Digital Substation and Condition Monitoring NXpower Monitor

The digital care-taker

Sept, 2023

Customers told us “what keeps them awake” and how they try to solve their energy distribution problems nowadays

“A **shutdown** is the worst scenario, so to avoid it we implement **frequent field checks** especially for our **ageing assets**”

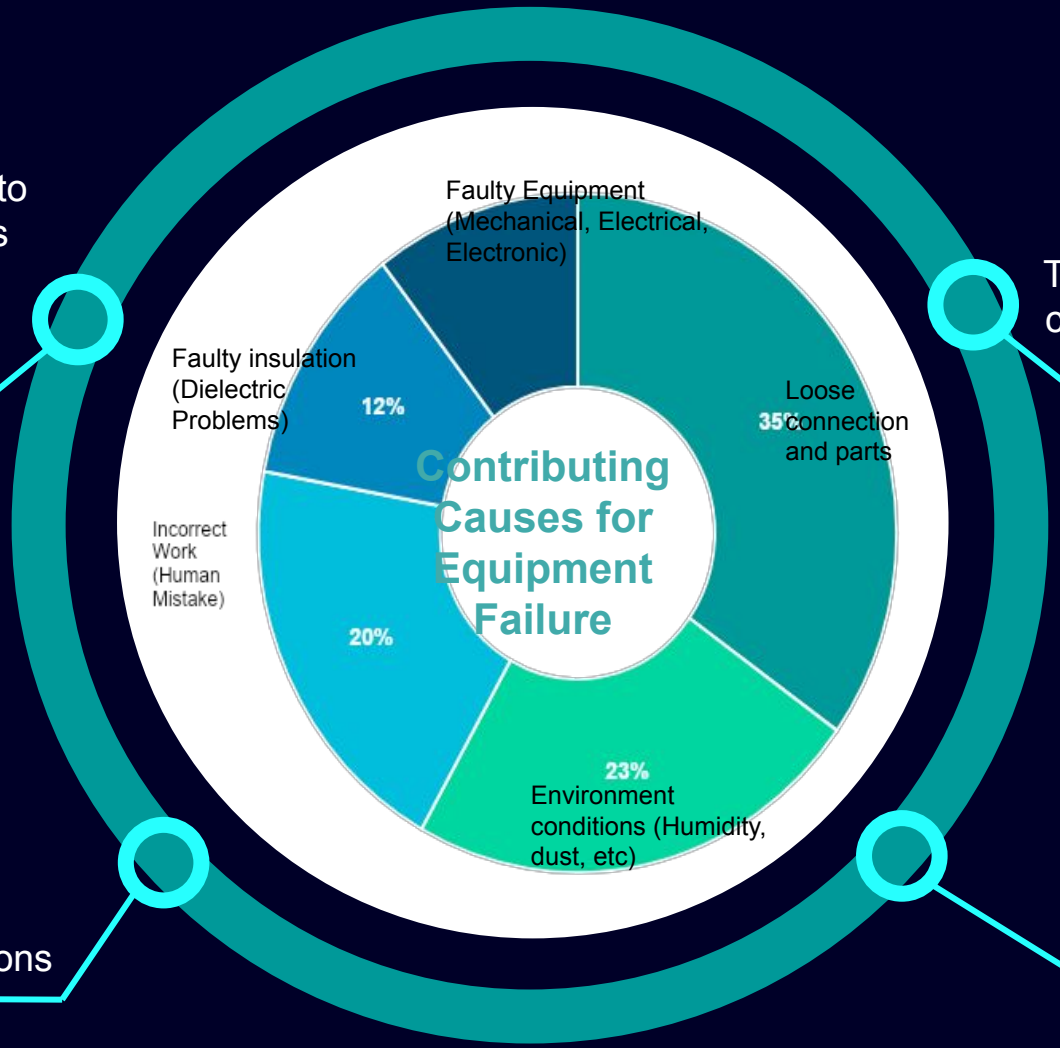
“To know what is happening I **depend on specialized personnel**, either to make a **field inspection** or to get access to the **existing system for a report**, so I simply wait for someone available”

“Our **maintenance planning** is based on the providers recommendations, I would like to **adapt** the frequency to our real **site needs** to gain reliability”

The most common causes of electrical distribution asset's failures are well-known and operation/ maintenance managers implement several measures to monitor SWGRs, but this implies some challenges too.

Frequent visits to electrical assets to conduct preventive maintenance

Thermal scanning of connections through portable devices



Shutdowns to check components and switching devices, check bolted connections (e.g. torque measurements), cleaning of equipment, etc.

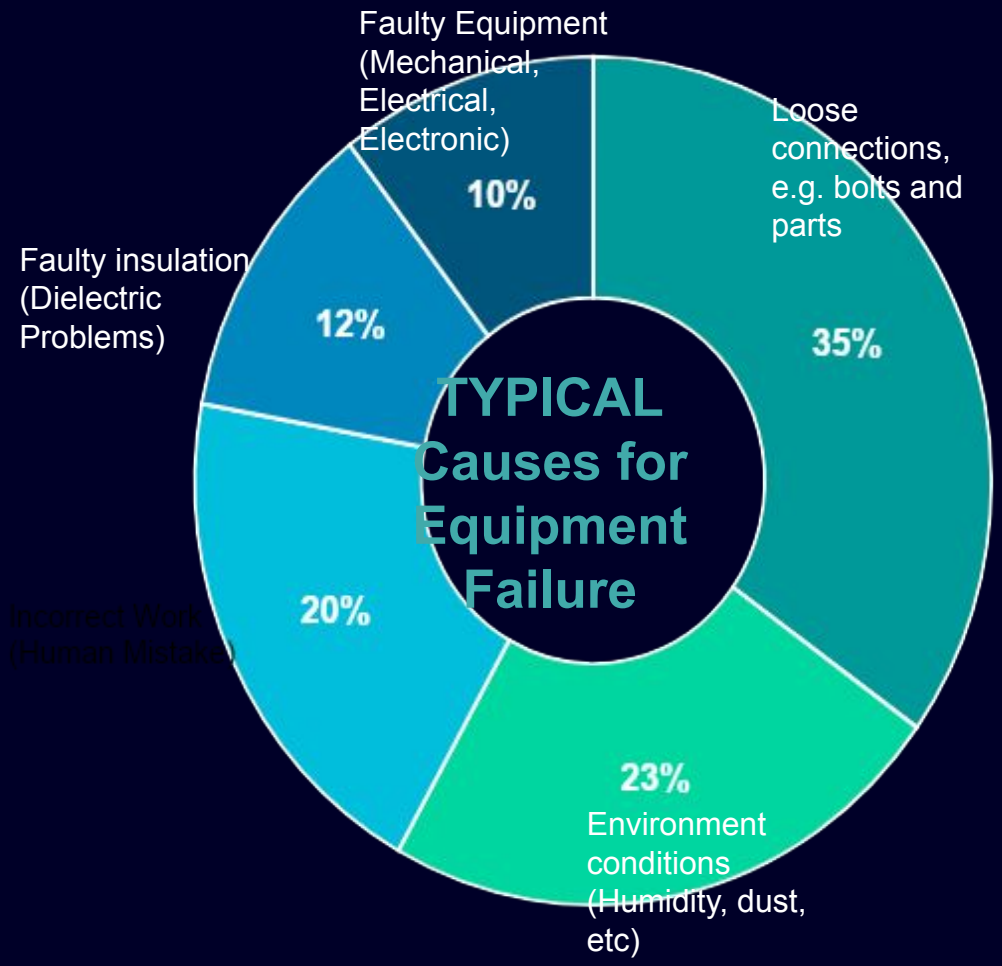
Visual inspections

These measures imply the following **challenges:**

- Most of the time manual process, which calls for visit at site.
- Manual data collection and analysis for decision making.
- Dependency on experts with domain critical knowledge.
- Risk of overlooking of gradual degradation or failure not visible at the time of inspection.
- The optimization of OPEX & improved risk management is not taken care of

Source: https://www.hsb.com/TheLocomotive/ElectricalPreventiveMaintenance.aspx

Unplanned Shutdowns can be reduced 85% by using a proper condition monitoring system



Examples of early failure detection (e.g. slow changes of behavior/ measured values)

1 Temperature Monitoring
Can detect loose connections (e.g. bolted busbar connections or cable terminations)
and insufficient contacting (e.g. withdrawable VCB)

2 VCB Monitoring
Can detect faulty VCB mechanism / components (e.g. trip coils, spring charge motors, switching time)

3 Partial Discharge Monitoring
Can detect faulty components / installations (e.g. MV cables, insulators, bushings, voltage transformers)

4 Humidity Monitoring
Can prevent condensation and corrosion (which might lead to mechanical and electrical failures)

WHAT CAN WE DO ?

