ELECTRICAL POWER QUALITY

What is it ? Why is it important?
How do we analyze it? How do we improve it ?

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Schneider Electric

Schneider Electric

Topics of discussion

1. What is Power Quality?
2. Power Quality Monitoring & Auditing
3. Harmonic Mitigation
4. Power Factor Correction
5. Remote PQ Test Kit & Services Provided
6. Value Proposal Summary

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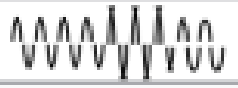
What is Power Quality

An ideal three-phase Electrical Energy Supply system has the following characteristics for each phase:

- Nominal magnitude
- Nominal frequency (60Hz)
- Sinusoidal waveform
- Symmetry on all 3 phases

A disturbance of one or may of these parameters constitutes a Power Quality disturbance

Disturbance category	Waveform	Effects	Possible causes
Transients		Equipment malfunction and damage	Lightning or switching of inductive / capacitive loads
Interruption		Downtime, equipment damage, loss of data possible	Utility faults, equipment failure, breaker tripping
Sag		Downtime, system halts, data loss	Utility or facility faults, startup of large motors
Swell		Equipment damage and reduced life	Utility faults, load changes
Undervoltage		Shutdown, malfunction, equipment failure	Load changes, overload, faults
Overvoltage		Equipment damage and reduced life	Load changes, faults, over compensation
Harmonics		Equipment damage and reduced life, nuisance breaker tripping, power losses	Electronic loads (non-linear loads)
Unbalance		Malfunction, motor damage	Unequal distribution of single phase loads
Voltage fluctuations		Light flicker and equipment malfunction	Load exhibiting significant current variations
Power frequency variations		Malfunction or motor degradation	Standby generators or poor power infrastructure
Power Factor *		Increased electricity bill, overload, power losses	Inductive loads (ex. motors, transformers...)

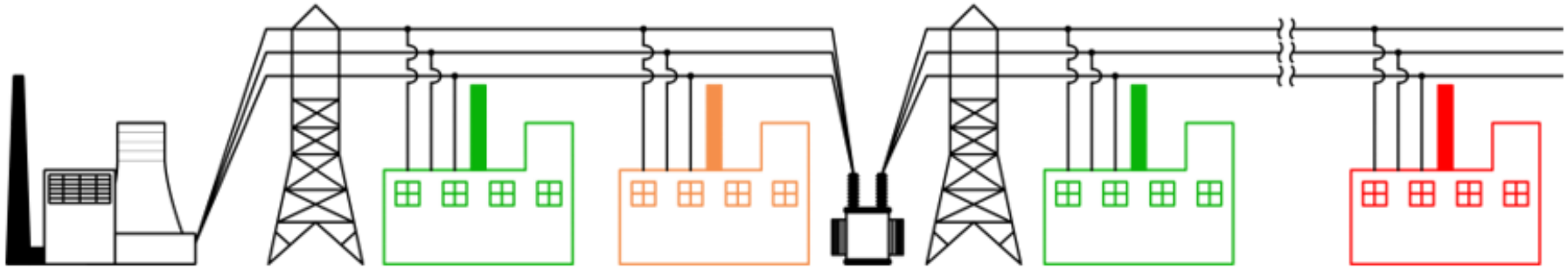
Supply-side vs. Demand-side Power Quality

If the source providing Power to a customer has Power Quality disturbances, the customer will "see" these PQ disturbances.

- Without a "high-end" Power Quality Meter, the customer will not be able to discern whether the origin of the PQ disturbance is supply-side or demand-side.
- Typical supply-side disturbances are *Voltage Sags* and *Voltage Transients*.

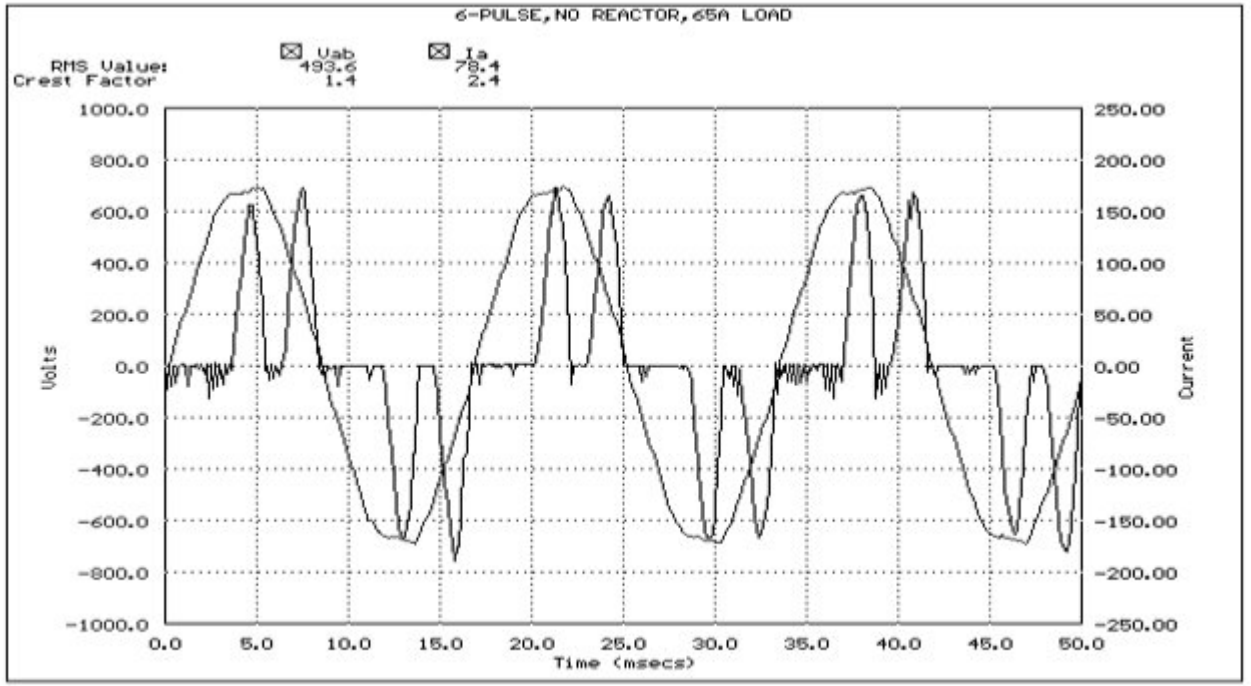
Even if the source is free of Power Quality disturbances, the customer can "create" their own demand-side PQ disturbances.

- Typical demand-side disturbances are *Harmonic Distortion*, *Voltage Sags (aka Flicker)* and *Power Factor*.



