Power Quality Regulations for Distribution of Electricity in India

Presentation to Forum of Indian Regulators (FOIR)

1st Dec’2015 New Delhi

International Copper Association India
Copper Alliance

Asia Power Quality Initiative (APQI)

- **Asia Power Quality Initiative (APQI) (www.apqi.org)**, is a joint effort of the International Copper Association (ICA), International Copper association India (ICAI), the Electrical and Electronics Institute, Thailand, the University of Bergamo (Italy), and the European Copper Institute (ECI, Belgium), to create an independent platform that builds awareness and capacities on issues related to Power Quality.

- The initiative has local chapters in as many as seven Asian and Southeast Asian countries under the APQI Platform. In India, the ICA India facilitates the initiative.

- APQI aims to engage industry, services, government, energy managers, energy auditors and consumers on the importance and significance of power quality in the economy. APQI works with a wide range of academicians, policy makers, regulators, engineers and energy professionals in India, China, Thailand, Malaysia, Indonesia, Philippines and Vietnam.

- The NSN members of the APQI believe that poor power quality results in higher costs in maintenance and replacement of electrical and electronic devices, production chain interruption and losses, high electricity bills, lower production output quality and significant financial losses.

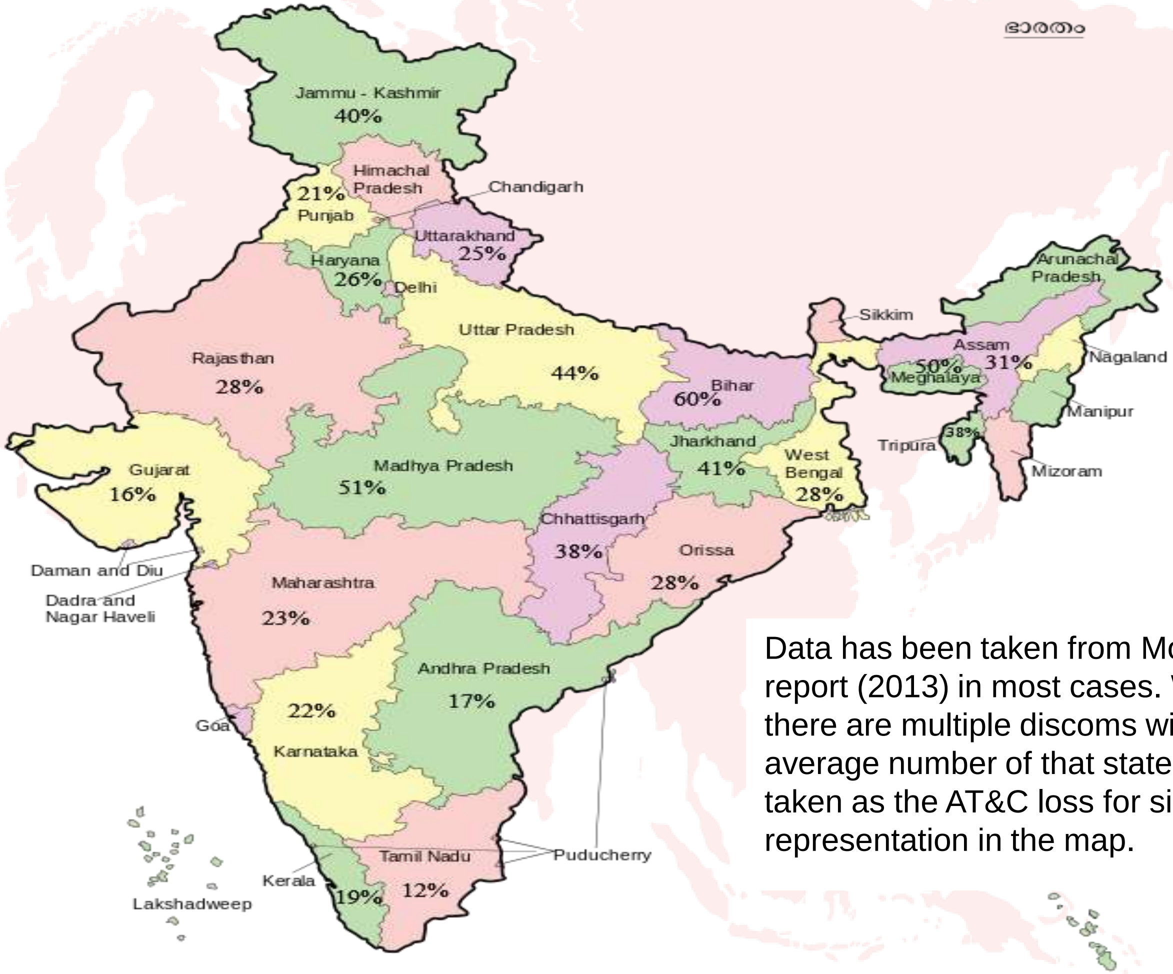
- APQI seeks to make power quality a key part of all discussions on power. The initiative builds on the previous success of the Leonardo Power Quality Initiative (LPQI) established in Europe by the European Copper Institute, Belgium, with financial support from the European Commission.

