BIMSTEC ENERGY CENTRE
Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation

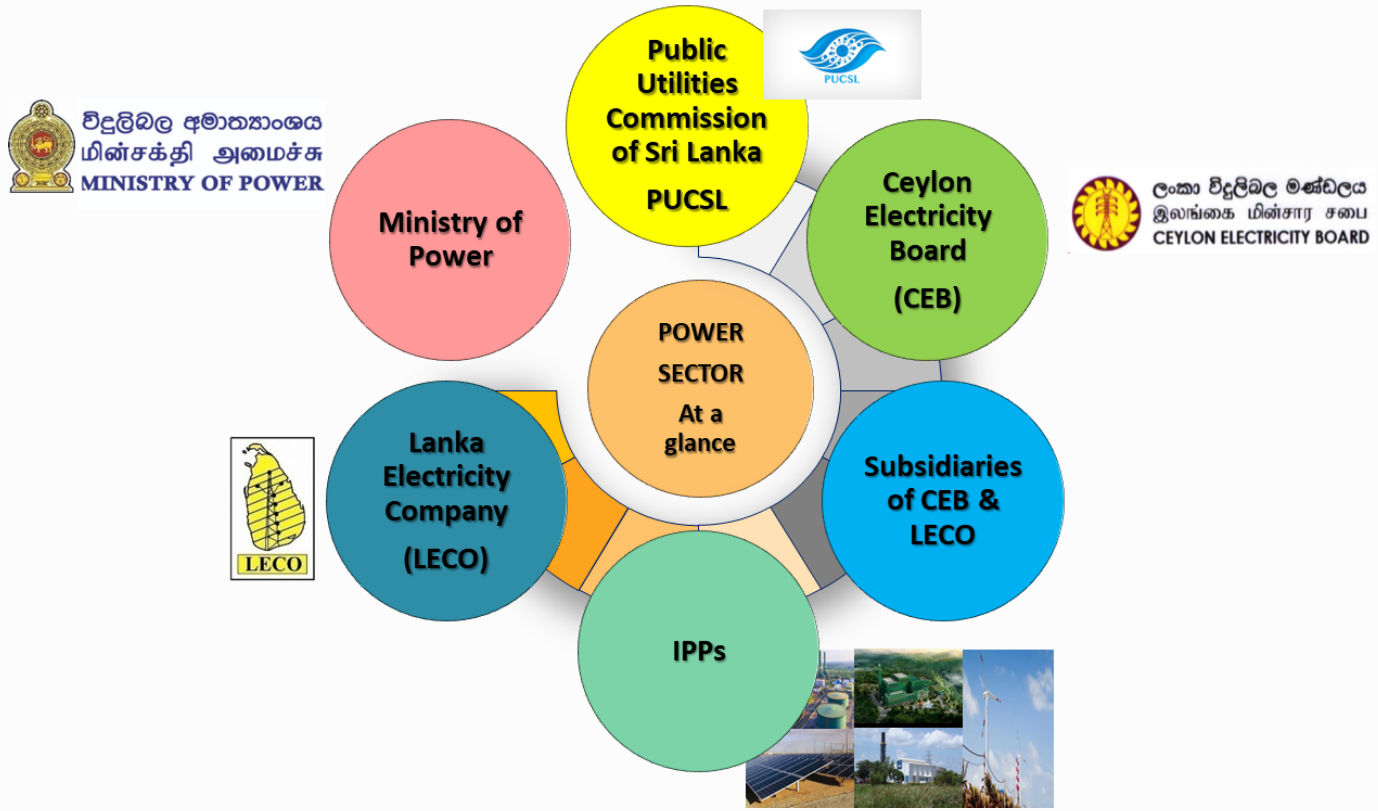
Online Knowledge Sharing Workshop on Best Practices in Maintenance of Transmission Systems

Maintenance Practices of Transmission System of Sri Lanka

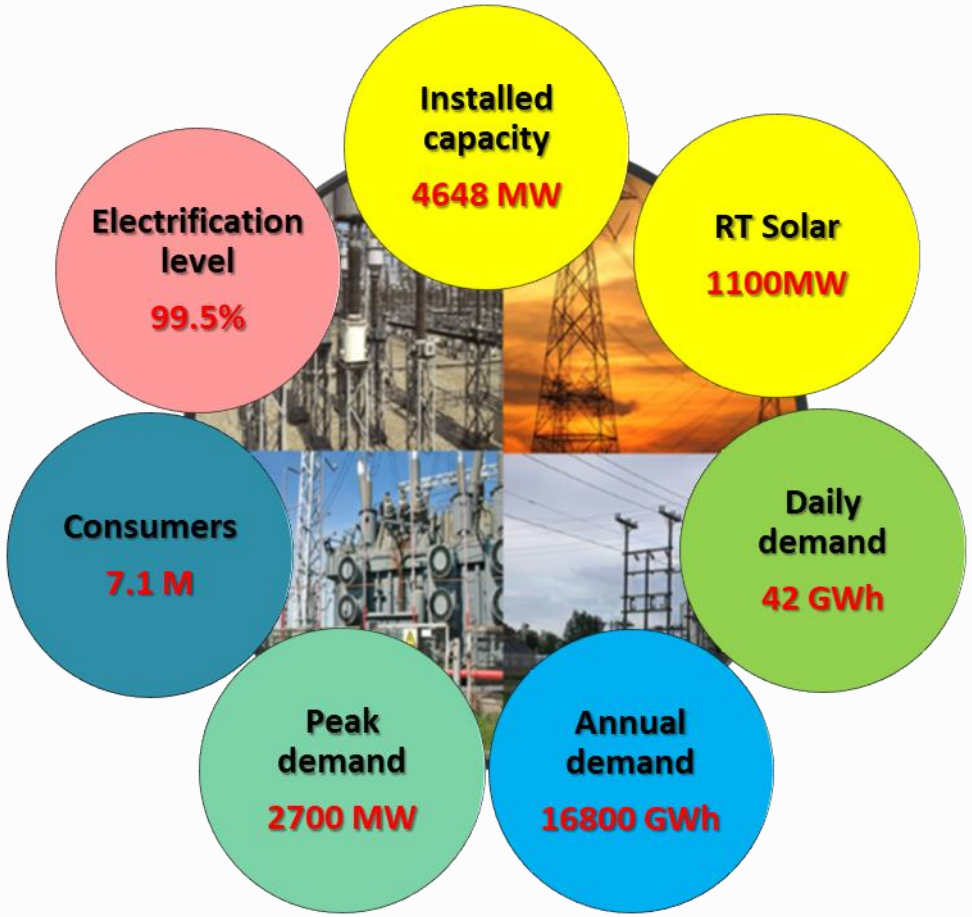
PRESENTED BY
ENG. D.D.U DOMPEGE & ENG. C.H.D. GAMAGE

- OVERVIEW OF THE POWER SECTOR AND TRANSMISSION NETWORK OF SRI LANKA
- OVERVIEW OF THE MAINTENANCE APPROACH
- MAINTENANCE STRATEGIES
- RELATED OTHER PRACTICES

