Power Quality Audit

Approach & Methodology

Poovar Island Resorts, Trivandrum

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FICCI International Copper Promotion Council India Copper Alliance unicorn mission critical facilities apqi ASIA POWER QUALITY INITIATIVE

Introduction to Unicorn MCF

Assessment Services

Power Quality Audits, Thermal Assessments, Datacenter Assessments

Consultancy, Design & Engineering

of Mission Critical Facilities

Implementation,

Power Quality Solutions, Mission Critical Facility Project Management

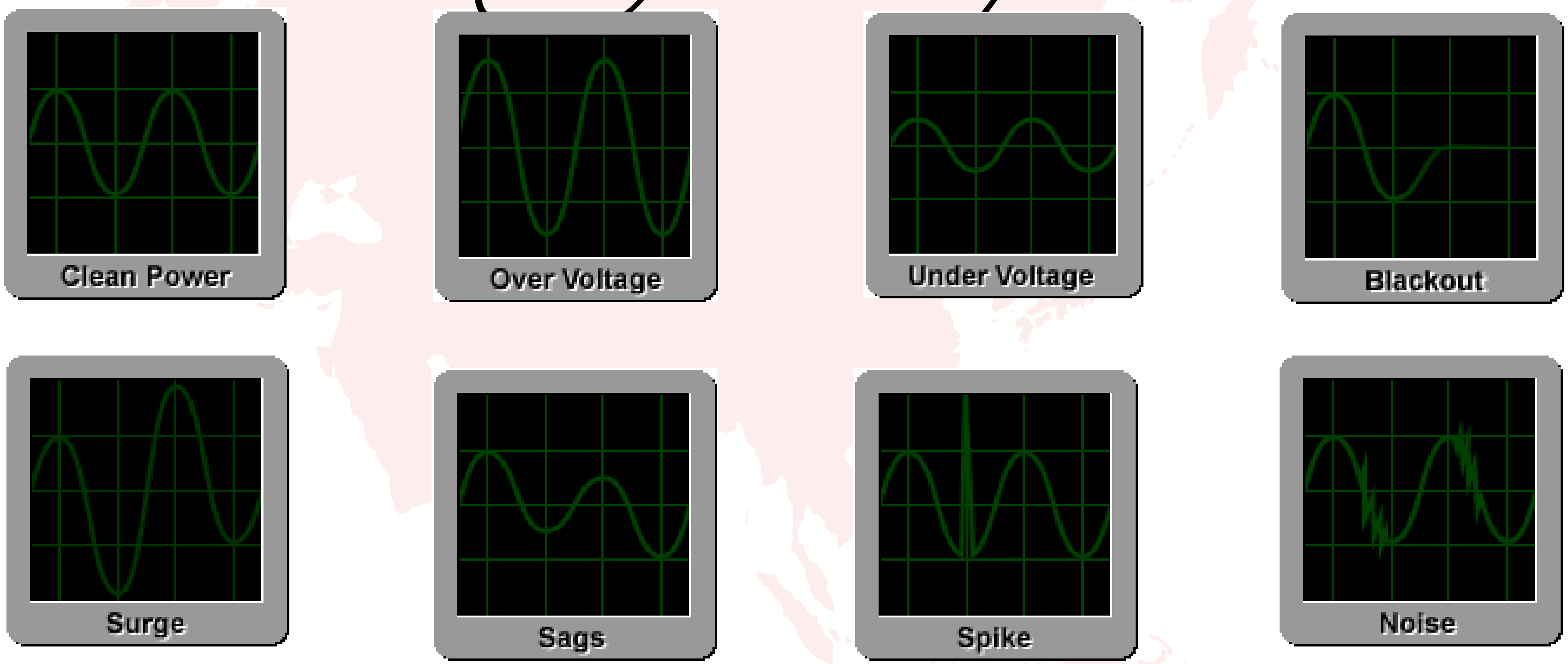
Outline

Power Quality Problems that can impact your operation

- *The Economics of power quality problems*
- *Power Quality Audit Stages*
- *PQ Standards*
- *PQ measuring instruments*
- *Power Quality Audits Do's & Don'ts*
- *Power Quality Audit Case Study*
- *Conclusions*

Power Quality Problems

"Any occurrence manifested in Voltage, Current or Frequency deviation, that results in failure or malfunctioning of the equipment (load) in a facility."



POWER PROBLEMS
are the largest cause of Production / data loss?

