7-294-13

Closing the Gap

PROVIDING FEEDBACK ON AS-BUILT BUILDING PERFORMANCE

UCL

Using simulated co-heating tests to understand weather driven sources of uncertainty within the co-heating test method

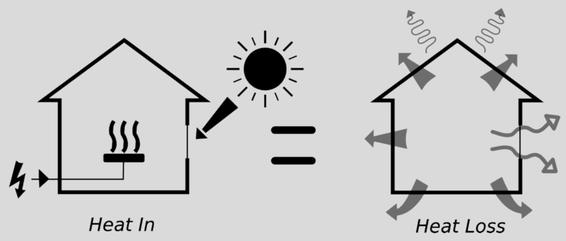
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Co-heating is an ***in situ method*** for measuring heat loss across the entire envelope (*HLC*)[1], therefore picking up both variations in fabric performance and unpredicted losses[2]. As an in situ test it measures heat loss resulting from real conditions and the full construction process.

Some of the strongest evidence of a ***design vs. measured performance gap*** has come via co-heating[3] and it is cited as a key tool in providing feedback and quality control to close the gap[4].

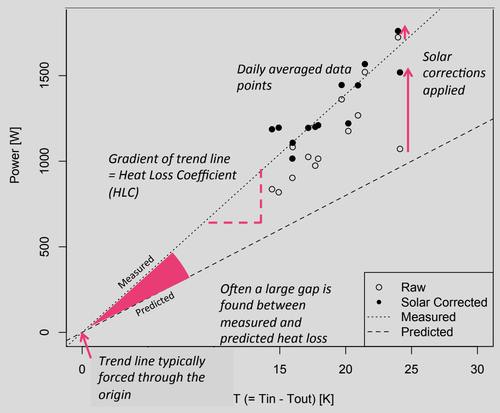


$$Q + R.S = HLC \cdot \Delta T$$

ELECTRIC POWER; SOLAR GAINS; HEAT LOSS COEFFICENT; INTERNAL-EXTERNAL TEMPERATURE DIFFERENCE

The method is based upon an approximated ***energy balance***. Whilst the test building is kept at a constant internal temperature, heat input will equal heat loss. This data is then daily averaged to minimise dynamic behavior. Analysis takes the form of linear regression or multi linear reression[5,6].

Despite the potential benefits, the use of co-heating has been limited by its duration, reliability, testing season and invasive nature. These issues are strongly linked to the incumbent weather during testing. Therefore, the effect of ***four key weather variables*** on the *HLC* measurement are explored in this research.



Method

To use simulated co-heating tests to examine weather driven sources of uncertainty. Firstly by looking at full weather years, then by examining each variable, in turn, in hypothetical weather scenarios.

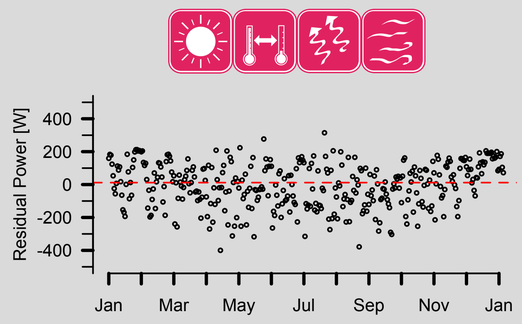
Symbols indicate which weather variables present in each simulation





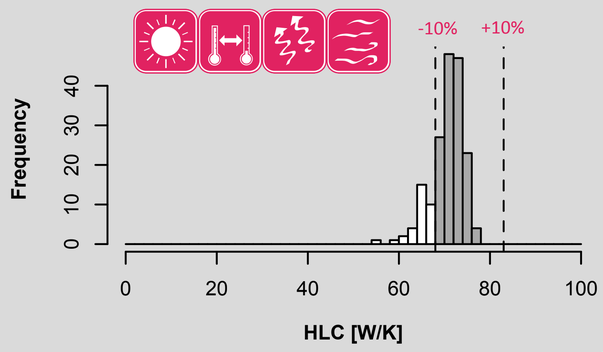
Full Weather

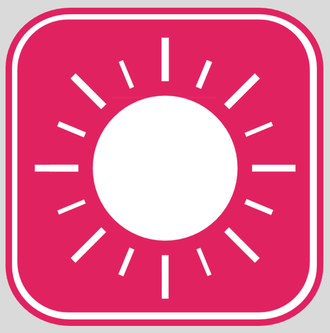
Examining a typical (Gatwick, UK) weather file with simulations throughout the year can establish the extent of deviations and trends from the true heat loss *(HLC)* measurement.