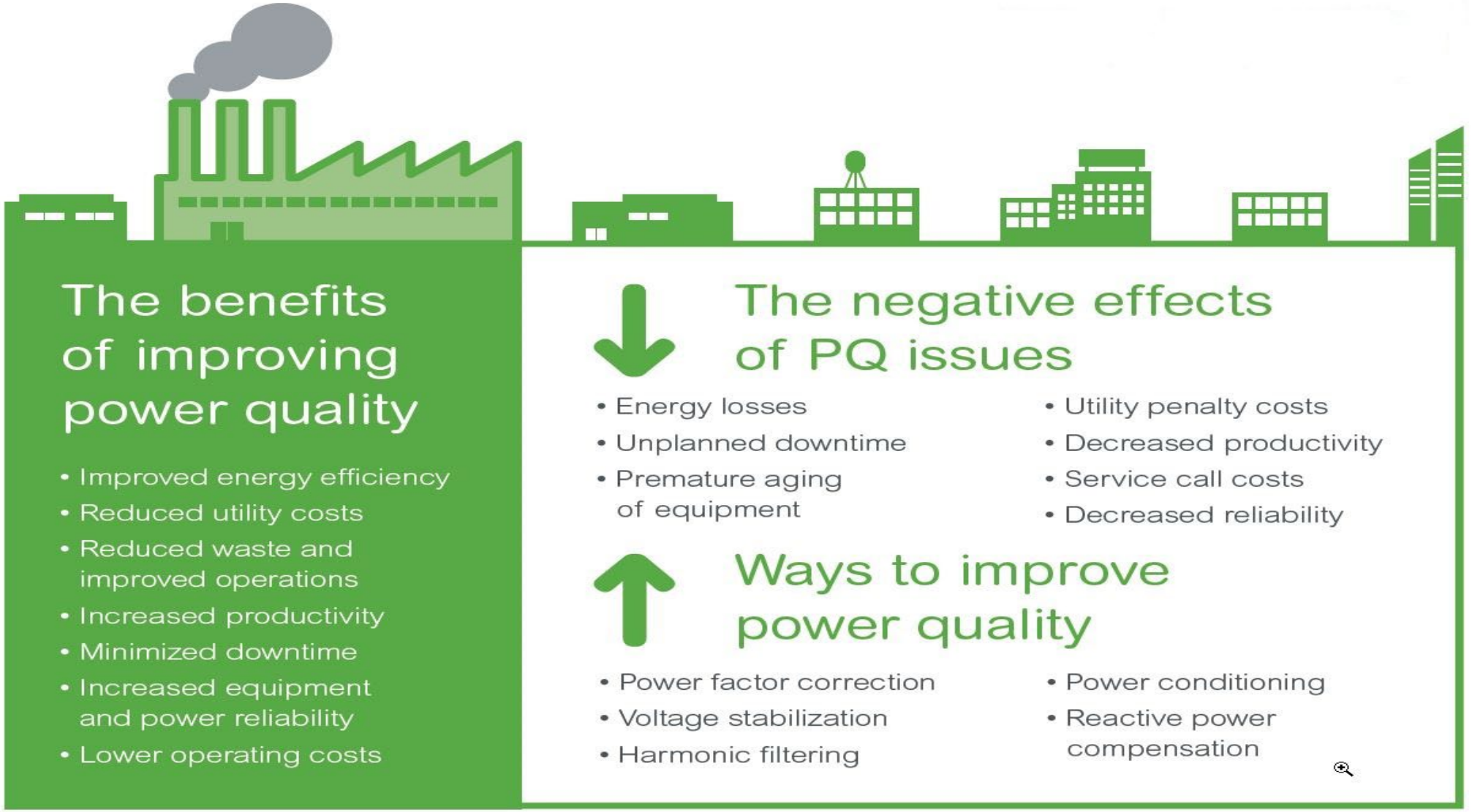
Primary Causes of Increasing Prevalence of PQ Problems

1. A massive increase in the installation and use of non-linear loads.
   - Non-linear load usage increases approx. 70% per year.
2. An increased reliance on the sensitive equipment for the control of production and business processes.



Energy Efficient Equipment

Benefits of improving your Power Quality



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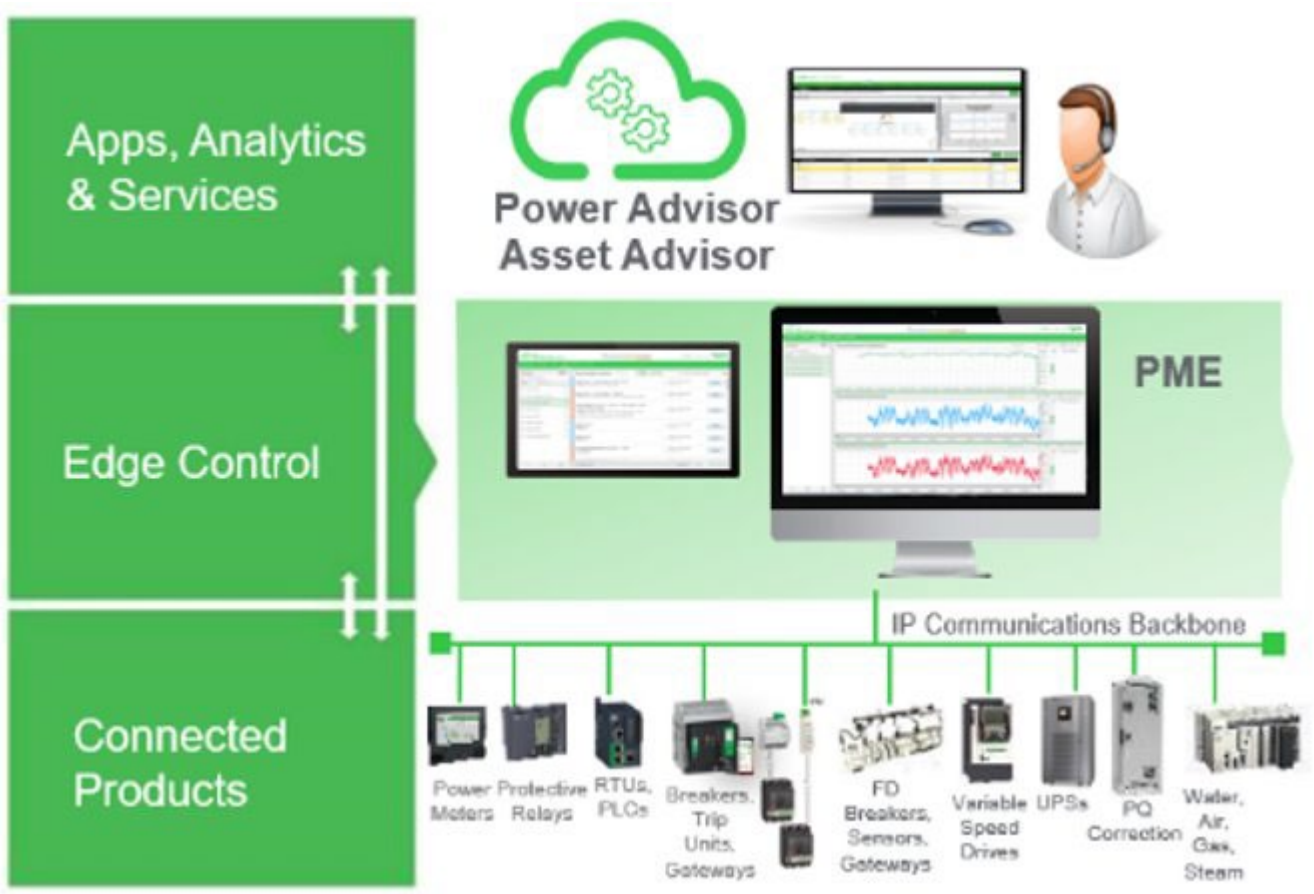
Include Digitization in your Design

1. Provide clients access to advanced analytics and recommendations through the Connected Services Hubs and **EcoStruxure Advisors technology.**
2. Improving data visibility thanks to offers like **PME** at the Edge or in the Cloud.
3. Digitizing the electrical distribution installed base with **Power Meters, Relays, Sensors, etc. Voltage distortion**



Power Quality Audits

- Investigate specific problems with your power system
- Complete PQ Audit: Measurement, Analysis & Report with Recommendations
- Temporary On Site measurements or Remote measurements by PQ Engineers

