Network Modernization

Upgrading and Modernizing Nama Distribution Substation to enhance Efficiency, Reliability & Resilience

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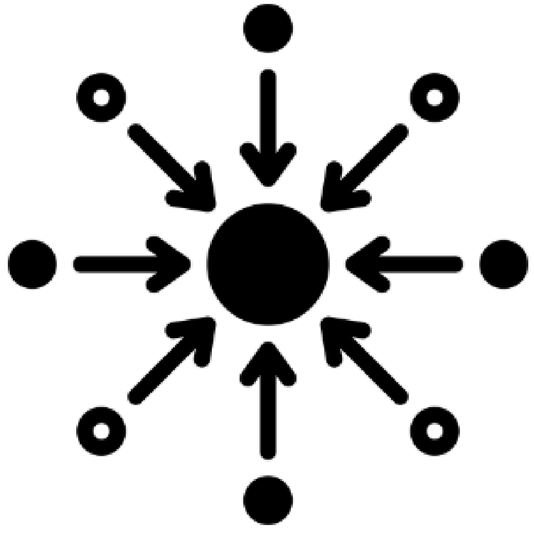
Nama Electricity Distribution

Challenges in Distribution System Design

- **Technology Developments**
- **Power Demand Growth**
- **Plot Demand and Cost Increases**
- **CO2 Emission & Sustainability Goal**

OBJECTIVE



Optimized Design

Smart Operation

Towards Sustainability

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Focused Area

1. Sustainable PSS Building – 3D Model Design approach
2. Digital Signal Transmission using IEC 61850
3. Integrated MV SWGR with Protection Relay
4. 33kV RMU instead of 33kV Outdoor Gantry
5. Power transformer orientation
6. Energy Efficient Lighting system
7. AC Temperature setting at $24^{o}C$
8. AC Water recycling system

1. Sustainable PSS Building Design

Civil Design Optimization

PSS Civil Building – factors considered

Plot Selection	• Near to the Customer or Grid side. • Plot condition, Groundwork Cost
Plot Utilization	• Maximum utilization of plot. • 2PSS in one Plot, 1 PSS capacity of 3x20MVA
Plot Optimization	• Minimizing the building size, footprint. • One structure Building, Vertical Building
Mother Soil Utilization	• Isolated footing, Excavate the footing area only. • Reuse of mother sand after the test.
Resilience to Climate change	• High Humidity, Heavy rain and flood, Wind pressure, Sun direction, are taken care to protect inhabitants.
Seismic Resistant Building	• Seismic factors considered in the Building structural design to withstand the effect of ground shaking, Earthquake, Soil liquefaction .
Fire Resistant Building	• Wall's, Door's, Fire Alarm, Fire Extinguisher, Smoke extraction, Escape route are considered in Building Design as per NFPA.

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PSS Civil Building – factors considered

Flood Resistant	• Sea water level considered (Every year Sea water level increasing) • Elevated Building (Height raised Building)
Natural Light usage	• Bigger Windows with Mechanical, Noise, UV protection. • It minimize the energy consumption and reduces the CO2 emission
Concrete Usage & Waste reduction	• Minimizing the Building size and its Concrete requirement • Well Calculated Concrete needs and its wastage are controlled
Sustainable Materials	• Ready-mix Concrete, readymade steels, Local available and manufacturing materials, etc., • ICV is major consideration.
Water Usage & Waste reduction	• AC water recycling – eliminate the need of External water supply connection and monthly changers.
3D –Design	• Which results in superior what-if model assessments where constraints and issues may be readily identified, evaluated.
Energy Efficient Building	• Insulated walls, Window's and Doors. LED lights with motion-controlled sensors and Controlled AC Temperature reduces the energy consumption and decreased greenhouse gas emissions.

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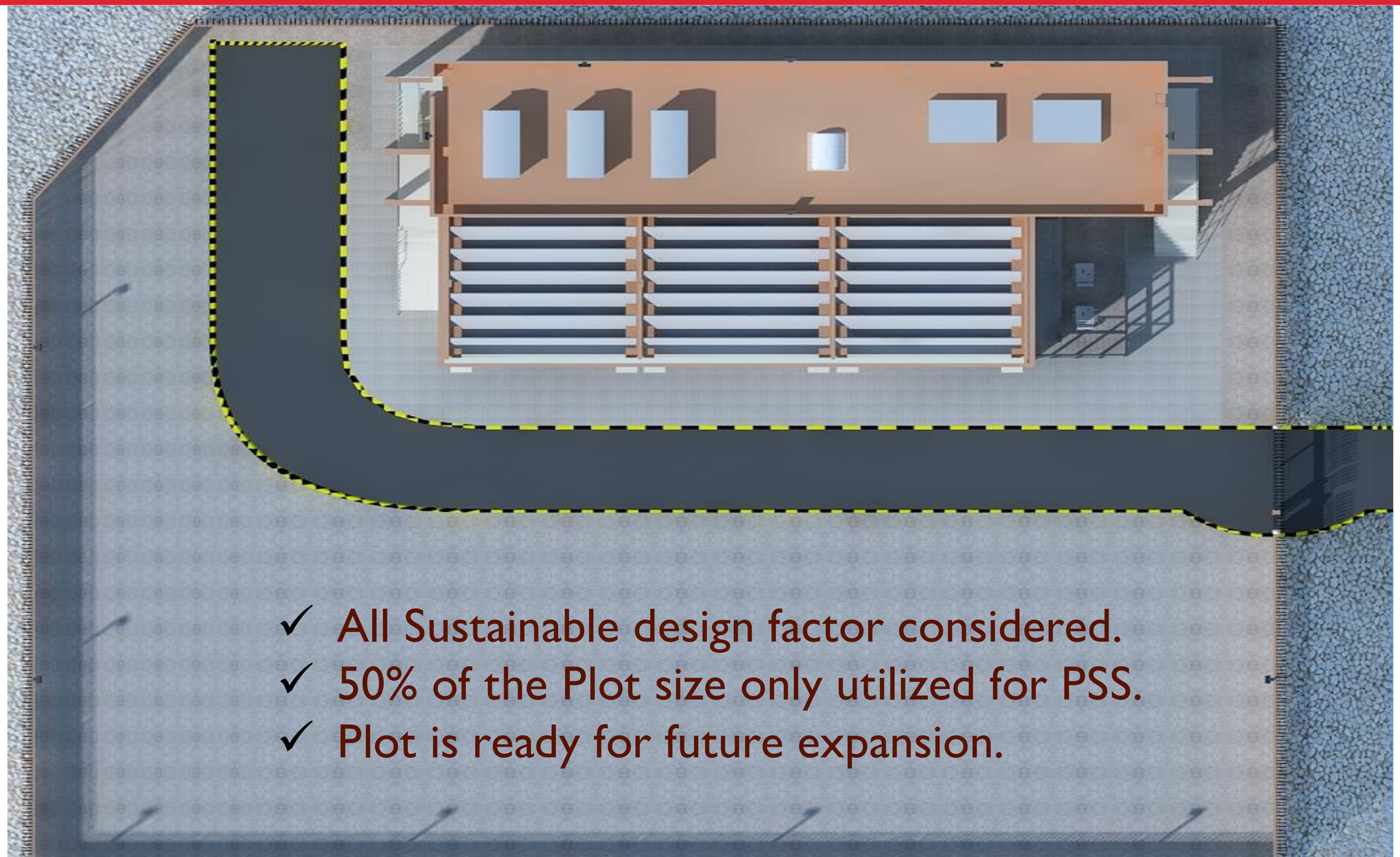
PSS Building -3D Design

PSS Building -3D Design

PSS Building -3D Design



- ✓ All Sustainable design factor considered.
- ✓ 50% of the Plot size only utilized for PSS.
- ✓ Plot is ready for future expansion.

