Independent Validation Report

ECO Field Trial (115 homes)

ECO Field Trial

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Executive Summary

AirEx has developed the first affordable smart air brick solution for the retrofit housing market.

The product is an IoT-enabled smart ventilation control system that replaces conventional airbricks in pre-1950s dwellings. It monitors relevant environmental parameters like temperature and humidity and subsequently opens or closes air-vents to optimise ventilation. Using cloud-based IoT algorithms, AirEx minimises cold airflow whilst ensuring sufficient air exchange to prevent moisture build-up, timber rot or poor indoor air quality.

The results of this case study across 115 homes show that AirEx reduces whole house heat loss by 12% - 16% and ground floor heat loss by 20%-23%. These results place AirEx as one of the most cost-effective energy efficiency solutions on the market, with a modest payback of 2-3 years based on a £450 installed price. With an average improvement of 3 EPC points per home, AirEx delivers a cost of £150 per EPC point gained.

12-16 %

Whole House heat loss reduction

2-3 Years

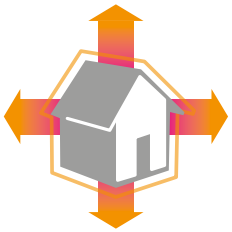
Payback on reduced energy bills

3 SAP POINTS

Improvement

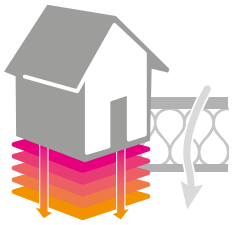
Energy Savings Impact

During 2019-20 winter AirEx successfully completed the UK's first ever ECO *Demonstration Action* programme. The robust (115 homes) field trial were designed to demonstrate the energy savings benefits of AirEx. The key outcomes from the pilot are:



+12 %

Whole House Heat Transfer Coefficient (HTC) improvement
Comparison of pre & post installation, excluding outliers.
+16% improvement with outliers included.



+20 %

Ground floor U-value improvement
Pre & Post U-value improvement based on ECO trial (17 properties)

Cost Savings

The analysis concludes that by reducing an average property's heat loss by 12-16%, AirEx saves £70-£90 per annum on an average gas-heated property (and £170-£220 per annum on an average electrically heated property). Based on an installed cost of £450, this generates a modest payback of 2-3 years.

The table below demonstrates the expected Lifetime Bills Savings for three geographical areas:

GAS	South	Midlands	Scotland
Annual savings in £	£70.10	£76.10	£88.00
Lifetime Bill Savings (LBS) score	£1,699.20	£1,845.60	£2,134.90

ELECTRIC	South	Midlands	Scotland
Annual savings in £	£177.30	£192.60	£222.80
Lifetime Bill Savings (LBS) score	£4,299.70	£4,670.10	£5,402.20

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Trial Overview

The trial was carried out on 115 occupied properties between November 2019 & April 2020. These were comprised of:

99 Experimental properties
Received full AirEx systems plus SmartHTC[2] monitoring equipment

16 Control properties
SmartHTC monitoring equipment was installed

The majority of these homes were located in the South East (Portsmouth) area and in the Midlands (Walsall and Wolverton) area. The sample contained a combination of mid-terraced, end-terraced and semi-detached properties with between 1 and 6 bedrooms and between 1 to 8 occupants.

The project team monitored three key metrics pre & post AirEx installation during the trial:

Whole fabric heat loss
HTC (Heat Transfer Coefficient)

Sub-floor void temperature

Ground floor thermal transmittance (U-values)

Across the 115 properties, AirEx collected 5 million data points describing the sub-floor and indoor environment over the duration of the trial. The results have subsequently been independently validated by a team of researchers, building physics experts and statisticians, who concluded that this level of granular measurement and product performance understanding is unprecedented under ECO and SAP/RdSAP, programmes and accreditations which drive the UK retrofit market.

| Figure 1
A typical mid-terraced property located in the Portsmouth area

| Figure 2
A typical semi-detached property located in the Walsall area

[2] SmartHTC method is explained in the “Technical Analysis” section

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Results

Reduction in whole house heat loss (HTC)

What was measured?

SmartHTC is a technique developed by BTS (Build Test Solutions) for measuring the thermal performance of houses, defined by the 'Heat Transfer Coefficient' or HTC.

The Heat Transfer Coefficient encompasses all of the heat lost from a dwelling during the winter, through the walls, roof, floor and windows, and by air movement from outside to inside the home.

