Towards Better Estimation Of Energy Use In Dwellings

A Framework To Couple Agent-Based Modelling With A Dynamic Building Simulation Model

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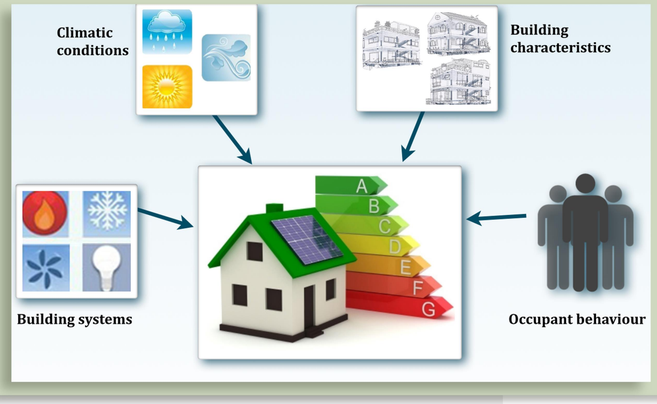
Energy consumption in buildings is influenced by several factors related to building characteristics; such as buildings' systems and buildings' controls, and the behaviours of their occupants.

Global temperature is predicted to increase due to the increase CO2 emissions. UK summer is predicted to be hotter.

Uncertainty to the resilience of UK climate, to the predicted increase in temperature and the impact on energy consumption due to the potential increased use of cooling systems.

Many dynamic buiding simulation tools are used in industry to estimate energy performance.
Results show variations between predicted and actual performance.

It may be linked to the way occupants are represnted in these models.



Occupant behaviour

-Greatly influence energy use by with building systems
-Variations in energy use among identical apartments
-Evidence of take-back effect in energy efficient buildings
-"Forgiveness" factor associated with environmental attitude
-Energy savings of 40% by changes in occupant behaviour

But still underestimated in DBSM and considered as

-Static agents
-Similar schedules
-Similar schedules
-Similar schedules

So attempts to

Understand the relationships between occupant behaviour and energy use, and model dynamic occupant behaviour:

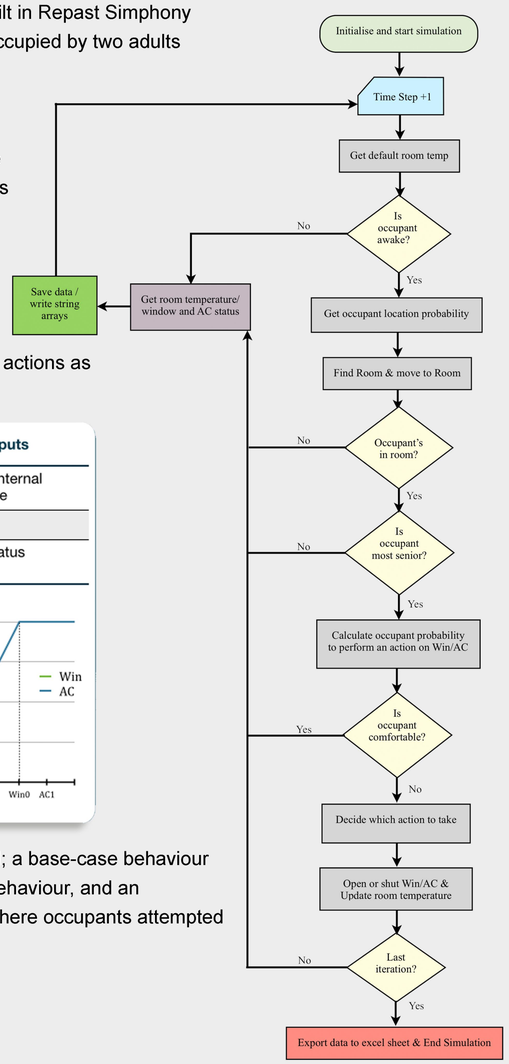
-Stochastic markov-chain model
-Sensor-based networks model
-Monte Carlo models
-Diversity profile models
-Agent-based models

This PhD attempts to model detailed occupant behaviour in dealing with summer overheating in domestic buildings using agent-based modelling.

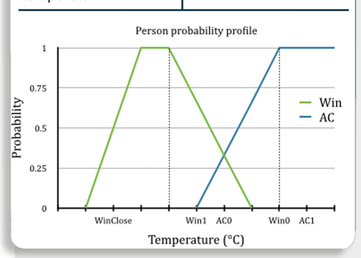
-Realistic dynamic representation of occupants in domestic buildings
-Contribute to bridging the gap between estimated and actual energy use in buildingsn by linking the ABM to a Dynamic Building Simulation Model

Initial exploration of a manually linked ABM and DBSM model

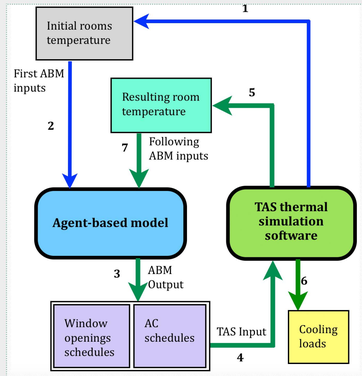
A pilot Agent-Based was built in Repast Simphony platform to simulate a flat occupied by two adults for 24 hours a day, where occupants are awake from 8:00 AM till 11:00 PM. The model covered only the interactions of the occupants with the room's window (opening or closing) and mechanical cooling system AC (turning on or off), but will be expanded to cover more actions as research progresses.



