London-Loughborough Centre for doctoral research in energy demand

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Simulation of domestic heat demand shifting through short-term thermal storage

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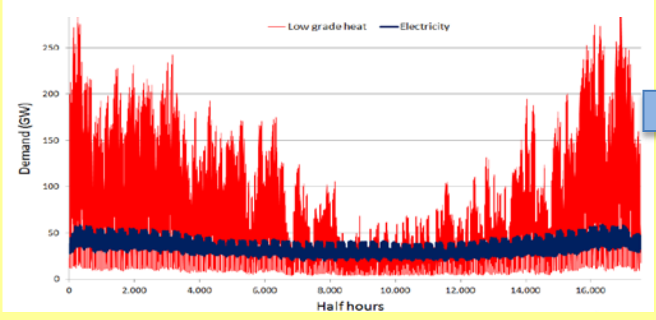
INTRODUCTION

Heating is the dominant energy consumer and CO_2 emitter in domestic buildings. A solution to this is electrification (e.g. via heat pumps) powered by renewable or low carbon grid electricity. Wide-scale application of these will induce tough energy security and resilience challenges for the energy system.

Half hourly heat & electricity demand



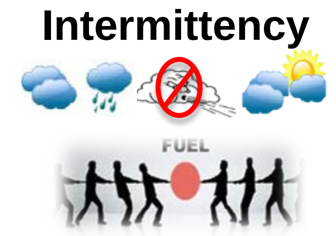
Factors affecting the energy system

- **Electrification of heating**
- **Increased use of heat pumps**
- **Climate change mitigation**
- **Fuel poverty alleviation**

Renewables

PROBLEMS

Intermittency



Price/Supply shocks

GRID LOAD BALANCING

Peak to off-peak demand variation

SECURITY of SUPPLY

Variable and unpredictable supply

OPPORTUNITIES & MOTIVATION

Storage is VITAL for greater uptake of renewables & electrification of heating [1]. Failure will impact climate change mitigation and renewable energy targets.

The UK has ~26 million homes, 13.7million with hot water tanks. Opportunity exists to apply effective Thermal Energy Storage (TES)

Decouple supply and demand timing to enable load levelling

BUT

How and at what cost? How to maximise the benefits?

RESEARCH QUESTION

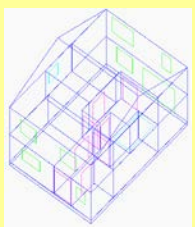
Can short-term thermal storage be used to shift domestic heat demand by 4 hours, and how would it impact the thermal comfort levels?

METHODOLOGY

- Use IES <VE>
- Dynamic thermal modelling
- Create building & TES models
- Benefit and impact analysis

The Model

2 bed detached house in Loughborough



Models created in IES-VE

Model 1: BaseCase (Based on the actual building construction)

Model 2: Hi TM Case (Based on internal retrofits with high thermal mass materials

