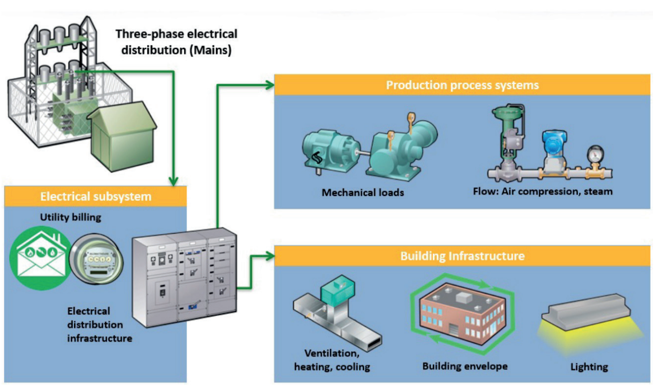
Energy efficiency

Why do we care about energy efficiency?

Energy prices **are skyrocketing** due to various factors: market integrations, price and availability of input, competition, regulatory and policy-related costs, geopolitical frictions, inflation, and many others. The future is uncertain, so monitoring power consumption and quality is becoming more important than ever before.

Energy efficiency is **the use of less energy to perform the same task** or **produce the same result.**
Energy-efficient homes and buildings use less energy to heat, cool, and run appliances and electronics. And energy-efficient manufacturing facilities use less energy to produce goods.



How to assess the baseline?

1. Profile your system. How many motors or compressors do you have? What size are they? Which controls do they use?

2. Log energy consumption (kW, kWh & power factor) at main panels and the main loads over business cycles.

3. Verify that all component locations are identified in the plant profile – especially the most energy-consuming sub-systems.

What are the main benefits of having energy efficient systems in industrial plants?

1. **Saving money** – Improve energy efficiency and reduce energy consumption.
2. **Optimizing assets that consume energy** – Identify and troubleshoot problem areas to avoid downtime.
3. **Gaining a competitive edge** – Increase productivity, cut costs, and promote energy management best practices.
4. **Where do I start? Explaining the baseline**

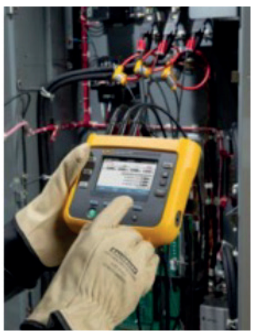
The first challenge is to realize how energy is distributed across the industrial plant and how much energy is being consumed by various sub-systems:

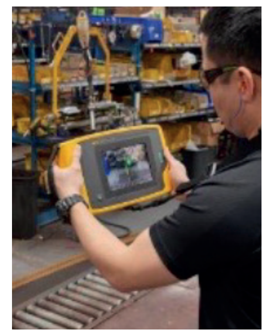
The baseline analysis will be extremely important when we will try and tackle issues with efficiency, quality of energy, and power used in our industrial plant. When completed, your baseline information should allow you to:

- **Find out where and when** energy is being used
- **Measure, log, and compare** the parameters for an appropriate time
- Move downstream of the main panel to find energy hogs and issues thanks **to mobile solutions**
- Compare the energy profile with the facilities' operation, daily, weekly, mothly etc.
- Assess quality of the **provided energy**
- **Prevent downtime** and act on time with a proactive maintenance plan
- Troubleshoot PQ issues before the **damage is done**

What are we looking for:

Power Quality issues	Mechanical issues	Electro-mechanical issues	Thermal issues	Compressed air leaks
Unbalance, harmonics, and energy waste due to reactive power etc.	Friction/heat caused by excessive vibrations and/or misalignment etc.	Variable speed drives and motors issues etc.	Too much heat generated due to insulation or installation problems and/or too much heat lost due to HVAC/ building insulation problems etc.	Up to 30% of electrical energy delivered to the compressors might end up “in-the-air”.





Focusing on Power Quality

What is Power Quality and how do we define it?

