160±2mm (16 cm)
	Height	400±2mm (40 cm)
	Total length	400±2mm (40 cm)
Approx. weight		22.85kg (50.38lbs)±4%

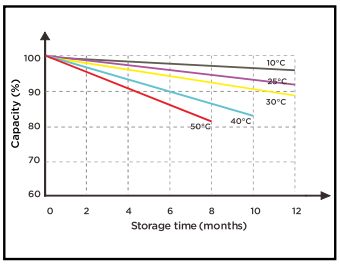
Characteristics

Electrical Parameters (25°C)	Rated Voltage	25.6V
	Rated Capacity (C_5)	100Ah@25°C
	Energy	2560Wh
	Cell Type	New Cell
	Cell Brand	BYD Cell
	Charge Efficiency	99.5 %@ 0.2C
	Discharge Efficiency	97-99%@ 1C
Terminal Diameter		M10
Internal resistance (Fully charged, 25°C)		≤10mΩ
Cycle life		>6000 cycles @ 0.2C 80%D.O.D
Capacity affected by temperature	40°C	101%
	25°C	100%
	0°C	90%
	-10°C	75%
Nominal operating temperature		25°C± 3°C (77°F± 5°F)
Operating temperature range	Discharge	- 20°C~ 60°C (-4°F ~ 140°F)
	Charge	0°C~ 45°C (32°F ~ 113°F)
	Storage	0°C~ 40°C (32°F ~ 104°F)
Protection Level		IP50
Charge Voltage		28V
Standard Charge Mode (25°C±2°C, <75%RH)		0.2CA Constant Current to 28V, then Constant Voltage 28V until the current drops to 0.02CA, before use, rest 30 minutes
Recommended Charge Current		50A
Maximum Charge/Discharge Current		100A
Discharge Cut Off Voltage		24V
Communication Protocol		RS485/RS232/CAN
Parallel Conection		Upto 16
Mechanical	Cells	8 Strings
	Container	Metal

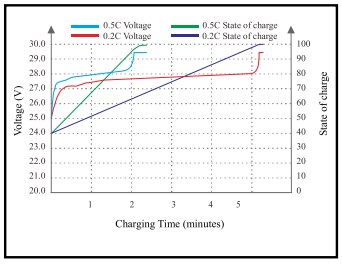
Cycle life on D.O.D (25°C)



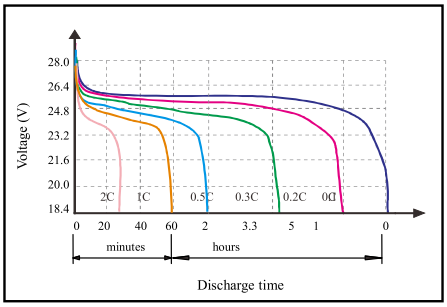
Self Discharge Characteristics Curve



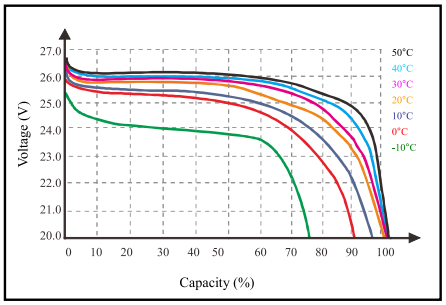
State of Charge Curve (25°C)



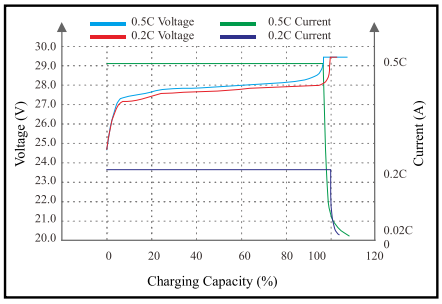
Discharge characteristics (25°C)



Temperature affect on discharge characteristics (0.5C)



Charge characteristics (25°C)



Product specification are subject to change without prior notice.

AMPS MIDDLE EAST FZ LLC
#703, 7TH Floor, Deira Twin Tower,
Baniyas Square,Deira, Dubai (UAE)

EASTMAN AUTO & POWER LTD.
ASF Towers, 249, Udyog Vihar Phase-4, Gurugram,
Haryana-122016, India

www.eastmansolar.ae
sedsales@eastmansolar.ae

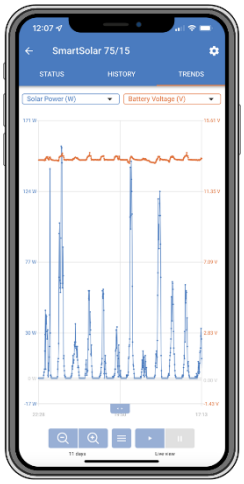
SmartSolar Charge Controllers with load output
MPPT 75/10, 75/15, 100/15, 100/20-48 V

www.victronenergy.com

SmartSolar Charge Controller MPPT 75/15

Bluetooth sensing Smart Battery Sense

Bluetooth sensing BMV-712 Smart Battery Monitor



Stored trends

Bluetooth Smart built-in
The wireless solution to set-up, monitor, update and synchronise SmartSolar Charge Controllers.

VE.Direct - For a wired data connection to a Color Control GX, other GX products, PC or other devices

Ultra-fast Maximum Power Point Tracking (MPPT)
Especially in case of a clouded sky, when light intensity is changing continuously, an ultra-fast MPPT controller will improve energy harvest by up to 30 % compared to PWM charge controllers and by up to 10 % compared to slower MPPT controllers.

Load output
Over-discharge of the battery can be prevented by connecting all loads to the load output. The load output will disconnect the load when the battery has been discharged to a pre-set voltage (48 V model: interface with a relay).
Alternatively, an intelligent battery management algorithm can be chosen: see Battery Life.
The load output is short circuit proof.

Battery Life: intelligent battery management
When a solar charge controller is not able to recharge the battery to its full capacity within one day, the result is often that the battery will continually be cycled between a 'partially charged' state and the 'end of discharge' state. This mode of operation (no regular full recharge) will destroy a lead-acid battery within weeks or months.
The Battery Life algorithm will monitor the state of charge of the battery and, if needed, day by day slightly increase the load disconnect level (i.e. disconnect the load earlier) until the harvested solar energy is sufficient to recharge the battery to nearly the full 100 %. From that point onwards, the load disconnect level will be modulated so that a nearly 100 % recharge is achieved about once every week.

Programmable battery charge algorithm - See the software section on our website for details

Day/night timing and light dimming option - See the software section on our website for details

Internal temperature sensor - Compensates absorption and float charge voltage for temperature.

Optional external battery voltage and temperature sensing via Bluetooth
A Smart Battery Sense or a BMV-712 Smart Battery Monitor can be used to communicate battery voltage and temperature to one or more SmartSolar Charge Controllers.

Fully discharged battery recovery function
Will initiate charging even if the battery has been discharged to zero volts.
Will reconnect to a fully discharged Li-ion battery with integrated disconnect function.

SmartSolar Charge Controller	MPPT 75/10	MPPT 75/15	MPPT 100/15	MPPT 100/20-48V
Battery voltage (auto select)	12/24 V			12/24/48 V
Rated charge current	10 A	15 A	15 A	20 A
Nominal PV power, 12 V 1a,b)	145 W	220 W	220 W	290 W
Nominal PV power, 24 V 1a,b)	290 W	440 W	440 W	580 W
Nominal PV power, 48 V 1a,b)	n. a.	n. a.	n. a.	1160 W
Max. PV short circuit current 2)	13 A	15 A	15 A	20 A
Automatic load disconnect	Yes			
Max. PV open circuit voltage	75 V		100 V	
Peak efficiency	98 %			
Self-consumption – load on	12 V: 19 mA 24 V: 16 mA			26 / 20 / 19 mA
Self-consumption – load off	12 V: 10 mA 24 V: 8 mA			10 / 8 / 7 mA
Charge voltage 'absorption'	14,4 V / 28,8 V (adjustable)			14,4 V / 28,8 V / 57,6 V (adj.)
Charge voltage 'float'	13,8 V / 27,6 V (adjustable)			13,8 V / 27,6 V / 55,2 V (adj.)
Charge algorithm	multi-stage adaptive			
Temperature compensation	-16 mV / °C resp. -32 mV / °C			
Max. continuous load current	15 A			20 A / 20 A / 1 A
Low voltage load disconnect	11,1 V / 22,2 V / 44,4 V or 11,8 V / 23,6 V / 47,2 V or Battery Life algorithm			
Low voltage load reconnect	13,1 V / 26,2 V / 52,4 V or 14 V / 28 V / 56 V or Battery Life algorithm			
Protection	Output short circuit / Over temperature			
Operating temperature	-30 to +60 °C (full rated output up to 40 °C)			
Humidity	95 %, non-condensing			
Data communication port	VE.Direct (see the data communication white paper on our website)			
ENCLOSURE				
Colour	Blue (RAL 5012)			
Power terminals	6 mm² / AWG10			
Protection category	IP43 (electronic components), IP22 (connection area)			
Weight	0,5 kg		0,6 kg	0,65 kg
Dimensions (h x w x d)	100 x 113 x 40 mm		100 x 113 x 50 mm	100 x 131 x 60 mm
STANDARDS				
Safety	EN/IEC 62109-1, UL 1741, CSA C22.2			
STORED TRENDS				
Data stored	Battery voltage,current and temperature, as well as load output current, PV voltage and PV current.			
Number of days trends data is stored	46			

1a) If more PV power is connected, the controller will limit input power.
1b) The PV voltage must exceed Vbat + 5 V for the controller to start.
Thereafter the minimum PV voltage is Vbat + 1 V
2) A PV array with a higher short circuit current may damage the controller.

Appendix 6 Guarantee and Warranty from Suppliers

TERMS OF WARRANTY

1) GENERAL LIABILITY

In lieu of any warranty claim, the terms of warranty for Chloride Exide (U) Ltd (hereafter called the Company) in respect of any defect or failure of equipment supplied or for any loss, injury or damage attributable thereto is limited to making good by replacement or repair (at the Company's discretion) defects which under proper use appear therein and arise solely from faulty design, materials or workmanship within a specified period.

This warranty applies solely to equipment supplied or work carried out by the Company and no claim for consequential damages, however arising, will be considered. Also, the warranty specifically excludes defects caused by fair wear and tear, the effects of careless handling, lack of maintenance, faulty installation by third party (s) other than Chloride Exide Uganda Ltd, and incompetence on the part of the equipment user, acts of God or any other cause beyond the Company's reasonable control. Also, any repair or attempt at repair carried out by any other party(s) invalidates all warranties.

2) NEW EQUIPMENT

2.1 General Terms

Standard warranty period for all the product categories, is as detailed in the schedule below, subject to the specific terms detailed in clause 2.2.

NOTE:

- ✓ Consumables e.g. magnesium rod, heating elements, thermostat are not covered by Warranty and upon signing up with the company a service contract agreement, they can be checked during maintenance checks.
- ✓ Components making up the system are covered individually under the specific item's warranty terms.

CATEGORY	CUEL Full Warranty period
Batteries	1 year
Inverters	1 year
Charge controllers	1 year
Solar panels	10 years
Solar water heater	5 years
Solar water Heat pump	1 year

2.2 Specific Terms

The warranty on equipment installed by others is conditional upon the defective unit being promptly returned, without attempts to repair, to Chloride Exide Uganda Ltd service center and collected thereafter when repaired and or replaced. No element of site repair is included in the warranty and any site attendance costs will be payable in full at standard service call out rates.

3) CONTRIBUTORY WARRANTY

If equipment failure occurs in the normal course of service having been competently installed and when operating within its specified duty limits, warranty will be provided as detailed in the table under section 2.1 above. For items falling under the section marked 'full warranty', Chloride Exide (U) Ltd will repair or replace the failed equipment at no cost to the customer.

Exclusions and additional details: -

a) PV Modules

- ✓ Up to Ten years - Panel will be replaced at no charge based on quality issues Including Frame, Cable, and junction box.
- ✓ Up to Twenty-Five years - Panel will be replaced at 50% of prevailing price based on 80% of power output of the solar panel

Note:

- ✓ In the event a third party is used, breakages of Solar panels during transportation and Installation is not covered on warranty.
- ✓ Damage of junction boxes due to either wrong wiring or lightning is not covered on warranty if the installation wa not done by Chloride Exide Uganda Ltd.

Solar Structure

Standard warranty of five years to cover warranty on material defects subject to the solar structure caveats and environmental (no chemical or biological effects) conditions and a one-year warranty on workmanship. Below conditions apply.

- ✓ For wind speeds above 30m/s Client to provide wind breakers.
- ✓ Where security is an issue, its the clients responsibility to provide appropriate means to mitigate the same.
- ✓ Solar structure design assumes a fairly flat ground and where the ground is too sloppy the Client will be advised on the possible measure(s) to take to ensure the system is safe and secure.

4) NEW INSTALLATIONS

Standard warranty period for all new installations is **one year** from date of commissioning excluding the named products (if applicable) to which their standard warranty (see Clause 2) is applicable. During the warranty period defects caused by faulty design, materials or workmanship will be rectified at no charge, though if the Company is called to site to rectify a defect which on investigation is caused by faulty operation, lack of maintenance or general carelessness, all charges for labour, transport and materials used will be payable in full at the Company's standard rates. Upon lapsing of the one year period, labour and transport charges will apply for all subsequent warranty repairs or replacement at the standard Chloride Exide (U) Ltd chargeout rates.

5) PROOF OF PURCHASE

Proof of purchase in the form of the original invoice is required to be shown before Warranty repair or replacement is approved

Customer Name_____

Customer Signature_____

Date_____

D&S DAVIS & SHIRTLIFF
know HOw through experience

Water Pumps
Borehole Service
Swimming Pools
Water Treatment
Generators
Solar Equipment
Irrigation

DAVIS & SHIRTLIFF LTD • PO Box 41762-00100, Nairobi, Kenya • Tel: (+254 20) 6968 000, 0711 079000 • Fax: (+254 20) 557617 • headoffice@dayliff.com

TERMS OF WARRANTY

1) GENERAL LIABILITY

In lieu of any warranty, condition or liability implied by law, the liability of Davis & Shirtliff (hereafter called the Company) in respect of any defect or failure of equipment supplied or for any loss, injury or damage attributable thereto **is limited to making good by replacement or repair** (at the Company's discretion) defects which under proper use appear therein and arise solely from faulty design, materials or workmanship within a specified period. This period commences after the equipment has been dispatched or, if applicable, installed by the Company and at its termination all liability ceases.

This warranty applies solely to equipment supplied or work carried out by the Company and **no claim for consequential damages,** however arising, will be entertained. Also, the warranty specifically excludes defects caused by fair wear and tear, the effects of careless handling, lack of maintenance, faulty installation, and incompetence on the part of the equipment user, acts of God or any other cause beyond the Company's reasonable control. Also, any repair or attempt at repair carried out by any other party **invalidates all warranties**.

2) NEW EQUIPMENT

2.1 General Terms

Standard warranty period for all the brands (hereafter called the named products) is as detailed in the schedule below, subject to the specific terms detailed in clause 2.2.

