A System for Disaggregating Residential Electricity Consumption by Appliance

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THERE are many opportunities for reducing electricity consumption in buildings, but identifying and quantifying them is often perceived to be too time-consuming or too expensive to justify. The average consumer currently receives a monthly bill as a signal of their consumption. Most building owners don't have a good sense of how much energy different appliances and activities consume. In fact, people consistently over-estimate the impact of less-energy-consuming appliances and less-effective conservation activities, and under-estimate the impact of more-energy-consuming appliances and more-effective conservation activities [1].

Many studies have shown whole-house electricity-use feedback interfaces, even if displaying only instantaneous power, to motivate savings of 5-15% (see [2],[3] for a survey of this field). Larger savings are potentially achievable if more detailed data were available not only to the user but also to automated building control systems or to electricity suppliers, allowing them to reward peak-shifting loads or subsidize equipment upgrades. However, most solutions for obtaining appliance-specific feedback are expensive

Project Undertaken

Research on Non-Intrusive Load Monitoring (NILM), a technique for discerning individual appliance operation from whole-house measurements, has been underway for over 20 years [4],[5]. Most implementations utilize changes in the total real (P) and reactive (Q) power of a building as signatures for each appliance state transition. There are a small number of commercially available systems that implement NILM, albeit marketed for utilities as a tool for performing load research.

As a proof of concept, and in order to obtain preliminary data that would help us evaluate the feasibility of using NILM to support electricity audits in a residential building, we decided to focus our attention on one of the top residential loads: the refrigerator. We installed a NILM prototype system in an apartment building, and a plug-level power meter was used to accurately track the individual consumption of this appliance. The experiment consisted in monitoring this load for a week, using the two methodologies (NILM and plug-level meters), and then comparing the estimated energy consumption as computed by each.

Results and Discussion

Fig. **1** shows the results of the experiment over the course of a few minutes. The NILM system underestimated the energy consumption of the refrigerator by 15% for the duration of the experiment (1 week). These results, although limited to a single appliance, show promise for the feasibility of utilizing NILM for supporting the goal of residential electricity audits. Even if not for the energy calculations, estimates of when the refrigerator cycles take place (when the events occur) can be helpful. Perhaps the most significant source of error for this experiment was the refrigerator's defrost cycle.

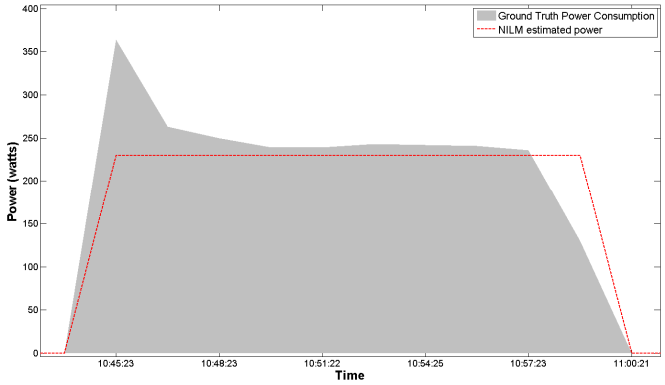

Fig. 1. Power consumption of the refrigerator as estimated by NILM (dashed line) and measured by the plug-level meter (filled gray area).

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