

# How do you measure energy consumption?

## Application Note

### With power, demand... and a power quality tool

With energy costs high, and getting higher, many facilities are trying to reduce their energy consumption. Most have not previously analyzed their monthly energy usage, traced it to operational components, or broken out the utility fees. And until you understand how you're using energy, it's hard to make smart decisions on how to reduce consumption.

#### Core components of energy

If you haven't measured energy before, take a minute to understand how it differs from volts and current. When we talk about the "energy" supplied by the utility, we're talking about two primary components: power and demand.

**Power, kW**, is commonly measured in Watts, which indicate the rate at which energy is expended in one second. Watt-hours describe the total energy expended over other time periods, such as a month, as recorded for ac energy use by our electrical utilities. Watt-hours measure actual work, such as heating or cooling buildings, moving objects or liquids, etc.

**Demand, kVA**, measures the total requirement that a customer places on the utility to deliver voltage and current, without regard to the efficiency of that delivery or whether or not it does actual work.

Now let's start measuring. Use a regular digital multimeter with an accessory current probe to measure the voltage and then

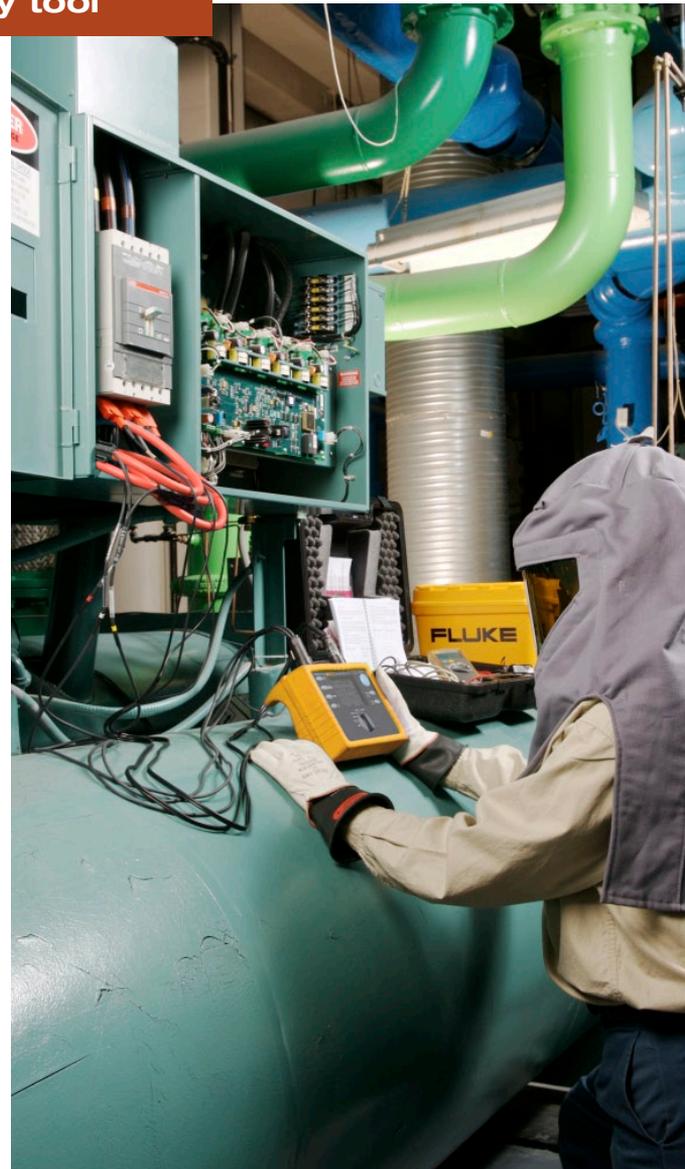
the current, and then multiply the two values to get demand—kiloVoltAmperes (kVA.)

This works for a simple single phase circuit where the load remains stable for the period of the two measurements. For a real-life load, we need to account for a few other elements.

#### Power factor, imaginary power, and harmonics

**Power factor.** If the circuit is operating at 100 % efficiency (which rarely happens), then demand is also a measure of power. In reality, power (kW) is usually less than demand (kVA). The difference, kW/kVA, is called power factor (PF). Utilities often collect a penalty charge if PF falls below 0.95. Some utilities are setting the bar even higher. Remember: Low power factor is bad; high power factor is good.

