London-
Loughborough Centre
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in energy demand

Domestic Thermal Energy Storage:

A study of the present and future benefits and impacts

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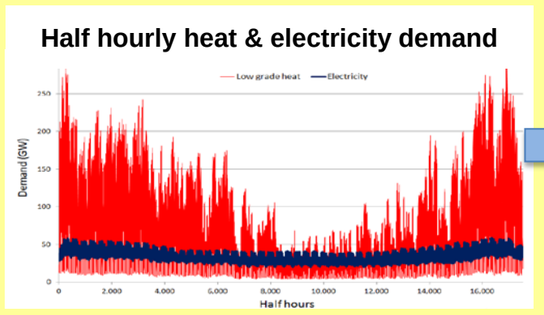
INTRODUCTION

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.



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

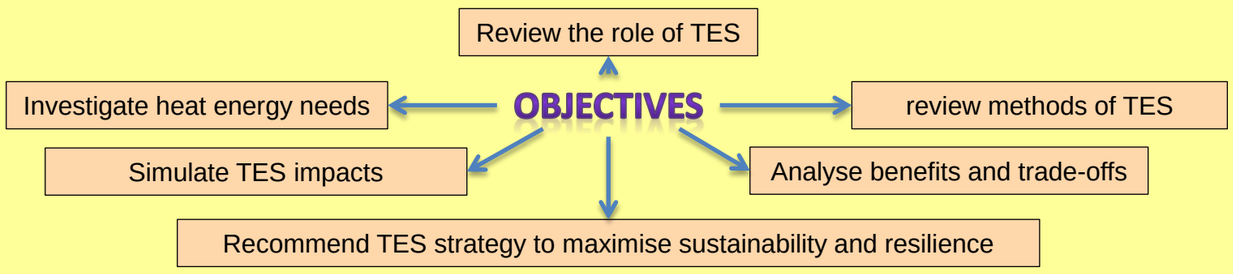
Storage is VITAL for greater uptake of renewables & electrification of heating [1]. Failure will impact climate change mitigation and renewable energy targets.

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?

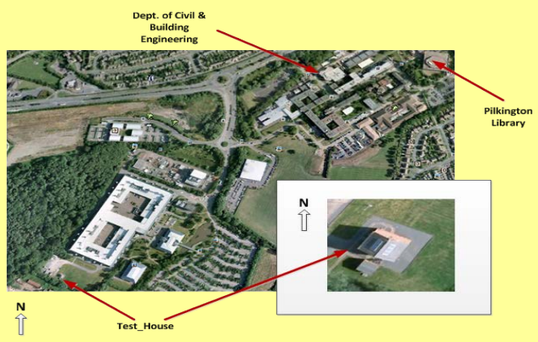


METHODOLOGY

- Dynamic building simulation
- Bottom-up modelling approach
- Domestic building & TES models
- Demand shift sensitivity analysis
- Benefit and impact analysis

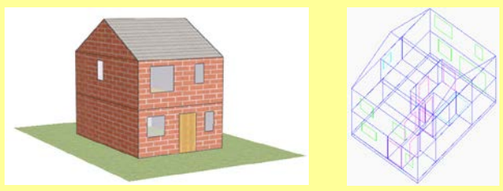
1st CASESTUDY

Simulation of domestic heat demand shifting in a 2 bed detached house in Loughborough



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

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



Models created in IES-VE

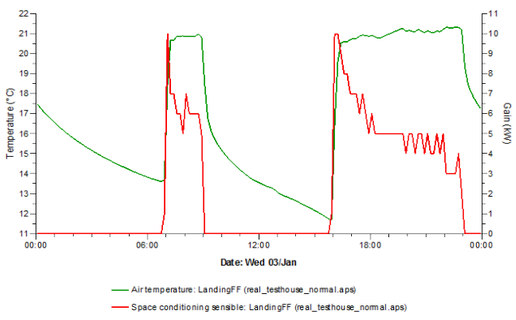
Key parameters & assumptions :

1. Electric heating system with proportional control
2. Heating 'On' times:7-9am & 4-11pm (weekday) & 7-11pm on weekends
3. Multi-zone dwelling built to 90's reg.
4. Nottingham weather data - 2005.
5. Casual gain: cooking, TV, occupants and lighting.
6. Infiltration = 0.5 l/s, Window opening = 5% 8am – 11pm
7. Fixed occupancy schedule ; 2 adults & 1 child, different for weekdays & weekends
8. Acceptable internal temperature = 19℃ to 21℃