SRI LANKAN POWER SECTOR

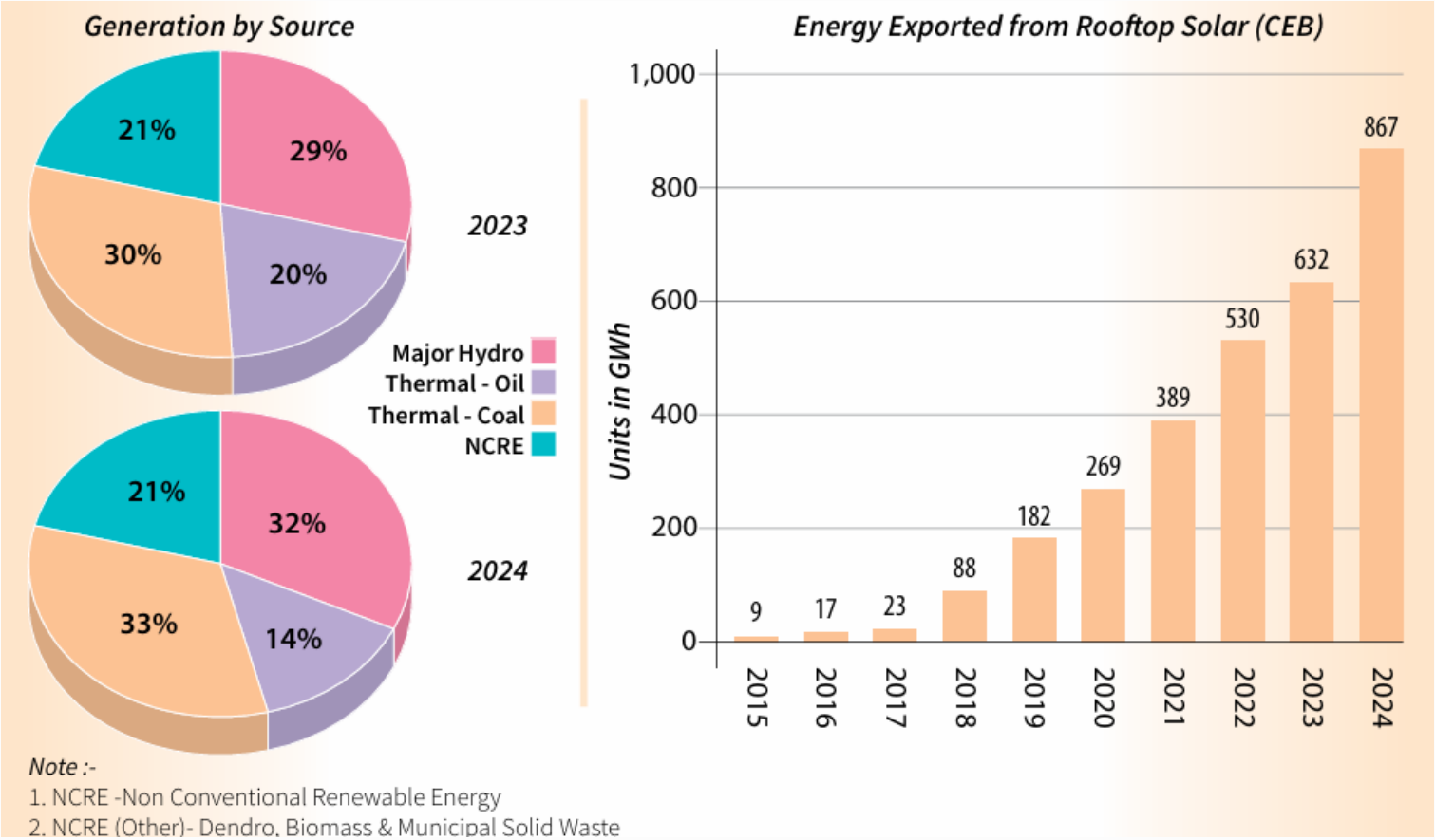


SRI LANKAN POWER SECTOR

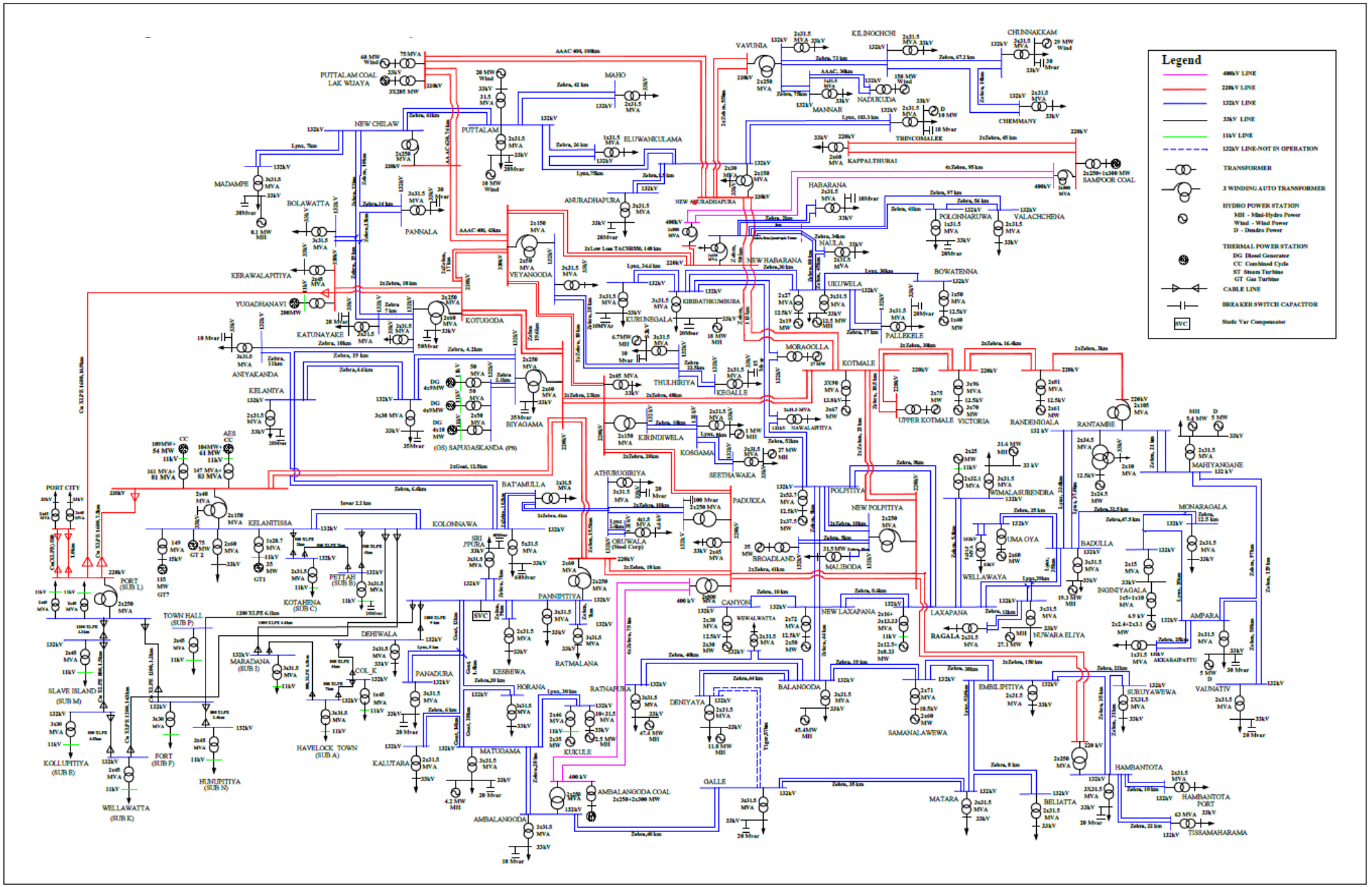


- Per capita Electricity Consumption 693 Kwh /person
- Annual revenue 2 B USD
- Energy Losses 9.5%
- Share of Electricity in total Energy 13%

