Using Integrated Simulation as a Test Bed for Heat Pump and Microgeneration Performance Analysis

Research Review and Look-ahead

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Why Modelling?

- field trials and lab tests are a rich source of data on device and systems performance
- both are expensive and scope is often limited
- properly calibrated simulation models can fill in the in performance knowledge
- used appropriately, modelling is useful for answering “what if ?” questions
- … and to examine performance over a diverse range of situations

Integrated Modelling

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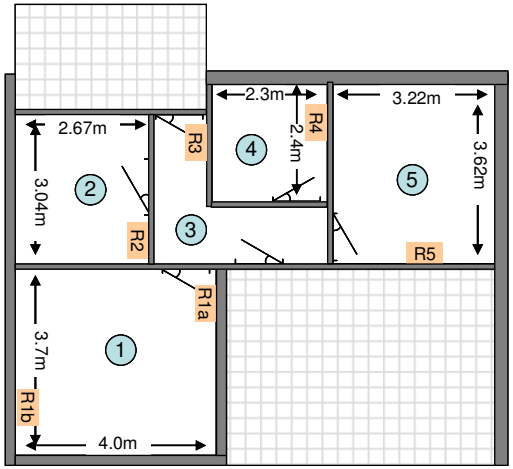
- integrated modelling involves the development of a mathematical model that enables the modelling of a technology in a “realistic” context
- a good example is building simulation (e.g. ESP-r, EnergyPlus)
- e.g. heat pump analysis - detailed BS model would include the heat pump, heat distribution system, control system, building geometry and fabric and occupants
- … and simulation would involve running the model with site-specific climate data and user-defined control constraints
- the output is time series data that can be used to quantify: device efficiency, fuel consumption, energy costs, start-up times. on/off cycling, temperatures, thermal comfort, etc.

Example 1: Westfield ASHP

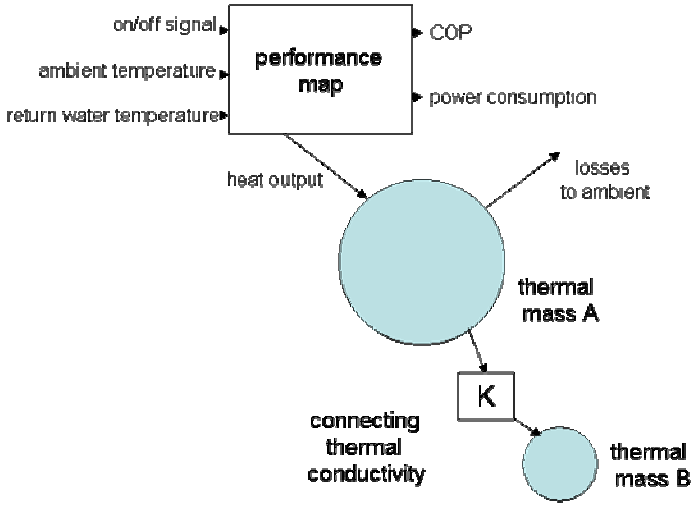
- this modelling exercise complemented a field trial of ASHP technologies
- field trial captured a comprehensive amount of performance data but over a short period of time
- integrated simulation model was developed on ESP-r to determine annual performance: COP, energy consumption, energy costs and ability to maintain comfortable conditions

