

How Healthy Is Your Electrical Infrastructure?

Moving Beyond the MSB: Distributed Power Quality Monitoring in Modern Hospitals

Thursday 30th July

IHEA QLD

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nhp.com.au



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AGENDA

- **Understanding Power Quality**
- **Impact on Electrical Systems & Compliance Monitoring**
- **Analysis, Mitigation & Continuous Improvement**

How do we go from this?



To this...

Compliance
Resilience
Efficiency
Safety
Trust + Confidence



Section 1

Understanding Power Quality & Harmonics

The Modern Hospital Grid: An Electrified Organism

Electrification + Digitization = Exponential Grid Complexity

Changing Profile

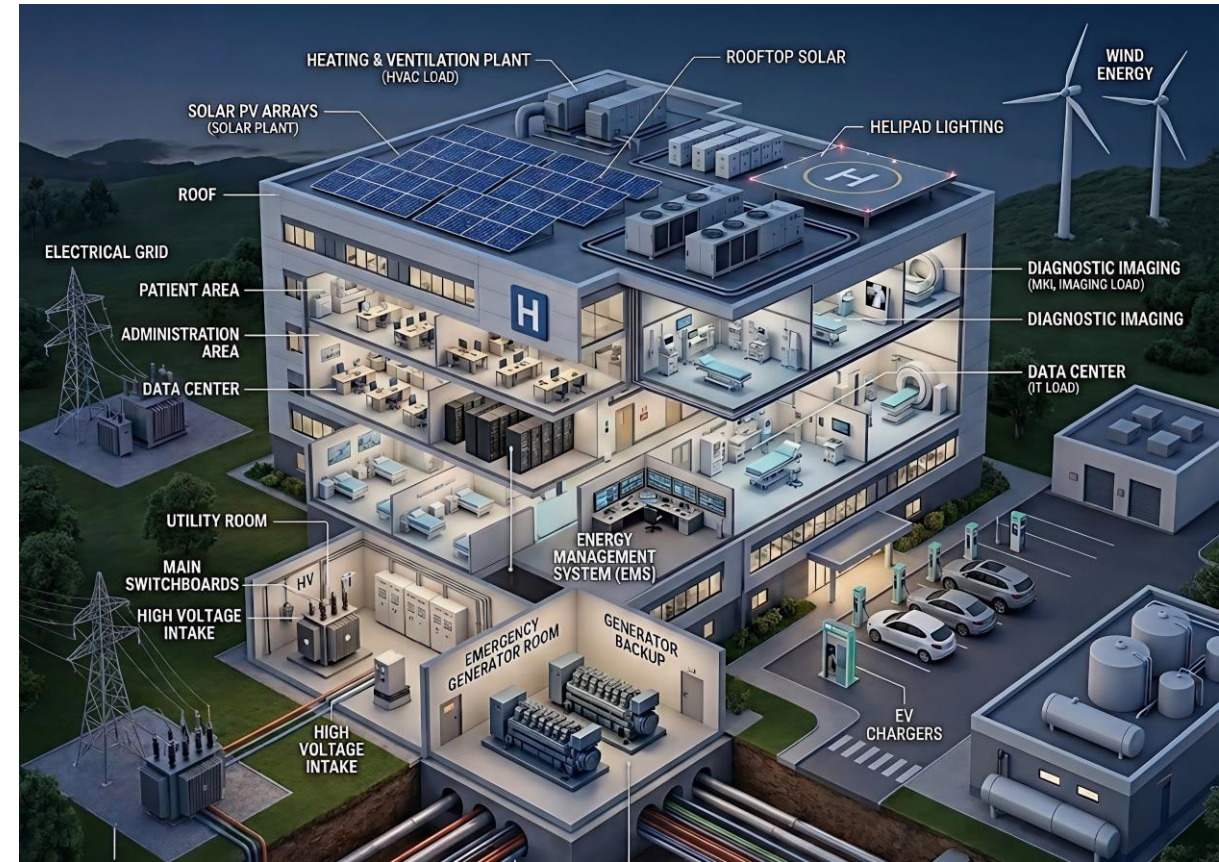
Hospitals are undergoing rapid electrification to meet strict sustainability goals, adopting digitally enabled, high-tech infrastructure.

New Baseline

Facilities are moving from traditional linear electrical loads to predominantly non-linear loads driven by switch-mode power supplies (SMPS).

Vulnerability

Hospitals can't afford interruptions, a power failure can have major consequences. Minor disturbances now threaten clinical services.



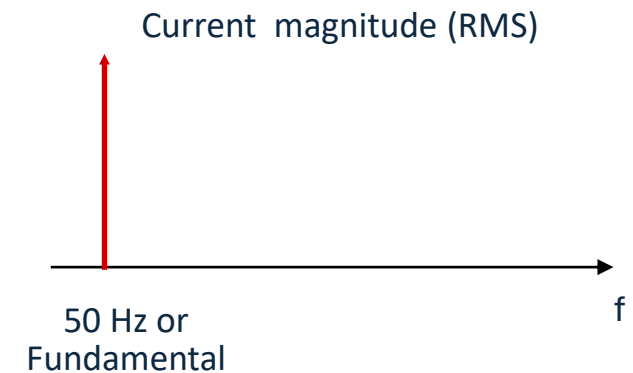
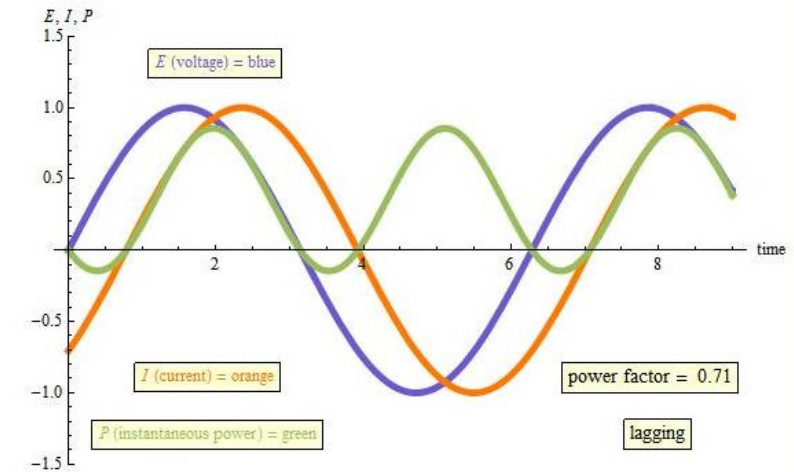
Behaviour: Linear Devices

Linear Load

- Current waveform is similar to voltage waveform
- Draws current sinusoidally when energized by a sinusoidal voltage

Example linear loads

- Induction motors
- Incandescent lights
- Resistance heaters



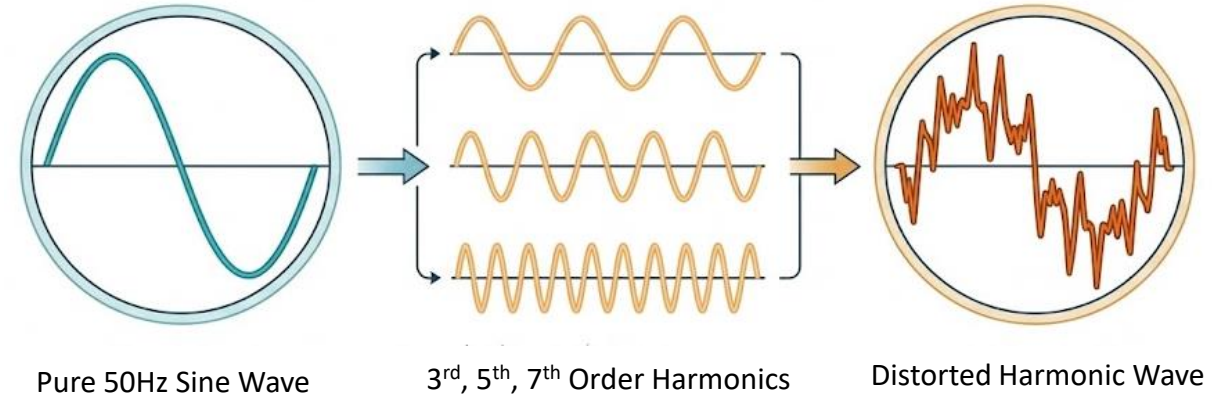
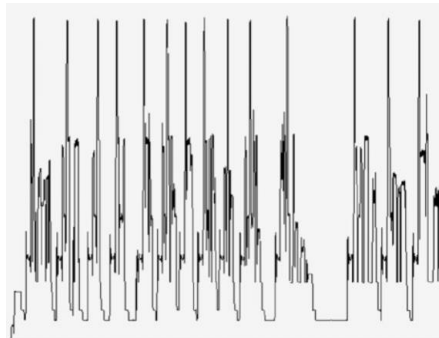
Behaviour: Non-Linear Devices