NOTE:

- ***Consumables e.g., cartridges are not covered by Warranty.***
- ***Components making up the plant or system are covered individually under the specific item's warranty terms.***
- ***Warranty will not be honoured for any equipment that fails within the warranty period where all or some of the payment remains due.***

MODEL	PRODUCT DESCRIPTION	D&S WARRANTY PERIOD (Years)	FULL WARRANTY (Years)	50% WARRANTY (Years)
DAYLIFF SOLAR	Solar Modules	25	10	15
	Huawei SUN2000 Series up to 25kW	10	10	0
	Future Pumps (SF2 and SE1)	10	5	5
DAYLIFF SOLAR & VESSELS	Huawei: SUN2000 Series above 25kW & Power-M Lithuim-Ion Batteries: Champion, DLIP and Huawei	5	5	0
	Solar water heaters: UFD, UFS, UFX, UVT, UVR, CWS, HPW	5	3	2
	GWS & DVX Vessels (diaphragm), Dayliff Polyglas Tanks (up to 16") GRP Filters: CX and DX	5	3	2
HUNTER	Sprinklers & Rotors	5	3	2
DAYLIFF PUMPS & CONTROLLERS	Pumps: DS, DIN, DB, DDC, DDP, DHF, DDJ, DE, DMS, DZ, SVH Motors: Bareshaft Controllers: Italtecnica switches & Controllers	3	2	1
DAYLIFF WATER TREATMENT	Dayliff & Pentair Composite Tanks (18" -63" tanks), Klorman	3	2	1
DAYLIFF BOREHOLE	PVC Borehole pipes, Submersible cable	3	2	1
PEDROLLO	All Surface and Submersible Pumps, Controllers & Accessories	3	2	1

DAB PUMPS	Pumps: SPP, DTRON, Esybox	3	2	1
KOHLER	Engines: KD, KDI	3	2	1
SUBMERSIBLE MOTORS	Pedrollo PD, Dayliff DSM & DSD, Tesla Motors	2	1	1
DAYLIFF PUMPS, CONTROLLERS & VESSELS	Pumps: DBH, DBE, DDC(E), DDP(E), DDW, DDG, DDS, DDF, DDA, DSD, DSP, D3SP, DSS, DDV, DDF, DQ, DDT, DHF, DFP, DWY, DWX, DWW, DWV, DWC, Aquasmart 45, Afridev, India MkII	2	1	1
	Controllers: Sunverter, Trevitech, SCT/M, AVS, Assembled Panels, Dayliff Pump Controller, Standard Control Panels, SmartCon2, and Dayliff Pumpverters	2	1	1
	Dayliff Varem & GWS bladder type vessels	2	1	1
DAYLIFF POOL	Dayliff DPL/DPX Pumps, Heat Pumps, PoolChlor, Pool equipment and accessories, Steam and Sauna, Dayliff Pool Solar Panels, Suncommand, Dayliff & IPP lights, Dayliff Jacuzzi Spa, and Fountain Jets and Lights	2	1	1
	Certikin & Midas Pool equipment and accessories	2	1	1
DAYLIFF GENERATORS	DGY, DGC, DGJ, DGP, DLY	2	1	1
DAYLIFF WATER TREATMENT	Dayliff & Atlas Filtri RO & Softeners, Seko, Mixtron & Dosatron pumps, Dayliff & Mapro blowers, Hach Equipment	2	1	1
DAYLIFF SOLAR	Huawei Backup Box , Opti & Victron Inverters & Charge Controllers, Growatt, Ultraverter, Lorentz pumps, DDPS, DDWS, DHFS, DPSolar, Sunflo (A, B, S, X),Sunfridge, Sunflex & Solar Controllers	2	1	1
DAVEY	All Pumps	2	1	1
GRUNDFOS	Pumps: SP, CR, CM, AP, UP, SE1, UPS, DDE, DDC Accessories: CUE, MP204, RSI	2	1	1
DAYLIFF IRRIGATION	Hunter Controllers & Accessories, Dayliff Irrigation Accessories	2	1	1
DAYLIFF PAYGO	Pumps & Equipment	2	2	0
DAYLIFF SMART METERS	Smart Meters & Prepaid Meters	2	1	1
DAYLIFF DIGITAL ENGINEERING	Power and Energy Meters, Panel Servers	1	1	0
	Building Automation Servers, Sensors, and Actuators	1	1	0
	IoT Remote Terminal Units (RTU), Gateways & Protocol Converters, Wireless Transceivers	1	1	0
	Industrial Drives & Soft starters	1	1	0
	Programmable Logic Controllers (PLC), Human Machine Interfaces (HMI)	1	1	0
	Industrial Actuators & Process Instruments	1	1	0
DAYLIFF ENGINE PUMP, GENERATORS & POWER TOOLS	Engine Pumps: DC, DCT, DCX, DCI, Pressure Washers Generators: DG, DG-D, DGW, Mower-P, Mower-S, Multi-4 Engines: DOB, DLA, DLV Tools: Trimmers	1	1	0
OTHER DAYLIFF & BIOLIFF	Champion VRLA Batteries, Izzy & Vispra Inverters, Street lights, Pathway lights	1	1	0
	Sita Purifiers & Lamps, SoSafe products, SBR System, Ecorock, Biopure, Enpure System & WWTP	1	1	0
	Drytek, Express, Smart 2	1	1	0
	Dayliff valves, Dayliff water meters	1	1	0
	Solar Structure & SunTower	1	1	0
GRUNDFOS	SQ, SQF and SP motors	1	1	0
DAVEY	Chlorinators, Testers, and accessories	1	1	0
DAYLIFF ECONO ENGINE PUMP, GENERATORS	DC(Econo), DG(Econo)	6 months	6 months	0

2.2 Specific Terms

The warranty on equipment installed by others is conditional upon the defective unit being promptly returned free to D&S Workshop and collected thereafter when repaired. No element of site repair is included in the warranty and any site attendance costs will be payable in full at standard charge out rates.

3) CONTRIBUTORY WARRANTY

If equipment failure occurs in the normal course of service having been competently installed and when operating within its specified duty limits, warranty will be provided as detailed in the table under section 2.1 above. For items falling under the section marked 'full warranty', D&S will repair or replace the failed equipment at no cost to the customer. Customers will however be required to make a 50% contribution for repair or replacement of all equipment failures outside this window but within the overall warranty period. Reference pricing is the prevailing Davis & Shirtliff Market price at the time of making the claim.

Exclusions and additional details: -

a) PV Modules

Up to Ten years **-** Panel will be replaced **at no charge** based on quality issues Including Frame, Cable, and Junction Box.

Up to Twenty-Five years - Panel will be replaced **at 50% of prevailing price** based on 80% of power output of solar panel.

Note:

- Breakages of panels during transportation and installation is not covered on warranty.
- Damage of junction boxes due to either wrong wiring or lightning is not covered on warranty.

b) Huawei Inverters

Standard warranty on Huawei SUN2000 Series can be extended by 5, 10 or 15years at an extra cost billed to the customer.

c) Dayliff Reverse Osmosis (BRO/DRO) and Dayliff Ultrafiltration (BUF/DUF) Plants

Standard warranty on Dayliff RO Plants and Dayliff UF Plants is one year from the invoice date. An operator's log must be produced at the point of lodging the claim demonstrating regular use of Dayliff Antiscalant Chemicals as proof of proper plant operations. Davis & Shirtliff will not bear any warranty cost obligation arising from the use of chemicals other than those specified during plant design or because of improper plant operations.

d) Solar Structure and SunTower

Standard one year warranty to cover material defects and workmanship subject to the solar structure caveats and environmental (no chemical or biological effects) conditions.
Below conditions apply;

- For wind speeds above 30m/s, Client to provide wind breakers.
- Solar structure design assumes a fairly flat ground and where the installation area has a steep gradient, the Client will be required to make arrangements for levelling the ground.

e) Engines and Generators

Standard warranty on fixed speed Engines and Generators is two years or 1,200 running hours (whichever comes first) from the invoice date. However, for the Outboard Engines the warranty period is 1 year or 1,000 running hours (whichever comes first) from the invoice date. A **maintenance chart** must be produced at the point of lodging the claim as a proof of proper maintenance routine. Davis & Shirtliff will not bear any cost obligation resulting from incorrect mounting or storage according to the Standard Mounting, Maintenance and Operation Manual.

f) Dayliff Pump Sets

Warranty will be applied on the individual components.

g) Electric Motors and Power Equipment

Standard warranty on new electric motors is as detailed by model in table 2.1 above, whether being part of a named product or not, though since motors can fail due to many factors beyond the Company's control, any warranty is conditional upon the following: -

- The motor is provided with an approved control panel, including an appropriate electro-magnetic starter with correctly rated overload, for all three phase installations and high current cut-out for single phase installations. In addition, for all three phase submersible borehole installations, a high and low voltage plus phase control relay must be provided.
- For Submersible motors failures resulting from power-related faults (single phasing, overvoltage, undervoltage, overload, etc) warranty will be conditional upon the control panel having been supplied by D&S.
- For submersible motors above 7.5kW, warranty will be conditional upon the equipment being fitted with a monitoring & communication device – iDayliff, MP204 or equivalent.
- The pump and control panel are permanently installed with fixed electrical connections. Any installations involving temporary connections will not be covered by the warranty.
- No claim will be entertained when there is evidence that a motor has operated with electricity supply beyond the manufacturers' specified limits and tolerances for frequency, voltage and phase symmetry, nor when there is evidence of incorrect connection to the power supply.
- Where the named product carries a shorter warranty period than two years, the warranty on the motor will be equivalent to that of the named product.

h) Water Pumps

Most pumps supplied are designed specifically for applications involving clean, cold (up to 30^0C) water. **No warranty** will be provided against wear and subsequent damage if the pumped water **does not conform to this condition** unless the pump has been specified by the Company or the manufacturer.

As all pumps are water lubricated **serious damage** can occur if they are run without water. For this reason, the Company specifically excludes itself from any warranty claims where there is evidence that damage to the pump has been caused by running dry or other damage resulting from installation conditions not approved by the manufacturer.

i) Digital Engineering Solutions

Standard warranty period for software deployment including Internet of Things (IoT), Power Monitoring System, Building Management Systems (BMS), Supervisory Control and Data Acquisition (SCADA), and Programmable Logic Controller (PLC) / Human Machine Interfaces (HMI) systems is **three months** from date of **practical completion**. This does not cover changes/addition of new features not in the contract/proposal. Software upgrades, updates and reinstallations will be scoped, and costs billed to the customer.

Equipment listed in Table 2.1 as part of Digital Engineering Solutions should be operated within design conditions. Davis & Shirtliff **will not** bear any cost obligation resulting from incorrect installation (where undertaken by the customer) and use according to the Standard Installation, Maintenance & Operation Manual.

j) Theft of Equipment

Equipment stolen from site during or after installation will not be covered under warranty. Clients will be expected to offer security during and after installation.

4) EQUIPMENT REPAIRS

Standard warranty period for all repaired equipment is **three months** from date of collection or installation by the Company provided the warranty claim is attributable to a defect in any spare part fitted during repair. Failures caused by defects in components not repaired are specifically excluded. Also, due to the fact that failure can be caused by many factors beyond the Company's control, the warranty period on re-wound motors is limited to **one month** when equipment re-installation is carried out by the Company and **no warranty** will be given on re-wound motors when re-installed by others.

5) NEW INSTALLATIONS

Standard warranty period for all new installations is **six months** from date of commissioning excluding the named products (if applicable) to which their standard warranty (see Clause 2) is applicable. During the warranty period defects caused by faulty design, materials or workmanship will be rectified at no charge, though if the Company is called to site to rectify a defect which on investigation is caused by faulty operation, lack of maintenance or general carelessness, all charges for labour, transport and materials used will be payable in full at the Company's standard rates. Upon lapsing of the six month period, labour and transport charges will apply for all subsequent warranty repairs or replacement at the standard Davis & Shirtliff chargeout rates.

6) PROOF OF PURCHASE

Proof of purchase in the form of the original invoice is required to be shown before Warranty repair or replacement is approved.

Davis & Shirtliff Ltd, Kenya, Nairobi, Dundori Road Industrial Area, PO Box 41762 - 00100, Tel: +254 20 6968000, headoffice@dayliff.com

Davis & Shirtliff (International) Ltd, Kampala, Uganda, Jinja Road, PO Box 22824, Tel: +256 783 065273, UGEnquiries@dayliff.com

Davis & Shirtliff Tanzania, Dar es Salaam, Gerezani Road, PO Box 10725, Tel: +255 22 2112515, daressalaam@dayliff.com

Davis & Shirtliff Zambia, Lumumba Road, PO Box FW 112, Lusaka, Tel: +260 211 845010/1, DeptZMsales@dayliff.com

Davis & Shirtliff Rwanda, Kigali, Muhima Road, BP 7039 +250 252 504039, kigali@dayliff.com

Davis & Shirtliff Zimbabwe, Harare, 16911 Nongerai Complex Seke Road +263 24 2576246, +263 24 2576247, zimbabwe@dayliff.com

Davis & Shirtliff DRC, Lubumbashi, No. 20734, Boulevard Msiri +243 978 115412, +243 852 758553, drc@dayliff.com

Davis & Shirtliff South Sudan, Tong Ping, Juba Nabari Plot No. 9, Tel: +211 927 000020, juba@dayliff.com

Davis & Shirtliff Zanzibar, Mlandege Street,Tel::+255 774 202069, zanzibar@dayliff.com

Davis & Shirtliff Somalia, Mogadishu, Villa Baydhaba Buulahuubey,Tel: +252 619 332 540, somalia@dayliff.com

Davis & Shirtliff Ghana, Accra, Nii Adjetey Osae Ave East Legon, behind AH Hotel,Tel:+233 552 711 577, ghana@dayliff.com

June 2024

BYD Battery-Box Limited Warranty

This Limited Warranty applies to BYD Battery-Box LV Flex Lite ("Product") installed individually or in parallel (on the condition that the Usable Energy of Products is less than 50kWh in total) in Middle East and Africa excluding South Africa on or after Oct. 1st, 2021.

Shenzhen BYD Electronic Co., LTD ("**BYD**") provides the warranties in this document ("**Limited Warranty**") to the person who purchases the Product for their use and puts the Product into operation for the first time (**"Original Buyer"**).

1. LIMITED WARRANTY

1.1. Warranty Start Date

Generally, Warranty Start Date is the first day after six (6) months from the Production Date of the Product (Refer to the Appendix of this Limited Warranty to find out the Production Date). But if Original Buyer can provide the written documents (such as receiving note) to prove the time when Product is delivered to the installation site where the Product is installed and operated for the first time ("Delivery Date"), Original Buyer can choose the first day after thirty (30) days from the above Delivery Date as Warranty Start Date.

1.2. Limited Product Warranty

BYD warrants that the Product will be free from defects in materials or workmanship for five (5) years from Warranty Start Date, subject to the exclusions and limitations set out below.

