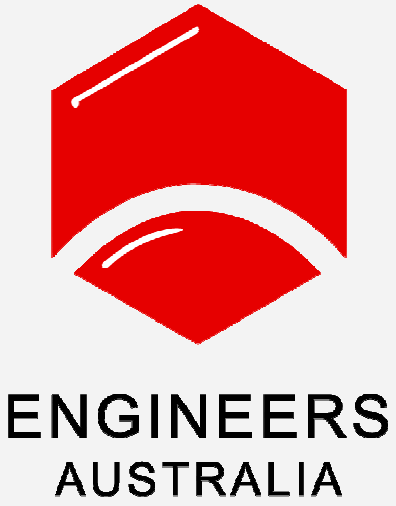
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EESA
Electric Energy Society of Australia

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Jointly Presents

Mitigating Power Quality Risks to Facilitate the Energy Transition

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ENGINEERS
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Acknowledgement of Country

Engineers Australia acknowledges the Traditional Custodians of the Countries throughout Australia and recognises their continuing connection to land, waters, skies and community.

We recognise Aboriginal and Torres Strait Islander Peoples, as the oldest continuous cultures on earth and our first engineers.

We pay our respects to them and their cultures: and to Elders past and present.

Today we present from Kaurna Country

EESA UPCOMING WEBINARS:

DATE	EVENT
2[2nd] May	Tour of Gepps Cross Clipsal Factory & Innovation Centre
2[nd] September	Integrating Nuclear Power into the Australian Energy Grid, Dr. Robert Barr
22[nd] October	Australia's Path to Net Zero, Michael Bielinski, Siemens Asia Pacific

Aaron Grant

Global Power Quality Solutions Manager, AZZO Pty. Ltd.

Mitigating Power Quality Risks to Facilitate the Energy Transition

EESA – May 5, 2025

AARON GRANT

GLOBAL PQ SOLUTIONS MANAGER

AZZO PTY LTD

AARON.GRANT@AZZO.COM.AU

OFFICE: +61 1300 00 AZZO (2996)

Personal Intro


OUR VISION
We bring technology together
to enable global energy transformation
Sustainable - Reliable - Efficient - Safe
AZZ
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Our solutions range from simple energy monitoring systems to utility-scale power automation projects, with a strong focus on renewables. We are thought-leaders in energy transformation helping guide the industry toward a sustainable future.

AZZO

technology comes together®

AZZO IS A GLOBAL ENGINEERING COMPANY SPECIALIZING IN:

SYSTEMS INTEGRATION

Design, supply, deployment and commissioning of digital systems for monitoring and control of energy management and power automation to enable electrification and renewable energy transformation

ENERGY IoT

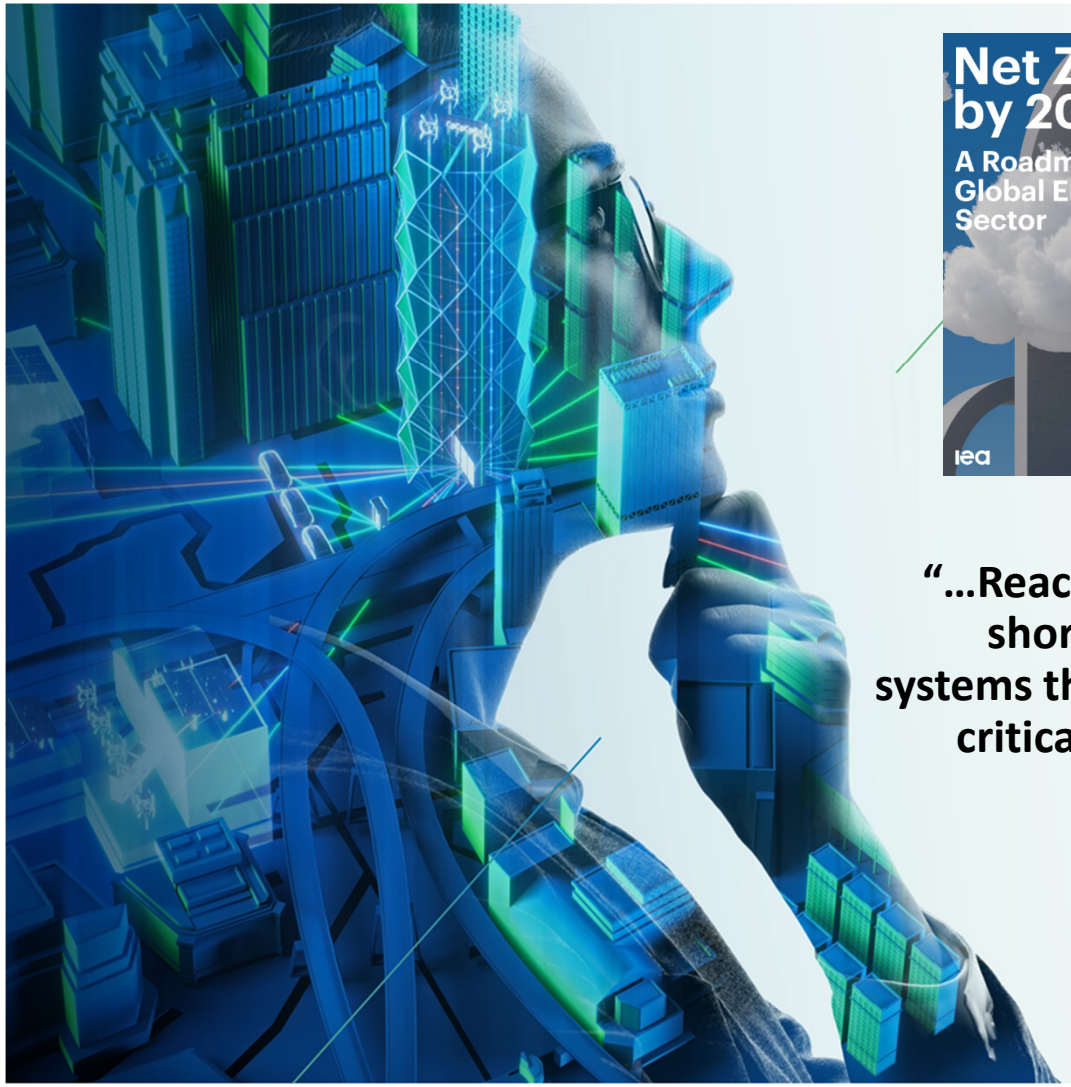
We create and operate IoT applications, connecting customer sites to our cloud services with secure networks

