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BRE Technical Report

SAP Appendix Q – Evidence underpinning saving attributed to the AirEx system

CONTENTS

Background

The product

AirEx is an automated passive underfloor ventilation system for suspended timber floors developed and commercialised by U-Floor Technologies ("UFT"). Standard airbricks are replaced with adjustable air bricks, the aperture of each of which is controlled in response to humidity and temperature sensor data to ensure humidity levels in the underfloor space are controlled so as not to lead to moisture problems. Since the counterfactual is for permanently open airbricks, this should result in a relative reduction in the air change rate of the under-floor void. The potential benefits of this are a consequent improved/reduced floor U-value and a reduction in the air infiltration rate through the suspended floor.

Purpose of report

This report is concerned with the recognition of AirEx system in SAP through the SAP Appendix Q process. Further detail on the process to recognise innovative energy saving products in SAP can be found on the NCM/PCDB website[1].

The purpose of this report is to detail the research and evidence underpinning the energy saving attributed to the AirEx system and to make it available to Domestic Energy Assessors (DEAs), construction clients, specifiers, product suppliers and the wider industry. It is this saving that can be used by DEAs in the RdSAP calculation to produce an EPC for a dwelling. The mechanism by which DEAs can do this is through an API detail of which can be found on the NCM/PCDB website[2].

This report is an updated version of the report submitted and agreed with SAPSIG (SAP Scientific Integrity Group)[3] and BEIS, the government department responsible for SAP. It was prepared by BRE (BEIS's SAP contractor) in collaboration with UFT.

[1] See https://www.ncm-pcdb.org.uk/sap/page.jsp?id=20

[2] See https://www.ncm-pcdb.org.uk/sap/appendixq-api.jsp

[3] For further detail on SAPSIG's terms of reference see https://www.bregroup.com/sap/sapsig/

Methods

As part of an **Energy Company Obligation (ECO) scheme**, a field trial was conducted to establish the impact of AirEx on the heat transfer coefficient (HTC) and the ground floor U-value. HTC measurements were successfully recorded on 66 properties. The AirEx bricks were set in dynamic mode, where they open and close in response to temperature and humidity levels, for the first phase of the trial (dynamic phase). In a second phase, the AirEx bricks were left open to simulated pre-install (open phase). The measurements were carried out using the SmartHTC tool developed by Build Test Solutions (BTS)[4]. During this ECO trial, ground floor U-value measurements pre and post install were successfully conducted on 17 of the properties.

In addition, BRE assessed data from three other studies provided by UFT:

- The **University of Sheffield** conducted a field trial where pre and post install ground floor U-value measurements and air permeability measurements were successfully recorded on four occupied properties.
- The **University of Salford** recorded ground floor U-value and air permeability measurements pre and post install on the Salford Energy House.
- Pre and post install airtightness measurements were recorded in a property of the **Borough of Hackney.**

The results from all four studies[5] are summarised in Figures 1 to 4.

Firstly, we analysed the SmartHTC dataset, and attempted to establish an HTC percentage improvement. We then analysed all ground floor U-value and airtightness measurements collectively. We used SAP2012 and SAP10 to model the cumulative impact of U-value and airtightness improvements on HTC to check results from all datasets are reasonably consistent.

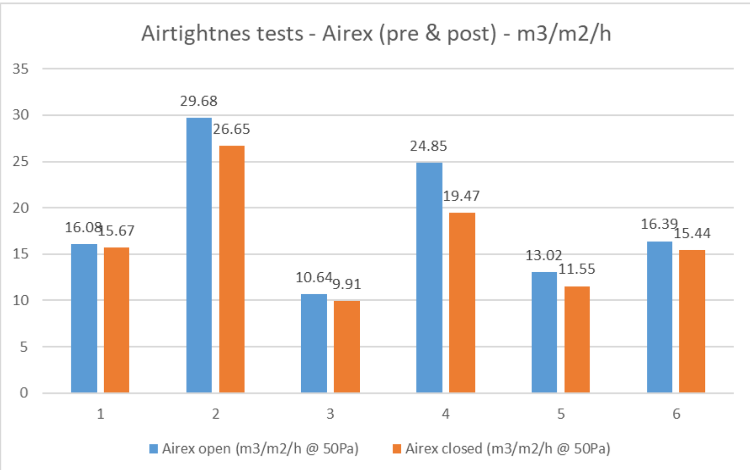

Figure 1 – Pre (blue) and post (orange) AirEx Airtightness measurements (m3/m2/hr @ 50Pa) recorded over the various field trials. Measurements 1-4 were recorded as part of the University of Sheffield trial on four occupied homes, measurement 5 was recorded in the Salford Energy House and measurement 6 was recorded on a property from Hackney.

