Interactive Workshop
Harmonics and Power Quality

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Power Quality – Standards & Regulations in de-regulated environment

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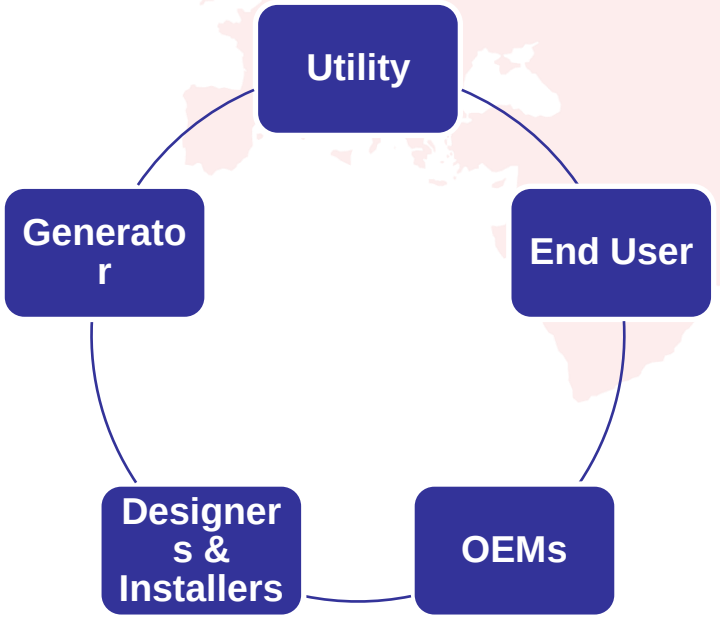
Roadmap

- PQ in Indian context
- Financial impact of Poor PQ – Indian Ignorance
- PQ Priority of Implementing agencies
- Policy in vogue, Legal Provisions in place
- Asia Power Quality Initiative (APQI)
- Way Forward Action Plans

Power Quality

Productive factor	Customer Expectation	Utility KPI Expectation
• Availability • Quality of Supply (QoS) • Low cost	• Reliability • Quick restoration • Timely information	• Electrification, • Profit Maximization • Least Cost Power and • Least Outages

What is meant by Quality?
Who is responsible for Quality?



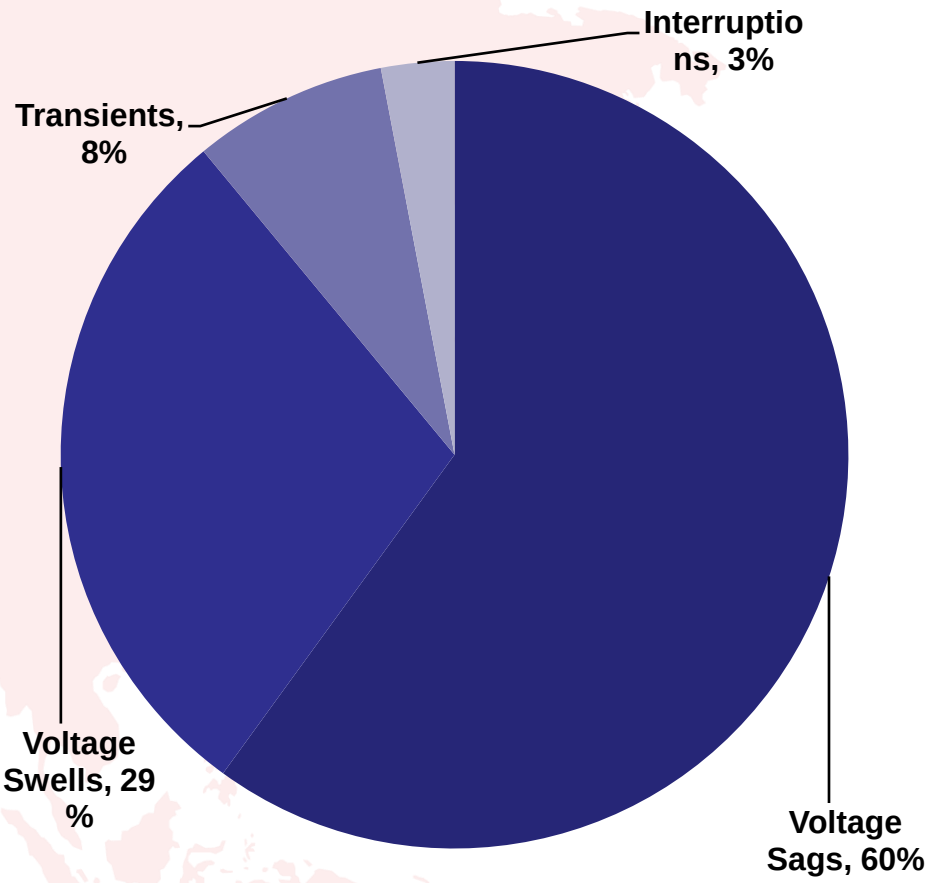
Poor PQ

- Improper or Costly Operation
- Failure of equipment or power supply
- Safety issues