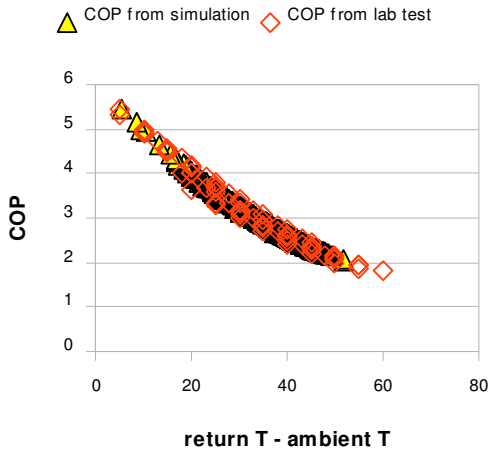


Example 1: ASHP

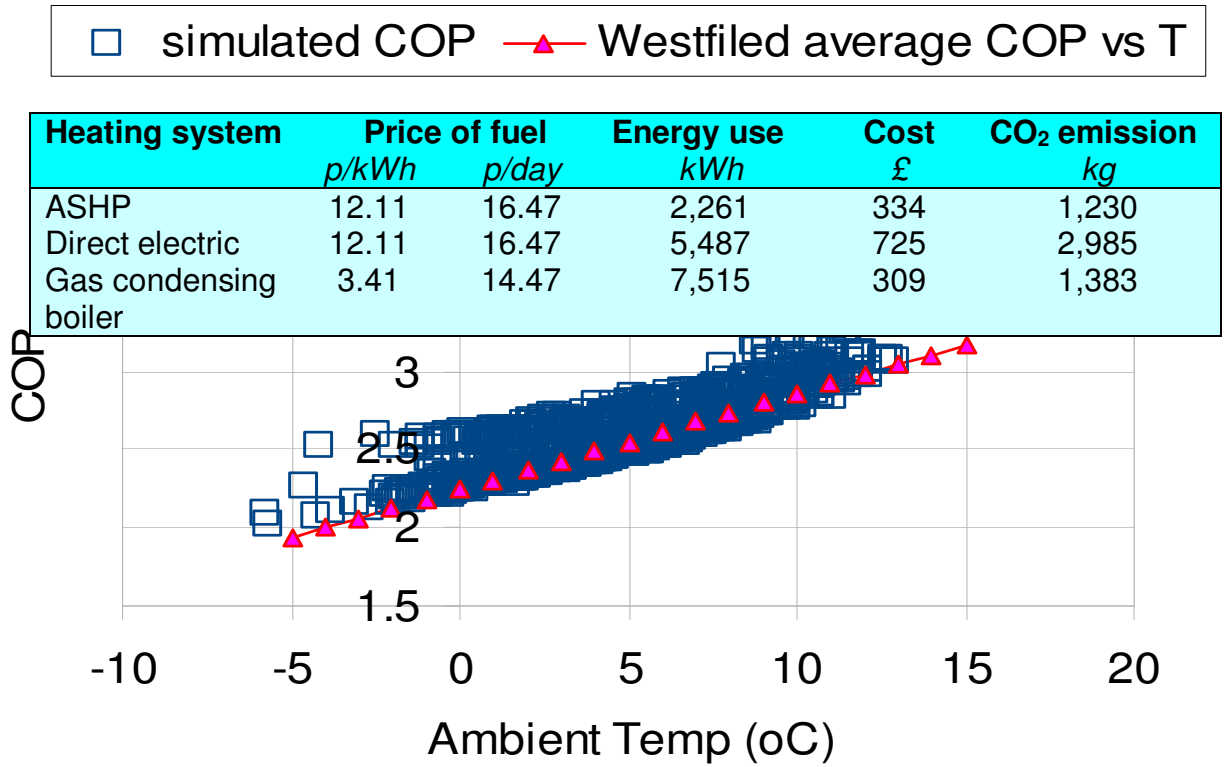
- ASHP model development involved:
- physical device → abstract engineering model → software model → debug → calibration/verification

- the model was *calibrated* using lab test data





Example 1: ASHP



Heating system	Price of fuel		Energy use	Cost	CO_2 emission
	p/kWh	*p/day*	*kWh*	*£*	*kg*
ASHP	12.11	16.47	2,261	334	1,230
Direct electric	12.11	16.47	5,487	725	2,985
Gas condensing boiler	3.41	14.47	7,515	309	1,383

