

Report



Chimney Sheep™ Draught Excluders for Chimneys

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Carried out for: Chimney Sheep Ltd
Unit 4 Derwent Drive
Derwent Howe Industrial Estate
Workington
CA14 3YW

Compiled by: Dr Haniyeh Mohammadpourkarbasi and Prof. Steve Sharples
School of Architecture
University of Liverpool
Liverpool
L69 7ZN

SUMMARY

The building stock in the UK is among the oldest in Europe, and the rate of renewing this aging stock is very slow, at less than 1% per year. To achieve substantial improvements in building energy efficiency in the short term, refurbishment has become a critical activity for the construction sector, particularly in housing. The UK government is committed to an 80% reduction in carbon dioxide (CO₂) emissions by 2050. Since approximately a quarter of the UK's carbon emissions come from domestic energy use, various governmental schemes have been introduced to reduce domestic carbon emissions significantly. These schemes include substantial investments in loft and cavity wall insulation, double glazing, and exterior cladding.

However, for older and harder-to-heat homes, the issue of heat loss through existing but unused open chimneys is often overlooked, despite the fact that an unblocked open chimney flue is akin to leaving a window open throughout the winter months. Small yet cost-effective improvements in energy efficiency and thermal comfort could be achieved in rooms with open chimneys by using an insulating and relatively airtight draught excluder, which can be removed when not needed—such as during the summer months when the chimney could provide a cooling airflow.

This report explores the potential of one such device—the ‘Chimney Sheep,’ a simple and effective wool-based solution for blocking chimneys when not in use. Advanced computer simulations have been employed to estimate the energy, CO₂, and cost savings resulting from the application of the ‘Chimney Sheep’ in three types of dwellings across three locations in the UK. Results indicate that using a ‘Chimney Sheep’ can:

- Prevent up to 4% of heated air from escaping up the chimney.
- Offer payback times of less than six months for poorly insulated dwellings.
- Provide thermal effectiveness nearly equivalent to completely blocking or removing a fireplace, but at a much lower cost, while still allowing some air movement up the flue to prevent damp.
- For a well-insulated house in a warm city like London, reduce discomfort hours during hot summer weather by up to 63%.

1. INTRODUCTION

1.1. Energy Conservation in Dwellings and Chimneys

The Government and devolved administrations set targets to eradicate fuel poverty among vulnerable households by 2010, with a goal that, 'as far as reasonably practicable,' no household should be in fuel poverty by 2016 (2018 in Wales) [1]. The energy efficiency of a dwelling is a primary determinant of household fuel poverty. Additionally, since approximately a quarter of the UK's carbon emissions come from energy used in homes, it is crucial that energy conservation in dwellings becomes a major performance objective in building design and renovation.

Significant progress is being made through various governmental schemes aimed at reducing carbon emissions in existing housing by providing subsidised loft and wall insulation services. According to the Energy Saving Trust, these are among the most cost-effective ways to lower heating bills [2].

However, this investment is compromised if the home is draughty, as excessive heat loss can occur through gaps. Draught-proofing is one of the most affordable ways to save energy at home but is often overlooked [3]. Chimneys are significant sources of air leakage, potentially losing as much heat as all the draughty windows and doors combined. While chimneys are effective in removing fire smoke, stale air, moisture, and indoor pollutants when a solid fuel or wood fire is burning, they also create a mechanism (through buoyancy forces) that can remove warm air from a room heated by other means, such as central heating or electric heaters. This can lead to discomfort from draughts and increased heating costs due to warm air escaping and cold air entering.

Thus, addressing chimneys is a critical decision in the refurbishment of old housing. Chimney stacks are prominent features of the UK's urban skyline. Until the 1960s, virtually every new house was built with chimneys. Until 1965, the construction of fireplaces and chimneys was governed by local laws and good practice, prior to the introduction of Building Regulations. Many chimneys built before this period are either still used as a primary or secondary heat source or serve as aesthetic elements within the home [4]. The English Housing Survey report [5] provides insights into the prevalence of chimneys in older homes. In 2008, England had approximately 22.2 million dwellings, with just over one million vacant. Of these, 57.4% (12,168,800) were built before 1965. Excluding around 1,100,000 flats, this leaves approximately 11,068,800 houses and bungalows. Therefore, there are roughly eleven million houses and bungalows in the UK with chimneys built before the introduction of Building Regulations in 1965 [5]. This suggests that potentially millions of pounds are spent on domestic heating that escapes through these outdated chimneys.