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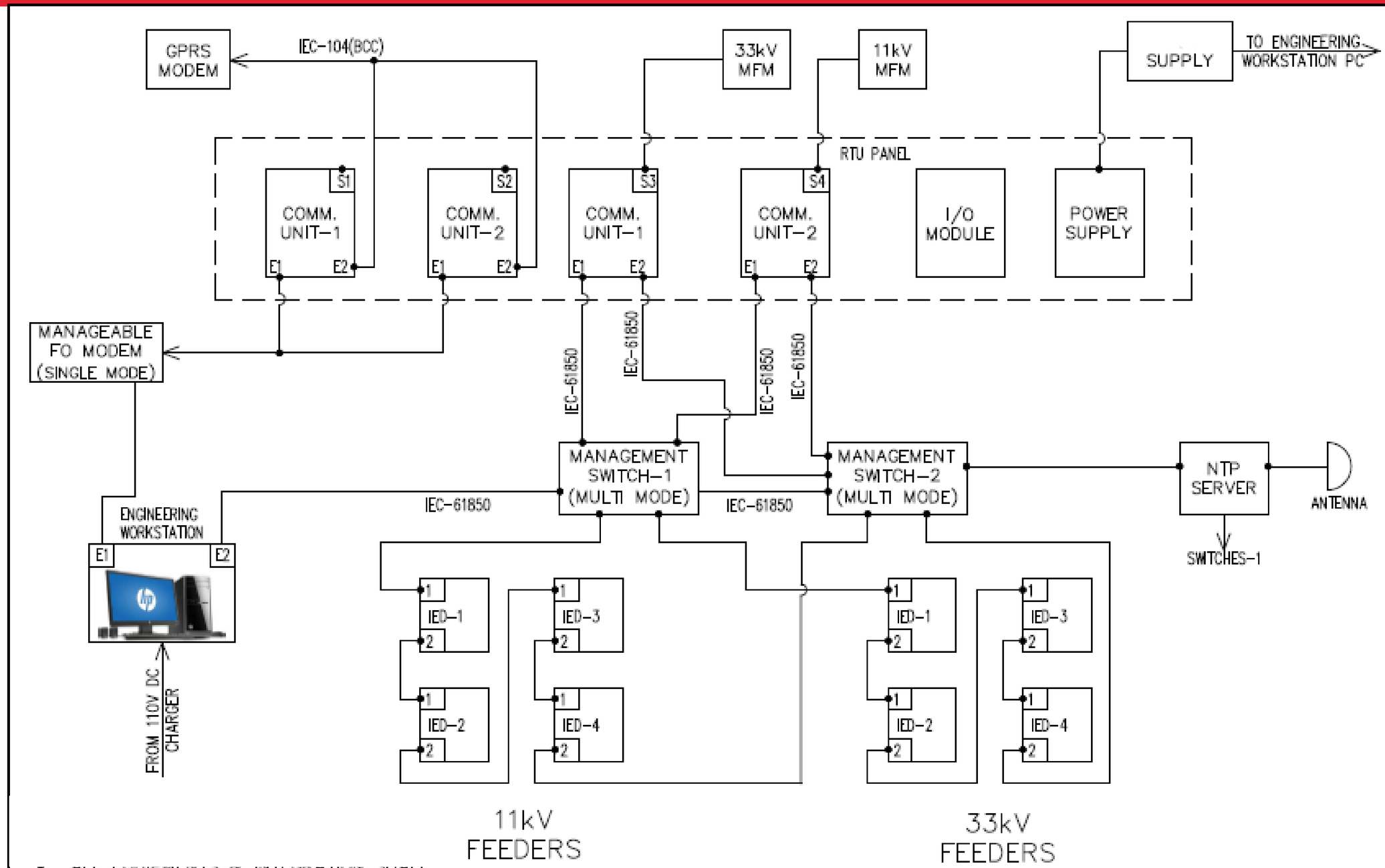
2. Digital Signal Transmission using IEC 61850

Digital Substation

Digital Signal Transmission

#	Name	# Fdrs	Points Per Feeder						Points Per Station					
			61850/Modbus			HW			61850/Modbus			HW		
			DI	DO	AI	DI	DO	AI	DI	DO	AI	DI	DO	AI
1	33KV INC	3	42	7	8	1	0	0	126	21	24	3	0	0
2	33/11KV TX-RTCC	3	0	0	0	31	7	1	0	0	0	93	21	3
3	11KV INC	3	0	0	0	1	0	0	0	0	0	3	0	0
4	11KV BS	2	41	9	8	1	0	0	82	18	16	2	0	0
5	11KV OG	15	34	8	8	1	0	0	510	120	120	15	0	0
6	11KV SAT	2	21	5	6	1	0	0	42	10	12	2	0	0
7	11KV CAP	3	20	5	8	25	12	0	60	15	24	75	36	0
8	STATION COMMON	1	1	0	4	33	2	0	1	0	4	33	2	0
9	SUMMERY:	32	159	34	42	94	21	1	821	184	200	226	59	3
		No. of the Signals (25% Spare) :										283	74	4
		No. of the cards (25% Spare) :										18	5	1

Digital Signal Transmission



Digital Signal Transmission

	IEC 61850	Modbus	Hard Wire	Total
DI (BI)	821		283	1104
DO (BO)	184		74	258
Analog		200	4	204
Total	1005	200	361	1566
% Use	64.2%	12.7%	23.1%	
1no.of MP + 1RTU				

Soft Signal (IEC 61850 and Modbus) is 76.9%

Hardwire (Analog) is 23.1%

IEC 61850, Modbus communication is available in most of the equipment's and its relays

RTU Panel – 1no and Marshalling Panel- 1no

Less pair cables, trays, cable glands, terminations, gland earthing, testing & commissioning. CAPEX reduced.

Fault identification & Trouble shooting is easy. OPEX reduced.

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3. MV Switchgear with Protection Relays (Integrated)

Electrical Design Optimization

MV SWGR with Protection Relays

33kV Switchgear with Control and Protection Relays Pilot Project Successfully Commissioned.