1.3. Limited Performance Warranty

a) BYD warrants that the Product will (i) retain sixty per cent (60%) of its Usable Energy for seven (7) years from the Warranty Start Date ("Original Period") (If the Product connecting to the internet within the Original Period, the period of the Limited Performance Warranty will extend to ten (10) years); or (ii) reach the Minimum Throughput Energy, whichever comes first, on the condition that the Product is operated in a normal manner that adheres to the manual guidelines provided by BYD.

b) The Minimum Throughput Energy means the total output energy of the Product recorded in the control module of the Product.

c) The Usable Energy and Minimum Throughput Energy for each Product Model are set out in the table below:

Product Model	Usable Energy(kWh)	Minimum Throughput Energy (MWh)
LV Flex Lite	5	14.85

d) For this Limited Warranty, the remaining Usable Energy is as measured and calculated using the following testing method and values, while the ambient temperature is between 25~ 28° C:

- Discharge the battery with constant current until the battery reaches End of Discharge Voltage ("EODV") or its self-protective voltage.
- Wait for 10 minutes.
- Charge the battery with constant current and constant charge voltage to its full capacity.
- Wait for 10 minutes.
- Discharge the battery with constant current until it reaches EODV or its self-protective voltage. Record the current, voltage and time.
- The remaining Usable Energy is the integral of discharge time and current multiplied by voltage.

Test value list:

Product model	End of discharge voltage(V)	Constant charge voltage(V)	Constant current(A)
LV Flex Lite	40	59	20

1.4. Limited Performance Warranty for additional battery modules

If Original Buyer purchases additional battery modules after the initial installation of the Product (“Subsequent Product”), the warranty in clause 1.3 applies to the Subsequent Product from the sale date recorded in the seller`s invoice to the Original Buyer of that Subsequent Product.

1.5. Warranty Limitations

The Limited Warranties in clauses 1.2 and 1.3 are subject to and must be read together with the limitations, exclusions and limitations set out below.

2. EXCLUSIONS AND LIMITATIONS

2.1. Disclaimer

a) To the extent permitted by law, the warranties in this Limited Warranty are the only express warranty given for the Product. BYD disclaims all statutory and implied warranties, including without limitation, any warranties of merchantability, fitness for a particular purpose, or non-infringement. To the extent permitted by law, in so far as such warranties cannot be disclaimed, BYD limits the duration and remedies of such warranties to the duration of this Limited Warranty and, at BYD's option, the repair or replacement services described below.

b) Neither seller of the Product nor any other person is authorized to make any warranties on behalf of BYD other than those contained in this document or to extend the duration of the warranties beyond the periods specified above.

2.2. Limitation of Liability

Except as provided in this warranty and to the maximum extent permitted by law, in no event will BYD be liable for any consequential, incidental, special or punitive damages (including without limitation of loss of profits, harm to goodwill or business reputation, or delay damages) arising from or out of the Product or its installation, use, performance or non-performance, or any defect or breach of warranty, whether based on contract, warranty, negligence, strict liability, or any other theory. BYD's aggregate liabilities, if any, in damages or otherwise, shall not exceed the purchase price paid by the Original Buyer for the Product.

2.3. Warranty Limitations

The Limited Warranty in clauses 1.2 and 1.3 does not apply to any defect or deterioration resulting from:

a) the Product not being installed, maintained or operated by the Operating Manual;

b) exposure of the Product to movement or shaking following installation, or temperatures greater than 50°C or less than -10°C;

c) Original Buyer failing to notify BYD or a BYD Authorized Service Partner (**"BYD Partner"**) of the defect or deterioration within 30 days of Original Buyer becoming aware of the defect or deterioration;

d) the Product not being installed within one (1) month from Warranty Start Date;

e) operation of the Product with an inverter that is not a BYD certified inverter which are specified in the **BYD Battery-Box LV Flex Lite Minimum Configuration List**, which is available on the websites: www.bydbatterybox.com;

f) modification or repair of the Product without the approval of BYD or BYD Partner;

g) a force majeure event (e.g. natural catastrophes, such as flooding, fires, earthquakes, lightning or other abnormal environmental conditions, war, etc.);

h) noticeable damage to the Product that occurred during transportation;

i) changes to national or regional laws, regulations or directives; or

j) the Product not being operated for any period of 6 months or more.

2.4. Warranty Exclusions

The Limited Warranty in clauses 1.2 and 1.3 does not apply:

a) if the Product was not purchased in Middle East and Africa;

b) if Original Buyer does not grant BYD or BYD Partner access to the performance data of the Product over the Internet upon request after reporting the warranty claim or manipulate such data;

c) to wear and tear in the appearance of the Product (including but not limited to any scratches, stains, mechanical wear, rust or mould) which does not impair its function;

d) to any damage to property or personal injury arising from any defect if the state of scientific and technical knowledge at the time when the Product is sold to Original Buyer was not such as to enable the defect to be discovered;

e) if the invoice for the Product and the information listed in clause 4 below is not provided with the warranty claim; or

f) if the serial number on the Product can no longer be identified or has been modified.

2.5. Exclusion for Larger Installed Systems

The Limited Warranty in clause 1.3 does not apply to a Product which is installed in parallel with other Products which have a combined Usable Energy of more than 50 kWh.

3. REMEDY FOR BREACH OF WARRANTY

3.1. Subject to the exclusions and limitations set out above, if the Product fails to comply with the Limited Warranty in clauses 1.2 or 1.3, BYD will repair or replace the non-conforming Product or parts thereof within the warranty term at no charge (or provide a partial refund) on the following conditions.

3.2. Whether to repair or replace the Product will be determined by BYD in its sole discretion.

3.3. The Product or any of its parts to be replaced will have the same performance and reliability as the original Product. If the production of the relevant type of the Product or any of its parts has been discontinued, withdrawn from the market, or are otherwise unavailable, BYD may replace the Product or parts with a similar Product or part (which may include previously used parts that are equivalent to new in performance and reliability).

3.4. If BYD does not repair or replace the defective Product or parts, BYD will refund Original Buyer an amount of money calculated as follows:

a) If the Product fails to comply with the Limited Performance Warranty in clause 1.3, BYD may calculate the refund using one of the two refund formulas below:

i) Refund = maximum claim amount* x (warranted Minimum Throughput Energy - output energy of the Product recorded in the control module of the Product)/ warranted Minimum Throughput Energy; or

ii) Refund = maximum claim amount* x (warranted remaining Useable Energy - remaining Useable Energy)/ warranted Usable Energy; and

b) If the Product cannot be operated, BYD will calculate the refund as follows:

Refund = (maximum claim amount*/60) x (60 - number of months since Warranty Start Date).

*The maximum claim amount is the market value of the Product (or an equivalent Product) determined by BYD if it were purchased new and free of defects.

3.5. The remedies as set out above are the sole and exclusive obligations of BYD to Original Buyer under this Limited Warranty and BYD will have no other liability to Original Buyer if the Product fails to comply with the Limited Warranty.

4. FULFILMENT

4.1. If Original Buyer wishes to make a warranty claim under this Limited Warranty, the warranty claim must be reported in writing to BYD Partner (or, if Original Buyer is unable to contact them, BYD Global Service) including the information specified in the table below.

1	Installation Date*	
2	Invoice Number*	
3	Battery-Box Configuration*	e.g. LV Flex Lite(X modules)
4	Serial Number of the Product*	
5	Serial Number of Modules	
6	Serial Number of BMU	
7	Firmware Version BMS/BMU	
8	Inverter*	
9	Inverter Configuration	
10	Serial Number of the Inverter	
11	Firmware Version of Inverter	
12	Working Mode	e.g., On-Grid +Backup
13	Place	e.g., indoor
14	Comments	
15	Error Information	
16	Country	
17	Street and Number	
18	Postcode and City	

* mandatory to provide

Contact information:

BYD Global Service

Address: No.3009, BYD Road, Pingshan, Shenzhen, 518118, P.R.China

Service Mailbox: bboxservice@byd.com

Telephone: +86 755 89888888- 47175 (CN)

Website: www.bydbatterybox.com

4.2. BYD or BYD Partner is authorized to invoice its inspection costs if:

a) the inspection of the Product by BYD or BYD Partner shows that the Limited Warranty does not apply, for whatever reason; or

b) no defects were found during the inspection of the Product, and it works without error.

4.3. Unless otherwise agreed with BYD or BYD Partner, any replaced Product or parts shall be either made available for pick up by BYD or BYD Partner within four weeks after the replacement or (if required by BYD or BYD Partner) disposed of by Original Buyer and BYD will pay Original Buyer reasonable costs of disposal.

4.4. The replaced Product or parts become the property of BYD.

4.5. The original warranty periods for the Product shall still apply to any repaired or replacement Product which means the warranty for the repaired or replaced parts will be the remaining warranty period for the originally purchased Product.

4.6. BYD or BYD Partner shall not be responsible or liable in any way to Original Buyer for any non-performance or delay in BYD's performance of its obligations under this Limited Warranty due to occurrences of force majeure events such as natural disasters, war, riots, strikes, unavailability of suitable or sufficient labour, material, or capacity or any unforeseen event beyond its control.

5. OUT OF WARRANTY

In the event the Product is out of warranty, BYD may (in its discretion) provide certain after-sales service to Original Buyer, but all the costs and expenses, such as parts, labour costs and travel expenses, shall be borne by Original Buyer. To request such after-sales service Original Buyer must provide sufficient information about any defects, to enable

BYD Partner to determine whether such defects are capable of repair.

6. MISCELLANEOUS

6.1. This Limited Warranty is governed exclusively by local law, without regard to its choice of law provisions.

6.2. The local courts of Hong Kong shall have non-exclusive jurisdiction for further disputes about a warranty claim arising from this Limited Warranty. In case of a judicial assertion, BYD, but not BYD Partner, is responsible for sending or receiving lawsuit documents.

6.3. Original Buyer may be entitled to legal rights regarding the sale of goods according to national law. This Limited Warranty does not limit their possible statutory rights or rights arising from the purchase contract.

6.4. If any provision or part of a provision of this Limited Warranty is held or found to be void, invalid or otherwise unenforceable (whether in respect of a particular party or generally), it will be deemed to be severed to the extent that it is void or to the extent of voidability, invalidity or unenforceability, but the remainder of that provision will remain in full force and effect.

6.5. As a condition of making a warranty claim Original Buyer agrees that any dispute on technical facts relating to claims brought under this Limited Warranty may be referred by BYD to expert determination by the then-current Resolution Institute Expert Determination Rules, except that:

a) the expert must be a reputable testing organization such as TÜV Rheinland, TÜV SUD, Intertek, UL, CQC or CGC or any other mutually acceptable neutral third-party testing organization (**Expert**);

b) the costs of the Expert, including any costs of shipping any Product to the Expert for testing, are payable by Original Buyer if:

i) Original Buyer does not withdraw Original Buyer claim within 14 days of BYD notifying Original Buyer that it intends to refer the dispute to an Expert; and

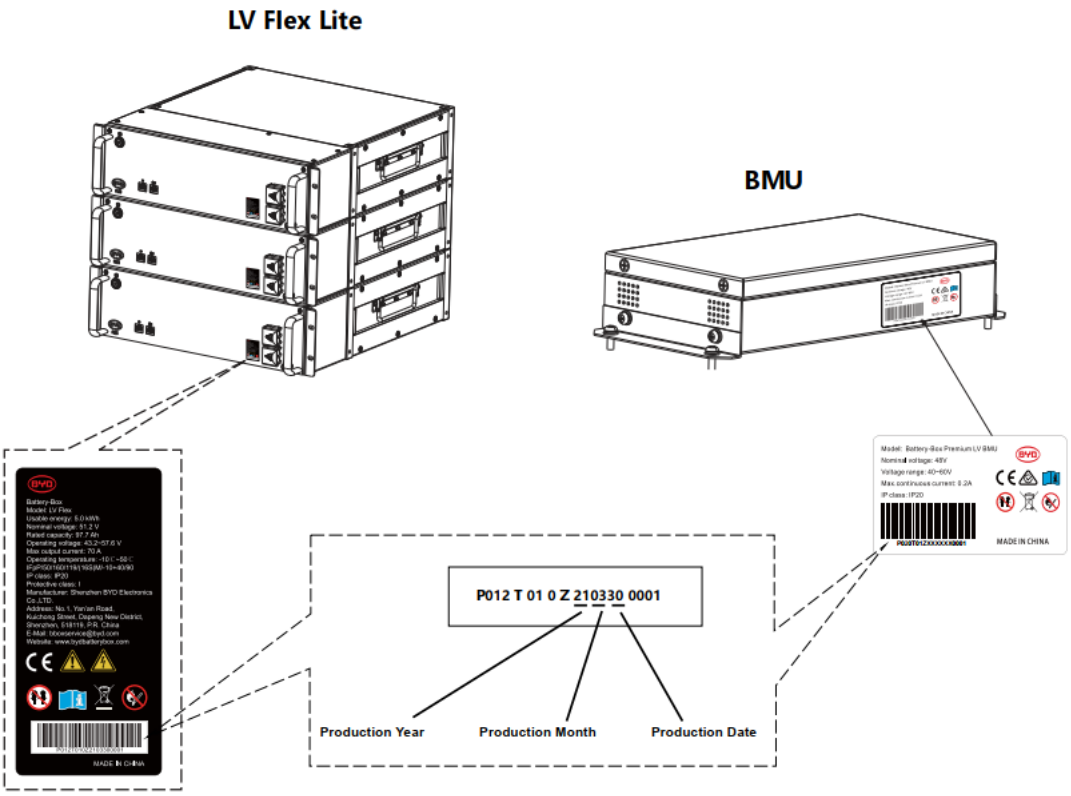
ii) the Expert determines the dispute in favour of BYD.

In all other cases, BYD will pay those costs.

Appendix

The Production Date of the Product could be read from the serial number on the label of the Product as shown in the drawing below. The definition of the serial number regarding the production date are the same for the battery modules and BMU.

In the example drawing below, the “21” underlined means the production year is 2021, “03” means the production month is March, and “30” means the production date is the thirtieth day of that month.



Appendix 7 Draft Service Agreement for Streetlights

AGREEMENT FOR MAINTENANCE AND SERVICING OF STREETLIGHTS

1. PARTIES

This agreement is made between …… (*the Client*) and ……. (*the Contractor*)

2. RECITAL

The Parties have entered a contract (*Ref. No.: ……*) for service, repair, and maintenance of streetlights on selected roads in the municipality/city as per the attached Terms of Reference, effective this …… day of ……., …….