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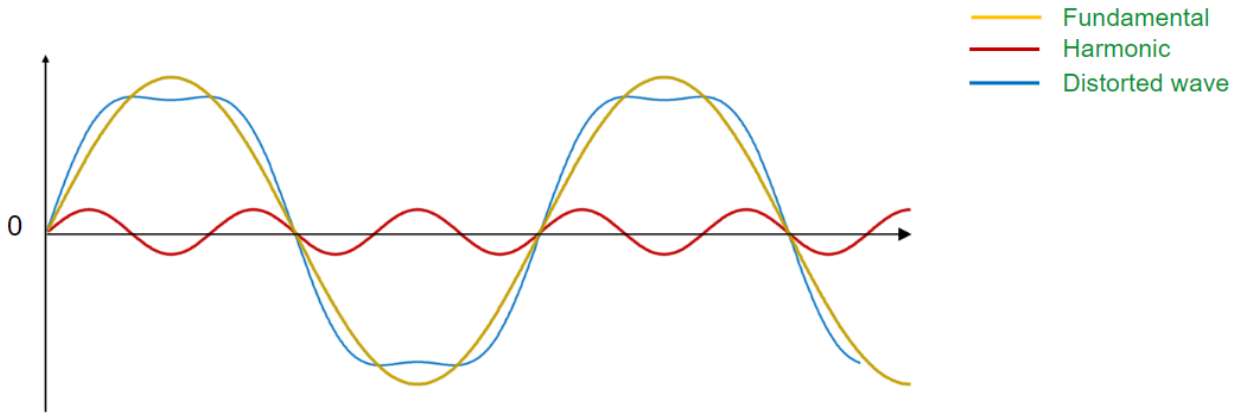
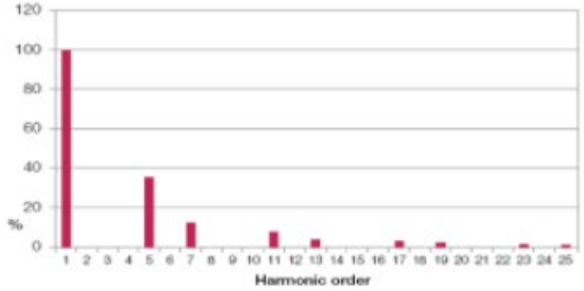
What are Harmonics?

- **Harmonics are frequencies in the distribution network that are INTEGRAL multiples of fundamental frequency.**
- **Its presence creates DISTORTION in the VOLTAGE and CURRENT deviating them from the sinusoidal waveform.**
- **Harmonic currents are caused by NON-LINEAR LOADS connected to the distribution system.**
  - Called non-linear because the current they absorb is distorted even if the supply voltage is perfectly sinusoidal.
  - Effects 1-phase and 3-phase loads.
  - Effects current and voltage.
  - Harmonic Spectrum will indicate Harmonic Orders (1, 5, 7, 11, 13, etc.) 3rd harmonic on neutrals.
  - 3-phase devices DO NOT produce triplen (H3, H9, H15, etc.) harmonics.
  - 1-phase devices DO produce triplen harmonics.

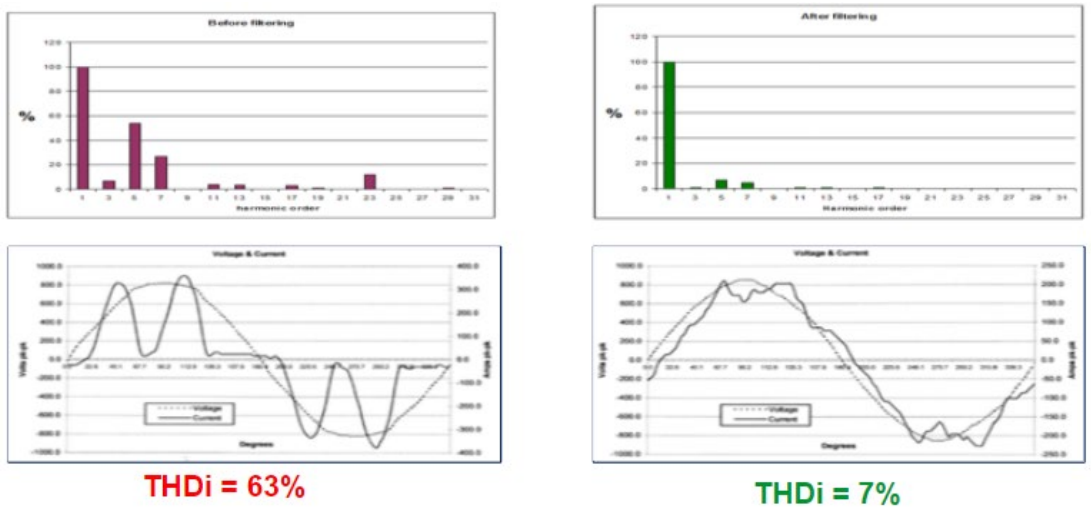




Why Manage Harmonics?

Harmonics are a possible cause of nuisance:

- Its presence creates **DISTORTION** in the **CURRENT and VOLTAGE** deviating them from the sinusoidal waveform.
- Overload of distribution networks due to increase in RMS currents.
- Overload of neutral conductors where current exceeds total phase currents.
- Overload, vibration and premature ageing of generators, transformers and motors.
- Overload and premature ageing of Power Factor Correction capacitor banks (**specifically capacitor banks that are NOT de-tuned).**
- Distortion of the supply voltage that can disturb sensitive loads such as sensors or medical process equipment.
- Disturbance in communication networks and telephone lines.



THDi = 63%

THDi = 7%

Compliance to Standards and Utility Provider Requirements:

- IEEE-519, IEC61000, ER G5/4-1, Local Utility

IEEE

IEEE 519: Recommended Practices and Requirements for Harmonic Mitigation in Electrical Power Systems

ena energynetworks association

ER G5/4-1: Planning levels for Harmonic Voltage distortion and the connection of the non-linear equipment to Transmission system and Distribution network in UK

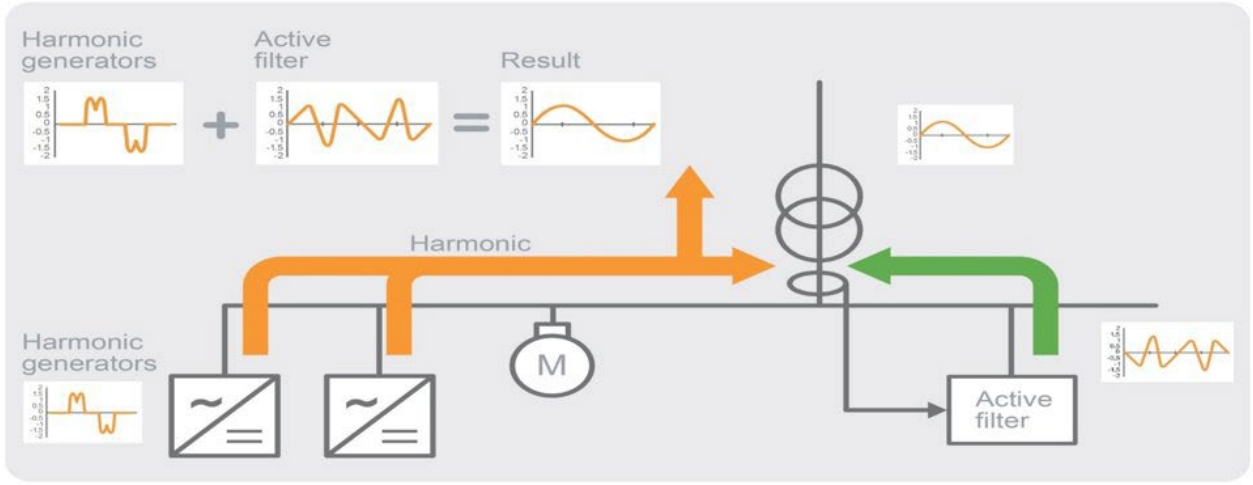
IEC

IEC 61000-3-6: Assessment of Emission for distortion due to loads in MV & HV Power Systems

Principle of Active Harmonic Filtering

Harmonic Filters are FLEXIBLE for any type of installation:

- **Can be used for all types of harmonic producing loads (e.g., VFD/VSD, LED lighting)**
- **Can be applied to:**
  - A single load in the case of a predominant harmonic generator in an installation.
  - Connections at the low voltage busbar level, or;
  - To mitigate the harmonics generated by a group of loads.
- **Adaptability to future load changes**
- **Easily scaled to future connected loads**
- **Fast (correction response is <2 cycles, effect can be seen immediately)**
- **Effective (can reach the targeted compliance of any standard or regulation)**
- **No Resonance (since there are no passive capacitors used, the risk is almost zero)**



AccuSine+ Applications & Benefits

AccuSine+ Applications:

> AccuSine PCS+

Industry segment

Infrastructure & Building segment

> AccuSine PCSn

Building segment

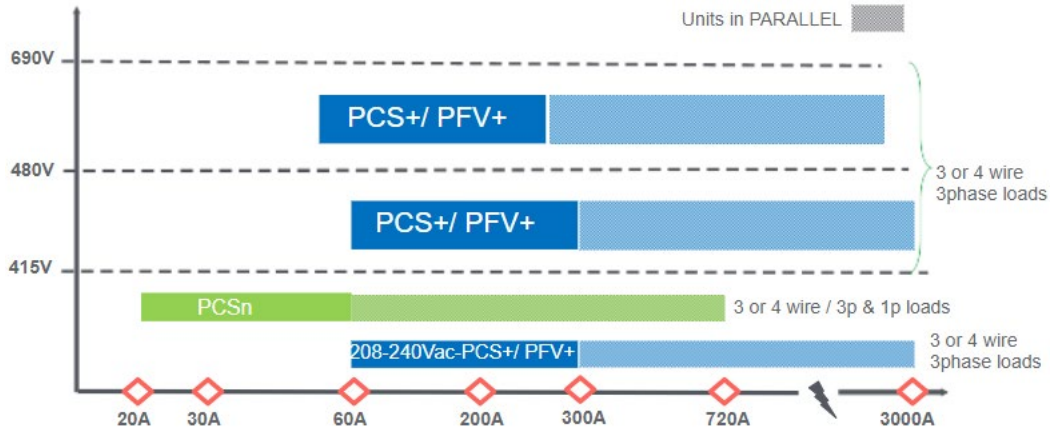
Industry segment

> AccuSine PFV+

Industry segment

Infrastructure & Energy segment

AccuSine+ Range by Capacity:



* PCS+ / PFV+ can be used for MV Applications upto 15KV with Special Transformers

AccuSine+ Range by Function:

	Phase harmonics	Neutral harmonics	Power Factor Correction	Mains Current Balancing	Environment conditions	Volt – VAR support	Flicker
AccuSine PCS+	■		■	■	Harsh & heavy Industrial		
AccuSine PCSn	■	■	■	■	Commercial & light industrial		
AccuSine PFV+			■	■	Harsh & heavy industrial	■	■

- AccuSine solves both Displacement PF (cos φ) and True PF.
- AccuSine PCSn is not the same as PCS+
  - PCS+: harsh electrical (e.g. DC drives) and mechanical environments (e.g. IP54)
  - PCSn: less harsh environments (e.g. commercial type loads – UPS, LED loads etc, IP20)
- Ultra fast power factor correction can be done using AccuSine PFV+.
- Hybrid VAR compensation can be an engineered solution of VarSet & AccuSine PCS+/PFV+

Benefits:

Reduce Capital expenditure (CAPex) & Operational expenses (OPex)

- Decreased line Current Irms
  - Reduce oversizing of Cables, Transformers, Busbars, Circuit
  - Possible expansion without requiring additional resources and equipment

Integration with Management Systems

- Performance Monitoring
- Remote Control
- Power Quality Assurance
- Reduced Losses
- Improvement in Network & Asset lifespan

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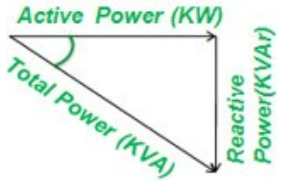
What is Power Factor?

The Utility/Generator as a source provides VOLTAGE while the Consumer/User derives CURRENT from this source to fulfill their requirement.

- The product of this process is **POWER** having three components
- **Apparent Power (S) (kVA)** is the basis for the electrical equipment rating.
- S = V x I
- **Active Power (P) (kW)** is the real power transmitted to loads such as motors, lamps, heaters and is transformed into mechanical power, heat or light.
- P = V x Ia
- **Reactive Power (Q) (kVAR)** is required to generate the magnetic field inside the motor.
- Q = V x Ir



Apparent Power (S)
- Transformer, Switchgear , cables are designed as per apparent energy

Active Power (P)
- What delivers the real power (Mechanical power)
- What customers are billed for

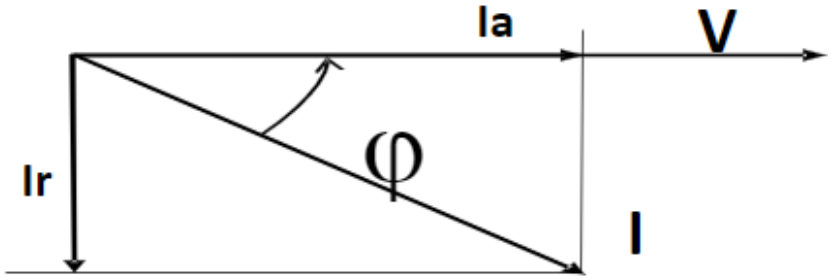
Reactive Power (Q)
- Responsible for Heating loss
- Cannot avoid this.
- Low efficiency motors consume more reactive power

What is Power Factor Correction?

The network must supply **Active Power (P)** and **Reactive Power (Q)** to loads such as motors.

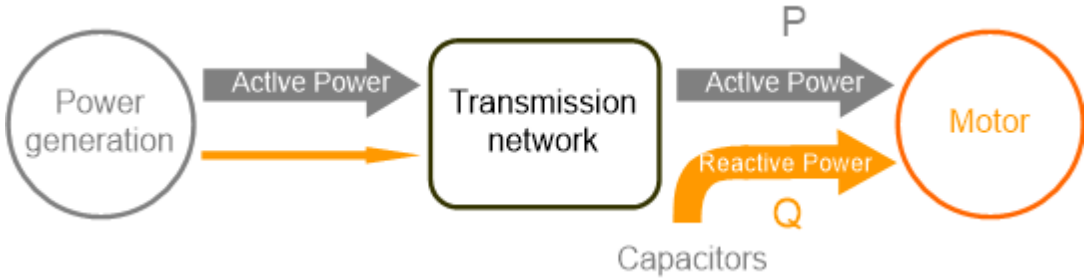
In the vector representation, the **Current (I)** can be split into two components:

- Ia is called the **"Active"** component,
- Ir is called the **"Reactive"** component