Power Quality is a set of parameters that defines the characteristics of supplied power and can describe the impact they have on the performance, efficiency, and longevity of electrical power systems and all of its components.

There are numerous standards and regulations applicable when assessing the Power Quality health and its impact on the systems across the globe; with the most important being:

- **EN 50160**
  European Standard – Transferred to local regulations

Applicable for: **Power Utilities**

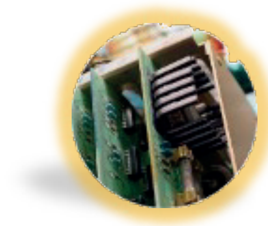
Focusing on:

- Voltage and voltage variations
- Frequency
- Voltage Harmonics (1–25)
- Unbalance
- Mains signaling

- **IEEE 519**
  Recommended Practices and Requirements for Harmonic Control in Electric Power Systems

Applicable for:

Equipment Manufacturers



Focusing on:

- ITIC (ex. CBEMA) curve
- Total THD
- Voltage Harmonics
- Current Harmonics

- **IEC 61000-4-30:2015**
  International Electrotechnical Commission Power quality measurement methods

Applicable for:

End-Users

Focusing on:

- Voltage & Current
- Frequency
- Power & Energy
- Harmonics
- Unbalance
- Inrush currents
- Transients

Power Quality impact on energy consumption, performance and efficiency of industrial systems

Key areas where energy waste may occur are related to your power quality: unbalance, total harmonics distortion, transients, voltage regulation dips and swells, and power factor.

Changes to equipment; additions or adjustments, moves, and age can all have a significant effect on waste energy over time.

Unbalance
With a balanced, 3-phase system, the phase voltages and currents need to be either equal or extremely close in terms of amplitude and phase. Any unbalance in these areas can lead to diminished performance levels or even premature failure. Poor motor performance occurs because of anti-torque and premature motor failure due to unbalance causes excessive heating of coil wires.

The biggest costs that can be incurred relate to equipment replacement and lost income caused by circuit protection trips, as well as the associated downtime and labor costs to fix the problem. But unbalance also affects energy costs as they reduce motor performance.

One of the best ways to identify voltage unbalance issues in advance is to look at the voltage that is measured at the connection to the public electricity network (service entrance). Under the EN50160 power quality standard, voltage unbalance, as a ratio of negative to positive sequence components, must be less than 2% at the point of common coupling. If the voltage is not well balanced at the service entrance, the power in the entire facility is unbalanced and must be fixed as soon as possible by the distribution network operator.

Unbalance can be present at one single load only, or a branch in the internal electric infrastructure, for example, an electric motor or even an array of motors. So, it's good practice to check the input voltage and input current on the understanding that the unbalance of these two parameters should not exceed 2% and 6%, respectively. Current unbalance is a direct consequence of voltage unbalance, and if the voltage is balanced, then current unbalance is caused by and unbalance in the loads.

Total harmonic distortion
Measuring total harmonic distortion (THD) identifies how much of the distortion of voltage or current is due to harmonics in the signal. While it is normal to have some current distortion, anything over 5% voltage distortion on any phase warrants further investigation. If this level of distortion is not dealt with, it can cause such issues as high current flowing into neutral conductors, motors and transformers running hot (which shortens insulation life), poor transformer efficiency (or the need to use a larger transformer to accommodate harmonics), and audible noise and vibrations due to saturation of the transformer core (noise and vibration are a sign of wasted energy).

The largest THD expenses relate to the shortening of the operational life of motors and transformers. Of course, if the equipment affected forms part of a production system, income can be reduced there as well, since harmonics reduce motor and transformer efficiency and performance.

The best way to identify such issues is to carry out measurements against the normal level for the motors, transformers, and neutral conductors that serve the electronic loads. It is important to monitor current levels and temperatures within transformers to ensure they are not overburdened and to understand that neutral current should never exceed the capacity of the neutral conductor.

Harmonics are often caused by specific machines or electric installations and happen only if these assets are switched on. Therefore, it is very helpful to log measurements with a time stamp so that the intermittent presence of harmonics can be related directly to certain processes.