Non-Linear Load

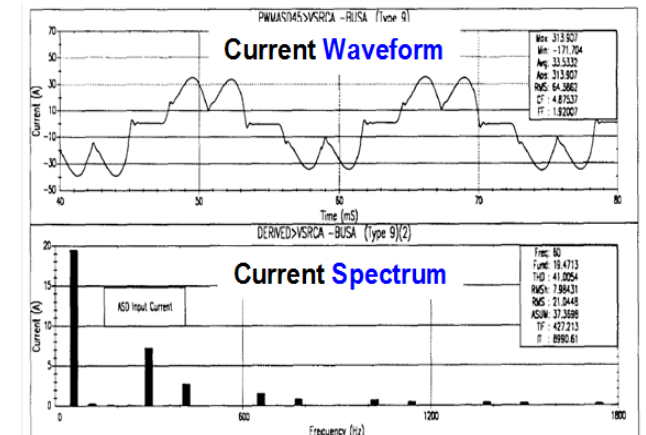
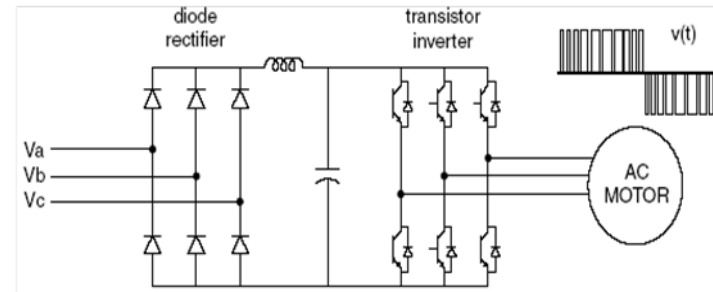
- Current waveform is dissimilar to voltage waveform

Example non-linear loads

- Variable frequency drives
- Switch-mode power supplies
- Sensitive Medical Devices
- UPS systems
- LED's



$$X_k = \sum_{n=0}^{N-1} x_n e^{-j \frac{2\pi}{N} nk}, \text{ where } k = 0, \dots, N-1$$



The Internal Conflict: **Originators vs. Prosumers**

Hospitals have the most aggressive polluters and the most vulnerable prosumers

Originators (Generators)



UPS



Variable speed
drive (VSD)



PC



LED Lighting



HVAC Chiller

Modern efficiency loads generate significant odd-order harmonics. For example, standard 6-pulse UPS systems can generate 30-40% Total Harmonic Distortion (THD).

The Clash:

Disturbances originating in the mechanical plant room seamlessly propagate through the network to impact operations in the cardiology wing.

Prosumers (Vulnerabilities)



Digital X-Ray



MRI



ICU Patient Monitor



Telemetry

Diagnostic imaging and life-support systems require near-perfect sinusoidal voltage to operate without glitching, artifacting, or losing synchronization.

Section 2

System Impacts & Compliance Requirements

Impacts: Increased Operating Costs

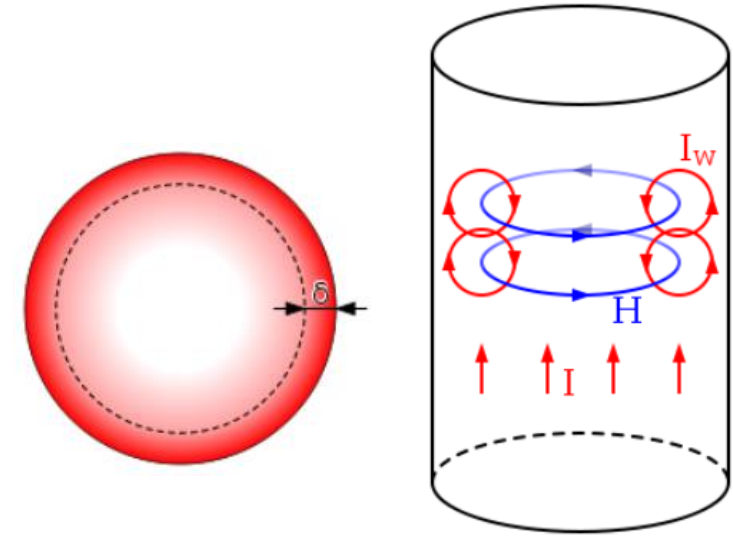
Facility pays more for the same load

1. Increased RMS Current Drawn
2. Overheating of standard electrical supply/Tx
3. Conductor losses
4. Poor power factor
5. Oversizing Cables, Tx, Protection devices
6. Positive, Negative & Zero Sequence effects

$$P_{EC} = P_{EC-1} \sum_{h=1}^{h_{\max}} I_h^2 h^2$$

$$P_R = \sum_{h=1}^{h_{\max}} I_h^2 R_h$$

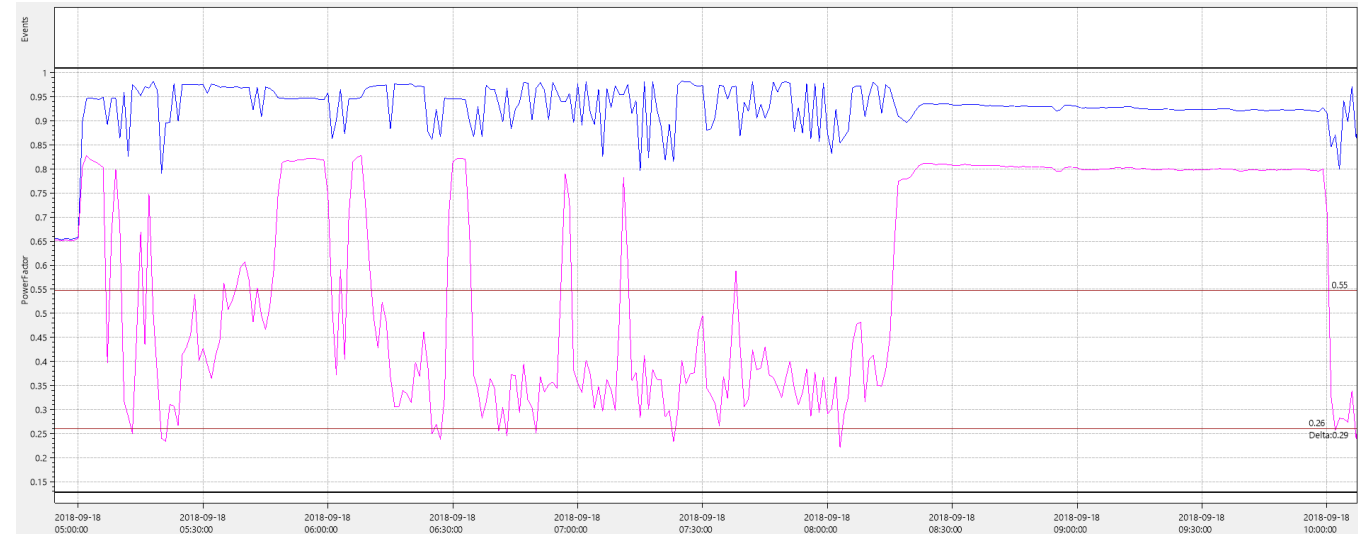
$$pf_{true} \leq pf_{dist} = \frac{1}{\sqrt{1 + (THD_I / 100)^2}}$$



➤ Higher Electricity Costs

➤ Lower System Efficiency

➤ Increased Capital Exp



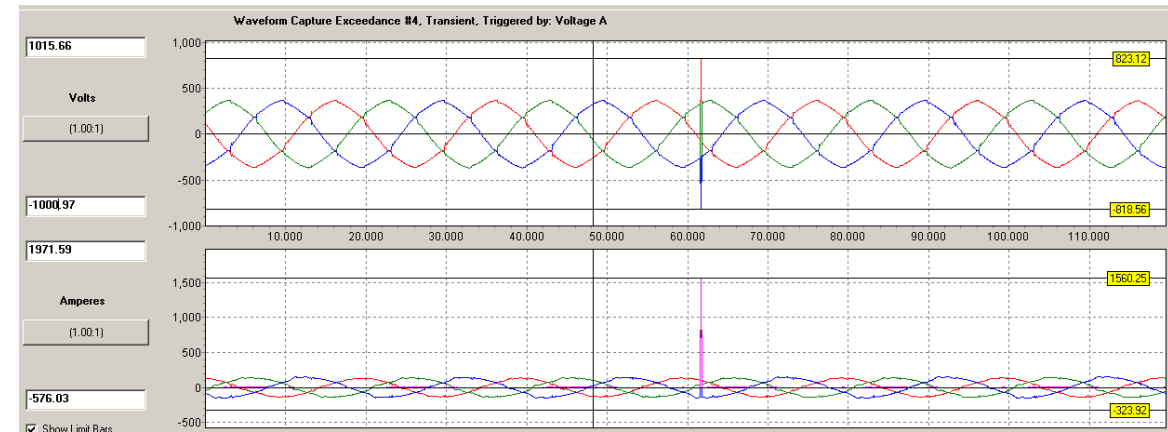
Impacts: Reduced Asset Life & Maintenance