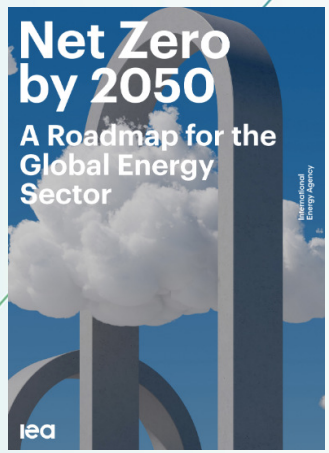
LIFECYCLE SERVICES

Providing cybersecurity assurance, power quality engineering, site and fleet management, network operations support and service level agreements

- How harmonic distortion and other power quality issues can impact the safe and efficient operation of electrical plant and equipment
- Impacts of distributed energy resources on power quality
- Mitigation strategies

Key Discussion Points





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***INTERNATIONAL ENERGY AGENCY* (Foreword – 2021)**

"…Reaching net zero by 2050… requires nothing short of a total transformation of the energy systems that underpin our economies. We are in a critical year at the start of a critical decade for these efforts."

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AS/NZS 61000.3.6: Limits for harmonic currents emission
Industrial & commercial installations
Ensures minimal distortion

AS/NZS 61000.3.7: Electromagnetic compatibility (EMC)
fluctuating loads in MV and HV power

AS/NZ 61000.3.100:
National Electricity R stem.

AS/NZS 4777: Grid cor
DER inverter testing an
Ride-through and anti-is

IEEE 519: International guideline which guides the 61000.3.x maximum permissible levels for harmonic distortion in voltage and current within power systems. It ensures grid stability and reliable performance by controlling the impact of non-linear loads at the point of common coupling (PCC).

Key PQ Standards in Australia

Key PQ Standards in Australia

- **AS/NZS 61000.3.3 & 5: Electromagnetic compatibility (EMC) - Limits** - *Limitation of voltage fluctuations and flicker in low-voltage power supply systems*

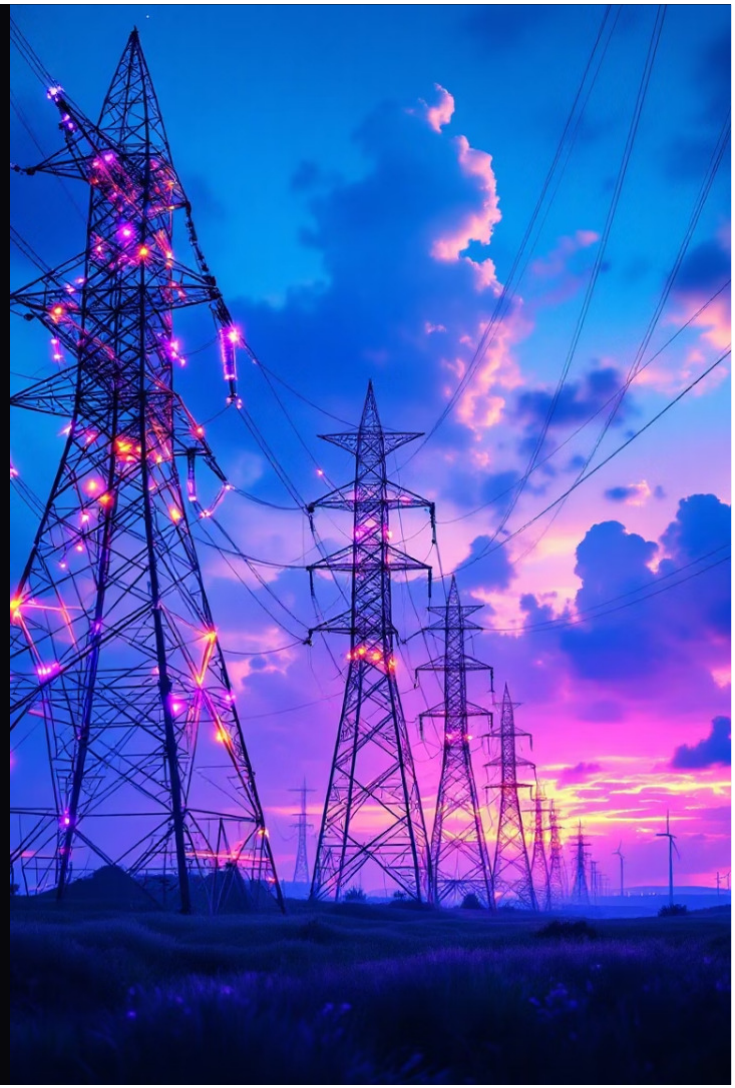
- **AS/NZS 61000.4.30:** *defines methods for measuring and interpreting power quality parameters in AC power systems, ensuring reliable and repeatable results. It covers aspects like voltage dips, harmonics, flicker, and unbalance to support compliance and system stability.*