Simulation control

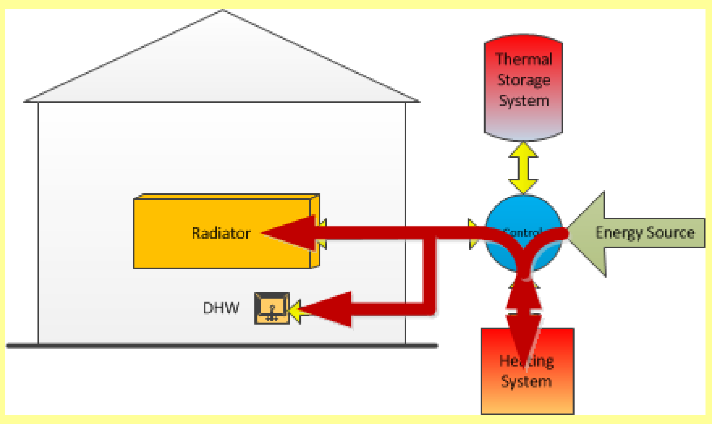
Period: 1st January to 31 January

1 minute simulation resolution

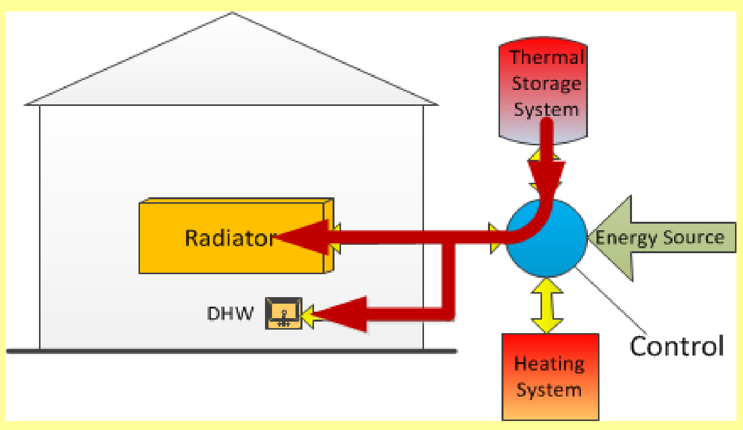
10 days pre-conditioning

Key parameters & assumptions :

1. Heating 'On' times:7-9am & 4-11pm (weekday) & 7-11pm on weekends
2. Nottingham weather data - 2005.
3. Casual gain: cooking, TV, occupants and lighting.
4. Fixed occupancy schedule ; 2 adults & 1 child.
5. Acceptable internal temperature = 18℃ to 21℃

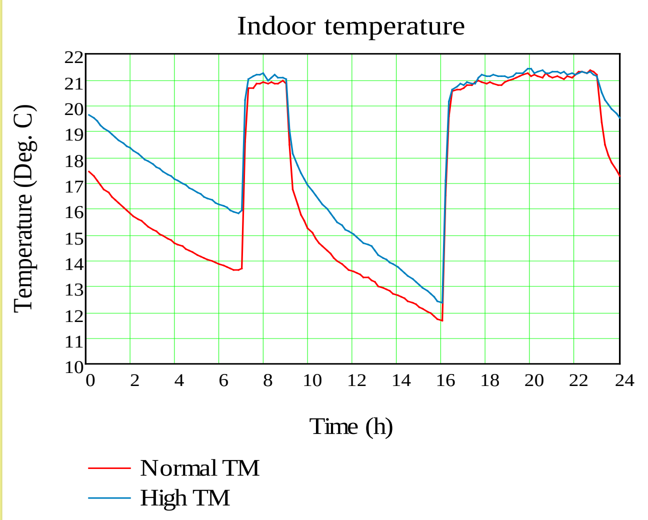


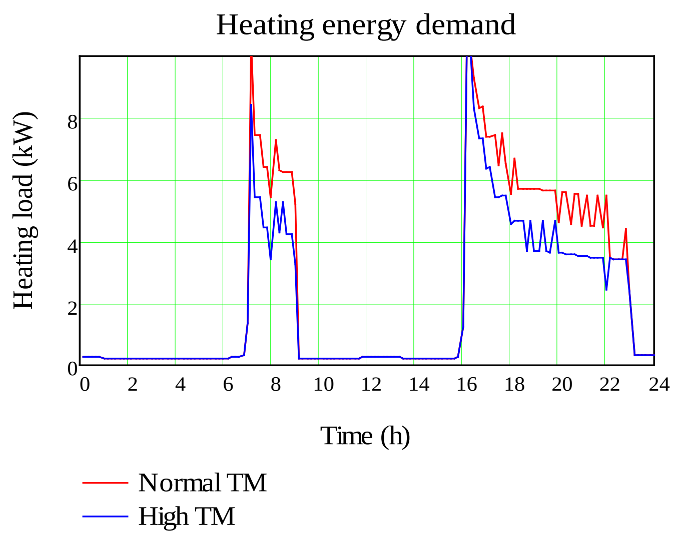
Normal operation except for the period 6pm to 10 pm



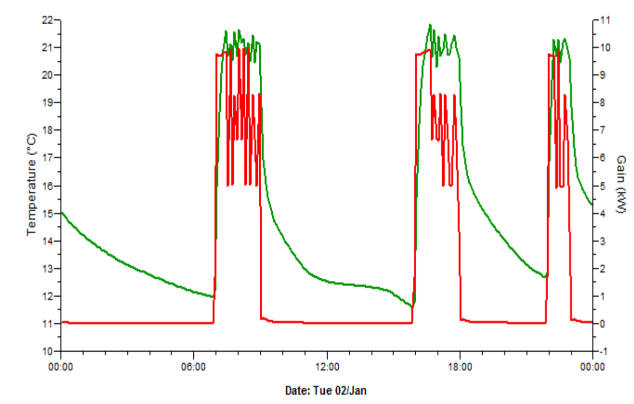
Operation from 6pm to 10 pm.