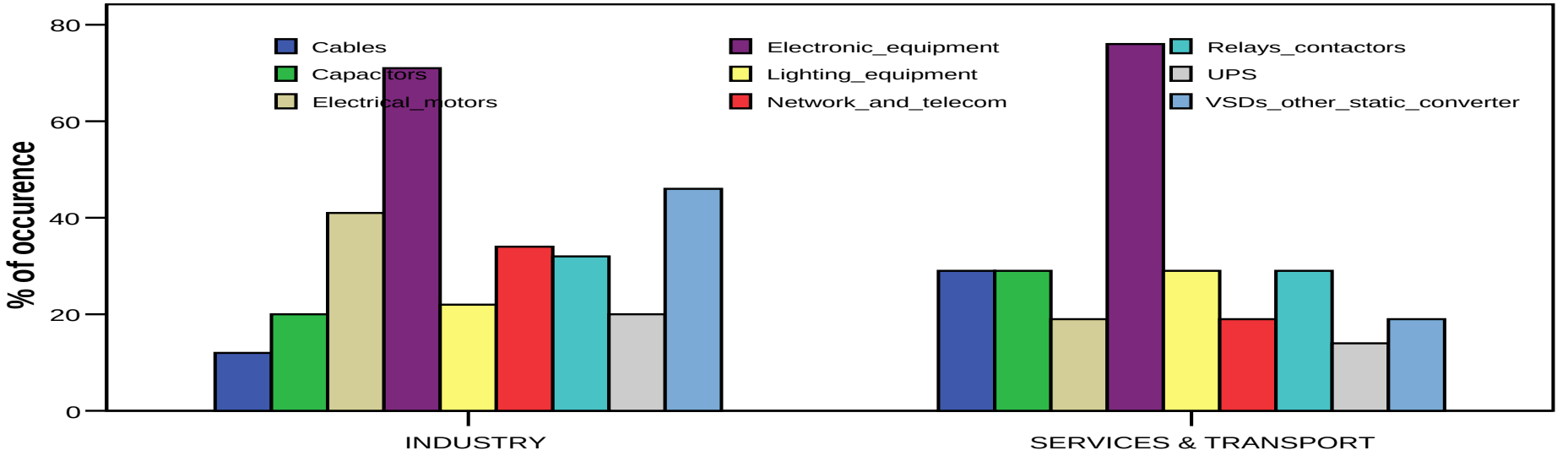
Power Quality and Financial Losses

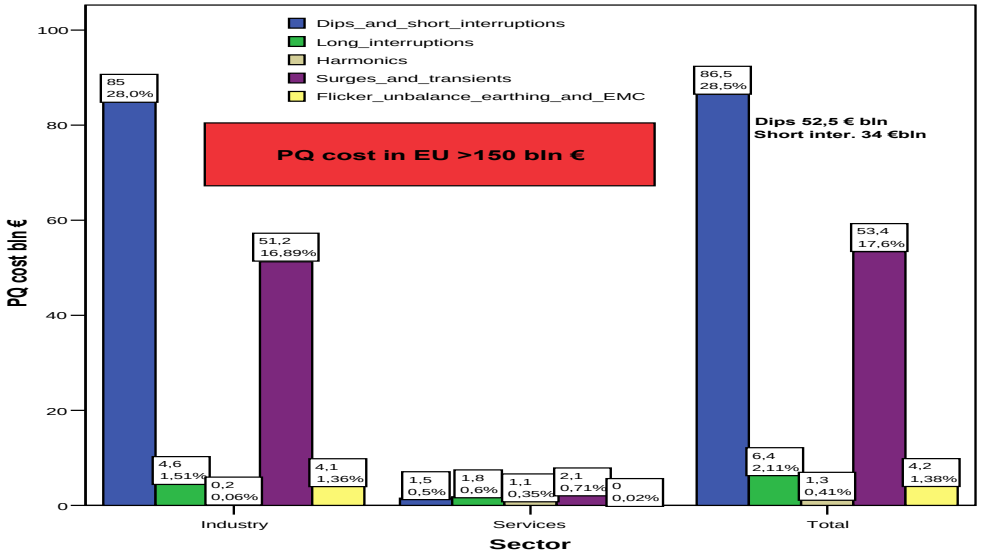
- Power quality is a financial problem – not a technical problem alone.
  - PQ causes $120B/year in economic loss in the US (EPRI, DOE).
  - EU looses €150 Billion every year (LPQI Survey)
- Economic Impact of Poor Power Quality in India
  - Outages a Major Cost:
  - Directly measurable – DG Sets, Inverters /Battery
  - (Wartsila Study) 100,000 Cr investment plus annual opex 30,000 Cr
  - Indirect Cost (Disruption, Opportunity Lost etc) –not easy to measure
  - Some estimate - 6% of GDP.

