



**SENSITIZATION WORKSHOP ON REA'S HARMONIZED TECHNICAL STANDARDS (DESIGNS & SPECIFICATIONS):
PATHWAY TO SUSTAINABLE ELECTRIFICATION PROJECTS.**

APRIL, 2021



RURAL ELECTRIFICATION AGENCY

ENERGY = EMPOWERMENT = EFFICIENCY

Programme Agenda

Time	Activity	Action By	Duration
9:00 – 10:00	Registration	All	1hr
10:00 – 10:10	Welcome remarks and workshop declared opened	MD/CEO REA	10mins
10:10 – 10:30	Presentation on REA Harmonised Technical standards and specifications	ED/(TS)	20mins
	SECTIONAL PRESENTATION		
10:30 – 10:40	a) Grid Extension	Engr Tom Inegbedion	10mins
10:40 – 10:50	a) Injection substation	Engr. Shehu/Engr. Seriki	10mins
10:50 – 11:00	a) Solar Mini-Grid	Engr. Uche Honnah	10mins
11:00 – 11:10	a) Solar Street Light	Dr. Garry Naman	10mins
11:10 – 11:20	a) Solar Home system	Ms. Simisola Sobowale	10mins
11:20 – 12:05	Q/A	Engr Tom, Shehu, Uche, Garry, Simi, Audi	45mins
12:05 -12:15	Remarks by	Chairman REA Contractors	10mins
12:15 – 12:25	Future Work	GIZ	10mins
12:25 -12:35	Vote of Thanks	Director Projects	10mins
12:35 – 12:40	Lunch/Departure	All	5mins

WORKSHOP RATIONALE

- **Harmonization:** The main purpose of the workshop is to present the harmonised technical standards to critical stakeholders, sensitise them and gather their feedback.
- **Feedback:** Feedback obtained from this workshop will help the agency finalise the technical standards and implement these standards in several rural electrification projects.
- **Incorporation:** Previously developed technical standards – Technical Services (TS) Directorate, Rural Electrification Fund (REF) and Nigerian Electrification Project (NEP) will be incorporated as well.



5 Pillars to Sustainable Deployment of Projects

Technical

Economical

Environmental--

Social

Institutional

- **Technical standards**
- Energy availability
- Overall efficiency
- Daily availability of services

- Cost for capital investment
- Operational maintenance cost
- Productive energy uses (income generating)
- Employment generation

- Emission of CO₂/kWh
- Kerosene displaced from lighting
- Other fuels displaced for cooking

- Hospital/school and public places served
- Micro credit availability
- Subsidy availability

- Management capability required
- Operation and maintenance skill required



GRID EXTENSION

Engr. Tom Inegbedion



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➤ General Guidelines

- ✓ Material Requirements
- ✓ Thermal Ratings
- ✓ Short Circuit Ratings
- ✓ Mechanical Loading Conditions
- ✓ Electrical Service Conditions and Physical Environment
- ✓ Prevention of Unauthorised Access

➤ Allowable Voltages

- ✓ System Supply: Standard A.C. voltages (230 1 phase & 400V 3 phase systems) and frequency (50Hz $\pm 0.5\%$ and $\pm 2.5\%$ variation under system stress).
- ✓ Standard types of supply/wire systems for single phase and three phase supply systems.
- ✓ Also, different insulation and earthing requirements for both cables and metal structures.

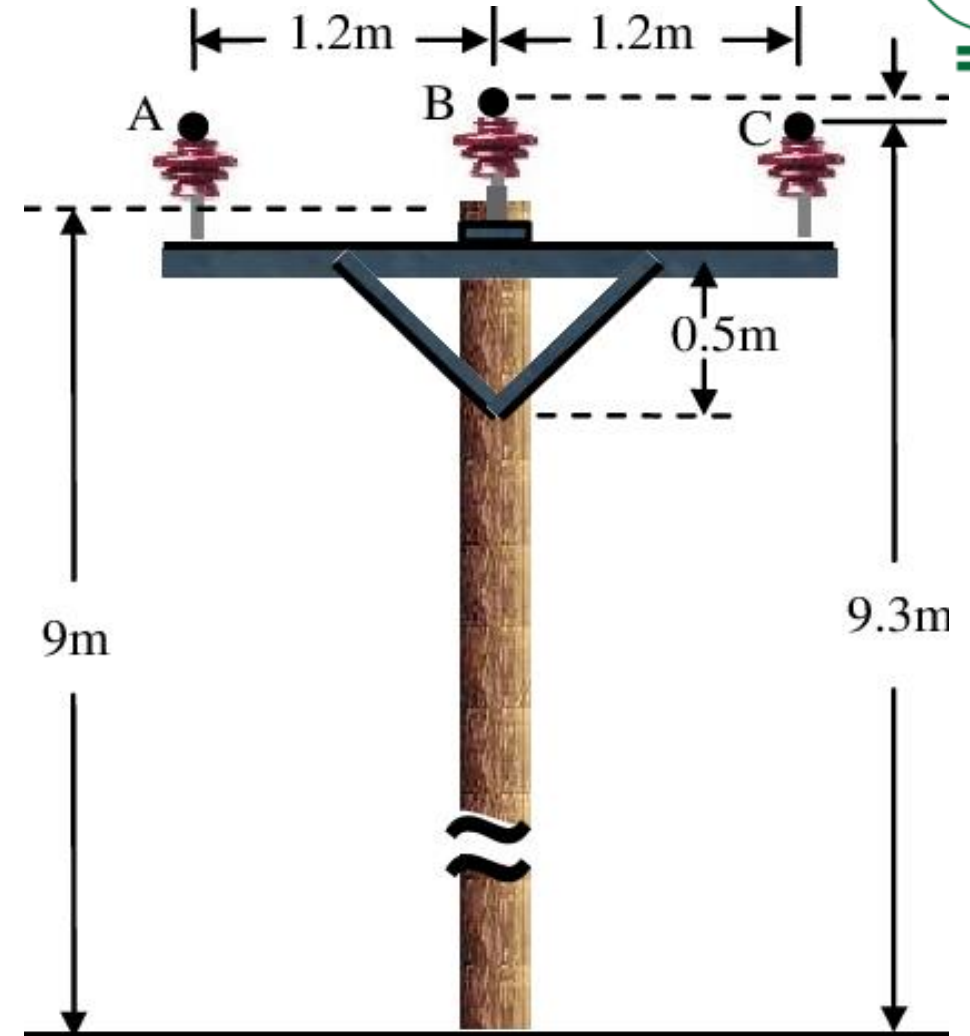


➤ **Equipment and Installation of Devices**

- ✓ Support structures; metal or reinforced concrete poles, gantry guy, stay assembly
- ✓ Overhead materials; conductors, insulators, line hardware, accessories
- ✓ Underground materials; cables, termination kits, lugs
- ✓ Substation equipment; transformers, shunt capacitors, arresters, feeder pillars