Power Quality & The Modern Age

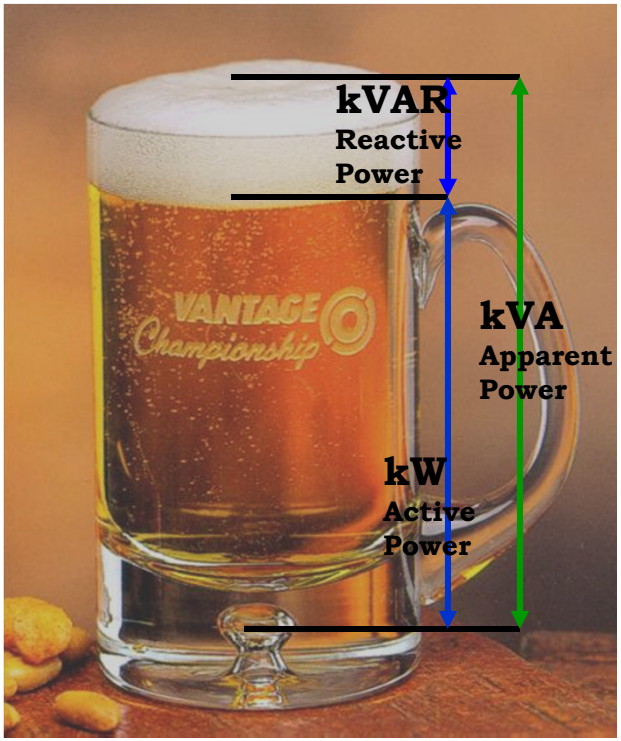
Modern power generation increasingly relies on renewable and distributed energy sources, which often interact poorly with the complex, sensitive electronic loads common today.

This mismatch leads to power quality issues such as voltage fluctuations and harmonics, causing equipment malfunction and increased operational costs.

Advanced solutions are required to address the challenges of integrating complex loads and modern generation technologies, ensuring Sustainable, Stable & Secure networks for the digital age.



Power Factor: The Beer Analogy



Mug Capacity = Apparent Power (KVA)

Foam = Reactive Power (KVAR)

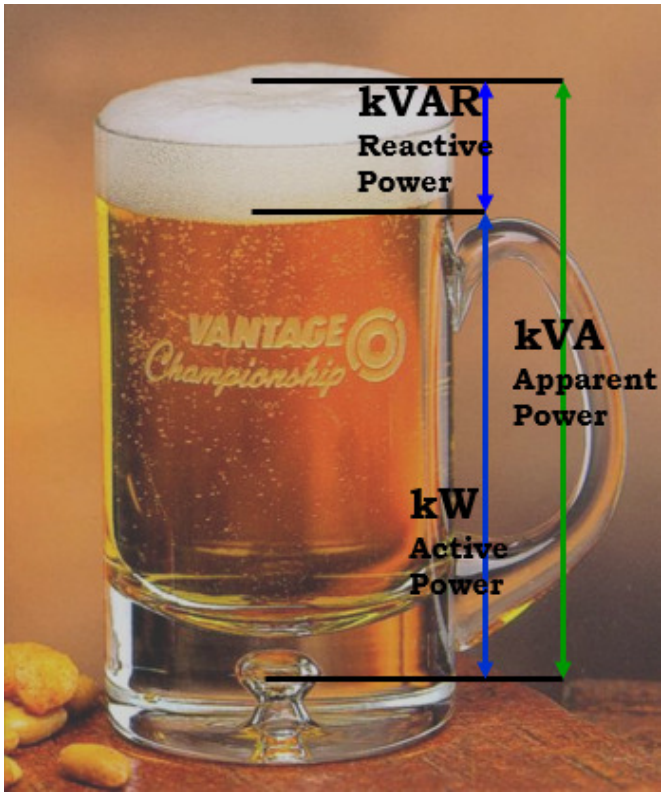
Beer = Real Power (kW)

$$\text{Power Factor} = \frac{\text{Beer (kW)}}{\text{Mug Capacity (KVA)}}$$

Capacitors provide the Foam (KVAR), freeing up Mug Capacity so you don't have to buy a bigger mug and/or so you can pay less for your beer !

What Are You Focusing On?

Standard Displacement PF



Harmonic rich PF = True PF

The Path to PQ Risk Mitigation

- Identify what poor PQ is & know the symptoms vs problems
- To mitigate, you need to identify the PQ risks
- Understand and appreciate the value of “clean **power**” compared against “clean **generation**”
- Continuously monitor and mitigate → Be aware. Be curious. Learn. Respond.
- Work **with** your utility rather than waiting for them to force you!