Residuals from the regression process increase during the summer months, typically outside the testing season.

Results for the regression derived *HLC,* during the testing season of Oct-Mar, are shown in the histogram. Significantly, a trend for underestimating the *HLC* exists.

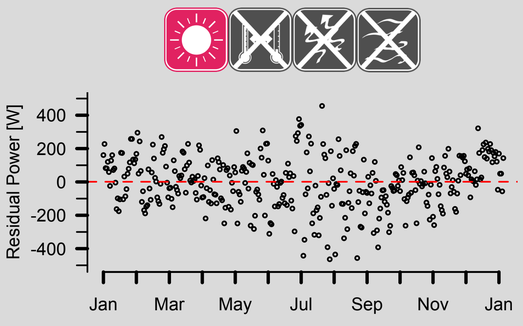




Solar Radiation

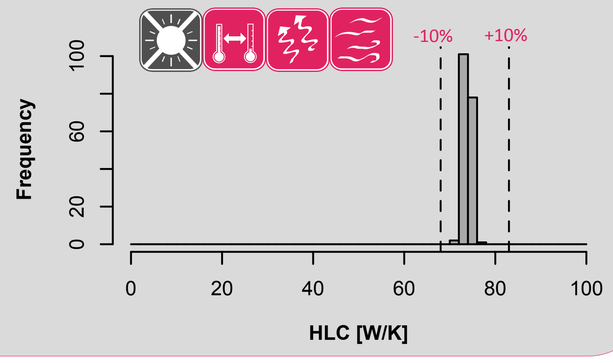
The presence of solar radiation can effect the co-heating result in three ways:

- Determination of gains
- Thermal Storage
- Overheating



Solar generated residuals are large, with their magnitude increasing during the summer.

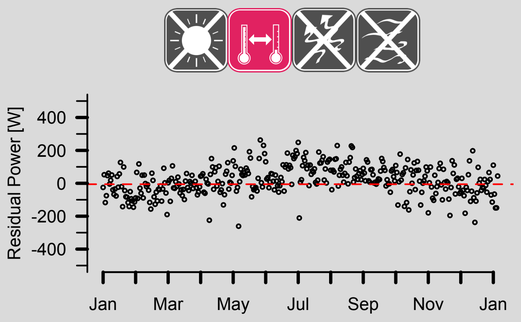
The histogram shows that in the absence of solar gains the heat loss coefficient can be determined much more reliably, even with the other variables present.





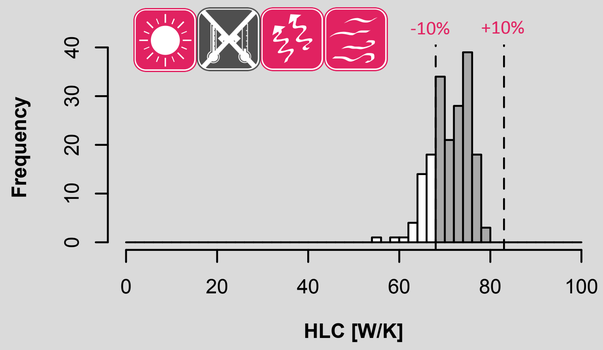
External Temperature

The varying external temperature leads to lags in the energy balance and further thermal storage effects.



Residuals generated solely by the changing external temperature show a positive trend in the summer when ΔT is smaller.

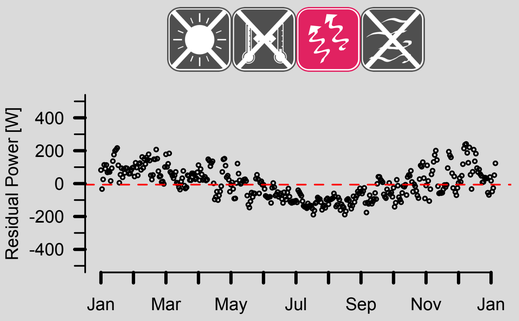
Keeping external temperatures constant does not significantly alter the reliability of the result in the histogram. The small range in ΔT values may effect the regression.