Similarly, chimney stacks are among the most common issues in the exterior fabric of buildings, with over three million houses experiencing chimney stack problems (see Figure 1). Consequently, finding a solution to retain chimneys while preventing heat loss is essential.

	percentage	number (000s)		percentage	number (000s)
exterior fabric			interior fabric		
wall finish	22.6	5,026	ceilings	16.9	3,758
windows/frames	18.5	4,114	walls	12.4	2,758
roof covering	15.6	3,469	doors	10.8	2,402
chimney stacks	15.1	3,358	floors	5.8	1,290
gutters/downpipes	13.6	3,025	any interior faults	30.2	6,716
doors/frames	12.2	2,713			
fascias	11.3	2,513	building structure		
wall structure	4.8	1,067	any structural faults	8.4	1,868
stacks/wastes	5.2	1,156			
valley gutter	4.6	1,023	services and amenities		
roof structure	3.2	712	fences	15.0	3,336
bays	2.7	600	kitchen	12.9	2,869
DPC (damp proof course)	3.3	734	boundary walls	9.5	2,113
porches	2.0	445	bathroom	8.7	1,935
conservatories	1.6	356	primary services (gas and electricity)	11.1	2,469
party parapets	0.8	178	CH boiler/distribution	5.3	1,179
dormers	0.7	156	other heating	3.1	689
balconies	0.4	89	hot water	2.3	512
any exterior faults	54.4	12,098			

Figure 1. Dwellings with faults to different building components, 2008[6]

1.2. Chimney Sheep

This report gives the results of the potential energy, CO₂ and cost savings in dwellings with chimneys resulting from the use of the ‘Chimney Sheep’, a draught excluder for chimneys. The ‘Chimney Sheep’ is designed and manufactured by ‘Chimney Sheep Ltd’ to prevent the heat loss from chimneys. This is achieved by fitting the wool head of the Chimney Sheep into the narrow part of the flue. The Sheep comes in five sizes which fit the vast majority of chimney flues. Figure 2 shows different shapes of ‘Chimney Sheep’:



Figure 2. ‘Chimney Sheep’[7]

For chimneys which are not in use, a ‘Chimney Sheep’ offers a cost-effective way to prevent warm air escaping up the chimney and prevent cold air coming down into the home. They can also be re-used too.

The manufacturer claims some benefits for the ‘Chimney Sheep’ [8] are:

Environmental Credentials

- It is a sustainable product as wool is a naturally occurring, sustainable product.
- It can be washed several times, but at the end of its life is compostable.
- The handle is made out of recycled plastic, and at the end of its life can be recycled again.

Heat and Carbon Saving

Chimneys are cleverly designed to draw air up and out of a building. The use of a ‘Chimney Sheep’ prevents heat loss due to stack effect by blocking the flue. Therefore, it results in the reduced use of fossil fuels from primary heat sources and, thereby, also reduces carbon emissions.

Other benefits

- Stops debris, soot and bird mess.
- Reduces outside noise entering the room.
- Allows a little ventilation.
- Sizes available to fit all chimneys.

1.3. Objectives

The main objectives of this report are:

- To demonstrate the potential annual energy, carbon and cost savings when the ‘Chimney Sheep’ is employed. This effect has been measured for three types of houses in three cities across the UK with three different weather conditions: Aberdeen in the north of Scotland, Liverpool in the northwest of England and London in the south of England
- To evaluate the effect of the ‘Chimney Sheep’ on the operative temperature of the house and cooling energy consumption for a typical terrace house under weather data for London during summer
- To estimate the extent of this effect on the UK’s carbon reduction by evaluating the number of houses with chimneys

2. TEST METHODOLOGY

Dynamic thermal computer modelling using the advanced thermal simulation package DesignBuilder was undertaken to calculate changes in annual heating energy consumption resulting from the installation of the ‘Chimney Sheep’.

2.1. Computer Modelling and Simulation

A typical 19th-century terrace house, including end-terrace and detached variations, was modelled using the advanced thermal simulation package DesignBuilder. To assess the impact of using the ‘Chimney Sheep’ to seal the chimney in a well-insulated house compared to a pre-refurbished house, an airtight refurbished end-terrace house was also modelled and simulated in DesignBuilder. The retrofitted model included very high levels of insulation, timber-framed triple-glazed windows, and high levels of air tightness (1.0 ACH@50Pa). Tables 1 and 2 compare the thermal features of the models before and after refurbishment.

For all models, occupancy densities and period profiles were based on a family of four (two adults and two children). Internal heat gain allowances were assigned according to the activity of each zone within the building. Simulations were conducted with all treated zones maintained at a nominal set point temperature of 22°C and heated to set points ranging from 18°C to 22°C, depending on usage. Table 3 details the height and diameter of the modeled chimney for all the houses.