NOW THEREFORE, in consideration of the above, the Parties do hereby agree as follows:

3. DEFINITIONS

When initially capitalized in this Maintenance Agreement or amendments thereto, the following words or phrases shall have the meanings specified

a) Dawn: The time between full dark and sunrise when a Photocontrol senses sufficient sunlight to turn off streetlights
b) Dusk: The time between sunset and full dark when a Photocontrol senses the lack of sufficient sunlight and turns on streetlights
c) Effective Date: The specified date in the Contract for the commencement of the Maintenance activities
d) Solar Panel: is the energy generating component responsible for harvesting energy from the sun and converting it to a usable form of electric energy
e) Battery: This is the energy storage and supply component of the system. Its capacity is measured in Ah.
f) Charge Controller: It harvests the current to charge the battery during the daytime and discharges the battery during the night to power the LED lamp.

g) Luminaire: This is the lamp module that transforms electric energy to light energy.
h) Streetlight Pole: This supports all components of the streetlight, including internal wiring and protection devices.
i) Base: This is the concrete platform on which the supporting pole is anchored with bolts and nuts.
j) Streetlighting System: Refers to the entire unit which includes the pole, batteries, solar panels, LED luminaire, Charge controller, internal wiring, and base.

4. GENERAL TERMS AND CONDITIONS OF THE AGREEMENT

The contractor shall operate and maintain the streetlighting systems within the locality of the City/Municipality in accordance with the following terms and conditions.

a) **Operation Time**: The streetlights shall operate from dusk to dawn, unless under prolonged repairs.
b) **Frequency of Maintenance**: The Contractor shall carry out routine maintenance of the streetlights every three (03) months. Works shall be completed within five (05) days.
c) **Contractor's Personnel**: The Contractor shall mobilize certified and skilled personnel to site to carry out maintenance and repair works. A personnel schedule shall be shared with the Client prior for issuance of work and access permits.
d) **Contractor's Equipment and Tools**: The Contractor shall have inventory of all appropriate tools and machines and work-at-height equipment to carry out maintenance of the streetlights. The equipment should be in good working conditions to reduce downtime.
e) **Spare Parts**: The Contractor shall always maintain a suitable inventory of all critical spares like LED luminaires, solar panels, charge controllers, batteries, and wires.

f) **Repairs and Downtime**: The Contractor shall replace all faulty parts on the streetlight within two (02) days, upon notification from the Client.

5. ROLES AND RESPONSIBILITIES

a) Contractor's Obligations

The Parties agree that the Contractor shall be responsible for the following tasks with regards to the Contract.

- Quarterly routine inspection and preventive maintenance, and submission of a status report on performance of the streetlights.
- Keep updated inventory lists and records showing, Geographic Information Systems (GIS) location of streetlight facilities, performance at different service intervals, lamp rating, type of pole and luminaire, etc.
- Replacement of malfunctioned LED luminaires, batteries, solar panels, controllers, and wires.
- Replacement of all damaged poles and fixtures that might be damaged by traffic accidents, weather, or related incidences.
- All concrete and civil works associated with pole replacements.
- Relocation and upgrade of streetlighting facilities in the event of road widening projects.
- Upgrade works in terms of need for change in equipment technology and standards.
- Provide all information such as documents, photographs, and testimonials related to the works performed under the Contract.

b) Client's Obligations

The Parties agree that the Client shall be responsible for the following as per the terms of agreement.

- Provide all relevant and required information to the contractor to fulfill the Contract.

- Provide the Contractor with reasonable ingress and egress for the performance of services under this Contract.
- To approve payment requests and effect payment to the contractor as stipulated in this contract in a timely manner.
- Upon notice, investigate and pursue claims against any parties responsible for accidents involving damage to streetlighting installations.

6. QUALITY OF WORKS AND WARRANTY

The works, components and materials shall conform to the technical specifications, drawings, surveys, models, samples, patterns, and other requirements in the contract, which must be held at the disposal of the Client or the Engineer for the purposes of identification throughout the period of performance. The contractor shall provide to the client warranty of two years for all equipment against manufacturer defects and poor workmanship.

7. CLAIMS, PAYABLES AND TAXES

a) **General:** All payment claims by the Contractor shall be paid quarterly upon submission of invoices and verification of worksheets by the Client's technical representative for non-warranty works.

b) **Cost of Spares Parts**: Appended to this Contract are the itemized costs of all major system components. These will be subjected to the following terms.
   - The Client shall pay for spare parts used in replacing vandalized equipment.
   - The Contractor shall bear the costs of parts replacement due to failure during the defects liability period, as this is deemed a warranty replacement.
   - The Contractor shall bear the cost of parts replacement due to poor workmanship.

c) **Emergency Repairs:** Charges for works done on emergency basis, as requested by Client, shall be based on actual costs in the approved bill of quantities, and paid as per the terms of Contract.

d) **Labor charges**: Unit labor charges include professional charges, cost of sundries and consumables, and specialized support equipment. This shall be payable for both routine maintenance visits and emergency response.

e) **Transport charges**: Transport charges include personnel facilitation and movements, and delivery of materials. This shall be payable for both routine visits and emergency response.

f) **Disputed Claims**: If any portion of any bill is disputed, the undisputed amount shall be paid when due.

g) **Taxes**: The Client shall pay all applicable sales tax, transaction privilege tax, use tax or like tax assessed or assessable as the result of the Contractor providing services hereunder.

8. PERFORMANCE SECURITY

Within seven (7) days after the signature of this Contract, the contractor shall furnish the Client a performance security in the form of bank guarantee or insurance bond in the amount of 10% (ten percent) of the total contract price, which shall remain valid until the completion and handover of all works pertaining to this contract.

9. DURATION OF CONTRACT

This Service agreement shall terminate after three (03) years from the effective date. The Contract shall be extended for a subsequent period of three (03) years under the same terms and conditions, unless either party issues a notice of its intention not to renew within ninety (90) days prior to scheduled termination.

10. PENALTIES

a) The contractor shall not be responsible for delays caused by force majeure or occurring caused by the Client. In such cases, the contractor shall be entitled to an extension of time equal to the period lost due to such event(s).

b) In case the Contractor fails to carry out maintenance works within the term specified hereunder due to unjustified reasons, for each working day delayed in the completion of the works, the Contractor shall pay to Client a sum equal to 0.25% of the total contract price per day as liquidated damages. However, the maximum amount of the liquidated damages shall not exceed 10% (ten percent) of the total contract price. Once this limit has been reached, it will be deemed that the contractor has failed to meet their contractual obligation, and the contract will automatically be terminated, without further reference to the contractor

11. NON-WAIVER

The failure of either Party to insist upon strict performance of any of the provisions of this Maintenance Agreement, or to exercise any of the rights or remedies provided by this Maintenance Agreement, or any delay in the exercise of any of the right or remedies, shall not release either Party from any of the responsibilities or obligations imposed by law or by this Maintenance Agreement, and shall not be deemed a waiver of any right of either Party to insist upon strict performance of this Maintenance Agreement.

12. TERMINATION

Both parties may terminate the Contract due to any fundamental breach of the contract, which include, but shall not be limited to the following.

1) If either party is bankrupt or goes into liquidation.
2) If the Contractor fails to respond to a notice for service within a reasonable period as per the terms of Contract, which represents a fundamental breach of contract.
3) If the contractor, in the judgment of the Client has engaged in non-professional, unethical, corrupt, fraudulent, collusive, or coercive practices in executing the contract.

13. GOVERNING LAW AND VENUE

Unless provided otherwise in the request for quotation, bid document or any other documents, the contract shall be subject to and construed following the laws of the Republic of Uganda. The place of jurisdiction is the Republic of Uganda.

14. FORCE MAJUERE CLAUSE

"Force Majeure" means an event or situation beyond the control of the contractor that is not foreseeable, is unavoidable, and its origin is not due to negligence or lack of care on the part of the contractor. Such events may include, but not be limited to, acts of wars or revolutions, fires, floods, epidemics, quarantine restrictions, and freight embargoes.

If a Force Majeure situation arises, the contractor shall promptly notify the Client of such condition and the cause thereof. Unless otherwise directed by the Client in writing, the contractor shall continue to perform its obligations under the contract as far as reasonably practicable and shall seek all reasonable alternative means for performance not prevented by the Force Majeure event.

The contractor shall not be liable for forfeiture of its performance security or retention monies held, liquidated damages, or termination for default if to the extent that its delay in performance or another failure to perform its obligations under the contract is the result of an event of Force Majeure.

15. APPENDICES TO THIS CONTRACT

The following documents shall be an integral part of the Contract.

- Signed copy of the Contract
- Signed Code of Conduct for Public Service Providers
- Approved Bills of Quantities from the Contractor
- List of critical spare parts
- Terms of Reference for Servicing of Streetlights

- Technical specifications and datasheets of the equipment
- Contractor's Personnel Schedule
- Contractor's Equipment Schedule
- Schedule of Works
- Streetlight Testing Framework
- Any other written documents required under the provision of this contract

16. SIGNATORIES TO THE CONTRACT

For CLIENT

.....

For CONTRACTOR

.....

Appendix 8 UNRA Streetlighting Specifications

TECHNICAL SPECIFICATIONS FOR SOLAR STREET LIGHTING SYSTEM

Sr. No	Components	Specification for Solar street light fitting
1.	PV module	400 Wp under STC (configured as Two panels of 200Wp)
2.	Battery	Minimum 25.4V, 100 AH capacity Lithium Ferro Phosphate battery. CE marked, paired with suitable MPPT charge controller.
3.	Light Source	White Light Emitting Diode (W-LED) At most 90 Watt, W-LED luminaire, dispersed beam, soothing to eyes, with the use of proper optics and glass diffuser. LED Chip should be compliance to IES: LM-80 (Approved Method for Measuring Lumen Maintenance of LED Light Sources and LED lumen depreciation time to L70). Test report for same should be submitted.
4.	Light Out put	The luminaire must use high efficacy W-LED with minimum 140 lumens per watt (and UV free). [A certificate to be submitted by the System supplier to the Engineer during certification] **For single light level (No Dimming profile):** Minimum 100 Lux when measured at a point 4 meters below the light. The illumination should be uniform without dark bands or abrupt variations, and soothing to the eye. Higher light output will be preferred. **For Multiple Light levels(With Dimming Profile):** The luminaire should have two levels of light to take care of different lighting needs during the night. Minimum 100 Lux when measured at a point 4 meters below the light (at'' High'' illumination level). The illumination Should be uniform without dark bands or abrupt variations. Minimum 50 Lux at lower illumination level. (Higher light output will be preferred) The luminaire shall be tested for Electrical, Photometry and Color parameters as per IES LM-79:2008 for following performance parameters like: 1) Total luminous flux: ≥ 12,000 lm. 2) Luminous efficacy (i.e. system efficacy): ≥ 140 lm/W. 3) Colour Temperature: At most 4000 K

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		4) CRI ≥ 70 5) Luminous intensity distribution should follow the batwing patterns in polar curves. 6) Require validation report using .ies file, which is generated during luminous intensity distribution test and using maintenance factor 0.8 and pole height of 10m., Road width 7m and Pole span 44m. The average illuminance level uniformity should comply with requirement as BS EN 13201 -2:2015, wherever applicable. 7) The luminaire should be tested for all type tests as per IEC 60598-2-3 standards.
5	Mounting of light	Pole height 10 m above the ground level and 2 m from road edge.
6	Electronics Efficiency	Overall total Efficiency of the Electronics should be Minimum 90%
7	Duty Cycle	Dusk to dawn: First 4 Hours full light , rest of the time at lower light (50%) level. (**No dimming will be preferred**)
8	Autonomy	3 days or Minimum 33 operating hours per permissible discharge with fully charged Lithium-Ferro Phosphate Battery.
9	Ingress Protection – IP	Optical and Control gear compartment - IP 65 / IP 66
10	Impact resistance of casing	≥ IK 08
11	Steel Pole	Galvanized Steel Pole (If painted only white paint) Circular tapered or Octagonal Tapered without any midwelds horizontal to pavement (One piece) with baseplate as per drawing
12	Connectors	Only snap on connectors shall be used similar to MC4 No taping nor twisted conductors shall be allowed.

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TECHNICAL DETAILS:

PV MODULE

i. The PV module should have Mono-crystalline silicon solar cells and must have a certificate of testing conforming to IEC 61215 Edition II from IECQ accredited Laboratory.
ii. The power output of the module under STC should be a minimum of 200Wp per panel.
iii. Two Panels per Luminaire to create a total of 400Wp.
iv. The module efficiency should not be less than 16 %.
v. There should be a Name Plate fixed inside the module which will give:
    a. Name of the Manufacturer or Distinctive Logo.
    b. Model Number
    c. Serial Number
    d. Year of manufacture

BATTERY

i. Minimum 25.6V, 100 AH capacity Lithium Ferro Phosphate Battery.
ii. Battery pack should have proper 'Battery management System' (BMS) for cell balancing, over charge and over temperature protection.
iii. Battery should conform to the latest International standards.
iv. A minimum Cycle life @ 80 % DoD of 2500 cycles and 25 °C, using Grade A cells.
v. There should be a Name Plate fixed on the Battery module which will give:
    1. Name of the Manufacturer or Distinctive Logo.
    2. Model Number
    3. Serial Number
    4. Size or Battery Rating

LIGHT SOURCE

i. The light source will be a white LED type.
ii. The colour temperature of white LED used in the system should be in the range of ≤4000K.
iii. The light output from the white LED light source should be constant throughout the duty cycle.
iv. The lamps should be housed in die cast aluminium housing.
v. The temperature of heat sink should not increase more than $20^{o}C$ above ambient temperature during the dusk to dawn operation.
vi. The Luminaire should weigh ≥ 7kg

ELECTRONICS

i. The total electronic efficiency should be at least 90 %.

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ii. Charge controller must be MPPT Type.
iii. Electronics should operate at an appropriate voltage suitable for proper charging of the battery.
iv. No Load current consumption should be less than 20 mA.
v. The PV module itself should be used to sense the ambient light level for switching ON and OFF the lamp.
vi. The PCB containing the electronics should be capable of solder free installation and replacement.
vii. Necessary lengths of wires/cables, switches suitable for DC use and fuses should be provided.

ELECTRONIC PROTECTIONS

i. Adequate protection is to be incorporated under "No Load" conditions e.g. when the lamp is removed and the system is switched 'ON'.
ii. The system should have protection against battery overcharge and deep discharge conditions.
iii. The System should have protection against short circuit conditions.
iv. Protection for reverse flow of current through the PV module(s) should be provided.
v. Adequate protection should be provided against battery reverse polarity.
vi. Load reconnect should be provided at 80% of the battery capacity status.

MECHANICAL COMPONENTS

I. A corrosion resistant metallic frame structure should be fixed on the pole to hold the SPV module.
II. The frame structure should have provision so that the module can be oriented at the suitable tilt angle.
III. Pole should be Hot dip galvanized pipe as per Hot dipped galvanized in accordance with BS EN 150 1461 1999.
IV. The galvanized surface shall then be degreased and left with a smooth finish to prepare for painting.
V. Pole Columns manufactured in galvanized tubular steel shall have shaft and base sections manufactured from continuous lengths of new steel tube and shall not contain any welded or stepped sections.
VI. The base section of columns shall have a minimum wall thickness of 4mm and have base compartment openings of a minimum 600 x 115mm
VII. The pole should have the provision to hold the luminaire.
VIII. The battery shall be pole mounted in enclosure, which should be in water proof (IP 65) corrosion resistant enclosure, with anti-theft locking.