Time Based Maintenance on Switchgears

Primary Elements
- AC Pressure tests on Circuit breakers
- Insulation tests on power cables and control wires
- Contact resistance tests

Secondary Elements
- Lubricate operating and link mechanism
- Check control wire for loose connections
- Secondary injection tests

Time Based Maintenance on Transformers

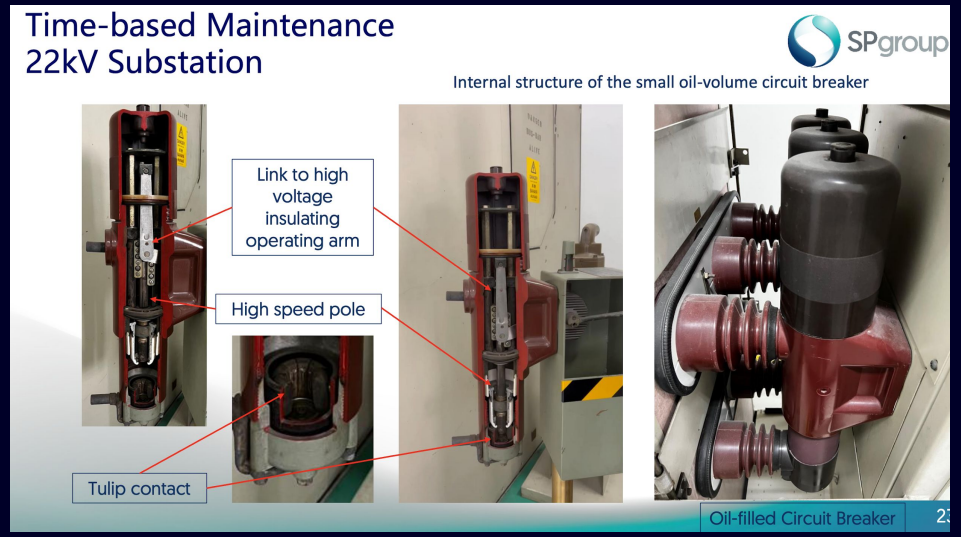
Primary Elements
- Dielectric test on oil
- Purify oil in main tank or replace if necessary
- Replace oil in tap changer compartment
- Ratio test on all tap positions
- Insulation resistance test

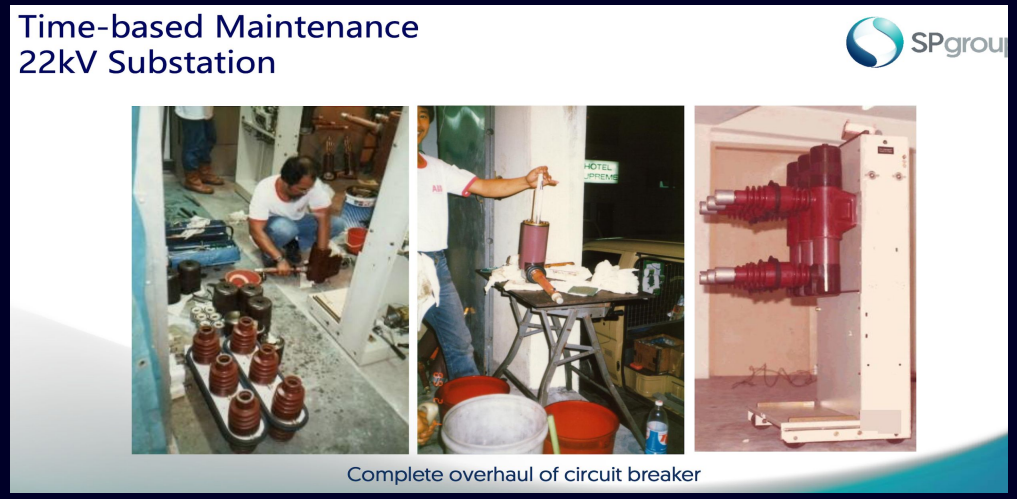
Secondary Elements
- Calibrate and check gauges & relays
- Clean cable termination
- Replace all gaskets
- Check control wire for loose connections

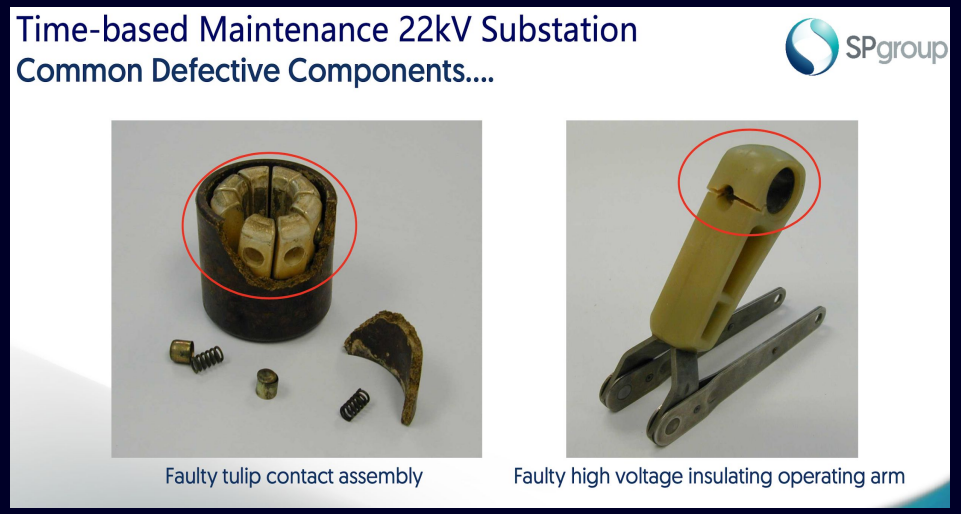
Past Time-based maintenance on Small Oil-Volume Circuit Breaker

- Complete overhaul of circuit breaker

TIME BASED MAINTENANCE



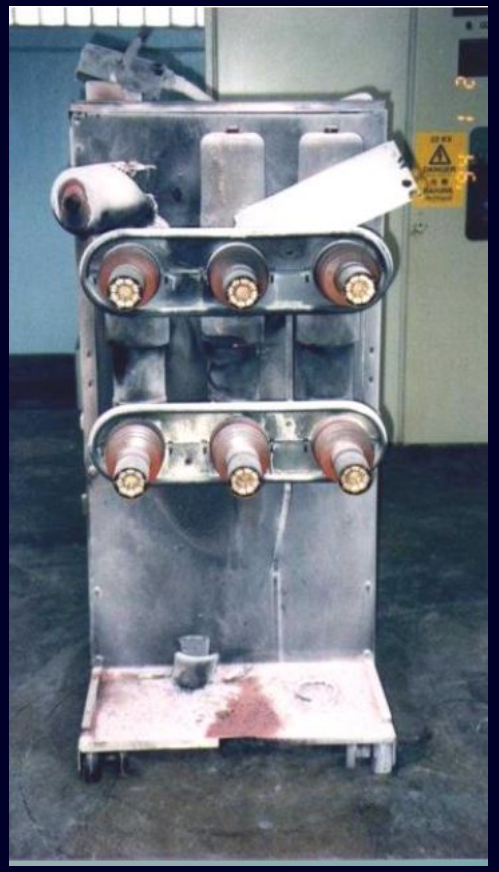




Once a year annual shutdowns
Annual maintenance

IS IT ENOUGH ?

TIME BASED MAINTENANCE



Uncovered hidden components within circuit breaker & bus-bar

— But It cannot prevent power failures

WHAT ELSE CAN WE DO. ?

CONDITION MONITORING

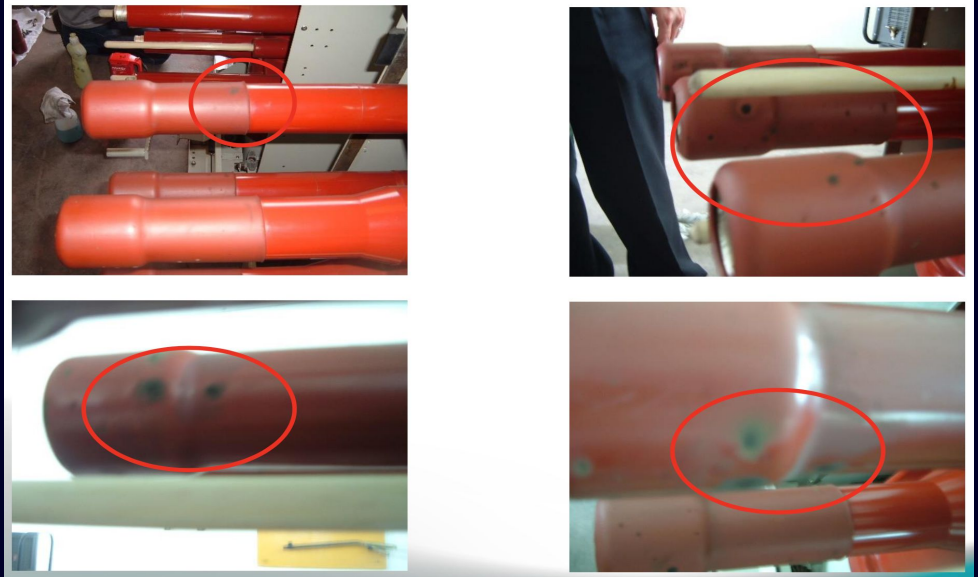

Acoustic Partial Discharge detection


TEV Partial Discharge detection


Hot Spot detection

We currently conduct manual condition monitoring every 6 months for 11,000+ stations