De-mystifying Power Quality (PQ)

Utilities key focus areas

Reliability of supply	AT&C Loss	Energy Efficiency
• 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	• 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 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

State-wise AT&C Loss (in %)



Data has been taken from MoP rating report (2013) in most cases. Wherever there are multiple discoms within state, average number of that state has been taken as the AT&C loss for simplicity and representation in the map.

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

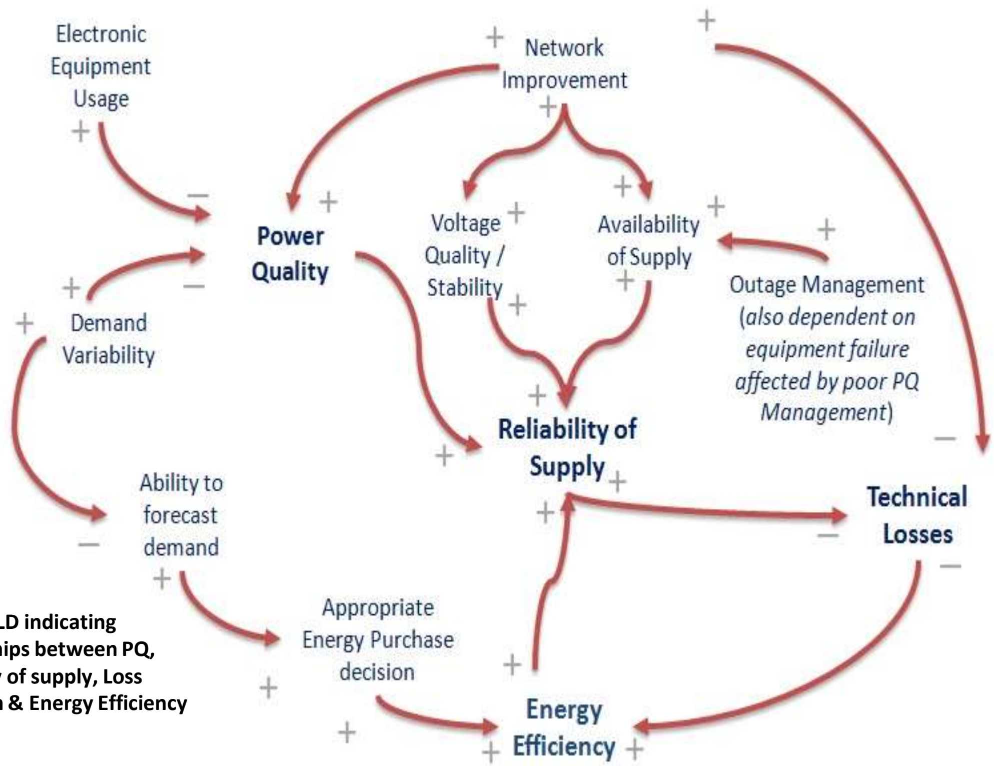


Figure - CLD indicating relationships between PQ, Reliability of supply, Loss Reduction & Energy Efficiency

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

Existing Power Quality Regulations and Prevalent Tariff Orders in India

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
- SAIFI
- SAIDI
- CAIDI

Voltage
- Voltage variation
- Voltage unbalance
- Voltage monitoring and management in some states