ASIA POWER QUALITY INITIATIVE

Causes	%
Power aberrations	45.30
Fire or Explosion	9.40
Hardware or Software Error	8.20
Flood & Water Damage	6.70
Earthquake	5.50
Network Outage	4.50
Human Error or Sabotage	3.20
HVAC Failure	2.30
Others	6.70

Solution ?

POWER QUALITY & RELIABILITY

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TRADITIONAL GOAL

- No Sustained Interruptions

GOALS WITH “PQ“ ASPECT ADDED

- No Sustiained interruptions
- No over voltages & under voltages
- No sags & swells or small interruptions
- No impulsive or oscillatory transients
- No steady state problems like harmonics, unbalance, notching, flicker e.t.c.
- No interference –Noise- EMI & RFI

FICCI

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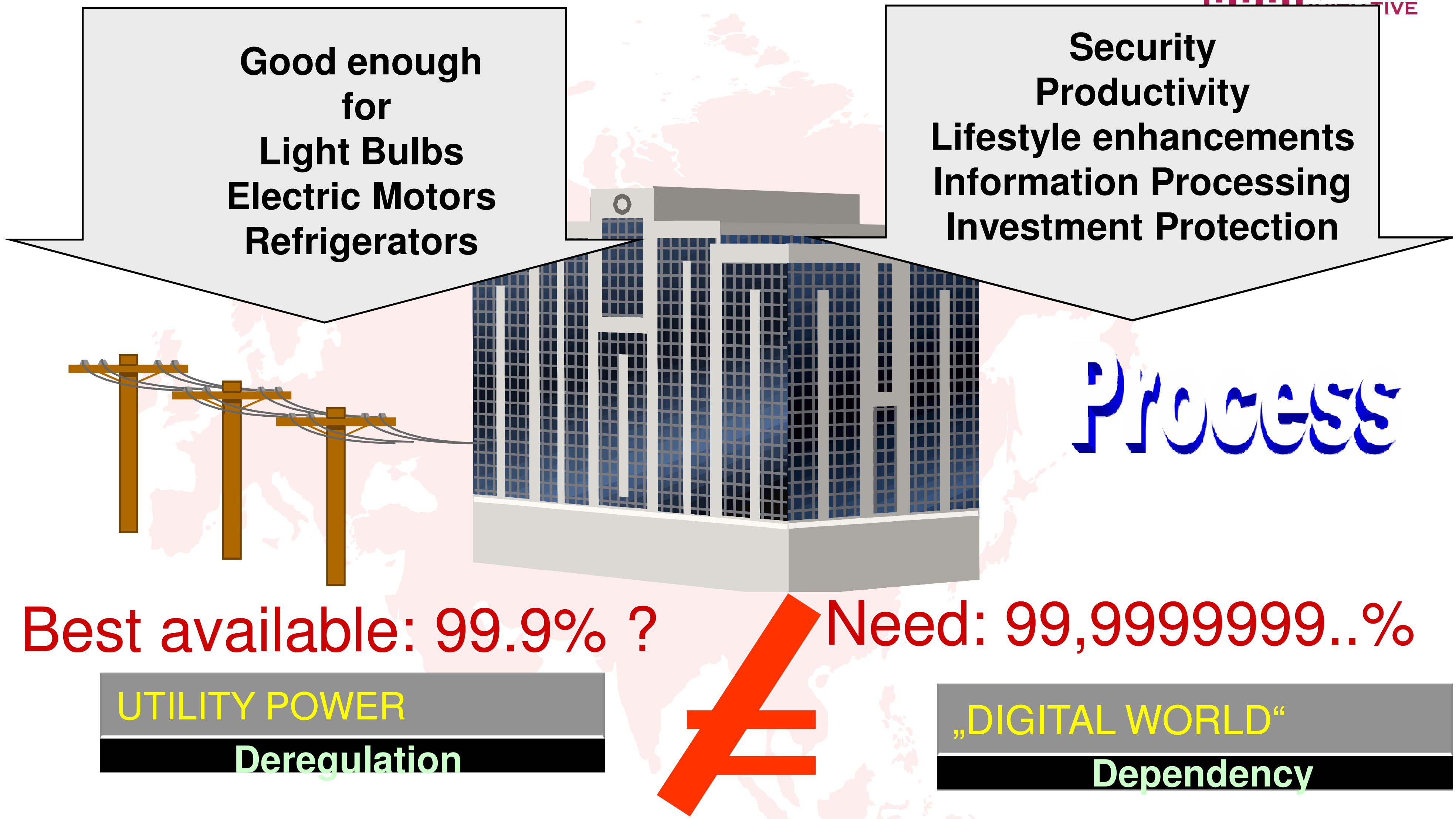
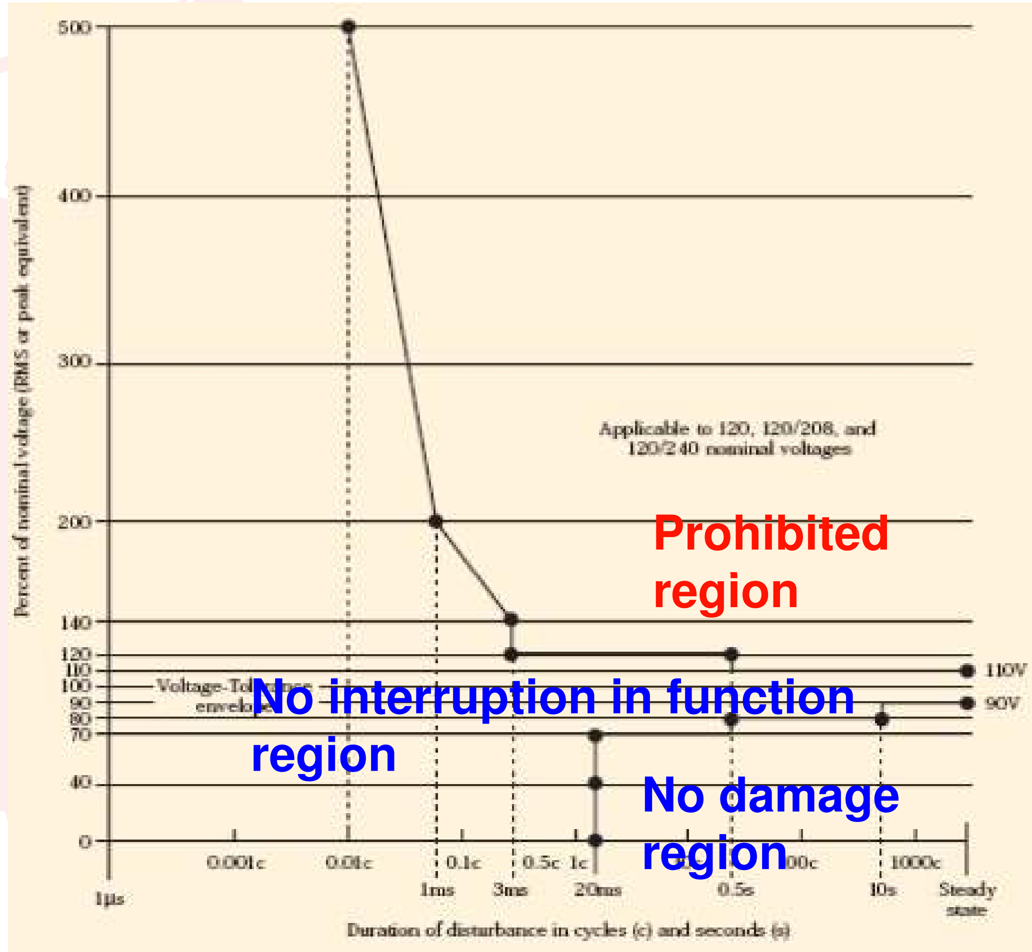
Power Consuming Economy