CONDITION BASED MAINTENANCE



Tracking spots showed high electrical stress at circuit breaker arms

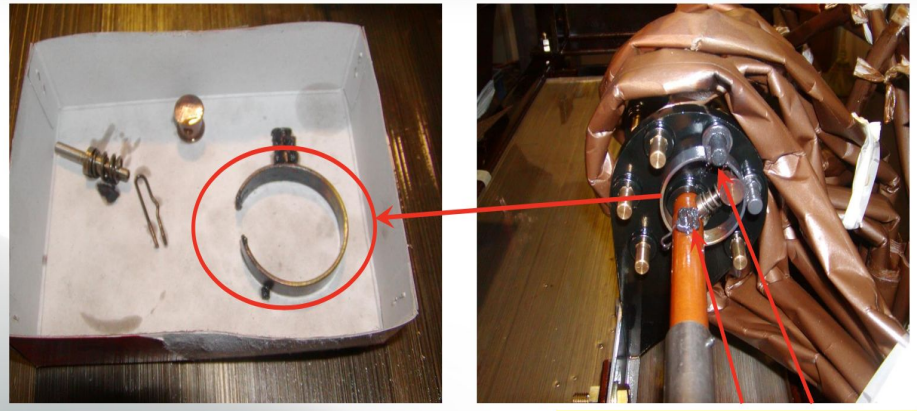
Discovered by condition monitoring

Transformer : HT 22kV Cable termination

Picked TEV signals

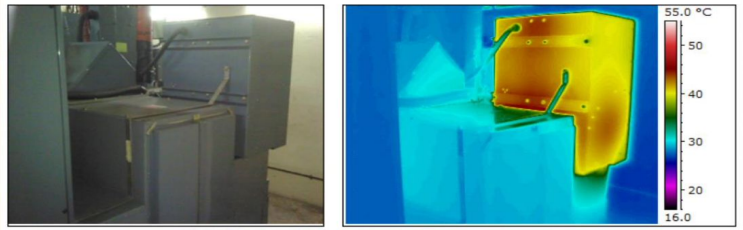
Suspected void discharge

Severe Overheating @ Tap Changer



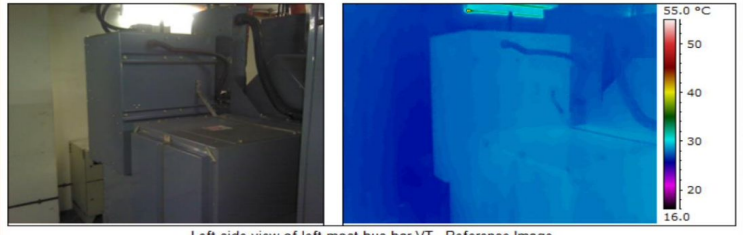
Broken Metallic Ring at Tap Changer

Abnormal Signal Picked up by Thermal imager – 22kV Switchgear



Right side view of right most bus bar VT - Thermal anomaly

Abnormal Thermal image with high surface temperature due to deteriorated PT



Left side view of left most bus bar VT - Reference Image

Reference image: Normal Thermal image with good PT within the same substation

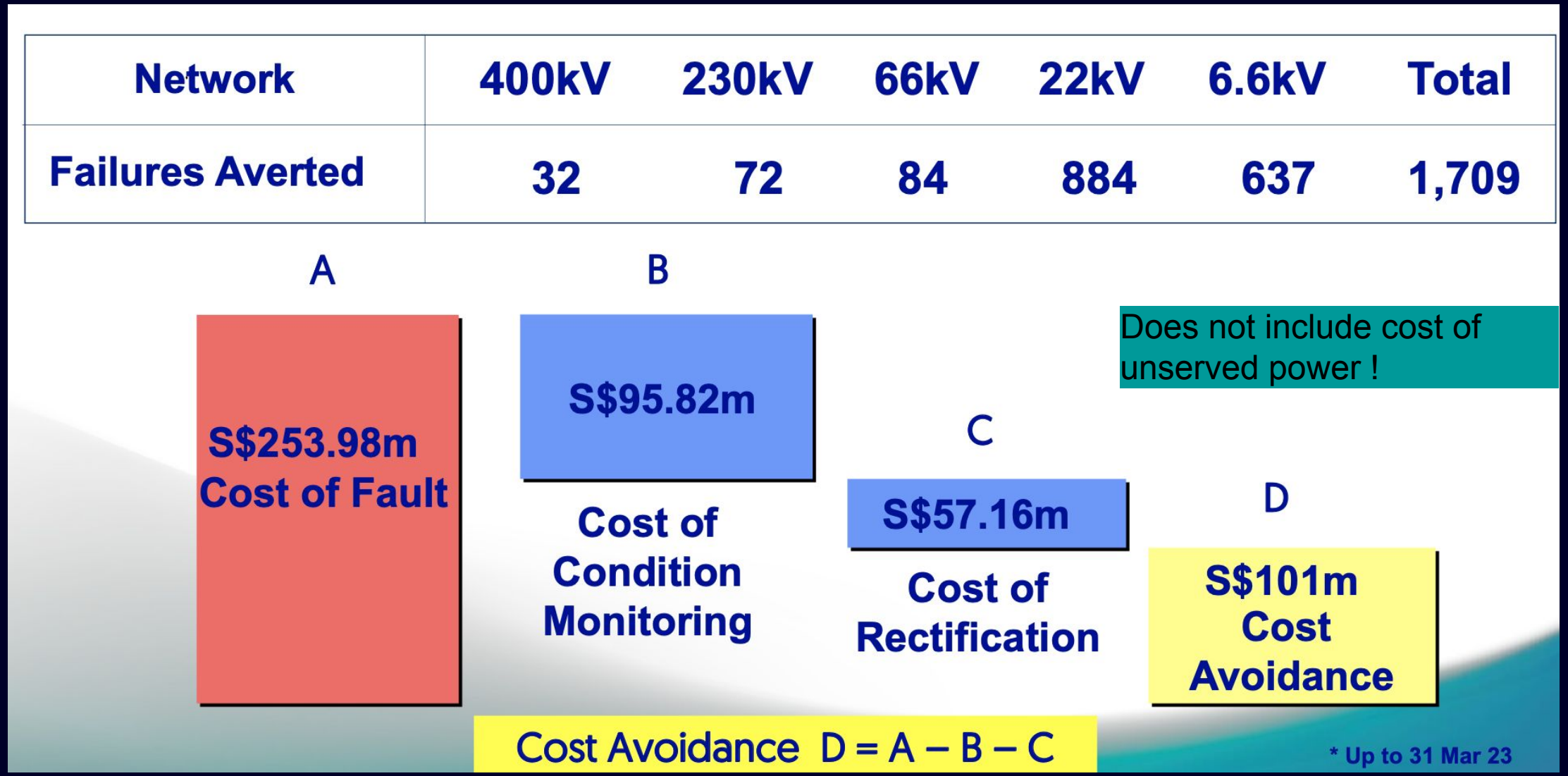
OUTCOMES OF CONDITION BASED MAINTENANCE

Network Failures Averted by Condition Monitoring

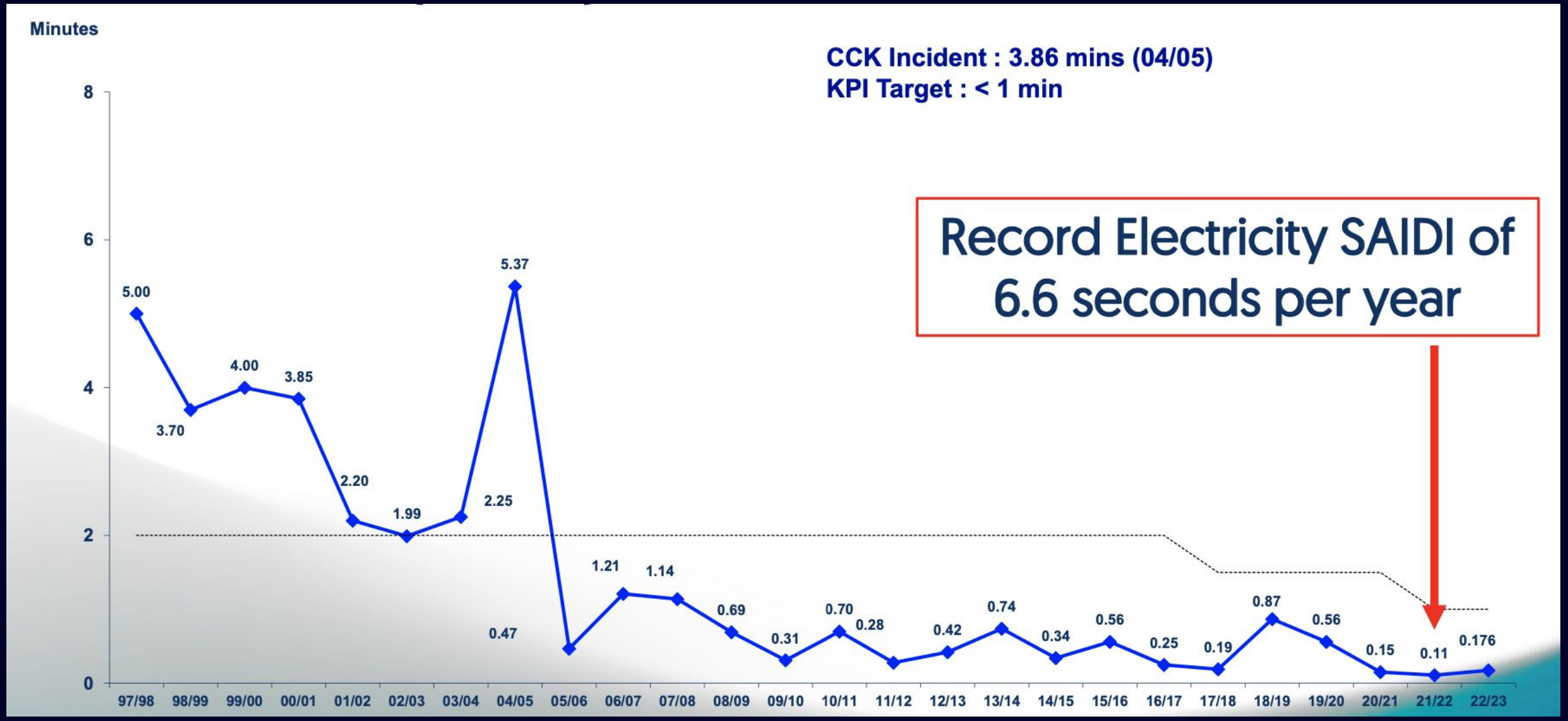
Network	FY 01/02	FY 02/03	FY 03/04	FY 04/05	FY 05/06	FY 06/07	FY 07/08	FY 08/09	FY 09/10	FY 10/11	FY 11/12	FY 12/13	FY 13/14	FY 14/15	FY 15/16	FY 16/17	FY 17/18	FY 18/19	FY 19/20	FY 20/21	FY 21/22	FY 22/23	Total
400kV	0	1	1	2	0	3	1	1	1	0	1	0	5	1	1	0	1	2	7	1	0	3	32
230kV	1	3	0	1	10	7	5	8	5	8	3	2	6	3	1	1	5	0	1	0	2	0	72
66kV	1	3	2	7	6	4	13	5	11	2	5	3	2	1	3	5	8	2	0	0	1	0	84
22kV	27	11	23	31	36	45	11	15	15	40	28	10	20	28	30	18	18	20	36	102	154	166	884
6.6kV	1	5	41	39	3	34	39	14	23	31	21	27	15	39	56	26	33	42	39	44	34	31	637
Total	30	23	67	80	55	93	69	43	55	81	58	42	48	72	91	50	65	66	83	147	191	200	1709 *