Equipment ages faster than expected

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1. Overheating of Tx and supply equipment
2. Harmonic resonance
3. Interference in Telco/Control/Timing systems
4. Malfunction of equipment (computers, UPS, sensitive loads)

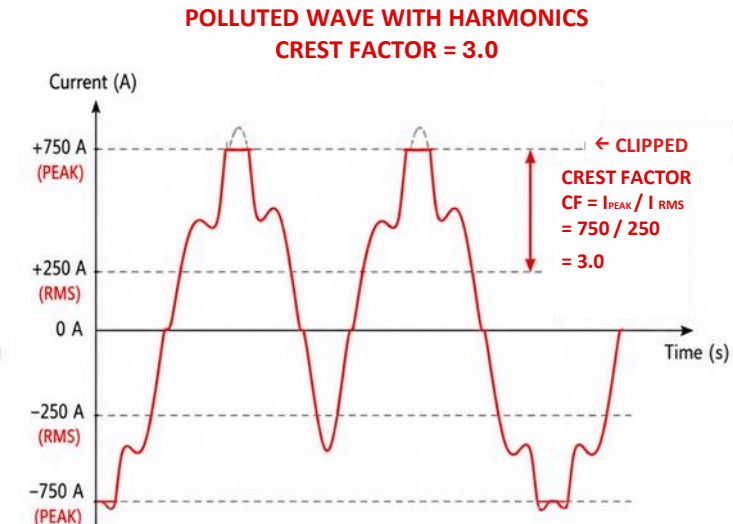
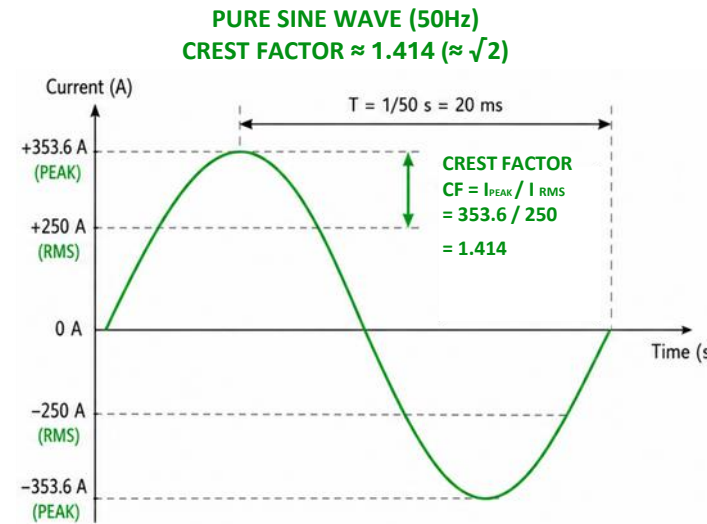
- More Frequent Maintenance
- Increased Replacement Costs
- Unplanned Asset Failures



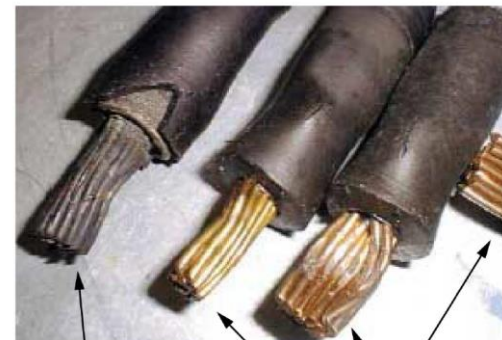
Impacts: Operational Disruption & Downtime

Equipment does not operate as expected

1. Malfunction of computers UPS, sensitive loads
2. Harmonic resonance Instability
3. Interference in Telco/Control/Timing systems
4. Voltage Distortion affects neighboring equipment
5. Generator Instability & frequent starting
6. Protective device nuisance tripping
7. Increased Neutral Current
8. Under protection leading to major failures



- Extended Downtime
- Cancelled Procedures
- Reduced System Reliability



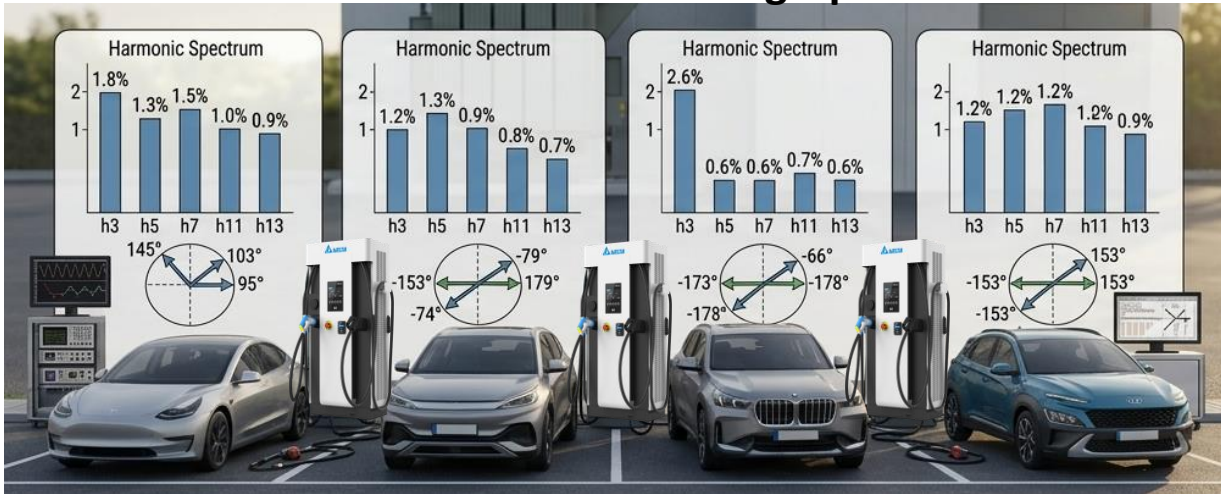
Oxidised Neutral conductor

Line Conductors



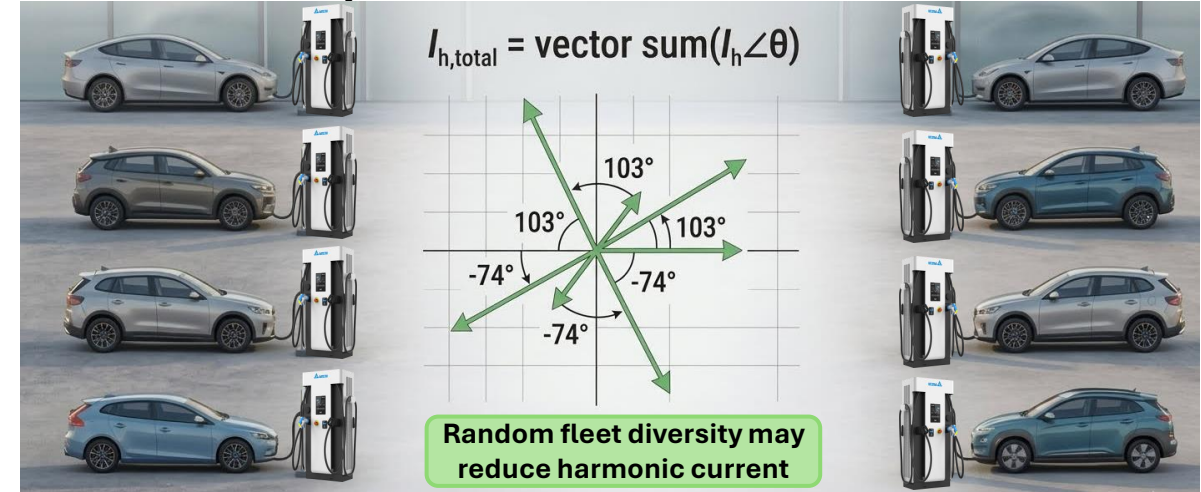
Unpredictable behaviour: EV Charging Infrastructure

