

BEYOND YOUR UTILITY METER

Three Energy Monitors for Your Toolbox



The right tools can help you evaluate your energy usage, cut your utility bills, and curb your electricity use.

Story & photos by Guy Marsden

Way back when, on my way to improving my home's energy efficiency, I made a plug adapter for an inexpensive digital clamp-on multimeter to start identifying the energy hogs in my home. The adapter was an AC plug wired to an AC socket with three accessible wires between. A digital AC meter clamped around the hot wire to measure the current to a particular device. I would read the amps, then multiply this value by 120 volts to get watts. Then, I'd multiply the watts by the number of hours the appliance was on to calculate watt-hours, dividing by 1,000 to get kWh.

This device worked well enough, but it was limited in its scope and application, and could not accurately and over time measure intermittent loads like refrigerators that cycle on and off. Thankfully, consumer products are available to do this job, helping consumers find the energy wasters in their homes.

Watt & Watt-Hour Meters

One of the simplest consumer devices is the watt/watt-hour meter used to measure the power and energy consumption of an individual appliance. The Kill A Watt meter (\$20–\$50) simplifies the measuring process and adds many great features, such as calculating energy cost and averaging energy consumption over time. The meter plugs directly into a wall outlet, which can make it difficult to read since it may be low on the wall or even plugged in behind the appliance it's measuring. So I typically use it with a short extension cord to make it easier to read. Watts Up? and Brand Electronics meters (\$95–\$235) are a bit pricier, but are easy to read since they have their own power cord. All of these devices record an appliance's energy use and cost over time, and record accumulated kWh.



This clamp-on ammeter measures current in the conductor it surrounds. Multiplying the measured current by 120 V gives watts.



A Kill A Watt meter plugs directly into an outlet, and measures watts and kWh directly for whatever is then plugged into it.

Data Logging Dedication

But watt-meters only give a small window into a home's overall power use, since they are limited to measuring 120 VAC appliances—they can't accommodate 240 VAC loads—and can only measure one appliance at a time instead of the whole household. (They can measure several appliances if used with a plug strip.) So about four years ago, I bought a HOB0 data logger that records information from up to four sensors, such as temperature, voltage, and current. A simple monitoring package runs about \$300 (logger, \$100; Lite software package, \$35; and a couple of current sensors, \$90 each). This is a science-nerd tool and requires some patience to set up and get used to. The HOB0 is programmed via a computer's USB port and can run for months on its own internal battery. It can record at intervals of 1 second up to 1 day. I have found that a 1-minute interval is fine for electrical monitoring. (I also used it to record temperature data for my solar heating system; see Access.)

Energy Gotchas & Fixes

My first energy epiphany came when I used my Kill A Watt to measure a digital video recorder (DVR)—it uses about 52 W on standby! It is basically a desktop computer that's on all the time, consuming more than 1.2 kWh each day. To cut its energy use, I plugged it into a timer, which turns it on at 6 p.m. and off again at 2 a.m., and programmed the DVR to dial in and get programming updates at 1 a.m. Each month, this saves 25 kWh. At my local utility rate of 18 cents per kWh, that's more than \$50 saved each year!

The timers that I use are digital with battery backup, and cost about \$10. They can be programmed to the minute and set for specific days as needed, and have a convenient manual override button. The timers use a miniscule amount of power (0.2 W when the internal relay is off and 0.8 W when on)—the old rotary ones that use clock motors draw about twice as much. Other items I control with timers are the wireless network router, cable modem, decorative lighting, and heat recovery ventilator system.