COSTS AVOIDANCE

Network	400kV	230kV	66kV	22kV	6.6kV	Total
Failures Averted	32	72	84	884	637	1,709



SAIDI


Minutes
CCK Incident : 3.86 mins (04/05)
KPI Target : < 1 min
Record Electricity SAIDI of 6.6 seconds per year
8
6
4
2
0
5.00
3.70
4.00
3.85
2.20
1.99
2.25
5.37
0.47
1.21
1.14
0.69
0.31
0.70
0.28
0.42
0.74
0.34
0.56
0.25
0.19
0.87
0.56
0.15
0.11
0.176
97/98
98/99
99/00
00/01
01/02
02/03
03/04
04/05
05/06
06/07
07/08
08/09
09/10
10/11
11/12
12/13
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14/15
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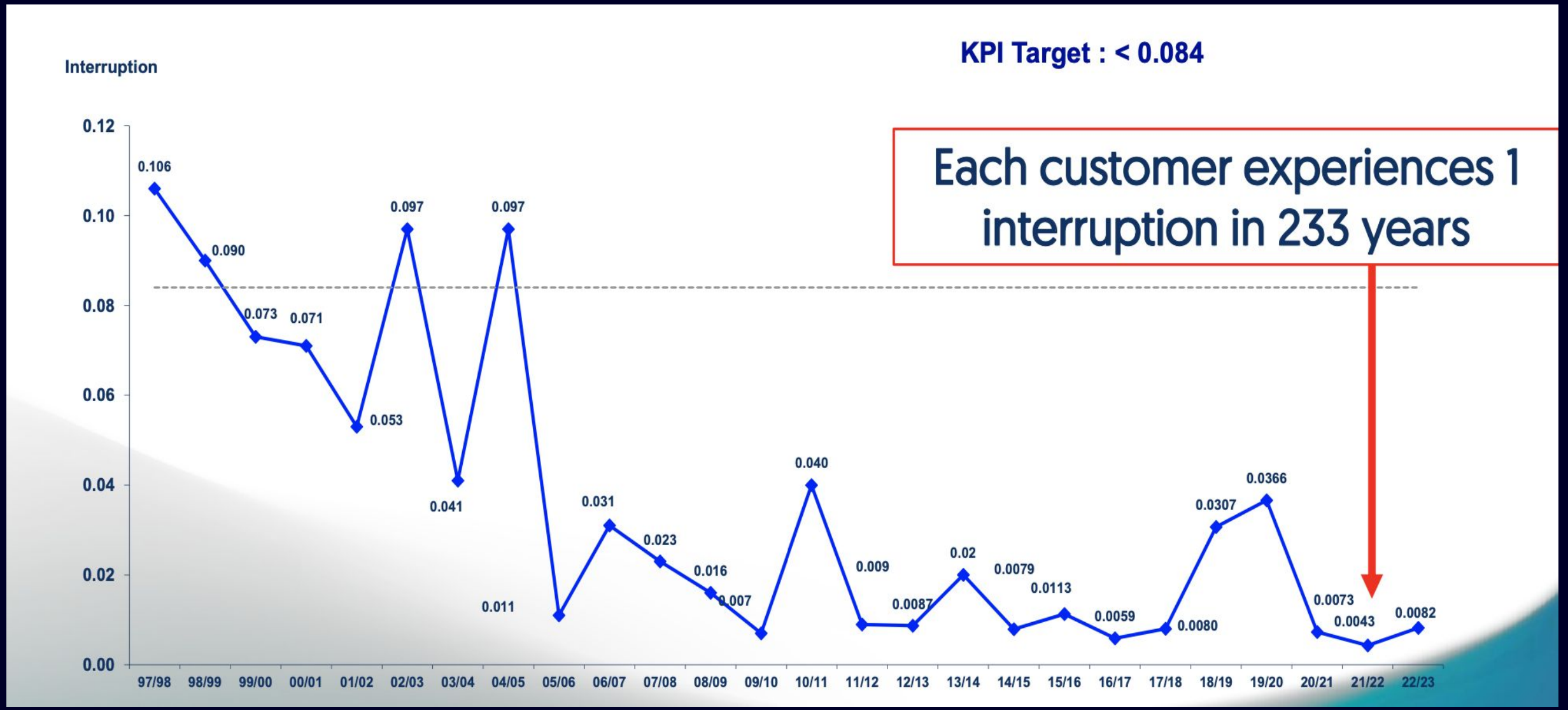
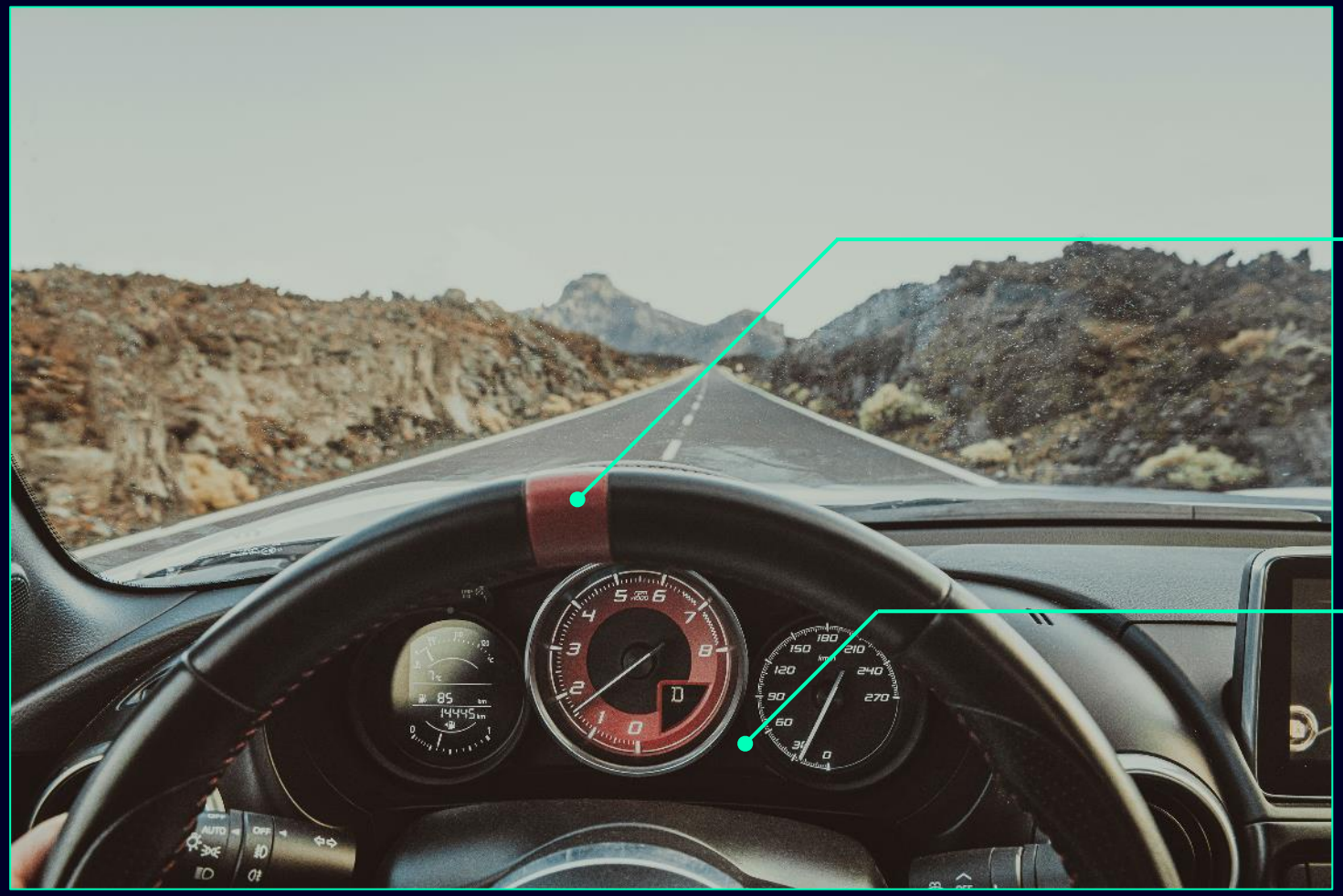
18/19
19/20
20/21
21/22
22/23