The metric is W/K, the rate of heat loss in watts per degree in temperature difference between inside and out. The lower the number, the better the overall fabric is at retaining heat.

Sample size and methodology

The project team installed SmartHTC monitoring equipment in 115 houses. Out of this sample, valid HTC results were obtained on 82 properties: 66 houses with AirEx fitted and operating; plus 16 control houses which were monitored as control group (i.e. no AirEx fitted, instead using conventional air bricks).

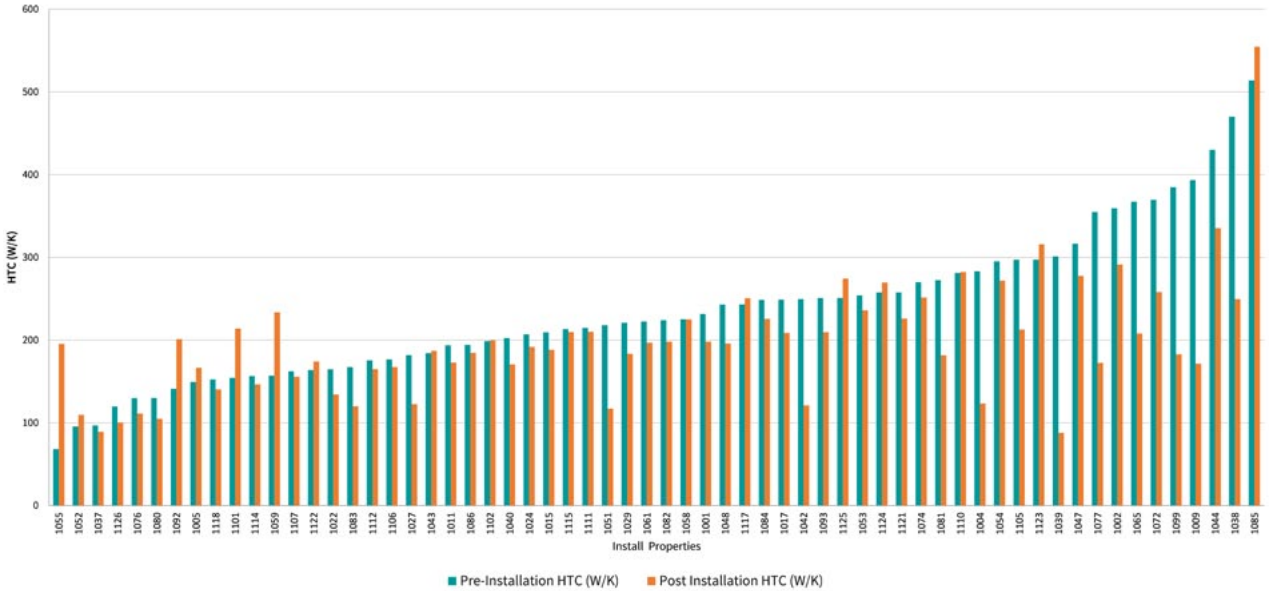
Within the installed group, the AirEx units remained fully open for half of the monitoring duration to simulate a 'pre-install' state; and for the other half of the monitoring duration the Airex units were operational (open & close in response to measured condition) to represent 'post-install' state.

Results - Reduction in whole house heat loss

Figure 3 shows the results for all HTC monitored properties, whereby the teal bars show HTC values in 'pre-install' stage (fully open mode) and the orange bars show HTC values in 'post-install' stage (air bricks open & close in response to measured conditions).

As can be seen from ***Figure 3***, the HTC values improved (reduced) in the majority of the properties after switching to post-install stage. The **HTC performance gain** is statistically significant and is in the range **12%** to **16%**, excluding/including the 6 possible outliers [4]. The **Confidence Interval** for these samples is **9.1%** and **9.5%** respectively.