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MV SWGR with Protection Relays

- All components (CB, CT, VT, Earth switches, Protection relays in same cubical.
- Separate Control and Protection Relay Panels Eliminated
- Cable work between SWGR & CRP & its Malfunction Eliminated.
- CRP Panels fixing support work Eliminated
- Cable Tray work and Panel Earthing work reduced.
- Control room space saved.
- CRP Manufacturing and Delivery time delay issues avoided
- CAPEX Saving RO. 6500 per Switchgear (Approx)

4. Transformer Orientation & Ventilation

Optimized, Efficient, Reliable and Resilience Network

Transformer Orientation & its losses

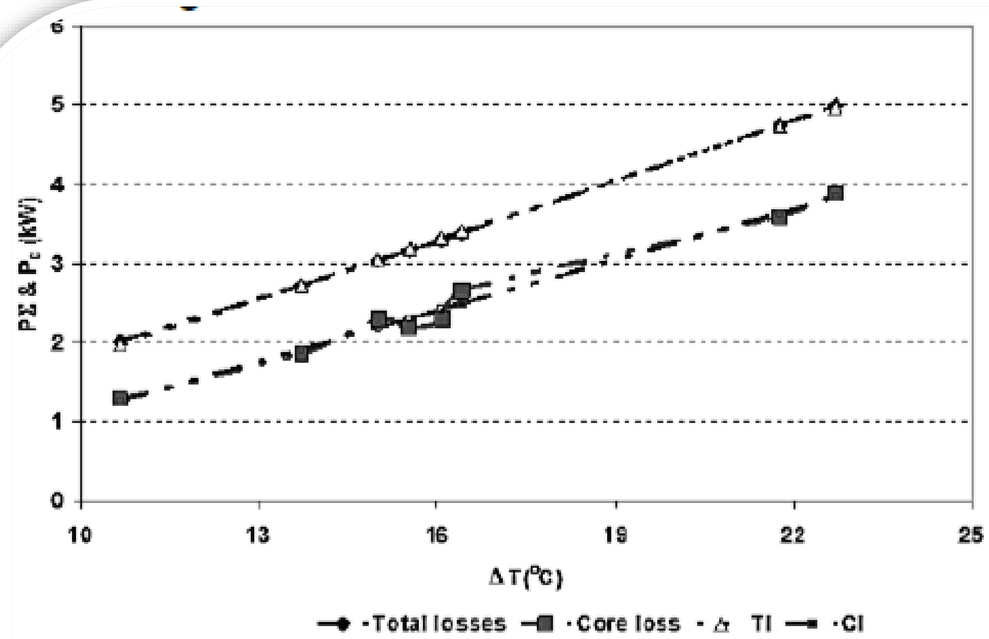


Figure 1. The power losses versus the temperature rise

It is seen that the core and total losses linearly rose as the temperature rise increased. Based on this curve, the total power loss and the core loss output powers would increase as the temperature rise increased too, with the average of 0.25 kW/°C and 0.30 kW/°C respectively. Figu

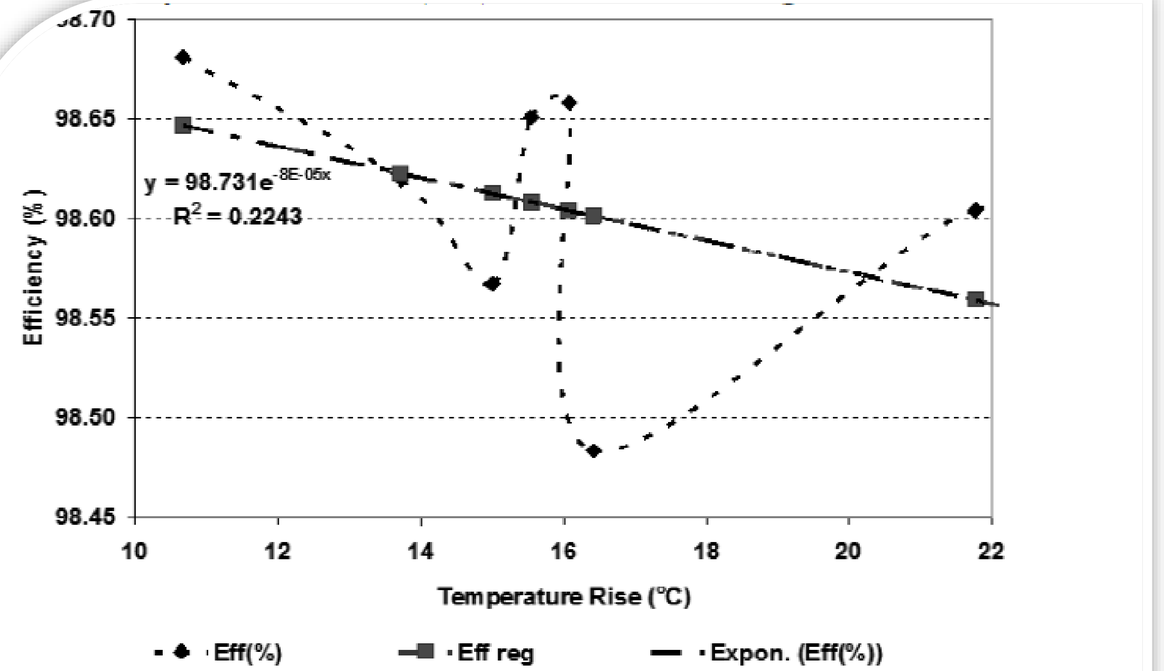


Figure 3. The efficiency to the temperature rise

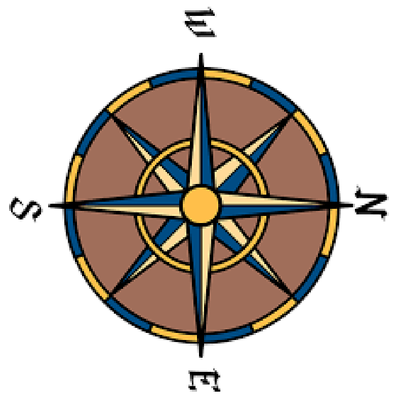
The increasing temperature rise made the transformer efficiency fairly reduced. The efficiency would reduce as the temperature rise increased as the average of -6.41 %/°C.

"According to the IEC354 loading guide for oil immersed power transformers [1], " "The hotspot temperature in a transformer winding is the sum of three components: the ambient temperature rise, the top oil temperature rise, and the hot spot temperature rise over the top oil temperature"

eea journal **Investigation of Transformer Losses and Temperature Rise,** Feb 2018**.**
"The thermal effect, moisture, acidity, oxygen etc., were controlling factor in determine transformer lifetime".
"For every 1°C ambient temperature reduction, from standard 30°C, release approximately 1% of overloading capability [35-36]"

