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Modelling energy performance in 'old' buildings

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Urban Energy Research Group

- Formed 2005
- Multi-disciplinary group
- Currently 7 members of staff
- ~15 PhD students
- £4.0m external funding awarded
- ~**100** academic publications (journals and conferences) + other non-academic reports

UERG

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Core research themes

- Building performance simulation/modelling
- Low and zero-carbon buildings
- Historic and traditional buildings
- Fuel poverty
- Life-cycle assessment
- Energy consumption monitoring / modelling
- Adaptation to future climates

All with a focus on the building user.

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Research projects

- Tarbase (EPSRC/Carbon Trust)
- Historic and traditional buildings (Historic Scotland + PhD)
- Concrete to Cookers (EPSRC)
- Building - low carbon climate change future (EPSRC ARCC)
- Measures for solid wall dwellings - CALEBRE (RCUK/E.on)
- Adaptation and resilience in energy systems (EPSRC ARCC)
- Office buildings – refurbishment and LCA (PhDs)
- Schools and factories – energy utilisation (PhDs)
- Wind farms – community involvement (PhD)
- Fuel poverty and refurbishment campaigns
- Whole life analysis of building components (RAEng)

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Modelling – SAP & RdSAP

SAP introduced in 1995 as a compliance tool for UK Building Regulations

- 2001 Updated to provide compliance for the EPBD
- 2005 update introduced the RdSAP
- 2009 update moved to monthly calculation
- 2012 update included regional climate information

Used for Energy Performance Certificates and Green Deal financial decisions

Modelling – Dynamic Simulation

- Calculation of building performance from first principles of building physics
- Use permitted by Non-Domestic UK Building Regulations
- Many different software packages available
- We used IES-VR in this work

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UK energy assessment methods

1. Dimensions
2. Construction
3. Ventilation / Infiltration
4. Thermal elements
5. Domestic Hot Water
6. Internal gains
7. Solar gains
8. Space heating
9. Total energy use → Fuel use → EPC rating
   → Green Deal

Steady State
UK energy assessment methods

Standard Assessment Procedure (SAP)

Existing Dwellings

RdSAP 2005

- Database of constructions and rules for simplification
- Annual calculation

RdSAP 2009

- Database of constructions and rules for simplification
- Monthly calculation
- Applicable since April 2011

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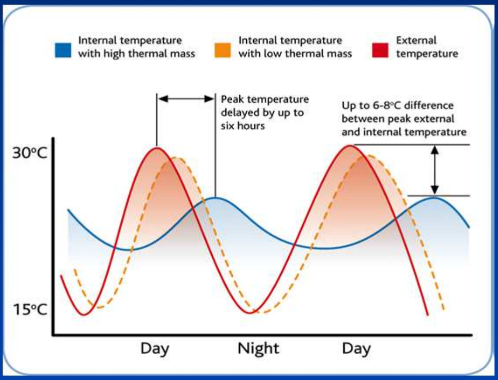
What's missing? – Thermal Mass

- Measure of a material's ability to absorb heat or cool, store it, and release it later
- Provides natural temperature control
- Year long benefits



The Concrete Centre, 2009

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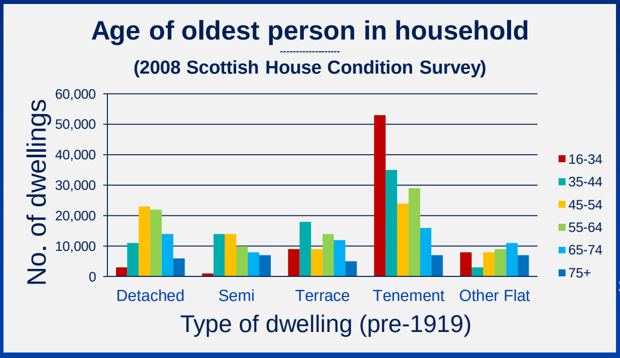
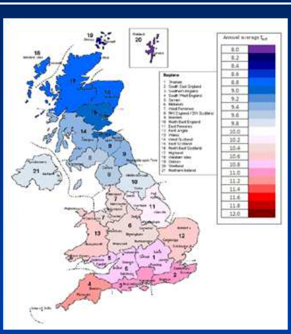
What's missing? – Occupancy Effects