SAIFI


KPI Target : < 0.084
Interruption
0.12
0.10
0.08
0.06
0.04
0.02
0.00
0.106
0.090
0.073
0.071
0.053
0.097
0.041
0.097
0.011
0.031
0.023
0.016
0.007
0.040
0.009
0.0087
0.02
0.0079
0.0113
0.0059
0.0080
0.0307
0.0366
0.0073
0.0043
0.0082
97/98
98/99
99/00
00/01
01/02
02/03
03/04
04/05
05/06
06/07
07/08
08/09
09/10
10/11
11/12
12/13
13/14
14/15
15/16
16/17
17/18
18/19
19/20
20/21
21/22
22/23
Each customer experiences 1 interruption in 233 years

What is the role of IoT and Substation Maintenance?



SCADA is necessary for operation

… like a steering wheel.

IoT simplifies operation and maintenance

… like driver assistance and fault evaluation systems.

Review of Customer pain points

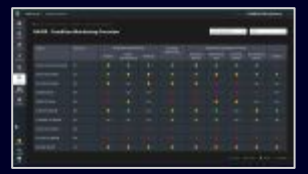
Identified use cases & value proposition
Journey from pain points to customer values

Asset transparency

Pain points:
Missing transparency
Periodical travel to substations
No centralized local/remote HMI
Weak basis to make any decisions

Customer values:
- Real-time sensor data collection
- Support on KPIs to help decision making
- Easy to access

Condition Monitoring, Predictive Maintenance



Pain points:
Unplanned shutdown
Manual & frequent preventive maintenance
Weak basis to make CAPEX decisions

Customer values:
- Online health status of connected equipment
- Continuous monitoring, instant alarms, early warning of upcoming needs for actions
- Accurate diagnosis of possible faults

- **OPEX saving**
- **CAPEX deferment**
- **Risk management**
- **Sustainability**
- **Safety, Cybersecurity**

Energy Monitoring

Pain points:
Missing transparency on loads
Missing energy saving potentials

Customer values:
- Visualize energy consumption trends
- Visualize electrical parameters
- Develop performance targets for energy management programs

Documentation

Pain points:
Missing documents, when needed most
Incomplete documents

Customer values:
- Important baseline for continuous improvement
- Manuals, drawings & Reports in one place

Digital Care Taker – Siemens NXpower Monitor

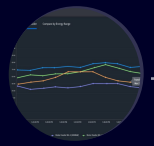
Delivers value to customer's requirements whilst utilizing our global domain knowledge

Asset transparency

Instant access to any location

Energy Monitoring/ Sustainability

(e.g. optimization of CO_2 emission mix)



Documentation

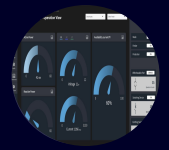
All manuals, drawings and reports easily available

Health Status

Continuous monitoring, instant alarms, early warning of upcoming needs for actions

Operational Transparency/ Benchmarking

Supports with KPIs and facts to make decisions



Service & Maintenance

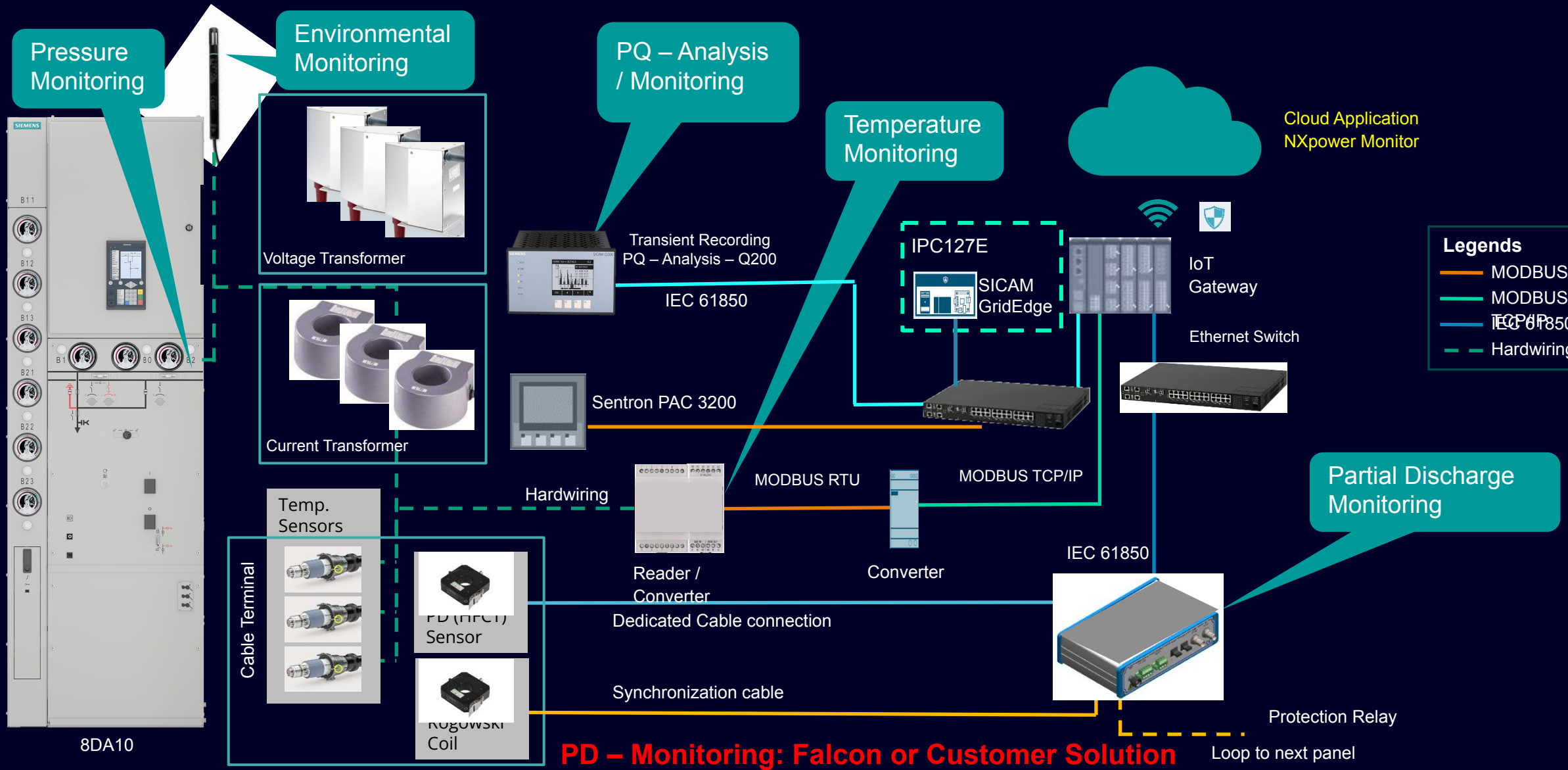
Better planning of maintenance, implement predictive maintenance