Table 1. Pre and post refurbishment thermal features of a 19th century terraced house [9],[10]

Element	Roof	Walls	Floor	Windows	Doors
Typical existing construction (Fabric U-value, W/m ² K)	0.40	2.10	0.50	4.80	3.00
Upgraded (refurbished) fabric construction (Fabric U-value, W/m ² K)	0.15	0.11	0.12	0.78	1.00

Table 2. Thermal features of a 19th century detached house [9]

Element	Roof	Walls	Floor	Windows	Doors
Typical existing construction (Fabric U-value, W/m ² K)	0.44	1.7	0.70	4.80	3.00

Table 3. Diameter and height of modelled chimney

Diameter of chimney (mm)	Height of chimney (mm)
408	7500

Weather Data for Simulation

The historic weather data for Aberdeen, Liverpool and London were used to evaluate and compare the effect of using ‘Chimney Sheep’ with blocking or removing chimney on heating energy demand and comfort levels inside the house.

Table 4. 2009 monthly mean external air temperature (°C) for Aberdeen, Liverpool and London

Weather data scenarios	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Aberdeen	3.1	3.2	4.5	6.6	8.9	11.7	13.5	13.4	11.5	8.9	5.1	3.9
Liverpool	4.1	4.2	5.7	8.2	11.6	14.2	15.9	15.9	13.6	10.6	6.5	5.0
London	4.1	4.3	5.8	8.3	11.6	14.2	15.9	15.9	13.6	10.7	6.5	5.1

2.2. Calculation of the Costs Savings

The total cost savings per annum due to applying ‘Chimney Sheep’ is calculated by the following relation.

Total costs saving = [gas usage for heating before applying ‘Chimney Sheep’ (kWh) - gas usage for heating after applying ‘Chimney Sheep’ (kWh)] × energy price

The exact relationship has been used to evaluate the annual savings from removing or blocking a chimney. Table 5 presents the energy cost per kWh, which is used for calculation.

Table 5. Energy prices

Fuel	£ per unit
Natural Gas	£0.1204 or 12.04p/kWh
Grid Electricity	£0.2691 or 26.91p/kWh

2.3. Calculation of the Carbon Saving

The carbon savings per annum due to applying a ‘Chimney Sheep’ or blocking the chimney were calculated using the below relation:

$\text{CO}_2 \text{ emission (kg) per annum} = \text{total energy savings per annum (kWh)} \times \text{Fuel emission factor (kgCO}_2\text{/kWh)}$

Table 6 shows the conversion factors used to work out the greenhouse gas emissions associated with energy use.

Table 6. Energy conversion factors

Fuel	units	KgCO ₂ e per unit
Natural Gas	kWh	0.18290
Grid Electricity	kWh	0.20705

3. RESULTS

3.1. DesignBuilder Predictions

Results from Applying ‘Chimney Sheep’

Pre and post-refurbished houses in different cities under current weather conditions were simulated to see the effect of using ‘Chimney Sheep’ on annual heating consumption, energy cost savings and carbon emission reduction. Simulation results given in Table 7 show savings for the pre-refurbished end terrace house in different cities. More than a 4% reduction in heating demand and CO₂ emission can be seen after applying ‘Chimney Sheep’ in all three cities for the existing 19th century 3-bedroom terraced house. Saving of more than £50 in annual energy bills for the house in all cities can be seen.

Table 7. Savings results from using ‘Chimney Sheep’ in an existing 19th century 3 bedroom end terraced house

items	Savings in gas usage for heating kWh/yr	Savings in energy bill- Electric Heating £/yr	Savings in energy bill- Gas Heating £/yr	Reduction in CO ₂ emissions - Electric KgCO ₂ e/yr	Reduction in CO ₂ emissions- Gas KgCO ₂ e/yr	Savings per annum (%)
Aberdeen	1481.59	£398.70	£178.38	306.76	270.98	4.35
Liverpool	1282.8	£345.20	£154.45	265.60	234.62	4.26
London	1143.42	£307.69	£137.67	236.75	209.13	4.14

Savings for an existing 3 bedroom detached house are presented in Table 8. Although results indicate that saving in a detached house is around 50% less than the savings in end terrace house but then again more than £30 savings in annual heating bills can be seen after applying ‘Chimney Sheep’.

Outcomes for the refurbished house presented in Table 9 confirm over 1.5% reduction in savings for all three cities.