SRI LANKAN POWER SECTOR



SRI LANKAN TRANSMISSION SYSTEM



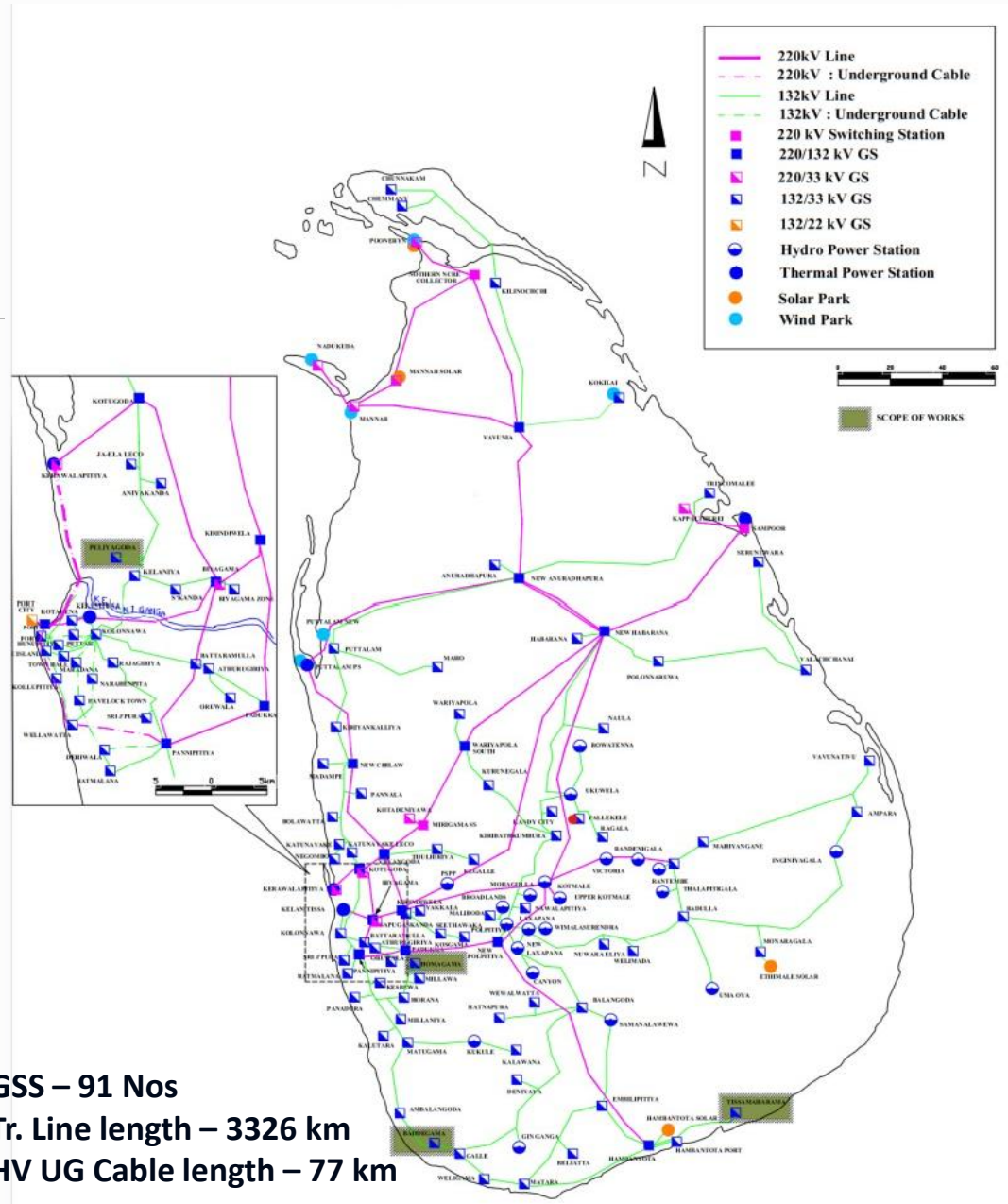
SRI LANKAN TRANSMISSION SYSTEM

LENGTH OF OVERHEAD (OH) & UNDER GROUND (UG) TRANSMISSION & DISTRIBUTION LINES (km)	2023	2024
220 kV Route OH	976	976
220 kV Route UG	22	22
132 kV Route OH	2,350	2,350
132 kV Route UG	55	55

Transmission level 220/132kV

Distribution level – 33/11kV

DETAILS OF SUBSTATIONS	Units	2023	2024
Grid SS (132/33 kV)	Nos.	62	63
	MVA	4,990	5,080
Grid SS (220/132/33 kV)	Nos.	4	4
	MVA	1600/380	1600/380
Grid SS (220/132 kV)	Nos.	9	9
	MVA	4,010	4,010
Grid SS (220/33 kV)	Nos.	6	6
	MVA	624	624
Grid SS (132/11 kV)	Nos.	9	9
	MVA	855	855



GSS – 91 Nos
Tr. Line length – 3326 km
HV UG Cable length – 77 km

NETWORK OVERVIEW – GRID SUBSTATIONS

Types of Grid Substations
- Air Insulated (AIS)
- Gas Insulated (GIS)

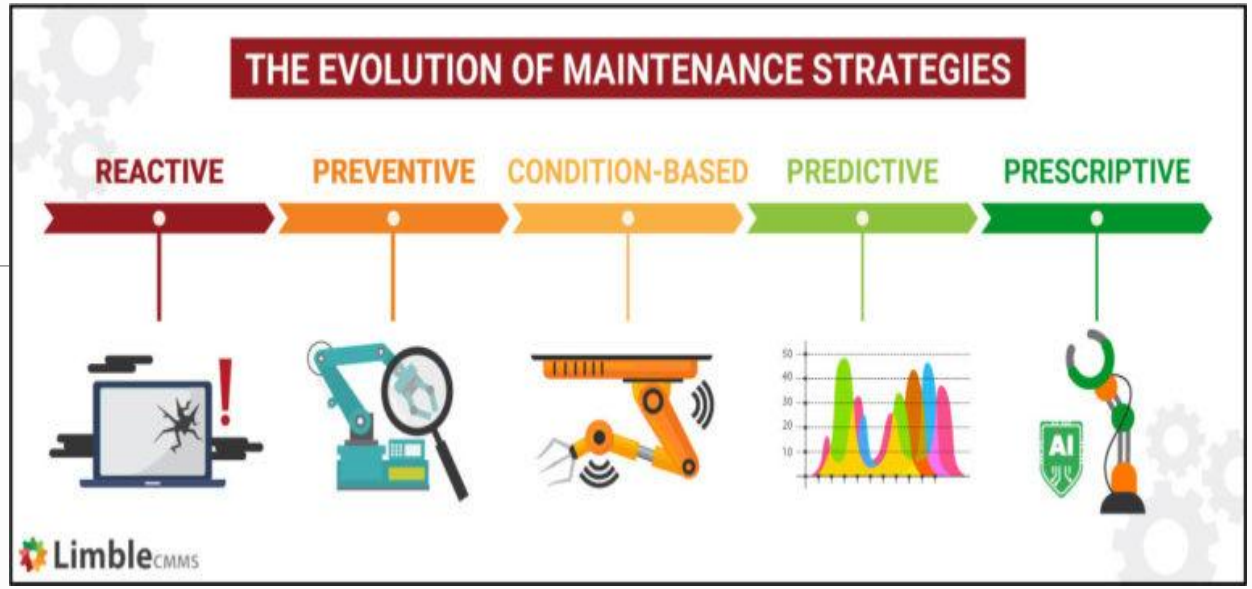
Types of Overhead Lines
- Goat
- Zebra
- Lynx
- Tiger
- AAAC