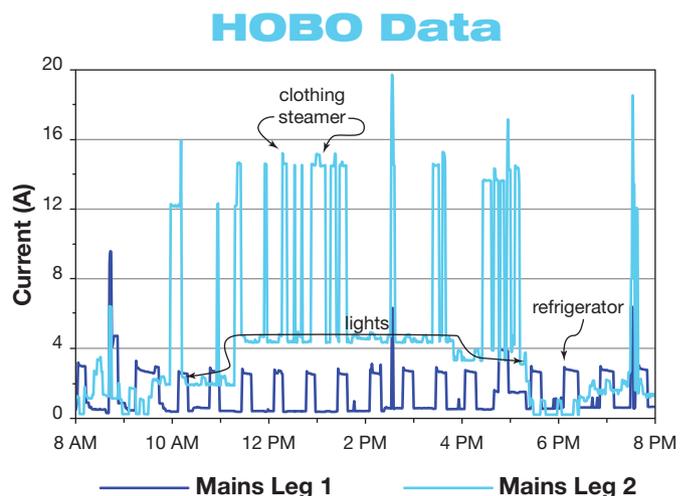


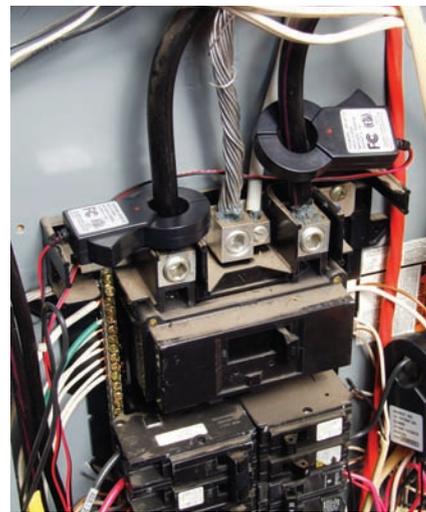
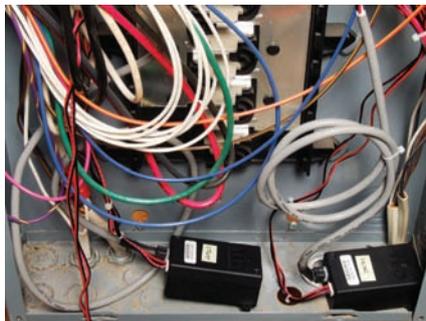
The HOB0 data logger with current sensors.

I installed the HOB0 in my breaker box with the current sensors clamped around each leg of the main power cables. I would download the day's data to my laptop, and use the PLOT function to create graphical views of energy use over time.

Trying to correlate our energy use patterns with the graphed data was like reading a mystery novel. The first thing that I noticed was two "heartbeats" that cycled on and off all day—our two refrigerators. (My wife uses a small under-counter fridge to store fabric dyes for her business.) Other wiggles and bumps in the graph plots were lighting and the well pump (big, short spikes). The HOB0 software allows labeling the graphs and customizing them in many ways.

The graphs show a detailed timeline, which you can correlate with specific times of electric usage—and figure out what loads were running. A graph plot that shifts up and remains constant for an hour or more typically corresponds





Left: TED Gateway is plugged into the wall, to receive data from its circuit monitors.

Center: TED energy-monitoring units in the breaker box.

Right: The current-detecting clamps, which attach to the energy monitors.

to the lighting load. Electric water heaters typically produce high peaks on a graph. I used my HOBO to help my neighbors identify their big energy hog—a water heater which was constantly cycling throughout the day. I helped them install a timer to shut it off during the day, when they were not home.

Sleuthing with TED

For folks who don't like to fiddle with daily downloads and want a more user-friendly and less expensive interface, The Energy Detective (TED) may offer a simpler solution for whole-house energy monitoring.

The base model TED 5000 (\$199) installation is fairly simple: a box sits in the breaker box and wires into a breaker, and two clamps clip over the main electric cables. This energy monitoring unit (EMU) sends signals through the house wiring to TED's Gateway, a small, black box that looks like a wall power supply

and plugs into any standard household outlet. This unobtrusive device is a Web server. It also transmits a wireless signal to an optional battery-powered LCD display up to 100 feet away to show real-time stats. But the main feature of the TED system is that you can plug a network cable into the Gateway that connects to your router and see a beautiful energy dashboard with detailed graphs of your home's energy use right on your computer. This only works within your LAN—if you want to monitor your home power from the Internet, you can use the Google PowerMeter (more on that later).