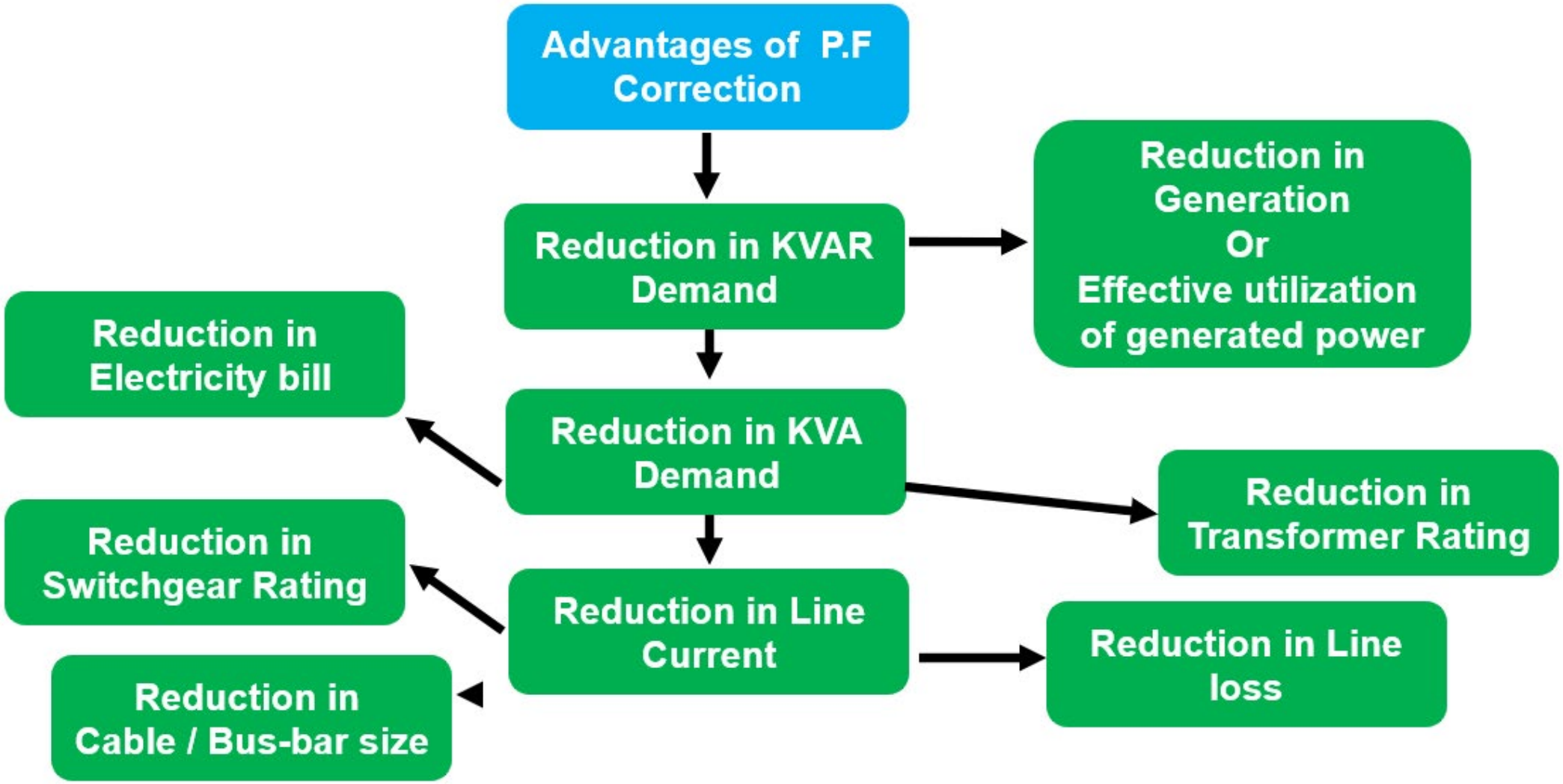


Reactive Power Compensation

- The principle of **"Reactive Power Compensation"** is to generate the reactive power close to the load, so that the supply source could be relieved.
- **Capacitors** are most commonly used to supply reactive power.



Why Correct Power Factor?



Green

Reduce carbon footprint and achieve sustainability goals

Reduce carbon footprint

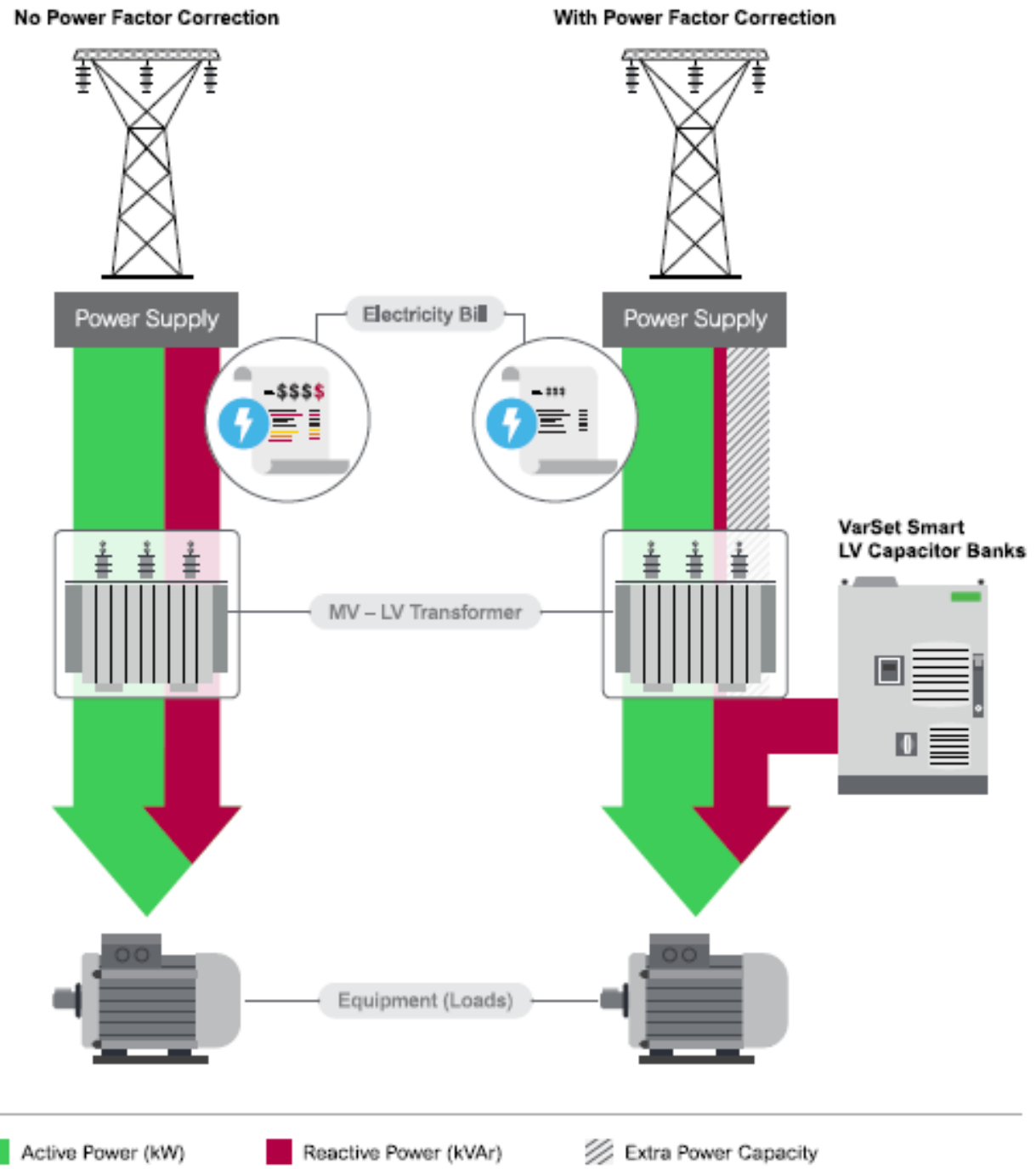
- Use power more efficiently
- Fewer CO_2 emissions

Unlock extra system Capacity

- 36% increase in power capacity*
- 30% optimization in transformer rating
- 25% optimization in cable cross section