➤ **Overhead Distribution Lines**

- ✓ Overhead distribution lines construction
- ✓ Overhead lines with bare conductors
- ✓ Overhead lines routing across roads/farmlands
- ✓ Space between OHL conductors
- ✓ Supporting Structures
- ✓ Tree Cutting



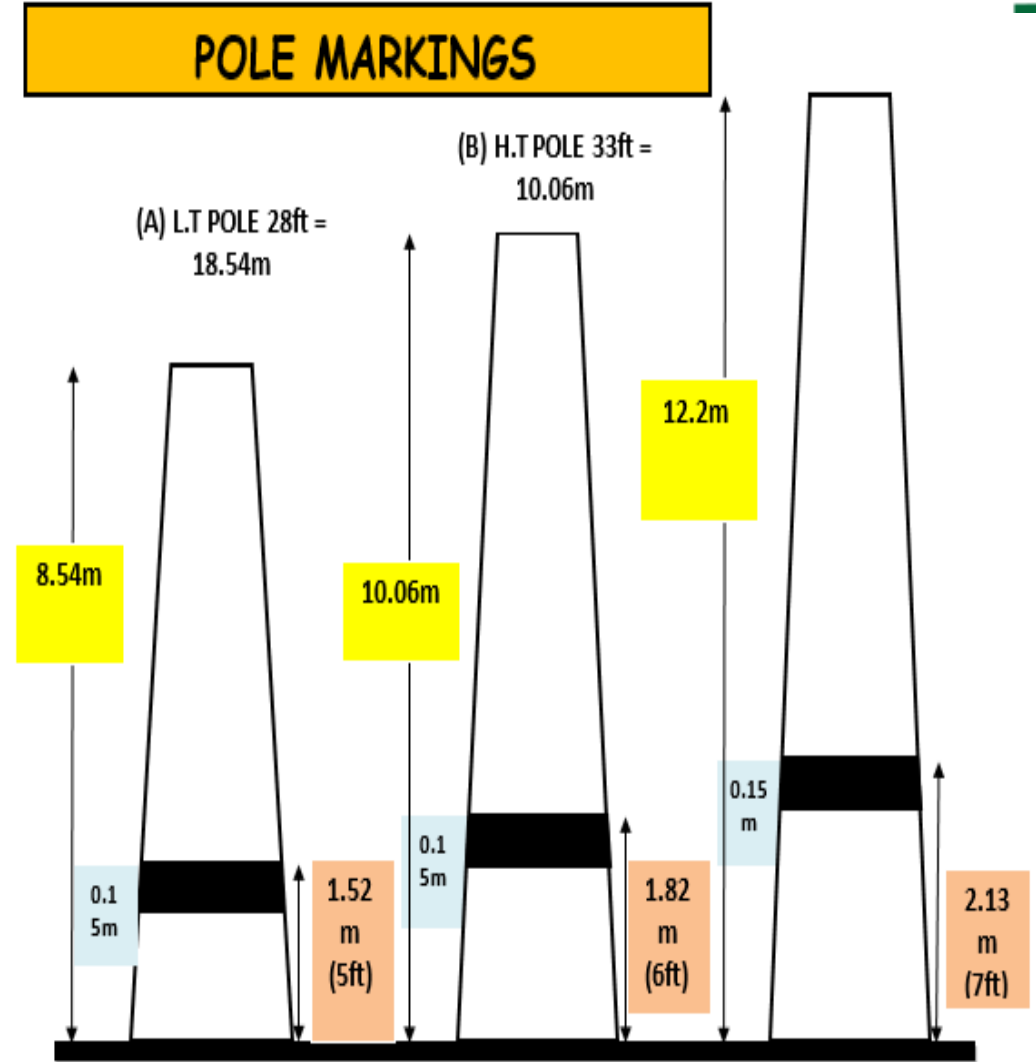
TYPICAL HIGH TENSION OVERHEAD LINE (HT-OHL)

➤ Concrete Poles

- ✓ Pre-stressed steel reinforced concrete pole (H, square & circular section).
- ✓ Pole dimensions according to application (LV only, LV/HV systems).
- ✓ Holes for D-iron and shackle insulators
- ✓ Spanage distance of High Tension (HT)/Low Tension (LT) poles.
- ✓ Pole identification and numbering format.
- ✓ Pole markings to aid in the process of erection have also be considered.
- ✓ Danger Plates