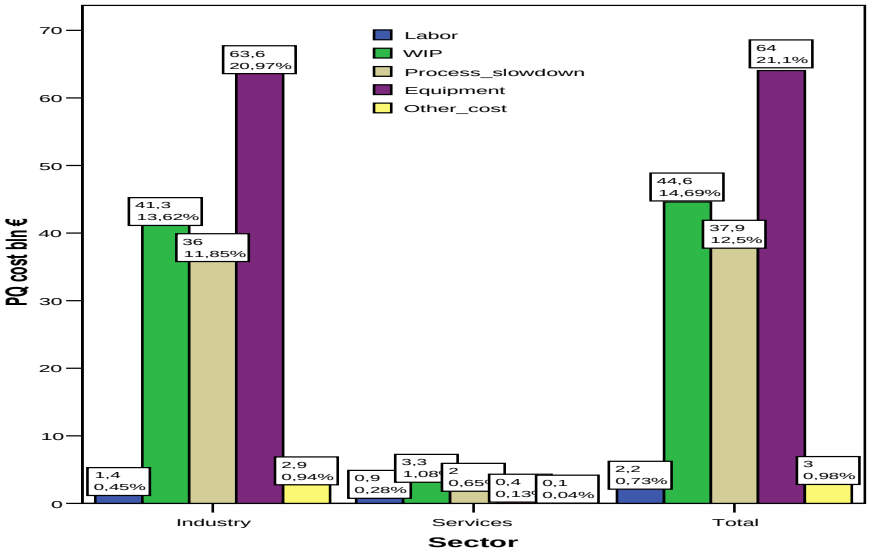
Types of PQ Issues Faced



Equipment affected n Cost afflicted







Utilities key focus areas

Reliability of supply

- Major concern for Indian electrical power system is to maintain reliable power supply
- The end customer has become more demanding and conscious about interruption free supply
- High DT failure rate - which forms a critical piece of the distribution network reduces quality and reliability of supplied power

AT&C Loss

- Public distribution companies are facing huge burden of losses (Rs. 2.4 lakhs cr. (Rs. 2400 billion)) and high average AT&C losses (28%)
- Distribution companies are exploring and investing in all areas including network improvement, IT to meet their loss reduction targets (See - state-wise AT&C loss)

Energy Efficiency

- Energy Efficiency emerged as a key policy priority in India's energy sector since Energy Conservation Act, 2001
- The EE market in India has an investment potential of USD $10 billion and that improving EE could save up to 184 billion KWh of generated electricity
- Poor EE also affects the environment and the profitability of the utility consequently Indian economy

Interrelation of utilities key focus areas with Power Quality

Causal Loop Diagram (CLD)
Demystifying relationships between PQ and the strategic initiatives of (1) reliability of supply (2) loss reduction and (3) energy efficiency

