Knauf Energy Solutions SMETER verification study

Interim summary report

Background and purpose

This interim report contains the results from a verification study undertaken by the Leeds Sustainability Institute (LSI) of Leeds Beckett University on behalf of Knauf Energy Solutions (KES) to verify the performance of a SMETER technology developed by KES for determining the HTC of domestic buildings.

This study builds on the previous TEST project (2022) in which the KES SMETER technology was deployed in two homes. A further four homes were tested by the LSI using the electric coheating test methodology to derive the heat transfer coefficient (HTC), before the KES SMETER data collection began, to calculate a HTC while the home was occupied. These homes were: in different regions; were detached, semi-detached and end of terrace; and included one home with MVHR.

The coheating was undertaken with furniture and furnishings in place and without additional sealing of ventilation to align the condition of the homes during the occupied KES testing.

The study was designed so that the teams at the LSI and KES would remain blinded to the data collected by either team.

At the time of writing, good agreement between the Coheating HTC and in-use SMETER HTC has been found in two of the homes. The conditions required for blinding meant that the KES data checking protocol for heat data could not be implemented. In addition, the dispersed locations of the homes and tight project timescales led to a non-compliant installation with sensors not placed as per floor plans. This has delayed the final results of the two remaining homes.

Methods

Coheating test

Each of the four homes was tested using the electrical coheating method (Johnston, 2013) this test is used to determine the Heat transfer coefficient of the building fabric in watts (W) of heat energy moving through the fabric to the external environment per degree kelvin (K) of temperature difference between internal and external temperature.

The HTC is derived by the use of electrical resistance heaters to maintain a quasi-steady state internal temperature throughout the home over an extended period of time. By monitoring internal and external environmental temperatures the HTC of the building fabric can be determined.

During a coheating test the near constant elevated internal temperature of the test home can lead to excessive heat loss across party elements with neighbouring homes, most commonly party walls. Heat flux plates were mounted on the party walls of each test homes in each space they were present to monitor the flow of heat through these walls. A correction was then applied in the analysis of the coheating data.

The verification tests carried out as part of this study varied from the method set out in the Leeds Beckett Coheating method (Johnston, 2013), in order to replicate the condition in which the homes would be during in-use monitoring. Firstly, the homes were in a furnished state, with furnishings, appliances and other occupant belongings left in place. Where practical large furnishings such as sofas or beds were moved away from the centres of rooms to allow for uniform temperatures and airflows during the coheating test.

Secondly, purpose provided ventilation was not sealed, this included active ventilation such as extract fans and extractor hoods. Passive ventilation such as air bricks were also left unsealed. Where they were present, trickle vents in windows were moved to the closed position, as this reflected the state of ventilation in occupied homes based on the experience of the LSI research team.

Inclusion of homes from the 2020 SMETER TEST project.

Two additional dwellings were added to the four tests completed as part of this project. These two additional homes were tested as part of the TEST project in 2020 (Allinson, 2022). Although broadly comparable, the protocol for coheating varied between the two studies. Specifically, during the TEST project, homes were in an unoccupied state with no furniture or occupant belongings present. Furthermore, rather than being tested with purpose provided ventilation unsealed, the TEST project sealed all vents during coheating. Ventilation heat losses were then estimated using air pressure tests, estimated ventilation heat loss was then included in the coheating HTC as a final step.

In-use data collection

KES installed their SMETER technology in each home, using smart meter data and a number of temperature and humidity sensors distributed through the home and surface-mounted temperature on boiler pipework. Data from these devices was transmitted to a hub which would upload data to KES. A separate in-line heat meter was also installed in the heating system flow and return pipes, and data from this device was transmitted by a separate hub to an independent, third party platform. This would enable the calculation of an HTC with and without heat meter data as well as an estimated energy consumption in the following heating season. This final stage was included in order to demonstrate accuracy via energy estimation. This allows the accuracy of HTCs to be reported without using a separate benchmarking method.

In-use HTC would be calculated at three stages with incrementally more data, initially 52 days of monitored data without heat meter data, a second HTC incorporating 32 days of heat meter data and a third HTC incorporating 52 days of heat meter data.