Pay less for power

- Electricity bills can be reduced by 10%
- ROI within 12-24 months



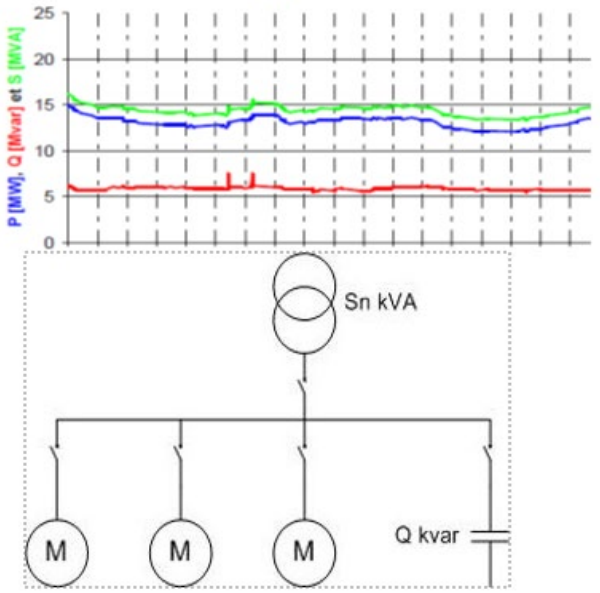
** Based on raising Power Factor from 0.70 to 0.99*

Efficient Power Factor Correction

The inductive effect of motor loads can be offset by using locally connected capacitors:

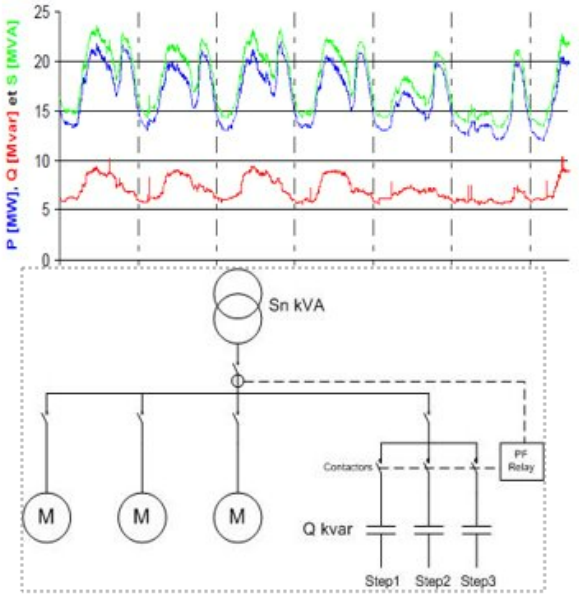
- If a load has a capacitive value, Inductors (also known as Reactors) can be connected to correct power factor.
- Where the kVAR rating is **Less than or equal to 15%** of the supply transformer rating, **Fixed** compensation can be used if the power factor requirement is more or less steady.
- Where the kVAR rating is **Greater than 15%** of the supply transformer rating**, it is advisable to install Automatic** compensation, which should also be used if the power factor is fluctuating over time.
  - This correction unit consists of a number of capacitors that are switched by a number of contactors.
  - Depending on the load and power factor of the network, the controller will switch the necessary blocks of capacitors in step to ensure the power factor stays above the selected value.

Fixed Compensation



Steady & regular demand

Automatic Compensation



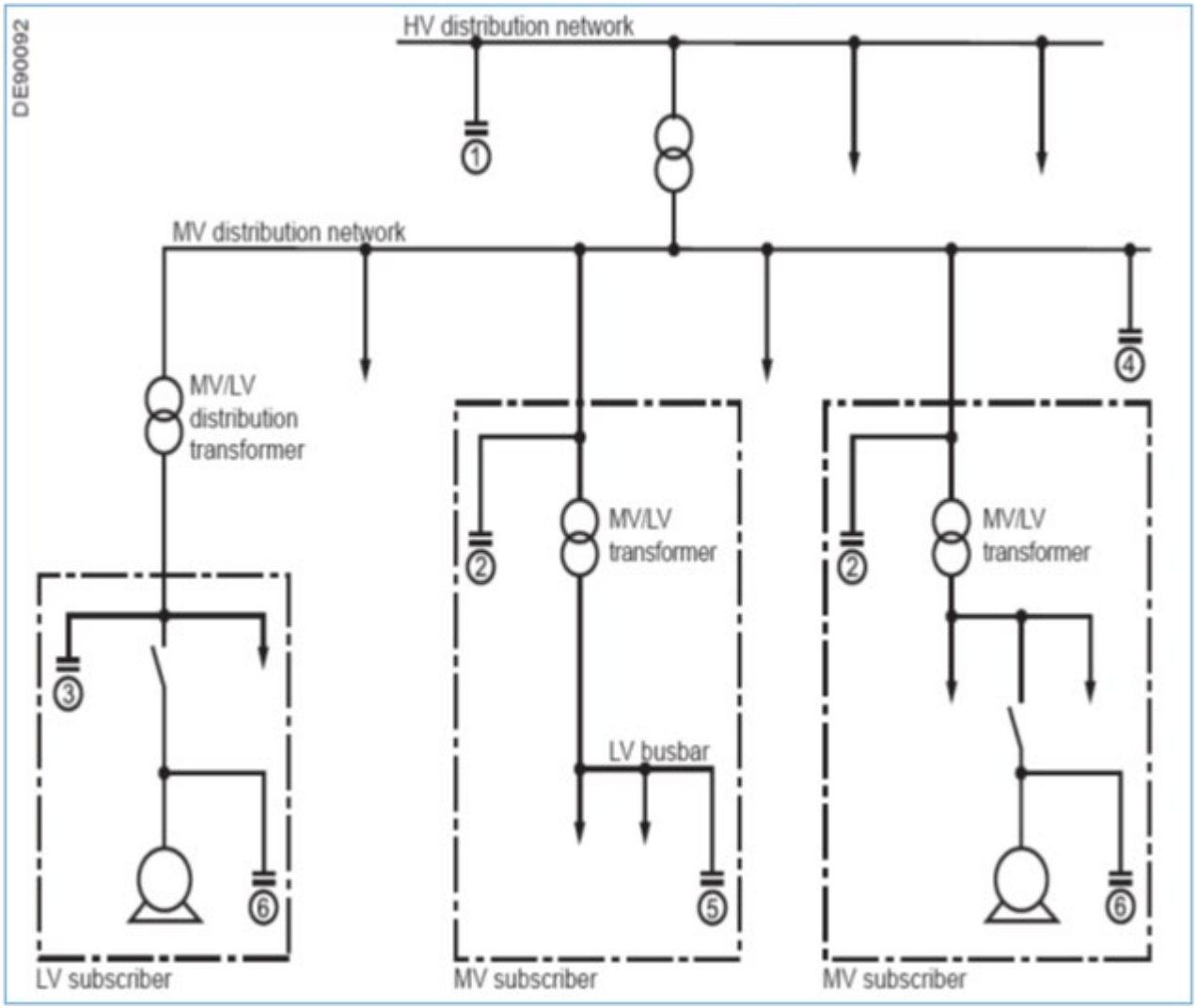
Variable demand

day/night, week/weekend, summer/winter

PF Controller measures P.F. & switches steps in & out to maintain user defined target P.F.

Selection of the ‘Compensation Mode’

Compensation mode	Characteristics
Global • on HV distribution (1) • at MV level (4) • at LV level (3)	Economical solution for non fluctuating loads. No benefit for the downstream installation.
By sector • at MV level (2) • at LV level (5)	Convenient for a large installation, with workshops having different load factors
Individual • at LV load side (6)	Very appropriate when the load power is significant compared to the subscribed power. Ideal technical configuration, as the reactive energy is produced exactly where it is needed, and adjusted to the demand



PowerLogic™ PFC Capacitor Bank Offer

Variable or Unstable loads

Network Harmonics	TDDi	<8%	TDDi	<20%	TDDi	>20%
	THD (U)	<3%	THD (U)	<7%	THD (U)	>7%
Automatic Compensation	PowerLogic™ PFC Capacitor Bank (Standard)		PowerLogic™ PFC Capacitor Bank (Detuned)		PowerLogic™ PFC Capacitor Bank and AccuSine PCS+ (Hybrid Solution)	
						
	480 and 600V/60 Hz From 50 to 250 kvar		480 and 600V/60 Hz From 50 to 200 kvar		480 and 600V/60 Hz From 250 to 1000 kvar	PowerLogic PFC and AccuSine PCS+

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Appearance & Features

Our power quality site audit and data measurements will help you discover any hidden weaknesses and validate the real efficiency of your current electrical distribution.