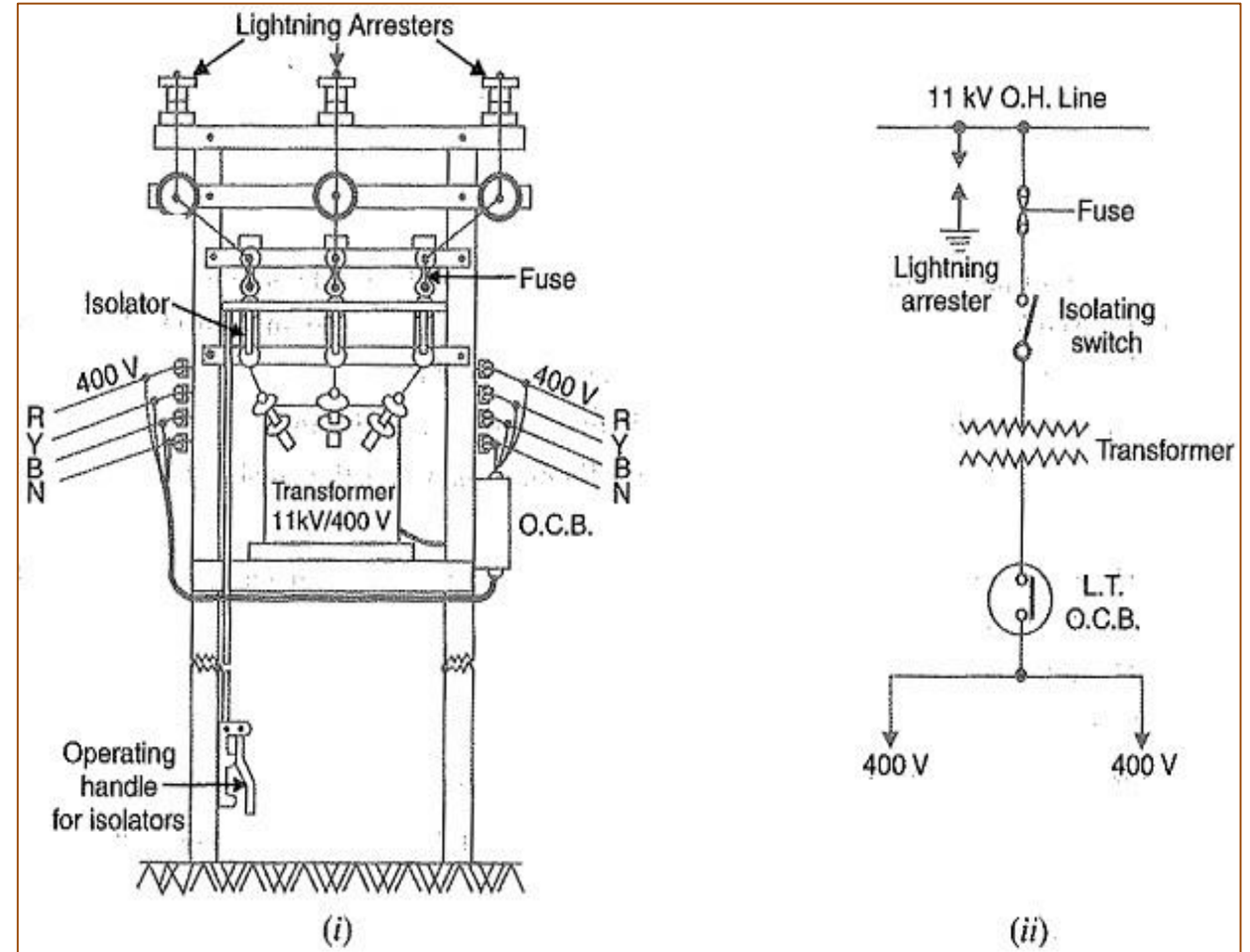
➤ Steel Towers/Steel Poles

- ✓ Structural members of supporting structures according for ISO and SON.
- ✓ Required thickness of steel members which include shaped steel, steel pipes & steel plates have also been considered.



➤ Installation of Transformers

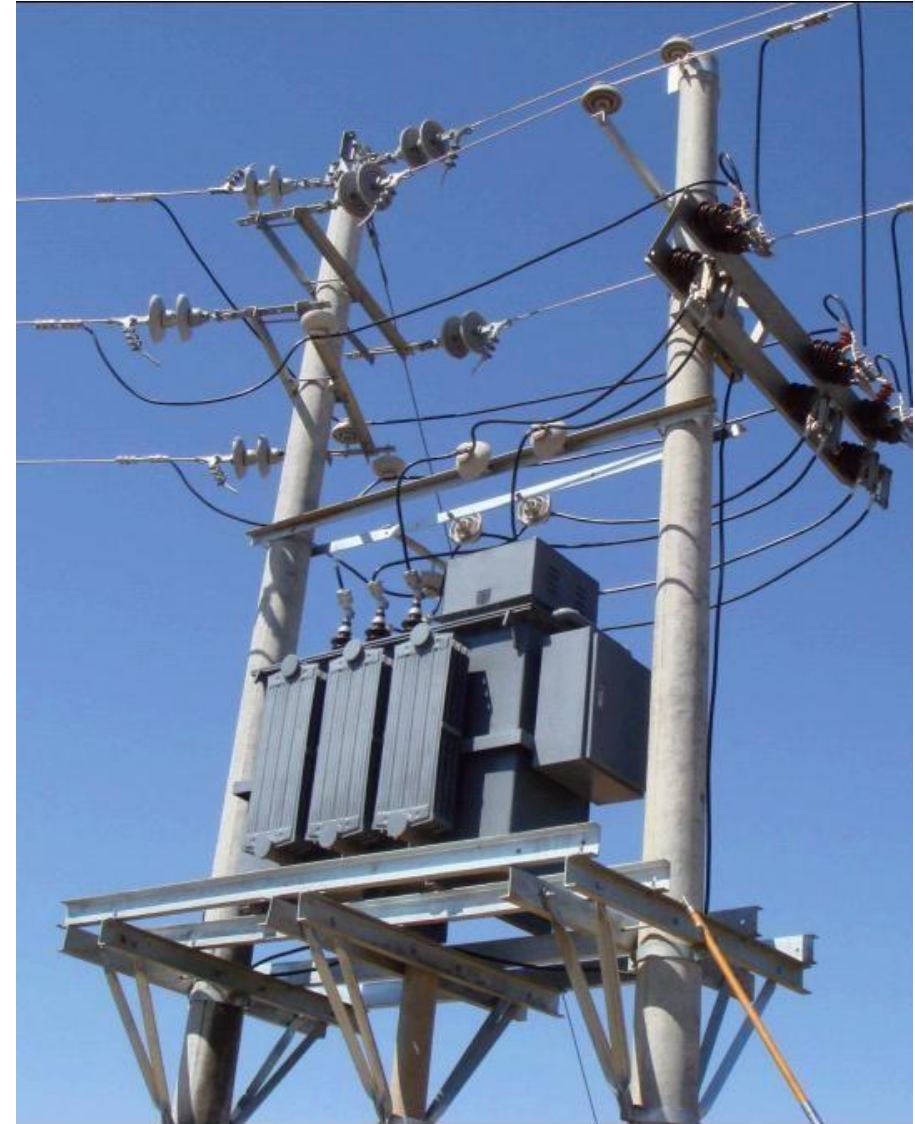
- ✓ All transformers must be new
- ✓ Minimum rating for distribution transformers ($\geq 200\text{KVA}$).
- ✓ 3 phase transformer Vector group of Dyn11
- ✓ Transformer earthing not $< 70\text{sqmm}$ bare copper, earthing resistance of $< 10\Omega$ and substations protected using voltage rated lightning arrester.
- ✓ Transformer winding material must be pure copper.
- ✓ All transformers shall be Europe-based or made in Nigeria with approved ISO compliance.