Integrates all substation equipment and is vendor agnostic

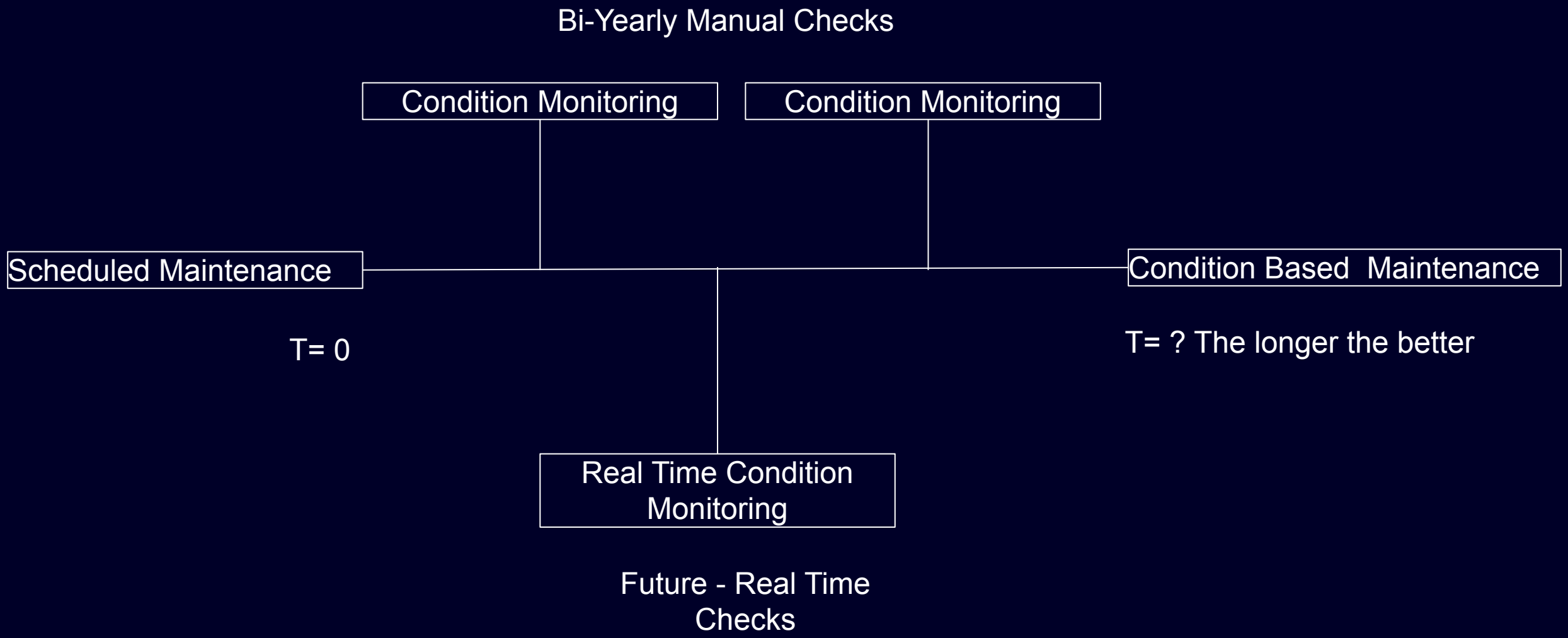
IoT connectivity and Condition Monitoring Modular Options available and their Benefits

	Operational Data	Monitor Busbar Joints & Cables' Terminations	Monitor Circuit Breaker	Monitor Insulation
Field Device	Operational Data	Monitor Busbar Joints & Cables' Terminations	Monitor Circuit Breaker	Monitor Insulation
Use Case	Asset KPIs , Operations Insights, Op. Counter, Alarms	Health Index, Condition Monitoring Time Series, Maintenance (Alarms)	Health Index, Maintenance (Alarms)	Health Index, Maintenance (Alarms)
Benefits	• Get operational insights • See graphic KPIs • Energy Benchmarking of equipment • Asset Transparency anytime from anywhere	• Identify local overheating at terminals to prevent power outages. • Awareness of ambient conditions that lead to main failures: humidity (Dew Point), corrosion, oxidation • Main failures start in cable terminals resulting from e.g. false mounting, cable isolation damage, etc. and can be detected by its temperature.	• Aging of the main contact based on I2T. • Aging on mechanical components based on operations. • Performance based on breaking timing. • Auxiliary component status based on trip coil analysis and motor spring charger to identify potential issues on command execution and recharge	• Detect the quality of isolation before an arc flash is produced. • Determine the deterioration of the insulation before fatal switchgear breakdown and associated power outage.
	Asset Transparency	Temperature & Humidity Monitoring	CB Monitoring	PD Monitoring
	Minimum Recommended to gain full app insights		Optional	Optional

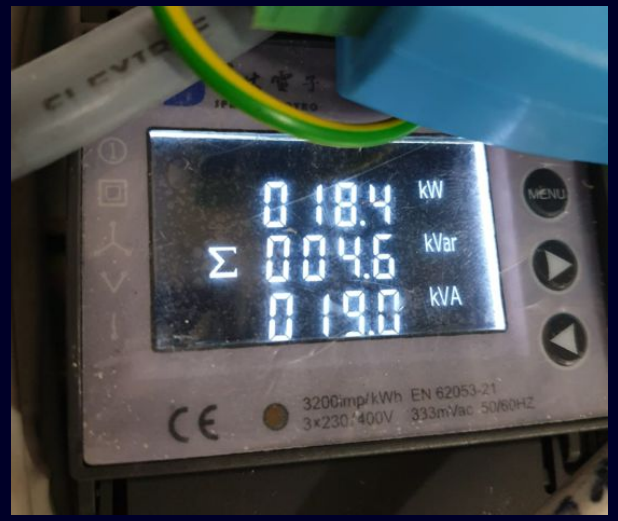
Condition Monitoring in GIS - System architecture example

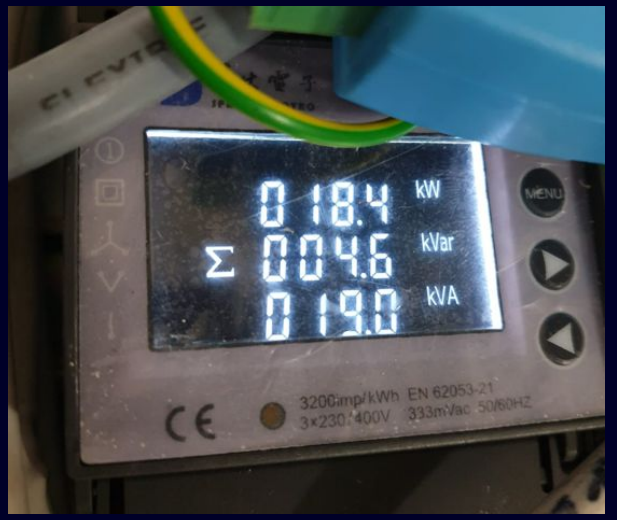


RANGOON 22 KV Substation – First Digital Substation



CONDITION MONITORING - PT AND CT SENSOR





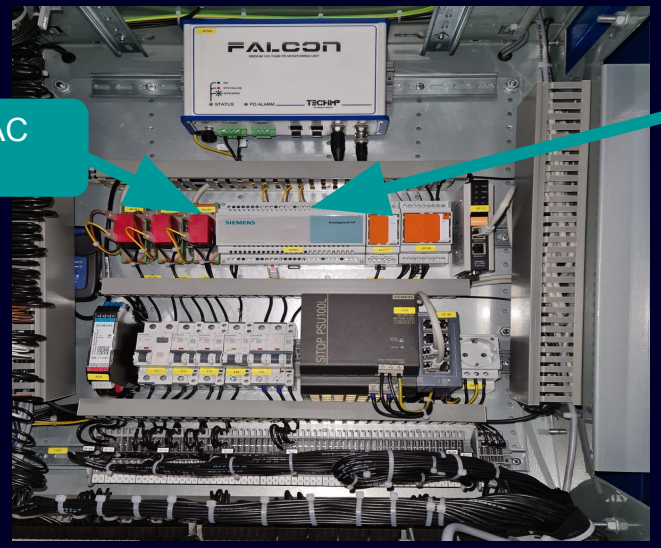
CONDITION MONITORING – HUMIDITY AND THERMAL SENSOR/CAMERA

WATER SENSOR AND THERMAL SENSOR

Condition Monitoring: Circuit Breaker Monitoring

Crucial component monitoring (e.g. Circuit Breaker Monitoring)

- Faulty equipment
  e.g. faulty trip coils, VCB spring charging mechanism, VCB timing
- Electrical Lifetime
  of the main VCB contacts based on I2t
- Mechanical lifetime
  of the VCB based on number of operations



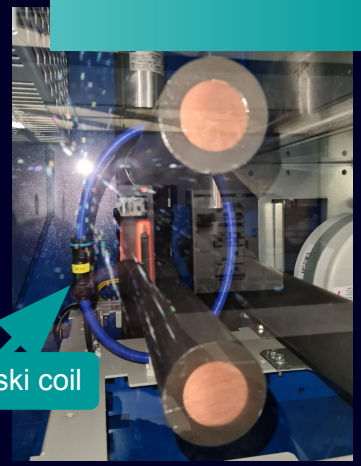
Hall sensors and VCB monitoring device in LV Compartment

Condition Monitoring: Partial Discharge Monitoring

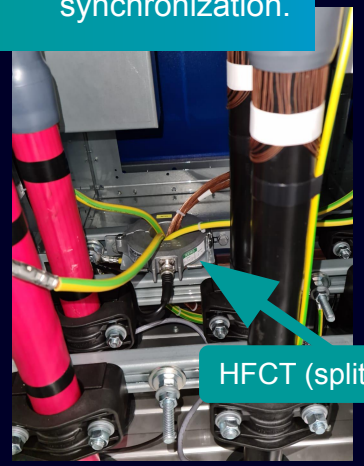
- Defective components
  e.g. damaged insulators, bushings, voltage transformers
- Degradation of insulating media
  e.g. aging
- Faulty manufacturing
  e.g. sharp edges of busbars instead of rounded edges
- Faulty installation
  e.g. wrong installation of voltage transformers at GIS
- Aggressive environment conditions
  e.g. ingress of dust and moisture

PD Monitoring unit

GIS: Earth screens of all MV cables in a feeder through an HFCT (High-frequency-CT) and one Rogowski coil per busbar section for synchronization.