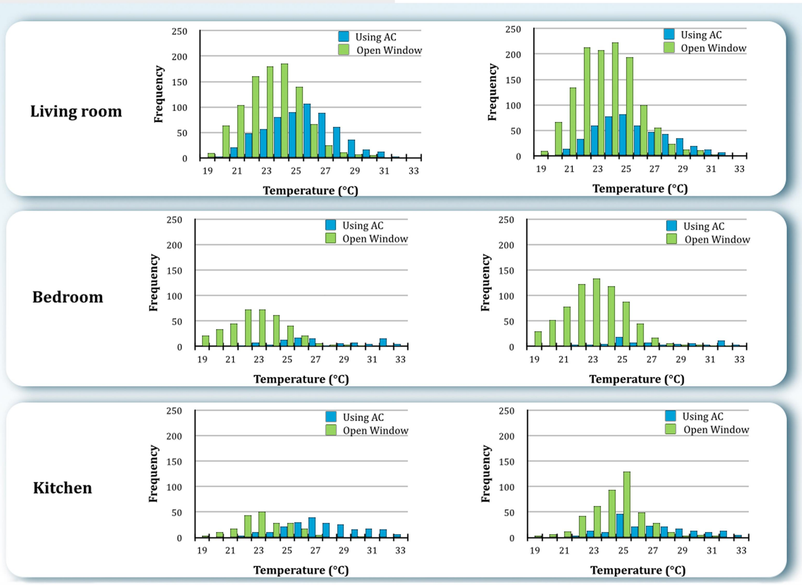
Model Input	Model outputs
Location probability	Resultant internal temperature
External Temperature	AC status
Default internal temperature	Window status



Two cases were considered; a base-case behaviour that represented a typical behaviour, and an improved-case behaviour where occupants attempted to save energy.



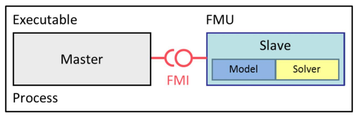
1. TAS produces initial internal temperature where no cooling or windows actions.
2. Default temperature used only for the first time.
3. ABM produces schedules based on input internal temperature.
4. ABM outputs are used in TAS to re-estimate internal temperature and cooling loads.
5. TAS produced resulting temperature.
6. TAS produces resulting cooling loads that will be used to compare energy consumption.
7. Resulting temperature from now on are used as inputs to ABM model, then repeat from step (3)



Current Development

Using Functional Mock-up Interface to establishCo-simulation between EnergyPlus and ABM.

The Functional Mock-up Interface (FMI) is a standard for exchange of models between different simulation environments. FMI is linked to the Modelica project, but can be used for other modelling solutions as well.
The interface specifies how a model is exported as a combination of XML files and compiled C-code. The XML files provide information about the model (inputs, outputs, states etc.) while the C-code provides the model dynamics.
A model exported with FMI is called a Functional Mock-up Unit (FMU). A FMU is a zipped file (with file extension .fmu) containing all of the model files.



Once this co-simulation is established, the next step is to expand the model to include more behaviours and occupancy patterns. Also, more occupants' actions such as the use of blinds, lighting, fans, heating systems, etc. will be included. One of the objectives of this research is to investigate how occupants can optimise their response to overheating, so optimal and sub-optimal behaviours will be built into the model to identify ways to avoid sub-optimal behaviours.
Moreover, currently the model assign seniority as a simple way to represent decision-making, however, modelling decision-making and negotiation within the household, the social interaction and the influence of other agents in neighbour household to change energy behaviours will be properly investigated and included in the model. Future steps also include data collection from operational residential buildings, by monitoring and interviewing occupants, learning how they deal with overheating, and how they change their behaviours. The data will be used to test the assumptions made in the model about occupants' behaviours, and to validate the model after making any necessary changes. Currently, the researcher is working on expanding the model and preparing the data collection process to closely monitor a recently built residential development in north London.

References:

1- Function Mock-up Interface. Modelica Association Project, https://www. fmi-standard.org/ (accessed 17.06.15).

2-Dullin, T., 2015. Functional Mock-Up Unit Import in EnergyPlus For Co-Simulation. pp.1–11.

3-FMI, M.A.P., 2015. FFunctional Mockup Interface for Model Exchange and Co-Simulation, Version 2.0,