- Portable and compact case.
- CT's and voltage taps for temporary and retrofit installations.
- Fully programmable energy meter with other inputs.
- On-board logging of all data and events eliminates 'holes'.
- Secure 3G/GPRS transmission back to web-hosted EMS.
- Real-time and historical data published to secure datacentre for analysis and reporting.
- Email alarming and reporting.

How it is installed

- The portable power quality meter will be installed in your electrical distribution system for a short duration depending on disturbance profile discoveries.
- Live electrical equipment will require de-energization during meter installation and removal.
- The meter can be mounted to the exterior of the cabinet or equipment.
- 120V power supply will be required to power the meter and allow for live data collection/monitoring.

What it allows SE to do

- **PME reporting based on true data** compared to offline loggers CSV (comma separated values) data that can be manipulated.
- Comprehensive power quality audit to **identify root cause of power disturbances.**
- **Verification of PQ compliance for utilities** – transmission and distribution systems.
- Prepare feasible options for solving Power Quality issues.
- Verify energy savings for energy efficiency projects.
- Additional **risk analysis** assessment during our Field Services Expert journey.
- Collect relevant PQ data to specify and size AHF, PFC and/or other power quality solutions.

50%

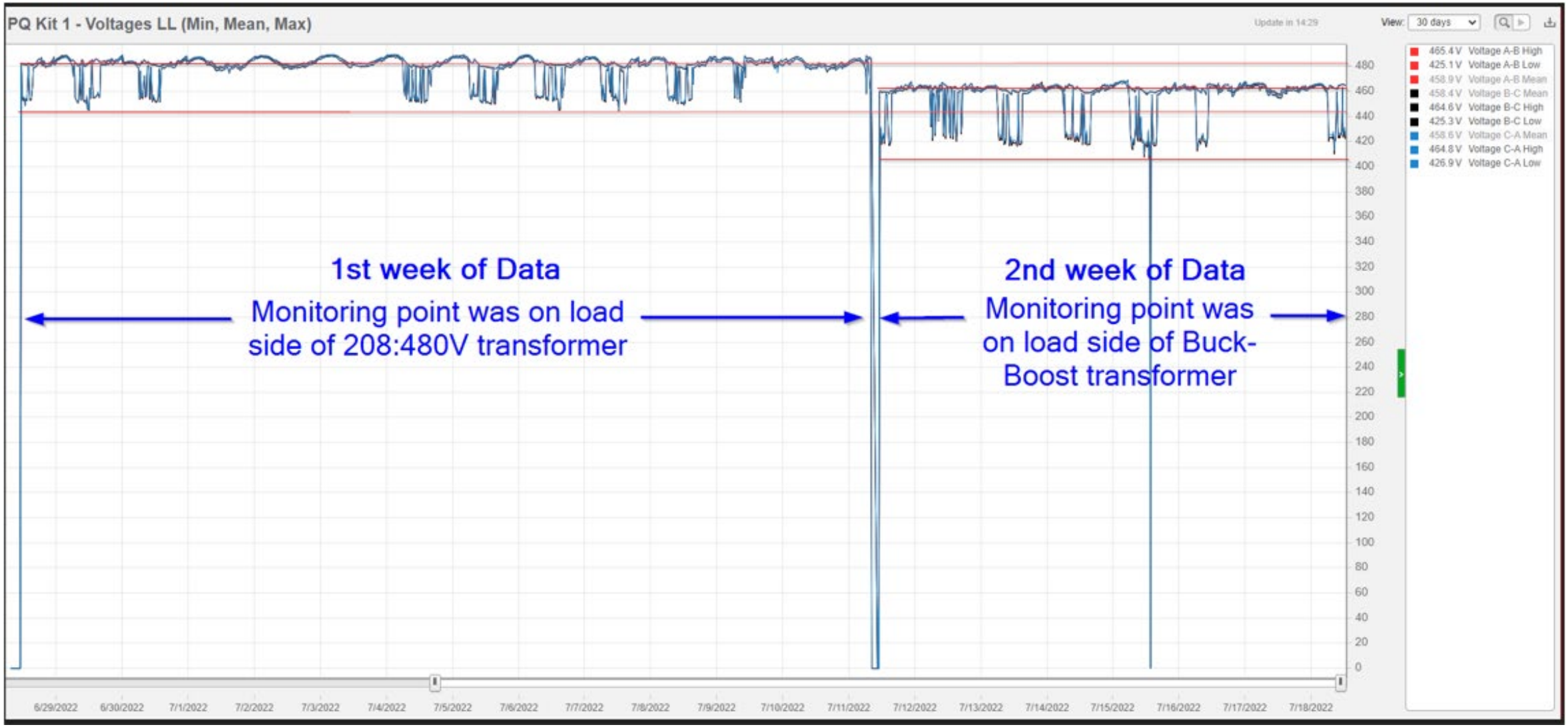
of mission-critical power outages are due to PQ issues

70-80%

of power disturbances originate inside facilities

1319 14th Avenue Calgary Voltage Measurements

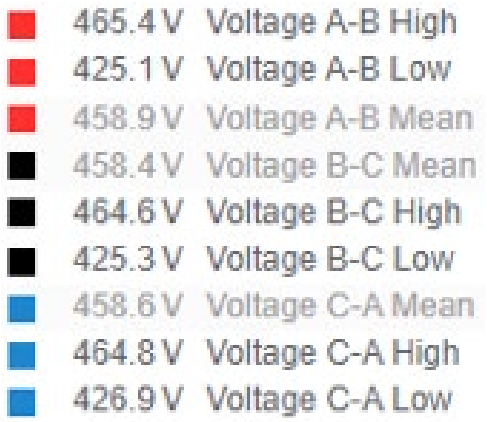
Enmax 208V supply dedicated to tower crane operation.
208:480V site transformer located on ground, downstream of utility supply.
480:460V Buck-Boost transformer located downstream of 208:480V transformer, on top of a tower crane.