Figure 3 | Whole House Heat Transfer Coefficient Pre & Post AirEx Installation



[4] Outliers: outliers were identified where properties' HTC improvement was observed to be 'unusually high', which could be due to unusual occupancy patterns

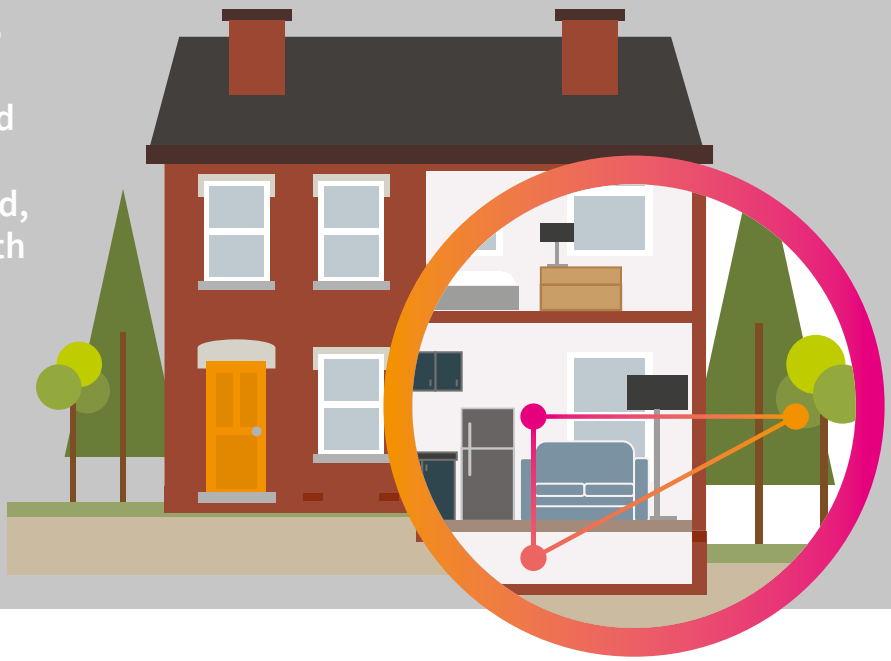
Results

Warmer underfloor cavities

What was measured?

In addition to the Smart HTC method and the U-value monitoring method, in order to obtain further data on the AirEx system's energy savings performance, the project team monitored the temperatures in multiple locations.

The differences in average air temperature in the underfloor void before and after installation of the AirEx bricks was monitored, and then corroborated with indoor air temperature readings.



Sample size and methodology

The project team monitored the underfloor void temperature for the entire sample: all 99 properties in the installed group for the entire duration of the winter (between November 2019 – April 2020), via half-hourly measurements.

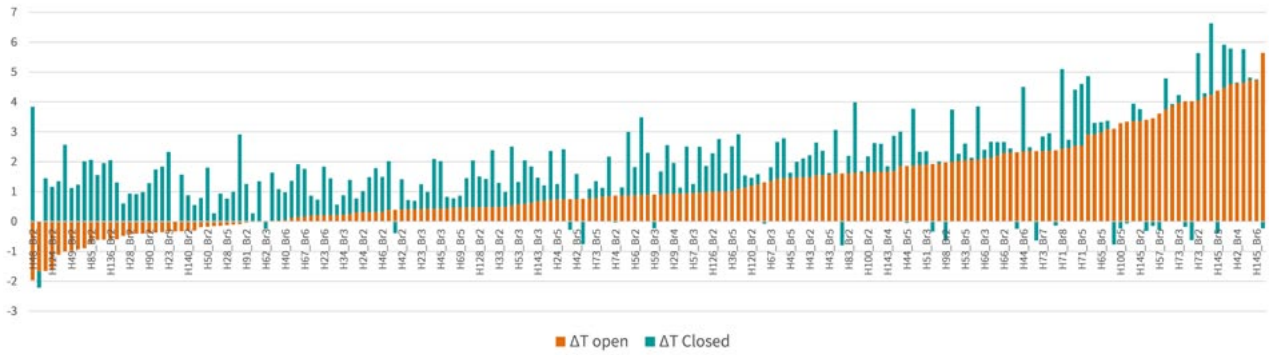
Temperature sensors were placed at 4 different locations in the underfloor void. The average duration for floor void temperature monitoring was 12.5 weeks. This resulted in a very detailed, granular level of raw data: over 5 million data points.

Results - warmer underfloor cavities

During the study the project team analysed the underfloor void temperature against both external and internal (room) temperatures. The results in both cases support the basic thermodynamic theory behind the AirEx technology: by reducing the temperature gradient across the floor, the heating requirement is reduced.