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QUALITY AND WARRANTY

i. The street lighting system (including the battery) will be warranted for a period of five years from the date of supply.
ii. The PV module(s) will be warranted for a minimum period of 25 years from the date of supply. The PV modules must be warranted for their output peak watt capacity, which should not be less than 90% at the end of Ten (10) years and 80% at the end of Twenty five (25) years.
iii. The Warranty Card to be supplied with the system must contain the details of the system**.**

OPERATION and MAINTENANCE MANUAL

An Operation, Instruction and Maintenance Manual, in English and the local language, should be provided with the Solar Street Lighting System. The following minimum details must be provided in the Manual:

- Basic principles of Photovoltaics.
- A small write-up (with a block diagram) on Solar Street Lighting System - its components, PV module, battery, electronics and luminaire and expected performance.
- Type, Model number, Voltage & capacity of the battery, used in the system.
- The make, model number, country of origin and technical characteristics (including LM-80 report) of W-LEDs used in the lighting system.
- About Charging and Significance of indicators.
- Clear instructions about erection of pole and mounting of PV module (s) and lamp housing assembly on the pole.
- Clear instructions on regular maintenance and troubleshooting of the Solar Street Lighting System.
- DO's and DONT's.
- Name and address of the contact person for repair and maintenance, in case of non-functionality of the solar street lighting system.

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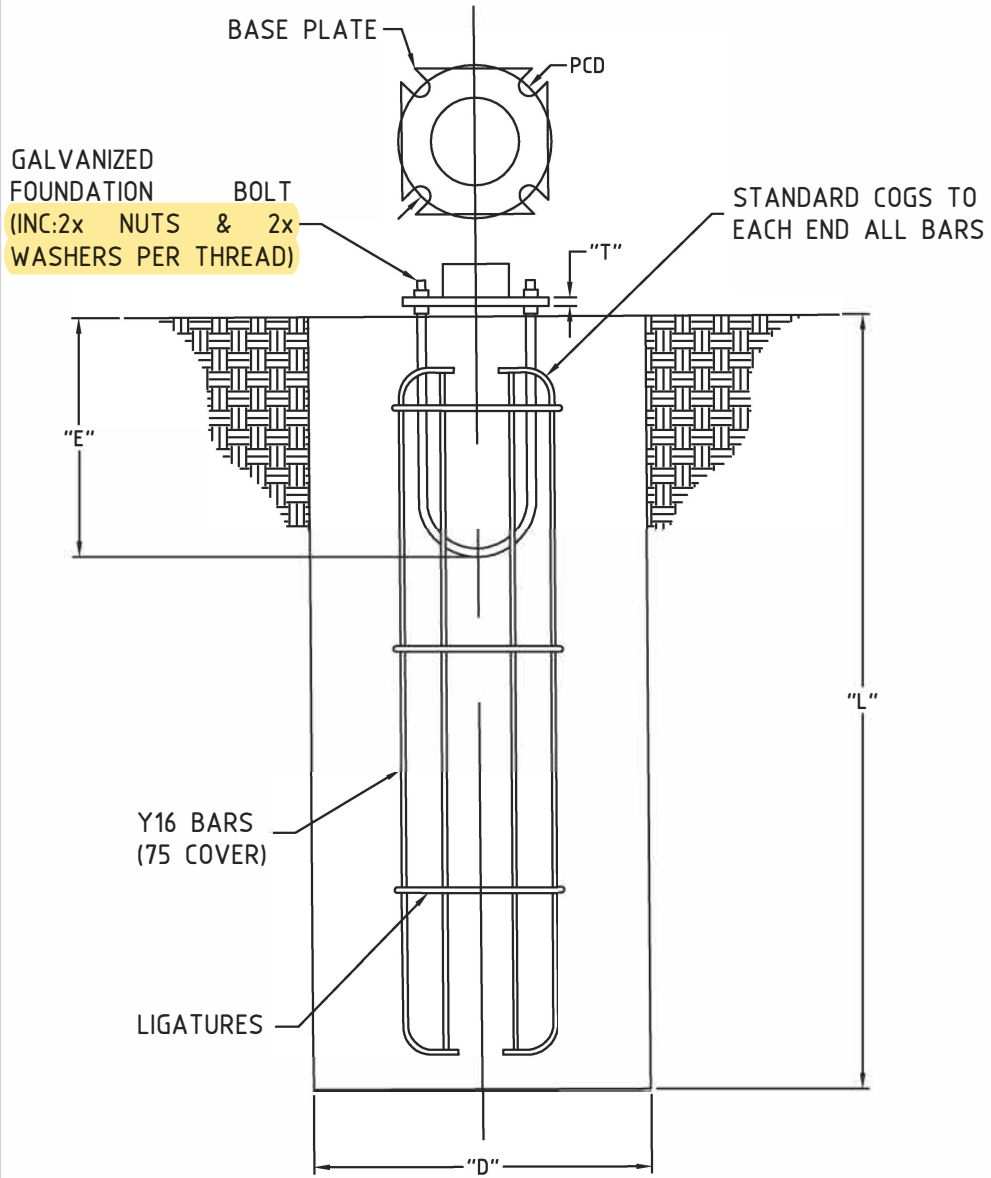


POLE HEIGHT	FOUNDATION BOLT (mm)	"T" (mm)	"D" (mm)	"L" (mm)	"E" (mm)	BARS	LIGATURES
3 METRE	16x550x350 PCD	16	610	1470	MIN 400	Y16	R6 500 C/C
4 METRE	16x550x350 PCD	16	610	1660	MIN 400	Y16	R6 500 C/C
5 METRE	20x550x350 PCD	20	762	1660	MIN 400	Y16	R6 500 C/C
6 METRE	20x550x350 PCD	20	762	1670	MIN 400	Y16	R6 500 C/C
8 METRE	20x550x350 PCD	20	762	1800	MIN 400	Y16	R6 500 C/C
9 METRE	24x550x350 PCD	25	762	1970	MIN 400	Y16	R6 500 C/C
10 METRE	24x550x350 PCD	25	762	1970	MIN 400	Y16	R8 500 C/C
12 METRE	24x550x350 PCD	25	762	2250	MIN 400	Y16	R8 500 C/C
15 METRE	30x850x466 PCD	30	762	2750	MIN 700	Y16	R8 500 C/C
18 METRE	30x900x500 PCD	30	762	2750	MIN 750	Y16	R10 500 C/C
20 METRE	30x900x500 PCD	30	1028	2400	MIN 750	Y24	R10 500 C/C

IMPORTANT NOTE

ALL FOOTING DETAILS ARE INDICATIVE ONLY. FOOTING SIZES WILL VARY ACCORDING TO A NUMBER OF FACTORS INCLUDING SOIL CONDITION, WIND LOADING AND TERRAIN CATEGORIES. IN ALL INSTANCES IT IS THE RESPONSIBILITY OF THE CONTRACTOR TO OBTAIN ENGINEERS COMPUTATIONS AND SPECIFIC COLUMN MANUFACTURERS INFORMATION TO DETERMINE THE FOOTING DETAIL REQUIRED FOR EACH SITE. NOTE THE ABOVE FOOTING DETAILS ARE BASED ON TERRAIN CAT 2, CONCRETE STRENGTH OF 32MPa AND AN ALLOWABLE LATERAL SOIL BEARING OF 50KPa PER METRE DEPTH.

Uganda National Roads Authority

Authorised Signature

Drawn NC * Date

Project Engineer WC * Date

INDICATIVE FOOTING DETAILS FOR OCTAGONAL COLUMNS

Scale NOT TO SCALE | Date 14/09/06

AutoCAD File

Drawing No. DS12-02-03 | Revision No. 0

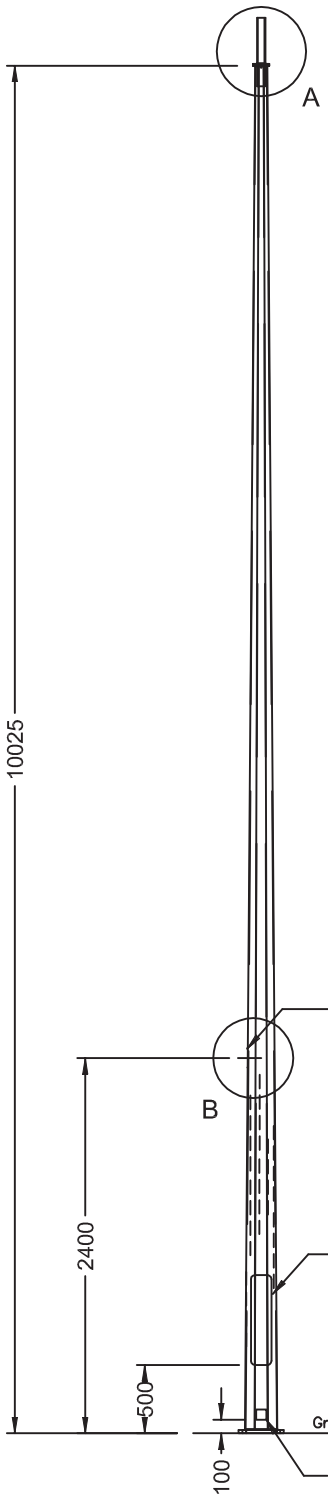
1.All dimensions shown are in mm.

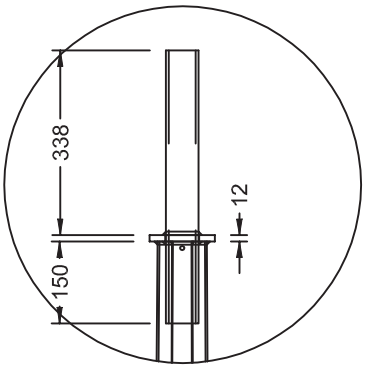
2.Column design to comply with AS 1170 &

3.All welding to comply with AS 1554.

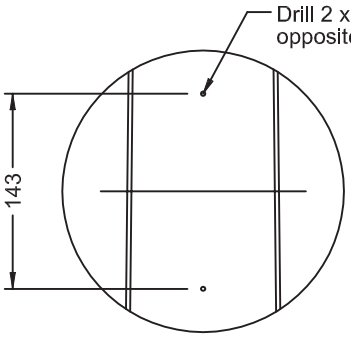
4.Galvanizing to conform to AS/NZS 4680.