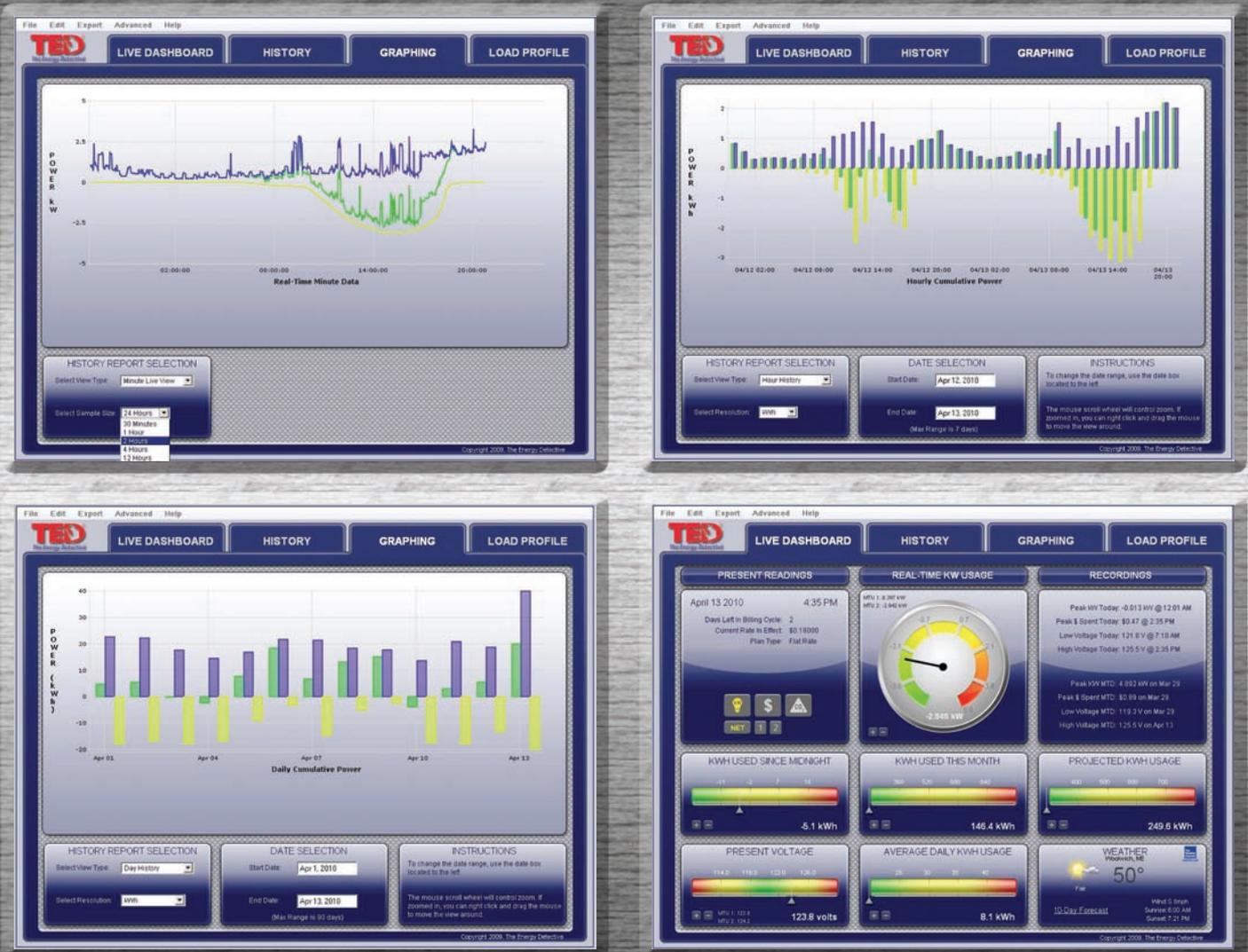
I set up the TED 5000 unit with two sets of sensors so I could monitor incoming utility power and my solar-generated power. The installation was fairly straightforward, but I needed to call tech support to get the solar power graph functions to work properly. The TED screen creates a third line on its graphs for the net energy usage. In the screen shots (opposite page), blue