Types of UG Cables
- XLPE
- Oil (still we are maintaining a oil cable more than 40 yrs old)

MAINTENANCE – WHY?

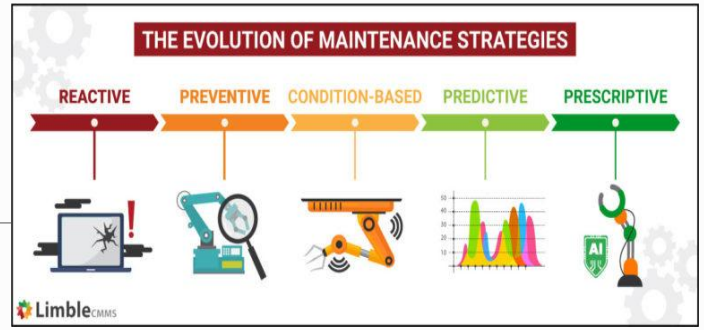
- Safety
- Supply quality & Reliability
- Affordability for consumers
- Organizational sustainability
- Statutory requirements

MAINTENANCE STRATEGIES



Strategy	Trigger	Focus	Cost Level	Maturity
Reactive	Failure	Repair	Low initially, high later	Basic
Preventive	Time / Usage	Prevention	Medium	Traditional
Condition Monitoring	Equipment condition	Detection	Medium–High	Modern
Predictive	Data trends	Forecast	High	Advanced
Prescriptive	AI decisions	Optimization	Very High	Future-ready

MAINTENANCE APPROACH



As a tropical country,

Regular cleaning, washing, lubrication, and moisture & dampness control are essential. Therefore, we still continue to emphasize a time-based & routine maintenance.

However, slowly shifting from traditional approach to modern strategies

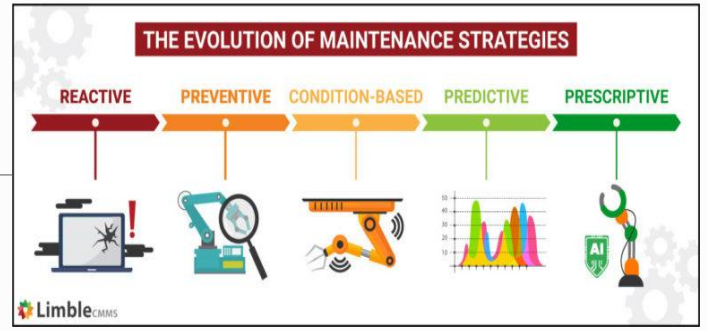
Shifting towards data driven + analytics based approaches:

Information obtained in routine inspections utilized for;

preventive maintenance approach

Further analyzed within the CMMS to support predictive maintenance

MAINTENANCE APPROACH



For aged, critical, or high-value network assets,

We prioritize condition-based and risk-based approach

(Specially for vulnerable assets like Power Transformers, SA, CVTs and CTs which are prone to catastrophic failures)

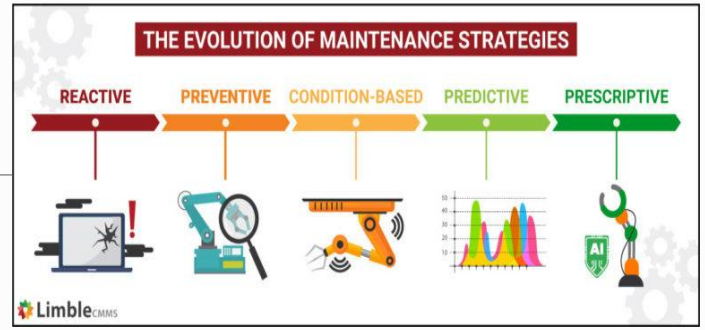
Asset management branch is to take over such equipment for close monitoring, regular sophisticated testing, data analysis and remedial.

Present focus on

DFR, tan Delta, furan analysis, CB dynamic testing

Modern technologies of thermal imaging, high resolution cameras, corona and PD measurements, drone based and LiDAR based inspections for transmission lines.

MAINTENANCE APPROACH



For aged, critical, or high-value network assets,

Risk based assessments using CMMS

Supported roles

Proper vegetation management for transmission lines
Spares and inventory management
Age analysis, replacement & rehabilitation management
Staff training and up skilling
Team building & outbound training
Safety awareness