Transformer Orientation & its losses

Earlier Design



Present Design

5. 33kV RMU instead of 33kV Outdoor Gantry

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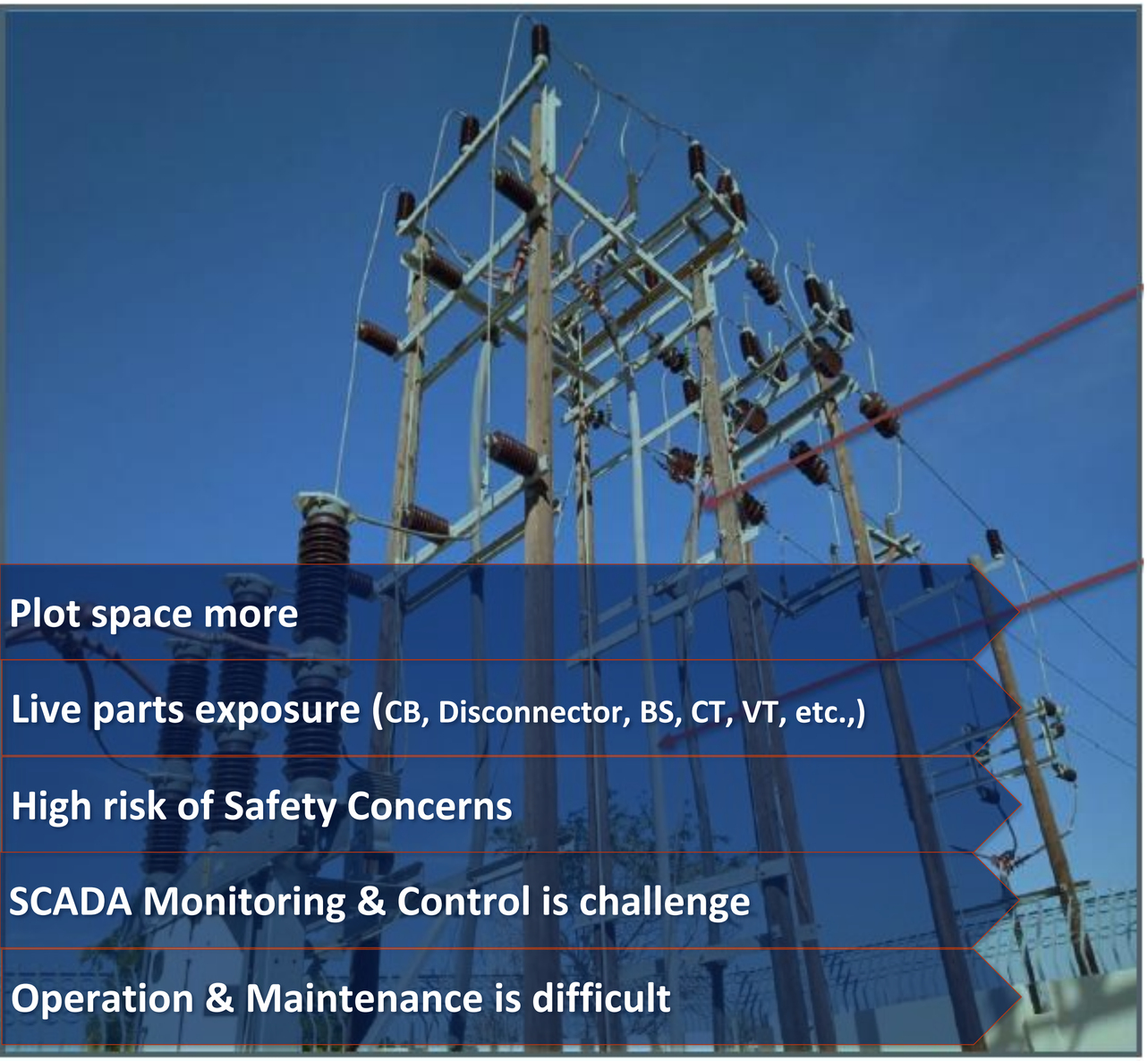
33kV RMU replaced the 33kV Outdoor Gantry

Existing - 33kV Gantry Arrangement



- Plot space more
- Live parts exposure (CB, Disconnector, BS, CT, VT, etc.,)
- High risk of Safety Concerns
- SCADA Monitoring & Control is challenge
- Operation & Maintenance is difficult

New - 33kV RMU Arrangements

- Less Plot space requirements
- All Components - 33kV CB, CT, VT, etc., in the Metal enclosure
- Motorized operation and Auto-reclosing capability
- SCADA Monitoring & Control
- No exposure of live parts
- Operation and Maintenance is easy

6. PSS Lighting Design

Optimized, Energy Efficient Design towards Sustainability

PSS – Indoor & Outdoor Lighting System

Existing System

Indoor – Fluorescent light fittings

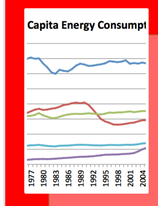
Outdoor – Sodium lamps with poles

Manual Operation

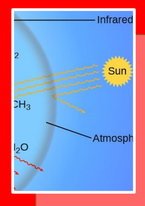
Heat generate / dissipation is more

Over a time, luminaire will lose almost 40%

Operation, Safety Constraints

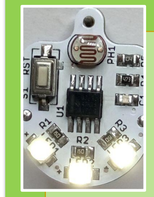


Energy consumption is more



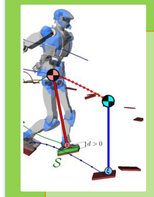
Co2 and Greenhouse gas emissions is more