Energy Savings from Timers & Switched Outlets

Phantom Load Appliance	Hours / Day, if Phantom Load Unswitched	Hours / Day Timers or Switches "On"	Hours / Day of Phantom Load	Phantom Energy Use (Watts)	Daily Wasted Energy (Wh)	Average Monthly Wasted Energy (kWh)	Annual Wasted Energy (kWh)	Savings on Grid-Tied PV System Cost*	Annual CO ₂ Savings (Lbs.)**
LCD TV, 37 in.	24	6.0	18	1	18.0	0.55	6.57	\$39.42	5.65
DVD player	24	6.0	18	4	72.0	2.19	26.28	157.68	22.60
Digital video recorder (DVR)	24	8.0	18	52	832.0	25.31	303.68	1,822.08	261.16
Stereo receiver	24	6.0	18	2	36.0	1.10	13.14	78.84	11.30
CD player	24	6.0	18	2	36.0	1.10	13.14	78.84	11.30
2 wireless routers	24	18.0	6	6	36.0	1.10	13.14	78.84	11.30
Cable modem	24	18.0	6	8	48.0	1.46	17.52	105.12	15.07
Laser printer	24	0.2	24	7	166.6	5.07	60.81	364.85	52.30
Multi-function ink-jet	24	0.2	24	3	71.4	2.17	26.06	156.37	22.41
Amplified speakers	24	0.5	24	7	164.5	5.00	60.04	360.26	51.64
Propane room heater	24	11.0	13	5	65.0	1.98	23.73	142.35	20.40
Totals						47.01	564.11	\$3,384.65	485.13

* Based on a 4 kW system at \$8 per W, no incentives included.

** Based on 0.86 Lbs. of CO₂ per kWh (for Maine utilities).



Clockwise from upper left: TED's 24-hour graph, 2-day graph, 13-day graph, and TED's live dashboard display provides real-time data, as well as historical, financial, and weather information.

represents utility electricity used; the yellow is solar energy produced; and the green is net energy consumption. TED's main dashboard page displays real-time data, such as kWh used since midnight, energy used this month, projected kWh usage, and average daily kWh usage, along with cost, CO₂ offset, and more. Graphing tools can display real-time views plotted by the second, minute, hour, day, and month. I find this scalability particularly useful to track down unusual loads—you can watch the real-time graph in “seconds mode” and turn on a light, and the graph line will jump right away.

The TED graphing function allows me to pull up the “Minute Live View” in the morning so I can examine the last 12 hours of nighttime electricity use. By hovering the mouse over the lowest consistent dips (when the fridge is off), I can see the total combined phantom loads—about 0.201 kW (201 W), which I'm still trying to find with my Watts Up? meter. For deeper statistical analysis, the software exports data for spreadsheets.

Google's PowerMeter displays exported PV output as “negative” usage.



Overall, TED is an impressive tool for learning about energy consumption—you become much more conscious of your home as an energy system. It takes a while to learn how to interpret the graphs and correlate them with what lights or appliances are drawing power. Just as with the HOBO data logger, I found the information fascinating but much more user-friendly.

Ogling Google

For checking on your house's energy consumption remotely, Google's new PowerMeter application (free) syncs with TED to integrate with your iGoogle page (www.google.com/ig). Only a few simple steps in the TED user interface are needed to connect it to PowerMeter, which gives you a 48-hour graphical snapshot of your energy usage. However, the low resolution of PowerMeter is more limiting than TED and frankly, a bit disappointing—you just can't dig into the fine details.