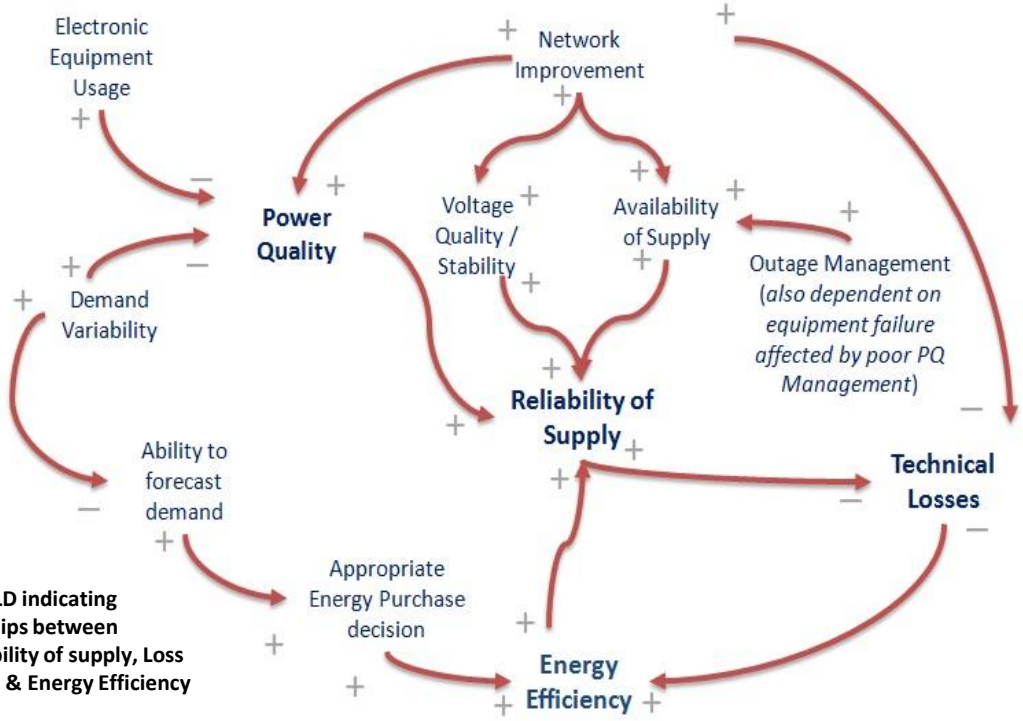


Figure - CLD indicating relationships between PQ, Reliability of supply, Loss Reduction & Energy Efficiency

Focuses on the technical aspects and excludes the commercials aspects including, Metering, Billing and Collection (MBC) efficiencies and Commercial Losses (including Theft), etc. / APQI pManifold Analysis, 2014

- It can be seen from diagram that investing in 'Network Improvement' improves power quality, reliability of supply which in turn will reduce technical losses and improve Energy Efficiency.
- PQ can be key differentiator for tomorrow's utility business models that is fast changing and it is no more about 24X7 supply alone

Key PQ issues in electrical network and its measures for improving performance – 1/2

- **The growing use of electronic loads in networks – means increased concerns about P Q.**
- **Some of the PQ disturbances in network are caused due to following key three factors:**

Natural Causes

- Faults or lightning strikes on transmission lines or distribution feeders
- Falling of trees or branches on feeders during stormy weather conditions

Transmission

- Transformer energization or feeder capacitor switching
- Equipment failure because of poor O&M

Non-linear loads on consumer side

- Power electronic loads (UPS, Adjustable Speed Drives (ASD), converters, etc.), arc furnaces and induction heating systems
- Switching on or off of large loads, etc.

See - Some of the physical manifestations of PQ issues on the electrical network systems

Measures by utility operators to improve electrical network system -2/2

- **Flexible AC Transmission System (FACTS)** devices increase the ability of transmission capacity of lines, and help control power flow over designated transmission, electronically and statically

- **Distribution Static Compensator (D-STATCOM)** is used for voltage regulation, compensation of reactive power, correction of power factor and elimination of current harmonics

- **On-Load Tap Changer (OLTC)** transformers are used between multiple voltage levels to regulate and maintain the voltage, which is supplied to customers. The OLTC transformer equipped with automatic voltage control (AVC) is the most popular and effective control device

- **Automatic Voltage Regulators (AVRs)** are units that regulate the voltage to ensure electronic units like rectifiers continue to operate during extreme mains voltage variations, without getting damaged

PQ issue especially harmonics affects electrical network assets too

Main issues caused by harmonics in the network systems

- Harmonics, one of the growing PQ issue, are caused by the non-linearity of customer loads.
- Harmonic currents flow upstream from non-linear loads, through the impedance of cables and transformers and creates harmonic voltage distortion
- Harmonic currents also create increased heating in electrical cables, leading to premature ageing and overstressing of the electrical insulation
- Nuisance tripping of protective devices, often dependent on periodic zero crossing of waveform, overheating of conductors (burn off, damage), etc.