Impact of Technology Advancement

Distri
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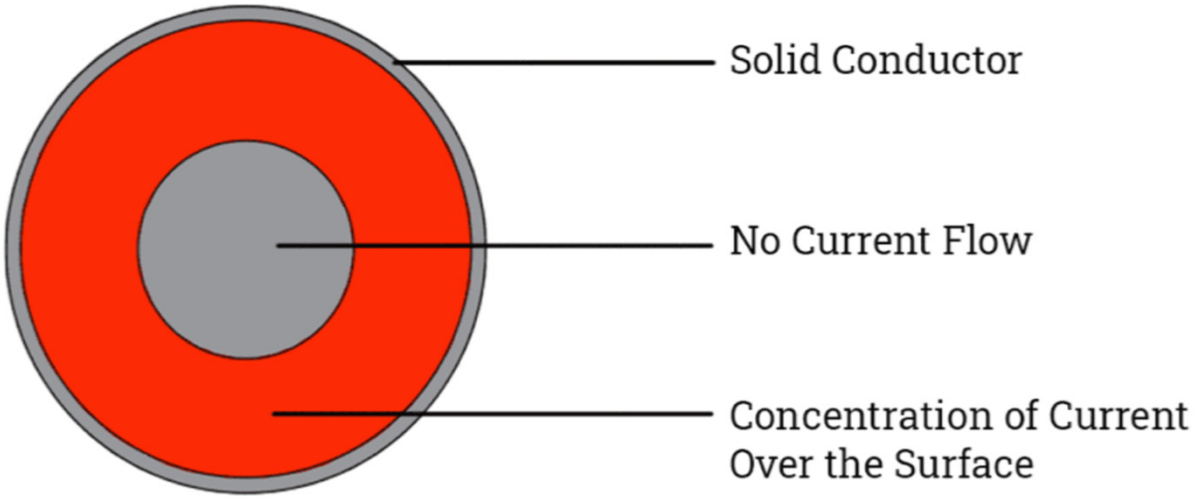
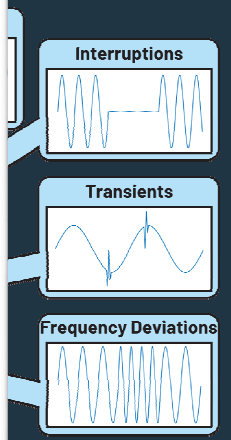
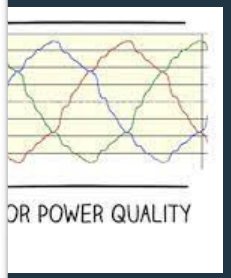
Skin Effect







Consequences of poor Power Quality - Symptoms

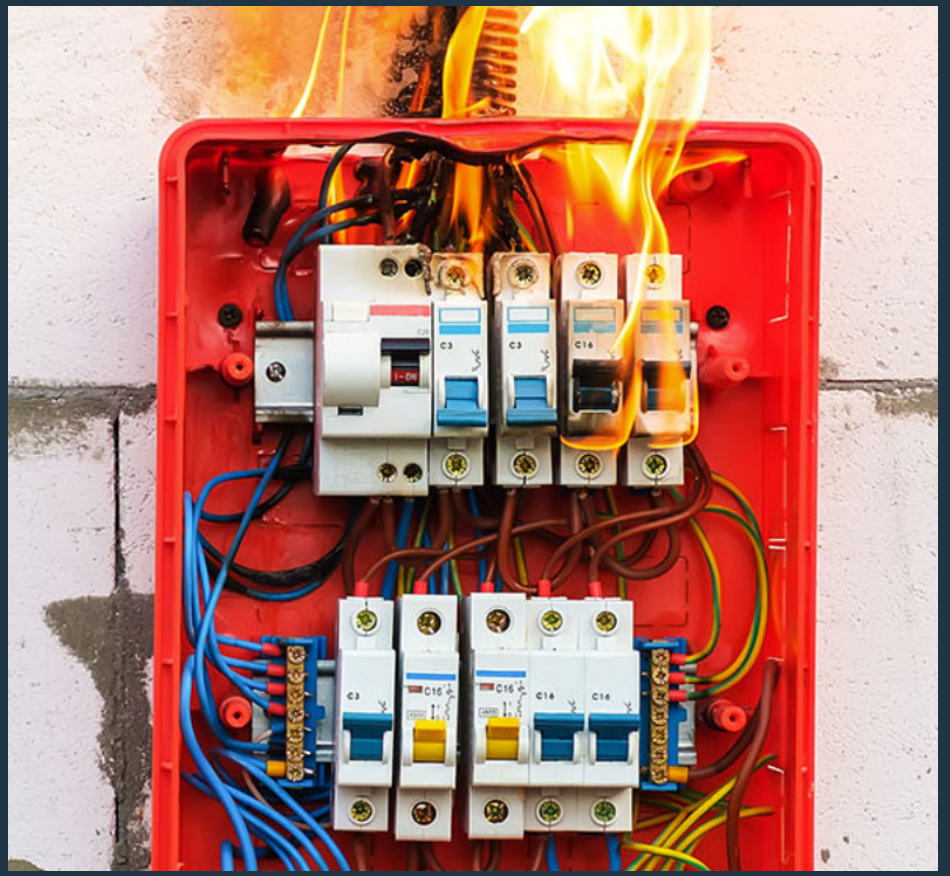
- **Overheating** of transformers, motors, generators, and cables → insulation damage & shortened equipment life.
- **Increased losses** and reduced efficiency in cables and transformers.
- **Malfunction** of sensitive electronics (relays, sensors, PLCs) → random tripping & unexpected shutdowns.
- **Transformer derating** due to thermal stress.
- **Resonance** issues from network capacitance/inductance → transients, circuit breaker trips, voltage flicker.
- **Poor PQ propagation**: Voltage distortion affecting other customers on the network.
- **EMI interference**: Harmonics coupling into communication lines.
- **Utility penalties** for excessive harmonic injection.