Example 2: MicroCHP

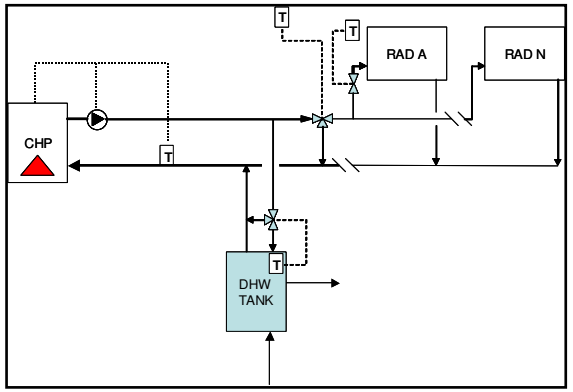
- this work was part of a larger project into microCHP model development and performance analysis
- objectives: examine the performance of microCHP in typical UK housing & evaluate benefits of thermal storage

detached

terraced

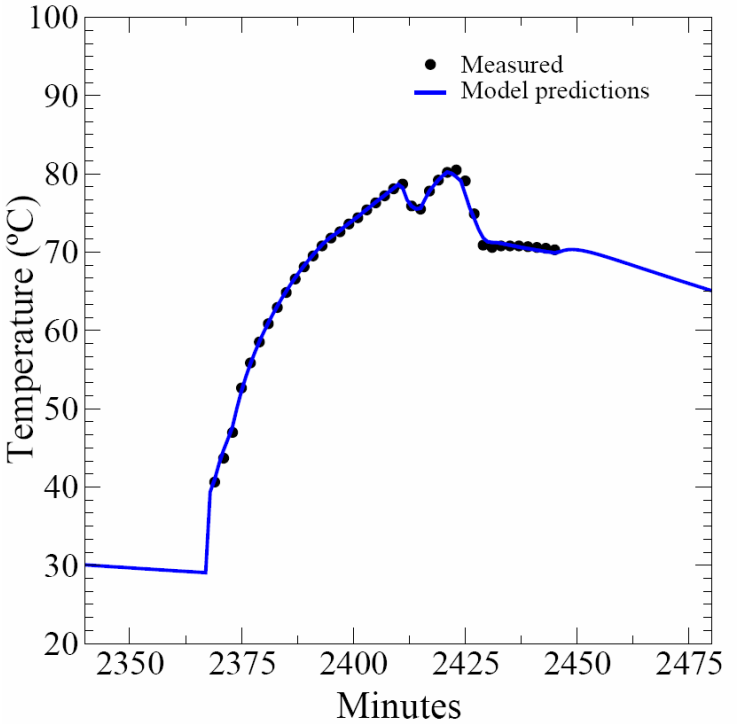
semi-detached

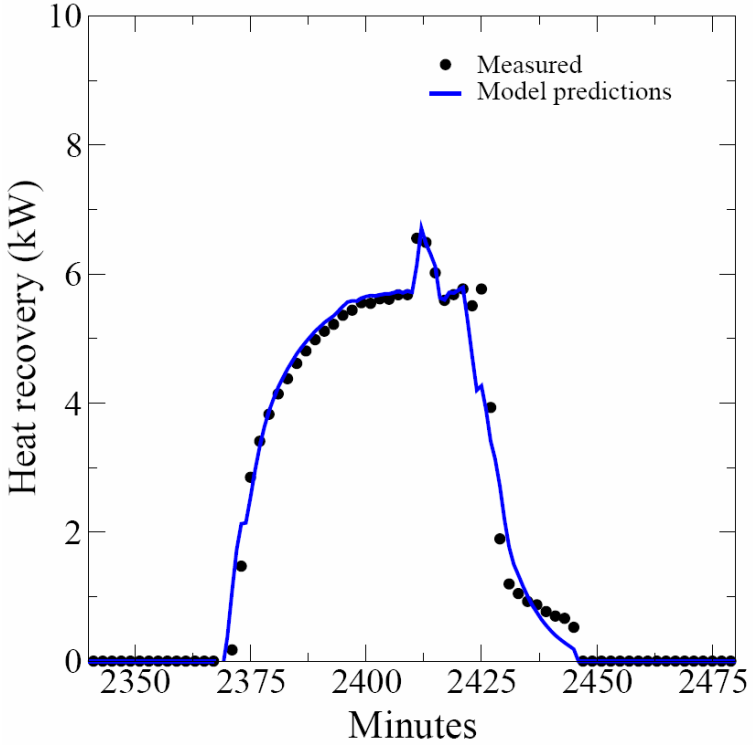
flat



Example 2: MicroCHP

- models developed and calibrated using lab data





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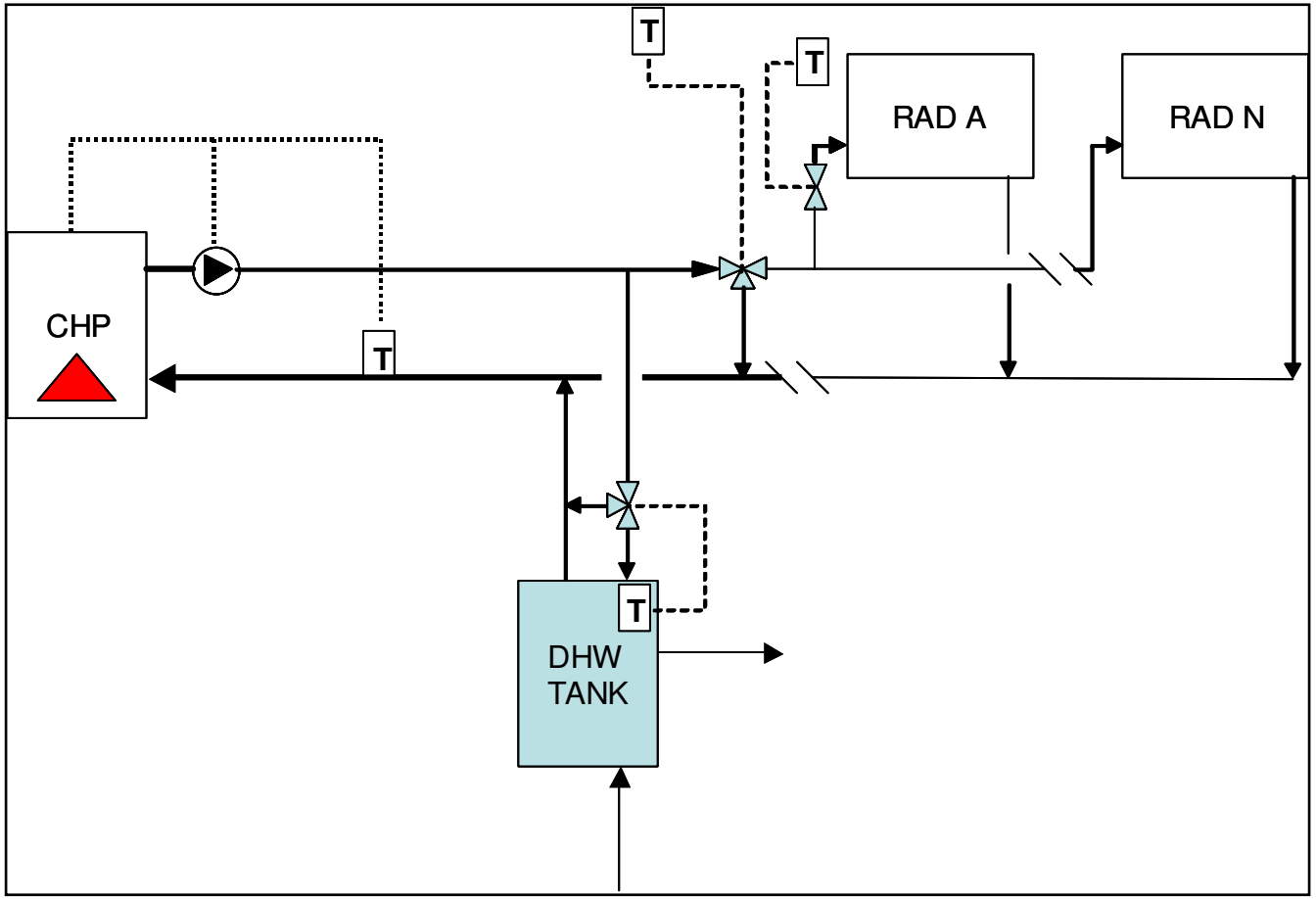