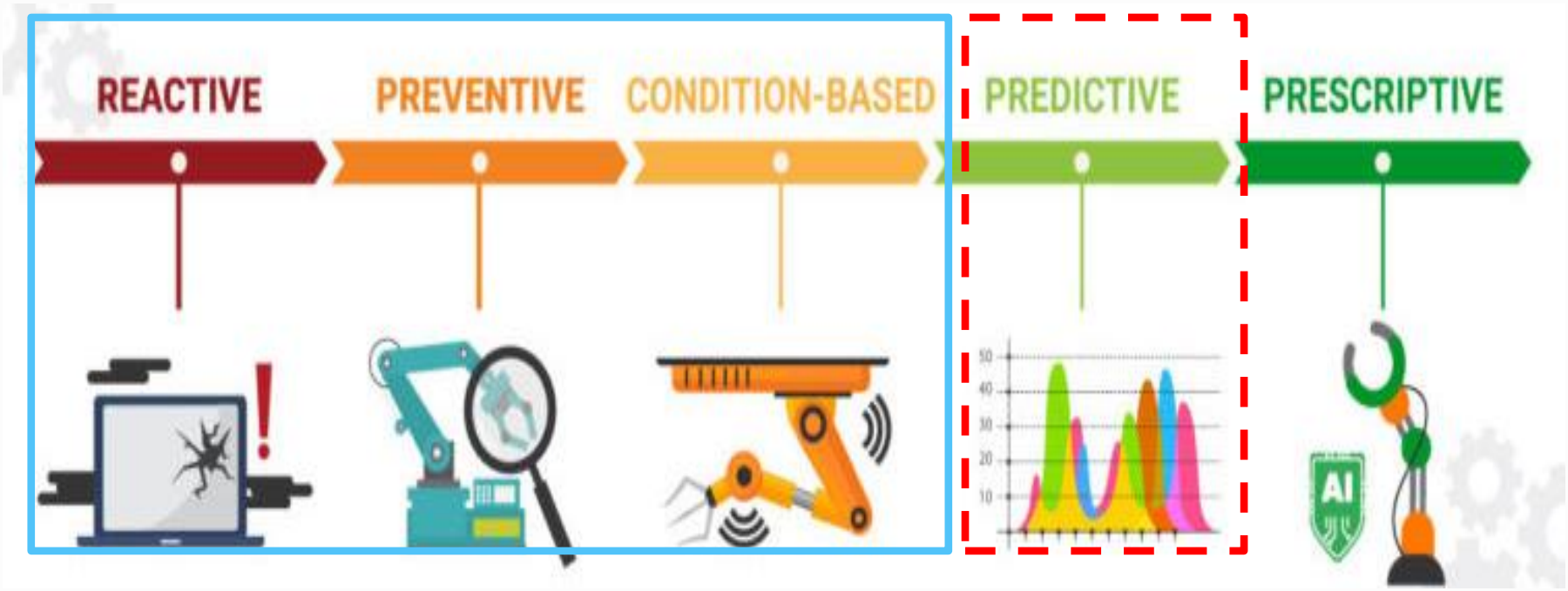
MAINTENANCE APPROACH - FUNCTIONAL

Branch	Unit	Area of Focus
Transmission Operation & Maintenance Branch (2 branches for South West part and North East part)	Operation & Maintenance Units	Maintenance of Grid Substations
	Transmission Line Maintenance Unit	Maintenance of Overhead Transmission Lines
	Cable & Centralized Services	Maintenance of Underground Cables & Several Condition Monitoring Tests
Asset Management & Condition Monitoring Branch	Maintenance Engineering Unit	Condition Monitoring
	Maintenance Planning Unit	Standardization of Maintenance Activities
	Material Management Unit	Asset procurement & Material Management

MAINTENANCE APPROACH - FUNCTIONAL

Branch	Unit	Area of Focus
Protection, Controls & Grid Automation	Development	Development, fault Analyzing, System reviews
	Maintenance	Maintenance of protection system
	Substation Automation	Automation and SCADA
Communication and SCADA Services		SCADA services to the NSO Communication Services for the operations Services for protection systems

CURRENT PRACTICES



REACTIVE MAINTENANCE

- Maintain clear emergency response procedure
- Ensure availability of basic spares & tools
- Record failure details immediately
- Conduct post failure Analysis
- Utilize analysis to avoid repetition of possible similar failure types
- Adopting the concept of “Total Productive Maintenance” to avoid probable breakdowns

PREVENTIVE MAINTENANCE

- Based on OEM Recommendation and field experience
- Using checklist and SOPs
- Align with outage planning
- Avoid over maintenance (review intervals periodically)
- Ensure proper documentation after each task

	Switchgear item	Power Transformer (220/132/33kV & 132/33kV)
	Make	All
	Type	All
	System Voltage	220/132/33kV

	Inspection and Test	Maintenance Intervals	Remarks
1	Oil & Winding temperature inspection (by indicator)	Hourly	Note 1
2	Daily Inspection	Daily	Note 2
3	Oil level inspection in Main Tank & OLTC (by indicator)	Daily	-
4	Inspection of Dehydrating Breather in Main Tank	Weekly	-
5	Inspection of Dehydrating Breather in OLTC	Weekly	-
6	Measurement of oil PPM & BDV in OLTC	6 months	
7	Measurement of oil PPM & BDV in Main tank	6 months	
8	General Inspection (Annually)	Annually	Note 3
9	General Cleaning	Annually	Note 4
10	Inspection of oil level of the TF bushings	Annually	-
11	Inspection of oil level of the Cable sealing ends (if available)	Annually	-
12	Measurement of Insulation Resistance of Main TR (5kV DC, 1 min) HV - E, LV - E & HV - LV	Annually	
13	Measurement of insulating resistance of all cooling fans with 500V Insulation Resistance Tester	Annually	
14	Measurement of current of cooling fans	Annually	
15	Measurement of insulating resistance of OLTC Motor with 500V Insulation Resistance Tester	Annually	
16	Measurement of current of OLTC Motor	Annually	
17	Alarm & Trip Simulation	Annually	Note 5
18	Thermometer Calibration	Three Years	Note 6
19	OLTC Service/ Overvaul	As per OEM recommedation	-

	Switchgear item	SF6 Gas Circuit Breaker (220kV & 132kV)
	Make	All
	Type	With Spring Charging CB mechanism
	System Voltage	220kV & 132kV

	Inspection and Test	Maintenance Intervals	Remarks
1	Inspection of SF6 Gas Pressure using inbuilt pressure guage	Monthly	Note 1
2	General Inspection	Annually	-
3	General Cleaning	Annually	Note 2
4	Measurement of Insulation Resistance (5kV DC, 1 min) (Top to Earth, Bottom to Earth, Top to Bottom)	Annually	Note 3
5	Measurement of Contact Resistance of Primary Connecting Clamps (100A DC)	Annually	-
6	Measurement of Drive Motor Current and Spring Charge Time	Annually	-
7	SF6 Gas Leak Check	Annually	-
8	Circuit Breaker Timing Test	Two to Three Years	-
9	Circuit Breaker Anaysis (Timing & Dynamic Resistance)	Five Years	Note 4
10	SF6 Gas Quality Check	Five Years	-
11	SF6 Gas Density Guage Check	Five Years	Note 5
12	SF6 Gas pressure check using external device	Five Years	Note 6

	Switchgear item	Current Transformer (220kV, 132kV & 33kV)
	Make	All
	Type	All
	System Voltage	220kV, 132kV & 33kV

	Inspection, Cleaning and Test	Maintenance Intervals	Remarks
1	General Inspection	Annually	Note 1
2	General Cleaning	Annually	Note 2
4	Measurement of Insulation Resistance (5kV DC, 1 min) Primary to Earth.	Annually	-
5	Measurement of Contact Resistance of Primary Connecting Clamps (100A DC)	Annually	-

	Switchgear item	Capacitive Voltage Transformer (220kV, 132kV & 33kV)
	Make	All
	Type	All
	System Voltage	220kV, 132kV & 33kV

	Inspection, Cleaning and Test	Maintenance Intervals	Remarks
1	General Inspection	Annually	Note 1
2	General Cleaning	Annually	Note 2
3	Testing of Ferro resonance	Annually	Note 3
4	Measurement of Insulation Resistance (5kV DC, 1 min) Primary to Earth.	Annually	
5	Measurement of Contact Resistance of Primary Connecting Clamps (100A DC)	Annually	Note 4

	Switchgear item	**GIS**
	Make	**ABB**
	Type	**ZX1.2 & ZX2**
	System Voltage	**33kV**

	Inspection and Test	**Maintenance Intervals**	**OEM Recommendation**	**Remarks**
1	Testing of Healthyness of Vaccum Interruptor	One Year	Not specified	
2	General Cleaning & Inspection	Two to Three Years	Four Years	
3	Alarm and Trip Testing	Two to Three Years	Four Years	
4	SF6 Gas Leak Testing	Two to Three Years	Four Years	
5	Operational check of Switchers (CB, Disconnectors & Earth Switchers) *Note 1*	Two to Three Years	Four Years	*Note 2*
6	Testing of SF6 Gas pressure	Five Years	Four Years	
7	Functional Testing of Switchers (CB, Disconnector & Earth Switchers)	Five Years	Five Years	*Note 3*
8	Testing of SF6 Gas Quality	Ten Years	Not specified	
9	Circuit Breaker Operating Mechanisms Inspection & Maintenance	Ten Years (OEM advice need to taken)	Ten Years or 10000 Operations	
10	Three Position Disconnector Operating Mechanisms Inspection & Maintenance	2000 Operations (OEM advice need to taken)	2000 Operations	

CONDITION MONITORING

- Monitoring only the critical parameters
- Establishing baseline values
- Analyzing trends
- Defining clear thresholds
- Initiated Partial Discharge Analysis of HV Under Ground Cable following two consecutive failures in last five years.