Harmonic Prevention and Reduction

- Use of Active and Passive filters improves power factor thereby reducing high frequency harmonics and controlling output current
- Use of capacitor banks or filters in local grid helps reduce reactive power demand or harmonics issues by reactive power compensation
- Harmonic Mitigations Transformers (HMTs) have become a leading economical solution nowadays to improve the system reliability. When energized, they provide harmonic treatment and have excellent energy saving characteristics

Policy Initiatives

Policy Initiatives

- Development & Inclusive Growth
- Setting up Future Roadmap
- Implementable and Feedback Loop

Electricity Act 2003 Provision

- Suspension of Distribution License when failed to maintain quality of electricity(section 24 (1)(a))
- Adjudication by CERC and SERCs
- District Co-ordinations Committees
- Central/State Advisory Committee

Regulation Provisions

- Electricity Grid Code issued by CERC & SERCs
- Standard of Performance issued by SERCs
- Distribution Code issued by SERCs
- Technical standards issued by CEA
- Equipment standard issued by BIS

How does the PQ reflect in current Indian standards?

There are certain provisions of PQ in the Indian electricity standards and regulations. But there are scopes of strengthening and improving awareness

- Indian markets generally follow IEEE standards.
- BIS has its own initiatives to align standards with global standards.
- Central Electricity Authority (CEA) has specified regulations
- The electricity regulators are essentially focused on continuity of supply.
- Regulators usually specify their own regulations to handle PQ issues.
- Regulators are not very focused on the harmonics issue of the PQ.
- Lot of scope remains for bringing in awareness and uniformity in standards and regulations.

A summary of the current standards and regulations is provided next

CEA, CERC and SERC Power Quality Regulations

CEA	CERC	SERC
• Central Electricity Authority (GRID Standards) Regulation, 2010 • CEA(Technical Standards for Connectivity to the Grid) Amendment Regulation, 2013	• CERC (Indian Electricity Grid Code) Regulations, 2010	• State Grid code • State Supply Code • Standard of Performance (SOP) of distribution licensees

- Common Power Quality aspects covered under current regulations for distribution licensees:

Reliability	Voltage	Current	Harmonics
• SAIFI • SAIDI • CAIDI	• Voltage variation • Voltage unbalance • Voltage monitoring and management in some states	• Current unbalance in few states	• THD_V limits in majority of states • THD_I in limited states

- However, there is no well established monitoring and implementation framework for Power Quality in Indian Regulations.

PQ Regulations in Maharashtra

Regulation Structure

Relevant Regulation	Voltage	Harmonics	Reliability Indices
• State Grid Code. • Standard of Performance Regulations. • Supply Code. • Distribution Open Access Regulations.	• Specifies the voltage variation limits for EHT, HT and LT voltages • Provision for compensation to be paid by licensee to consumer for failing to maintain standard	• Consumer to control harmonics as per IEEE 519-1992 within 3 months and as per relevant commission order. • Penalty for low /high harmonics as per notification from the Commission issued as and when.	• SAIFI, SAIDI and CAIDI

Key Highlights

- ***No monitoring and implementation framework for voltage variation and harmonics***
- **Consumer is responsible for taking corrective action for harmonics injection.**
- **Provision for penalty for harmonics in accordance with relevant orders of the Commission. *However, no such penalty or incentive is ever specified so far.***

Roadmap

Way Forward

- Industry be encouraged to collect data concerning the impact of PQ on their production. Also they may involve Academic Institutions for this purpose for PQ Audit, study and R & D.
- Utility and Industries needs to form PQ forums involving consumer welfare Activists and Academicians for identifying PQ related issues and to take up with Regulators for redressal in line with EA 2003 provisions.
- Industries needs to fund these activities or Utility can create fund through ARR like in DSM or EE.
- SERCs may set up PQ monitoring committee in line with Orissa ERC
- Government may set up District Coordination committee as envisaged in the EA 2003, this may help improving PQ performance in Rural India
- ERCs should enable Utilities to install PQ monitoring equipment
- Utility shall have to keep record on PQ related data, the same shall be forwarded to ERCs
- PQ performance of utility may have to be assessed by ERCs, penalty/reward have to be taken into account while evaluating their Revenue Requirements.

Asia Power Quality Initiative (APQI)

A neutral collaborative platform shared by National Support Network (NSN) Partners to promote education and awareness and facilitate policy changes.

A reference for all PQ matters in Asia

- A network of European /Asian PQ experts
- Standardization/certification body participation
- Leads appropriate PQ study (PQ Survey, PQ Application)
- PQ Regulation report

Education & training fine tuned for individuals

- Print publications
- Electronic library

Lead the dynamic through adequate knowledge management & E-dissemination

- Website
- Forums
- Seminars
- Webinars