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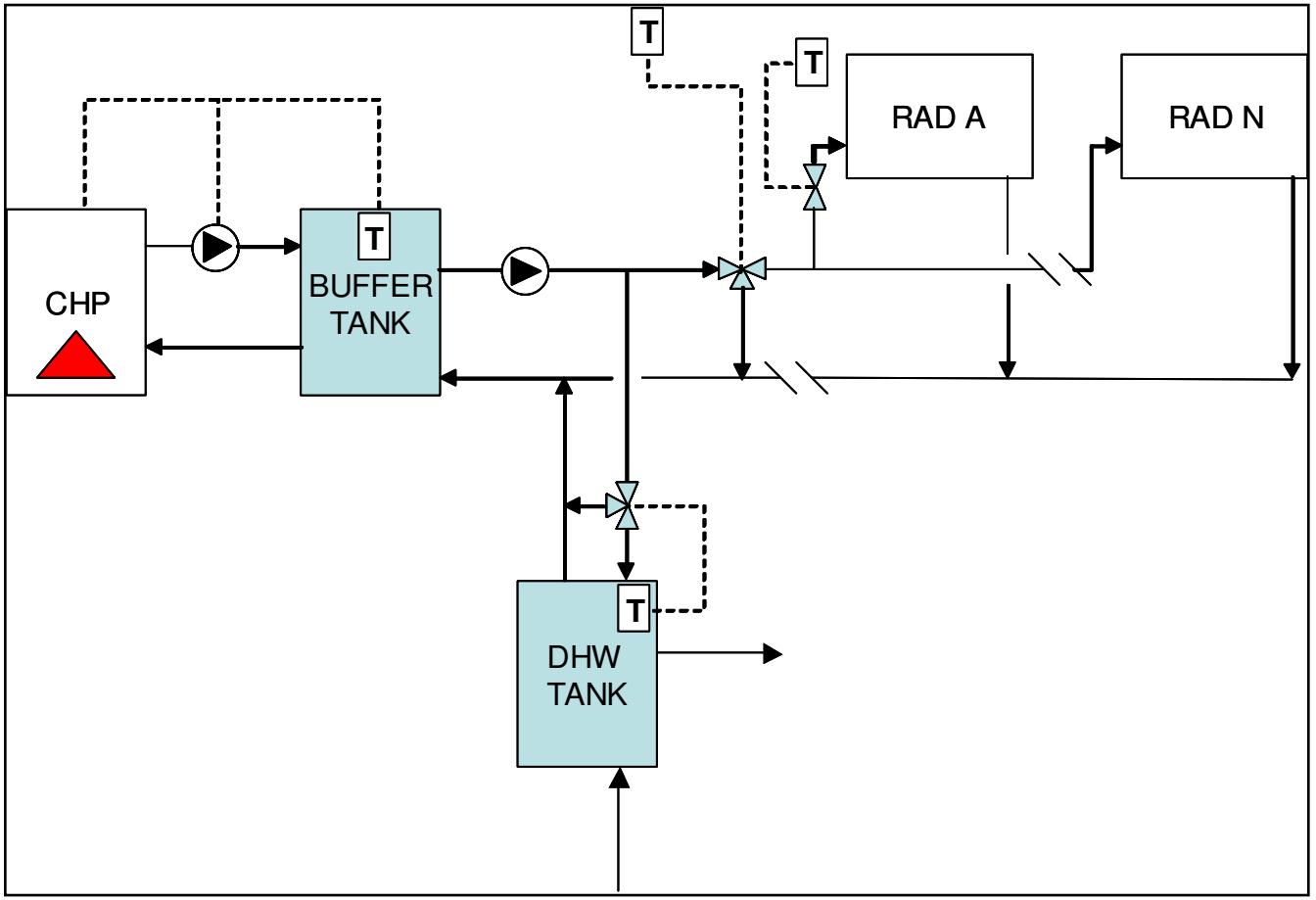