5. Paint finish to AS 3887 category long term.

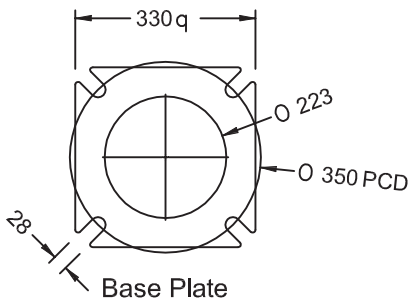




DETAIL A



SIDE ELEVATION B

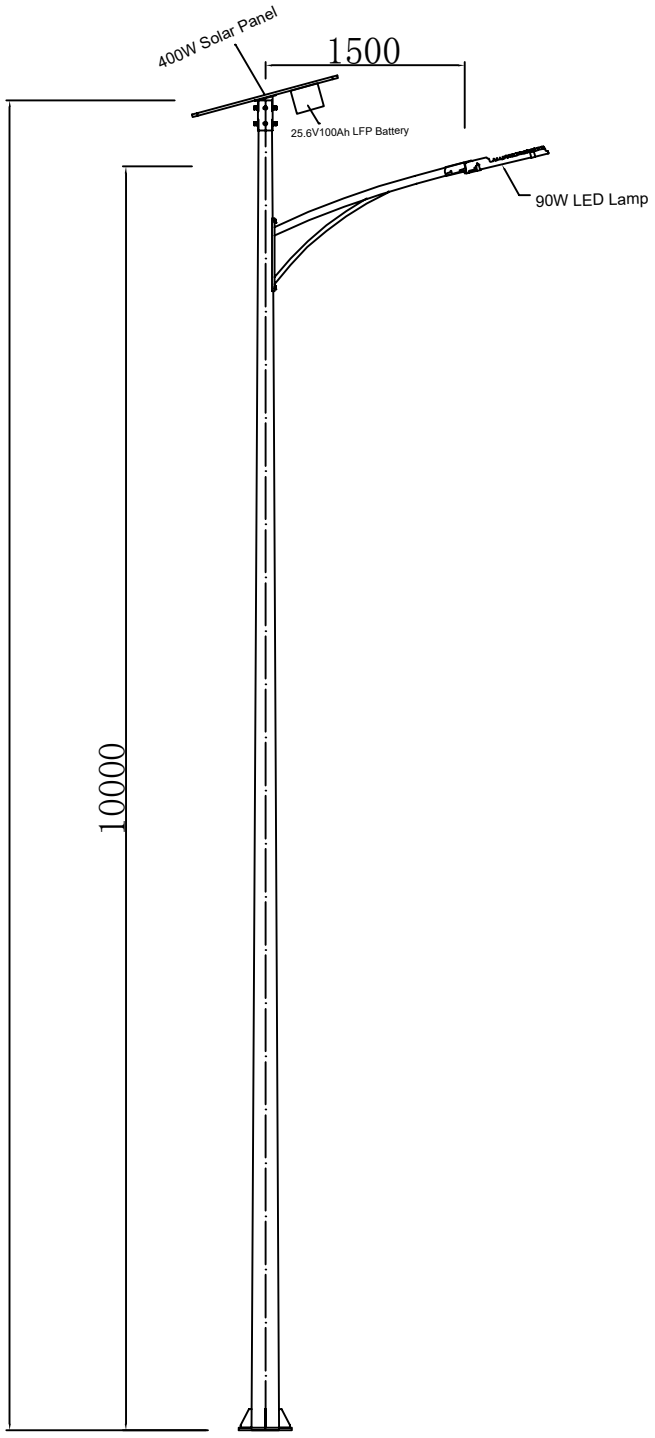


Uganda National Roads Authority

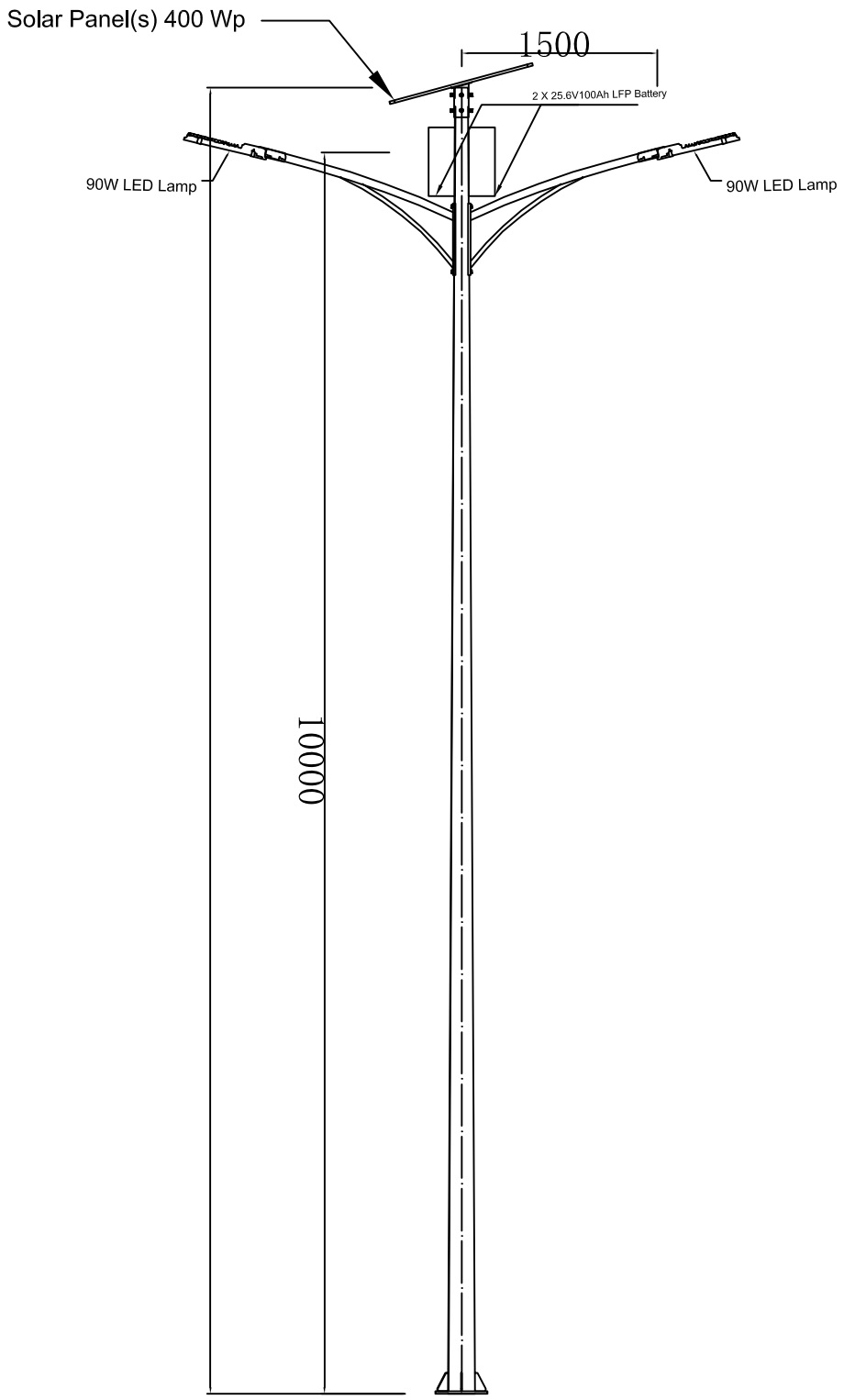
Authorised Signature			
Drawn	NC	*	Date
Project Engineer	WC	*	Date

12.0m IMPACT ABSORBING COLUMN BASE PLATE MOUNTED

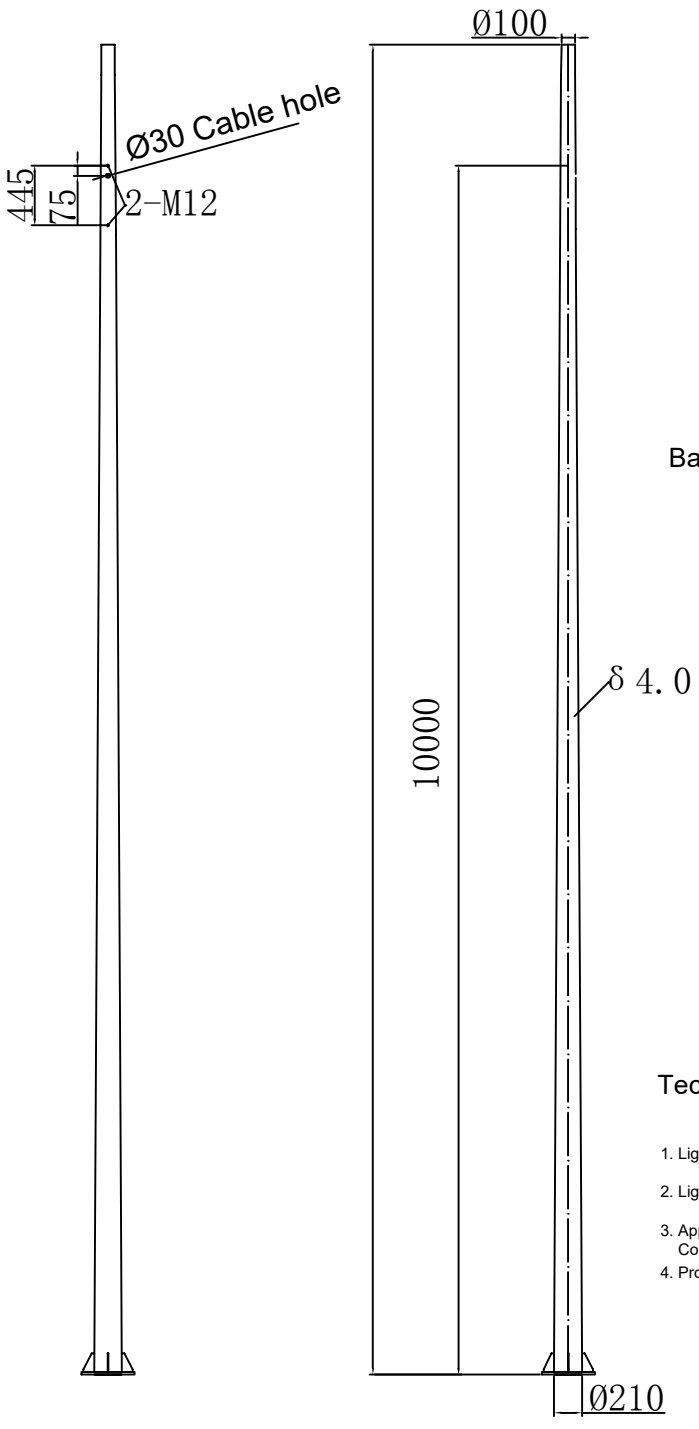
Scale: NOT TO SCALE	Date: 14/09/06
AutoCAD File	
Drawing No.: DS12-03-10	Revision No.: 0



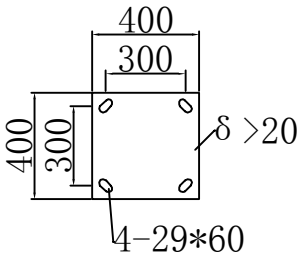
Installation simple drawing					



Installation simple drawing					
KK	20/07/2023				



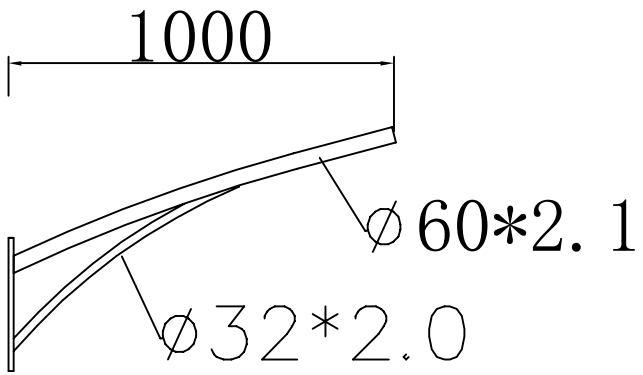
Base Plate enlarged image 2:1

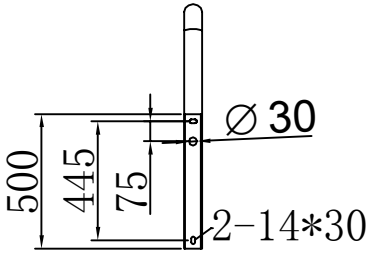


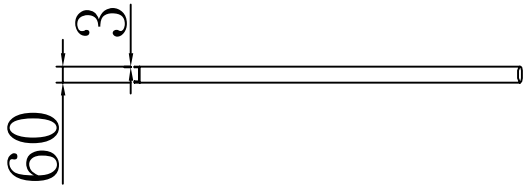
Technological requirements

1. Light pole material: High quality Q235
   Process: bending, closing, welding
2. Light pole apply hot-dip galvanizing process
   thickness of the zinc layer: 86μm.
3. Appearance of the light pole: Spray plastic process
   Color: Customized
4. Produced under international standard of roads lighting

Solar Street Lighting Pole Drawing					





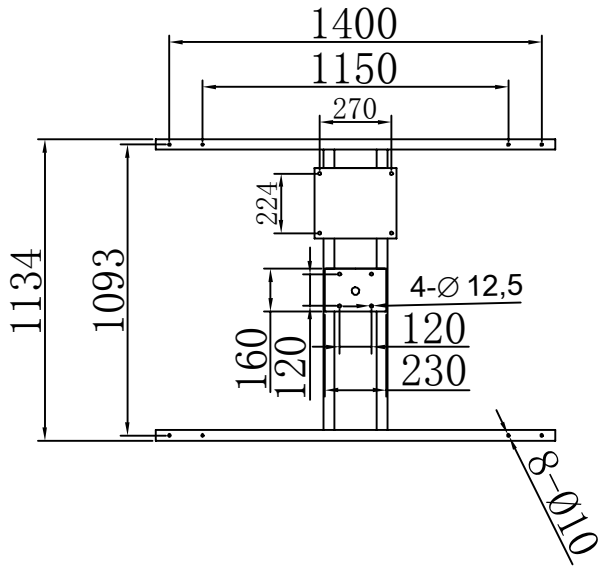


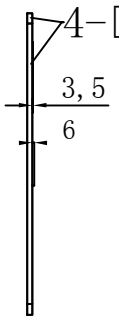
Technological requirements

1. Lamp arm material: High quality Pipe
   Production Process： bending/welding forming

2. All weldments: hot-dip galvanizing process,
   thickness of the zinc layer: 86μm.
3. Appearance of the lamp arm： Spray plastic process
   Color： Customized
4. All standard parts are made of stainless steel

Lamp arm drawing					

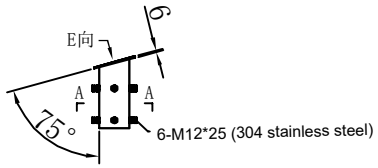


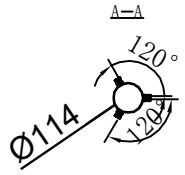


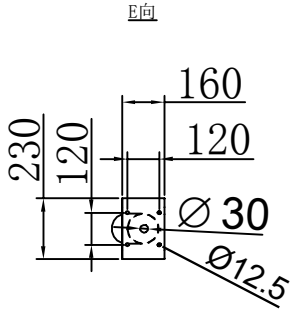
Technological requirements

1. Solar panel Rack and pole top cover: high quality steel plate and steel pipe
   Production Process： laser / welding forming

2. All weldments: hot-dip galvanizing process,
   thickness of the zinc layer: 86μm.
3. Appearance： Spray plastic process
   Color： Customized
4. All standard parts are made of stainless steel



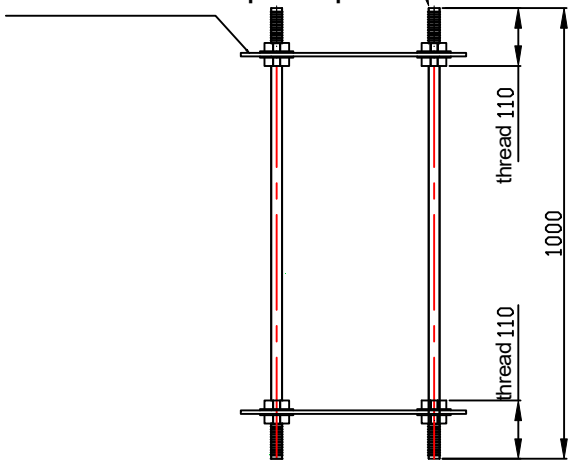


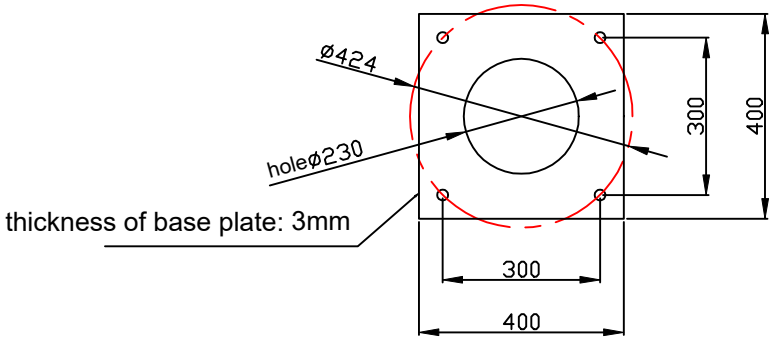


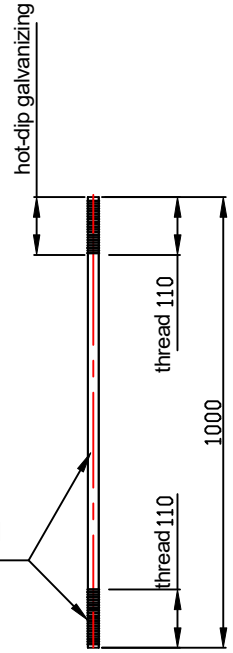
Rack /pole top cover					

4-M27*1000 Galvanized bolt

thickness of base template plate: 3mm







May Non be hot-dip galvanizing

Technological requirements

1. Steel: High quality Q235
2. Top thread of the Base screw: hot-dip galvanizing process
3. Other parts of the Base screw: Non hot-dip galvanizin
4. Base plate,bolts, nuts all can disassemble，easy to transport
5. galvanized nuts 4pcs,
   non-galvanized black nuts 12pcs
   galvanized oversized flat pad 4pcs,
   non-galvanized panel 2pcs.