[4] See https://buildtestsolutions.com/thermal-performance/smarthtc/

[5] All studies are available from https://www.airex.tech/

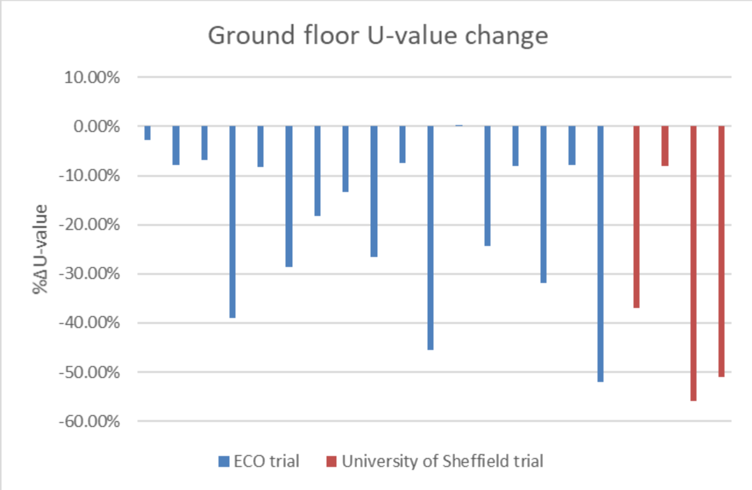

Figure 2 - Percentage change in ground floor U-value observed on the 21 pre and post measurements. In blue are the 17 measurements recorded during the ECO trial, in red are the four measurements recorded as part of the University of Sheffield trial.

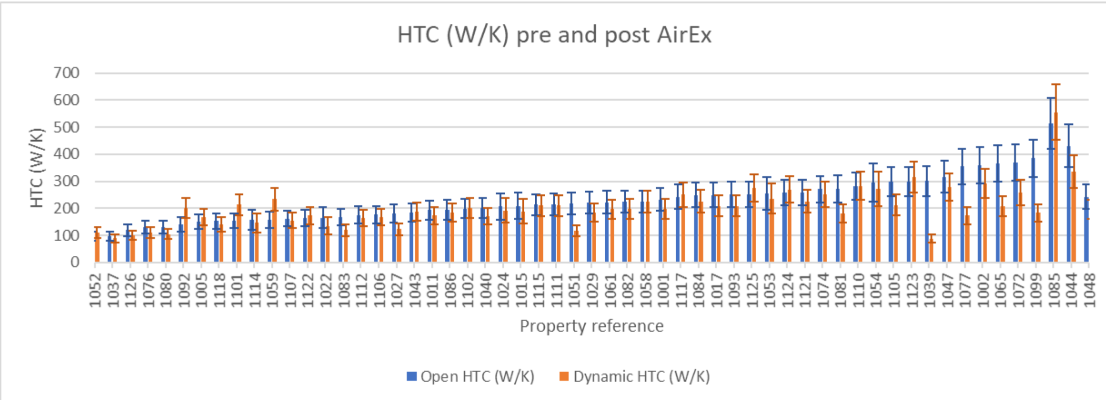

Figure 3 - SmartHTC measurements recorded as part of the ECO trial. Each property is assigned a reference number. Open measurements are for the pre-install phase, dynamic measurements correspond to the post-install phase. The error bars show the confidence levels declared by BTS.