TYPICAL 11/0.4KV POLE MOUNTED TRANSFORMER

➤ **Critical Grid Extension Standards (According to NERC)**

- ✓ Standards for Feeder pillar specification and installation and civil works.
- ✓ Standards for Incomer transformer cables found in 11KV/400V & 33KV/400V substations.
- ✓ Standards for Substation Upriser cable dimensions for 200,300, & 500KVA transformers.
- ✓ Standards for ganged isolators and anti-climb guards.
- ✓ Standards for various tension sets, Bolts, Nuts, Washers, split lock washers.
- ✓ Standards for Surge arresters which must be gapless Metal-Oxide type made of Zinc-Oxide polycrystalline element, housed in polymer insulating materials and suitable for the pole-top mounting arrangement, etc.





INJECTION SUBSTATIONS

Engr. Shehu/ Engr. Seriki



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➤ Electrical Works (1/2)

❖ Switchgear and Fuse Gear Assemblies

- ✓ Covers design, manufacture, assemblage, installation, testing and commissioning of all 33kV and 11kV switch gear requirements.

❖ Capacitive Voltage Transformers (CVTs)

- ✓ Provides standards for accuracy in metering and metering codes.

❖ Station Service Transformer

- ✓ Standards which takes into account the auxiliary loads of the main substation.
- ✓ Also, combined CTs and Voltage Transformer (VTs) shall be deployed where there is a space constraint.

❖ Lightning Arresters

- ✓ Standards which must take cognizance of the energization of the different lines, equipotential bonding of metal frames of equipment, leakage current monitor with surge counter, etc.
- ✓ Every electric equipment or support exposed to liability or injury must be effectively protected against such liability.



➤ Electrical Works (2/2)

❖ Control Panels

- ✓ Standards, including the frames which must be fireproof, waterproof & vermin proof.

❖ Protection Panels

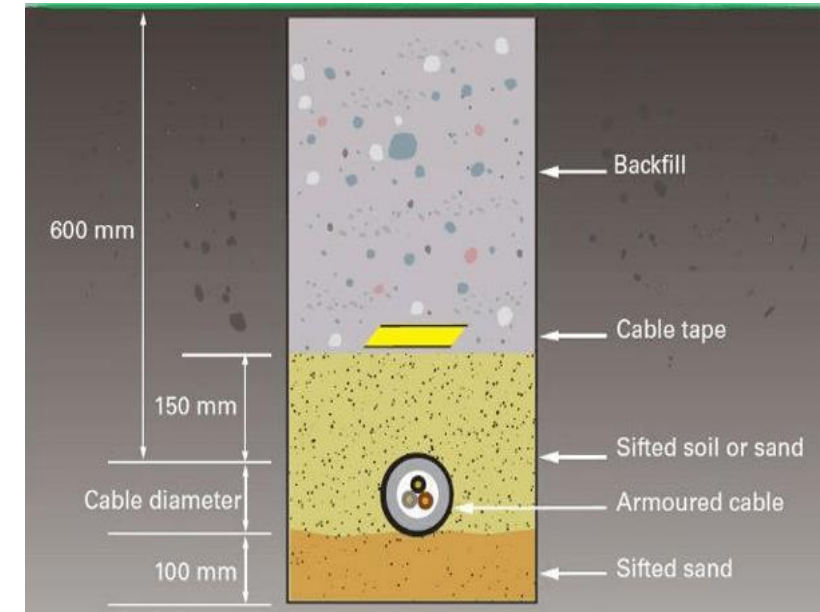
- ✓ Standards taking into account the construction dimension and earth considerations.

❖ Cables for Underground Transmission Lines

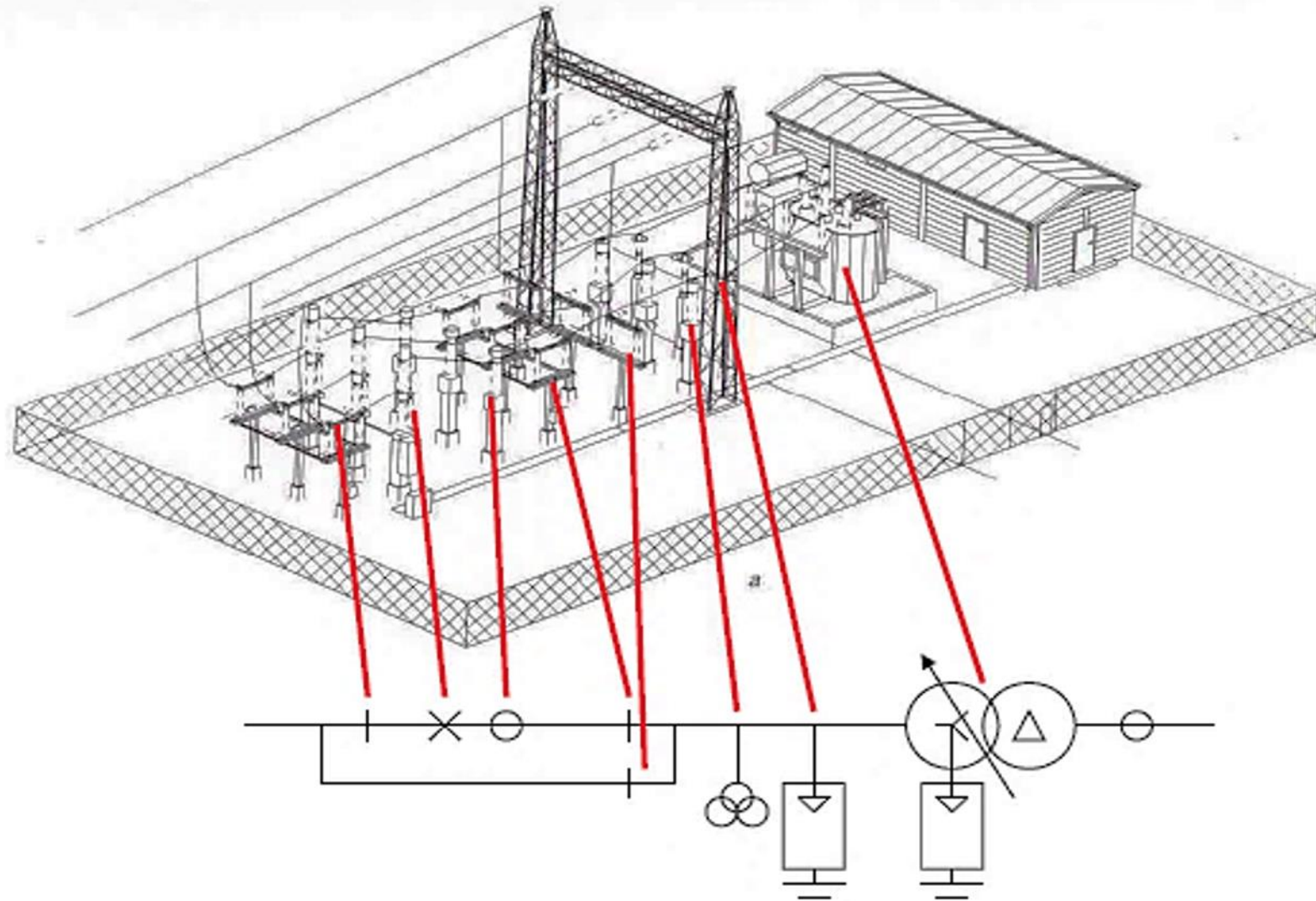
- ✓ Standards covering electrical, mechanical & construction characteristics, including annealed copper, aluminium & semi-hard drawn aluminium wire at specified electric resistance.
- ✓ Also covers insulation materials like butyl rubber, ethylene-propylene rubber or polythene compounds, etc