Individual EV Harmonic Fingerprint



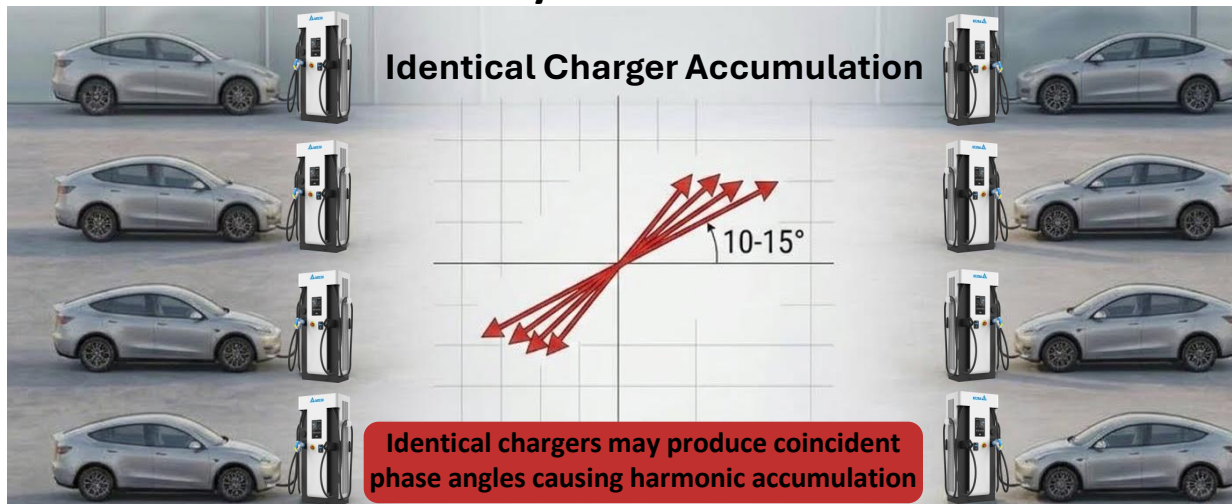
Individual EV models exhibit vastly different harmonic magnitudes and phase angles

The Diversity Benefit – Harmonic Cancellation



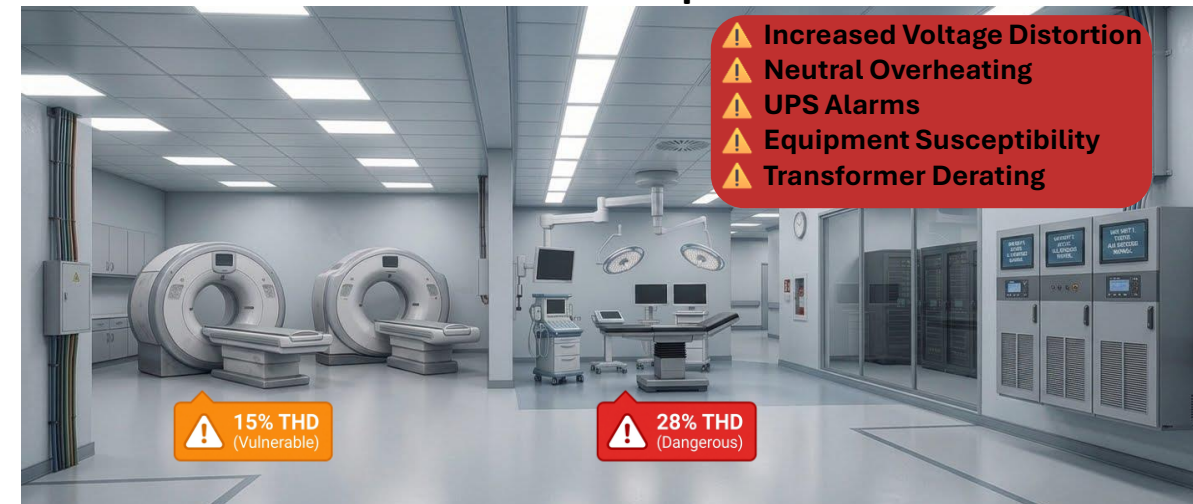
A natural mitigation strategy, reducing THD seen by the upstream transformer

The Risk of Similarity – Harmonic Addition



Vectors are aligned, harmonic currents add together, creating a large resultant harmonic arrow.

Critical Infrastructure & Hospital Risks



High harmonic levels can impact critical equipment reliability, compromising patient safety.

Power Quality: Power Factor

State based regulatory requirements

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VIC Electricity Distribution Code 2026

Table 4

POWER FACTOR LIMITS						
Supply Voltage in kV	Power Factor Range for Customer Maximum Demand and Voltage					
	Up to 100kVA / 100 kW		100 kVA – 2 MVA 100 kW – 2 MW		Over 2 MVA / 2 MW	
	Minimum lagging	Minimum leading	Minimum lagging	Minimum leading	Minimum lagging	Minimum leading
< 6.6	0.8	0.8	0.8	0.8	0.85	0.85
6.6	0.8	0.8	0.85	0.85	0.9	0.9
11						
22						
66	0.85	0.85	0.9	0.9	0.95	0.98

QLD Electricity Connection Manual



Part of Energy Queensland

Table 41 Power factor performance standard

Nominal supply voltage ¹	Power Factor range
50kV - 250kV	0.95 lagging to unity
1kV <50kV	0.90 lagging to 0.90 leading
<1kV	>0.8 lagging but not leading

Note 1 - At all other voltage ranges the requirements are as specified by the *NER*, unless detailed in a contract.

PF	Current	Increase vs PF = 1	Losses (I ² R)
1.00	100 A	0%	0%
0.95	105 A	+5%	+11%
0.90	111 A	+11%	+23%
0.80	125 A	+25%	+56%

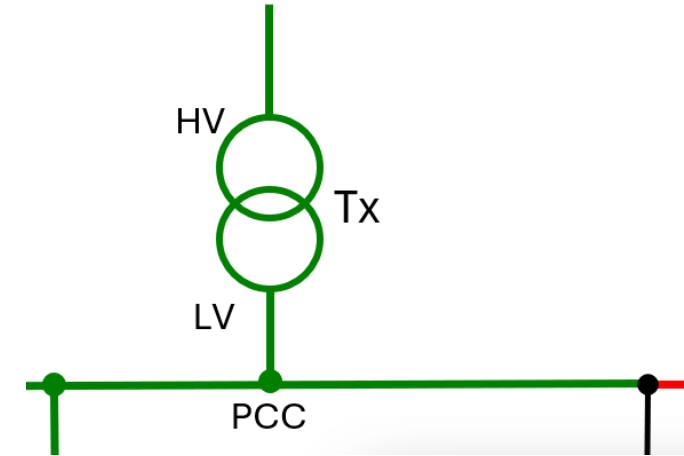
$$I \propto \frac{1}{PF}$$

Power Quality: IEC 61000 – IEEE 519:2022

Voltage Harmonics

Table 1 – Compatibility levels for individual harmonic voltages in low and medium voltage networks (percent of fundamental component) reproduced from IEC 61000-2-2 [5] and IEC 61000-2-12 [6]

Odd harmonics non-multiple of 3		Odd harmonics multiple of 3		Even harmonics	
Harmonic order h	Harmonic voltage %	Harmonic order h	Harmonic voltage %	Harmonic order h	Harmonic voltage %
5	6	3	5	2	2
7	5	9	1,5	4	1
11	3,5	15	0,4	6	0,5
13	3	21	0,3	8	0,5
$17 \leq h \leq 49$	$2,27 \cdot \frac{17}{h} - 0,27$	$21 < h \leq 45$	0,2	$10 \leq h \leq 50$	$0,25 \cdot \frac{10}{h} + 0,25$
NOTE The compatibility level for the total harmonic distortion is THD = 8 %.					



IEEE STD 519-2022

Table 1—Voltage distortion limits

Bus voltage V at PCC	Individual harmonic (%) $h \leq 50$	Total harmonic distortion THD (%)
$V \leq 1.0$ kV	5.0	8.0
$1 \text{ kV} < V \leq 69$ kV	3.0	5.0
$69 \text{ kV} < V \leq 161$ kV	1.5	2.5
$161 \text{ kV} < V$	1.0	1.5 ^a

Table 2—Current distortion limits for systems rated 120 V through 69 kV

Maximum harmonic current distortion in percent of I_L						
Individual harmonic order ^b						
I_{sc}/I_L	$2 \leq h < 11^a$	$11 \leq h < 17$	$17 \leq h < 23$	$23 \leq h < 35$	$35 \leq h \leq 50$	TDD
$< 20^c$	4.0	2.0	1.5	0.6	0.3	5.0
$20 < 50$	7.0	3.5	2.5	1.0	0.5	8.0
$50 < 100$	10.0	4.5	4.0	1.5	0.7	12.0
$100 < 1000$	12.0	5.5	5.0	2.0	1.0	15.0
> 1000	15.0	7.0	6.0	2.5	1.4	20.0

^aFor $h \leq 6$, even harmonics are limited to 50% of the harmonic limits shown in the table.