Quality power supply ?

A voltage vs. time envelope developed by the CBEMA (now ITIC); this curve specifies the maximum voltage deviations that a computer power supplies should be able to ride through or withstand a function of that deviation's duration.



Technologies to Improve Reliability –

Performing a Facility Power Quality Audit

Power Quality Audit

Helping you identify and address power quality and reliability concerns before they impact your facility's performance and bottom line

Power Quality Audit

Objective

In conducting an audit, the power quality auditor must find answers to four questions:

1. **Is the facility's wiring and grounding as per electricity code? and is it adequate ?**
2. **What is the quality of the ac voltage supplying the equipment?**
3. **What is the impact of the electric utility's power system?**
4. **What solutions are indicated by the audit data?**

This last question is, of course, the most important. The best outcome of any power quality audit is

Whether the problem was solved ?

The Cost of PQ Problems

- Factors affecting the costs
- Typical costs as a function of industry
- Options for improving performance
- Evaluating the economics of power conditioning
- Understanding power quality variations and the impacts on your equipment

Factors affecting PQ Costs

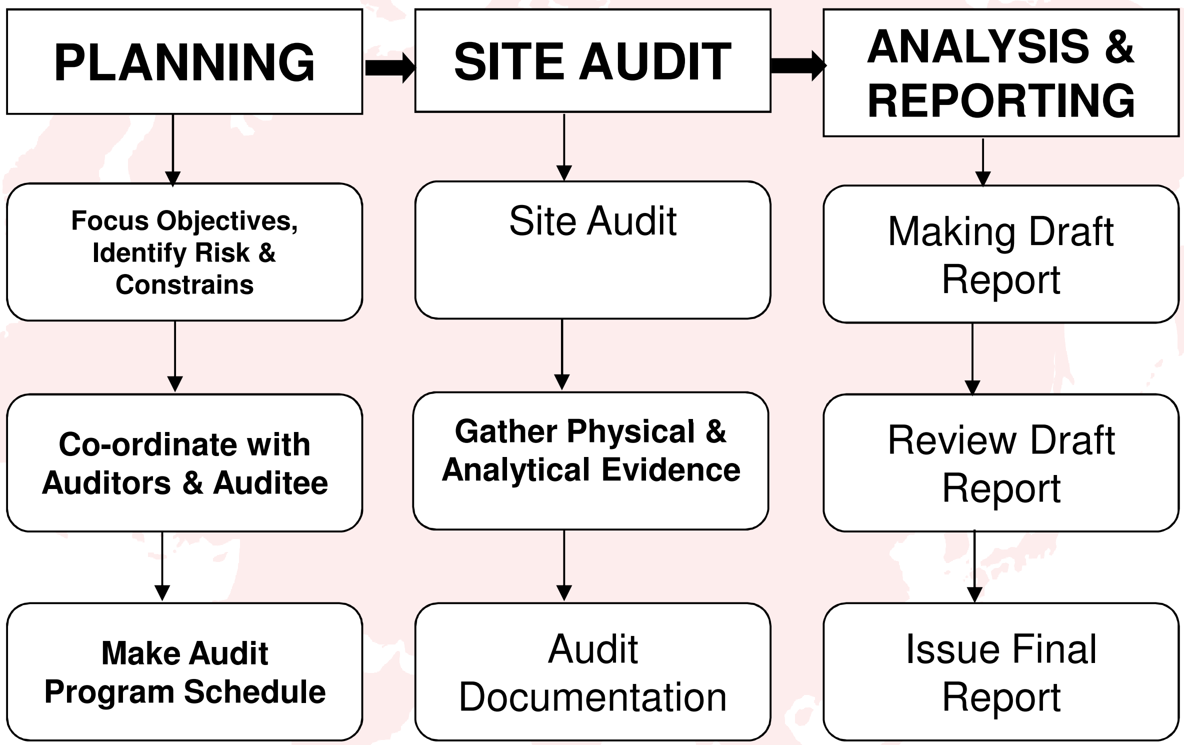
- Losses due to aberrations
- Lost production / Scrap
- Costs to restart
- Labour costs
- Equipment damage and repair
- Other costs

Power Quality Audit
……focus

Power quality investigations focus on the cost impact of power problems. These can include

- Facility or equipment downtime
- Identifies the scope of enhancing maximum reliability
- Process or equipment restart
- Repair or replacement of damaged devices and equipment
- Operating at less than optimal efficiency
- Increased utility demand charges

