London-Loughborough EPSRC CDT
Centre for Doctoral Training in Energy Demand

Inter-model comparison of indoor overheating risk prediction for English Dwellings

Giorgos Petrou[1], Anna Mavrogianni[2], Anastasia Mylona[3], Rokia Raslan[2], Gurdane Virk[4] and Michael Davies[2]

1 UCL Energy Institute, University College London, Central House, 14 Upper Woburn Place London WC1H 0NN, United Kingdom, Email: giorgos.petrou.16@ucl.ac.uk
2 UCL Institute for Environmental Design and Engineering, University College London, Central House, 14 Upper Woburn Place, London WC1H 0NN, United Kingdom
3 CIBSE, 222 Balham High Road, London SW12 9BS, United Kingdom
4 Atkins, Euston Tower, 286 Euston Rd. Kings Cross, London NW1 3AT, United Kingdom

Key Points

1. The choice of building simulation software impacts the predicted overheating risk.
2. Wind-driven natural ventilation significantly influences the observed differences.
3. Empirical validation of simulated indoor temperatures in naturally ventilated dwellings is required.

Introduction

- **Domestic overheating** is a growing concern due to the projected increase in frequency of extreme heat episodes along with the progressively higher levels of building thermal insulation and air-tightness [1].
- Through the Technical Memorandum 59 (TM59), CIBSE aims at providing a common procedure for predicting the overheating risk, using Building Performance Simulations (BPS) tools [2].

Research Questions:

- Does the prediction of overheating risk differ significantly between two commonly used BPS tools?
- What algorithmic differences are responsible for the discrepancies, if any, in the predictions?

Methods

- A base-case model, chosen to be representative of a typical London flat [3], was modelled in *EnergyPlus 8.6* and *IES VE 2016,* following TM59. Eight further iterations were developed which assessed factors identified by literature as being influential towards the risk of overheating (table 1).
- Within each software, the default algorithmic options were used. Natural ventilation was modelled by the *Airflow Network* in EnergyPlus and *MacroFlo* in IES VE.
- Overheating risk was compared through an inter-model comparison.

Table 1: Key physical characteristics of the nine models.

Code	Description
BC	Floor level: 11.2 m, orientation: south facing, single aspect, top level flat, Lightweight construction: Timber frame, external brick layer and internal plasterboard. U-values: Wall – 0.17 W/m²K, window – 1.28 W/m²K, floor – 0.18 W/m²K, roof – 0.13 W/m²K. Window Solar Heat Gain Coefficient = 0.5
G	Ground-level flat, floor level: 0 m, flat of similar temperature above
M	Mid-level flat, floor level: 5.6 m, flats of similar temperature above and below
W	West-facing flat
N	North-facing flat
E	East-facing flat
HW	Heavyweight construction: Concrete blocks, int. dense plaster and carpet
SH	Shading: Overhang external shading, length of 2.2 m and width of 0.5 m
DA	Dual aspect model with a second window included in the bedroom

Results

- Indoor temperatures in EnergyPlus models were higher than IES VE with a mean temperature difference of 0.64℃ and a greater inter-quartile range suggesting greater fluctuations (figure 1a).
- EnergyPlus predicted a high overheating risk in seven out of the nine models, while IES VE did not predict a high risk in any case (figures 1b, 1c)