Current
- Current unbalance in few states

Harmonics
- 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.***

PQ Regulations in Gujarat

Regulation Structure

Relevant Regulation	Voltage	Harmonics	Reliability Indices
• State Distribution Code. • SOP Regulations. • Power System Management Standards Regulations.	• Limits of variation for neutral voltage. • Limits for variations for EHT, HT and LT voltages as per IS standards. • DISCOM to monitor voltage during peak and off-peak hour for improvement in co-ordination with user.	• Distribution licensee responsible for monitoring harmonics at regular interval at strategic points of HT consumer premises. • Distribution licensee can also measure the level of harmonics generation of any customer on receipt of complaint from other affected consumer(s) • Limits of harmonics are as per CEA standards for renewable generators • Consumers to follow IEEE 519.	• SAIFI, SAIDI and MAIFI

Key Highlights

- ***No clarity in monitoring and implementation methodology*** for Harmonics and Voltage regulation. ***No compensation on account of failure to maintain voltage and harmonics within prescribed limits.***
- It is DISCOM's prime responsibility to comply with voltage and harmonics regulation by providing sample compliance tests to the Commission in a format and manner specified by the Commission.
- Provision for voltage monitoring in 11 kV feeder and 22/11 kV sub-station. However there is no clarity about other voltage levels feeder and sub-station.

PQ Regulations in Tamil Nadu

Regulation Structure

Relevant Regulation	Voltage	Harmonics	Reliability Indices
• State Distribution Code. • SOP Regulations. • Supply Code. • Tariff Order.	• The Commission from time to time will order the permissible limits for voltage variations after periodic reviews. • Specifies the permissible limits of voltage variation for 240 V, 415 V, 11 kV, 22 kV.	• As per CEA standards • Penalties apply for failing to maintain standard – implemented through tariff order. • Consumer to install harmonics suppression equipment .	• SAIFI, SAIDI and MAIFI.

Key Highlights

- DISCOMs need to monitor the voltage, frequency and power factor at peak and off peak hours and take reasonable measures for improvement of the same in co-ordination with users. No monitoring provision for other power quality parameters.
- ***No clarity in monitoring methodology and implementation for Harmonics and Voltage regulations. No compensation on account of failure to maintain voltage within prescribed limits.***
- Consumer is liable to pay compensation at 15% of the respective tariff when it exceed harmonics injections limits specified by CEA. ***However the compensation is not levied with respect to the intensity of harmonics injected to the grid.*** Penalty of 15% of respective tariff is applied flatly irrespective of the amount of harmonics injected by consumer in the distribution grid.

PQ Regulations in Karnataka

Regulation Structure

Relevant Regulation	Voltage	Harmonics	Reliability Indices
• State Distribution Code. • Standard of Performance Regulations. • State Supply Code.	• Limits for variations for 230 V, 400 V, 11 kV and 33 kV as per IS 12360. • Limits defined for voltage unbalance.	• Limits of THD_V & THD_I as per standards specified by CEA. • Distribution Licensee needs to monitor harmonics at the point of common coupling (PCC) between supply and the Consumer (typically metering point). • Where the 'non-linear load' content is more than 20% of the 'connected load', it is recommended to have 'snapshots' of harmonic distortion levels both for current and voltage. • The Consumer needs to limit 'current distortion' levels within the acceptable limits stipulated by the Distribution Licensee from time to time.	The reliability indices mentioned hereunder shall be computed separately for urban and rural feeders a) Average number of Interruptions in 11 kV feeders. b) Average duration of Interruptions in 11 kV feeders d) Average number of Interruptions per consumer e) Average duration of interruption per consumer The standards will be laid down by the Commission.

Key Highlights

- ***No clarity in monitoring methodology and implementation for Harmonics and Voltage regulation***. *No compensation on account of failure to maintain voltage and Harmonics within prescribed limits.*

PQ Regulations in Andhra Pradesh

Regulation Structure

Relevant Regulation	Voltage	Harmonics	Reliability Indices
• State Grid Code. • Standard of Performance Regulations.	• Limits for voltage variations specified. • Penalty for not maintaining the limits of voltage variation. • Voltage unbalance limited to +/- 3% at the point of supply to consumer.	• Limits for voltage harmonics (THD_V) for the licensee at the points of supply to consumer is specified. • Limits specified for harmonics injection by consumer - voltage harmonics (THD_V) at the point of connection with licensee and current harmonics (THD_I) for current drawn from Transmission System at the point of connection.	• SAIFI, SAIDI and MAIFI

Key Highlights

- DISCOMs need to monitor voltage and harmonics as per prescribed limits. But ***no clarity on method of recording harmonics***
- ***No compensation*** on account of failure to maintain voltage variation and harmonics within prescribed limits.
- kVAh based billing charges customers for harmonic distortion but that is not keeping customer informed about rights and responsibility towards harmonic control.