Harmonics discussed so far go up to the 50th harmonic and all are derived from the fundamental frequency of the voltage, which is 50Hz. With the emerging application of power electronics such as frequency drives and converters, higher frequent harmonic components can pollute the network. These components have no relation with the fundamental power and are caused by the switching mentioned above. These so-called 'supra harmonics' interfere with process control equipment and can even bring processes to a halt.

Transients
Electronic devices are highly vulnerable to transients. These are impulsive voltages that are extremely short in time (less than 10 milliseconds) but may be very high in voltage (up to 6 kV). The impulses can be caused by switching heavy loads, discharging capacitors, and even lightning strikes. Once impacted by a transient, electronic devices may switch off or disrupt the processes that they are programmed to deliver.

To be sure that transients caused the problems, a measurement device that has a sufficiently high sampling rate must be used to capture the event. It is vital that these devices have a connection to ground, and the captured event is displayed so that the origin of the voltage pulse can be uncovered.

The only way to get these devices 'back online' after such an episode is to carry out a manual reset, which means production processes have to be stopped. In addition, the quality of all the products that were produced since the strike took place will have to be checked. To protect devices against transients, surge arresters can be installed that guide the voltage pulse to ground before it hits the electronic devices.

Voltage dips

A voltage dip is a temporary reduction in voltage level which can be caused by loads being added without plant managers help. These loads can draw down system voltage for a short moment if they draw high inrush currents. This can result in resets on electronic equipment or overcurrent protection trips. Dips on one or two phases of 3-phase loads can lead to the other phase(s) drawing higher current to compensate.

Income can be lost through voltage dips if a computer resets itself, for example, or through control system resets, variable frequency drive (VFD) trips and reductions in the life of uninterruptible power supplies (UPSs) because of frequent charge cycles. Any preventive maintenance strategy must involve tracking measurements on motors, UPSs, VFDs, and panels serving power to industrial controls or computer equipment. The obvious reason for taking this action would be to minimize downtime and costs.

To assess the severity of a dip, it's essential to measure the 'depth' of the dip (in percentage of nominal voltage) and its length (in milliseconds). With these two parameters it's possible to carry out a comparison against Information Technology Industry Council (ITIC) limits. Electronic equipment can cope with dips as long as they stay within those limits. If not, efforts to mitigate these dips must be taken. One problem with dips is that they often occur intermittently, so measurements need to be triggered to capture them automatically. If a previously defined trigger level is exceeded, measurement equipment would start to record the event.

Power factor

Not all power that is generated and transported to the end point is used efficiently and it is the effective power (measured in kW) that the end user pays for. Reactive power, which is also a part of the power transported via the infrastructure is not used and not charged to the end user, so it can be considered waste. This means that infrastructure such as cables, switches, and transformers are dimensioned to carry the total amount of power but only part of this infrastructure is used efficiently. This total power is called apparent power (measured in kVA).

The ratio of effective power over apparent power shows how efficiently the energy is used, with a ratio of 1 showing all apparent power is used and charged for. The lower this number, the less efficient usage of the apparent power is. Because energy suppliers cannot charge the end user for reactive power, a limit is stated in the contract. If this limit is exceeded, a significant fine can be incurred. The ratio of effective power over apparent power is called 'cosine phi' or 'displacement power factor' and, ideally, should never go below 0.95.

As well as a fine, another negative effect of a bad cosine phi can be overheating of the infrastructure. To avoid the problem, facilities need to install compensating elements, like capacitor banks, near heavy loads like motors with power of more than 50 kW, or centrally near the main switchboard.

Harmonics can also influence the power factor. If harmonics are present, compensation using capacitors on their own is not sufficient or may even worsen the situation, so it is essential to use filtering to reduce the negative effect of harmonics.

By tackling these five hidden Power Quality issues, facilities will be able to minimize unnecessary outlay, downtime, and equipment damage while maximizing productivity and energy efficiency at the same tim

Products and solutions from the Fluke Power Quality portfolio

Measurements approach and strategies

When preparing a proactive Power Quality and power consumption monitoring system, we need to take two important distinctions into account: the measurements’ duration and performance class.