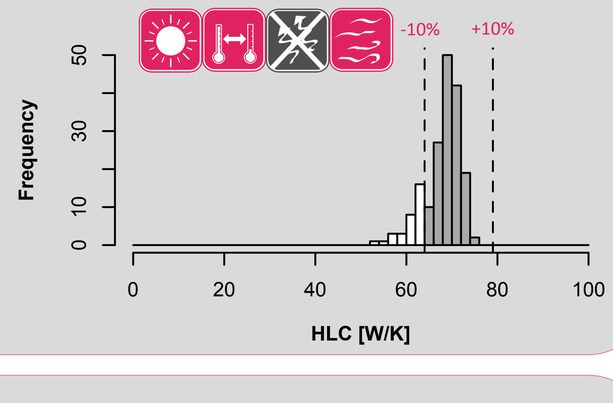
Long-wave Sky Radiation

Long-wave sky radiation losses are unmeasured in the co-heating method but can alter the total measured heat loss, varying with cloud coverage and sky temperature.



Residuals generated via sky radiation lead to a bias depending on the conditions and time of year of testing.

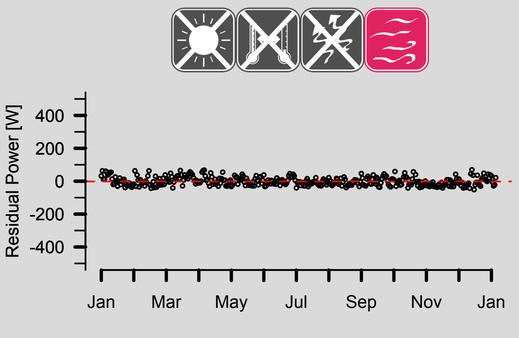
Removing sky radiation has little effect on the calculated *HLC*, although this reduces the true heat loss, as this loss mechanism is removed (note shift in histogram).



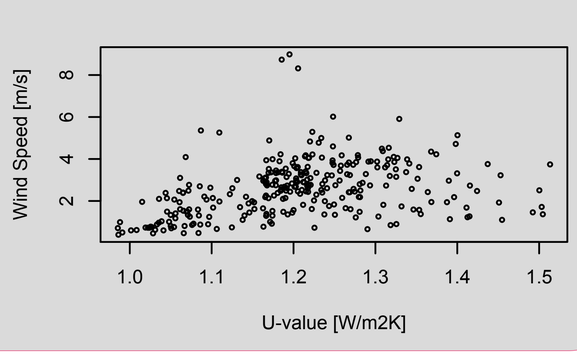


Wind

Wind can increases losses, in particular infiltration losses, depending on wind speed and direction and the construction of the test dwelling.



Simulation results indicate the effect of wind is small. However, field work has shown heat loss can be highly correlated with wind speed in some cases. This time the graphs shows the measured u-value from a field test, correlated with wind speed. This is strong when there is airflow in the cavity, a complex effect not accounted for in the simulation.



Conclusions

[1] *Solar radiation generates the largest uncertainty, even in this modestly glazed dwelling. It causes uncertainty through the calculation of solar gains, thermal storage effects and overheating.* ***[2]*** *The co-heating test method is more reliable in the absence of solar radiation, indicating when a test can reliably be performed.*

[3] *The co-heating method shows a tendency to underestimate the HLC in most cases.*
[4] *When comparing measured with designed HLC the incumbent weather (i.e. sky radiation) needs to be taken into account as it alters the predicted HLC.*

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References [1] Everett, R. 1985. Rapid Thermal Calibration of Houses. Technical report ERG 055 for the Science and Engineering Research Council, Milton Keynes, United Kingdom **[2]** Lowe, R.J. et al., 2007. Evidence for heat losses via party wall cavities in masonry construction. Building Service Engineering Research and Technology, 28(2), pp.161–181. **[3]** Stafford, A., Bell, M. & Gorse, C., Building Confidence – A working paper. Leeds, UK. **[4]** Wingfield, J. et al., 2011. Elm Tree Mews Field Trial – Evaluation and Monitoring of Dwellings Performance Final Technical, Leeds Metropolitan University, UK. **[5]** Wingield, J. et al., 2010. Whole House Heat Loss Test Method (Coheating)., LMU, UK **[6]** Siviour, J. 1981. Experimental Thermal Calibration of Houses. Technical report for the Electricity Council Research Centre, Chester, United Kingdom.