Power Quality Audit
Systematic Methodology

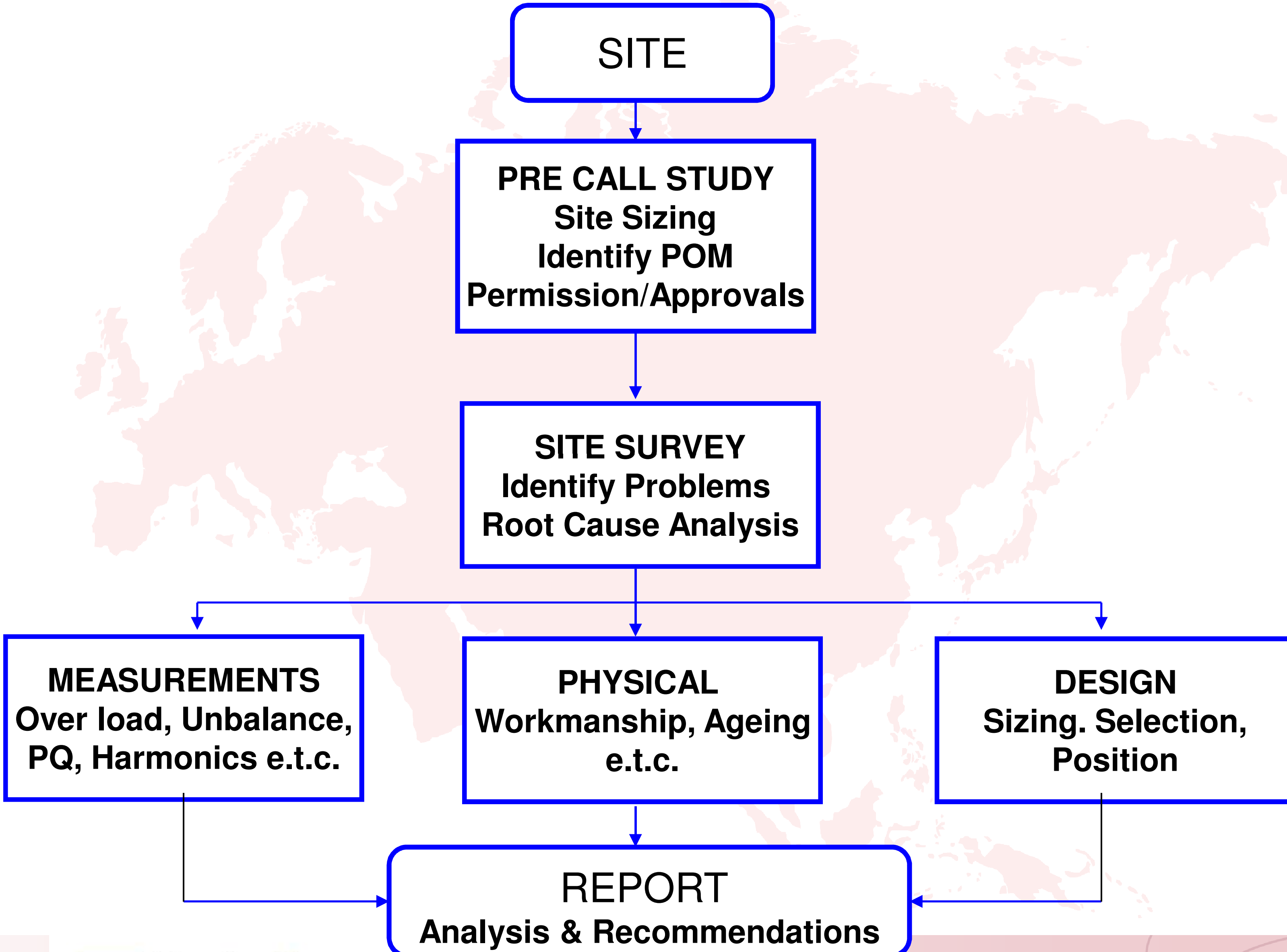


Audit Stages

- Pre Call Audit
- Site Survey & Measurements
- Analysis & Solution Formation
- Reports & Presentation

