E3T Energy Efficiency Emerging Technologies

Washington State University Extension Energy Program

Bonneville Power Administration

Energy Services

Western Area Power Administration

EMERGING TECHNOLOGIES SHOWCASE WEBINAR:

NON-INTRUSIVE LOAD MONITORING

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August 14, 2013
Question and Answer session

Q: In a demand response project, if I want to know if a particular appliance was turned off or not in response to an instruction, how can I use NILMS?

A: There are two separate issues – first there's a verification issue and second there's a measurement of what that change in load looks like over the duration of the event. A lot of that can be seen by looking at the Advanced Metering Infrastructure (AMI) meter on which we've done some testing. It's not completely accurate but the load changes do show up depending on how large the interruption is and depending upon if there's interference with other types of devices at the same time. The NILMS device would provide a sort of an improved magnifying glass on the event, which could be useful. EPRI has not done any specific testing using NILMS devices but that would be an area of interest for us.

Q: Were the tested NILM products able to detect plug-loads?

A: Based on our first round of testing with food vendors, the NILM products were not able to detect plug loads below 60 watts. 60 watts was the threshold for the most extensive technology that EPRI tested. That technology was able to identify 10 loads. The lowest plug load it could detect was with fans – two fans which combined had 160-170 watts.

However, when end-use load research was performed with lights and monitored at the circuit panel, monitors were able to pick up the light load. That appears to be a distinct advantage, because lights can be considered a plug load.

Q: Can these devices communicate in BACnet and be interwoven into existing EMON, Apogee, and Allerton systems?

A: Based on what EPRI has seen, the devices are not inter-communicable yet. Every technology has their own IP connection or they have their own collection method. Some of the vendors download data that can be collected and stored on-board or it could be fed on a continuous real time basis to the cloud. We have not seen any of these devices but there might be additional modules or there might be add-ons to hardware options that could allow and interface with other communication technologies.

Q: Were various types of sensors more or less accurate than others? I have been relying on high accuracy for CTs when measuring individual pieces of equipment; should I not?

A: CTs are certainly very accurate, much more accurate than a NILMS device. If you have the funds and your accuracy requirements are high, CTs are the best option.

However, CTs are an inconvenience to use in this way because they need to be installed inside the customer's home and this can intrude on the customer's comfort. Different technologies have different accuracies and both CT and NILMs technologies can vary in their performance based on the type of house. For example, single- or two-occupancy homes might show more disaggregation accuracy with CTs because the load traffic coming on and off is small.

A limitation of CTs, however, is that they don't always pick up lights when monitoring at the circuit level. It's very difficult to get all of the lights captured whereas the NILMS devices are pretty good at doing that. But then again CTs are much more accurate than the NILMs devices.

Looking forward, there are NILMS devices that are fairly accurate and we're optimistic that some of these new enhanced technologies will improve appreciably.

Q: What is the capability to discriminate the various parts of heat pump operation: heat pump, strip heat, and fan operation?

A: NILMs can do that fairly well. The heat pump operation can be disaggregated into its component pieces. The same thing can be done with refrigerators. Anything that has a multi-state can be disaggregated into its different states.

Q: How applicable is this to industrial scenarios and when will there be testing in an industrial setting?

A: There has been a lot of discussion and interest from our funders on the industrial side. No actual hardware technologies are on the market yet, or in any of the research phases. There are quite a few web analytics-based services being offered for industrial customers, where the data service provider comes into the facility and collects information about the process, square footage, number of lights, operations, etc. Based on an engineering analysis algorithm, an estimate can be made of the consumption of individual processes in the industrial plant. However, there appears to be a lack in products using non-intrusive load monitoring in that area. It would definitely be great to have a technology that would be low-cost, non-intrusive, or even non-invasive. The non-intrusive aspect does not have much significance in the commercial and industrial world – it's more of an issue for residences because customers are concerned about privacy and/or being inconvenienced by having an electrician going inside the house to do all the wiring. For commercial/industrial that is not an issue so non-intrusive load monitoring may have a limited application in industrial sectors even if it becomes available. That is our initial thought based on tests and research.

Q: What is the rest of the industry doing for metering when panels have numerous systems (lights, HVAC, Production) all in one panel? We are finding the CTs to be very costly to meter at a systems level.

A: Various customers have different ways – some are using engineering models and validating different circuit level consumptions with the engineering estimate. Some use DOE-2 or eQUEST or the like. You can program your facility characteristics and attributes into the software and get an estimate of how

much individual end-use consumption is for that type of facility. In terms of actually metering, there is increased interest and research in sensors. Some wireless sensors are being installed for individual end uses. These are supposed to be low cost, non-invasive type sensors that can collect energy measurements for smaller loads and then communicate that wirelessly to a central point. This information comes in terms of feedback from our customers and may not be an ongoing phenomena or it may well evolve into much more.

Q: What would be involved in a home application to correctly map equipment back to the NILM system?

A: It depends on the system that has been designed. Each system is a little different from one another. Most of the systems now require the homeowner to go through the house and turn devices on and off. This manually learning process means that the penetration is going to be much less than if it's an automatic learning process. Most of these devices are learning manually, not automatically. Thus, there is a risk of error if it doesn't necessarily match. The typical process is that the NILMS devices identify the load based on the transformers for the hardware-based and other cloud-based, clustering or statistical-based approach. Once the load is identified it matches it up. There are two items that need to be accurate: the first is to capture the entire load and the second is to name the load components correctly. Naming seems to be pretty accurate, we did not observe any end uses that were clearly mislabeled.

Some technologies have only preprogrammed or pre-defined load libraries which are very typical of conventional loads. New loads like emerging heat pump water heaters, LED lights, etc. are newer loads and don't have signal libraries in the unobtrusive technologies. There is a manual process for these technologies. In our testing we saw that most of them were able to identify the major loads very easily – air conditioning, water heating, clothes washer and dryer, for example. They did have some load labeling issues with smaller loads because they could be multiple loads, such as with a lab, fan, or compressor. At the 100 or 120 watt level there could be multiple loads drawing the same amount of power for the same amount of time. That is when these technologies would label them as load 1, load 2, or some sort of anonymous label without actually labeling the load. It depends on technology; EPRI thinks the technology is improving and that in the future there will be automatic load labeling as well. What is used now is mostly automatic load identification but semi-load labeling.

Q: Has there been interference issues with the wireless devices?

A: Functionally, no operational issues were observed with wireless devices. That said, EPRI did not do standard emissions testing on NILM to assess line-conducted or radiated emissions based on IEC 61000-4-6, 4-16 and 4-3 standards. This would have to be part of a future full-blown test to evaluate system compatibility and full functional features of NILM. This may be performed if there is interest.