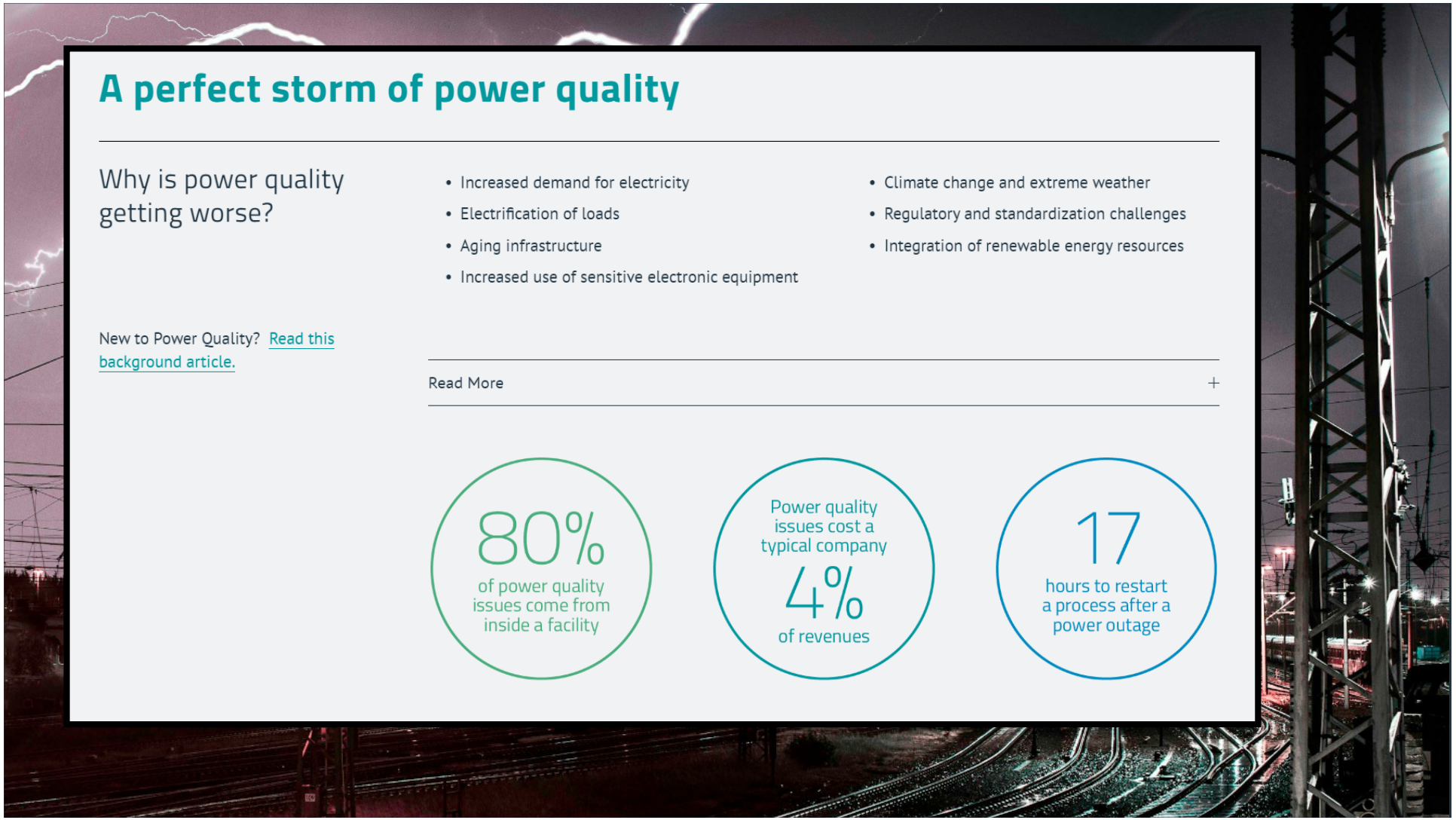
Consequences of Poor PQ Health

- Harmonics Cause Heating
- Heating Causes Insulation Breakdown
- Capacitor Failures
- Insulation Breakdown Causes Electrical Faults
- Electrical Faults Cause Catastrophic Equipment Failure
- High capital and operational expenditure
- Incorrect designs and implementation of “solutions”

Are you Misdiagnosing PQ Symptoms?

- Flickering and blinking lights
- Failing capacitors
- Excessive power bills
- Transformer issues, such as noisy, extra hot or premature failure
- Panels, neutral wiring, and other distribution equipment running hot
- Printed circuit board failures in drives, PLCs, industrial PC, etc.
- Premature motor failure
- Unexpected equipment shutdown
- Breakers tripping
- VSDs shut down
- Contactors dropping out
- Poor network communications





A perfect storm of power quality

Why is power quality getting worse?

- Increased demand for electricity
- Electrification of loads
- Aging infrastructure
- Increased use of sensitive electronic equipment
- Climate change and extreme weather
- Regulatory and standardization challenges
- Integration of renewable energy resources

New to Power Quality? Read this background article.

Read More +

80%
of power quality issues come from inside a facility

Power quality issues cost a typical company **4%** of revenues

17
hours to restart a process after a power outage

You are what you consume

You are what you consum


To mitigate, you need to identify the PQ risks
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Understand and appreciate the value
of “clean power” compared against
“clean generation”
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Distributed Energy Resources and Storages

Most Common Distributed Energy Resources and Storages:

1. Solar PV Systems
2. Wind Turbines Generators (WTG)
3. Microturbines
4. Battery Energy Storage Systems (BESS)
5. EVs and EV Chargers

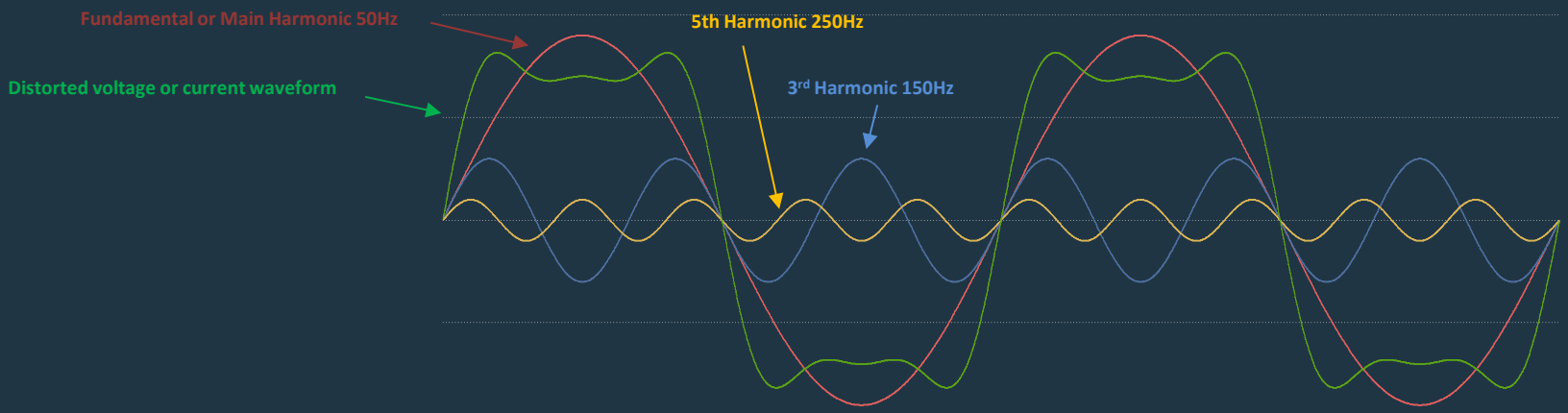
Requirement:

Distributed Generation needs to follow the utility grid requirement in terms of output voltage, current, phase and frequency when connected to the grid. Therefore, they need power electronics converters (PECs) to meet the utility requirement.

Consequence:

PECs use high frequency switching technology to convert the outputs to what is required.
High-frequency switching generates harmonics and distort the voltage and current waveforms in turn.

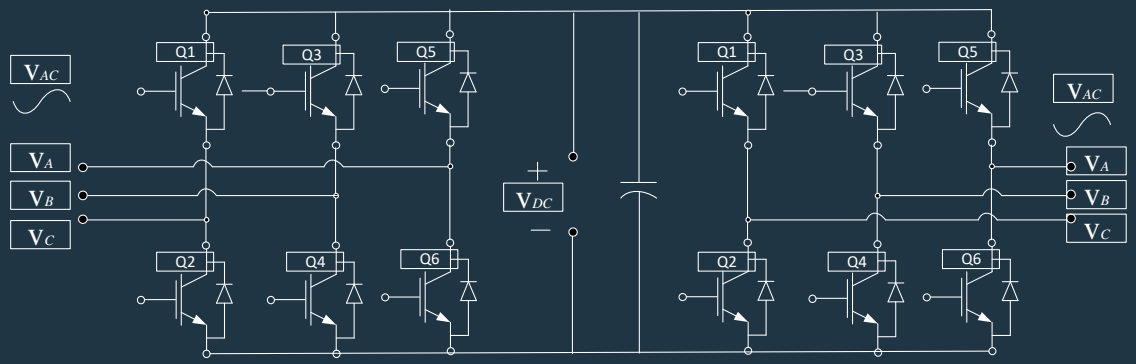
What Are The “Ghosts”?



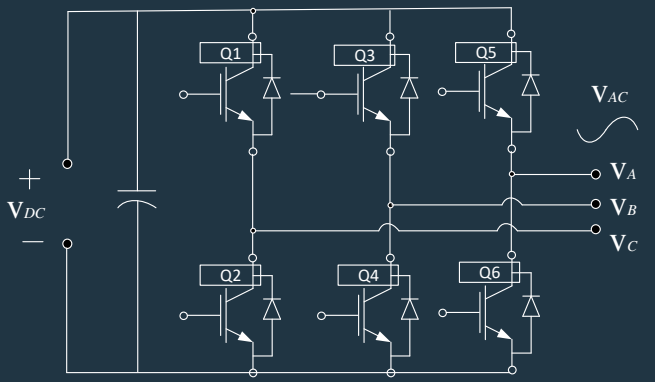
In an ideal world, voltage and current waveforms are perfectly sinusoidal.
In the real world, however, they are often distorted by nonlinear loads or sources.

A distorted waveform can be decomposed into summation of several ideal sinusoidal waveforms.
Fundamental component which has a frequency equal to the distorted waveform.
Harmonics which are waveforms with frequencies that are integer multiples of the fundamental frequency and amplitudes that are fractions of it.

How Are Harmonics Generated?



AC to AC Power Electronics Converter



DC to AC Power Electronics Converter

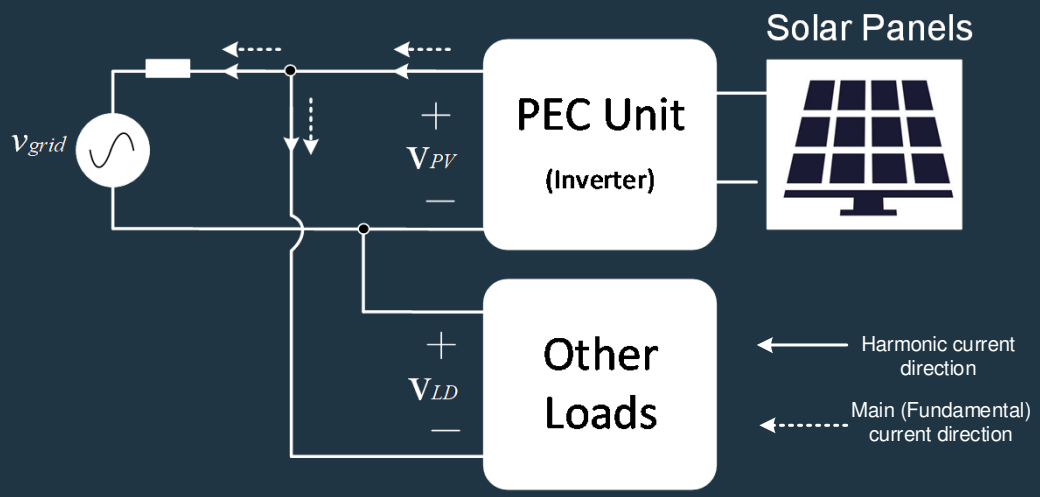
PECs use high-frequency switching devices such as IGBTs and MOSFETs to convert a DC or AC voltage to a voltage with waveform, frequency, phase and amplitude required by the load or utility grid.