RESULTS (to date)

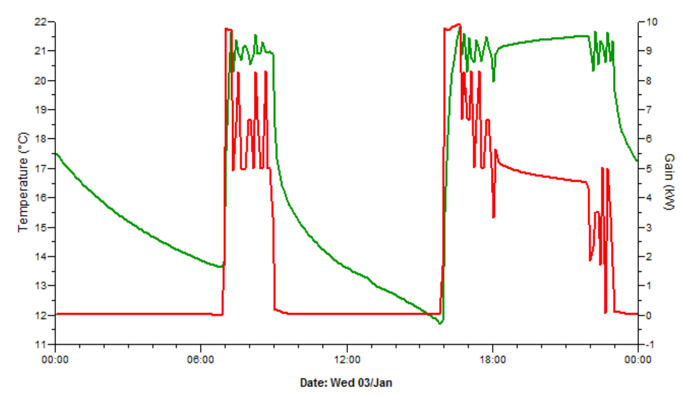




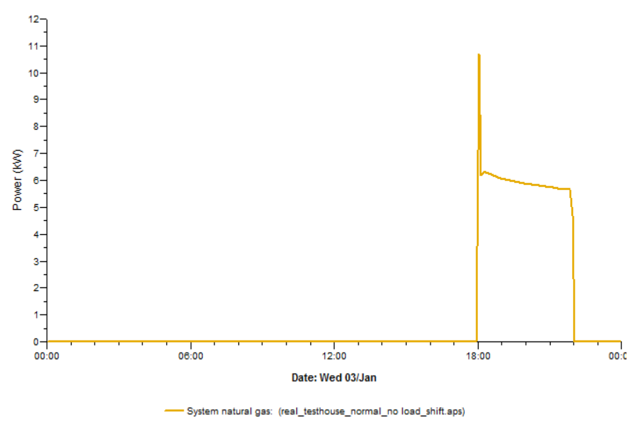
Room temperature and energy consumption for the two model cases. Hi TM Case needs ~12kWh (~21%) less energy. Heat loss reduced by ~1 hour.



Removing energy use from mains grid for 6-10pm (Basecase). Room temperature drops to ~13℃.



Supplying heat from the thermal store from 6-10pm (Basecase)



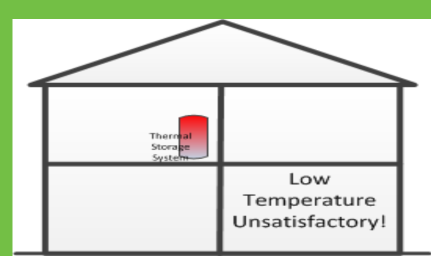
Energy shifted in time that will still ensure same room temperature (Basecase).

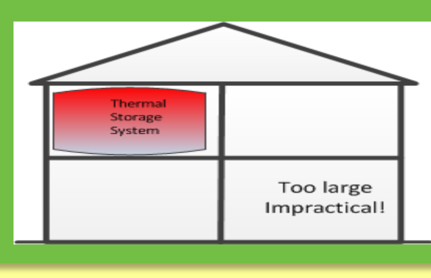
CONCLUSION

Heat demand shifting is possible through domestic TES, but how practical it is in terms of cost and size need investigating. Good building thermal performance will be necessary to reduce TES size and increase effectiveness.

FUTURE WORK & WORK IN PROGRESS

- TES system size with sensible & latent heat storage methods?
- Impacts of dwelling size, occupancy, & location?
- Benefits of domestic TES (economic & technical)?
- Develop a strategy for wide-scale application of TES in the UK.





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Reference

[1] ERP, 2011. The future role for energy storage in the UK, Main Report, The Energy Research Partnership, Technology Report. June 2011.

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