PQ Regulations in Madhya Pradesh

Regulation Structure

Relevant Regulation	Voltage	Harmonics	Reliability Indices
• State Grid Code. • Transmission Performance Standard Regulations. • Distribution Performance Standard Regulations. • State Supply Code.	• Limits for voltage variation specified. • Limits for voltage unbalance specified.	• EHT and HT Consumer to control harmonics as per the prescribed limits. • Distribution licensee responsible for monitoring harmonics at regular interval at strategic points of HT consumer premises.	• SAIFI, SAIDI and MAIFI

Key Highlights

- ***No clarity in monitoring and implementation methodology*** for Harmonics and Voltage.
- User need to install harmonic filters ***if DISCOM detects* and proves** to the consumer that the consumer's system is generating harmonics.

PQ Regulations in Delhi

Regulation Structure

Relevant Regulation	Voltage	Harmonics	Reliability Indices
• State Grid Code. • Supply Code and Standards of Performance Regulations.	• Limits for variations prescribed as per Indian Electricity Rules, 1956. • Voltage unbalance limit at the point of supply is specified.	• Requirement will be specified separately at an appropriate time after conducting a detailed study. • Not yet specified	• SAIFI, SAIDI and MAIFI

Key Highlights

- ***No clarity in monitoring and implementation methodology*** for Voltage and Harmonics.
- ***No compensation*** on account of failure to maintain Voltage and Harmonics within prescribed limits.
- No clarity on Harmonics as the regulations specify that it will be specified separately at an appropriate time after conducting a detailed study.

International Standard for Power Quality

IEEE 519 – 2014 and EN 50160

IEEE 519- 1992/ 2014

- IEEE 519-1992 specifies voltage and current harmonics limits up to 161 kV
- Updated IEEE 519 recommends multiplier for current harmonics to reduce lower order harmonics
- Most of the states adopted IEEE 519 - 1992 as prescribed limits

EN 50160

- Specifies standards for voltage variation, flicker, unbalance, harmonics voltage, mains signalling voltage

Voltage Distortion Limit by IEEE 519 (1992 & 2014)

Bus Voltage at PCC	Individual Voltage Distortion (%) - 1992	Individual Voltage Distortion (%) - 2014	Total Voltage Distortion THD (%) – 1992	Total Voltage Distortion THD (%) - 2014
V ≤ 1.0 kV	Not specified	5.0	Not specified	8.0
1 kV < V ≤ 69 kV	3	3.0	5	5.0
69 kV <V ≤ 161 kV	1.5	1.5	2.5	2.5
161 kV<V	1	1.0	1.5	1.5*

*High-voltage systems can have up to 2.0% THD where the cause is an HVDC terminal whose effects will have attenuated at points in the network where future users may be connected.

IEEE 519 –2014….*contd.*

Current distortion limits for systems rated 120 V through 69 kV by IEEE 519 (1992 & 2014 – no changes)

Individual Harmonic Order (Odd Harmonics)												
I_{sc}/I_L	3≤h<11 (1992)	3≤h<11 (2014)	11≤h<17 (1992)	11≤h<17 (2014)	17≤h<23 (1992)	17≤h<23 (2014)	23≤h<35 (1992)	23≤h<35 (2014)	35≤h≤50 (1992)	35≤h≤50 (2014)	TDD (1992)	TDD (2014)
<20*	4	4	2	2	1.5	1.5	0.6	0.6	0.3	0.3	5	5
20<50	7	7	3.5	3.5	2.5	2.5	1	1	0.5	0.5	8	8
≥ 50	10	10	4.5	4.5	4	4	1.5	1.5	0.7	0.7	12	12
100<1000	12	12	5.5	5.5	5	5	2	2	1	1	15	15
>1000	15	15	7	7	6	6	2.5	2.5	1.4	1.4	20	20