❖ Battery Banks

- ✓ Standards which include battery types, installation and safety considerations like extractor fans in battery bank room and provision of PPE to personnel.



The substation



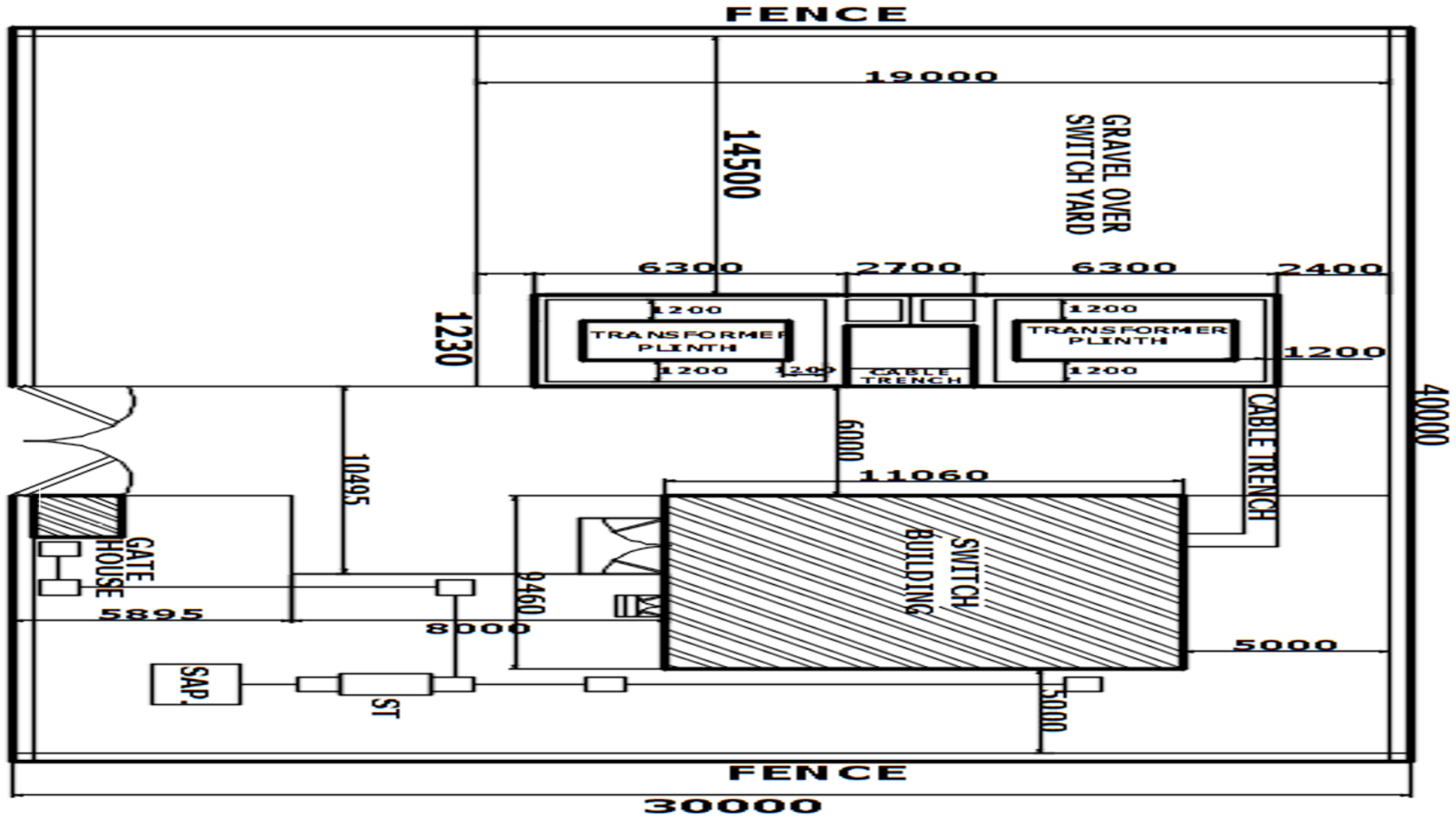
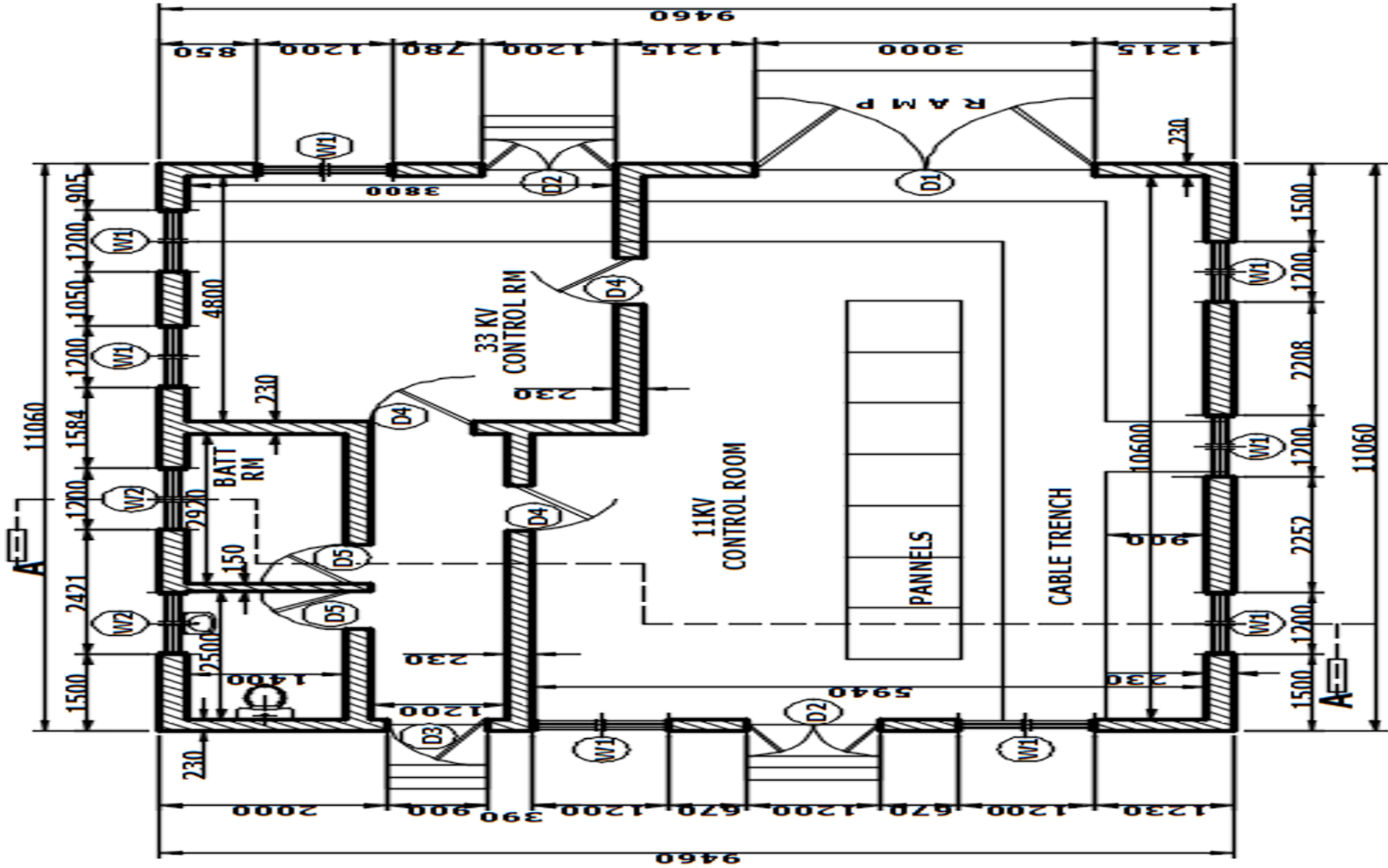