Present System



Indoor – Smart LED Lights

Outdoor – Smart LED Lights without Poles



Motion control operation

Heat generate / dissipate is Less

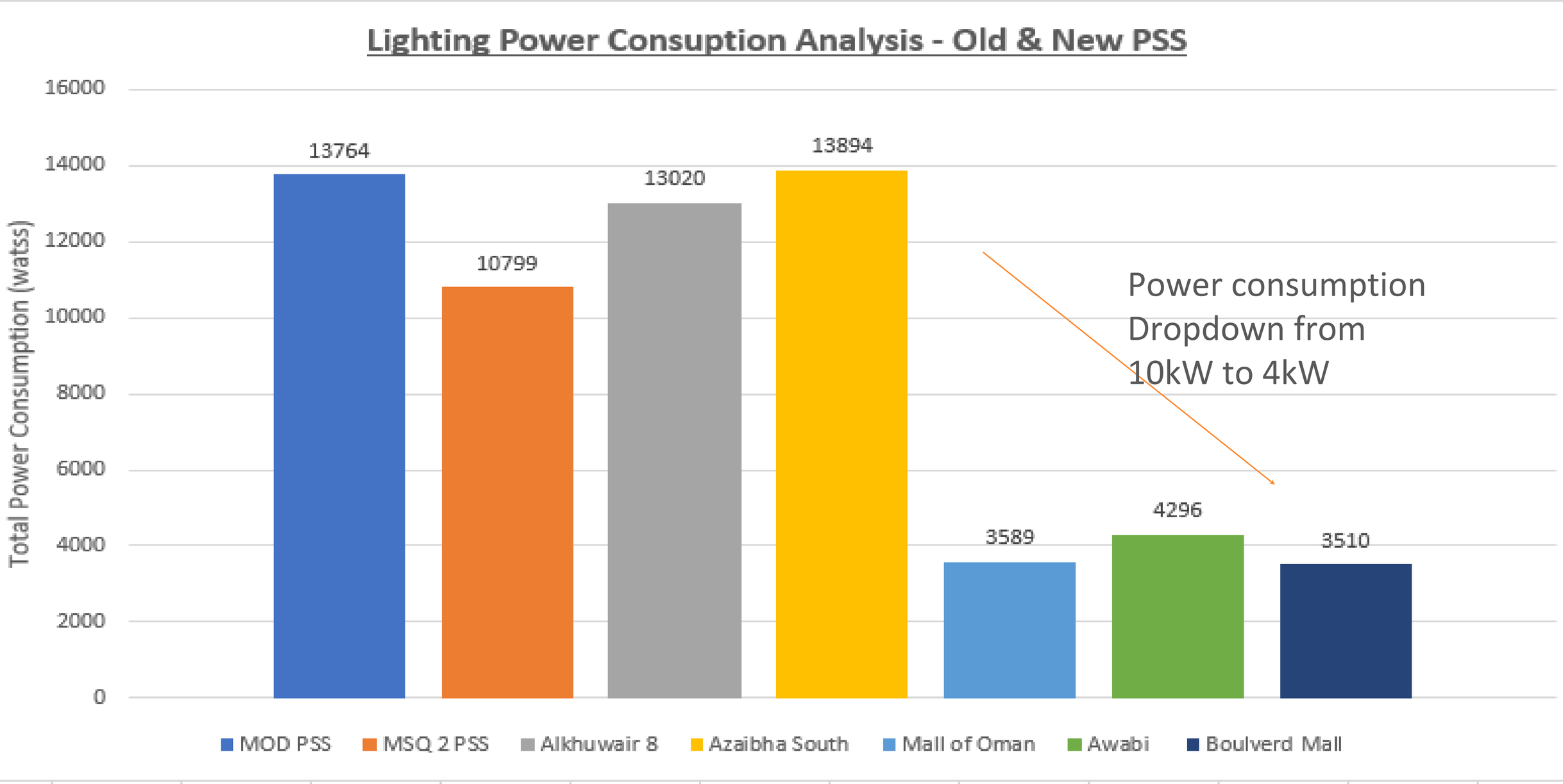
Easy to Operate, Handle and deposal

Better Performance

60% Energy efficient

Eco-Friendly, Co2 and Greenhouse gas emissions is less

Lighting System Consumptions – Case Study @ 7PSS's



Source : 2023 Units & Cost consumption data from 182 PSS

7. PSS - AC Temperature setting at 24°C

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PSS Equipment can operate 24^{0}C ?

33KV Switchgear

2.2 Environmental and operating conditions

WS switchgear may only be operated under normal operating conditions according to the specifications EN 62271-1 or the IEC Publication 62271-1.

Operation under conditions deviating from these is only admissible upon consultation with and approved by the manufacturer.

Ambient conditions (acc. IEC 62271-1)		
Temperature class		„minus 5 indoors“[4]
Min./max. ambient temperature	°C	(–5 / +40)[4]
Average value over 24 hours (max.)	°C	≤ 35[4]
Average rel. air humidity: 24 h / 1 month	%	(≤ 95/ ≤90)[4]
Max. installation altitude above sea level	m	≤ 1000[4]

[4] other values possible on request

11kV Switchgear

ITEM	CONDITIONS	METHOD
Ambient Temperature	-5°C to 40°C	Place panels in air-conditioned building or dry area within ambient temperature conditions.
Humidity	Less than 75%	Place drying agent in the cubicle Place panels in air-conditioned building or dry area within ambient temperature conditions.

Power Tx – RTCC AVR – MR Relays

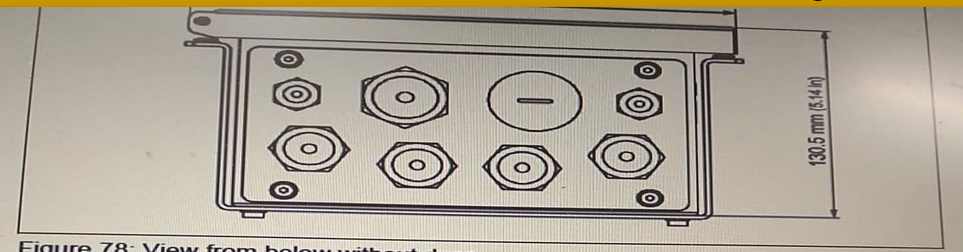


Figure 78: View from below without door

12.4 Ambient conditions

Operating temperature	-25°C...+70°C
Storage temperature	-40°C...+85°C

Table 52: Ambient conditions

12.5 Electrical safety

EN 61010-1 Safety requirements for electrical

Other Components




Parameter	Model: 2246 TPI	Model: 2257 TPI With Voltages	Model: 2245T TPI	Model: 2264 TPI
Signal input	Resistance Input (1k /100 /10)	Resistance Input (1k /100 /10)	4-20mA Input	BCD input
No. of positions.	1-39 position user selectable	1-39 position user selectable	1-39 position user selectable	1-39 position user selectable
Display	2 No's. 0.5" 7 segment LED	1. 2 No's Seven Segment Display (Tap Position). 2. 5 No's Seven Segment Display (voltages).	2 No's. 0.5" 7 segment LED	2 No's. 0.5" 7 segment LED
Outputs	T1-Indication only. T2-2Nos, 4-20mA DC O/P's. T4-4-20mA DC+RS 485 T5-4Nos. of 4-20mA DC O/P's.	4 No's of 4-20mA DC output	T1-Indication only. T2-2Nos, 4-20mA DC O/P's. T4-4-20mA DC+RS 485 T5-4Nos. of 4-20mA DC O/P's.	—
Communication	RS-485 Modbus RTU Protocol	RS-485 Modbus RTU Protocol	RS-485 Modbus RTU Protocol	—
Power consumption	5 Watts	8 Watts	5 Watts	5 Watts

Common specification for all the above models:

- Ingress protection : IP-20
- Auxiliary supply input : 90-260V AC/DC
- Operating temperature : 0°C to 60°C
- Terminals : Screwed Caged suitable for one 2.5 SQ.mm wire.
- Insulation : Greater than 20mΩ at 500V DC
- High voltage test : All terminals to Body. Withstood 2KV 50Hz AC for 1 minute.

PSS Equipment can operate 24^{0}C ?