Current distortion limits for systems rated 69 kV through 161 kV by IEEE 519 (1992 & 2014 – no changes)

Individual Harmonic Order (Odd Harmonics)												
I_{sc}/I_L	3≤h<11 (1992)	3≤h<11 (2014)	11≤h<17 (1992)	11≤h<17 (2014)	17≤h<23 (1992)	17≤h<23 (2014)	23≤h<35 (1992)	23≤h<35 (2014)	35≤h≤50 (1992)	35≤h≤50 (2014)	TDD (1992)	TDD (2014)
<20*	2	2	1	1	0.75	0.75	0.3	0.3	0.15	0.15	2.5	2.5
20<50	3.5	3.5	1.75	1.75	1.25	1.25	0.5	0.5	0.25	0.25	4	4
50<100	5	5	2.25	2.25	2	2	0.75	0.75	0.35	0.35	6	6
100<1000	6	6	2.75	2.75	2.5	2.5	1	1	0.5	0.5	7.5	7.5
>1000	7.5	7.5	3.5	3.5	3	3	1.25	1.25	0.7	0.7	10	10

IEEE 519 –2014….*contd.*

Current distortion limits for systems rated above 161 kV by IEEE 519 (1992 & 2014)

Individual Harmonic Order (Odd Harmonics)												
I_{sc}/I_L	3≤h<11 (1992)	3≤h<11 (2014)	11≤h<17 (1992)	11≤h<17 (2014)	17≤h< 23 (1992)	17≤h< 23 (2014)	23≤h< 35 (1992)	23≤h< 35 (2014)	35≤h≤ 50 (1992)	35≤h≤ 50 (2014)	TDD (1992)	TDD (2014)
<25	-	1	-	0.5	-	0.38	-	0.15	-	0.1	-	1.5
25<50	2	2	1	1	0.75	0.75	0.3	0.3	0.15	0.15	2.5	2.5
≥ 50	3	3	1.5	1.5	1.15	1.15	0.45	0.45	0.22	0.22	3.75	3.75

Recommendations for increasing current limits to reduce lower order harmonics by IEEE 519

Harmonics orders limited to 25% of values given below	Multiplier
5,7	1.4
5,7,11,13	1.7
5,7,11,13,17,19	2
5,7,11,13,17,19,23,25	2.2

Gaps in Indian Standards

Inconsistency in voltage variation

- ✓ Tamil Nadu does not specify the voltage variation limits for 33 kV and 66 kV.
- ✓ For voltage level 11 kV Tamil Nadu specifies limit as (+6% and -10%) whereas other states specify limits as (+6% and -9%).
- ✓ For voltage level 22 kV Tamil Nadu specifies limit as (+6% and -10%), Maharashtra specifies limit as (+10% and -12.5%), whereas other states specify limits as (+6% and -9%).
- ✓ For low voltage levels Tamil Nadu specifies limit as (+6% and -10%) whereas other states specify limits as (+6% and -6%).
- ✓ For EHT voltage levels, some states have voltage variation limits different from the central regulations as indicated below.

Limits for voltage variation at interconnection point				
Nominal Voltage (kV)	Maximum Limits (kV/%)		Minimum Limits (kV/%)	
	SERC Regulation	Central Regulation	SERC Regulation	Central Regulation
Madhya Pradesh				
400	+5%	+5%	-10%	-5%
220	+10%	+11%	-10%	-10%
132	+10%	+10%	-10%	-8%
Maharashtra				
66	73 kV	72 kV	60 kV	60 kV
Delhi				
66	73 kV	72 kV	60 kV	60 kV
Highlighted cells are the state limits, where it is different from the central regulations prescribed value				

Inconsistency in voltage unbalance

- ✓ It is observed that there are differences in approach towards the voltage unbalance amongst the selected States.
- ✓ Some States do not specify any standard for voltage unbalance.
- ✓ There are differences amongst the States which specify the standards for voltage unbalance.

State	Standard for Voltage Unbalance
Tamil Nadu, Maharashtra, Gujarat	No standard specified for voltage unbalance
Andhra Pradesh, Madhya Pradesh, Delhi	Voltage unbalance shall not exceed 3% at the point of supply to the consumer.
Karnataka	Voltage unbalance shall not exceed 3% at 33 kV and 3.5% at 11 kV.
CEA	• Voltage unbalance shall not exceed 3% at 33 kV and above. • Does not specify any standard below 33 kV.