FIGURE 3.3.1: SITE PLAN OF THE SWITCH YARD



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SOLAR MINI-GRIDS

Engr. Uche Honnah



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➤ Eligibility requirements for mini-grids

SIZE OF MINIGRID	NERC REQUIREMENT	REMARKS
≤100KW	REGISTRATION PERMIT (OPTIONAL)	For mini-grids under 100KW, there is added advantage in obtaining a permit to protect a developer's assets in the event of DisCos' emergence and subsequent acquisition.
≤1MW	PERMIT	Requires the use of mini-grid MYTO (Multi Year Tariff Order) methodology to determine customer tariffs. The permit provides transparency, protects the developer's investments and ensures cost-reflective tariffs for customers.
>1MW	LICENSE	Various licenses include: Embedded generation, off-grid electricity generation and distribution

➤ General Guidelines

- ✓ The service standards and technical specifications listed in the Harmonised Technical Standards for REA are complementary to the NERC Mini-Grid Regulations 3 and the NEMSA regulations but do not replace them .
- ✓ Applicants applying for Mini-grid projects in REA shall comply with the technical specifications set out in the Harmonised Technical Standards of the REA, as well as NERC Mini-Grid Regulations and the NEMSA regulations.
- ✓ These service standards are differentiated based on the size of the mini-grid, based on the same categorisation found in the NERC Mini-Grid Regulations
- ✓ Mini-grids rated above 100kW (of distributed electricity) are subject to different standards compared to mini-grids rated below 100kW
- ✓ Service standards are measured at the point of customer connection.



Overview of System Configurations/Categories



Configuration>>	Type 1	Type 2-A	Type 2-B	Type 3
Summary	Small systems, using direct current (DC) coupling of Photovoltaic (PV) generation to a battery via a Maximum Power Point Tracking (MPPT) charge controller and employing a single grid-forming inverter that produces single phase electricity.	<ul style="list-style-type: none"> Multiple bi-directional single-phase inverters connected in parallel create a single-phase (Type 2-A) or three-phase (Type 2-B) power output. The battery inverter capacity can be extended modularly. Solar PV is coupled to the AC bus using PV inverters and/or to the DC bus using MPPT charge controllers. 		<p>Large AC coupled systems using central three-phase battery inverters of typically</p> <hr/> <p>100 kVA and above per module.</p>
Battery inverter continuous output	Single small inverter <10kW	Parallel inverters totalling 10kW to 300kW, single-phase/three-phase	Parallel inverters totalling 150kW to 1000kW, three-phase	Central inverters >1MW, three-phase