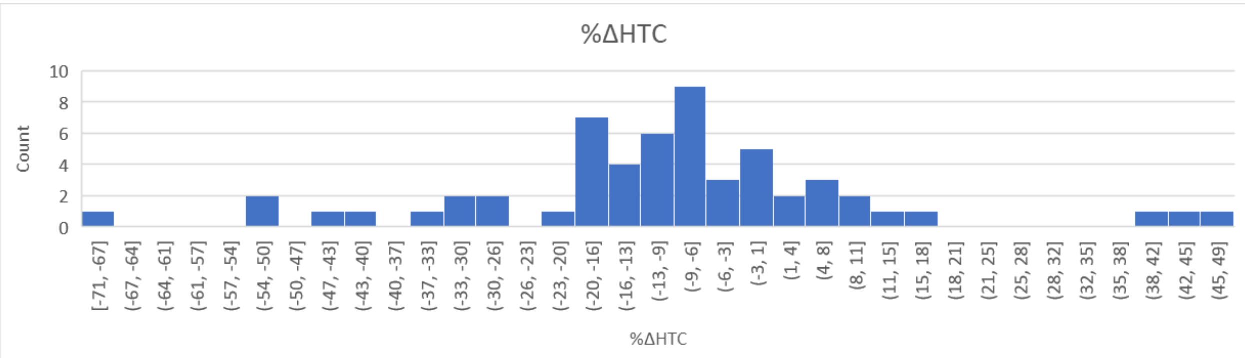

Figure 4 - Distribution of percentage change in HTC between the Open and Dynamic phases. The x-axis shows the binned HTC percentage change, the y-axis shows the count of datapoints.

The SmartHTC dataset came with some challenges arising from the first covid19 lockdown and elevated external temperatures during some of the monitoring period which we have addressed by selecting only the most reliable datapoints through two methods:

1) Excluding measurements where the Dynamic phase monitoring period occurred over 40% of the time during the first Covid19 lockdown. This reduced the dataset to 36 points and lead to an average HTC improvement of 7.4%.
2) Excluding measurements which were deemed ‘impossible’. We established a range of “maximum achievable” HTC improvement based on:
   - the scientific literature,
   - models based on field measurements of ground floor U-value and airtightness pre and post AirEx install, and,
   - modelling extreme cases of setting the ground floor U-value to zero W/m^{2}K and setting the whole dwelling air permeability to zero m^3/m^2/hr @50Pa.

   All models were run with SAP2012. The results showed that HTC improvements greater than 17.8%-33.1% were unlikely depending on the method used. We used the highest threshold to exclude datapoints which show an HTC improvement beyond 33.1%. We also excluded datapoints which showed an HTC increase beyond the measurements’ confidence levels calculated by BTS. By excluding ‘impossible’ datapoints, we reduced the dataset to 50 datapoints which gave an average HTC improvement of 7.4%, where the Wilcoxon signed-rank test confirmed statistically significant results.

We then analysed all ground floor U-value and airtightness measurements collectively. We used SAP2012 to quantify the expected savings from:

- the average measured floor U-value improvement of 22.9% calculated from the 21 pre and post install measurements, and,
- the average measured airtightness improvement, 11.3% improvement calculated from six pre and post install measurements.

The models were run on the five most common house types amongst the ECO trial to be comparable with the SmartHTC results.

We tested two scenarios. For the first scenario we used typical ground floor U-values as the starting U-value. Results of the models gave an average 4.9% HTC improvement. For the second scenario, we doubled the typical suspended timber floor U-value to account for potential uncertainties as suggested by floor U-value measurements reported by *Pelsmakers* et al (2017). The second scenario results gave an average 6.7% HTC improvement.

Results

Table 1 – Summary of HTC improvements and SAP ratings obtained from the three methods

	SmartHTC Method 1	SmartHTC Method 2	U-value and airtightness analysis	
			scenario 1	scenario 2
%ΔHTC	-7.4%	-7.4%	-4.90%	-6.70%
Average ΔSAP rating	+1.4	+1.4	+1.0	+1.2
Average ΔEI rating	+2.0	+2.0	+1.6	+2.0
Number of data points involved	36 SmartHTC	50 SmartHTC	21 U-values and 6 Airtightness	21 U-values and 6 Airtightness

Table 1 shows the calculated HTC improvements using the different methods with as much of the experimental data (direct HTC, airtightness and U-value measurements) as possible within the framework of the SAP model. We supplemented this with data from other relevant studies. We concluded that the different methods presented here are reasonably self-consistent. It is not possible to state which is the 'correct' one because each has their pros and cons in respect of the number of data points they encompass and the scope and robustness of the measurement.

Overall, we concluded that it is reasonable to recognise an HTC improvement of 6.6% which is a simple arithmetic average of the above range of the most robust results. This has been agreed with UFT.

Tables 2 and 3 show expected SAP rating improvements for the five common properties using SAP2012 and SAP10 respectively. Please note that the SAP2012 engine does not return unrounded SAP ratings.