CONDITION MONITORING TESTS

Equipment	Tests
Power Transformers	Dissolve Gas Analysis (DGA), Furan Analysis Oil Quality Tests (PPM, BDV, Acidity, Interfacial) Insulation Resistance, Tan Delta, Infrared Thermography
Circuit Breakers	SF6 Gas Quality, CB Timing Contact Travel & Velocity
Current Transformers	Capacitance Measurements, Tan Delta / Power Factor Insulation Resistance, Thermography Ratio / Polarity / Knee Point Tests
Capacitive Voltage Transformers	Capacitance Measurements, Tan Delta / Power Factor Insulation Resistance, Thermography Ratio / Polarity / Burden Tests

CONDITION MONITORING TESTS – EQUIPMENT IN USE

Omicron CPC 100
Omicron CPTD1
Omicron SD1

Megger Trax 220
TCX 120

Tan Delta Equipment
Idax 300
Meggar Bite 2P

Cibano300
Morgan Schaffer DGA Equipment
Omicron Franio (SFRA)

PREPARATION OF HEALTH INDEXES

		Condition Criteria	Original Weight
General	1	Age	5.00
Main Tank	2	Furan	10.00
	3 (a)	DGA - Level	8.00
	3 (b)	DGA - Trend	8.00
	4	DF	8.00
	5	Dielectric Frequency Response Analysis	8.00
	6 (a)	SFRA - Phase Based Comparision	2.00
	6 (b)	SFRA - Time Based Comparision	10.00
	7	Turns Ratio	2.00
	8	Leakage Reactance	5.00
	9	Winding Resistance ☐ Pri ☐ Sec	5.00
	10	Excitation Current	2.00
	11	Insulation Resistance	2.00
	12	Breakdown Voltage (BDV) of Oil	2.00
	13	Moisture in Oil	2.00
	14	Acid in Oil	2.00
	15	Interfacial Tension (IFT) of Oil	2.00
	16	Operational/Visual Condition	5.00
OLTC	17	Breakdown Voltage (BDV) of Oil	5.00
	18	Moisture in Oil	5.00
	19	Dynamic OLTC Scan, Ripple Slope	2.00
		Total	**100.00**

Power Transformers

S/N	Condition Criteria	Original Weight
1	Age	10.00
2	Number of Operations	10.00
3	Contact Resistance	25.00
4	Opening / Closing Time	10.00
5	Traveling Distance	10.00
6	Insulation Resistance	10.00
7	SF6 percentage	5.00
8	SF6 Dew Point	10.00
9	Operational/Visual Condition	10.00
		100.00

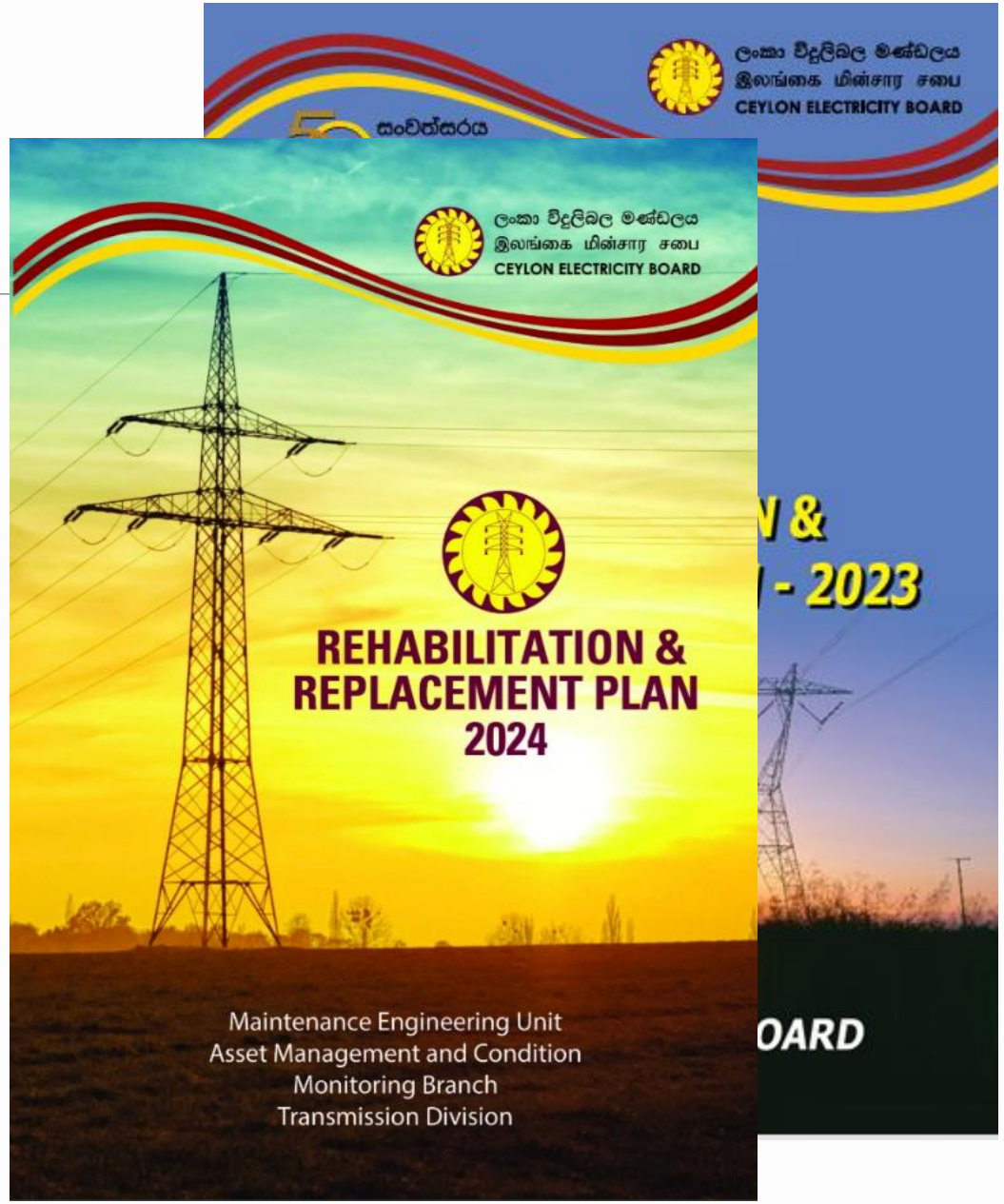
Circuit Breakers

S/N	Condition Criteria	Original Weight
1	Age	10.00
2	Tan δ	35.00
3	Dielectric Frequency Response Analysis	20.00
4	Ratio Check	5.00
5	Insulation Resistance	20.00
6	Operational/Visual Condition	10.00
		100.00