	Embedded parts				
			2023.5.29		

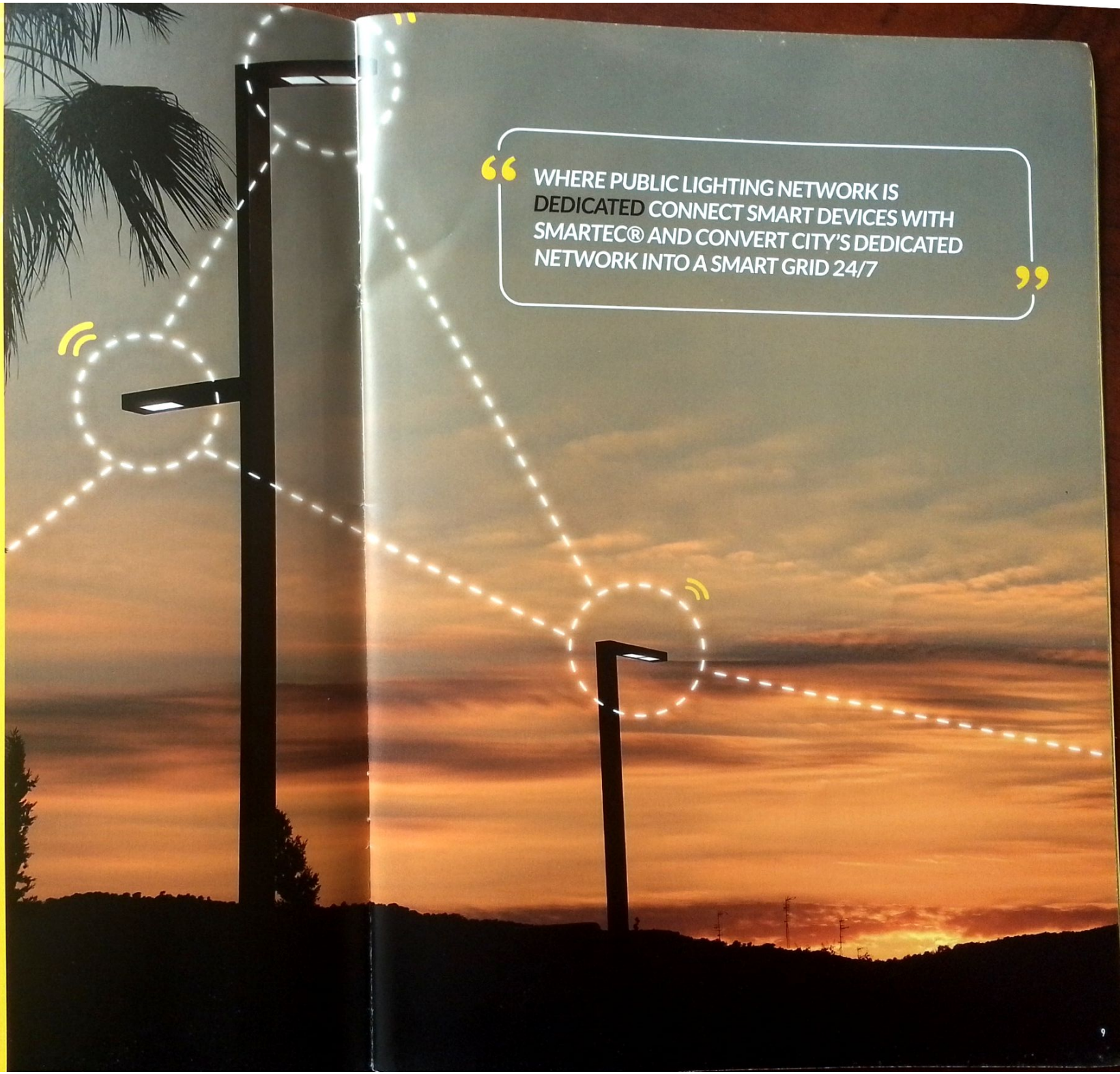
Appendix 9 Smartec® Smart Lighting System Catalog

FUTURE PROOF LIGHTING
AS A STARTING POINT

New technologies are transforming the way we conceive our environment. The introduction of LED technology within the outdoor lighting market and the progressive disappearance of discharge lamps is an evidence of this digital revolution.

Smartec® estimates that in next half decade the market is offering only smart lighting solutions as public lighting represents the best distributed electricity infrastructure in towns and cities across the world. All this thanks to the backbone of a city that connects more than 360 million luminaires worldwide with access to the energy grid.

With Smartec® you **convert** your **network 12/7 to shared networks 24/7** where it is made possible to install a safety camera, an environmental sensor, a traffic counter or an electric vehicles charger on a lighting point while the energy still flows along the street.



> **“WHERE PUBLIC LIGHTING NETWORK IS DEDICATED CONNECT SMART DEVICES WITH SMARTEC® AND CONVERT CITY’S DEDICATED NETWORK INTO A SMART GRID 24/7”**

WHAT ABOUT SMARTEC® CITY

CONTROL OF THE CITY IN YOUR HAND

Through Smartec® hardware and software integrated in the city infrastructure, it is possible to enable adaptation to the global and specific needs of citizens, enabling the knowledge of devices' real-time status, data collection, energy saving, and fast decision process.

Smartec® software consists of an open database resident in the cloud or in the city's physical server as to access from anywhere and integrate with different brand software solutions, unlike devices' manufacturers and services providers.

Smart Lighting

Information signs

Pollution Control

Security

Smart garbage

Parking inteligente

WiFi Connectivity

Smart Transport

> *"IT IS PROVEN THAT IN THE EARTH PLANET THERE ARE ALREADY MORE TECHNOLOGICAL DEVICES TO COLLECT DATA THAN HUMAN BEINGS"*

WHAT ABOUT SMARTEC® LIGHTING

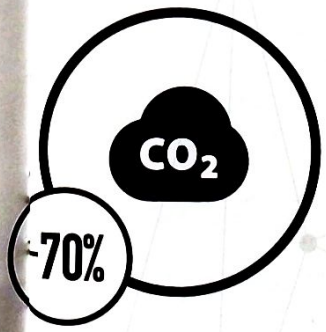
FOR A FIT LIGHTING

Smartec® Lighting allows the city to control and manage lighting installation by switching off and on, applying power regulation strategies, setting power saving and knowing status in real time.

Main objective is flexibility, sustainability, and care to energy saving while increasing efficiency.

> *SMARTEC® ESTIMATES THAT IN 5 YEARS THE MARKET IS OFFERING JUST SMART LIGHTING SOLUTIONS*

ENERGY



POLLUTION

MAINTENANCE

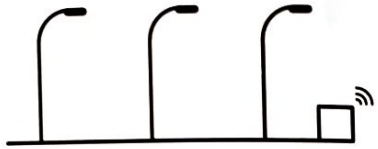
PUBLIC EXPENDITURE

SCALABLE SOLUTION

SMARTEC®

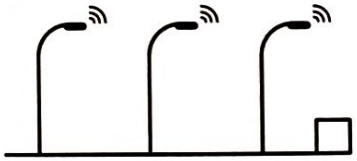
- Installation management by electrical panel, by luminaire using colored interactive icons
- Knowledge of current energy data by periods, by time interval or by electrical line
- Analysis about energy savings in power and Cost
- Display of consumption data for each luminaire in real time: current, voltage, power and power factor
- Real time commands and polling
- Flexible luminaire dimming, strategies storage, preset strategies, execution at selected date and time interval.
- Possibility of programming luminaires by dimming stages according to individual, group or gateway requirements
- Create levels of security by users
- Email alarms forwarding
- Statistical data download in different format
- Error and failure log and calendar
- CMG management gateway as to visualize status of power lines and measurements for the control panel

CONTROL PANEL MANAGEMENT



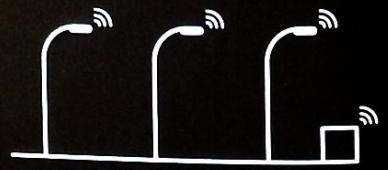
- *REMOTELY POWER ON -OFF*
- *ASTRONOMICAL CLOCK SWITCH*
- *ELECTRICAL MEASURES READING*
- *ANOMALIES AND LINE ALARMS (EMAIL)*

DOTDOT MANAGEMENT



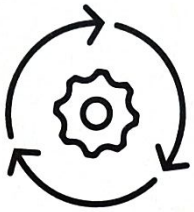
- *INDIVIDUAL AND GROUP MANAGEMENT*
- *ENERGY SAVING %*
- *LUMINAIRE FAILURE ALERT (EMAIL)*
- *REAL-TIME MONITORING*
- *ACCESS FROM ANY DEVICE VIA WEB BROWSER*
- *COMPATIBLE WITH DIFFERENT TECHNOLOGIES*
- *LIGHTING OUTPUT DIMMING*
- *PRE-PROGRAMMING AND ADJUSTMENT*

GLOBAL CONTROL



CONTROL PANEL MANAGEMENT + *DOTDOT MANAGEMENT*

INTEGRATION
PLUG & PLAY



We guarantee adequate implementation of the system, providing full support during the hardware installation and performing configuration of the software.

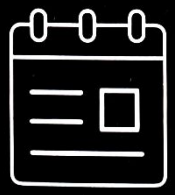
TRAINING
ALL YOU NEED TO KNOW

We offer training over our solutions so final user can take full advantage of the capabilities of the Smartec® system.

SECURITY
DATA PROTECTION AND RELIABILITY

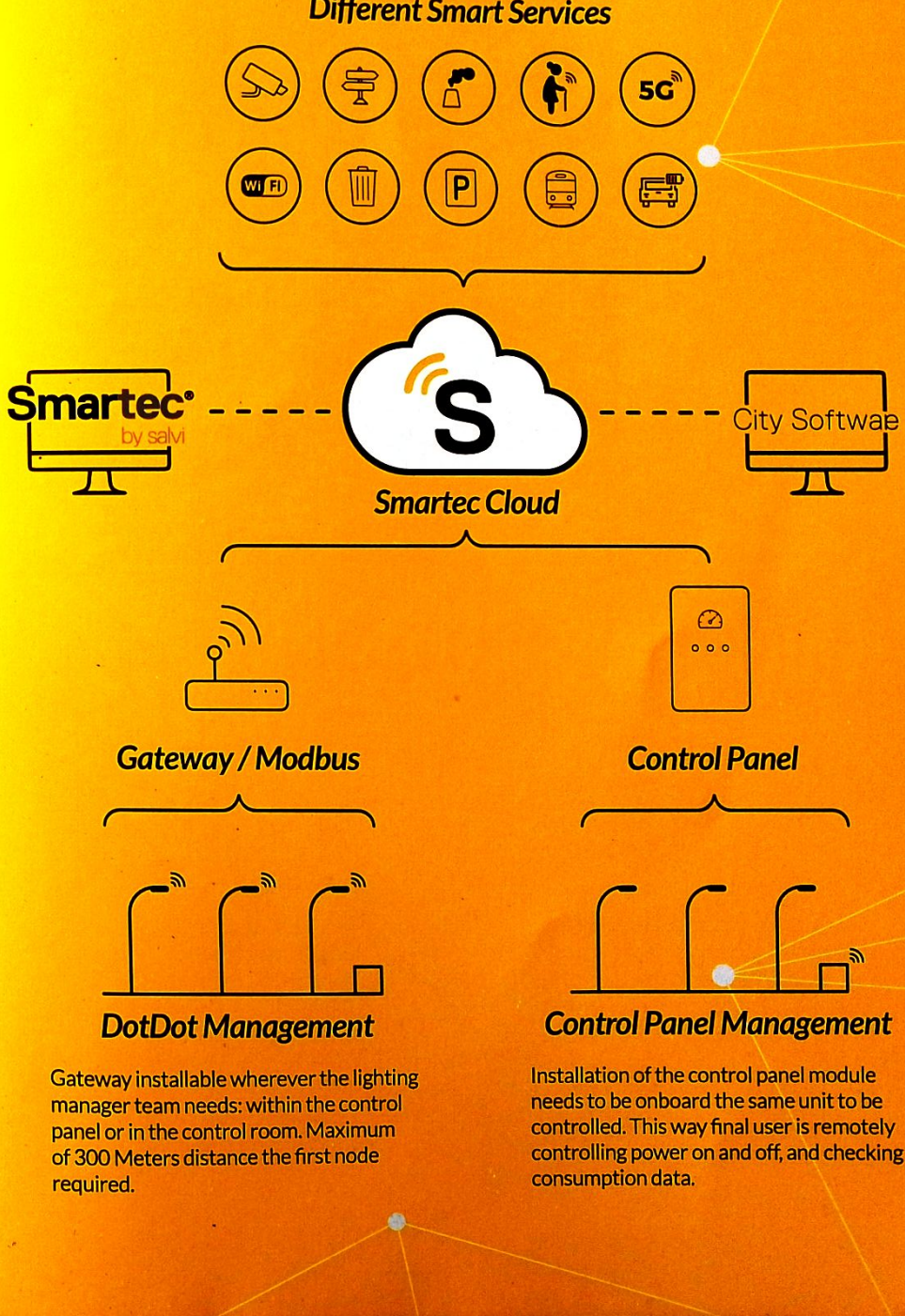
Smartec ensures security and reliability in data transmission protecting storage of the same.

DAILY USAGE
AN EQUIPMENT TUNED ON NEEDS



Manage daily the installation reading reports, tuning dimming strategies, analyzing alarms and programming onsite interventions.

HOW WE MAKE IT?



A SINGLE SOLUTION
FOR MULTIPLE NEEDS

For the operation of a smart city the key point is to meet the needs of its citizens and the city. By meeting one of the needs with active use of installed services we will meet our Smart objective.

- **Energy savings achievable goals**
- **CO2 pollution control**
- **Flexible dimming strategies**
- **Tailor made lighting for better mobility**
- **Easy management through a single open system**
- **Better lighting quality for increased safety**
- **Luminaires grouping and calendar strategies regulating different areas: (i.e. commercial or residential)**

CITIZEN:
Smartec® management and control features make a city much better informed about the health and performance status of its infrastructure as to improve the well-being of citizens. Smart lighting, and in particular dynamic lighting, can make citizens feel safer with a more comfortable and efficient lighting.

CITY:
Smartec® can help cities as achieve savings in energy, operations and maintenance, while helping to create a more attractive and secure environment. Smartec® allows the city to monitor and control the entire lighting infrastructure and get information about its performance.

MAINTENANCE:
One of the main benefits of intelligent lighting is increased performance knowledge, automated failure management and real time status reporting.

This will allow the city to automate the maintenance and repair services optimizing the on duty technical team workflow by allowing significant savings.