The typical industrial or commercial facility uses three phase energy distribution, and then uses that energy in a number of ways—to provide heating, operate three phase motors and motor drives, or handle single



Using a Fluke 1735 Power Logger to log power consumption at a chiller to determine equipment efficiency.



Setting up logging intervals.

phase loads such as computers and lighting. Three phases make it harder to measure power or energy usage, particularly if you plan to use improved efficiency to reduce energy use.

**Imaginary power: Volt-Amps Reactive (VAR)** is a strange type of current flow that produces no work, but is present on your electrical distribution system. It's part of the difference between power and demand and thus contributes to lowering power factor. It's usually caused by motor inductance, and is greater when those motors are not loaded to their full capacity. A constant speed motor driving a large air movement fan is an example where mechanical dampers have been used to regulate air flow, making a fan less efficient. This also reduces the load on the drive motor and increases imaginary power in the electrical supply system.

Many facilities opt to change their motor supply from direct line drive to an adjustable speed motor drive, so that they can optimize the motor's operation and speed to its load. That optimization uses energy more efficiently in the fan and motor and increases power factor.

**Harmonic currents**, reflected back into the supply system, are produced by the input rectifier loads of adjustable speed motor drives, computers, and similar electronic devices. Harmonics also reduce power factor.

**How to measure power**

To measure real power, we need a meter that can simultaneously measure voltage, current, and all the stuff mentioned above that lies in-between, over a one second period. A digital multimeter can't do that. The solution lies in a power quality tool.

Depending on the make and model you select, you can test single phase, split-phase, three phase (3 wire or 4 wire) measurement configurations, and measure or record, V, A, W, VA, VAR, PF and Harmonics. Some of the recording models also provide the means to record measurements over time to report the energy readings used by the utility—kWh, kVAh and kVARh (see Figures 1 and 2).

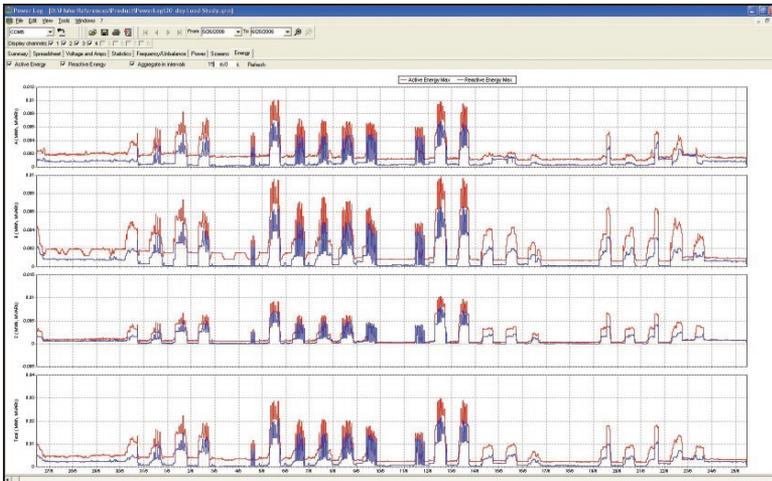
The good news here is that these tools will account for all of the issues mentioned above and accurately report energy use when it happens, as a function of instantaneous voltage and current measurements over time.

Power & Energy				
FUND DEMO 0:02:12				
	A	B	C	Total
kW	32.5	29.3	31.3	93.2
kVA	32.8	30.4	31.3	94.6
kVAR $\sim$	4.4	7.9	0.2	12.5
PF	0.98	0.96	0.99	0.98
Cos $\phi$	0.99	0.97	1.00	
kWh	1.196	1.078	1.151	3.425
kVAh	1.207	1.116	1.151	3.474
kVARh $\sim$	0.163	0.290	0.007	0.460
START 08/04/08 15:19:26 0:02:12				
PULSE CNT ON OFF		CLOSE ENERGY		MANUAL COUNTS RESET ENERGY

Figure 1. Fluke 435 energy screen. The Energy tab allows you to track accumulated kWh, kVAh, and kVARh.