Switching generates high-frequency harmonics across two distinct ranges:

1. Low-frequency harmonics, which are multiples of the grid frequency, typically ranging from 100 Hz to 5 kHz.
2. High-frequency superharmonics, which are multiples of the switching frequency, typically ranging from 10 kHz to 1 MHz.

Harmonics in Networks with PVs

The output DC voltage of a Solar panel needs a PEC to be converted to AC voltage and meet the grid requirement.



The output current from PEC unit has fundamental 50Hz and harmonics components.

As PEC is supplying the load as well as feeding into the grid, both fundamental and harmonic components flow to the loads and to the utility grid in the same direction.

Overview of Renewables and Battery Integration

- The rapid integration of solar and battery storage is driving our transition to renewable energy. However, the intermittent output of these systems and the resulting two-way power flows create challenges in maintaining consistent power quality.
- As more sectors upgrade to renewable energy and electrification, issues with power quality are becoming more widespread. If we don't address these challenges, the very benefits of our sustainable energy advancements could be compromised

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Continuously monitor and mitigate →
Be aware. Be curious. Learn. Respond.
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Act to succeed

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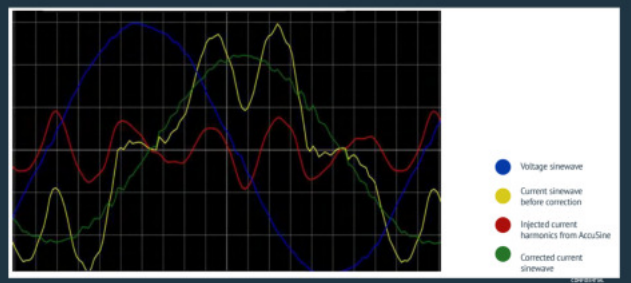
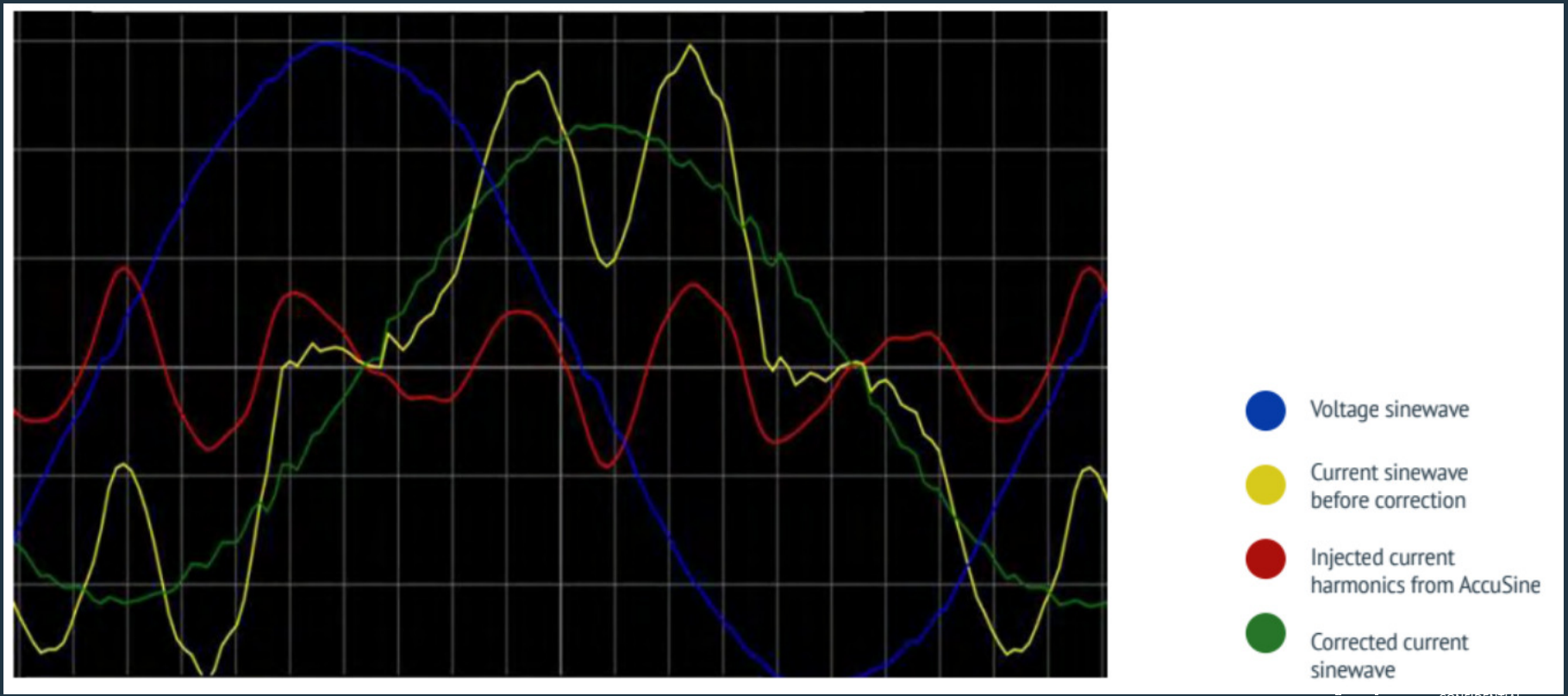
What’s in your sinewave?