However, Google's premise is that by sharing energy information we can all learn how to reduce our energy consumption. For instance, you can share your PowerMeter with other Google users and your data will show up on their iGoogle page for comparison—kind of a “competing with the Joneses” premise. The original purpose was to enable utility companies to send data from digital utility meters to this system and make energy use transparent to their consumers. (At this writing, 10 utilities have partnered with Google; check the Google Web site to see if your utility has joined. Note that TED will work with any utility—it does not interface with the utility equipment.)

Besides seeing how low you can go, PowerMeter lets you monitor your home's energy use from any location with Internet access. An interesting anecdote is the story of a woman who accessed her PowerMeter app on her cell phone on the way to work—and noticed that the power level seemed high by almost a kilowatt. Curious, she returned home to find a toaster oven that had been left on. Its white plastic housing was turning brown and looked like it was ready to catch on fire. Talk about saving the day! This is the type of increased energy awareness that these tools can create.

With or without the PowerMeter, the TED 5000 system is a good investment in a well-designed tool. You can use it to find the energy wasters among family members. Seeing your real-time energy use can help to change patterns of behavior. Family can be encouraged to compete in energy-saving activities—it's all about raising energy consciousness.

What's Your Energy Path?

TED requires a home computer network, but for those less digitally enabled, using a watt-meter can yield good results. With diligence and patience, you can find your entire home's phantom loads and control them with timers or power strips.

Tools like these can help you along the path to savings—both energy and cash. Eventually talking about kWh will be as common as talking about mpg is today. Almost everyone understands automobile fuel economy and can ballpark what kind of mileage their cars get—but people who understand kWh and know how much energy their homes use on a daily or monthly basis are not as common. Think about it—can you

Power vs. Energy

If you look at your electric bill, you will see that you are billed by the kilowatt-hour (kWh)—the amount of *energy* your household consumes. One kWh is equal to 1,000 Wh—like running a 1,000 W toaster oven for an hour. “Power” (W) is instantaneous usage, while “energy” (Wh or kWh) is power used *over time*. If you look at the label on an appliance or light bulb, you will see its rated watts—this is the power that it draws at any given moment.

To figure out how much energy an appliance uses, you need to factor in the amount of time it is running. To compute daily kWh, take the wattage and divide by 1,000 to convert it into kW, and then multiply by the number of hours you're using the item during one day.

If the device label shows amps rather than watts, you can use Ohm's law to calculate the power:

Volts × Amps = Watts

An electric heater rated for 10 A at 120 V uses 1,200 W, or 1.2 kW. If left on for 2 hours, it would consume 2.4 kWh (1.2 kW × 2 hrs.).

Many electric bills will also show the monthly kWh used for the last year, and some will show average daily kWh. Pull out your bill and look closely at these numbers, as this is the simplest metric to evaluate energy consumption. For comparison, in 2008, the average electricity consumption for a U.S. residential utility customer was 920 kWh per month. How does your household measure up?

rattle off how much energy your home used last month? That can be the frame of reference for improvement—all you need are the tools and information.

Access

Guy Marsden (guy@arttec.net) documents his passion for living sustainably at www.arttec.net. Guy is a self-taught electrical engineer who develops electronic prototypes for private inventors and small companies.

“Solar Heat Upgrade: Expanding & Improving an Owner-Installed System,” by Guy Marsden in *HP119*

Link to energy-monitoring products • <http://blog.mapawatt.com/2009/10/07/list-of-energy-monitoring-tools/>

Products:

Brand Electronics • www.brandelectronics.com

Google PowerMeter • www.google.com/powermeter

HOBO data loggers • www.onsetcomp.com

iGoogle • www.google.com/ig

Kill A Watt • www.p3international.com

The Energy Detective • www.theenergydetective.com

Watts Up? • www.wattsupmeters.com