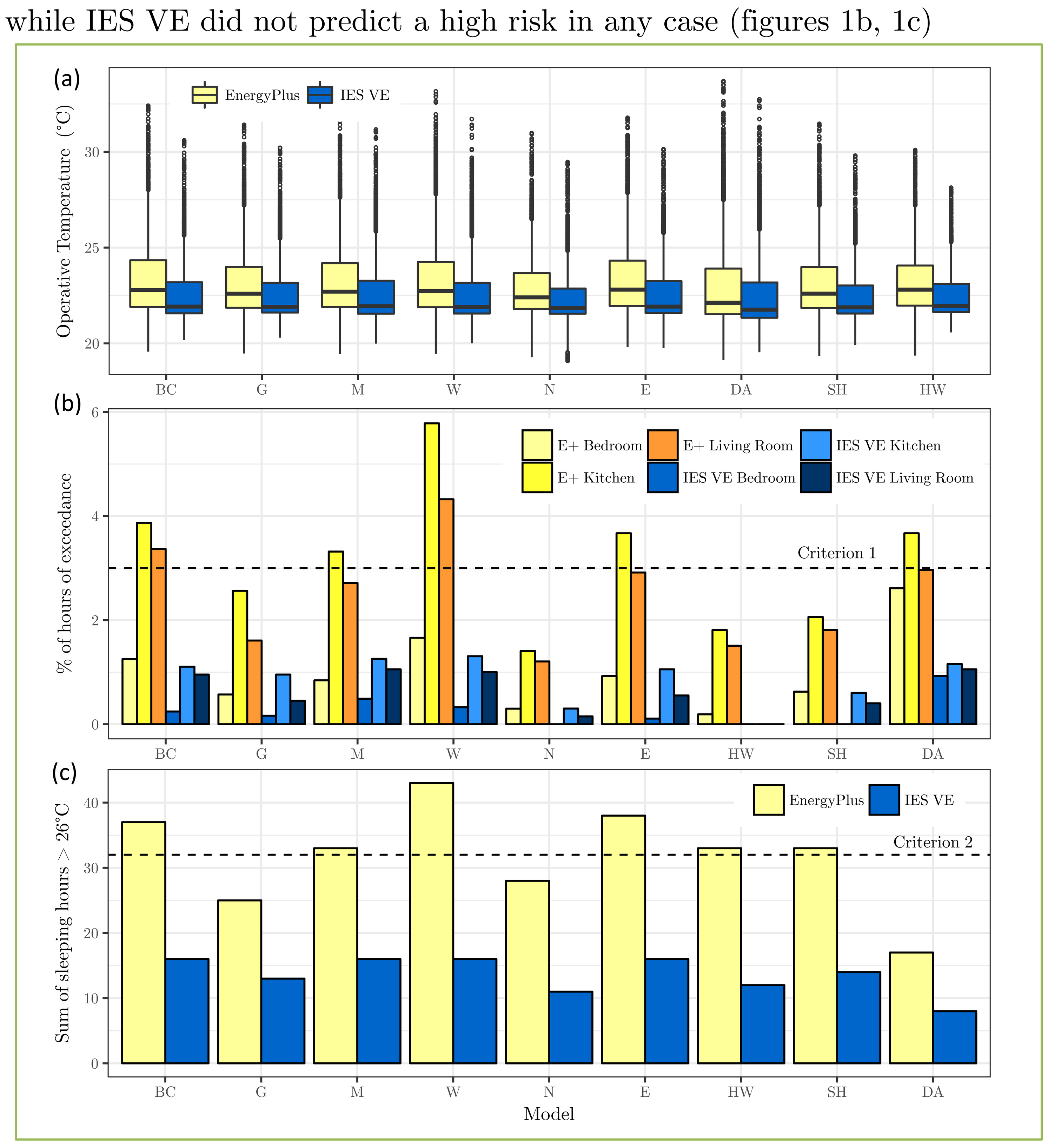

Figure 1: Part (a) is a box plot of temperature distributions for each model during the period of interest. Parts (b) and (c) display the results of criterion 1 and 2 for all models, respectively .

- Comparison of the heat mechanisms revealed that **external (natural) ventilation** dominated the differences in half of the cases.
- As shown in figure 2a, on a typical day the window flow rate predicted by IES VE exceeded the EnergyPlus equivalent by up to 135%.
- By setting the wind velocity to zero (figure 2b), the flow rates were in close agreement, suggesting that wind-driven ventilation is responsible for the observed differences.
- This result could relate to each software's method of estimating wind-pressure coefficients and wind turbulence.