Siemens Relay

Temperatures

Standards:	IEC 60255-6
Type test (in acc. with IEC 60068-2-1 and -2, Test Bd for 16 h)	–25 °C to +85 °C or –13 °F to +185 °F
Permissible temporary operating temperature (tested for 96 h)	–20 °C to +70 °C or –4 °F to +158 °F (clearness of the display may be impaired from +55 °C or +131 °F)
Recommended for permanent operation (in acc. with IEC 60255-6)	–5 °C to +55 °C or +23 °F to +131 °F
Limit temperatures for storage	–25 °C to +55 °C or –13 °F to +131 °F
Limit temperatures for transport	–25 °C to +70 °C or –13 °F to +158 °F
Storage and transport with factory packaging	

Ebrele Relays

Ambient conditions	
Temperature range	
Function Transport and storage	-15°C ... +60 °C -25 °C ... +65°C
Dry cold	IEC 60068-2-1, - 15 °C / 16 h
Dry heat	IEC 60068-2-2, + 65 °C / 16 h
Humid heat constant	IEC 60068-2-78 + 40°C / 93% / 2 days
Humid heat cyclical	IEC 60068-2-30 12+12 h, 6 cycles +55°C / 93%

ABB Relays

Environmental conditions

Description	Value
Operating temperature range	-25...+55°C (continuous)
Short-time service temperature range	• REF615, REG615, REM615, RET615, REU615 and REV615: -40...+85°C (<16 h) [23] • RED615: -40...+70°C (<16 h) [2, 3]
Relative humidity	<93%, non-condensing
Atmospheric pressure	86...106 kPa

SEL ATEX Relay

SEL 19 ATEX 0001X
II 3 G
Ex ec nC IIC T3 Gc

EN 60079-0:2012 + A11:2013, EN 60079-7:2015,
EN 60079-15:2010, EN 60079-11:2012

Ambient air temperature shall not exceed –20°C ≤ Ta ≤ +50°C

Note: Where so marked, ATEX and UL Hazardous Location Certification tests are applicable to rated supply specifications only and do not apply to the absolute operating ranges, continuous thermal, or short circuit duration specifications.

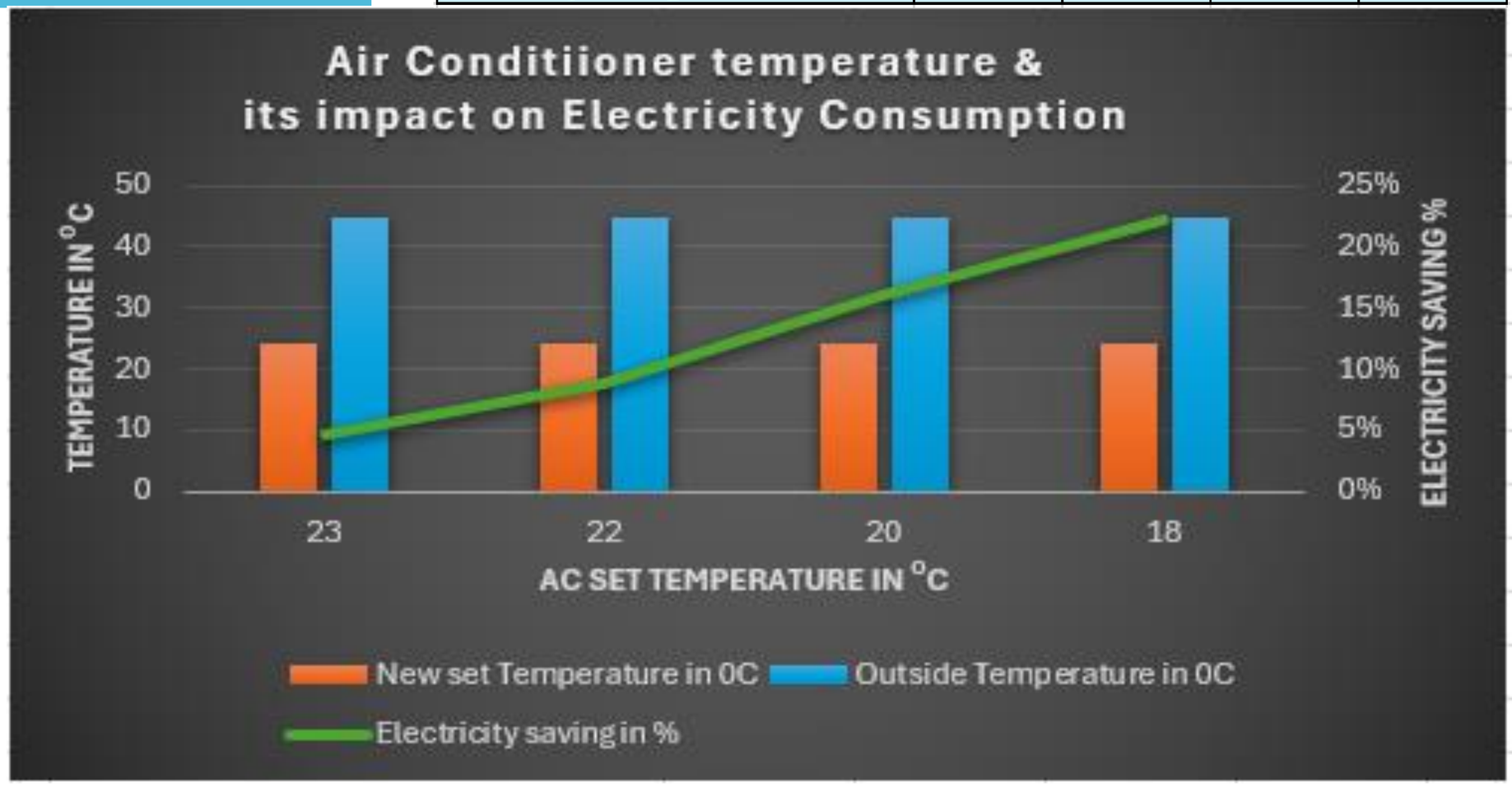
How much Electricity can be saved? – Case study analysis

Raising AC Temperature saves electricity

Here is the formula to find how much*:

$$\text{Percentage Savings} = \frac{(\text{new temperature} - \text{old temperature})}{(\text{outside temperature} - \text{old temperature})} \times 100$$

Air Conditinior Temperature - Case Study Analysis				
Current set Temperature in ^{0}C	23	22	20	18
New set Temperature in ^{0}C	24	24	24	24
Outside Temperature in ^{0}C	45	45	45	45
Electricity saving in %	5%	9%	16%	22%