Mode of Operation

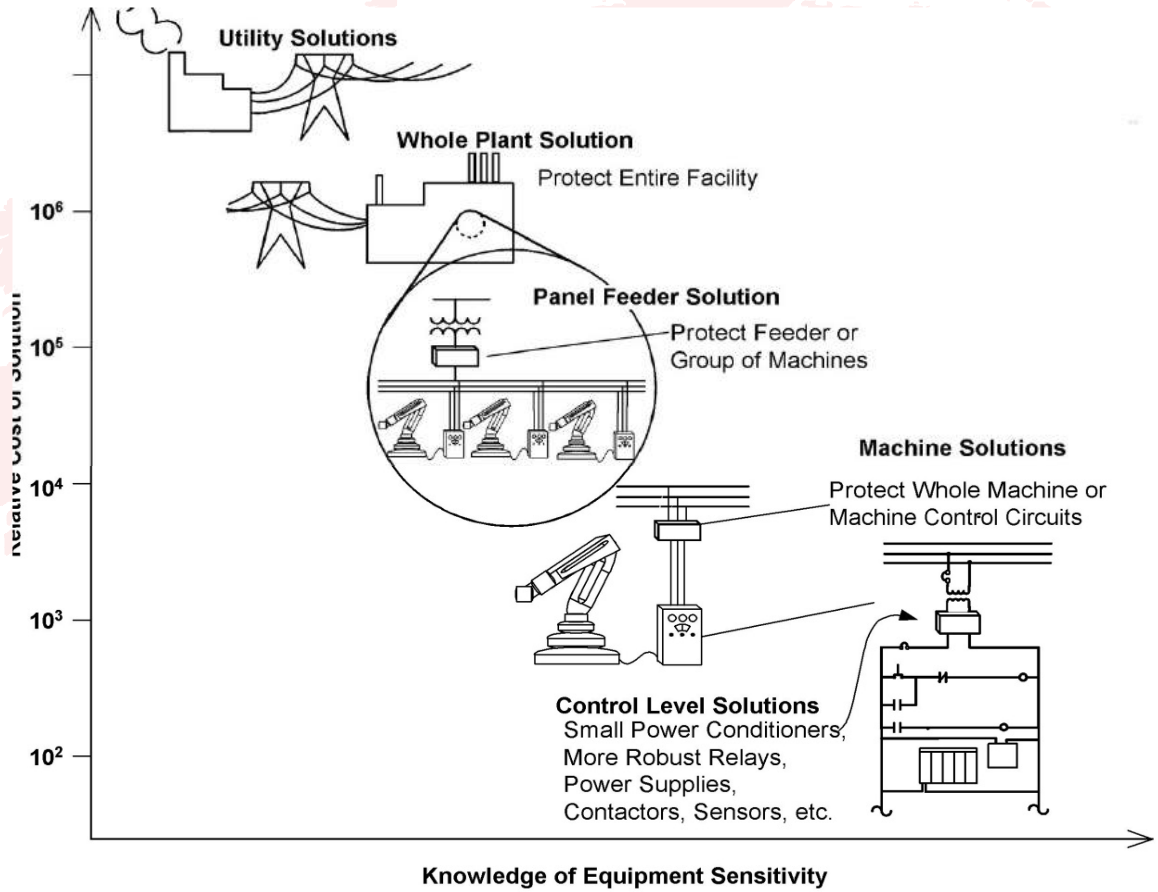
ASIA POWER QUALITY INITIATIVE



Pre Call Audit

- Pre Call Audit on all Blocks from PCC point to User side
- Study of Electrical layouts & schematics
- Identifying of ‘Point of Measurements’
- Study of Domain process & schedules
- Preparation of line schematic for measurement Audit

Points of measurements



Site Survey & Measurements

- Panels, Metering, Cables, Switch gears, Protections & distribution checkups
- Compliance checkup as per Statutory
- Identifying 'Bottle necks'
- Measurements – Snaps, Trend records, Graphs, Data, Events, Alarms
- Test & Analysis as per standards

Analysis & Solution

- Quandary data analysis
- Detailed Analysis of Trends, records, alarms and Snaps
- PQ & Reliability measurements
- PQ Aberrations forecast
- Cost analysis of PQ problems
- Solution formation in options

Report & Presentation

- Records,
- Observations
- Cause Analysis
- Evaluations & Comparisons
- Report on Regulatory Adherence
- Recommendations.

Codes & Standards

Power Quality

Grounding	IEEE Std 446, IEEE Std 141, IEEE Std 142, IEEE Std 1100, ANSI/NFPA 70
Powering	ANSI C84.1, IEEE Std 141, IEEE Std 446, IEEE Std 1100, IEEE Std 1250
Surge Protection	IEEE C62 Series, IEEE Std 141, IEEE Std 142, NFPA 78, L 1449
Harmonics	IEEE Std C57.110, IEEE Std 519, IEEE P519a, IEEE Std 929, IEEE Std 1001
Disturbances	ANSI C62.41, IEEE Std 1100, IEEE Std 1159, IEEE Std 1250
Life/Fire Safety	FIPS PUB94, ANSI/NFPA 70, NFPA 75, UL 1478, UL 1950
Mitigation Eqpt.	IEEE Std 446, IEEE Std 1035, IEEE Std 1100, IEEE Std 1250, NEMA-UPS
Telecom Eqpt.	FIPS PUB94, IEEE Std 487, IEEE Std 1100
Noise Control	FIPS PUB94, IEEE Std 518, IEEE Std 1050
Utility Interface	IEEE Std 446, IEEE Std 929, IEEE Std 1001, IEEE Std 1035
Monitoring	IEEE Std 1100, IEEE Std 1159
Load Immunity	IEEE Std 141, IEEE Std 446, IEEE Std 1100, IEEE Std 1159, IEEE P1346
System Reliability	IEEE Std 493

Codes & Standards
Harmonics

IEEE 519 Standard Limits

HARMONIC CURRENT DISTORTION LIMITS IN % OF I_L

$V \leq 69$ kV

I_{SC}/I_L	$h \leq 11$	$11 \leq h < 17$	$17 \leq h < 23$	$23 \leq h < 35$	$35 \leq h$	TDD
<20	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