Heating use	Thermal comfort
Attitude	Behaviour
Lighting use	Appliance use

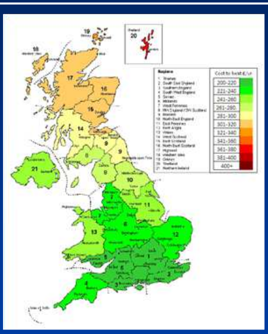


Source: SHCS, 2009

What's missing? – Climate / location



Average annual external temperature, °C



Heating cost, £/yr

RdSAP assumes Sheffield

Other variables?

Judgment of the assessor

Dynamic energy assessment methods

Dynamic Simulation Models (DSMs)

- Hourly climate data for location
- Assess thermal behaviour of construction
- Model internal environment changes and flows, using occupancy profiles
- Potentially greater precision, i.e. detailed input = detailed output

However…

Simplicity v Complexity

	RdSAP 2005	SAP/RdSAP 2009	Dynamic
Construction details	Some full Some default	Some full Some default	Some full Some default
Thermal Mass	✗	✗	✓
Include heat gains	✗	✓	✓
Thermal comfort	✗	✗	✓
Climate variables	Annual	Monthly	Hourly
Time to assess	1-2hrs + site visit	1-2hrs using plans	1-2 days + site visit
Cost to assess	££	££	£££ upwards

Simplicity v Complexity v Accuracy

Results for an Edinburgh tenement flat

Variable	Units	RdSAP 2005	SAP 2009	IES<VE>
Lighting electricity demand	kWh/year	297	298	329
DHW demand	kWh/year	2791 }10,619	2371 }5730	2729 }11,669
Space heating demand	kWh/year	7828	3359	8,940
Combined	kWh/year	10,916	6028	11,998
EPC rating		C	B	n/a

Actual gas usage = 12,527 kWh
(2010, energy aware occupants, boiler inefficient)

1. Thermal mass investigation

- 3 case study dwellings in 4 models:
  - RdSAP 2005, SAP 2009, RdSAP 2009, IES<VE>
  - Scottish historic solid stone wall homes
  - Challenging if old is cold, and if domestic models are suitable for the Scottish housing stock

Case studies

1) Tenement flat, Edinburgh
2) Small detached cottage, Dumfries
3) Small semi-detached bungalow, Edinburgh



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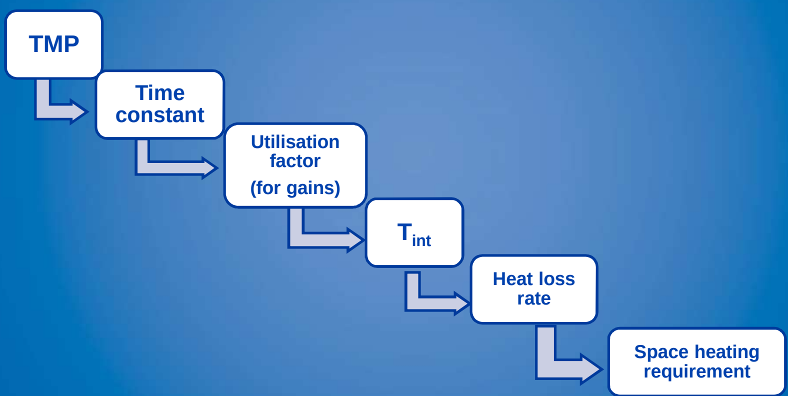
Thermal mass in the SAP