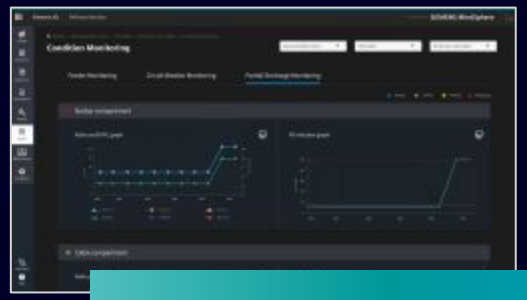


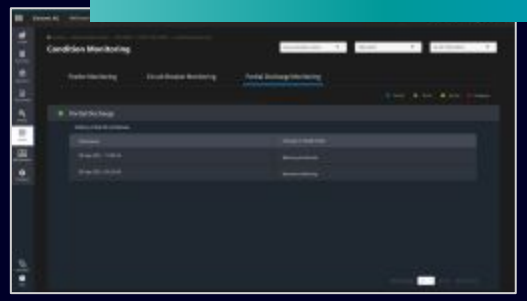
Rogowski coil



HFCT (split core)

AIS: Same Antennas used to receive temperature values from SAW sensors will be used for partial discharge detection





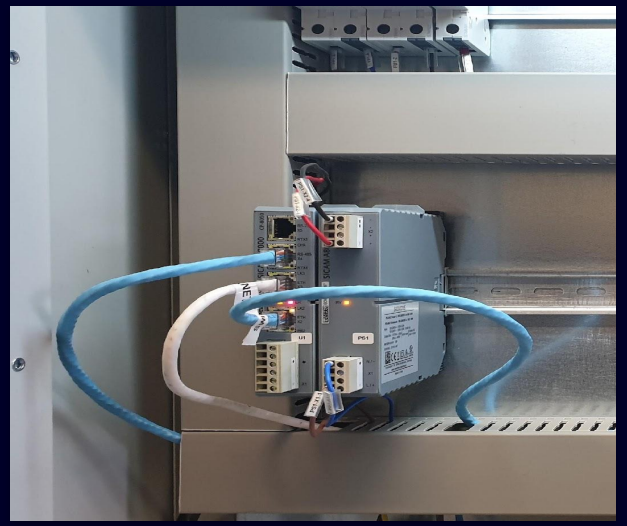
NXpower Monitor View

IoT Box & Gateway

- IoT Box and its purpose
  To contain the Gateway that enables the connectivity of the substation data to the cloud

- Footprint
  Wall mounted box - W*D*H: (600*250*600) {+/- 10% based on optional components)

- Main Components
  - Main Processor (CP8021, CP8022, CP8050)
  - Power Supply Modules
  - I/O
  - MCB and Others
  - Modem, Antenna



IOT Gateway

Locate
Summary
Operation
Documents
Energy
Health
Maintenance
Configure
Notification
Language
Help

Asia/Kolkata 2022-07-29 11:03 AM

SWG-NXAIR

2D 3D

SWG-NXAIR

Asset Information

Connectivity

Inventory Number	DFRT435345357JH
Purchase Order	PO-535211071
Supplier Name	Siemens
Supplier Reference	330123456FGH7653224
Commission Date	Sep 01, 2021

Energy Budget monitoring in FY

Current USD 25000

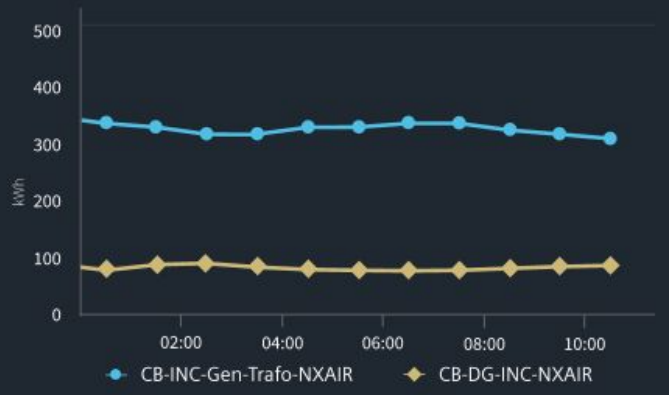
Availability in FY

Current Health Index

CO2 Emission in FY

59 t

Asset Utilization | Energy Consumption



Feeder	Panel Number	Status	Availability (%)	Alarms	Health index
CB-INC-Gen-Trafo-NXAIR	01	ON	80%	8	
CB-DG-INC-NXAIR	02	ON	50%	0	
DIS-TIE-OG-NXAIR	03	ON	50%	3	
MP-BM-NXAIR	04	ON	80%	0	
SWDP-OG-Trafo	05	OFF	20%	0	
BCM-M-M-NXAIR	06	EARTHED	80%	0	
CTR-MOT-OG-NXAIR	07	TRIPPED	50%	1	
CB-TRF-OG-NXAIR	08	EARTHED	50%	0	
CCP-OG-TIE-NXAIR	09	OFF	20%	0	
BSP-BSP-NXAIR	10	TRIPPED	80%	1	

No Data | Normal | Warning | Emergency

Locate
Summary
Operation
Documents
Energy
Health
Maintenance
Configure
Notification
Language
Help

Energy Monitoring

Feeder Selection

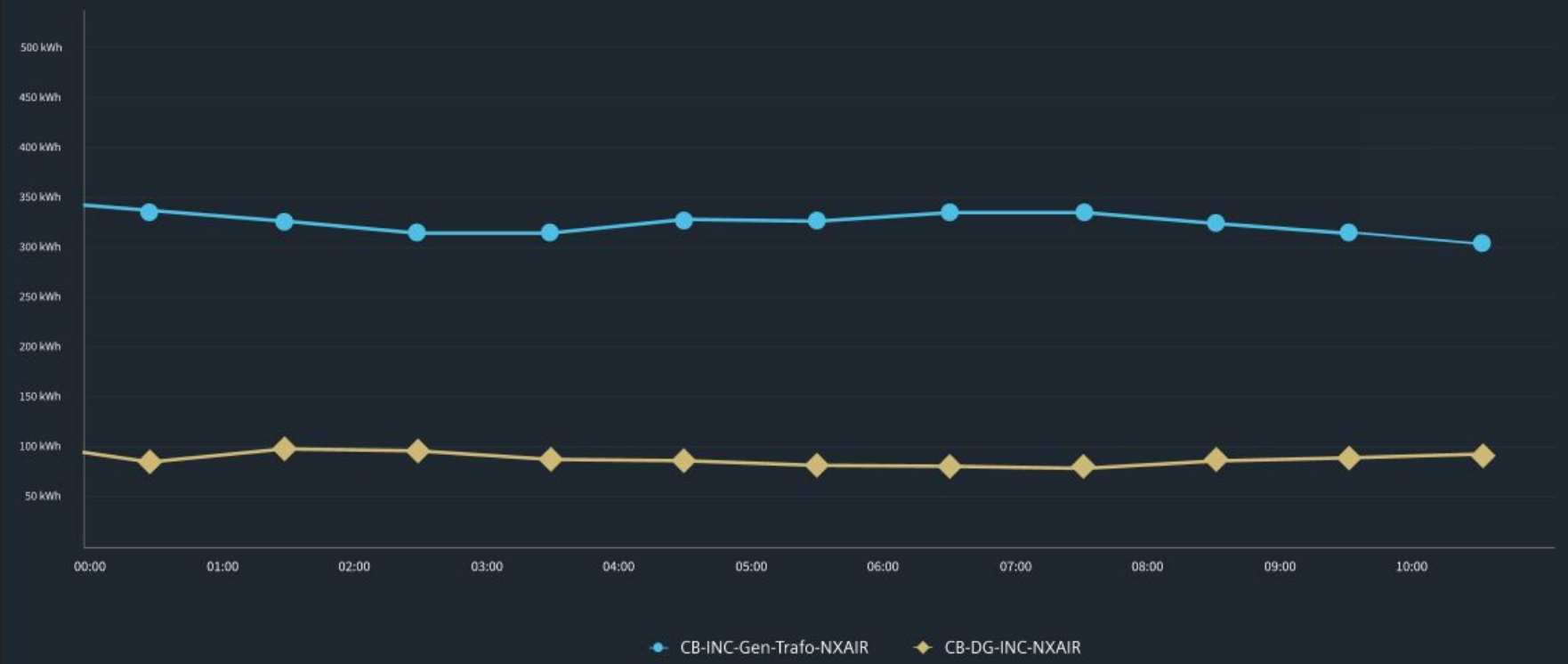
- Kalwa-Substation-H4161
  - SWG-NXAIR
    - [x] CB-INC-Gen-Trafo-NXAIR
    - [x] CB-DG-INC-NXAIR
    - [ ] DIS-TIE-INC-NXAIR
    - [ ] MP-BM-NXAIR
    - [ ] SWDP-OG-Trafo
    - [ ] BCM-M-M-NXAIR
    - [ ] CTR-MOT-OG-NXAIR
    - [ ] CB-TRF-OG-NXAIR
    - [ ] CCP-OG-TIE-NXAIR
    - [ ] BSP-BSP-NXAIR
  - SWG-8DB10
  - SWG-NXPLUS C
  - SWG-8DJH
  - Transformer
  - SWG-SIVACON S8
- Berlin Substation
- Spain Substation
- France Substation
- Turkey Substation
- Malaysia Substation

Compare (2)