Power & Energy				
FUND DEMO 0:00:29				
	A	B	C	Total
kW	32.5	29.3	31.3	93.2
kVA	32.8	30.4	31.3	94.6
kVAR $\sim$	4.4	7.9	0.2	12.5
PF	0.98	0.96	0.99	0.98
Cos $\phi$	0.99	0.97	1.00	
A <sub>rms</sub>	286	275	283	
V <sub>rms</sub> 115.87 112.05 111.72				
08/04/08 15:19:55 120V 60Hz 3Ø WYE EN50160				
VOLTAGE	ENERGY		TREND	HOLD RUN

Figure 2. Fluke 435 power screen. This is a real time view of all the common power calculations. The kW, kVA, kVAR, PF, dPF, along with V<sub>rms</sub> are displayed for each phase and total. The symbol to the right of kVAR indicates whether the load inductive or capacitive.



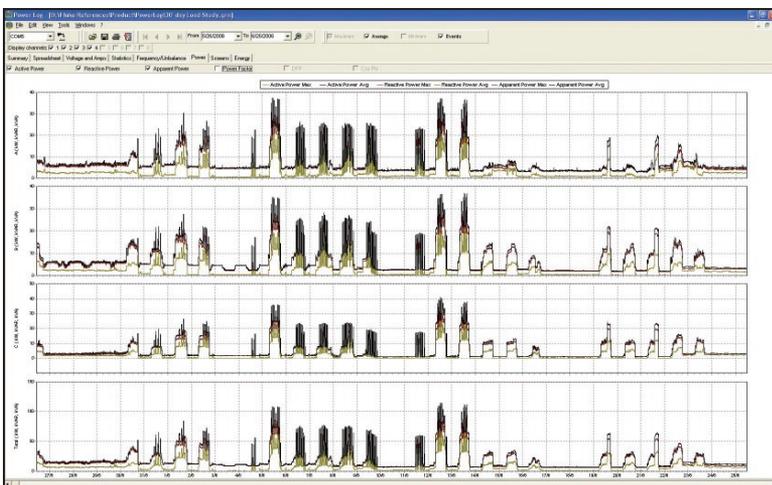
**Figure 3.** PowerLog “Energy.” This 30-day load study graph allows us to view the kWh and kVARh for each phase and total. An averaging period can also be selected to help match the billing period used by the local utility (typically 15 minutes).

**Timing**

Here’s the last complication. You can only measure energy as the work that your electrical system delivers to your loads, and that takes time. You can estimate what energy usage will be by observing power use for a short period of time. Using that information you can project longer term energy usage with some simple math.

Example: A 100 watt light bulb burning for one hour consumes 100 watt-hours of energy. That same bulb would use  $100 \times 24 \times 365 = 864,000$  watt-hours, or 864 kWh, over a year.

It gets a little more complicated with motors, variable speed motor drives, and computers, but if you measure the power usage for one hour and then apply some assumptions to the results, you can estimate the energy usage for a month or a year, provided the rate of energy usage stays the same. The other option is to do a 30-day load study with a power logger. That will get you the results shown in Figures 3 and 4, and an absolute understanding of your power consumption over time.



**Figure 4.** PowerLog “Power” view. In this view of the 30-day load graph we can view the kW and kVAR for each phase and total. From here we can identify our maximum values along with time and duration.

**Getting started**

Ready to measure power? Using your power quality tool, connect your voltage and current probes to your phase(s), and start monitoring. Check your Power (kW), Demand (kVA), and the resulting Power Factor. High PF is a good thing. Then check your detractors, VARs and Harmonics. If they are both low, then your power supply is pretty pure and you should be running relatively efficiently. In terms of energy consumption, kW and KVA are the values to compare over time, as you make changes within your facility to reduce consumption.

**If you really want to save money...**

So yes—you could use your multimeter to measure voltage and current, make your calculations, and go from there. But the whole point of energy reduction is that for the first time, electrical measurement accuracy makes a monetary difference. If your “energy” calculations are inaccurate, because they don’t account for power interferences in your system, then you really don’t know how much you’re consuming, or what impact your reduction efforts have. It’s worth it to use at least an entry-level power quality tool to get real energy values, and to then track those over time.

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

**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  
Web access: <http://www.fluke.com>

©2008 Fluke Corporation.  
Specifications subject to change without notice.  
Printed in U.S.A. 11/2008 3399367 A-EN-N Rev A

**Modification of this document is not permitted without written permission from Fluke Corporation.**