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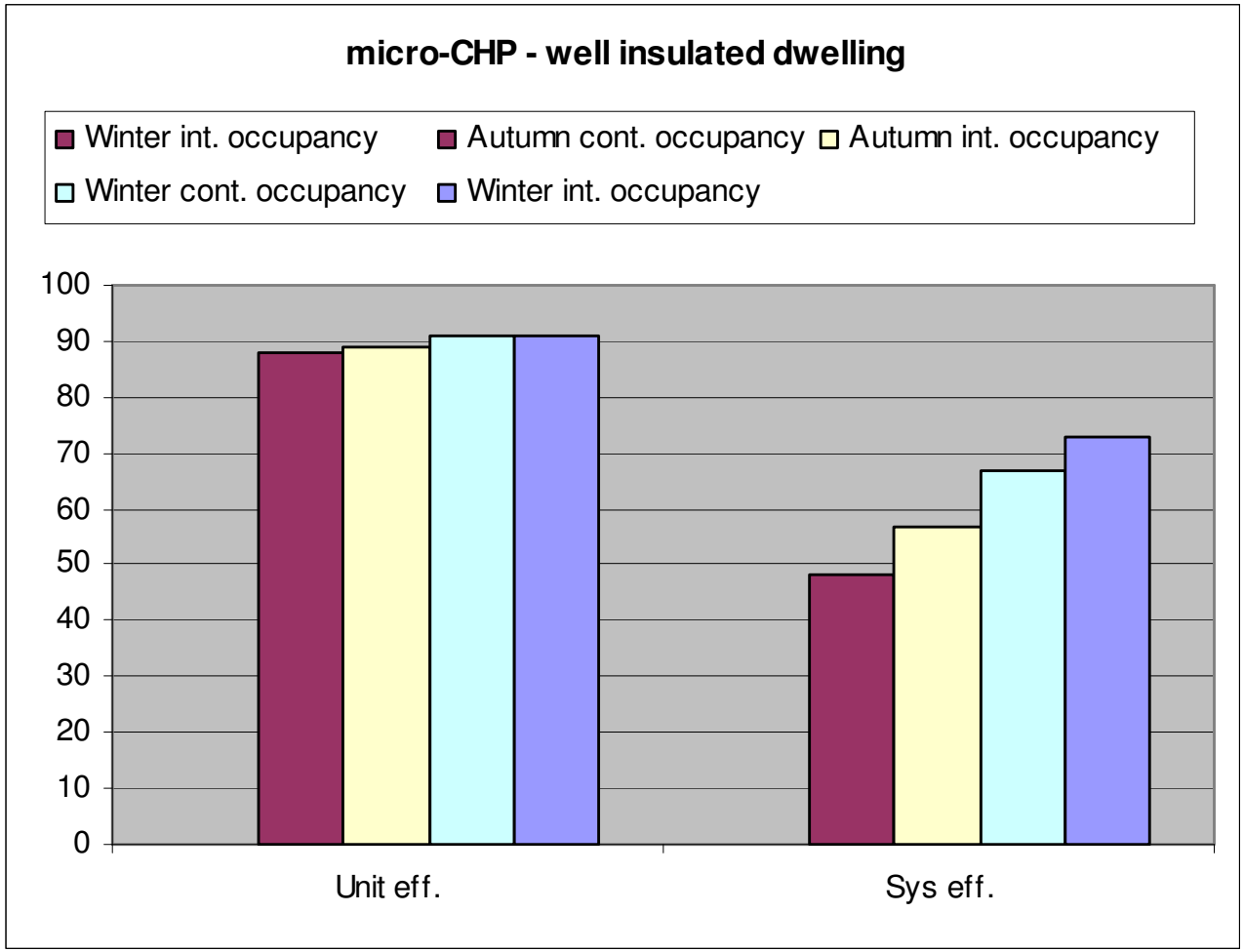