Short-term inspections

Troubleshooting

- Ad-hoc” measurements
- Connect and see immediately
- Analyze directly on the device
- Part of proactive maintenanceUnbalance

Long-term inspections

Logging

- In-depth analysis
- Connect and gather data
- Analyze on the device or in the software
- Part of energy management plan and/or proactive maintenance

The measurement performance classes are defined in the IEC 61000-4-30 standard as follows:

Standard - IEC 61000-4-30

Class B

- Present in editions 1 & 2
- **Obsolete in edition 3**

Class S

- Less stringent accuracy levels
- Statistical surveys
- Internal troubleshooting
- “Non-comparable” measurements

Class A

- Highest performance
- Highest accuracy levels
- Defined measurement algorithms
- Defined data aggregation intervals

When comparing Class S and Class A it is important to remember, that the Performance Classes are not only reflecting the measurement device precision, but also calculations, algorithms, and aggregation intervals.

Measurement devices in Class S will be a good choice for troubleshooting and internal analysis, while Class A is required any time we want to demonstrate the results to 3rd parties – utilities, network operators, external experts, and juridical bodies.

FLUKE ®

Fluke 173X series overview

Fluke 173X series is a go-to device whenever you are looking for an easy-to-use, yet powerful, multifunctional device in Class S for all internal power consumption and power quality analysis; both for short- and long-term measurements.

Three-Phase Power Measurement Loggers:

Fluke 1732 (without WiFi)
Fluke 1734 (with WiFi)

Key measurements:
Automatically capture and log voltage, current, power, power factor, energy, and associated values

- **Fluke Connect® compatible**
- **Convenient instrument power (battery/socket/ line)**
- **Highest safety rating in the industry:** 600 V CAT IV/1000 V CAT III
- Measure all three phases With included 3 flexible current probes
- Optimized graphical user interface on a bright, color touch screen
- Complete "in-the-field" setup through the front panel or Fluke Connect
- **Energy Analyze Plus** application software

Three-Phase Power Quality Loggers:

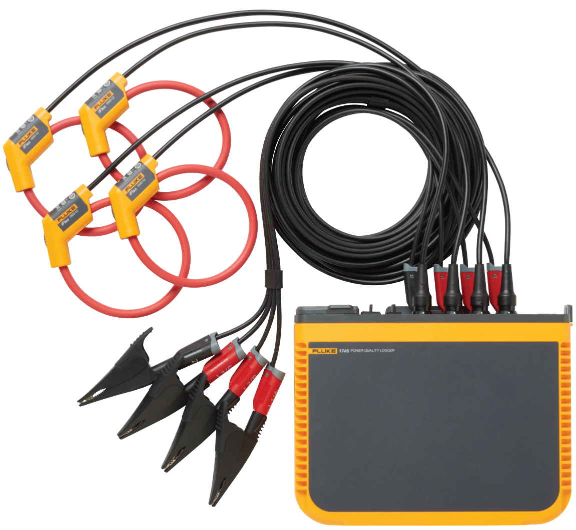
Fluke 1736 (without PQ Health and Bluetooth)
Fluke 1738 (with PQ Health and Bluetooth)

Expand your power quality analysis
Automatically capture and log voltage, current, power, harmonics, and associated power quality values. And capture dips, swells, and inrush currents with event waveform snapshots and high-resolution RMS profiles

Measure all three phases and neutral with four flexible current probes

Check the overall electrical system health with a **Power Quality Health Summary**

