FLUKE®

New method for reducing facility power consumption

Quantify power waste due to harmonics and unbalance

Application Note

It's a for-better-or-for-worse scenario for electrical distribution facilities. For better or for worse, due to the climb in energy prices, large consumers are now aware of and monitoring their power consumption. For worse, local utilities have had to field more customer support activity, aside from the usual supply and reliability concerns. For better, customers are now willing to consider consumption-reduction options that previously would not have been cost-efficient. Reducing per-customer consumption is a significant goal for utilities in capacity-limited regions, and many utilities are well-positioned to offer consulting on energy optimization.

Compared to five years ago, a large percentage of large commercial, lite-industrial and manufacturing facilities have now conducted a level 1 energy audit, improved their general practices, and identified and optimized the largest loads and systems in their facility.

Now what?

In parallel to all this, more than ten years ago the IEEE began an assessment of the academic work necessary to more accurately segment and quantify energy consumption in three phase electrical systems. It had been known for many years that there were gaps in the mathematical model underlying classical three phase power measurement calculations. In particular, the effects of reactive power, harmonics, and load unbalance were not considered in the classical methods used in most power quality and consumption monitoring.

At that point in time, harmonic distortion and load unbalance were viewed as imperfections in the purity of power that caused equipment performance issues, and in the case of power factor, diminished the usability of the distributed power. Quantifying the amount of power made unusable had never been considered. Harmonics and unbalance were troubleshooting concerns, not an energy consumption issue. Until energy became a premium.

Harmonics and unbalance require utilities to generate and deliver more power than is needed or used

If 100 kilowatts come into a facility and a portion of those kilowatts is made unusable by poor power quality, the facility is paying for 100 kW but only able to use 100 kW minus the wasted portion.

If a utility customer service agent could quantify the waste and multiply it by the rate schedule, then it would be pretty clear to the customer whether the amount of waste was expensive enough to merit fixing the power quality issues.

The outcome of the IEEE efforts was a new standard, IEEE 1459–2000, that went some way into enabling the calculation of waste due to power quality but in a very academic framework. Still missing was a clear definition of the physical quantity of power waste. Shortly after the new standard was issued, two professors at the University of Valencia in Spain set out to develop the math necessary to quantify power waste due to harmonics and unbalance issues.

Firstly, Professors Vincente Leon and Joaquín Montañana developed mathematical methods based on the recommendations of the IEEE1459–2000 standard that defined the sources of specific wastes. Then, they developed a measurement instrument with a computing system that calculated what they described as Unified Power.

Their breakthrough Unified Power measurement method took the best aspects of the IEEE1459 recommendations and calculated the energy wasting effects of reactive power, harmonics and unbalance in the electrical system.

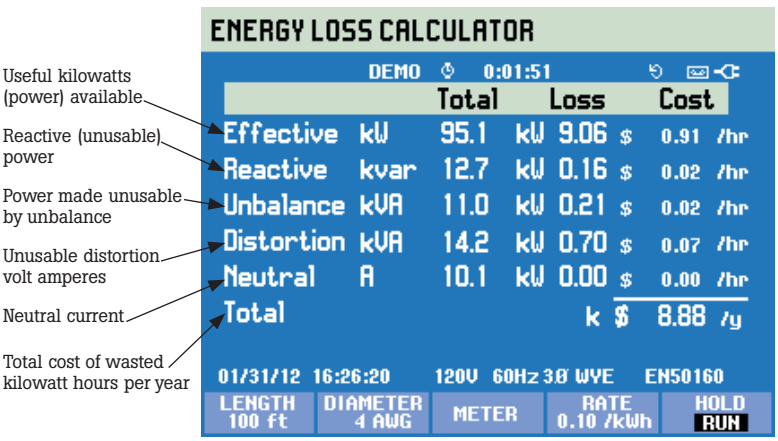
Fluke learned about the breakthrough and approached the professors about a partnership. Together, Fluke engineers and the professors transitioned the science from an academic instrument into a Unified Power measurement feature and an Energy Loss Calculator, now available in a portable, handheld power quality analyzer. Both parties hold patents, for different aspects of the new capability.

Unified Power measures harmonics and unbalance waste in terms of kilowatts, and by factoring in the cost of each kilowatt hour, it's possible to calculate the cost of waste energy over a week, a month or a year.

Field testing Unified Power – how much waste is there?

To confirm their hypotheses about the link between power quality issues and the effect on energy waste, the team carried out multiple field studies. One occurred at a mixed-use industrial park supplied by a local electrical cooperative. Some of the park's customers had significant inductive loads and the utility had already chosen to install power factor correction to reduce the effects of the poor power factor. However, when the Unified Power device was connected, it showed significant reactive power losses in the secondary of the power transformer in the park. The losses occurred primarily at night, when the inductive loads were not operating, but the power factor correction capacitors were. The energy losses were measured at 353.6k Wh/day (on average); multiplied by the utility's rate schedule this amounted to $14,000 per year. With this information in hand, the utility and the park manager devised a solution involving time-controlled relays that disconnected the capacitor bank at night. Payback time: less than one year.

A study was also devised for a large automobile plant. Six separate areas of the plant were surveyed, and numerous causes of energy waste were identified across the plant energy waste, including reactive power from discharge lamps and lightly loaded, inefficient transformers. The total waste amounted to $50,000 per year. By installing power factor correction on the discharge lamps and rationalizing the transformer arrangement, by using one high efficiency transformer instead of five lightly loaded inefficient transformer, the plant achieved significant energy savings.



A great opportunity for utilities

Addressing harmonics and unbalance often requires the support of an electrical engineer. Why not make that a service provided by the local utility? A utility engineer could assess the waste, identify the root cause, determine the best resolution—installing mitigation or unbalance compensation equipment or changing loads—and wrap it up in a recommended plan of action and time-to-ROI for the customer.

And with follow-up from the utility, the customer might even come to appreciate the overall associated improvements to equipment reliability, efficiency, life-span and downtime that come from improving power quality.

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Fluke Corporation
PO Box 9090, Everett, WA 98206 U.S.A.

Fluke Europe B.V.
PO Box 1186, 5602 BD
Eindhoven, The Netherlands

For more information call:
In the U.S.A. (800) 443-5853 or
Fax (425) 446-5116
In Europe/M-East/Africa +31 (0) 40 2675 200 or
Fax +31 (0) 40 2675 222
In Canada (800)-36-FLUKE or
Fax (905) 890-6866
From other countries +1 (425) 446-5500 or
Fax +1 (425) 446-5116
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