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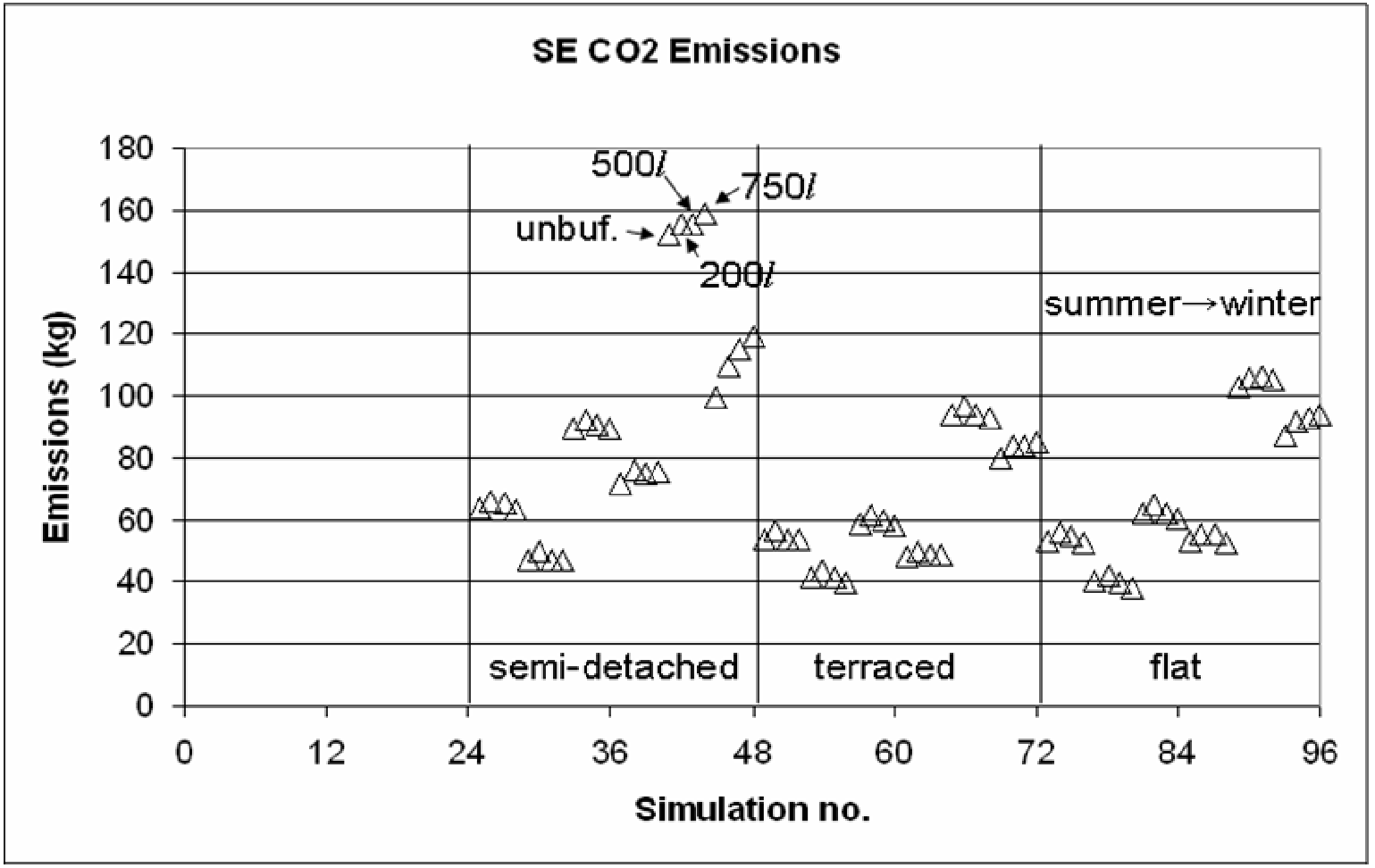

