D2: Metering and Data Information Systems

Disaggregating Electric Loads – Without Metering Them

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Lindsay Audin, Energywiz Inc.
www.energywiz.com
To your energy analysis toolbox, add automated load disaggregation software.

Software that automatically differentiates electric loads, without using submeters or data loggers, is now available.

Most offerings are focused on home and small business end users, but a few are designed for larger facilities.

This is a relatively new (i.e., since 2010) product, with some vendors still in pre-production or beta test phases.

Methods/claims/pricing vary, but all offer cloud-based services for Non-Invasive Load Monitoring (NILM).

Such software offers a new way to remotely audit and commission energy systems, potentially finding savings more quickly and easily than standard methods.
Disaggregating loads may reveal options for energy cost savings.

Utility billing data lacks the detail needed to disaggregate. Submetering and/or interval data are much better, but...

Software that disaggregates loads is now offered by 11 vendors, some since 2010.

Most focus on homes & small biz, but a few are geared to more complex commercial and industrial (C&I) loads.
Tracking interval data showed JC Penney that an off-hours lighting control system had failed, leaving the store lit all night.

To cut peak demand, electric fork lifts found to be charging at 3 PM were placed on a timer/relay to start charging at 10 PM.
Disaggregation methods vary based on data, hardware, and software.

Most rely on hardware and sub-metering of each circuit/load, using simple software to aggregate the loads for presentation and analysis. This may be expensive to install and is considered “invasive”.

Newer methods use a mix of sensors, algorithms, and software to remotely differentiate, identify, monitor, and analyze loads.
Monthly utility data offers a crude way to pick out 1 or 2 major loads.

Why might usage be higher here?

electric A/C
Hourly data across a month may reveal scheduling/trending issues.

What's going on here?

Weekends stand out, but note the high base load, even on Sunday nights.
15-minute data across a day/month reveals ops/equipment issues.

What’s causing this sawtooth shape?

- cycling A/C compressor

Every building load profile is an aggregation of the profiles of various loads occurring simultaneously.
Apply asset knowledge to **manually** disaggregate some loads.

But further separation and profiling of loads has required data loggers and/or submeters.
Disaggregation software uses one or more of the following methods:

- Sense kWh consumption in sub-interval periods (e.g., one minute or less), and IDs them via a load database.
- ID through database of known usage patterns based on algorithms involving probabilities (e.g., of time of use).
- Sense differences in AC wave form, and ID against database of known AC wave forms.
- Sense differences in high frequency (3 kHz – 100 kHz) electric signal noise, and ID against database of noises.
- One of the above to differentiate loads, but initially ID each differentiated load using human knowledge.
Some call the pattern of a refrigerator a “home’s heartbeat” due to its continuity and regularity.

Other loads (e.g., clothes & hair dryers) stand out clearly.

Loads may be identified using a database and/or human identification.

Algorithms determine run time, kWh/day, and cost.
kWh-based systems aimed at the home energy mgt. (HEM) market:

- Bidgely  www.bidgely.com
- Enetics  www.enetics.com
- Navetas (UK)  www.navetas.com
- Onzo (UK)  www.onzo.com
- PlotWatt  www.plotwatt.com
- Power House Dynamics  www.powerhousedynamics.com

All read energy data output from smart meter or meter strap-on devices in sub-interval periods (e.g., kWh/sec). Application is limited to homes & small biz (e.g., restaurant, 7-11, storefront retail).
HEM software output shows major load use/cost by month, week or day.
ID and differentiate complex loads via wave form and/or signal noise.

At right, we see AC wave forms for a CFL, a freezer, and a dishwasher. Disagg firms use proprietary wave form databases that grow as they add users.

The starting/Stopping of a load, or even flicking a switch, may also create a unique noise signal, easily differentiated each time it appears.

But both methods may still require human insight and knowledge to initially identify each load.
Software vendors using those sub-cycle / signal ID methods:

- Load IQ  www.loadiq.com
- Verdigris  www.verdigristech.com
- Verlitics  www.verlitics.com
- Wattics (Ireland)  www.wattics.com
- WattSeeker (France)  www.wattseeker.com

All involve installation of a few CTs hooked up to an on-site data collector that reads in msec or \( \mu \text{sec} \) durations. ID is via AC wave patterns or distortions, or signal noise signatures, at startup or after loads are running normally.
C&I software outputs show more detail. Services may include load analysis.

Here’s a week of data. Each color-coded load is separately profiled. The black line is total load.

Below are loads across a day, again color coded, but now also aggregated to show contributions to peak demand.

Software is sophisticated and more flexible.
FAQ

How new/proven are these products?
How much load is accurately disaggregated?
Smallest load that can be disaggregated?
How long/difficult to install and start to use?
Can it discriminate among simultaneous start-ups?
How about variable loads (e.g., VSD, dimming)?
Are any systems compatible with my EMS?
How is it priced?
What’s the cost for a 100,000 SF office building?
My Assessment (as of 9/13)

The HEM/small biz systems are useful, but so basic in output and methods as to be limited to facilities with perhaps 5-10 loads.

Systems focused on C&I loads are in beta (or other) stages with only a few operating sites in the US. European firms may be more established, but offered only minimal (or no) case studies.

Bottom line: by mid-to-late 2014, all C&I offerings may be ready for rollout. They show potential, but costs & abilities vary. Question all savings & payback claims.
Thank you for your time and attention.

Energywiz Inc. greatly appreciates the help provided by these suppliers and organizations in developing this presentation:

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