Fluke 174X series overview



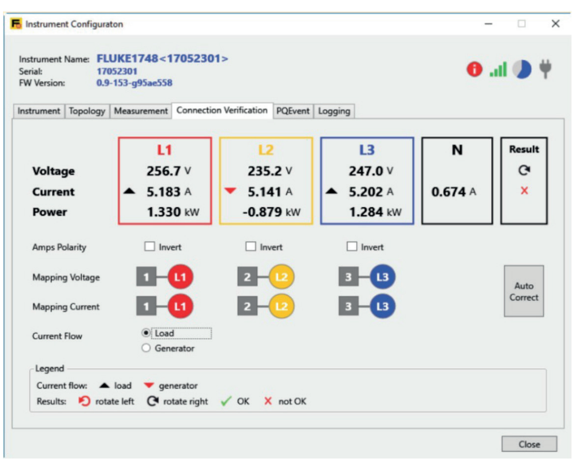
Class A Three-Phase Power Quality Loggers:

Fluke 1742 (Basic Energy studies)
Fluke 1746 (Energy + Basic PQ)
Fluke 1748 (Energy + Advanced PQ)

Transients/Waveform + RMS Profiles

Measure key power quality parameters: Measures harmonics and interharmonics for voltage and current, also captures unbalance, flicker, and rapid voltage changes.

- **Measure with premium accuracy:** Meets the rigorous IEC 61000-4-30 Class A Edition 3 standard for 'Testing and measurement techniques–Power quality measurement methods.'
- **One-touch reporting:** Create standardized reports according to commonly used standards like EN 50160, IEEE 519, GOST 33073 or export data in PQDIF or NeQual compatible format for use with third party software using the included Fluke Energy Analyze Plus Software.



Setup + connection + controls via PC/Mac (no on-board screen)

Fluke 174X series is designed to be your all-in-one power consumption and power quality logger, in full accordance with latest IEC61000-4-30 Class A standard. With easy configuration and reporting, the implementation and analysis is now easy, insightful, and efficient.

Fluke 177X series overview

Fluke 177X series is the latest addition to the Fluke PQ portfolio, combining troubleshooting and logging capabilities in one state-of-the-art solution. Fully portable with guided setup, premium design, and accessories, all in full accordance with IEC61000-4-30 Class A (also ready for upcoming Edition 4) is making it an ultimate PQ analyzer.

Control energy usage and quality with one device

- Measure in **full accordance** with **IEC 61000-4-30 ed.2 Class A**
- Register most important parameters of supplied energy:
  - *Voltage & Current*
  - *Frequency*
  - *Power & Energy*
  - *Harmonics*
  - *Unbalance*
  - *Inrush currents*
  - *Transients*
- Gather, manage, and report the results with Energy Analyze+ software
- Guided setup and clear user interface for immediate team buy-in
- All-in-one kit ready to go when you are

Key takeaways

Once your power quality study reveals areas where energy is being wasted, you can take steps to fix the issues:

1. Set up a preventive maintenance routine so you can continue to measure against your benchmark and catch issues as they arise

2. Install harmonic filters on loads that add to your facility's harmonic distortion

3. Address the sources of unbalance. This may mean setting up a repair or replacement schedule for large motors that have mechanical unbalance issues

4. Mitigate unbalanced load issues. In some cases, this may mean adjusting single-phase loads so they are more equally distributed across the phases

5. Replace blown fuses where necessary. A blown fuse on a bank of three-phase power factor improvement capacitors could also cause the problem; simply replacing the fuse can resolve a major unbalance

Power quality studies highlight a lot of what can be done to save energy, reduce energy losses due to issues throughout a facility, and lower energy costs. Power quality monitoring can show where the issues you're experiencing are coming from and how to fix them.

Beyond the energy savings, power quality studies have been shown to lead to some additional benefits:

- Discover potential failure points in assets that can cause major disruption
- Find equipment malfunctions that can lead to cascading issues
- Come across improperly installed breakers prone to accidental tripping

With the best-in-class and capability of the Fluke PQ portfolio, leveraging those benefits is now easier than ever before. Get your team buy-in with easy-to-use interfaces, stay safe with top safety features, gather and report your finding with just a couple of clicks, and eliminate PQ issues to obtain maximum energy efficiency and avoid future problems.

Get more information on **www.fluke.com**

Fluke. *Keeping your world up and running.™*

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