Blinding

The teams at the LSI and KES remained blinded to the data collection and analysis performed by the other team until the disclosure stages of the study. During coheating KES devices had either not been installed or were deactivated to ensure the study remained blinded to the coheating data.

In-line heat meter data was monitored by the LSI, with no access by KES, to detect problems with data collection and to prepare blocks of data for release to KES following a disclosure schedule as outlined below:

Table 1 Data disclosure stages

Disclosure stage	KES release	LSI release
1	52 day HTC – no heat meter data	32 days of heat meter data
2	32 day HTC – with heat meter data	Final 20 days of heat meter data
3	52 day HTC – with heat meter data	Coheating test HTC

The disclosure schedule allowed KES to calculate multiple HTC values with incrementally more data. Upon receiving each HTC result from KES the LSI released the next block of heat meter data, until finally releasing the Coheating HTC to KES.

Test homes

Four homes in England were tested in this study, each home was in an occupied state, with furniture and belongings largely left in place for the duration of the coheating test. Where practicable, large items of furniture were moved from the centre of the room to facilitate airflow, in accordance with the coheating protocol. Each home featured at least one party wall with a neighbouring home. No surveys or investigations of the building fabric were carried out as they were deemed unnecessary to achieve the goal of determining fabric HTC

Table 2 Home construction

Home	form	Construction
42 SHC	Semi-detached	Brick cavity wall
19 NR	Semi-detached	Solid brick
33 RR	Mid-Terrace	Brick cavity wall
43SR	Mid-Terrace	Brick cavity wall

Results

Following preliminary analysis of the LSI Coheating data, some further adjustments were made to the analysis to correct for errors in the solar heat gains and party wall corrections. The final LSI Coheating results were issued on 31/10/2025.

The HTC values calculated by the KES SMETER technology and the LSI coheating test are summarised in Table 3. Cells shaded green are in agreement with both the coheating HTCs. Cells shaded red are statistically different from both coheating HTCs. Of the 8 finalised HTCs, 7 of them are in agreement with the coheating values, with only 19NR showing a result which is in disagreement.

Table 3 further shows the values for CVRMSE and NMBE for different methods.

CVRMSE and NMBE are the statistical tests applied during the TEST project. These metrics allow two methods for calculating HTCs to be compared in a blind test and for the ‘gap’ between the reference method and the SMETER to be evaluated. A low CVRMSE implies a good agreement and a low NMBE implies that there is a low bias i.e. a low a tendency to be higher or lower overall. In addition to the CVRMSE and NMBE metrics, coheating and in-use methods can give a confidence interval. The KES confidence interval indicates repeatability or the spread of HTCs that are calculated using different random segments of the monitoring data (i.e. a block bootstrap method). Again, this is in line with methods used by other SMETERs during the TEST project. In addition to these statistics, KES calculates error metrics for each home and for large samples of homes based on the performance of its model. This metric is the error in estimating energy, given the calculated HTC and the way the home is being used. A summary of these metrics and their use cases is given in the Interim Appendix and will be addressed in the final project report.

CVRMSE and NMBE are calculated using both the coheating HTC with party wall correction, and the coheating HTC without party wall correction. These metrics were calculated for comparison to previous work such as the TEST report but it should be noted that, in the results reported so far, only two numbers were available for calculation. This is not typically considered sufficient for a representative assessment. Conclusions based on these numbers would therefore benefit from awaiting the final HTCs.

Some problems with the KES in-use monitoring equipment became apparent following full disclosure of in-use monitoring results. In 33RW a valid KES HTC could not be generated due to monitoring devices installed in locations that did not comply with the specification of the KES SMETER technology. The monitoring equipment has been repositioned, and a new monitoring period has begun, although this will be un-blinded. It is expected that this will allow the effects of different sensor placement on HTCs to be quantified.

The in-line heat meter installed in 43 SR was found to have been installed backwards, this made the flow measurements recorded by the device invalid. This was discovered late in the project – due to the impact of blinding on data checking - but before disclosure of any data by the LSI. It was therefore decided a new monitoring period would be started and the home would remain blinded until after sufficient in-use data had been collected.