Energy Consumption

Compare by feeder

Today | Last 7 days | 29/07/2022



NXAIR - Condition Monitoring Overview

Kalwa-Substation-H4161 | NXAIR

Feeder	Panel No.	Temperature Monitoring			Humidity Monitoring	Mechanical Operation Counter				
		Busbar	Cable Compartment	Bushing		Switching Device	Withdrawal Part	Earthing Switch	Bus Earthing Switch	Busbar
CB-INC-Gen-Trafo-NXAIR	01	Warning	Normal	Normal	Normal	Warning	Normal	Normal	Normal	Emergency
CB-DG-INC-NXAIR	02	Normal	Warning	Warning	Normal	Normal	Warning	Warning	Normal	Normal
DIS-TIE-OG-NXAIR	03	Warning	N/A	Warning	Warning	Warning	Emergency	Emergency	N/A	N/A
MP-BM-NXAIR	04	Emergency	N/A	N/A	Emergency	Emergency	Emergency	Emergency	Emergency	N/A
SWDP-OG-Trafo	05	Emergency	Warning	N/A	Emergency	Emergency	Warning	Warning	N/A	N/A
BCM-M-M-NXAIR	06	Warning	Normal	N/A	Warning	Warning	Normal	N/A	Warning	Normal
CTR-MOT-OG-NXAIR	07	N/A	N/A	N/A	Normal	Normal	Normal	N/A	Normal	Normal
CB-TRF-OG-NXAIR	08	Emergency	Emergency	Emergency	Emergency	Emergency	Emergency	Emergency	Emergency	Emergency
CCP-OG-TIE-NXAIR	09	Emergency	Emergency	Emergency	Emergency	Emergency	Emergency	Emergency	Emergency	Emergency
BSP-BSP-NXAIR	10	Warning	Warning	Warning	Warning	Warning	Warning	Warning	Warning	Warning

No Data | Normal | Warning | Emergency

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Kalwa-Substation-H4161

Search by Product Category, Product Type, Document Type

Upload new

Substation/Location	Product Category	Product Type	File Name	Document Type	Upload Date	Actions
Berlin Substation	Medium voltage gas...	NXPLUS C (up to 24kV,....	manual_asset 1.pdf	Asset Manual	10-11-2020	5
Kalwa-Substation-H4161	Medium voltage air....	NXAIR (up to 17.5kV 40kA)	maintenance_asset 1.docx	Maintenance Document	17-11-2020	3
Kalwa-Substation-H4161	Medium voltage air....	NXAIR M (up to 24kV, 25kA)	frontpic_asset 1.jpg	Asset Catalogue	20-11-2020	
Global / Generic document	Others	--	frontpic_asset 561.jpg	Asset Catalogue	15-11-2020	

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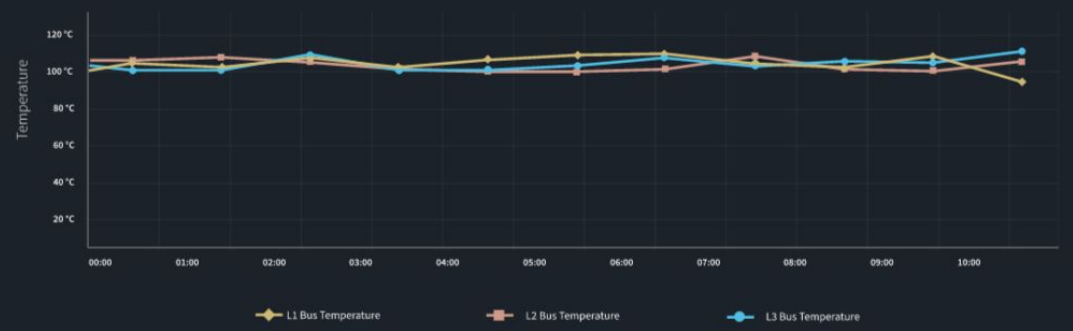
Feeder Monitoring | Circuit Breaker Monitoring | Partial Discharge Monitoring

No Data | Normal | Warning | Emergency

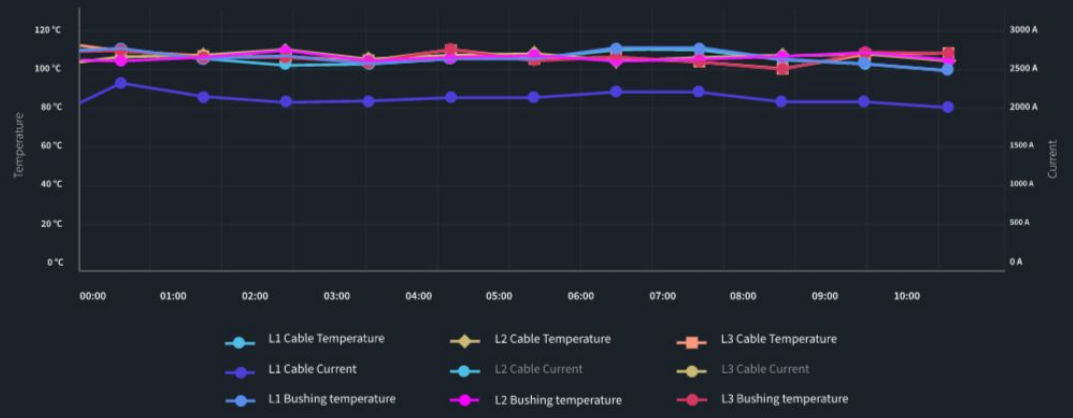
Busbar



Mechanical Operation Counter

The expected lifetime may vary depending on the actual condition.

Cable Compartment



Relative Humidity

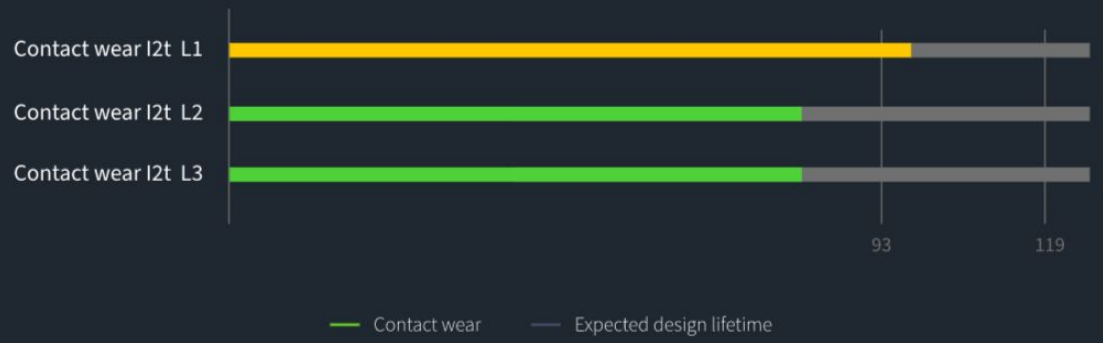
Note: The information provided on the health status of the Assets is merely indicative and not binding to you. However, this can be used as guidance in assessing the risk associated with Assets

Feeder Monitoring | Circuit Breaker Monitoring | Partial Discharge Monitoring

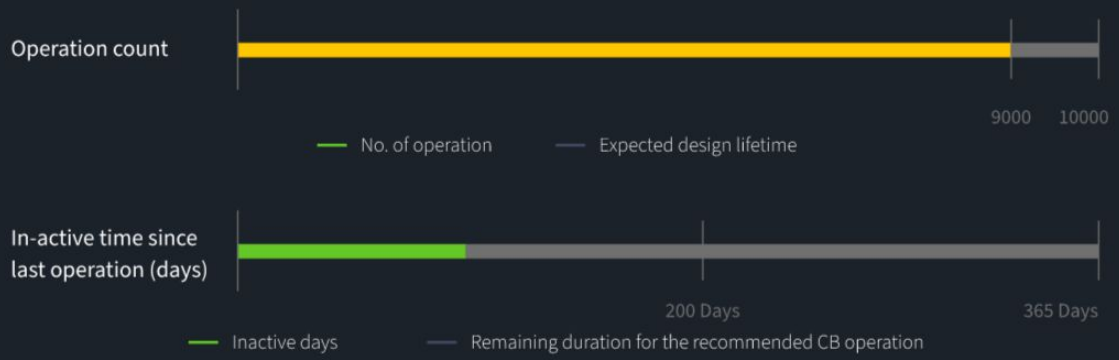
No Data | Normal | Warning | Emergency

Serial Number SDF4582662261256 | Circuit Breaker ON | Spring Reserve Drive CHARGED

Electrical Lifetime



Mechanical Lifetime



Readiness for Operation

Last switching operation

Operation since last acknowledge

Acknowledge

Expert View

Cable compartment

No alarms

Ratio and EPPC graph

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Condition Monitoring

Kalwa-Substation-H4161 | SWG-NXAIR | CB-INC-Gen-Trafo-NXAIR

Feeder Monitoring | Circuit Breaker Monitoring | Partial Discharge Monitoring

No Data | Normal | Warning | Emergency

Busbar compartment

Ratio and EPPC graph

PD indicator graph

Cable compartment

Ratio and EPPC graph

PD indicator graph

Condition Monitoring

Kalwa-Substation-H4161 | SWG-8DB10 | CB-INC-TRAF-8DB10

Feeder Monitoring | Circuit Breaker Monitoring | Partial Discharge Monitoring

No Data | Normal | Warning | Emergency

Partial Discharge

History of last 30 incidences

Timestamp	Change in Health Index
20 Sep 2021, 11:00:25	Warning to Normal
20 Sep 2021; 09:32:43	Normal to Warning

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Q&A