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Research Paper

Electrical-end-use data from 23 houses sampled each minute for simulating micro-generation systems

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HIGHLIGHTS

- Electric end-use data from eleven Canadian houses were gathered for one year.
- For each house data were sampled at a one-minute-timescale resolution.
- These data and previously gathered data from twelve other houses were analyzed.

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ABSTRACT

An improved understanding of the consumption patterns, end-uses, and temporal variations of electrical loads in houses is warranted because a significant fraction of a society's total electricity consumption occurs within residential buildings. In general, there is a lack of high-temporal-resolution data describing occupant electrical consumption that are available to researchers in this field. To address this, new measurements were performed and combined with data emanating from an earlier study to provide a database of annual measurements for 23 houses at a 1-min resolution that characterizes whole-house, non-HVAC, air conditioner, and furnace fan electrical draws, as well as the draw patterns of some major appliances. All houses were located in Ottawa, Canada. The non-HVAC measurements of this 23-house sample were shown to be in agreement with published estimates for the housing stock. The furnace fan was found to be the most significant end-use. These high-temporal-resolution data of electrical demands in houses can be used by researchers to increase the fidelity of building performance simulation analyses of different micro-generation technologies in residential buildings.

1. Introduction

Power flow in the reverse direction caused by distributed generation is the main issue limiting PV penetration levels in existing electricity distribution networks [1]. As was noted by Castillo-Cagigal et al. [2], in the future as higher levels of PV penetration occur, it will be more important to consume the electricity produced by PV on-site and the current widespread practice of exporting electricity generated by PV to the local electrical supply network will become less attractive. This is also true for any micro-generation technology. Consequently, electrical consumption characteristics of occupants will play an increasingly important role in determining the performance of micro-generation systems.

Saldanha and Beausoleil-Morrison [3] pointed out that both the magnitude and the temporal distribution of non-HVAC electrical loads influence the operation of energy conversion equipment within the building and in the electrical supply network. Their work also demonstrated that efforts to synthetically derive non-HVAC electric loads (e.g. Refs. [4–9]) may not adequately capture either the temporal variability nor the variation between households observed in the measurements.

Saldanha and Beausoleil-Morrison [3] summarized some of the past efforts in measuring and characterizing residential electrical demand patterns, such as those of Pratt et al. [10], Parker [11], Firth et al. [12], Knight and Ribberink [13], and Isaacs et al. [14]. Of these past efforts, the finest temporal resolution of gathered data was achieved by Firth et al. [12] and Knight and Ribberink [13] (who sampled the electric consumption of 72 houses in the U.K. at 5-min periods) and Isaacs et al. [14] (who sampled the electric consumption of 400 houses in New Zealand at 10-min periods).

Although Refs. [12–14] had robust samples, the major limitation of these works was that the temporal resolution of the gathered data was too coarse to accurately represent the

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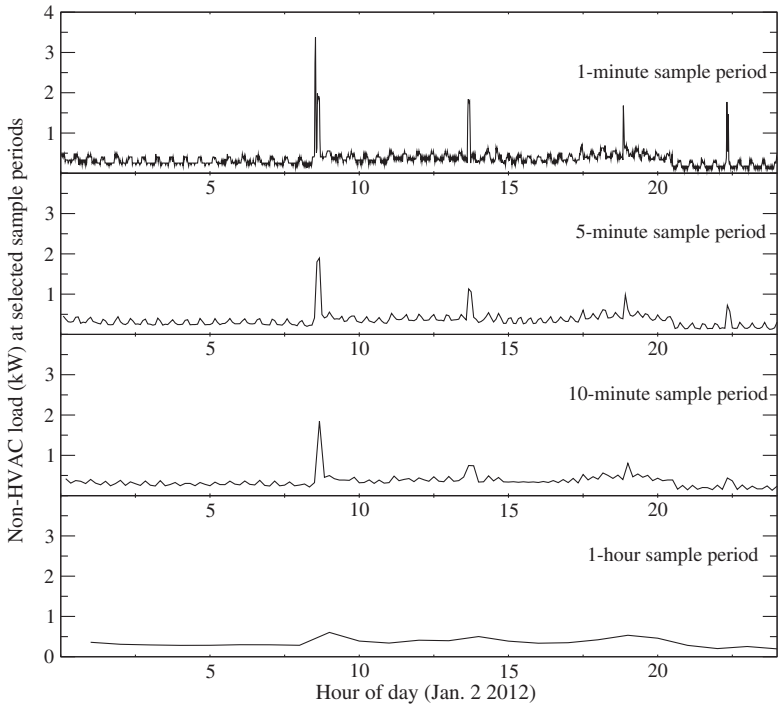