Appendix 10 Comments Redress Matrix

GENERAL COMMENTS ON DRAFT REPORT: OCT 30, 2024

1	General Comments	Consultant's Response	Reference
a)	The report should be quality assured by individuals would did not take part in writing since it will be easy for them to identity errors.	We have taken appropriate steps to ensure errors are eliminated using internal quality assurance measures	n/a
b)	The key staff should be in the list of contributors.	This list has been updated on Page ii	n/a
c)	Introductory letters shouldn't be attached on the report. Instead, minutes and attendances from stakeholder engagements are required.	Introductory letters have been removed from the appendices. Stakeholder meeting minutes are found in Table 7. Stakeholder meeting attendance lists are attached under Appendices	Chapter 4 Appendix 3
d)	The report has a series of recommendations for future management of street lighting scattered across many chapters/sections. These should be consolidated in the chapter of recommendations and given appropriate headings/sections. Also, a summary matrix can be created under this chapter of recommendations and include responsibility centres for purposes of follow up on who will be responsible for their implementation as well as provide guidance on the agency/timing for the same.	Recommendations have been reorganised in table format, with each recommendation tagged to relevant authorities for consideration.	Chapter 11
e)	The format of the report agreed upon at inception has been ignored. Rearrange the report into the agreed format and provide missing information as guided by the ToR.	The report has been re-arranged to fit the agreed format as much as possible.	n/a
2	**Executive Summary**		
a)	The executive summary should be concise and recast and in the following order: ➢ Background/introduction ➢ Objectives/Purpose of the study ➢ Approach to the study and what was done to arrive at this report	The Executive summary has been re-arranged as follows: ➢ Introduction and objectives ➢ Approach to the Study ➢ Baseline assessment and findings	Executive Summary

	➢ Key findings, including clear statistics ➢ Conclusions and Recommendations	➢ Lifecycle costs and O&M framework ➢ Conclusions ➢ Key recommendations	
b)	Stakeholder engagement shouldn't be the headline in the executive summary. Details provided therein should be taken back to the body. The content seems to be mainly recommendations and should be taken where it belongs.	Stakeholder engagements details have all be shifted to a dedicated chapter	Chapter 4
c)	There are several statements in the executive summary as well as in the main body which should be substantiated, re-phrased or removed altogether if no supporting documentation is provided. Examples include: ➢ *"Grid-powered Street lights have proved suitable for urban settings due to their overall low lifecycle maintenance costs, higher road luminance levels, deter vandalism and crime than solar streetlights"*. -Provide statistics of its usage to substantiate this statement ➢ "*Non-compliant streetlights should not be paid*". Does this statement imply payments have been made for non-compliant lights? ➢ *"54.74% of accessed USMID-AF road projects had compliant streetlights with respect to the URDM 2023"*. You are measuring performance against a standard which was not yet in place at the time of implementation. This would send a wrong message.	These statements shave been re-phrased. ➢ This statement regarding grid-powered lights is elaborated in detail under Chapter 7, section 7.3 ➢ The statement regarding payment has been omitted in line with the objective of the study. The word "compliance" has been substituted by "performance" ➢ The intent of the statement was to measure performance of the installed lights against standards in URDM 2023.	Executive summary Chapter 7, Section 7.3 Executive summary
d)	Some recommendations are written as policy decisions already made. For instance, a statement like "*Government to address the functional, organizational and funding gaps at UNBS to achieve delivery of its full mandate"* presupposes that this decision has already	This statement has been re-phrased as required in Chapter 11	Chapter 11 Recommendation No. 4

	been made. These statements should be rephrased to make them recommendations.		
e)	*There are some contradictions. If you are recommending grid powered street lighting, then you cannot at the same time recommend tax exemptions for solar products. This means you are recommending both options to be used concurrently.*	This recommendation has been rephrased whereby local authorities are given chance to choose the type of technology that is sustainable to operate in their location. See Chapter 11, recommendation no. (xii)	Chapter 11 Recommendation No. 1
f)	*The data presented on streetlights installed is confusing. The figures should be consistent. For instance, you could state all the streetlights counted during the study specifying which of those belong to USMID-1 and those of USMID-AF. There should be a disclaimer if counting never covered all the lights implemented. You cannot count more lights than those installed. Do not mix lights mentioned in the contract and those installed because this study is not intended to be a value for money audit. Refer to the overall objective of the study.*	The figures stated in our report have been clarified as number of streetlights assessed under our study. This is under Baseline Assessment	Chapter 2, Section 2.3, Table 3
3	**Appendices**		
a)	*Appendices should include the data collected during the study which can be referred to by the users of the report. The tables should depict numbers of all installed lights, non-functional lights etc per city/ municipal council,*	We have included technical data on smart lighting systems, technical specifications of proposed energy efficient streetlighting equipment, and UNRA data	Appendices 5, 8, and 9
b)	Other appendices expected include: ✓ A copy of ToR ✓ Stakeholder engagement minutes ✓ Special reports accessed from stakeholders ✓ Recommended specifications and technical designs for standard streetlights ✓ Draft Long term service agreements, guarantees and warranties for suppliers, vendors or contractors of streetlights	Appendices have been updated as follows ✓ Appendix 1 is the ToRs ✓ Stakeholder minutes are in Chapter 4 whereas attendance lists are in Appendix 3. ✓ Warranty and guarantee terms from Davis & Shirtliff, BYD and Chloride Exide are in Appendix 6	Appendices

	✓ Operation and maintenance frameworks ✓ Draft standards and guidelines for planning, design (should include a sample design) and installation of streetlights ✓ Schedule of people (Name & Title, organization) consulted during the study. ✓ Street light testing framework ✓ Comments redress matrix	✓ Proposed Long-term Service Agreement is Appendix 7 ✓ Proposed Operation and maintenance framework is covered under Chapter 9 ✓ Standards for planning and design are covered under Chapter 6 ✓ Schedule of people consulted is Appendix 2 ✓ Street light testing matrix is Appendix 4 ✓ Comments redress matrix attached	

COMMENTS IN VARIOUS SECTIONS OF THE MAIN DOCUMENT

NO	CLIENTS COMMENTS	CONSULTANT'S RESPONSE	Reference
	Preliminary		
	Include the other Key staff as contributors	A complete list of contributors has been included	n/a
2	**Executive summary**		
a)	**Stakeholder Engagements:** *This is coming in early & the contents seem to be recommendations which should be taken to that section*	A few statements have been re-phrased while most statements shifted to the Recommendations section	Chapter 11
b)	**Baseline Research Study:**		
i)	*The number of lights reviewed under the study don't necessarily mean the total number of lights in the contract. This needs to be clarified*	The wording with regards to the streetlights assessed during the study has been rephrased to represent only what was assessed and not the total number of lights in the contracts.	Executive Summary
ii)	*Make clear the points regarding vandalism and do not over emphasize on solutions that are outside the scope of study.*	The data on youth unemployment and poverty alleviation has been refined to the aim of the study	
iii)	*These technical design standards/guidelines should be included in the report*	Technical designs and guidelines are included in *Chapter 6 Technical Designs and Specifications*	Chapter 6, Sections 6.1 and 6.5
iv)	*What are the risks associated with disposal? These should be included in the report before embarking on recommendations.*	Risks associated with disposal of solar streetlighting systems are in *Chapter 9; Operation and Maintenance Framework*	Chapter 9, Section 9.5
c)	**Operation and Maintenance Framework (O&M)**		
	The source of costs included in this analysis needs confirmation	We have attached quotations from potential suppliers.	Appendix 5
d)	**Key Recommendations**		

	Other recommendations already provided above should be brought here. In addition, categorize the recommendations into Short Term, Medium Term and Long term where applicable. Review the tense used if these are recommendations.	Recommendations have been made more elaborate, specific, and precise.	Chapter 11
3	**Introduction**		
	The need for Street Lighting *These statistical projections of 2020 should have been confirmed already. We are now in 2024.*	Statement has been re-phrased.	Chapter 1, Section 1.4.3
	"The Study has shown enormous potential benefits for the Government to embrace street lighting initiatives." *Provide an appropriate sub-heading for this literature. It shouldn't be included under Overall Objectives.*	The aforesaid literature has been moved to a new a subheading *"Justification for Streetlight"*	Section 1.4.4
	Report Structure: *This is more critical, and the agreed format discussed during inception is being ignored.*	The Report Structure table has been edited as advised.	Section 1.7
	Street Lighting – Basic Definitions "A better understanding of street lighting technical definitions will facilitate one's perception and appreciation of this Report. Some of the key definitions are highlighted below" *Clarify here whether these are used during the assessment.*	All definitions were used in the assessment. They have been listed in the Introduction chapter	Section 1.4.1
4	**Stakeholder Engagement**		
	Move this chapter after Baseline Assessment	Stakeholder Engagement is now an independent Chapter	Chapter 4
	"*This is not accurate. There are no such details in verification report. Include all the necessary details including topics that were discussed.*"	During the site visits, Local Government leaders, Engineering Department staff, Consultants, Contractors, Police, and road users were consulted in respect to	n/a

		the Study. Details of the discussions, which were generally cross cutting and were enclosed in the Study's Field Verification Report.	
	Restructure this report to include sub-headings for each key stakeholder/institution consulted instead of using a table.	Table 7 categorises the information that was availed by each stakeholder the Consultant visited	Chapter 4
	"Does the manual adequately cover the aspect of street lighting? If not, provide an appropriate recommendation to Ministry of Works to Update the manual at some point."	A recommendation has been directed to MoWT regarding update of the manual	Chapter 11, Recommendation no. 2
	Did you access any study done under KCCA confirming this?	Yes, we did access report on the impact of streetlighting in Kampala city.	Reference no. 7
	There should be section dedicated for description of this concept (Smart Lighting Systems)	The Concept of Smart Lighting Systems is discussed under chapter 3.	Chapter 3, Section 3.4
5	**Baseline Assessment**		
	More explanation is required on the approach used for baseline assessment	Chapter 2 Baseline Assessment has been re-written to give context to the study	n/a
	"Public Lighting Technologies" *These definitions should be integrated with those under Section 1.8*	The definitions previously in the Baseline Chapter have been merged with those in Chapter 1: Introduction,	Section 1.4.1
	Provide a description of different road classes and their corresponding street light specifications.	This has been introduced into the report	Section 2.3, Table no. 4

	"2,406 and 6,694" *These should be taken as the total number of solar streetlights observed by the consultant and should not be taken to be the total number in all the contracts or total implemented because the actual figures are higher. For instance, the number of streetlights in contracts under USMID-AF are 10,873. Also, for USMID-AF, the nr installed should be qualified or referenced to the time of field assessment since implementation was still on-going.*	This has been re-phrased as advised. Therefore 2,406 and 6,694 are the number of streetlights whose performance was assessed/reviewed for this study under, USMID1 and USMID-AF, respectively	Section 2.3 Table no. 3
	Expand Table 4 to include the nr of streetlights there functional (even with low illumination). When you ONLY categorize them as non-compliant on account of light intensity it sends a very negative message that there is no value on what was done.	Table 4 has been revised accordingly	Section 2.3, Table no. 3
	As advised above provide details of those there functional (providing some form of light), then you can add the number of those whose illumination was less than the required 9 lux. Also, kindly note that URDM 2023 came into existence later after most of these lights were installed.	Initial statement has been revised for clarity. See statement no. viii under *Chapter 2: Baseline Study and Findings*	Section 2.3
	Section 3.3.2.4 Vandalism and Theft; "Definition of Poverty" *"This detail on poverty may not be relevant for this study"*	Statement has been eliminated	n/a
	Section 3.3.2.4 Vandalism and Theft; Youth Unemployment" *This could be summarized in a few sentences. This detail may not be relevant for this report.*	Statements have been edited to suit the scope of study as guided.	Chapter 2, Section 2.4.4
	Section 3.3.2.4 Vandalism and Theft; Low Community Vigilance	Statements have been edited to suit the scope of study	Chapter 2, Section 2.4.4

	This could be summarized into one paragraph that is relevant for this study		
	Section 3.3.2.5; Inadequate Design Methods and Material Specifications *Kindly note that implementation of urban roads using this manual is yet to begin*	The statements under this section have been revised.	Section 2.4.6
	Section 3.3.2.5; Inadequate Design Methods and Material Specifications Factory Acceptance Tests *To avoid future mistakes, this report should come up with a testing framework that involves UNBS as well, without which certification and payment cannot be completed.*	We have proposed a streetlighting testing framework in the report	Appendix 4
	Section 3.3.2.5; Limited Regulatory Framework for the Sector; Uganda Road Fund *It should be noted that funding from URF has always been inadequate to cover all the road maintenance activities. It is possible that even when a specified percentage is allocated for street lighting it will be very small to cover the O&M needs. Therefore, a general recommendation should be to increase the funding allocation from central government as well as allow flexibility for OSR generation to cover all road maintenance needs.*	This has been highlighted in *Chapter 11, recommendation*	Chapter 11, Recommendation no. 21
	Section 3.3.2.5 *This assignment is supposed to provide a report on market capability to implement the recommended technology (Feasibility to Implement).*	We have created a chapter for "Feasibility to Implement"	Chapter 8
	Section 3.3.4.3 Vandalism and Theft	This has been clarified and corrected to Community Vigilance	Section 2.4.4

	Community engagement is being mixed up with stakeholder engagements. These are different concepts.		
	"Section 3.5 Streetlighting Design Software" *Provide a sample design procedure for streetlights using this software. This should include design criteria, data requirements & input, and a clear description of the outputs from the software. Include some notes on the availability of this software*	We have provided a sample design procedures and outputs using the DIALux software.	Sections 6.2 and 6.3
	Section 3.6 Materials Specifications *Provide more detailed specs using the format borrowed from UNRA.*	Additional specification details have been attached in the Appendices.	Appendix 5
	Section 3.7.1 Hybrid Streetlighting System *Provide a detailed cost benefit analysis as expected.*	A detailed cost analysis has been included in the report	Chapter 7, Section 7.2 Tables 12 and 13
	Section 3.7.2 Smart Streetlighting System *It is not clear if this cost-benefit analysis has been carried out. Moreover, the comparison of different lighting systems did not include the smart Option.*	A cost benefits analysis was only carried out for grid, solar and hybrid systems for this study in Chapter 7. However, a comparison of the different lighting systems, including the Smart streetlighting system, is in Chapter 3	Sections 3.4, 7.2 and 7.3
	Section 5.3.4.6 Environmental and Social concerns/Recommendations on Disposal of Street Lighting Materials *Lack of disposal plans is a serious risk, and this study should propose a sample costed disposal plan to guide on how these hazardous materials can be disposed off.*	Proposed Mitigation and Disposal Strategies are discussed in the report. We have included the cost of disposal under *Life Cycle Cost analysis.* Also, Recommendation has been included related to waste management.	Chapter 5. Chapter 7, Section 7.2, Table no. 13. Chapter 11, Recommendation no. 8

6	**Chapter 4, Proposed O&M Framework**		
	Section 4.4 Basic Maintenance for Streetlighting Systems *Table 16 table should include frequency of these activities*	Table 16 has been amended to include frequency of activities.	Chapter 9, Section 9.4, Table 15
	Section 4.5 Lifecycle Costs – Assumptions *You need to provide a breakdown of the UGX 100,000 quarterly maintenance charge*	A breakdown and justification have been given for the UGX 100,000 service charge.	Chapter 7, Section 7.1
	Section 4.5 Lifecycle Costs *"Provide the source of these costs."* *A review of these costs should also include contract values from the different contractors as well as suppliers. Using rates from suppliers will not bring out the actual costs incurred by Government*	Quotations from the distributors of equipment have been included A projection that the costs used in this study could be subject to markup of up to 50% by contractors and service providers to cater for profits and inflation has been put under "*Cost of Technology, Assumptions"*	Appendix 5 Chapter 7, Section 7.1
	Smart Lighting: *"What would be the change for the Grid option is Smart lighting system is incorporated?"*	The key features of Smart systems are detailed in Chapter 3. Therefore, the significant change in O&M for Grid systems would be in the energy saving.	Chapter 3 Section 3.4
7	**Recommendations** *Expand this chapter to include all recommendations presented before this point as already advised.*	Recommendations have been reorganised under Chapter 11.	Chapter 11
8	**Conclusions** This conclusion must be made more explicit. It should include a list of conclusions following the objectives of the assignment.	Chapter 10 has been re-organised and made more explicit with conclusions relevant to the objectives of the Study.	Chapter 10