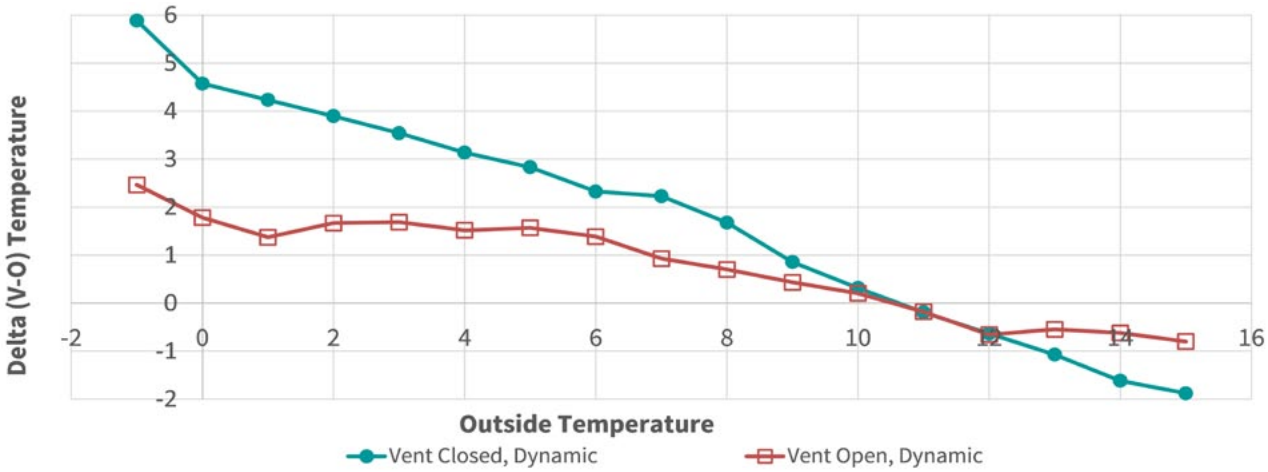
Figure 4 shows the overall ΔT (temperature difference) gains when the AirEx system is open vs closed. The green bars show the floor void temperature difference (outside vs void) when the AirEx is closed. The orange bars show the floor void temperature difference (outside vs void) when the AirEx is open. It can be seen that there is an improvement across the majority of the full sample such that the void is warmer when the AirEx is in closed mode compared to open.

Figure 4 | Temperature Difference gains when the AirEx system is open vs closed



The project team also analysed how the sub-floor void temperatures vary against external temperature. ***Figure 5*** shows that the ΔT between outside and the underfloor void is greater (the void is warmer) with the AirEx closed and this effect becomes more significant as the external temperature falls. When the outside temperature is 0 ºC, the void is 4.5 ºC warmer with a closed AirEx, but only 1.8 ºC warmer with an open brick. It can be assumed therefore that AirEx's energy savings impact increase when the weather is colder, when larger heat load is required to warm up the house.

Figure 5 | Average Temperature Difference for Open/Closed Vents



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Results

Reduction in U-value

What was measured?

AirEx regulates otherwise uncontrolled air flow in and out of the under-floor void zone. This has two main effects on the energy performance and comfort of the home.

Firstly, AirEx reduces uncontrolled air movement associated convection effects – air is instead held within the underfloor zone and in turn serves as an intermediary insulation layer. Secondly, the sealing off of air bricks reduces uncontrolled air leakage and associated heat losses and draughts.

The project team undertook in-situ U-value measurements to measure the first aspect. Thermal transmittance (U-value) is the rate of transfer of heat through matter, in this case through the ground floor.

Sample size and methodology

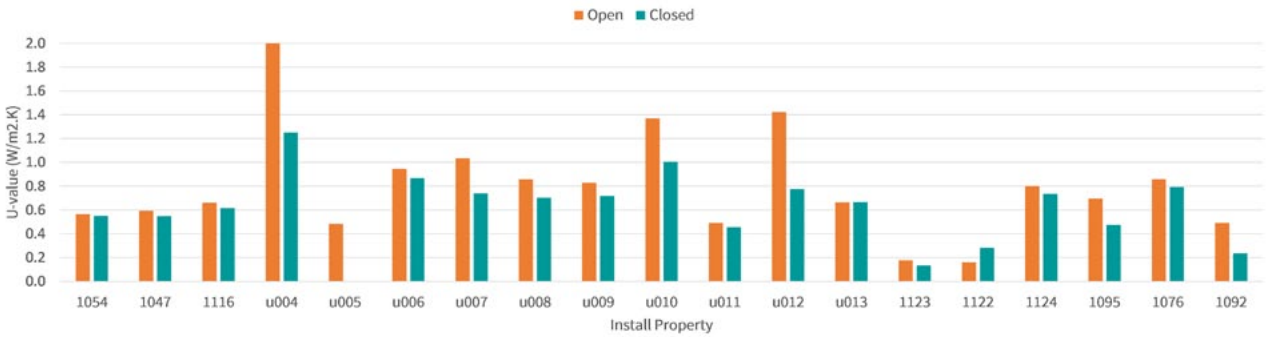
The project team successfully carried out U-value tests of ground floors during the trial on 17 properties, which showed the improvement in U-value that results from closed AirEx system compared to an open airbrick.

