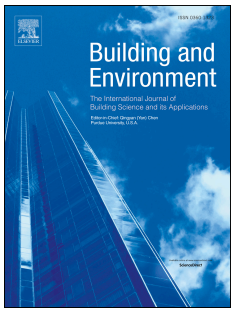
Accepted Manuscript



Simplified daily models for estimating energy consumption impacts of changing office building ventilation rates

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PII: S0360-1323(17)30500-0

DOI: 10.1016/j.buildenv.2017.11.002

Reference: BAE 5155

To appear in: *Building and Environment*

Received Date: 19 June 2017

Revised Date: 31 October 2017

Accepted Date: 2 November 2017

Please cite this article as: Ben-David T, Rackes A, Waring M, Simplified daily models for estimating energy consumption impacts of changing office building ventilation rates, *Building and Environment* (2017), doi: 10.1016/j.buildenv.2017.11.002.

Simplified daily models for estimating energy consumption impacts of changing office building ventilation rates

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Keywords: Building energy modeling; indoor air quality (IAQ); energy efficiency; heating, ventilation, and air-conditioning (HVAC) systems; high performance buildings; ventilation

ABSTRACT. This work presents simplified daily energy models to predict changes in office building electricity and natural gas energy consumption due to changes in the ventilation rate. The models provide day-resolved estimates based on 21 building and weather condition inputs. They use a "gray box" approach, with their functional form derived from physical principles of heat transfer and energy conservation, but with the values of 13 model coefficients estimated empirically. The training data was taken from 15,000 detailed office building simulations, comprising a dataset designed statistically represent the U.S. office sector in terms of location, building size, and building characteristics, and providing 3.78 million day-resolved data points. For electricity and natural gas energy consumption, the model fits resulted in R^2 = 0.89 and R^2 = 0.95, respectively. A case study in New York City indicated that the simplified models are useful screening tools for evaluating the energy implications of increasing ventilation rates, which can be desirable, for example, for enhancing workforce productivity in high performance buildings.

Nomenclature:

Symbol	Unit	Description
A_i	m^2	Surface area of exterior surface *i*
A_{roof}	m^2	Roof are
A_{window}	m^2	Sum of surface areas of all exterior windows
COP	-	Rated cooling coil efficiency
c_p	kJ/kg-K	Heat capacity of air
D_{occ}	occ	Number of occupants in the space (day-average)
E_{cool}	kWh	Daily cooling coil energy input
E_{heat}	kWh	Daily heating coil energy input
f_{cool}	-	Cooling coil efficiency modifier
f_{heat}	-	Heating coil efficiency modifier
h_{in}	kJ/kg	Indoor air enthalpy (day-average)
h_{out}	kJ/kg	Outdoor air enthalpy (day-average)
I_n	W/m^2	Direct solar irradiance (day-average)
K_{cond}	W/K	Building conductive heat transmission coefficient
M	W/occ	Occupant's metabolic heat gain
N_h	h	Number of occupied hours per day