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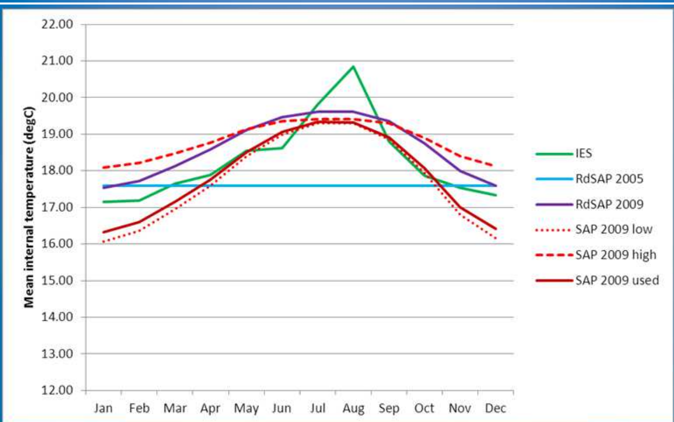
Thermal mass in the models



Tenement flat

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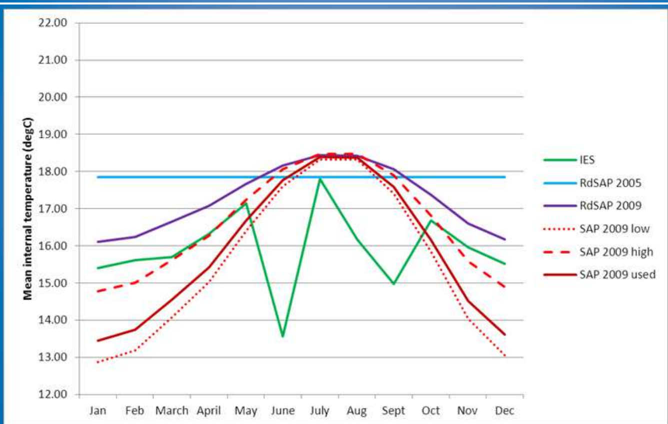
Thermal mass in the models



Detached house

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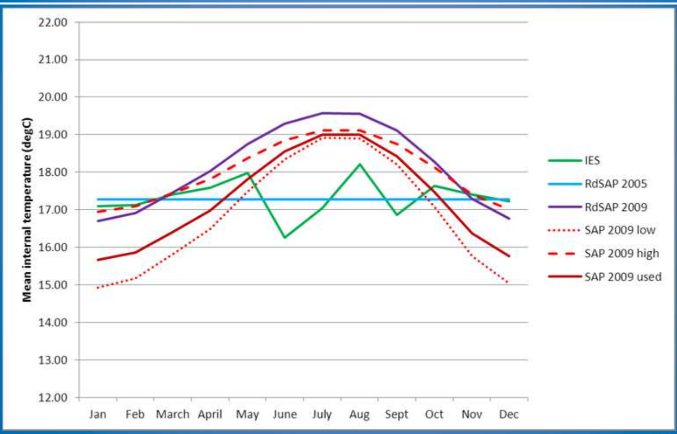
Thermal mass in the models