CEA defines **Voltage Unbalance** as the deviation between the highest and lowest line voltage divided by average line voltage of the three phases of supply.

Inconsistency in harmonics standards

At 11 kV level

- For voltage level 11 kV, Tamil Nadu, Gujarat and Maharashtra specifies THDv as 5% with individual harmonics content not exceeding 3% whereas Karnataka specifies THDv as 3.5% with individual harmonics content not exceeding 2.5%. Andhra Pradesh and Madhya Pradesh specify the cumulative THDv as 8% for 11 kV.

At 33 kV level

- For voltage level 33 kV, Karnataka specifies THDv limit as 3% with no individual harmonic content higher than 2.5% whereas Tamil Nadu, Gujarat and Maharashtra specifies THDV as 5% with individual harmonics content not exceeding 3% for 33 kV level. Andhra Pradesh and Madhya Pradesh specify the cumulative THDv as 8% for 33 kV.

Karnataka has inconsistency in its own Regulations

- Karnataka specifies THDv limit as 5% for 11kV and 33 kV in one regulation and 9% in another regulation. There are three different limits for single state.

Other inconsistencies

- For EHT voltage levels, some states (such as Karnataka and Maharashtra) have harmonics limits different from the central regulations as presented in next slide.
- Madhya Pradesh regulation recommends to follow IEC Std 1000-4-7 or IEEE limit and Delhi doesn't specify any harmonics limits so far.

Inconsistency in harmonics standards….*contd.*

State	SERC Limits	CEA Regulation
Tamil Nadu	CEA grid connectivity standard	• THD – 5% with single harmonic content not exceeding 3 % for 33 to 132 kV. • THD – 2.5% with single harmonic content not exceeding 2 % for 220 kV. • THD – 2% with single harmonic content not exceeding 1.5 % for 400 kV. • THD – 1.5% with single harmonic content not exceeding 1 % for 765 kV.
Gujarat	THD – 5% with single harmonic content not exceeding 3 %	
Maharashtra	HT &LT (Industrial only) need to control harmonics at the levels prescribed by IEEE STD 519-1992	
Delhi	Not specified	
Madhya Pradesh	a. IEC Std 1000-4-7 or IEEE Std. b. THD not exceed 1% at the interconnection point of EHV system in accordance with IEC Std. 1000-4-7 c. Cumulative THD_V – 3% (for 220 kV and 132 kV) d. Cumulative THD_V- 8% (for 11 & 33 kV)	
Andhra Pradesh	a. Cumulative THD_V – 3% (for 132 kV and above) b. Cumulative THD_V- 8% (for 11 & 33 kV) c. THD_V – 5% with single harmonic content not exceeding 3 %, THD_I – not exceeding 1% at drawl from transmission	
Karnataka	a. THD 3% at 33 kV and 3.5% at 11 KV with no individual harmonic higher than 2.5%. b. THD_V – 9% (for 400 V and 45 kV), 4% (for 400 V and 45 V), 3% (for 220V and above) c. THD_V – 5% (69 kV and below), 2.5% (69 kV up to 161 kV), 1.5% (161KV and above), 2% (HVDC terminals)	

Difference from International Standards

IEEE 519 is mostly referred to as standard across states

- Majority of the states are referring to IEEE 519 standards for harmonics limits.
- However, the cumulative THDv of 11 kV, 33 kV and 132 kV level in Andhra Pradesh and Madhya Pradesh are different from IEEE standards and CEA regulations.

CEA specified voltage limit is different from IEEE standards

- At 220 kV and 400 kV voltage level, harmonics limits prescribed by CEA Grid Standard and IEEE Standard are different.
- Between 69 kV and 132 kV, CEA Grid Standards and IEEE Standards differ in harmonics limits.

Need For Harmonious Development Of Standards

- In Indian Regulations mostly IEEE version has been referred to.
- However, BIS is considering changes to the IS 12360-1988 based on the IEC standards.
- India being a signatory to the WTO, it may be advisable to look into the IEC standards also, as IEEE standards are more widely adopted in the US region.