^bCurrent distortions that result in a dc offset, e.g., half-wave converters, are not allowed.

^cPower generation facilities are limited to these values of current distortion, regardless of actual I_{sc}/I_L unless covered by other standards with applicable scope.

where:

I_{sc} = maximum short-circuit current at PCC

I_L = maximum demand load current at PCC under normal load operating conditions

The Diagnostic Flaw: Main Switchboard Myopia

Diagnosing a localized infection by only checking the pulse at the MSB

Traditional Approach

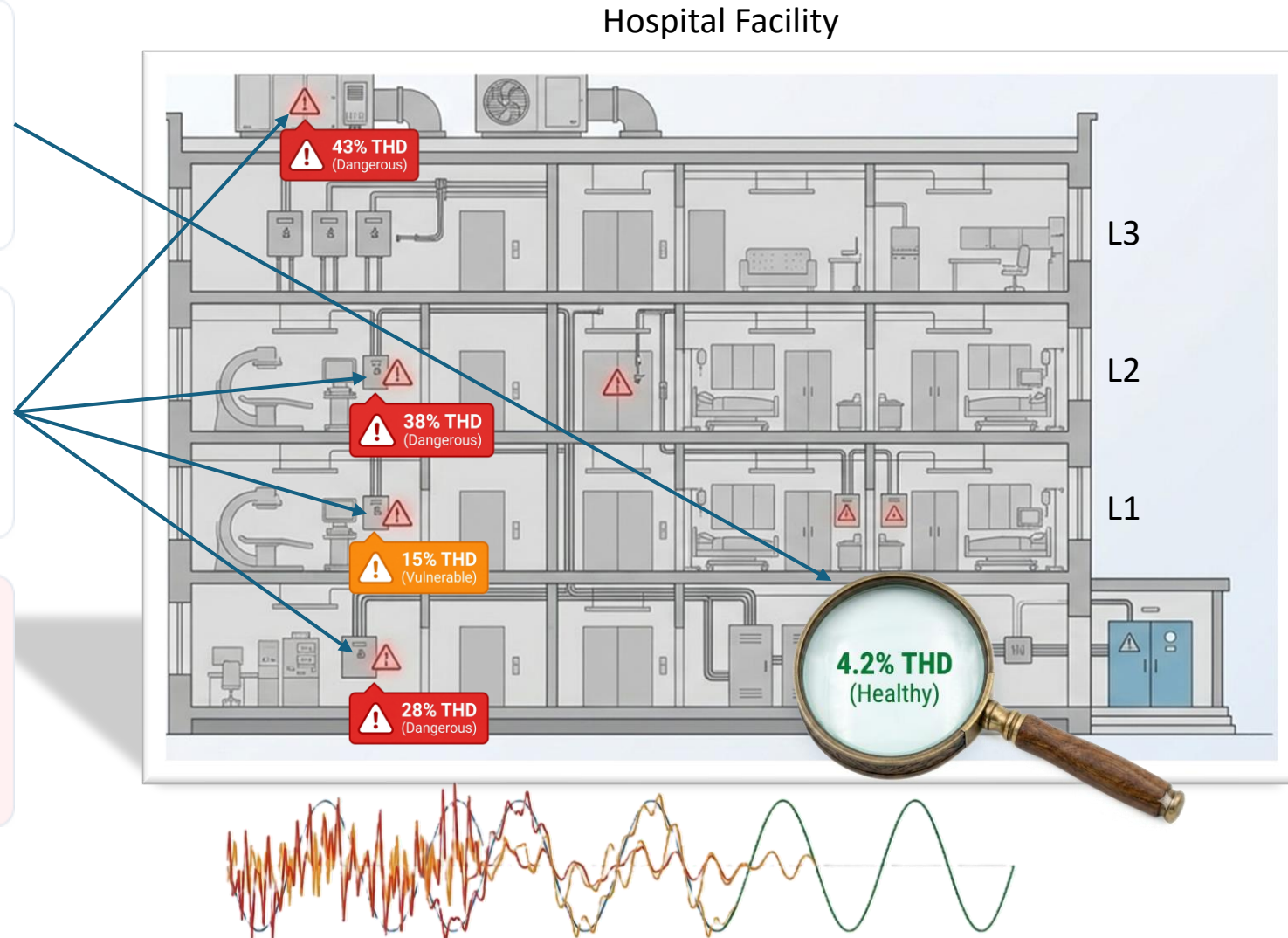
Historically, facilities measure PQ at the entrance. If the MSB meets clean-power thresholds, building is clean.

Blind Spots

Non-Linear Loads operate with offset phase angles. When they join back at the MSB, they oppose and cancel out.

Consequences

Facility manager sees PQ as healthy. Increased harmonics continue to degrade sensitive localized loads overheating conductors.



Section 3

Analysis & Continuous Improvement

4th Floor
IT Server Room

Ground Floor
Main Switchboard

Basement
Plant Room

3rd Floor
Open Theater

Main Switchboard

HUD Dashboard

SYSTEM HEALTHY

VOLTAGE STABLE

HARMONICS LOW

LOAD BALANCED

DIRT

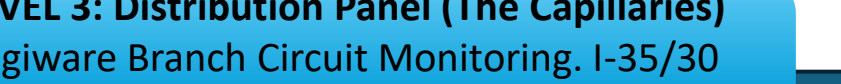
LEVEL 1: Incoming Power (The Heart)
DIRIS Q800 - Power quality instrument capturing aggregate events and waveforms.

LEVEL 2: Main Switchboard (The Arteries)
Digiware system. Centralized data aggregation.
D-70 display + M-70 gateway



LEVEL 2: Main Switchboard (The Arteries)
Digiware system. Centralized data aggregation.
D-70 display + M-70 gateway

LEVEL 3: Distribution Panel (The Capillaries)
Digiware Branch Circuit Monitoring. I-35/30
modules tracking specific loads (HVAC, Lighting,
Diagnostic IT)

A blue rounded rectangle with a gradient, containing the text 'LEVEL 3: Distribution Panel (The Capillaries)' in bold, followed by 'Digiware Branch Circuit Monitoring. I-35/30 modules tracking specific loads (HVAC, Lighting, Diagnostic IT)'. To the right of the rectangle is a large blue arrow pointing right, and below it is a graphic of a red capillary network on a skin-like texture.

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The diagram illustrates a power distribution system for a building with multiple floors. The system includes a utility power source, a backup power supply, and a central power distribution unit (DIRIS Q800). The system is connected to various loads, including servers, lighting, and HVAC. A callout box highlights "Minimal wiring, maintained accuracy, site consistency."

Building Layout:

- 4th Floor: IT Server Room
- 3rd Floor: Operating Theater
- Ground Floor: Main Switchboard
- Basement: Plant Room

Power Distribution Components:

- Utility power source:** Connected to the main switchboard.
- Backup power supply:** Connected to the main switchboard via a transfer switch.
- DIRIS Q800:** Central power distribution unit.
- ATyS pM or P + Comms module:** Connected to the DIRIS Q800.
- Webview-S/M:** Monitoring and control interface.

Power Distribution and Monitoring:

- The system is connected to various loads, including servers, lighting, and HVAC.
- Monitoring is provided by the DIRIS Q800 and Webview-S/M.
- The system is designed for minimal wiring, maintained accuracy, and site consistency.

