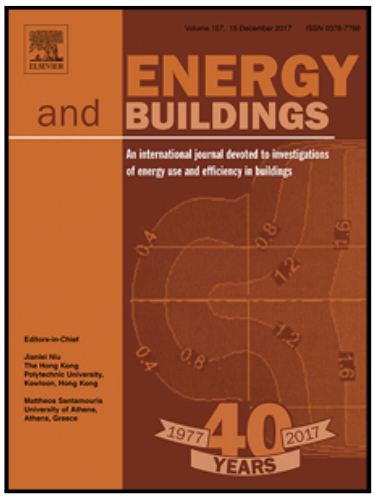

Assessment of primary energy consumption, carbon dioxide emissions, and peak electric load for a residential fuel cell using empirical natural gas and electricity use profiles

Kazunori Nagasawa, Joshua D. Rhodes, Michael E. Webber

PII: S0378-7788(18)31013-2
DOI: https://doi.org/10.1016/j.enbuild.2018.07.057
Reference: ENB 8728

To appear in: *Energy & Buildings*

Received date: 29 March 2018
Revised date: 14 June 2018
Accepted date: 25 July 2018

Please cite this article as: Kazunori Nagasawa, Joshua D. Rhodes, Michael E. Webber, Assessment of primary energy consumption, carbon dioxide emissions, and peak electric load for a residential fuel cell using empirical natural gas and electricity use profiles, *Energy & Buildings* (2018), doi: https://doi.org/10.1016/j.enbuild.2018.07.057

Assessment of primary energy consumption, carbon dioxide emissions, and peak electric load for a residential fuel cell using empirical natural gas and electricity use profiles

Kazunori Nagasawa[a,*], Joshua D. Rhodes[a,b], Michael E. Webber[a,b,**]

[a] *Department of Mechanical Engineering, The University of Texas at Austin, 204 E. Dean Keeton Street, Stop C2200, Austin, Texas 78712-1591*
[b] *Energy Institute, The University of Texas at Austin, 2304 Whitis Ave Stop C2400 Austin TX 78712-1718*

Abstract

This analysis uses empirical data for 20 single-family homes from a smart grid demonstration project in Austin, Texas to create intra-day natural gas and electricity use profiles on one-minute intervals based on cooling and heating degree days. Combining these intra-day energy use profiles with emissions factors and a linear programming model, temporal energy use profiles were evaluated to quantify primary energy consumption, CO_2 emissions, and peak electric load for a house with a residential fuel cell used as on-site power generation versus being connected to the electric grid. Results showed that natural gas use primarily peaked in the morning, while electricity use peaked in the afternoon. For fuel cell capacities of 0–3.0 kW_e and efficiency of 40%, total CO_2 emissions, including the fuel cell for the cooling day, were 1.7–1.9 times higher than the heating day. For a fuel cell capacity of 1.0 kW_e and efficiency of 40%, peak electric load decreased during on-peak hours (14:00–20:00) for the cooling and heating days by 60% and 44%, respectively. Effects of fuel cell capacity and efficiency on total primary energy consumption and CO_2 emissions showed that as the fuel cell capacity and efficiency increased, primary energy consumption and CO_2 emissions were reduced from the baseline values that represent conventional homes' patterns. These results show that the use of residential fuel cells can offer environmental benefits from reducing primary energy consumption and CO_2 emissions, and grid reliability benefits by reducing peak electric load.

Keywords: natural gas, electricity, empirical energy use profile, primary energy consumption, CO_2 emissions, peak electric load, fuel cell, residential building

*Corresponding author
**Principal corresponding author
Email addresses: nagasawa@utexas.edu (Kazunori Nagasawa), webber@mail.utexas.edu (Michael E. Webber)