3-4 HFMs (Heat Flux Monitoring plates) were installed minimum 3 weeks prior to the installation of AirEx, and then with the HFMs remaining in-situ untouched for a further 3 weeks post install.

Results - Reduction in U-value

Figure 6 demonstrates that significant improvement was observed in the majority of the properties. The average ground floor U-value improvement was 20%, with the highest improvement being 52%. The U-values were to an ISO-9869-1 defined uncertainty of 14-28%. The project team successfully proved the base assumption: through controlling airflow, the air layer at sub-floor void becomes slightly warmer, as such, reduces the thermal transmittance of the ground floor.

Figure 6 | U-value for Open/Closed Vents



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Results

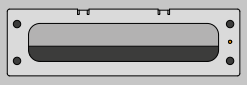
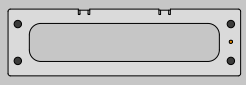
Improved airtightness

Whilst the 2019-2020 ECO Demonstration Action trial did not provide the opportunity to undertake air leakage tests on the properties, in order to contextualise the results, the below examples show that significant dwelling airtightness was observed in earlier trials, across 5 properties, with c. 9% average result for dwelling airtightness improvement across the sample.

Results - Improved air tightness

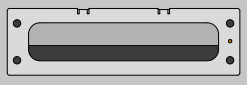
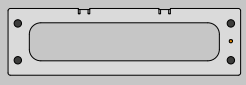
University of Salford trial (2018)

Based on Blower Door testing, installing AirEx improved whole dwelling airtightness by 10-11% (±1.5%)

	AirEx **OPEN** 	AirEx **CLOSED** 	Airtightness improvement
Salford Energy House	13.02 $m^3/h/m^2$	11.55 $m^3/h/m^2$	11.3 %

University of Sheffield trial (2016-17)

Based on Blower Door testing, installing AirEx improved whole dwelling airtightness by up to 20%.

	AirEx **OPEN** 	AirEx **CLOSED** 	Airtightness improvement
Property A	16.08 $m^3/h/m^2$	15.67 $m^3/h/m^2$	2.55 %
Property B	10.64 $m^3/h/m^2$	9.91 $m^3/h/m^2$	6.86 %
Property C	24.85 $m^3/h/m^2$	19.47 $m^3/h/m^2$	21.65 %
Property D	29.68 $m^3/h/m^2$	26.65 $m^3/h/m^2$	10.21 %