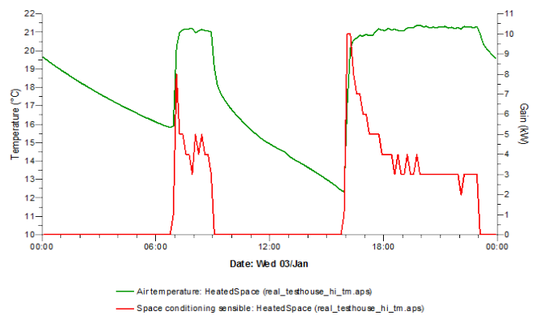
Simulation control

Period: 1st January to 31 January
1 minute simulation resolution
10 days pre-conditioning

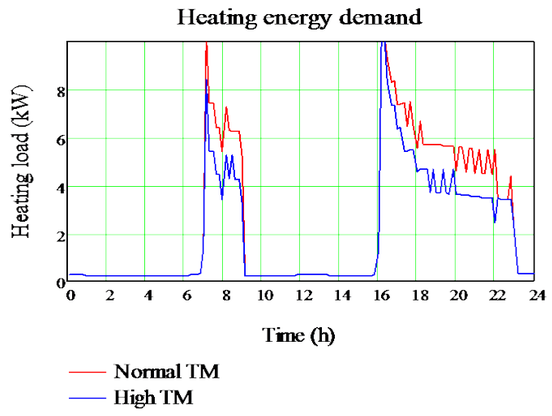
RESULTS (to date)



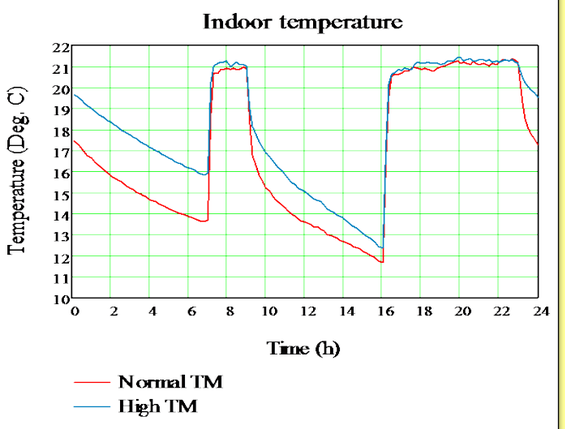
BaseCase: Weekday energy and space temperature profile



Hi TM Case: Weekday energy and space temperature profiles

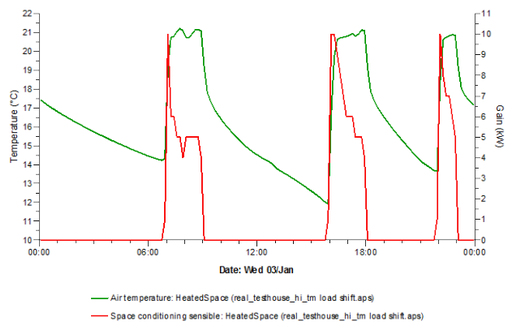


Energy use reduced from 58kWh to 46kWh

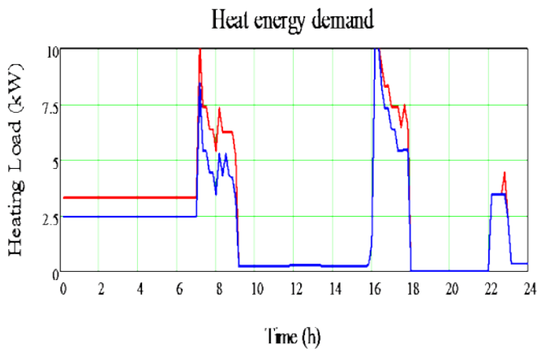


Heat loss reduced by ~1 hour

Effect of internal retrofit on energy consumption & indoor temperature profiles



Removing energy use from 6-10pm



Shifting energy use from 6-10pm to 12-7am

FUTURE WORK & WORK IN PROGRESS

- Develop and integrate TES models with the heating system model.
- Investigate TES performance requirement for ensuring acceptable room temperature from 6pm to 10pm.
- Investigate TES technologies (Sensible/Latent/Thermochemical).
- Investigate the impacts of dwelling size/occupancy/location on TES system requirement.
- Evaluate the benefits of using TES in domestic buildings.
- Develop a strategy for wide-scale application of TES in the UK.

Supervisors Dr. S. K. Firth, School of Civil and Building Engineering
Prof. P. C. Eames, Centre for Renewable Energy Systems Technology

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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