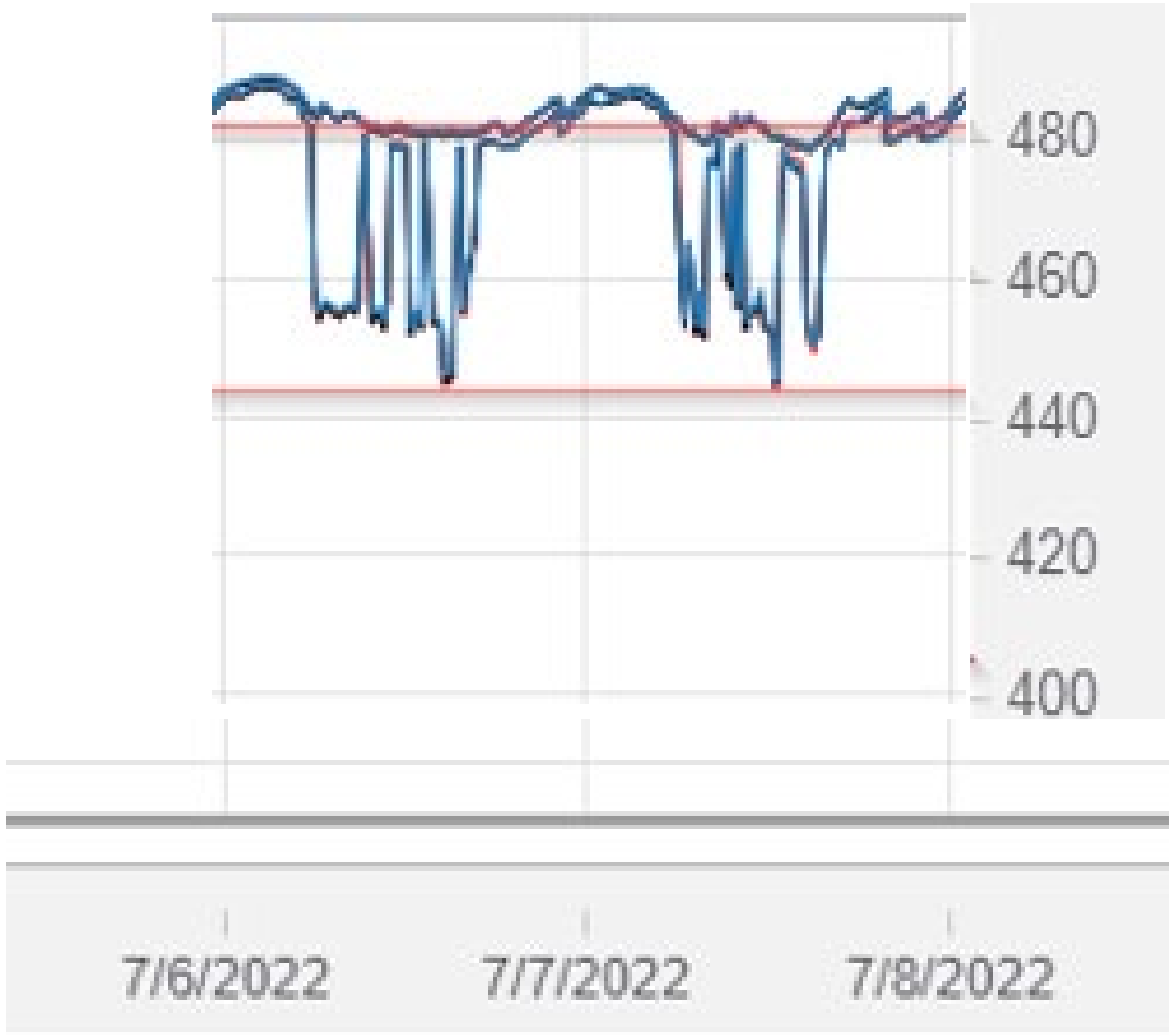


1319 14th Avenue Calgary Supply-side Analysis

Conclusion: Utility power not contributing to power quality issues.

- PQ monitoring system indicates that the voltage drops on the load side of the 208:480V transformer are within expected parameters for the proper function of electrical equipment.
- The largest voltage drops recorded are approximately **35Vrms** (480Vrms - 445Vrms).
- Represents a 7.3% drop from nominal voltage which is within tolerances.

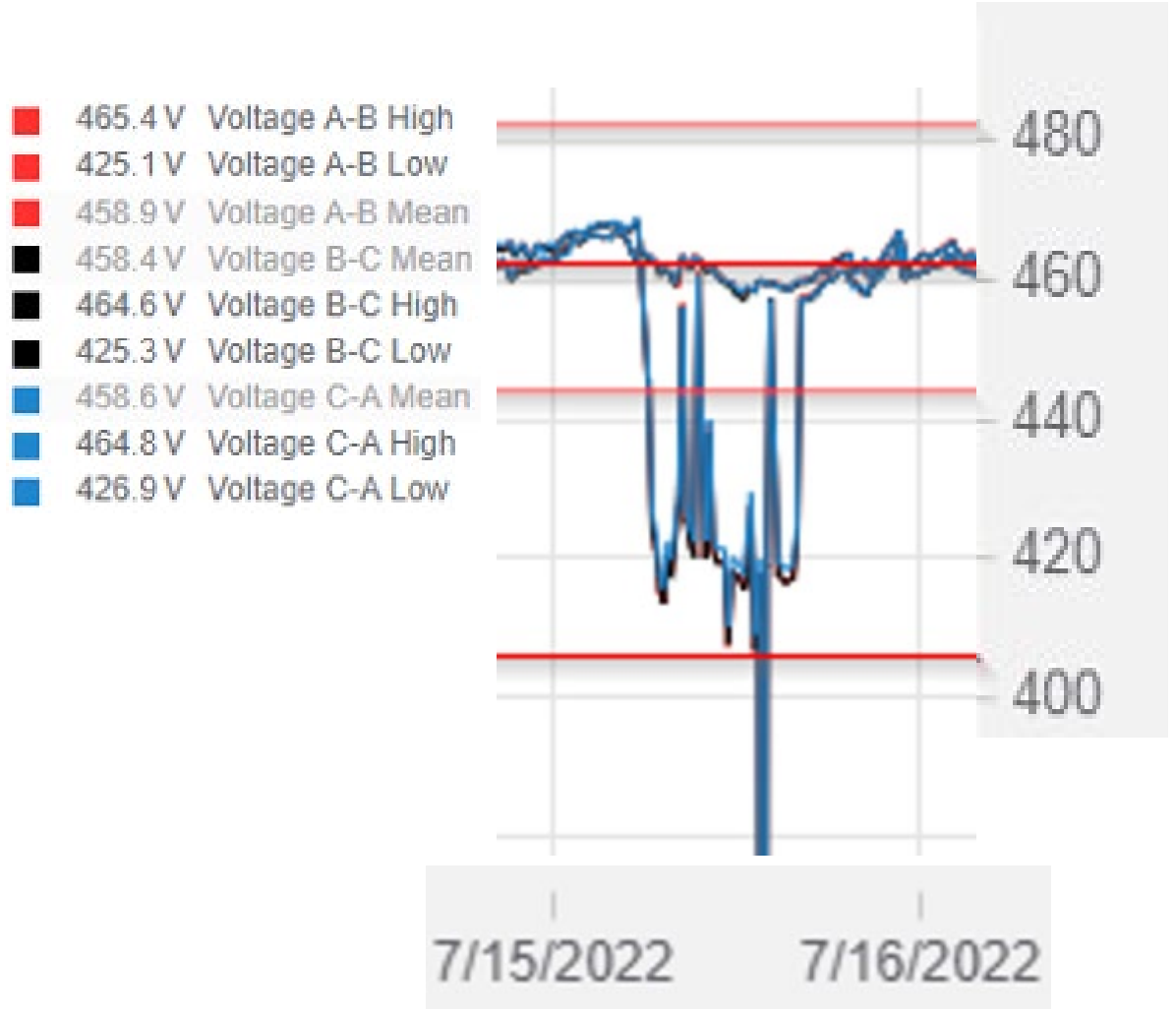




1319 14th Avenue Calgary Demand-side Analysis

Conclusion: Downstream electrical equipment (tower crane) contributing to power quality issues.

- PQ monitoring system indicates that the voltage drops on the load side of the Buck-Boost transformer on the top of the tower crane (480:460V) **Exceed** expected parameters for the proper function of electrical equipment.
- The largest voltage drops recorded are approximately **55Vrms** (460Vrms - 405Vrms).
- Represents a 12% drop from nominal voltage which is within tolerances and generally leads to shut down or malfunction of equipment sensitive to drops in supply voltage.



Voltage dropped to Zero during this incident. A result of equipment shutting down due to integrated safeties detecting low supply voltage.

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Schneider Electric offers a unique value proposal for Power Quality solutions

1. Investigate PQ problems anywhere in Canada
2. Diagnose and quantify problems onsite or remotely
3. Produce comprehensive engineering reports
4. Simulate network behavior as necessary
5. Design and deliver custom PQ mitigation solution
6. Validate performance
7. Support equipment through extended warranty and preventative maintenance

THANK YOU!

Any questions?