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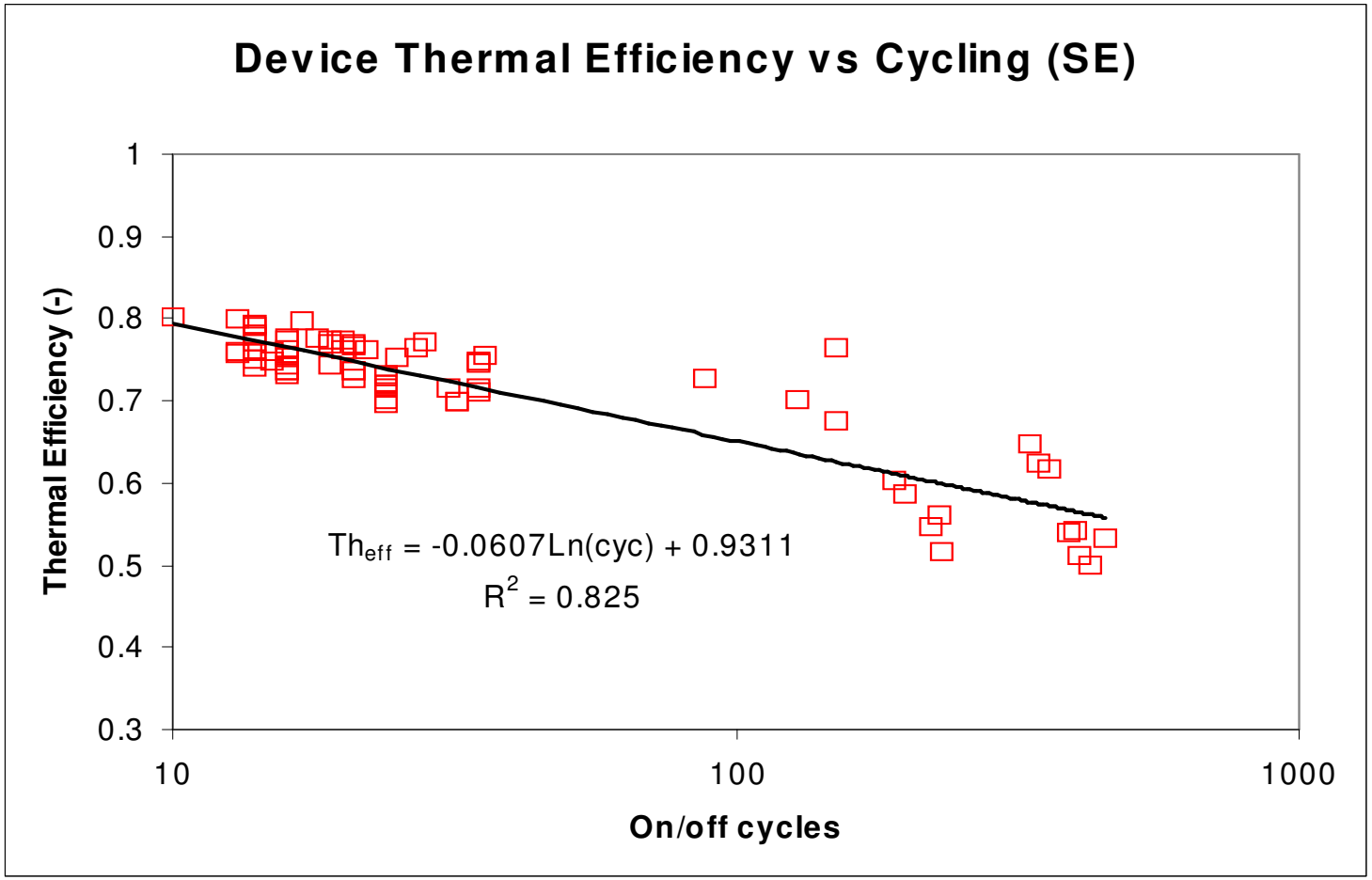

GSHP Modelling

- ESP-r has a suite of low-carbon generation models including GSHP
- GSHP model is of a similar form to the ASHP and microCHP models
- currently ground-coupled HX modelling is rather crude – mono-directional
- model will be developing model as part of ongoing research activities ….

GSHP-Related Research Activities

- HiDEF (UKRCEP): highly distributed energy futures, looking at the impact and potential of microgeneration for grid operations; this will include looking at the consequence of widespread uptake of GSHP and ASHP
- Hybrid Energy Systems (KTP, EPSRC): looking at the combinations of technologies best placed to deliver low-and zero carbon buildings

Planned GSHP Developments

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- Horizontal Systems: better characterisation of trench performance, specifically looking at close-to-surface climatic effects, influence of soil type, impact of freeze thaw, etc. Outcomes will be validated and improved models
- Demand Management: GSHP systems have a considerable thermal inertia making them useful in load control in future energy networks. Outcomes: assessment of load control potential of GSHPs

Links

- ESP-r (open source)

www.esru.strath.ac.uk/software/