Issues with HT consumers on Power Quality

Voltage and harmonics pollution in upstream distribution system	Many consumers are facing voltage variation and injecting Harmonics in to grid though regulations specify limits. Lack of implementation and monitoring framework fosters non-compliance.
High cost alternate source – loosing market competitiveness in business	Due to voltage variation, many continuous process consumers are opting for captive generation or higher voltage level i.e. above 22 kV or express feeders at additional cost. MV and LV consumers are forced to opt for UPS/ Inverter kind of power conditioning device
Measurement, verification and implementation framework	Several regulations specify power quality norms but few states have framework to monitor the consumers and utilities for implementing and maintaining power quality in distribution.
Economic loss	Increasing non-linear loads in the system is causing higher harmonic distortion resulting into failure of equipment, system, unexplained tripping, blockage of equipment capacity, loss of energy efficiency, safety hazard like fire etc.

Scope of improvement of PQ Regulations

- Harmonious development of standards –ease of application across states
- HT consumers to maintain standards
- Equipment /Appliance standards for LV consumers

Implications and disciplinary actions if large consumers fail to maintain voltage balance and harmonics.

Implications and disciplinary actions if distribution licensees fail to maintain voltage and load balance at points of supply.

Power Quality field survey and its findings

Objective of the survey

APQI intended to conduct a field survey on PQ with the following objectives:

- ✓ A PQ survey for a set of HT Industrial and Commercial consumers.
- ✓ Target States: Maharashtra and Gujarat.
- ✓ Target consumers to represent various sectors of the industry.
- ✓ Participation in survey to be voluntary.
- ✓ Survey to be of **dipstick** nature – not a detailed PQ survey/ audit.
- ✓ Intention of dipstick survey was only to broadly identify areas of problems and concerns in relation to Power Quality

Pre survey statistics

Pre Survey Details	Entities Count
Number of HT consumers approached	23
HT consumers expressed interest for participation	8
HT consumers not expressed interest for participation	15
Statutory concern for not participating	5
No participation due to lack of interest	10

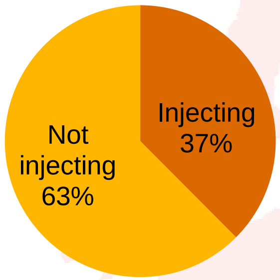
- About 23 HT consumers across Textile, Cement, Copper, Steel, Fertilizer, Petrochemical, Paper & Pulp, and Chemical and Industrial gas sector were approached in the pre survey to assess the willingness for power quality field survey.
- ***Statutory reason was a prime concern for some of the participants*** who were not open for the power quality survey.
- A significant proportion of approached entities ***did not have any interest*** for participation in the PQ survey.

Survey respondent profile

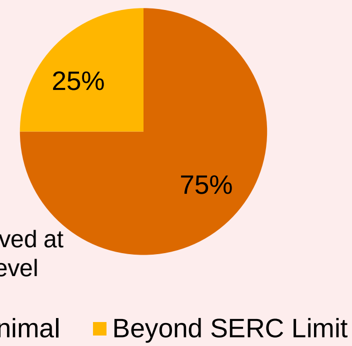
Respondent Segment	Product Line	Upstream Voltage Level	Contract Demand
Steel	Steel Sheets 24x7 process	220 kV/ 33kV Power use at 33kV, MSEDCL	More than 2 MVA
Automobile	Passenger vehicle manufacturer 24x7 process	22 kV, MSEDCL	More than 2 MVA
Alkali and Chemicals	Alkalis 24x7 process	33 kV, PGVCL	More than 2 MVA
Petrochemical Handling and Transportation	Petrochemical 24x7 process	22 kV, MSEDCL	More than 2 MVA
Fertilizer and Petrochemical	Nitrite and Methanol 24x7 process	22kV, MSEDCL	More than 2 MVA
Precision Engineering	Process control instruments – not a continuous process	430 volt, 3 Phase MSEDCL	Less than 1 MVA
Retail Mall-1	Commercial Mall – not a continuous process	22 kV, RInfra	More than 1 MVA
Retail Mall-2	Commercial Mall-not a continuous process	33 kV, Tata Power	More than 1 MVA