Fig. 1. Non-HVAC profile of one volunteer (H15) for a single day shown at various sample periods.

magnitude of some peak loads. Fig. 1 is shown to better illustrate this limitation.

In Fig. 1, the non-HVAC profile that was measured for one of the volunteers of this present research is shown for one sample day. This profile is plotted four times at increasing sample periods (from top to bottom) to demonstrate the effect that temporal resolution of this type of data has on the magnitude of observed peak loads. Longer sample periods were obtained by averaging the 1 min-timescale resolution data over longer periods. As can be seen, by increasing the sample period from 1 to 5 min, the observed peak load that occurs near hour 7 of the day has been dramatically reduced from approximately 3.5 kW to 2 kW. This effect is further exacerbated when the sample period is further increased to 10 min and 1 h. Note that 5 min was the previous best sample period achieved by Firth et al. [12] and Knight and Ribberink [13].

To address this knowledge gap, Saldanha and Beausoleil-Morrison [3] provided new measured data on the electrical consumption of 12 Canadian houses sampled at 1-min periods for an entire year. They argued that high-temporal-resolution data are required to increase the fidelity of building performance simulation analyses and to better support the study of innovative energy conversion systems (micro-cogeneration, on-site renewable electricity production, etc.). Cetin et al. [15] have also gathered end-use data at a 1-min timescale resolution from 40 houses in Texas (United States).

To further demonstrate that there is a demand for this type of data, several other researchers [16–19] have supported their work with these data provided by Saldanha and Beausoleil-Morrison [3]. A thorough literature review of all studies in this field was performed by Rowlands et al. [20]. They concluded by identifying that generating this type of additional electricity end-use data is a research priority going forward which indicates that the demand for this type of data is not yet satisfied.

1.1. Contributions

The purpose of this research is to improve the understanding of residential electricity consumption patterns at a high temporal resolution primarily to enhance the fidelity of building performance simulation based research efforts of micro-generation systems. Particular emphasis is given to the improving the understanding of non-HVAC consumption patterns because in this field HVAC consumption patterns are often simulated.

For this purpose, the current article builds upon the work of Saldanha and Beausoleil-Morrison [3] by gathering new measured high-temporal-resolution data on an additional 11 Canadian houses and making them available to other interested researchers.[1] These new measurements are predominantly from more recently constructed houses of row-house design compared to the houses sampled by Saldanha and Beausoleil-Morrison [3] that were predominantly of single-detached design and of older vintages. This current work is an expansion of a paper initially published in a conference [21].

The article first describes the methods used to gather and process these data in Section 2. These data are then combined with those of Saldanha and Beausoleil-Morrison [3] to provide a database of annual measurements for 23 houses at a 1-min resolution that characterizes whole-house, non-HVAC, air conditioner (A/C), and furnace electrical draws, as well as the individual draw patterns of some major appliances. Also in Section 2, some characteristics potentially relevant to electricity consumption (number of occupants, age, size) of the sampled houses are described to demonstrate the range of these characteristics contained within the sample.

For this database to be useful for its purpose, it is important to understand how well the 23 house sample represents the

[1] Interested researchers are invited to contact Ian Beausoleil-Morrison for access to any of these load profiles (ian_beausoleil-morrison@sbes.ca).

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