Codes & Standards

Harmonics

IEEE 519 Standard Limits (Utility)

HARMONIC VOLTAGE DISTORTION LIMITS
(in % of Nominal Fundamental Frequency Voltage)

Bus Voltage at PCC	Individual Harmonic Voltage Distortion	Total Voltage Harmonic Distortion (THD_V)
$V \leq 69$ kV	3.0	5.0
69 kV $< V \leq$ 161 kV	1.5	2.5
$V >$ 161 kV	1.0	1.5

Parameters in standard EN 50160

- *Supply voltage*
- *Nominal voltage of the system*
- *Declared supply voltage*
- *Normal operating conditions*
- *Voltage variation*
- *Flicker – Flicker severity – Short & Long term severity*
- *Supply voltage dip*
- *Supply interruption –prearranged & accidental,* (*long interruption & short interruption*)
- *Temporary power frequency over voltages*
- *Transient over voltages*.
- Harmonic voltages

…EN 50160…

Voltage Characteristics of Public Distribution Systems

Voltage

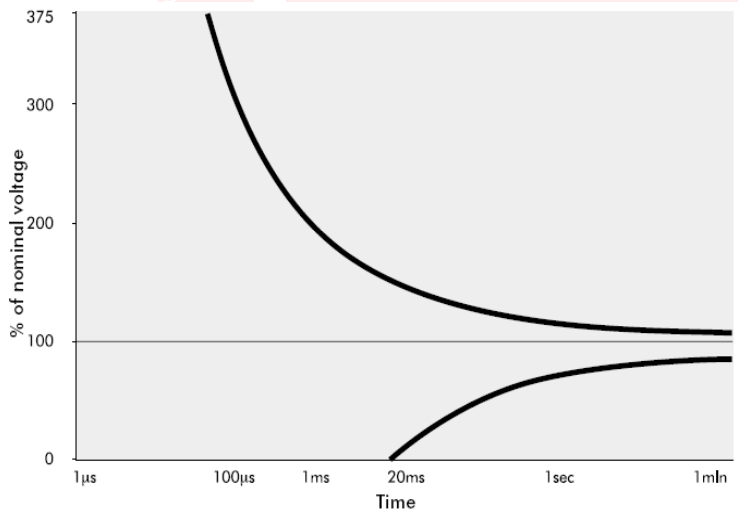


Figure 2 - CBEMA curve

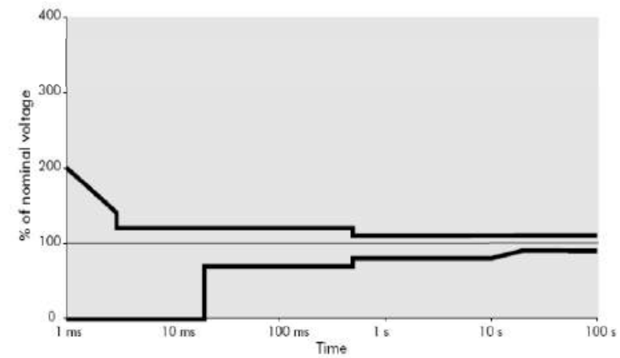


Figure 3 - ITIC curve

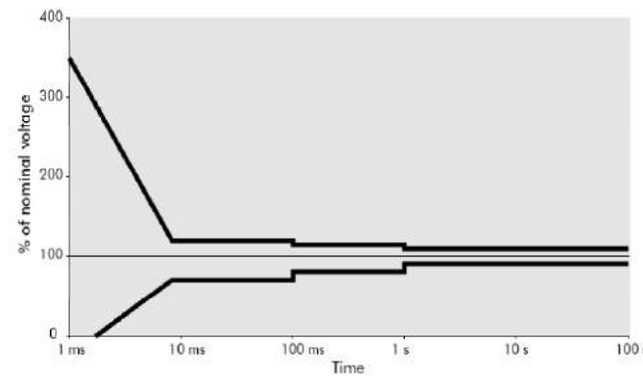


Figure 4 - ANSI curve

Power Quality Audit

Instruments

Three Phase PQ Analyzer
Single Phase Power Quality Analyzer
Voltage - Frequency Loggers
Energy Analyzer
Earth Testers & Insulation Testers
Wiring / Distribution & Conductor Impedance Analyzer
Cable Locators
Magnetic Field Meter & Static Charge Meter
Digital Tacho-meter
True RMS Digital Clamp-on Meter & Multimeter
Infrared Thermal imagers
Infrared Thermo meters
Power Log event view software,
PQ Analysis Software
and so on

Power Quality Audit
Do's & Don'ts

Do

- Let the customer know that most operating problems can be solved.
- Use language (written and spoken) that the customer can understand.
- Get help from power-quality experts when you encounter unfamiliar problems.
- Review your recommendations with others whenever possible.
- Follow-up. Be sure problems are resolved to the customer's satisfaction.
- Provide the customer with the specific action steps required to solve their power-quality problems.