Table 2 - Results when improving HTC by 6.6% calculated with SAP 2012. Percentage change in energy consumption, percentage change in fuel costs, percentage change in CO2 emissions, and the number of SAP and EI points gained. The SAP2012 engine does not report unrounded SAP ratings

detachment type	%ΔkWh/yr	%Δ£/yr	%ΔkgCO2/yr	ΔSAP rating	ΔEI rating
semi-dtch, 2 bed	-5.5%	-4.0%	-5.1%	1	2
semi-dtch, 3 bed	-5.5%	-4.1%	-5.2%	1	2
semi-dtch, 4 bed	-5.6%	-4.4%	-5.3%	1	2
mid, 2 bed	-5.6%	-3.8%	-5.2%	1	1
end, 3 bed	-5.5%	-4.1%	-5.1%	1	3
average	-5.5%	-4.1%	-5.2%	1	2

Table 3 - Results when improving HTC by 6.6% calculated with SAP10. Percentage change in energy consumption, percentage change in fuel costs, percentage change in CO2 emissions, and the number of SAP and EI points gained. The input file varied slightly from the input files used for SAP2012 runs

detachment type	%ΔkWh/yr	%Δ£/yr	%ΔkgCO2/yr	ΔSAP rating	ΔEI rating
semi-dtch, 2 bed	-5.1%	-4.1%	-5.2%	1.39	2
semi-dtch, 3 bed	-5.2%	-4.2%	-5.3%	1.39	2
semi-dtch, 4 bed	-5.4%	-4.5%	-5.4%	1.48	2
mid, 2 bed	-5.2%	-4.0%	-5.3%	1.23	1
end, 3 bed	-5.2%	-4.2%	-5.2%	1.45	2
average	-5.2%	-4.2%	-5.3%	1.39	1.8

As it is also a possibility for dwellings which would benefit from the AirEx system to be heated with old electric storage heaters, we have conducted a series of additional runs to show the expected rating improvements obtained with such heating systems (table 4). The SAP input files are identical to those used to produce table 3 except for the heating system.

Table 4 - Results when improving HTC by 6.6% calculated with SAP 2012. The files are identical to those used in table 3, except for the heating system which has been changed to an electric storage heater (Old, Large volume), heating code 401 from SAP2012 table 4a, with automatic charge control, control code 2402 from SAP2012 table 4e)

detachment	%ΔkWh/yr	%Δ£/yr	%ΔkgCO2/yr	ΔSAP rating	ΔEI rating
semi-dtch, 2 bed	-6.6%	-6.2%	-6.6%	3	3
semi-dtch, 3 bed	-6.6%	-6.2%	-6.6%	4	3
semi-dtch, 4 bed	-6.6%	-6.3%	-6.6%	4	3
mid, 2 bed	-6.7%	-6.2%	-6.7%	3	3
end, 3 bed	-6.5%	-6.1%	-6.5%	3	3
average	-6.6%	-6.2%	-6.6%	3.4	3.0

We also tested the 6.6%HTC improvement on a poorer performing dwelling (table 5) with external wall U-value of 1.7 (solid wall pre-1966, RdSAP2012), and uninsulated roof with U-value of 2.3 (pitched roof, no insulation, RdSAP2012). All other inputs stayed the same as for previous models (the heating system is a gas boiler).

Table 5 - Results when improving HTC by 6.6% calculated with SAP2012 using poorly performing archetypes. These have an external wall U-value of 1.7 (Solid wall pre-1966, RdSAP2012), and uninsulated roof with U-value of 2.3 (pitched roof, no insulation, RdSAP2012), the rest of input parameters are identical to the runs from table 3

detachment	%ΔkWh/yr	%Δ£/yr	%ΔkgCO2/yr	ΔSAP rating	ΔEI rating
semi-dtch, 2 bed	-5.4%	-4.3%	-5.1%	2	2
semi-dtch, 3 bed	-5.3%	-4.3%	-5.1%	2	2
semi-dtch, 4 bed	-5.4%	-4.5%	-5.2%	2	3
mid, 2 bed	-5.3%	-4.0%	-5.0%	1	2
end, 3 bed	-5.4%	-4.4%	-5.2%	2	2
average	-5.4%	-4.3%	-5.1%	1.8	2.2

Report Ends