Semi-detached bungalow

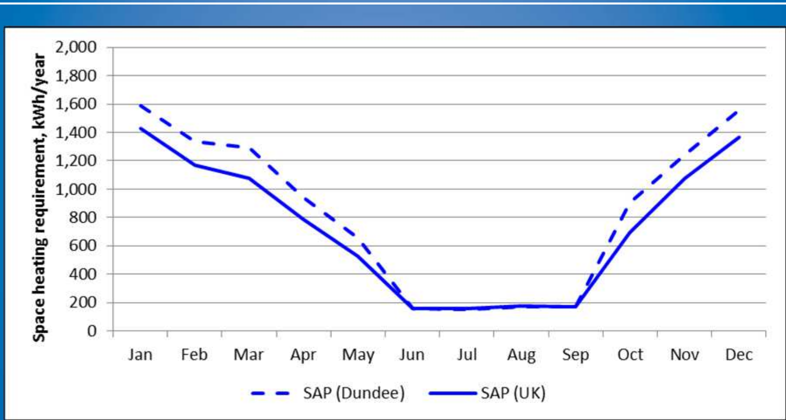
Key findings

- SAP can recognise the ability of thermal mass to dampen temperature fluctuations across the year
- The move to monthly steady-state calculations has made the calculation for winter space heating requirement more reliable across dwelling types
- The TMP *calculated* using construction information differs from that *assumed* in RdSAP 2009 significantly and alters the heating requirement
- Two dwellings with same construction will have different fabric losses

2. Location / climate investigation

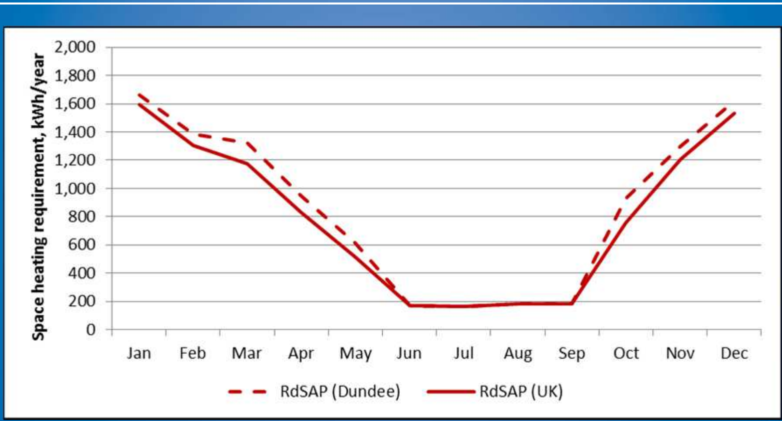
- Tenement flat in 3 models:
  - SAP 2009, RdSAP 2009, IES<VE>
  - We forced the models to use ‘local’ climate data
  - Space heating requirements