Current Transformers

REHABILITATION & ASSET REPLACEMENT

- Age wise analysis of Primary Assets
- Identification of Replacements
- Identification of Rehabilitations
- Augmentation and Rehabilitation Project Progress



MAINTENANCE STARTEGIES – TRANSMISSION LINES

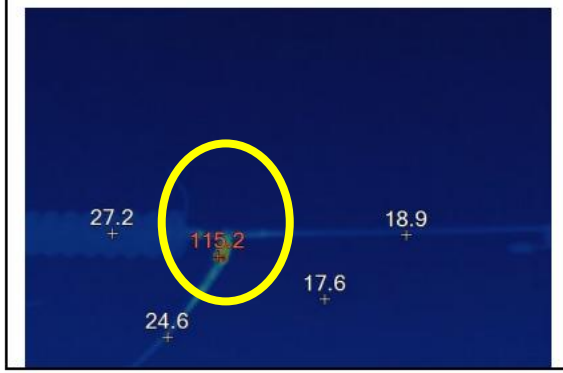
- Condition-based maintenance
  - Routine Inspections (Towers & Lines)
  - Thermography
- Preventive Maintenance
  - Earth conductor replacement program
  - Transposition and switching towers rehabilitation program
- **Hot Line Maintenance is Carried out including Bare Hand Method**

MAINTENANCE STARTEGIES – TRANSMISSION LINES

HOT SPOT RECTIFICATION

1. Transmission Line & Voltage : 132kV Galle-Matara
2. Tower Number : 67T
3. Circuit : C-2
4. Phase & Side of conductor : Bot, Galle Side
5. Responsible ES : K.L.G.P.Shaminda

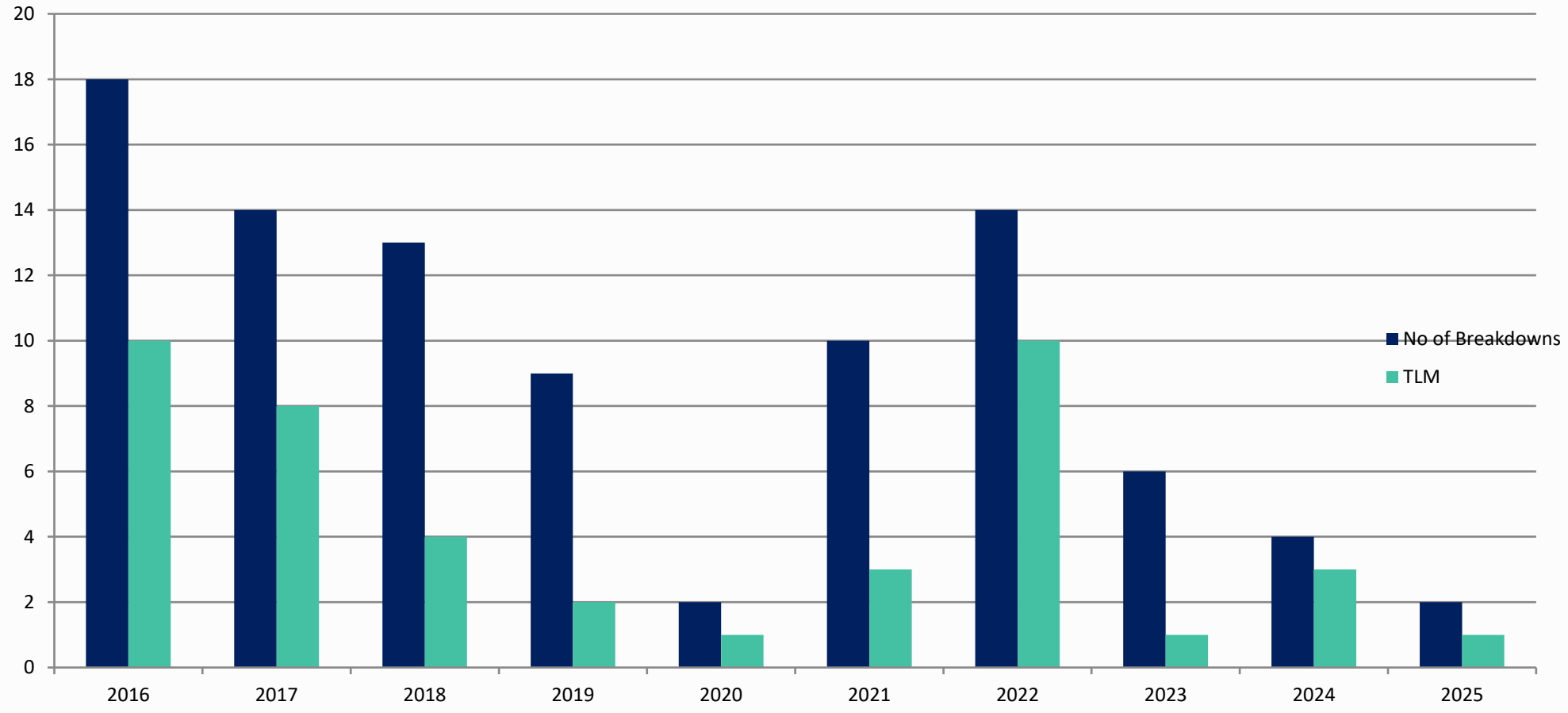
➢ **Details of Identified Hot Spot**

Image Taken By: K.L.G.P.Shaminda	Date:18.09.2021
Thermal Image	Observed Data
	T_{Max}=115.2°C I= 88A t = 20.00hrs