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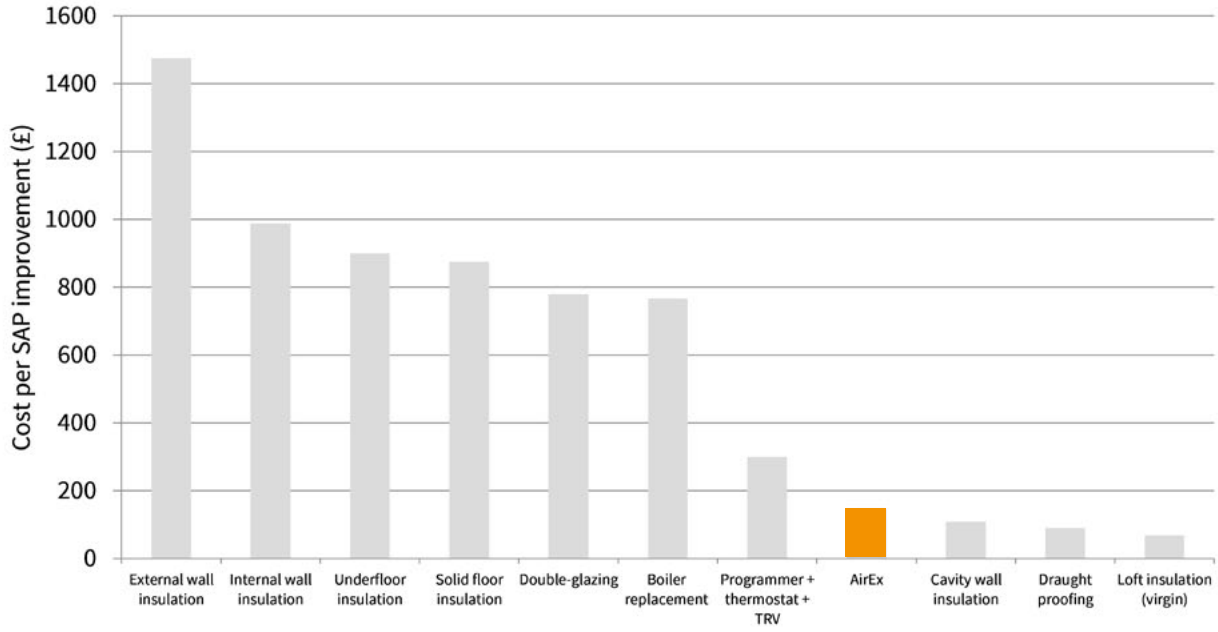
Comparison with different energy efficiency measures

AirEx is approximately one tenth of the cost of EWI (external wall insulation), IWI (internal wall insulation) or traditional underfloor insulation, and significantly lower than even the lowest cost retrofit measures (such as cavity wall insulation or loft insulation).

This is coupled with the energy bills savings, CO2 savings impact and the SAP improvement of the AirEx product, which makes it stand out from competing offerings.

Figure 7 | Cost per SAP improvement (£) of energy efficiency measures



As it can be seen from ***Figures 7,8 & 9***, only a very limited number of energy efficiency measures - such as loft insulation and cavity wall insulation – can compete with AirEx on payback and cost/SAP point gained. However, the market for these measures is nearly saturated.

In addition, competing products with higher savings are extremely disruptive for those living in the property, including enabling works, redecoration and removal/ replacement of furniture (the cost of which is not included in the comparison above). This further prevents uptake from customers.

In contrast, the AirEx product entails next to zero disruption to residents when installed (i.e. takes only 1 hour per property) whilst the energy savings and SAP upgrade benefits are significant.