Space heating requirement in SAP



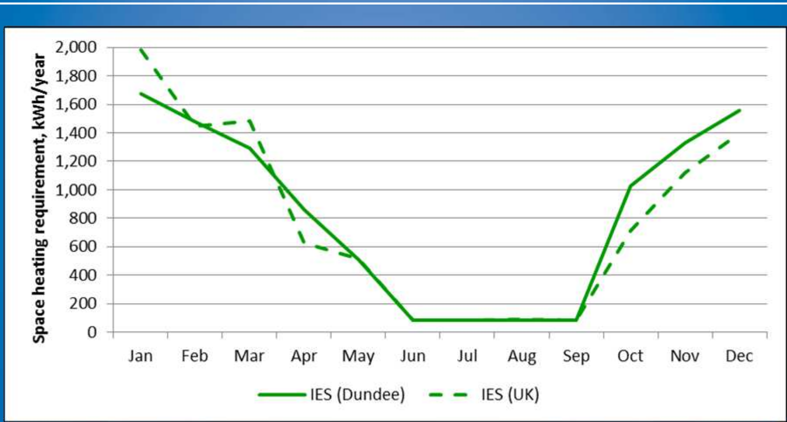
Tenement flat

Space heating requirement in RdSAP



Tenement flat

Space heating requirement in IES



Tenement flat

Key findings

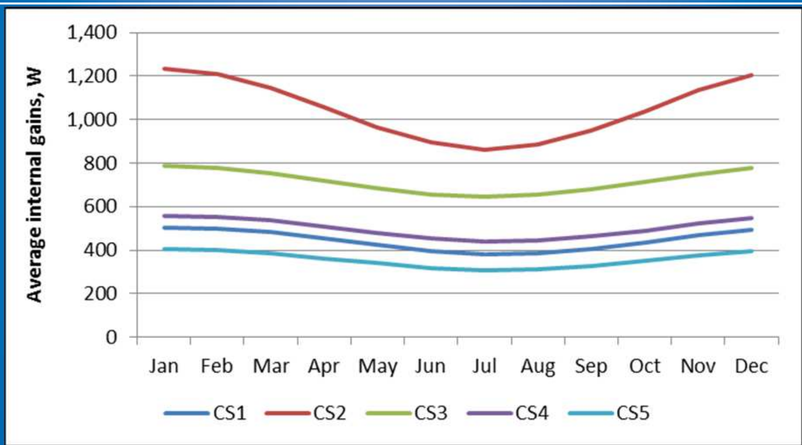
- Using the UK average climate instead of the local data underestimates the heating requirement in all models.
- Use local climate data wherever possible.

3. Occupancy effects

- SAP and RdSAP link occupancy to floor area
- IES allows input of actual occupancy
  - Metabolic gains
  - Time of day
  - Activity levels

Case studies

Internal gains – SAP & RdSAP



Calculation is based on floor area

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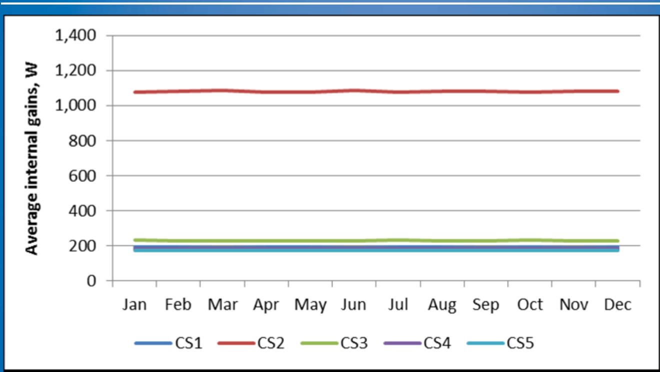
Internal gains – IES



Much larger house – more solar gain

Calculation includes metabolic, lighting and solar gains

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Key findings

- IES defines internal gains much better
- SAP and RdSAP are cruder

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4. Assessor judgment

- SAP and RdSAP require assessor to enter values. How robust are they to choices?
- 7 input parameters chosen – U values, dimensions, structural features like bridging.
- High, medium and low values of each entered (=2187 combinations)
- SAP rating calculated for each combination

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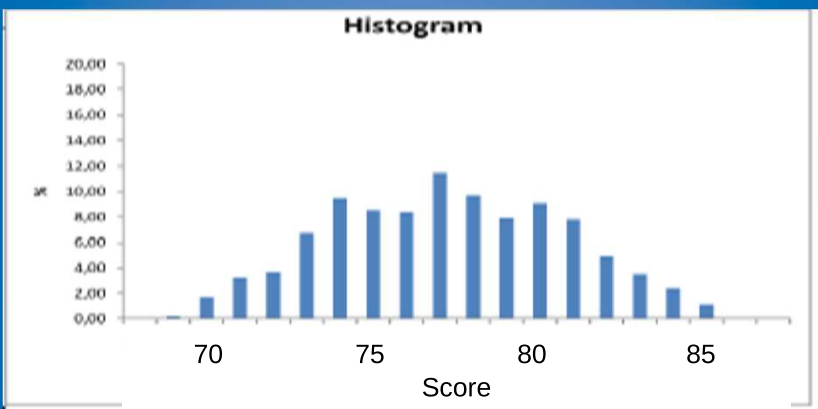
Sensitivity analysis



SAP score range 69-86 = EPC C-A on same house

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Key findings

- Assessors are human, mistakes can happen
- The cumulative effect of errors of judgment can amount to ±10% on the SAP rating score
- You have to be careful.

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Overall conclusions

- Modelling is important but not all models are the same. You need to be aware of their limitations.
- Entering the right data is crucial.
- The outcome may influence decisions on measures and funding (e.g. Green Deal).
- Will the building perform as the model predicts?

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Thank you for listening

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