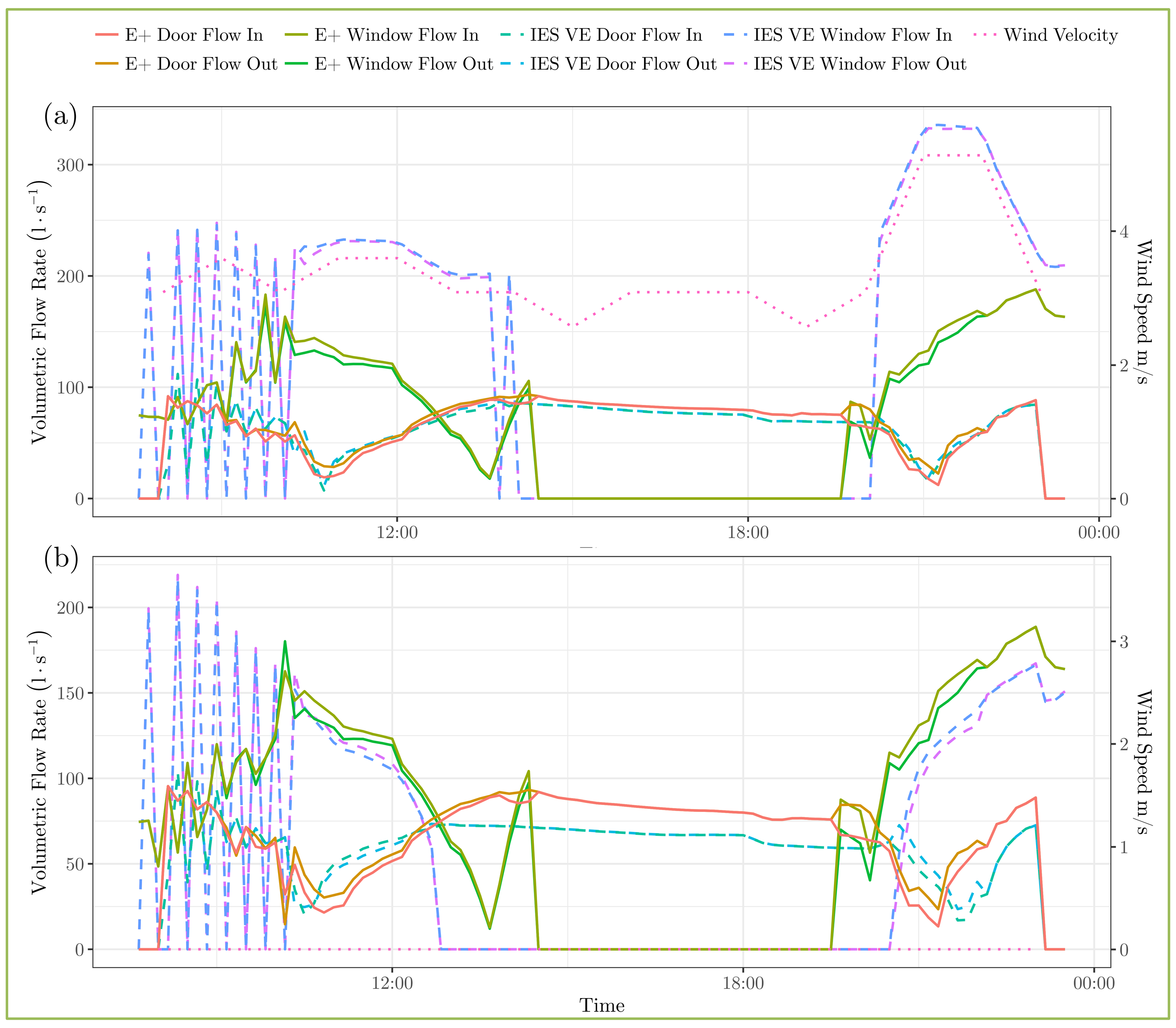

Figure 2: Line graphs of the predicted volumetric flow rate for the bedroom door and window in either software on the 15th of July. Part 2a is the comparison with the suggested weather file. In part 2b the wind velocity was set to zero.

Discussion & Conclusions

- The choice of BPS tool influences the predicted overheating risk
- Further research and empirical validation are needed to reveal which software may be considered more appropriate.
- TM59 may be improved through specifying the software and algorithms to be used.

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UCL
Loughborough University
EPSRC Pioneering research and skills
London - Loughborough Centre for doctoral research in energy demand
Central House
14 Upper Woburn Place
London, WC1H 0NN
www.lolo.ac.uk