Where a party wall correction has been applied, the effects of losses through party walls are not included in the HTC. No party wall correction means that the effects of these losses are included. The current definition of in-use whole house HTCs includes losses through party walls so the relevant results for KES are those that have no party wall correction.

Table 3 HTC Results

House	KES HTC			LBU Coheating results & SMETER 2020	
Stage	52 days - no heat meter data	32 days - plus heat meter data	52 days - plus heat meter data	Coheating PW Correction Applied	Coheating No PW Correction
Released	KES – 26/08/2025	KES – 01/09/2025	KES – 03/09/2025	LSI – 31/10/2025	LSI – 31/10/2025
42 SHC	209 ± 20	221 ± 22	219 ± 20	205 ± 12	210 ± 8
19 NR	268 ± 21	291 ± 29	296 ± 18	306 ± 11	312 ± 11
33 RW	Non-compliant install			172 ± 6	189 ± 8
43 SR	161	Pending heat meter data			
Genk KUL (MVHR, KUL)			224 ± 7	235 ± 39*	NA
Old Trafford (LBU 2020)			169 ± 13	169 ± 27	172 ± 27
NMBE (PW correction applied)	0.07 **6.7%**	0.00 **0.0%**	0.01 **0.8%**		
CVRMSE (PW correction applied)	0.11 **10.6%**	0.06 **6.1%**	0.04 **4.5%**		
NMBE (No PW correction)	0.09 **8.6%**	0.02 **1.9%**	0.01 **1.4%**		
CVRMSE (No PW correction)	0.12 **11.9%**	0.06 **6.4%**	0.05 **4.6%**		

**Genk coheating test was not conducted by the LSI*

Conclusions

The interim results of this verification study show that the KES SMETER technology is capable of calculating a value for the HTC of a home that is in good agreement with the HTC derived from the electrical coheating test.

This study shows a CVRMSE result of 4.6%-11.9%, depending on the KES product that has been installed. This is in-line with the CVRMSE performance of SMETERs in the TEST Project which ranged from 13.4% to 38.9%.

Although data is limited at this stage the use of heat output from the homes boiler appears to be beneficial to the system's ability to calculate an accurate HTC. The difficulties in achieving a result in two of the homes highlights the importance of sensor installation and placement in such tests.

References

Johnston, D., et al., *Whole House Heat Loss Test Method (Coheating)*. 2013, Leeds Metropolitan University: Leeds.

Allinson, D et. al. *Technical Evaluation of SMETER Technologies (TEST) Project*. 2022, Loughborough University: Loughborough.

Interim Appendix

Approach to Accuracy and Errors	Directly Measures Accuracy	No HTC benchmark required	Blinding Possible	Externally Validated
Performance of single house model • Energy Estimation Error (kWh or %) • HTC Upper Bound Error derived from EE error. Converts Energy Estimation error into "HTC-space" and units from kWh (or %) to W/K (or %). Demonstrates link between EE & HTC error given that parameter accuracy and model accuracy are inextricably linked. Upper bound based on attributing 100% of EE energy to mis-learned HTC. Can be used to fairly & independently distinguish between "gold standard" candidates	✓	✓	✓	LSI (Q1 2026)
Performance of many house models • Energy Estimation Error (kWh or %): performance of single house model over many houses, data from different periods. Includes for seasonal bias.	✓	✓	✓	LSI (Q1 2026)
Repeatability via Confidence Interval (bootstrapped) • Standard deviation (σ) of repeated sampling: same house, different segments of data, limited monitoring period. Does not include any seasonal bias.	✗	✓	✗	LSI
Reproducibility or reproduce measurement of HTC. • Standard deviation (σ) of repeated measurement: many individual houses, data from a different period. Single house requires 1-2 years (not 32 or 52 days) for sample size. Only works for "unbiased expectation at single-home level" algorithms, which is difficult to prove. Can't be blinded easily	✓	✓	✗	2 periods reqd. >52 days
Comparison of two methods (%) • Coheating vs SMETER or SMETER vs gold standard SMETER Panel. Typically CVRMSE / NMBE • Accuracy not measured directly. Less useful for models that are close to or more accurate than the "gold standard".	✗	✗	✓	LSI and TEST Project