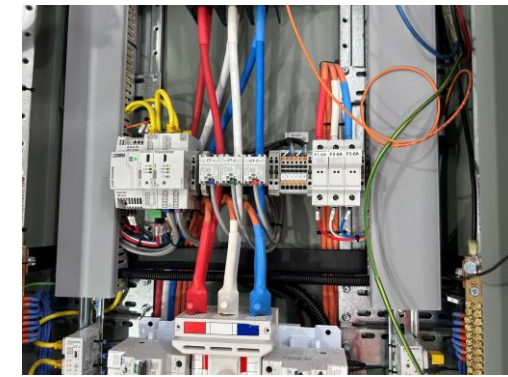
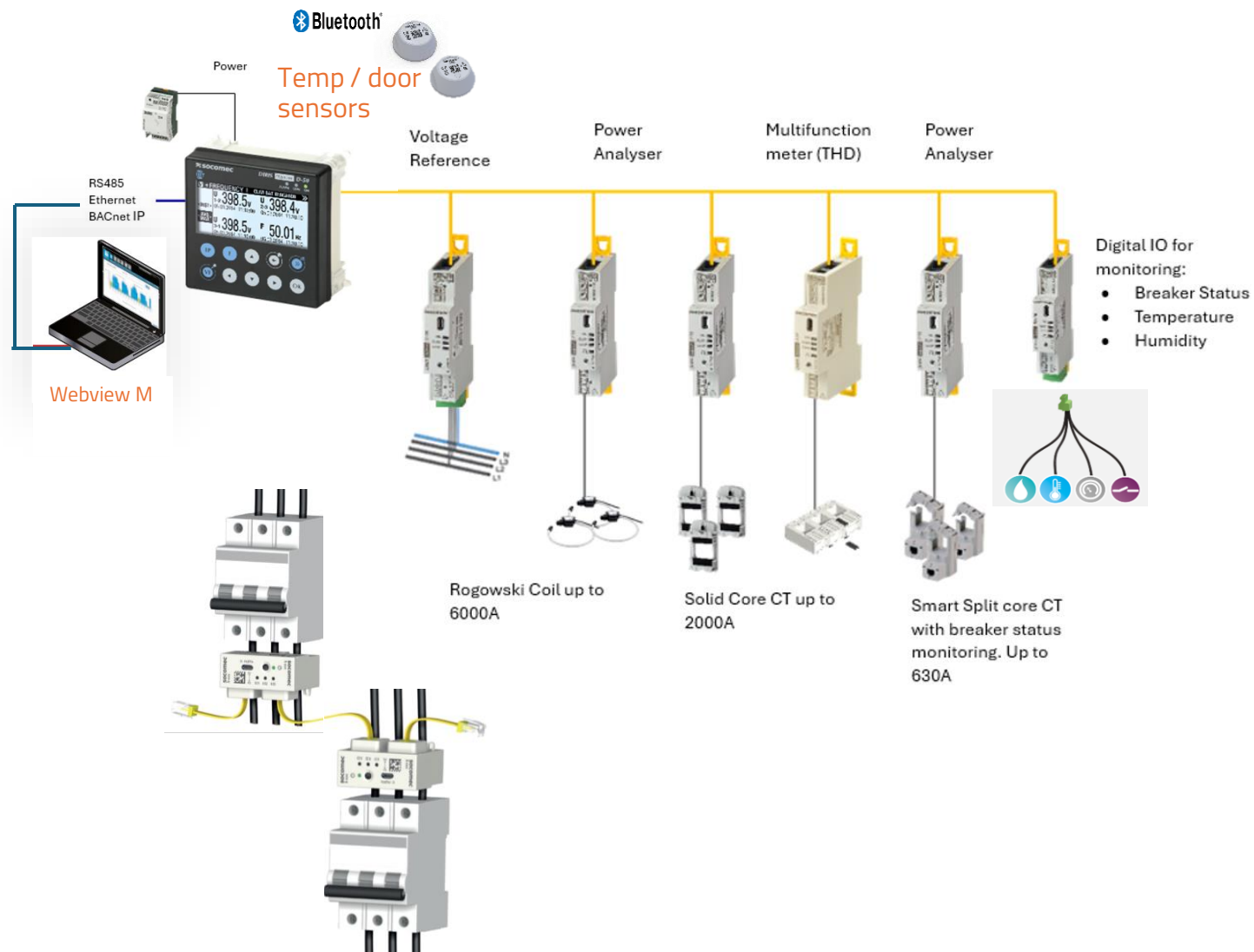
- Minimal wiring, maintained accuracy, site consistency.

SCADA/WEBVIEW

The Solution: DB Load Monitoring

Digiware Modular Power monitoring system

NHP





Monitor

Network Analysis

Load Analysis



Summary



Quality



Summary



U / I



Power



Energy



Quality

Electricity / Supply Capacity Control Device

2026/06/11 08:12:46

Inst

Avg

I

V

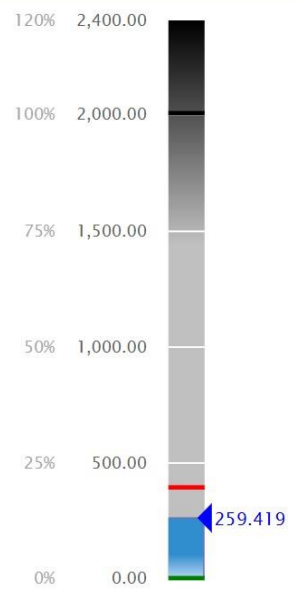
U

Reset Min/Max

Currents monitoring

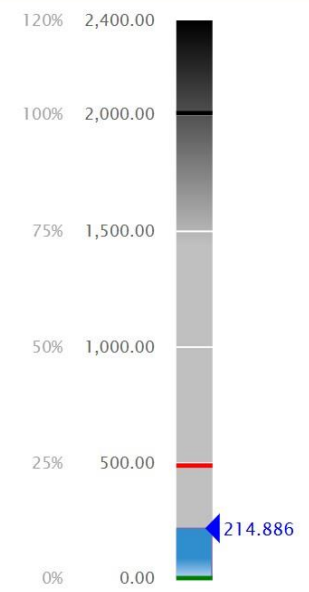


Ia(A)



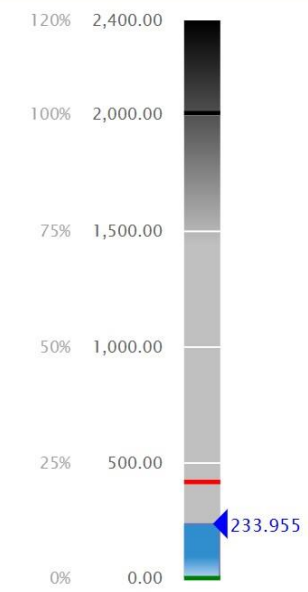
I Nom.	2,000.000 A
I Max.	391.101 A
I Min.	0.000 A
Available	1,740.581 A (87%)

Ib(A)



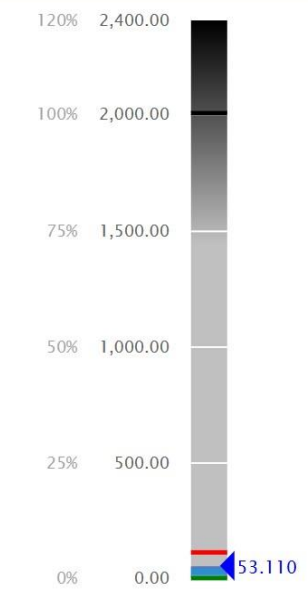
I Nom.	2,000.000 A
I Max.	485.245 A
I Min.	0.000 A
Available	1,785.114 A (89%)

Ic(A)



I Nom.	2,000.000 A
I Max.	414.402 A
I Min.	0.000 A
Available	1,766.045 A (88%)

IN(A)



I Nom.	2,000.000 A
I Max.	110.761 A
I Min.	0.000 A
Available	1,946.890 A (97%)



Organization

Time Period

Remark

On Current Year

From 2026-01-01 00:00

To 2026-06-11 08:23

☒ Auto Mode

Per Month

Validate



Consumptions

Consumptions



Analyse



Index



Per Tariff

Electricity / Supply Capacity Control Device

2026/06/11 08:23:49

Monthly Consumption : Electricity



Ea+ Ea- Er+ Er- Es

Legend

— Avg

▲ Min.

▲ Max.