Power Quality Audit

Do’s & Don’ts

Don’t

- Don't ever blame the customer. Even though most problems are caused within the customer's facility the audit process should focus on diagnosis and resolution rather than fault.
- Don't tell (or even hint) that the utility will re-build or re-structure any of the utility's electric feeds to the customer's facilities to resolve problems unless you are absolutely certain that this will take place. Be sure utility work will be completed in a time-frame acceptable to the customer.
- Don't solve a Rs. 1 X problem with a Rs.10 X solution.
- Don't overload the customer with everything you know about power quality and power protection equipments.
- Don't tell the customer to look in the Yellow Pages to find help. Remember, most customers know far less about this subject than you.

Power Quality Audit

Case Study

Site: Process Control Lab of a Space Research organization

Power Problem: Frequent UPS Systems failure (2 to 3) occurred especially at their Sections, Carbon Building and Impregnation plant.

Site Visit:

Frequent UPS Systems failure which is only with lower ratings up to 6 kVA and limited Online UPS.

Failures are at UPS output sections even in no load situations

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Case Study cont:

Measurements: High level of Transients (Notches) monitored between Phase to Neutral and Neutral to Ground or the Sockets provided for Portable UPS systems of the selected areas. Notches level is of 1000 events per 30 minutes which is very high in ON load and comparatively less in NO load situations.

Power Quality Audit

Case Study cont:

Observations:

- Electrical distribution system of the Facility is catering power to significant number of Non linear switching loads operation with Tyristors.
- High level of Notches monitored between Phase to Neutral and Neutral to Ground or the Sockets provided for Portable UPS systems of the selected areas.
- Notches level is of 1000 events per 30 minutes which is very high in ON load and comparatively less in NO load situations.
- Here the Notches observed are of low values (amplitude) but frequently occurring.
- These repetitive voltage transients are referred to as Voltage notches. This maximum amplitude of the transient could produce damage, and the voltage notches that cross the zero could result in zero crossing errors.

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Case Study cont:

Root Cause:

- System configuration of the these UPS systems are of True online double conversion light duty UPS with PFC correction at the front end. UPS configured of 'through neutral' without isolation for input and output.
- These UPS are normally incorporated with comparatively low energy built-in surge suppression may protect the UPS and its connected load from a limited number of hits, but it should not be relied upon as a complete transient solution
- Frequent notches observed with a deviation of maximum 100 Volts occurring around 10 hits per waveform, disturbing the PFC & Rectifier (and power supply) unit of UPS systems. The result is the frequent variation of DC bus of ups system. These type of DC transient voltages in 700 Volt DC bus results in IGBT Short circuit of inverter section, which is directly linked with the DC bus. Subsequent failures occurring in reverse mode up to rectifier section when DC bus get short circuited.

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Case Study cont:

Mitigation Method:

- As per the IEEE 1100 stated is section 9.11 recommending a networked Transient Voltage Surge Suppression device and UPS TVSS protection is required.
- The IEEE Standard 1100-1992 states the networked TVSS protection is needed, and UPS TVSS protection as follows:
- *UPS surge protection Section 9.11.3 UPS surge protection: "Lightning and other transient voltage producing phenomena are harmful to most UPS equipment and to sensitive electronic load equipment (e.g. via an unprotected static-switch bypass around the UPS). Therefore, it is recommended practice that both the rectifier-charger input circuit to the UPS and the associated UPS bypass circuits (including the manual maintenance bypass circuit) be equipped with effective Category B TVSS protection as specified in IEEE Std. C62.41-1991…"*

Power Quality Audit

Conclusions

- Power quality problems can be very expensive for IT & industrial facilities
- The problems are best addressed at the design stage when equipment specifications and facility design can take power quality issues in to consideration
- Monitoring can identify problems before they cause equipment failures
- The economics of power quality solutions will depend on many factors

– Size of loads requiring protection
– Load characteristics (e.g. inrush, power factor)
– Equipment sensitivity to PQ variations
– Characteristics of the supply system
– Facility layout

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Thank you

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