Design Requirements for Mini-grids



System component/aspect	Formula	Nomenclature
Grid-Tie Inverter	$P_{INV} = \frac{P_{PV}}{ILR \times \eta}$	<ul style="list-style-type: none"> • P_{INV}, Grid-Tie inverter capacity • P_{PV}, PV nominal capacity connected to the inverter • ILR, Inverter loading ratio also known as DC/AC ratio. ILR can be a maximum of two. The recommended value is 1.25 • η, Efficiency of the inverter at rated power
Battery Inverter	$P_B = DF \times P_{peak}$	<ul style="list-style-type: none"> • P_B, Battery inverter capacity under continuous load at 25°C ambient temperature • P_{peak}, Peak-load from demand assessment • DF is a design factor, the allowable range is 1.2 – 1.6
Grid-Tie Inverter and Battery Inverter capacity ratio	$1.8P_B < P_{INV} < 2P_B$ $P_{INV} \geq P_B + P_{peak}$	<ul style="list-style-type: none"> • Refer to row 1 and 2 of this table.
Battery	$n = \frac{Q_U \times DOD \times \eta}{E_{night}}$	<ul style="list-style-type: none"> • n is the number of autonomy days for the designed battery capacity • Q_U, Total nominal battery capacity in kWh • DOD, maximum allowable depth of discharge • η, round-trip efficiency for the proposed battery • For designing the mini-grid, recommended autonomy value is $1 \leq n \leq 2$
Diesel generator	$P_{gen} = DF \times P_{peak}$ $0.8P_B < P_{gen} < 1.2P_B$	<ul style="list-style-type: none"> • P_{gen}, General capacity in kW • P_{peak}, Peak-load from demand assessment • P_B, Battery inverter capacity • DF, Design factor for generator set is 1.2-1.4
Charge controller	$I_{CC} = DF \times I_{PV}$	<ul style="list-style-type: none"> • I_{CC}, the nominal current handling capacity of the charge controller • I_{PV}, Maximum current from PV string that the charge controller will have to face • DF, design factor should be between 1.2-1.3

PV module/Mounting



Property Description	Required Standard
Type of solar cells	Polycrystalline/Monocrystalline
	Solar cells embedded in EVA-layer (ethylene vinyl acetate)
Number of modules	Provide the number of rows mounted on the support structure
	An equal number of modules per row
Type of Frame	Anodised aluminium frame
Nominal power per module of solar cells	>300W at Standard Test Conditions (STC).
Slope	Between 10° to 15°
Height clearance	0.5m minimum clearance
The efficiency of PV modules	≥16%
Grounding	<10Ω earth resistance of support structure
Junction box	Weatherproof, IP 65 with bypass diodes and pre-configured cables
Depth of planting the PV structure	Not <1.5m
Equipotential bonding	16mm ² copper conductor to be used.
Junction box	Weatherproof, IP 65 with bypass diodes and pre-configured cables
Performance Warranty	Minimum of 10 years for 90%
	Maximum of 25 years for 80%
Static calculation	In accordance with ground conditions in considering wind speed and other risks



Energy Storage (Battery)



Property Description	Required Standard
Lithium-ion batteries	Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for large format secondary lithium cells and batteries for use in industrial applications (IEC 62619)
Battery charge controllers for photovoltaic systems	Performance and functioning (IEC 62509)
Safety requirements for secondary batteries and battery installations	Part 1: General safety information and Part 2: stationary batteries (IEC 62485-1 and 62485-2).
Battery Rack	Battery support structure/cabinet made of steel and insulated to ground Floor bearing capacity must allow carrying the weight of the battery
Battery cabling	Battery cables to be made of copper (16mm ² and 25mm ²), preconfigured with terminals according to the requirement of the battery quoted Cable length and cross-section should limit DC voltage drop to less than 1% Appropriate cable termination with lugs.
Reference battery life cycle	For lithium-ion or other technologies: 4,000 cycles at 80% depth of discharge and end of life 80% of nominal capacity
Paralleling of cells to get the requested capacity	For lithium batteries and others: paralleling of cells only allowed if explicitly specified by the manufacturer and if an adequate battery management system is installed
Operating temperature range in the battery room	10°C to 30°C, air conditioning is required for systems with more than 30 kW rated battery inverter power
Battery management	The algorithm calculating the switch-off point needs to consider the measured battery temperature to prevent deep-discharge and overcharging (low



Balance of system (BoS)



Type of requirement	Type 1	Type 2-A	Type 2-B	Type 3
Solar charge controller (if part of the system)_ Warranty 5years				
Minimum rated power per charge controller	>4.5KW			>100KW
Maximum Power Tracking (MPPT)	Yes			Yes
PV array operating voltage range	100-600VDC (>95% max. efficiency)			600-1200VDC (>95% max. efficiency)
Solar Inverter/Grid-Tie Inverter				
Total solar inverter capacity	Not Applicable (N/A)	≥5kW	≥10kW	≥100kW (Parallel stacks)
Type of inverter	>90% Transformerless (>96% efficiency) Min. 5 years warranty			
Battery Inverters				
Inverter system minimum rated power	≥6KVA continuous			≥100KVA continuous output at 25°C (Nominal power)
Nominal AC voltage	230V		230/400V	230/400V
DC Combiner Box for PV strings				
Box cabinet material	Powder-coated steel			
DC fuse/Breaker	Required if string configuration of more than 2 strings in parallel			
AC Combiner Box				
Box cabinet material	Powder-coated steel			
Over voltage arrestors	Integrated combined Type I and II			
Circuit Breakers	Sized according to battery inverter, self-consumption of the power plant and the peak current			



Diesel Generator

- ❖ The Applicant shall declare and present evidence that all the diesel generators comply with the following specifications: Rotating electrical machines – Part 1- Rating and performance (IEC 60034-1)
- ❖ The standards for diesel generators apply only to the relevant system type as indicated in Table 4.10 for diesel generators.
- ❖ The diesel generators may be installed inside the powerhouse, or under a suitable massive shelter, or outside with a canopy.
- ❖ Each Generator shall be supplied complete with all installation drawings and documentation, warranty, operation and maintenance manuals.
- ❖ The diesel generators shall be prime rated with an electrical output from each diesel generator as given below:
 - ✓ 5kVA (single phase); 10kVA (Single phase); & 16kVA (single-phase and three-phase options)
 - ✓ 25kVA, 40kVA, 60Kva, 80kVA, 100kVA, 150kVA, 200kVA, 500KVA, 1MVA > (Three phase options).
- ❖ The diesel generator set shall achieve the rated values and performance under the following specified conditions and shall deliver power within the following requirements:
 - ❖ Nominal Voltage: 415/240 V at alternator terminals.
 - ❖ Nominal Frequency: 50 Hz.
 - ❖ Power Factor: Maximum 0.8 lagging.
 - ❖ Overload greater than 2.0 p.u. for 10 seconds, with less than 30% voltage dip