Active Harmonic Filtration (AHF)



There is a clear solution ☺

Active Harmonic Filtration (AHF)




Work with your utility rather than waiting for them to force you!
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The Future **of PQ Pollution**

January 2025

Electricity Rate Designs for Large Loads: Evolving Practices and Opportunities

Andrew Satchwell, Natalie Mims Frick, and Peter Cappers (Berkeley Lab)
Sanem Sergici, Ryan Hledik, and Goksin Kavlak (The Brattle Group)
Glenda Oskar (U.S. Department of Energy)

Electricity demand from large-load customers such as data centers is projected to grow significantly in the near term. While these large loads play an important role in advancing technology innovation and economic growth in the United States, meeting their energy needs requires utilities and regulators to consider important financial and operational risks from underutilized investments or insufficient energy supply, infrastructure, and operational capabilities, with implications for all ratepayers. This paper provides an overview of how utilities and regulators are managing these risks through different tariffs, including rate structures and service agreements. Utilities, regulators, customers, and other stakeholders can use this paper as a foundation when discussing issues and sharing perspectives on developing new large load tariffs or reviewing existing ones.

The Future of PQ Pollution

Energy Markets & Policy
BERKELEY LAB

TECHNICAL BRIEF 1 |

January 2025

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Australia (ARENA) is actively addressing harmonic mitigation and grid stability through national standards, advanced inverter technologies, and improved compliance methodologies. These initiatives are crucial as large, non-linear loads—such as data centres and industrial automation—continue to grow.

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Key Takeaways

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Power quality issues don't just affect my facility—they impact neighbouring businesses and the wider electrical network. A proactive approach is essential for ensuring sustainability, stability, and security across interconnected systems, preventing disruptions and inefficiencies.

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Sustainability, stability, and security are directly proportional to PQ awareness and management in the green energy transformation.

UNLOCK YOUR ENERGY ECOSYSTEM®

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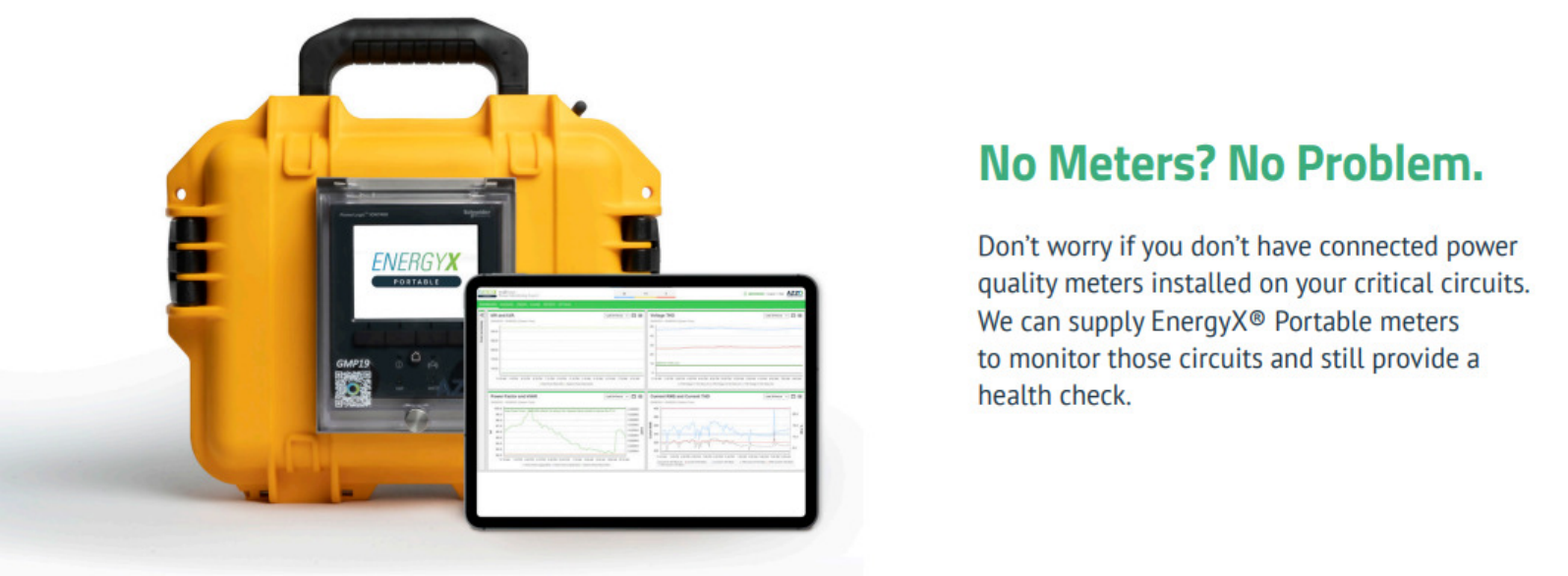
PQ stability is a choice. Waiting for others—like the utility—to take action is like ignoring a health problem until it's too late. Proactively addressing power quality strengthens reliability, maintains compliance, and keeps control over outcomes, rather than leaving them to those who have less at stake in your facility's success.

UNLOCK YOUR ENERGY ECOSYSTEM®

Benefits of Healthy Power Quality

- Improved energy efficiency.
- Reduced utility costs.
- Reduced waste and improved operational efficiency.
- Reduced emissions.
- Increased productivity.
- Minimised downtime.
- Increased equipment and power reliability.
- Lower operating cost.

No Meters? No Problem.



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New York Metropolitan Area
330 Changebridge Road
Suite 101
Pine Brook, NJ 07058

Los Angeles
10250 Constellation Blvd
Suite 2525
Los Angeles, CA 90067

AZZO AUSTRALIA
+61 1300 00 AZZO (2996)
Email Us

Adelaide
Tenancy B22
6 MAB Eastern Promenade
Tonsley, SA 5042

Melbourne
Waterman Business Centre,
175 Maroondah Hwy
Suite 30
Ringwood, VIC 3134