Figure 8 | Cost per annual savings (£) of energy efficiency measures

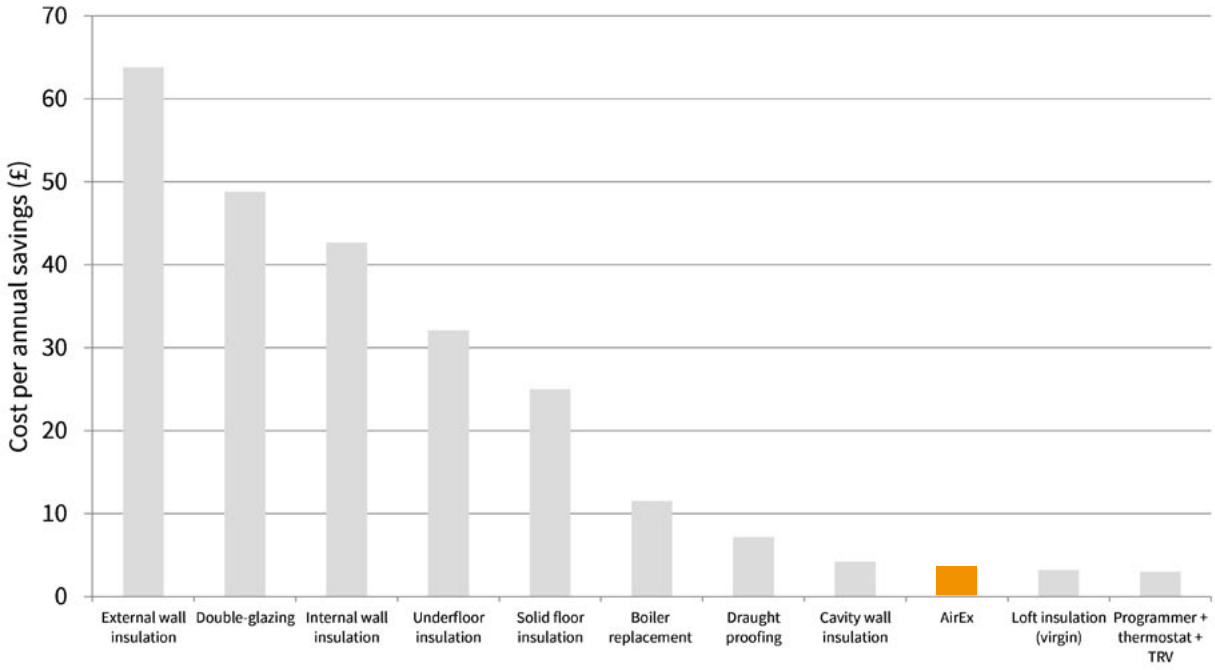
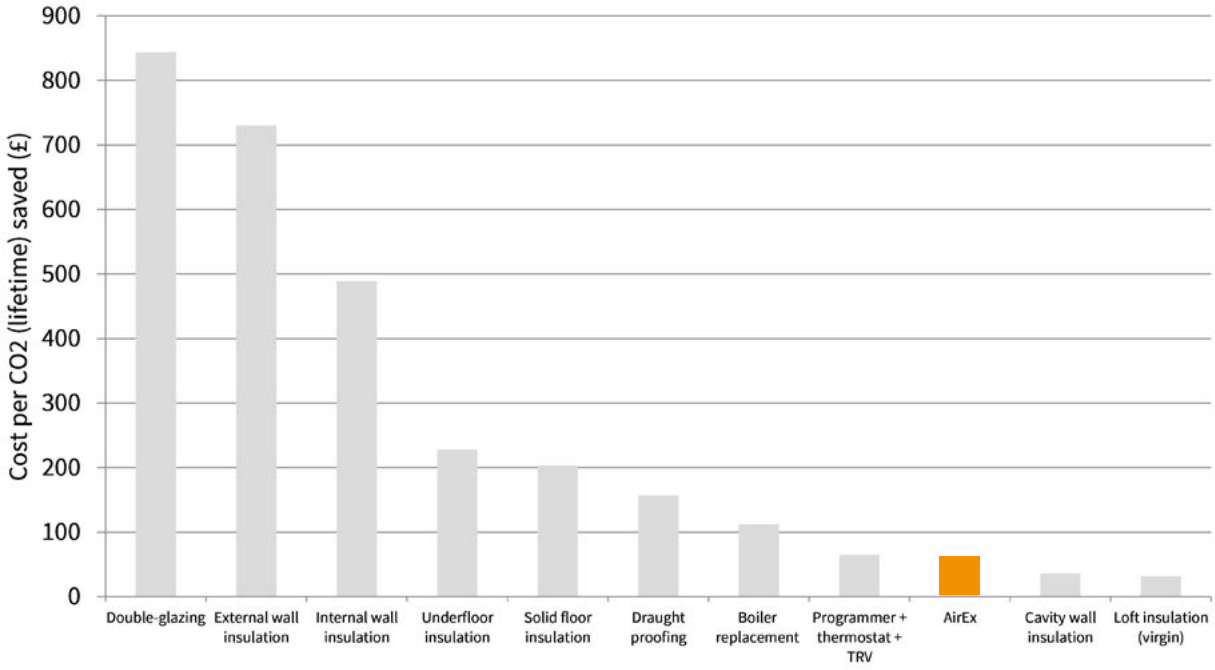


Figure 9 | Cost per CO2 lifetime saved (£) of energy efficiency measures



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Conclusions

As demonstrated in this Report, the AirEx product has the potential to reduce an average property's heat loss by 12-16%, which results in a modest 2-3 years payback via reduced energy bills.

The project team successfully completed the UK's first ECO Demonstration Action project and the AirEx product is currently undergoing further reviews from Building Research Establishment (BRE) for recognition within SAP/RdSAP.

Evidence suggests that there is an enormous potential for AirEx to be included in UK-wide and local energy efficiency schemes, such as:

- ECO (Energy Company Obligation);
- Green Homes Grant scheme;
- Warmer Homes Scotland scheme

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Sponsoring energy supplier: EDF Energy
Trial partners: Portsmouth City Council, Walsall Housing Group, Wolverton Community Energy
Performance monitoring partner: Build Test Solutions
Install partners: InstaGroup, Shropshire Green Energy Centre
Delivery partner: AgilityEco

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