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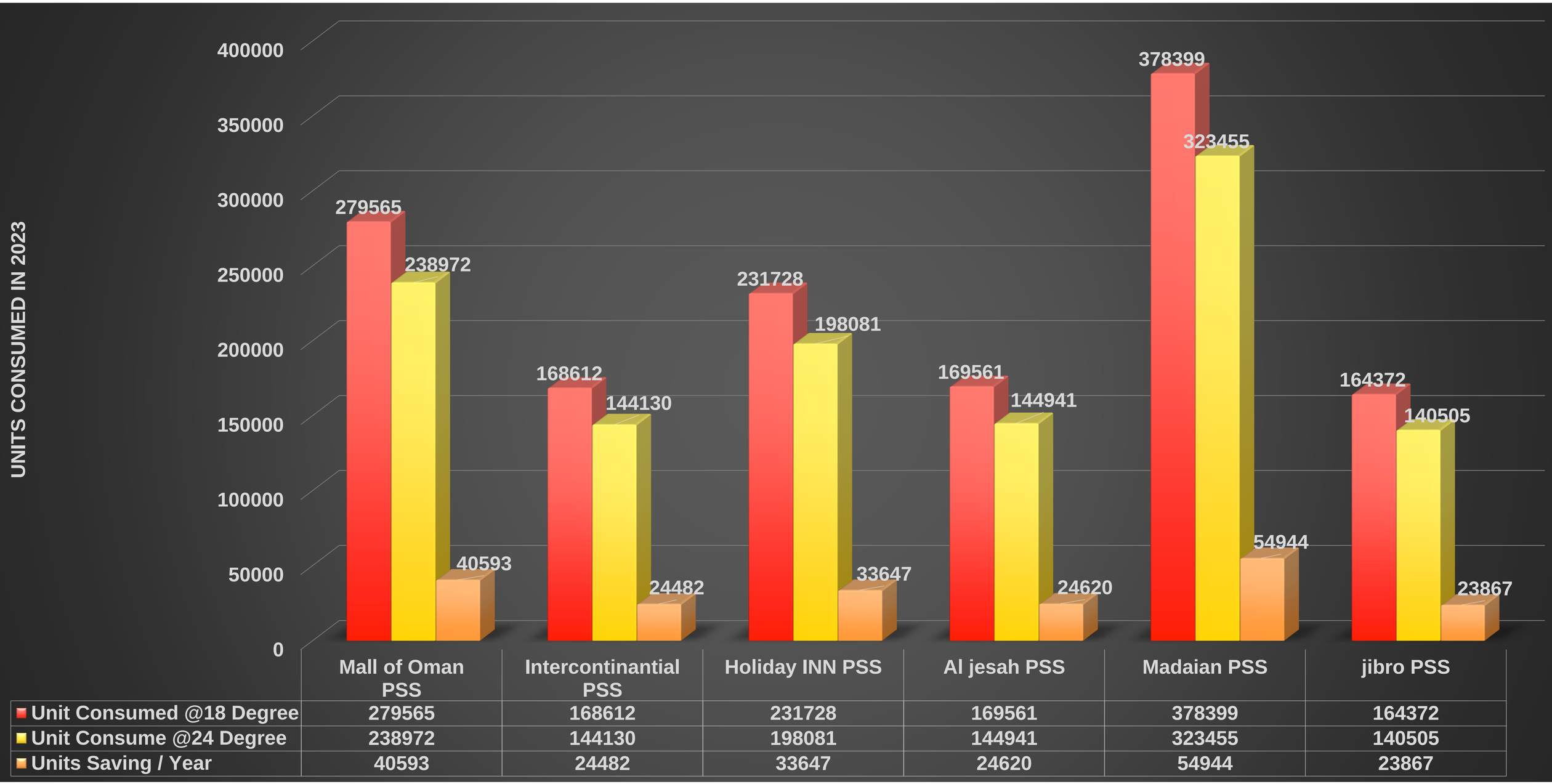
HVAC Units consumed – Case Study @ 6 PSS's



	Mall of Oman PSS	Intercontinantial PSS	Holiday INN PSS	Al jesah PSS	Madaian PSS	jibro PSS
Unit Consumed @18 Degree	279565	168612	231728	169561	378399	164372
Unit Consume @24 Degree	238972	144130	198081	144941	323455	140505
Units Saving / Year	40593	24482	33647	24620	54944	23867

Source : 2023 Units & Cost consumption data from 182 PSS

How much energy can be conserved?

PSS - LV Power Consumption Analysis				
AC Set Temp	**Unit's Saving / PSS**	**Cost Saving / PSS**	**Co2 Emission**	**TOE Ton oil equivalent**
18^{0}C to 24^{0}C	**33,692 units / Year**	**OMR 1,607 / Year**	**26.74 Ton**	**2.896 Ton**

One PSS Saving / Year

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If the Same implemented in all our PSS…

8. AC Water Recycling System

Optimized, Energy Efficient Design towards Sustainability

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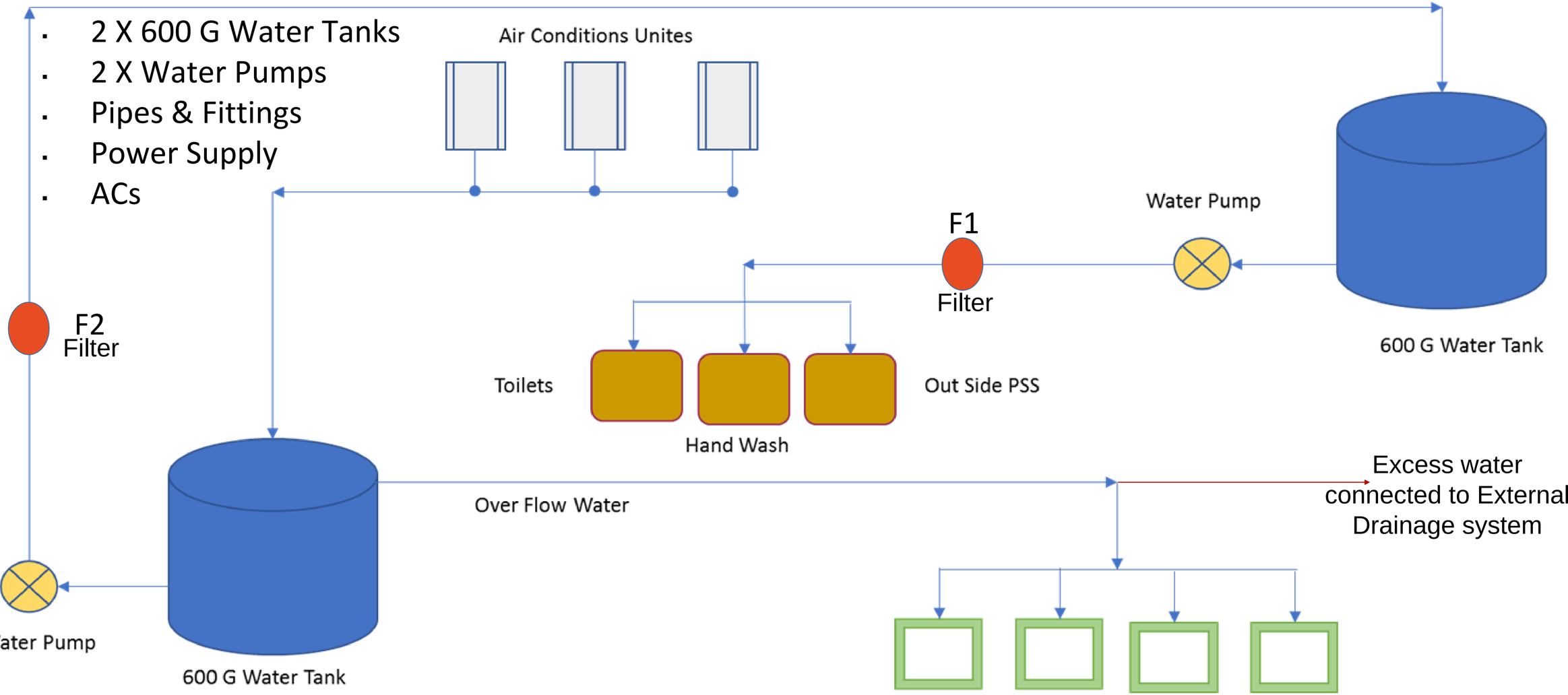
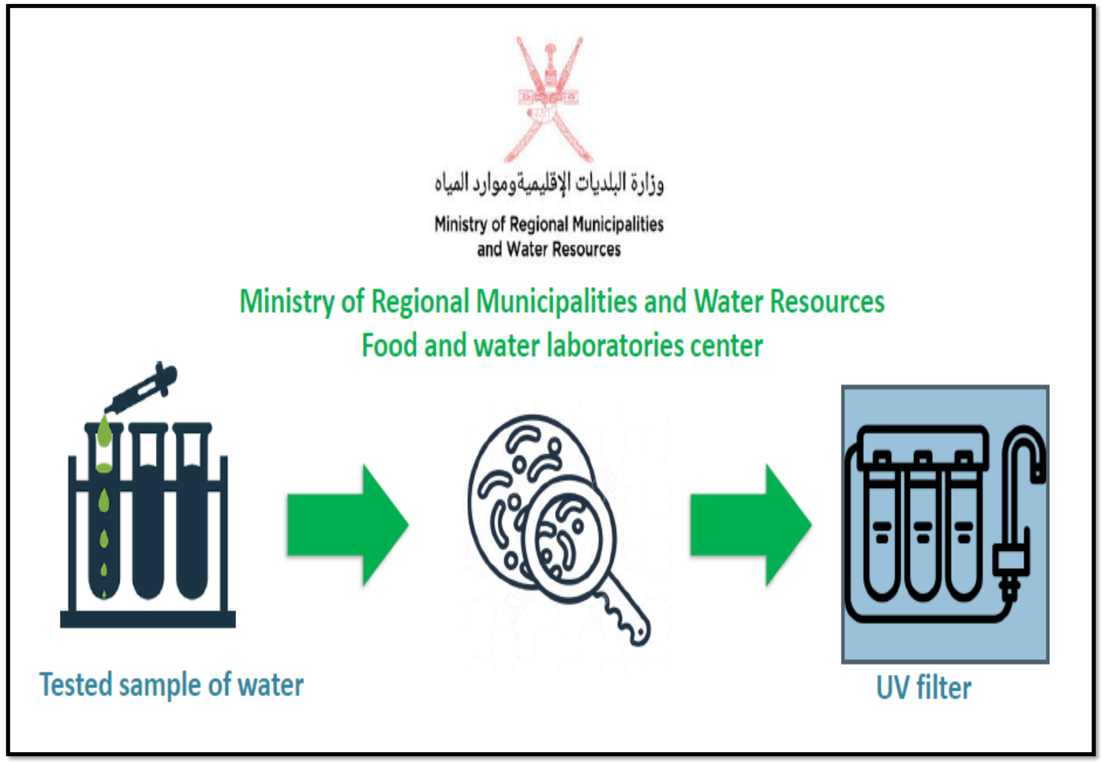
AC Water Recycling –Schematic Diagram