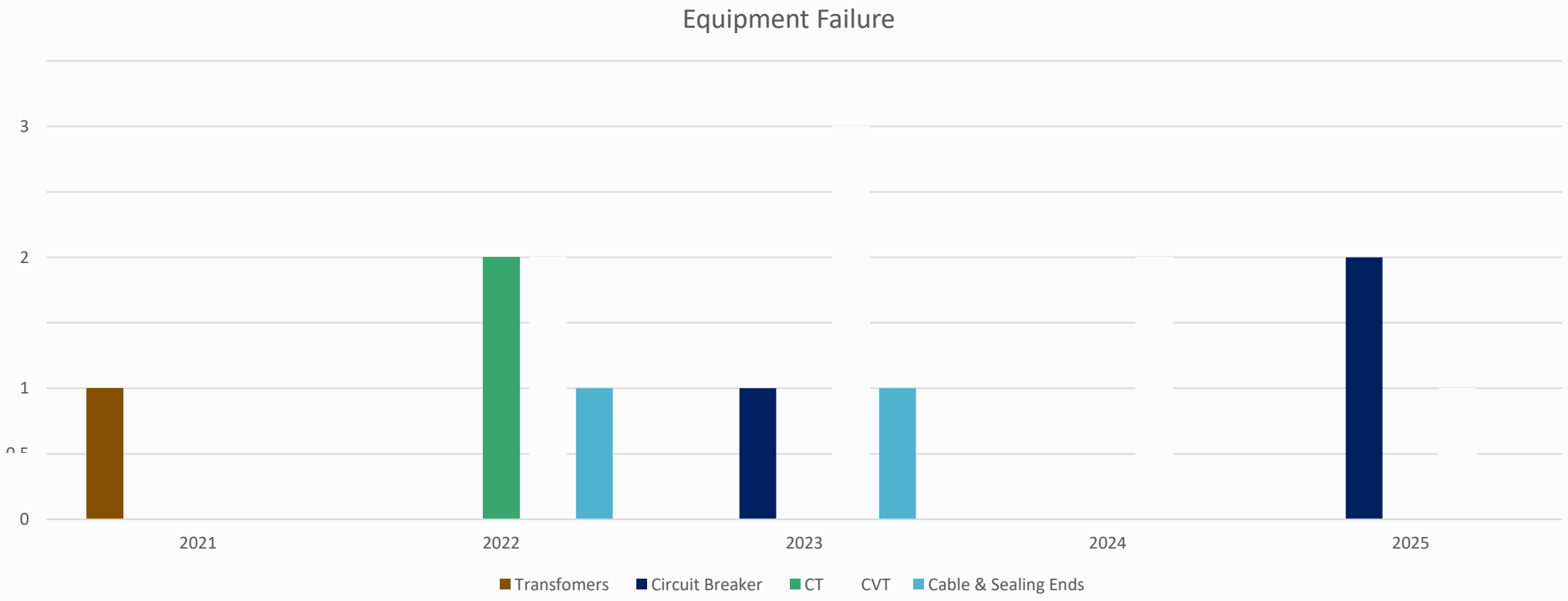
✓ **Details of Hot Spot Rectification**

Rectified By: K.L.G.P.Shaminda	Date:23.09.2021
Brief Description of Rectification Work: Removed oxides, Cleaned the surfaces, Applied contact grease, Refixed & Tighten the jumper nuts & bolts.	
Image Taken By: K.L.G.P.Shaminda	Date:23.09.2021
Thermal Image after Rectification	Observed Data
	T_{Max}= 28.1 °C I= 41A t = 14.00 pm

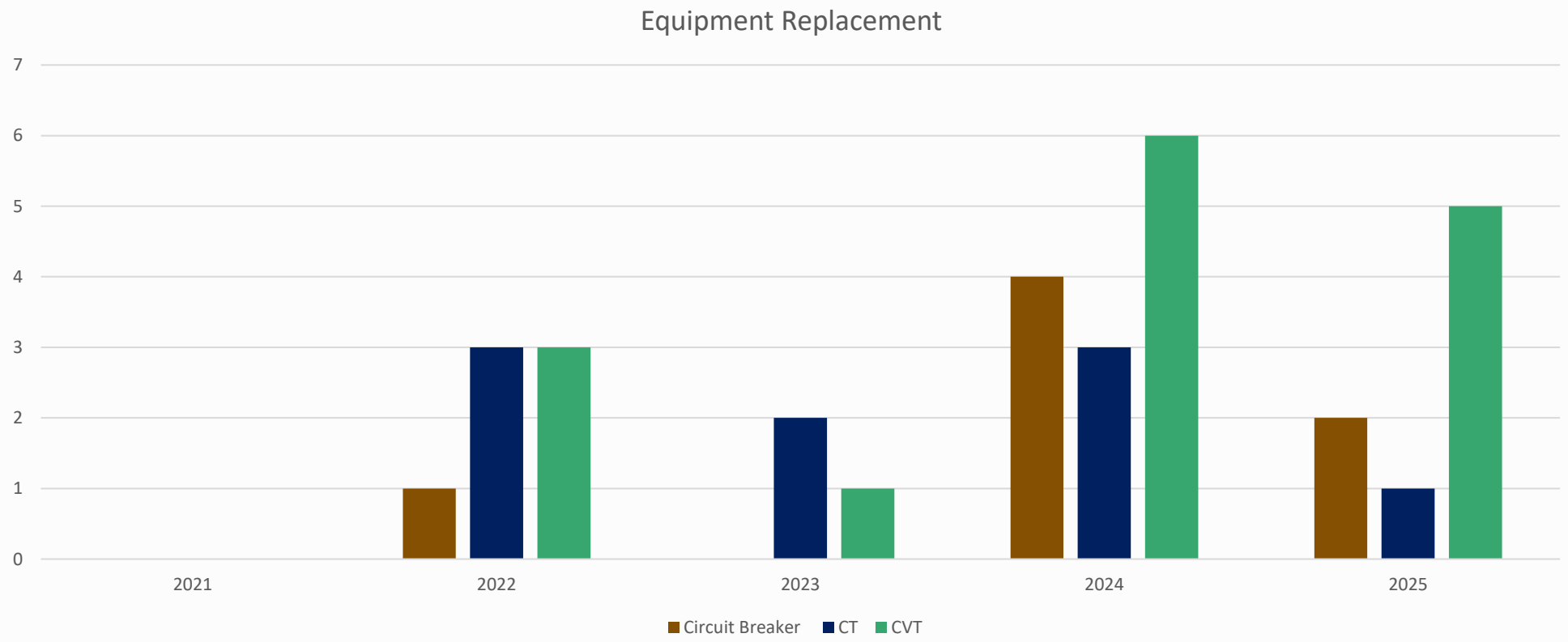
REFLECTIVE OUTCOME – TRANSMISSION LINES



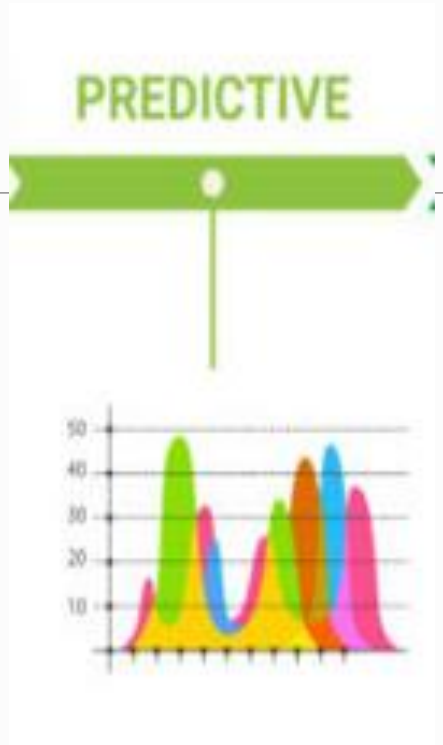
REFLECTIVE OUTCOME – GRID SUBSTATION



REFLECTIVE OUTCOME – MITIGATION OF BRAKEDOWNS



PREDICIVE MAINTENANCE – EXPECTATIONS



- Maintain high quality historical data
- Use trend analysis and degradation models
- Validate predictions with engineering judgment

OTHER APPROACHES

- Conducting regular health & safety trainings
- Conducting technical knowledge sharing sessions
- Conducting team building training sessions

THANK YOU FOR YOUR KIND ATTENTION!!!