Selected Period

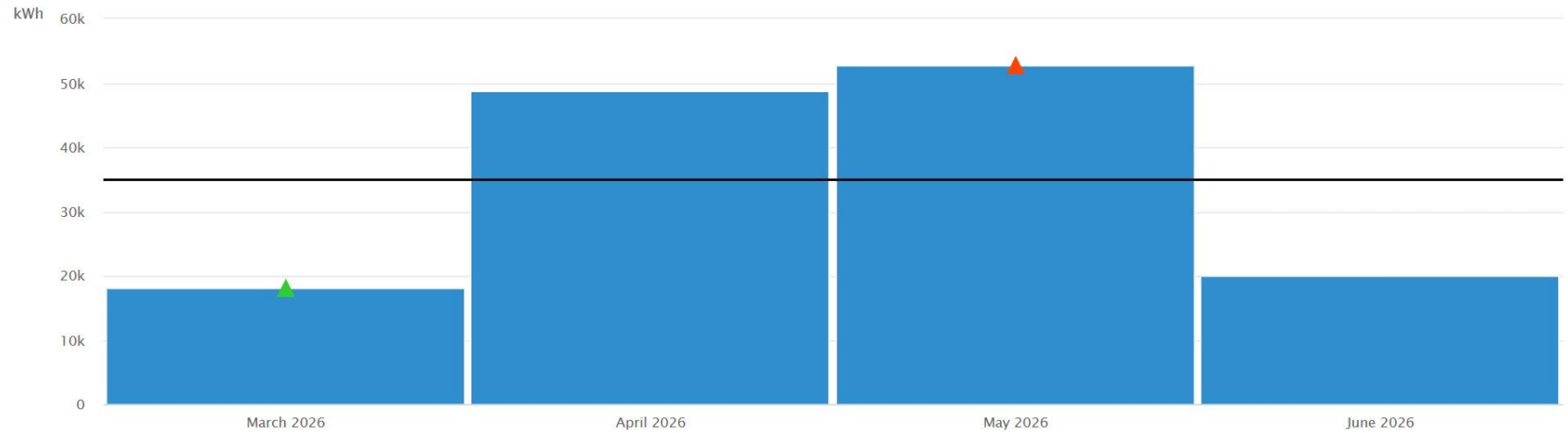
From 2026/01/01
00:00:00

To 2026/06/11 08:23:34

Total Consumption

Total over the period
139,709.15 kWh

Average per month
34,927.288 kWh



● Supply Capacity Control Device

 Organization

 Time Period

Remark

On

Custom

From

2026-06-10 00:00

To

2026-06-10 23:59

Auto Mode

Per

Hour

Validate

 Consumptions

Distribution

 Per load

 Per Usage

 Per Tariff

Mechanical Services/+ Mechanical Services

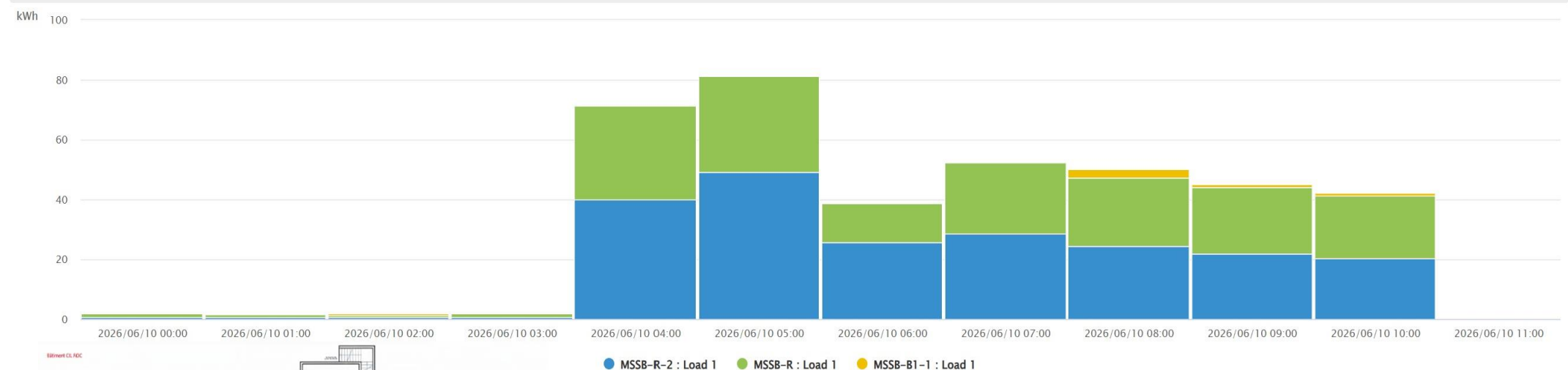
2026/06/11 08:37:09

Hourly Consumption per load : Electricity

Ea+ Ea- Er+ Er- Es

Selected Period		Total Consumption		
From	To	Total over the period	Average per load	Average per hour
2026/06/10 00:00:00	2026/06/10 11:59:00	389.965 kWh	129.988 kWh	32.497 kWh

[Download](#) [Print](#) [View in full screen](#)





Organization

View

Hierarchy

Filters

Navigation

Hierarchies > BuildingTotal

+ BuildingTotal 6

Time Period



Consumptions

Distribution



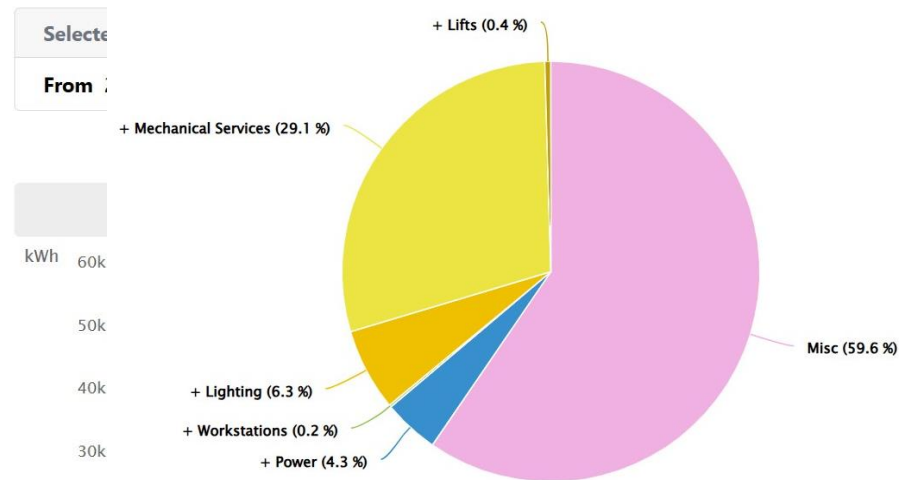
BuildingTotal/+ BuildingTotal

2026/06/11 08:25:25

Monthly Consumption per load : Electricity



Ea+ Ea- Er+ Er- Es



Total Consumption

Total over the period	Average per load	Average per month
139,709.15 kWh	7,353.113 kWh	23,284.858 kWh

Activate / Deactivate Detailed View

Download Print View in full screen

- DB-TEST-ROOM Power
- 53 - Workstations
- DB-L1-T1 Lighting
- MSSB-B1-1 : Load 1
- DB-L1-H1 Power
- 51 Workstations (Standing Desks)
- DB-L2-H1 Lighting
- Lift 1
- DB-L1-T1 Power
- 49 - Workstations
- DB-L1-T2 Lighting
- Lift 2
- DB-L1-T2 Power
- 48 MR_QR Room 105 106 107
- MSSB-R-2 : Load 1
- Misc
- DB-L2-H1 Power
- DB-L1-H1 Lighting
- MSSB-R : Load 1



Monitor

Network Analysis

Load Analysis

Summary

Quality

Summary

U / I

Power

Energy

Quality

Electricity / Supply Capacity Control Device

2026/06/11 08:17:54

THD

K-Factor

Crest Factor

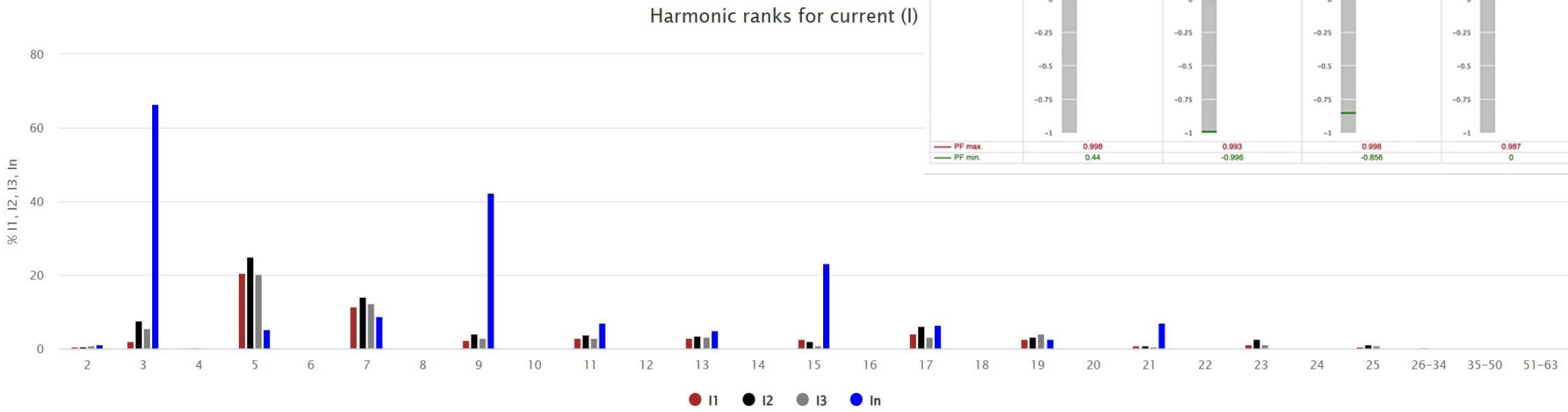
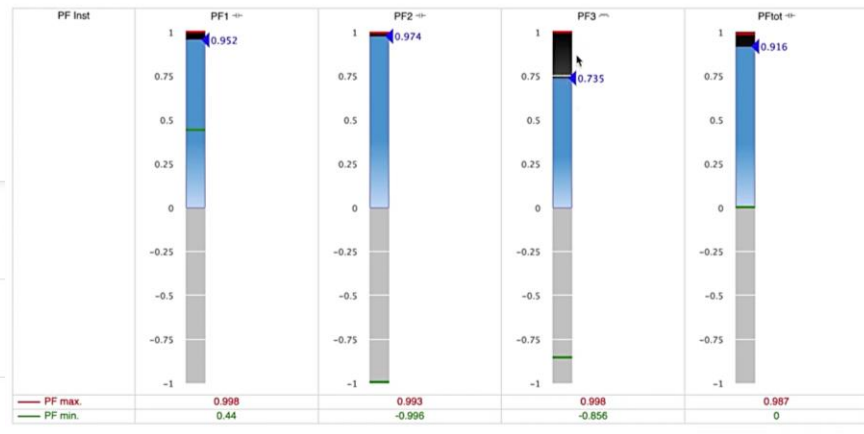
Reset Min/Max