Survey findings

Respondent injecting harmonics

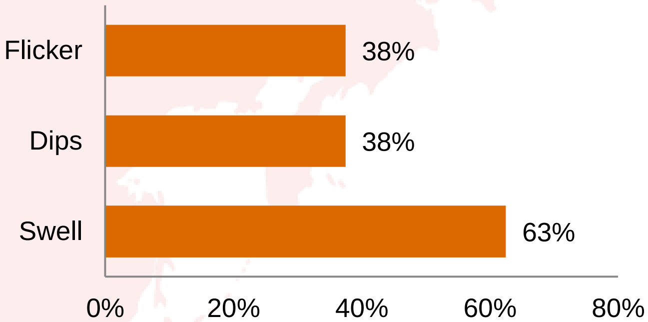


Respondent having voltage variation issue



Most voltage variation observed at 22 kV and below upstream level

Respondent having flicker, dips and swells issue



Sub-Sector	Voltage Level (kV)	Voltage Variation	Presence of Harmonics beyond limit	Harmonics injection	Flicker Events	Dips	Swell	Unbalance
Steel	33	Minimal	Current Harmonics	Yes	Very High	Few	Very High	No
Automobile	22	Minimal	Current Harmonics	Yes	No	No	High	No
Alkali and Chemicals	33	Minimal	No	No	No	No	Low	No
Petrochemical Handling Unit	22	Beyond norms	Current Harmonics	Yes	High	High	High	No
Retail Mall-I	22	Minimal	Current Harmonics	No	No	No	No	No
Retail Mall-II	33	Minimal	Current Harmonics	No	No	No	No	No
Fertilizer and Petrochemical	22	Beyond norms	Current Harmonics	No	No	No	No	No
Precision Engg.	0.43	Minimal	No	No	Yes	Few	High	No

Suggested approach to improve Power Quality in distribution of electricity

1. Regulatory interventions

PQ Indices /KPI for DISCOM performance	• Power quality indices/ KPI need to be additionally considered while evaluating the standards of performance of DISCOMs. PQ KPI shall include voltage variation, neutral voltage variation, voltage unbalance, dips, swells, transient, interruption at point of supply and harmonics.
Bringing consistency in standards	• Making the norms consistent among central and state regulations by considering all relevant power quality parameters and aligning the same to widely acceptable international norms.
Monitoring Framework (Methodology and Frequency)	• Establishing procedures for monitoring and management of all aspects of power quality i.e. continuity of supply, voltage regulation, and harmonics for all voltage levels in the regulations. • Monitoring cum reporting methodology, monitoring frequency and responsibilities need to be additionally incorporated in existing frameworks. Some of the existing regulations already specify the voltage monitoring and management provisions, but only at select voltage level.
PQ monitoring system at sub-station level	• Mandating installation of power quality monitoring instruments at transmission, sub-transmission and distribution sub -station and provision for phase wise installation of PQ monitoring systems at sub stations.

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1. Regulatory interventions….*contd.*

Expanding the PQ scope	• Expanding the applicability of existing frameworks beyond HT consumers.
Real time data reporting with smart system	• Mandating smart systems for network which communicates the real time information and power quality deviations existing in upstream and downstream to all stakeholders.
Specific harmonics monitoring provision	• Measurement and monitoring of harmonics is a largely ignored area. Therefore, specific provisions need to be created by the Regulators to limit harmonics injection by consumers and utilities
Reward and penalty programme	• Introducing penalties and disciplinary actions in regulations if utilities and consumers fail to comply with regulatory requirements. Introduction of incentive and penalty mechanism for consumers to maintain and comply with power quality norms.
Revision of existing penalty scale	• Increasing the existing penalty applicable for DISCOM for not complying with voltage and harmonics limit at the points of supply. Penalties shall be such that it creates sufficient deterrent for the offenders of Regulations.

2. Consumer awareness programmes

- Though there is provision for penalizing the utilities for not adhering to the voltage variation and harmonics limit, majority of the consumers are not using the provisions for following reasons
  - Absence of awareness among end users;
  - Very low penalty or compensation by utilities to consumers;
  - Absence of measurement and monitoring system at user end to track deviations and abnormal events.
- Distribution utilities need to design and implement awareness programmes for the consumers by engaging with them periodically through structured awareness programmes.

Demonstration of live PQ monitoring

PQ Monitoring and Disclosure Possible !

- Link1: http://infonode.electrotek.com/index.htm
- Link2: http://map.pqube.com/
- Link3: www.watchyourpower.org

Thank you

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