- 2 X 600 G Water Tanks
- 2 X Water Pumps
- Pipes & Fittings
- Power Supply
- ACs



Water – Test & Saving



No External Water
No Water Tariff

60,000 Gallon / Year

227 Cu.meter / Year

2.5 Ton Co2 avoided

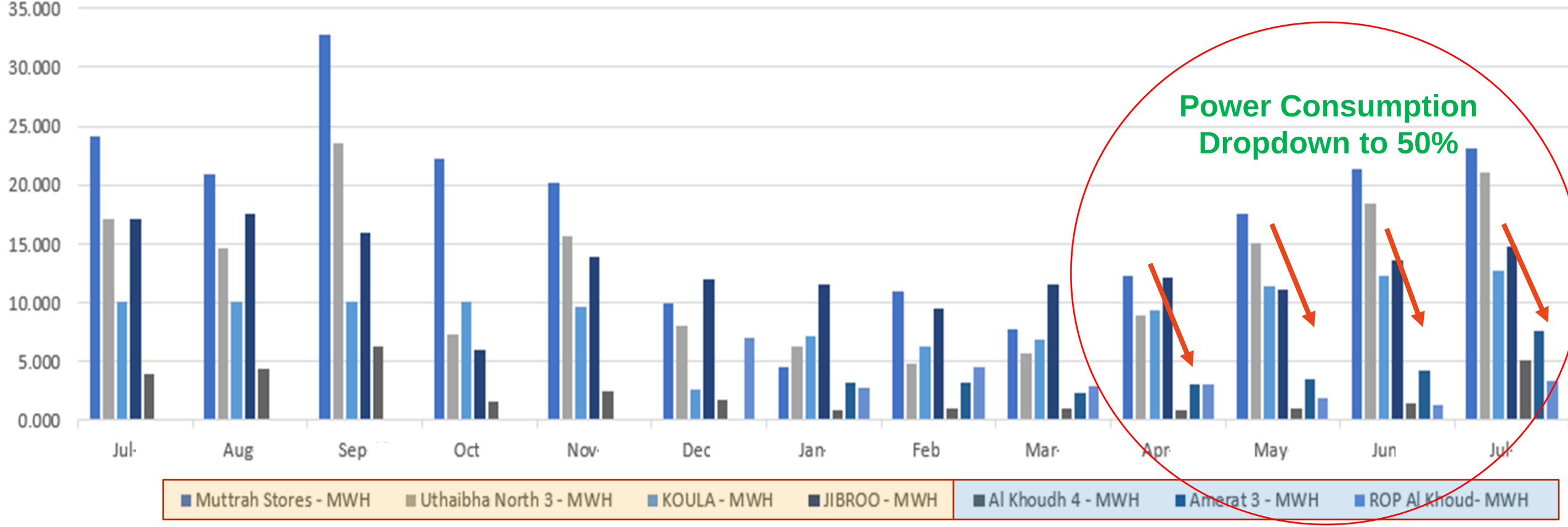
CAPEX & OPEX Reduced

LV Power Consumption

Optimized, Energy Efficient Design towards Sustainability

LV Power Consumption – Case Study @ 7 PSS's

Existing PSS vs Upgrading / New PSS



Source : 2023 Units & Cost consumption data from 182 PSS

How much energy can be conserved?

Year	Energy Consumed	CO2 Emission	TOE Ton oil equivalent
2023	34,946 GWh	27,734,966.29 Ton	3,004,814.33 Ton
2030 (Forecast)	54,954 GWh (57% Increase)	43,614,357.50 Ton	4,725,192.21 Ton

- If we adopt half (50 percent) such solutions, this will result in reduction of 50% additional GWh units of electricity and which is equivalent to the reduction of 50% carbon dioxide and TOE.

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Source : OETC 5 Year Capability Statement (2024-2028)

https://www.sunearthtools.com/tools/CO2-emissions-calculator.php#txtCO2_3

Conclusion

- Nama Electricity Distribution network substations - Plot footprint reduces 50%, Modern Equipment's and its power consumption reduces to almost 50%.

- It reflect, Nama Distribution network is - Energy efficient, reliable and resilience to future requirements and to meet the,

✓ CAPEX and OPEX optimization.

✓ Greenhouse gas emission reduction.

✓ Towards sustainability ESG Goal

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