THDi				
	THD Ia %	THD Ib %	THD Ic %	THD In %
Inst	25.020	31.650	25.600	83.800
Max	150.000 2026/02/15 15:40:48	150.000 2026/06/06 13:36:40	150.000 2026/02/14 14:58:01	150.000 2026/06/11 07:58:03
Min	0.000 2025/12/12 10:04:51	0.000 2025/12/18 06:35:46	0.000 2025/12/18 06:35:52	0.000 2025/12/18 06:35:49

THDu			
	THD Uab %	THD Ubc %	THD Uca %
Inst	1.670	1.550	1.590

Power factor monitoring

THDv			
	THD Va %	THD Vb %	THD Vc %
Inst	1.800	1.800	1.750



Organization

Supply Capacity Control Device

Measure

Current3

Avg. Ia☒

Avg. Ib☒

Avg. Ic☒

Voltage0

Avg. Va☐

Avg. Vb☐

Avg. Vc☐

Time Period

Favorites



Configuration

Rendering options

Rendering mode

Scale auto adjust

Display data table

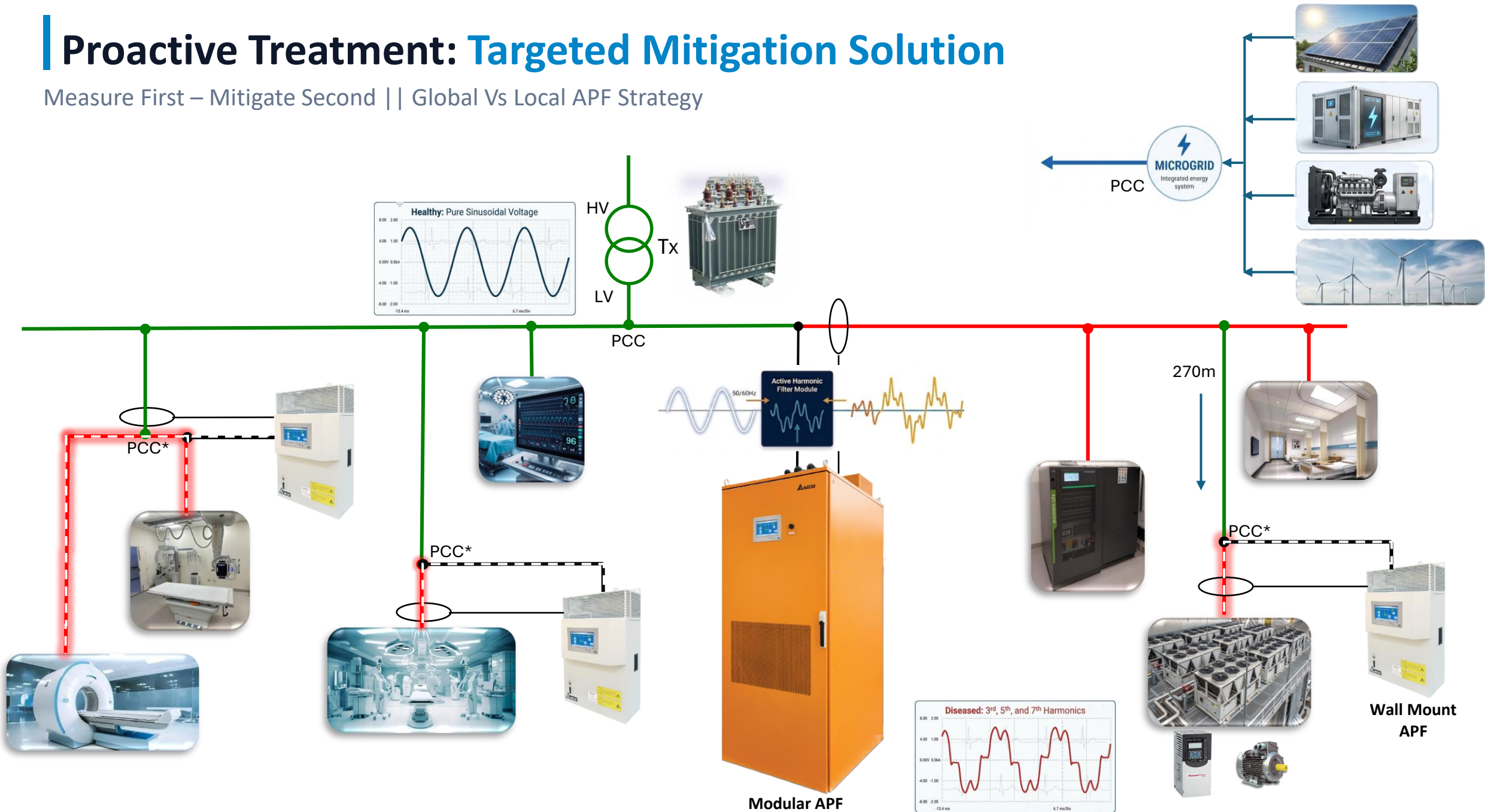
Supply Capacity Control Device : Avg. Ia

Supply Capacity Control Device : Avg. Ib

Supply Capacity Control Device : Avg. Ic

Proactive Treatment: Targeted Mitigation Solution

Measure First – Mitigate Second || Global Vs Local APF Strategy



Action Plan: Implementing the Health Check

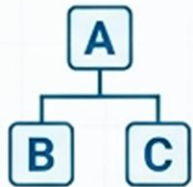
A structured, three-step path to infrastructure resilience

NHP

1 Assess & Segment

Conduct a gap analysis of current capacity.

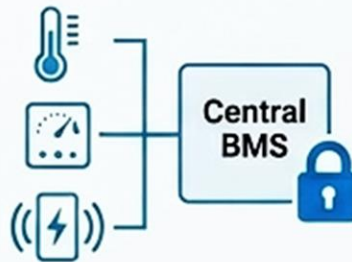
Identify Group A (Safety), Group B (Critical Clinical), and Group C (General) networks.



2 Deploy Distributed Sensors

Retrofit modular sub-metering at key vulnerability nodes and AS/NZS 3003 patient areas.

Integrate securely with the central BMS.



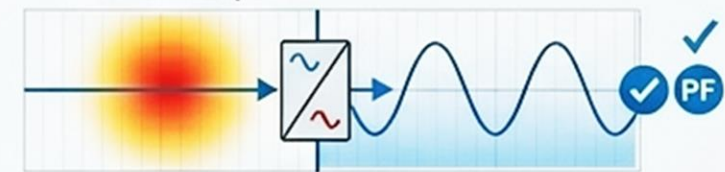
3 Optimize & Mitigate

Utilize 30-60 days of logged data to identify harmonic hotspots.

Deploy targeted active filtering and correct power factors to eliminate utility penalties.



Thermal hotspot



NHP

Schedule a Facility Infrastructure Audit
→ NHP Electrical Engineering Products



“The best electrical fault in a hospital is the one prevented before it impacts patients or operations”

Compliance – Regulatory obligations and uphold facility reputation.

Resilience – Prevent cancelled procedures, reduced downtime, data loss.

Efficiency – Reduce energy consumption, lower emissions.

Safety – Uninterrupted operation of critical medical equipment.

Trust + Confidence – Reliable, resilient, and future-ready healthcare.

NHP

Thank you



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NHP