Diesel Generator



Type of Requirement	Type 1	Type 2-A	Type 2-B	Type 3
Nominal capacity	No diesel generator	kVA prime power rating		
Nominal AC voltage range	N/A	220V- 240 V	220V-240V and 380V-415V	
Nominal frequency	N/A	50Hz		
Cable to connect the diesel generator to the AC combiner box	N/A	Armoured AC cable, unless the cable is installed inside a building		
Cable length and cross-section	N/A	Must limit AC voltage drop to less than 1%		
Bypass switch (to switch between diesel generator only and battery inverter to supply power to the network)	N/A	Yes		
The generator should include a canopy	N/A	Yes		
Day tank fuel capacity	N/A	80 litres	200 litres	200 litres
		or above	or above	or above





SOLAR HOME SYSTEM

Ms. Simisola Sobowale



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Product Tiers	Units	Tier 2	Tier 3	Tier 4	Tier 5
PV Type	Polycrystalline/Monocrystalline with Aluminium frame encapsulated in EVA Having				
Nominal Capacity	W_p	50	200	800	2000
Daily Capacity	W_h	200	1000	3400	8200
Nominal Voltage	V	12	12	12	24
Minimum service		Electrical Lighting, DC LED TV, phone charging, DC fan,	LED lamp, phone charging, DC fan, DC LED TV (20W), Fridge ($\leq 30W$)	LED lamp, phone charging, fan, LED TV (20W),	LED TV, Radio, LED lamp, phone charging, fan, laptop,
				Fridge ($\leq 30W$)	Fridge ($\leq 30W$)
Availability (day)	Hrs	4	8	16	23
Availability (evening)	Hrs	2	3	4	4
Warranty	Yrs	2	2	2	2
DC/DC		YES	YES	NO	NO
DC/AC		NO	NO	YES	YES





SOLAR STREET LIGHT

Dr. Garry Naman



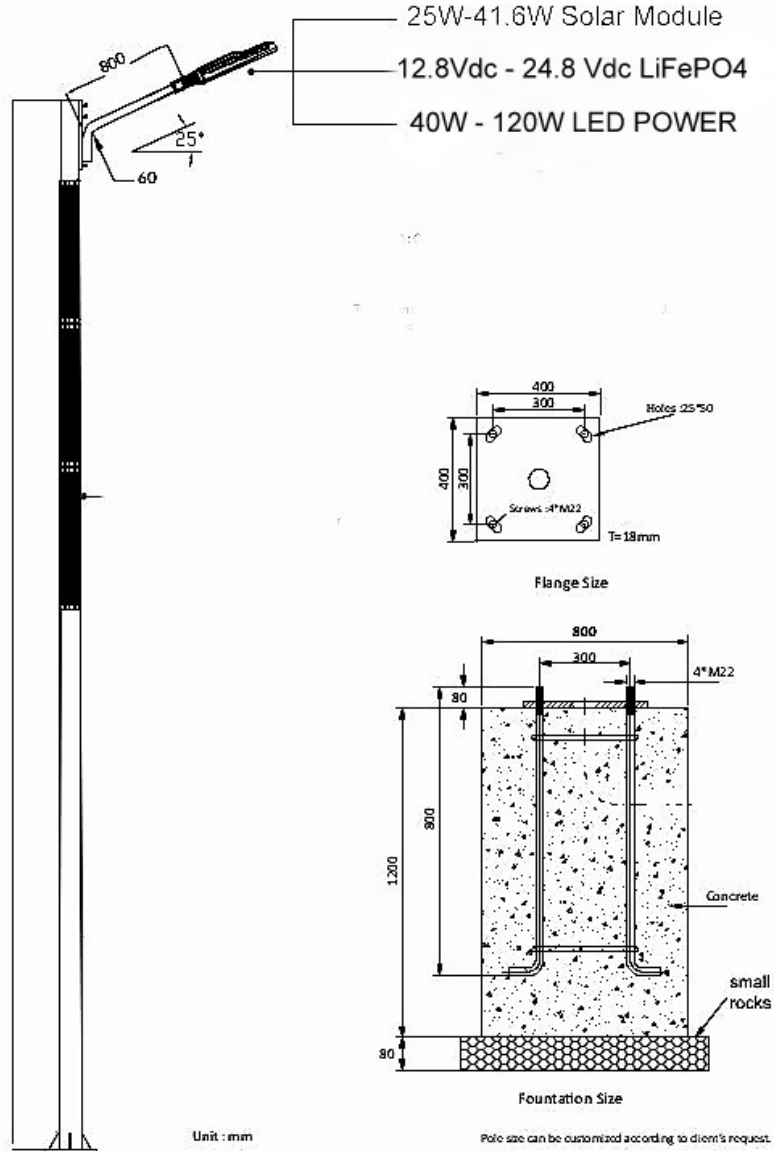
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Sr. No.	PROPERTY DESCRIPTION	RANGE
1	Led Power	40W-120W
2	Lumen Efficiency	100-110LW/W
3	System Lumens	2000-11000LM
4	Colour Temperature	3000K-6000K
5	Battery Spec	Lithium Iron Phosphate Battery (LiFePO ₄) 12.8Vdc TO 24.8Vdc 9AH TO 60AH
6	Solar Module	Monocrystalline 20Vdc TO 30Vdc 25W TO 41.6W
7	Charging Time	8H TO 10H
8	Operation Rainy Days (After Fully Charged)	5 TO 7 Rainy Days
9	Installation Height	6 TO 10m depending on led power
10	Control Type	Remote Control (Optional)
11	Operating Temperature	+20°C TO +50°C
12	Ip Rating	IP65
13	Body Material	Aluminium Alloy
14	Finish	Powder Coating
15	POLE FITTER DIAMETER (φ)	76mm TO 100mm
16	Mounting Type	Bracket Adjustable Bracket
17	Foundation depth	Not <1.28m

SOLAR STREET LIGHT (SSL)_Solar Street Light Installation: Height and Spans Between Poles

Structure & Size of Pole



S/N	LED Power (Watts)	Height of Pole (m)	Distance Between Poles (m)
1	40	7 to 8	19 to 23
2	50	7 to 9	23 to 27
3	60	7 to 9	27 to 31
4	80	8 to 10	31 to 35
5	100	8 to 10	30 to 35
6	120	9 to 10	30 to 35



Thank you



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