Table 8. Savings results from using ‘Chimney Sheep’ in an existing 19th century 3 bedroom detached house

items	Savings in gas usage for heating kWh/yr	Savings in energy bill- Electric Heating £/yr	Savings in energy bill- Gas Heating £/yr	Reduction in CO ₂ emissions - Electric KgCO ₂ e/yr	Reduction in CO ₂ emissions- Gas KgCO ₂ e/yr	Savings per annum (%)
Aberdeen	900.65	£242.36	£108.44	186.48	164.73	4.35
Liverpool	768.7	£206.86	£92.55	159.16	140.60	4.26
London	679.42	£182.83	£81.80	140.67	124.27	4.14

Table 9. Savings in an eco-refurbished 3 bedroom end terraced house results from using ‘Chimney Sheep’

items	Savings in gas usage for heating kWh/yr	Savings in energy bill- Electric Heating £/yr	Savings in energy bill- Gas Heating £/yr	Reduction in CO ₂ emissions - Electric KgCO ₂ e/yr	Reduction in CO ₂ emissions- Gas KgCO ₂ e/yr	Savings per annum (%)
Aberdeen	173.17	£46.60	£20.85	35.85	31.67	4.35
Liverpool	122.93	£33.08	£14.80	25.45	22.48	4.26
London	111.91	£30.11	£13.47	23.17	20.47	4.14

Results from Blocking/Removing Chimney

Changes in heating consumption, CO₂ emissions and energy cost for pre-refurbished end terraced house, detached house and refurbished terrace house in London, Liverpool and Aberdeen resulting from blocking/removing the chimney are given in Tables 10, 11 and 12. It can be concluded from the results that for both pre and post refurbished terrace house in all three cities, savings in heating consumption, CO₂ emissions and energy costs after blocking the chimney is only 0.5% more than using a ‘Chimney Sheep’. Comparing Table 11 and Table 8 shows that savings from blocking the chimney in a detached house is almost the same as applying a ‘Chimney Sheep’.

Table 10. Savings results from blocking/removing chimney in an existing 19th century 3 bedroom terraced house

items	Savings in gas usage for heating kWh/yr	Savings in energy bill- Electric Heating £/yr	Savings in energy bill- Gas Heating £/yr	Reduction in CO ₂ emissions - Electric KgCO ₂ e/yr	Reduction in CO ₂ emissions- Gas KgCO ₂ e/yr	Savings per annum (%)
Aberdeen	1632.19	£439.22	£196.52	337.94	298.53	4.35
Liverpool	1410.17	£379.48	£169.78	291.98	257.92	4.26
London	1258.29	£338.61	£151.50	260.53	230.14	4.14

Table 11. Savings results from blocking/removing chimney in an existing 19th century 3 bedroom detached house

items	Savings in gas usage for heating kWh/yr	Savings in energy bill- Electric Heating £/yr	Savings in energy bill- Gas Heating £/yr	Reduction in CO ₂ emissions - Electric KgCO ₂ e/yr	Reduction in CO ₂ emissions- Gas KgCO ₂ e/yr	Savings per annum (%)
Aberdeen	897.88	£241.62	£108.10	185.91	164.22	4.35
Liverpool	762.92	£205.30	£91.86	157.96	139.54	4.26
London	673.66	£181.28	£81.11	139.48	123.21	4.14

Table 12. Savings results from blocking/removing chimney in an eco-refurbished 3 bedroom terraced house

items	Savings in gas usage for heating kWh/yr	Savings in energy bill- Electric Heating £/yr	Savings in energy bill- Gas Heating £/yr	Reduction in CO ₂ emissions - Electric KgCO ₂ e/yr	Reduction in CO ₂ emissions- Gas KgCO ₂ e/yr	Savings per annum (%)
Aberdeen	215.3	£57.94	£25.92	44.58	39.38	4.35
Liverpool	159.03	£42.79	£19.15	32.93	29.09	4.26
London	144.72	£38.94	£17.42	29.96	26.47	4.14

Cooling Demand and Discomfort Hours

Cooling and ventilation are important, especially for a refurbished, airtight house in warmer cities like London. For this reason, discomfort hours have been simulated for the refurbished terrace house in London. For comfort calculations DesignBuilder uses ASHRAE Standard 55-2004, which states that when the air is very humid an operative temperature above 26.8°C is considered too hot, even when wearing summer clothes [11].

Discomfort hours are a measure of how many hours during a period of time internal temperatures exceeded 26.8°C i.e. the duration of discomfort. Figure 3 compares discomfort hours during summer (June, July and August) for post and pre refurbished terraced house under London current weather data with an open chimney flue, applying ‘Chimney Sheep’ and blocking the chimney.

Results indicate that not only can an open fireplace let heat escape through the chimney in winter, but that it can also, in the summer, allow warm air to enter the occupied space. Simulation results indicate that an open chimney can result in a 63% increase in discomfort hours during summer in a refurbished house compared to the same house with either a Chimney Sheep or a blocked chimney. Therefore, sealing the chimney during summer is just as important as blocking it during the winter.

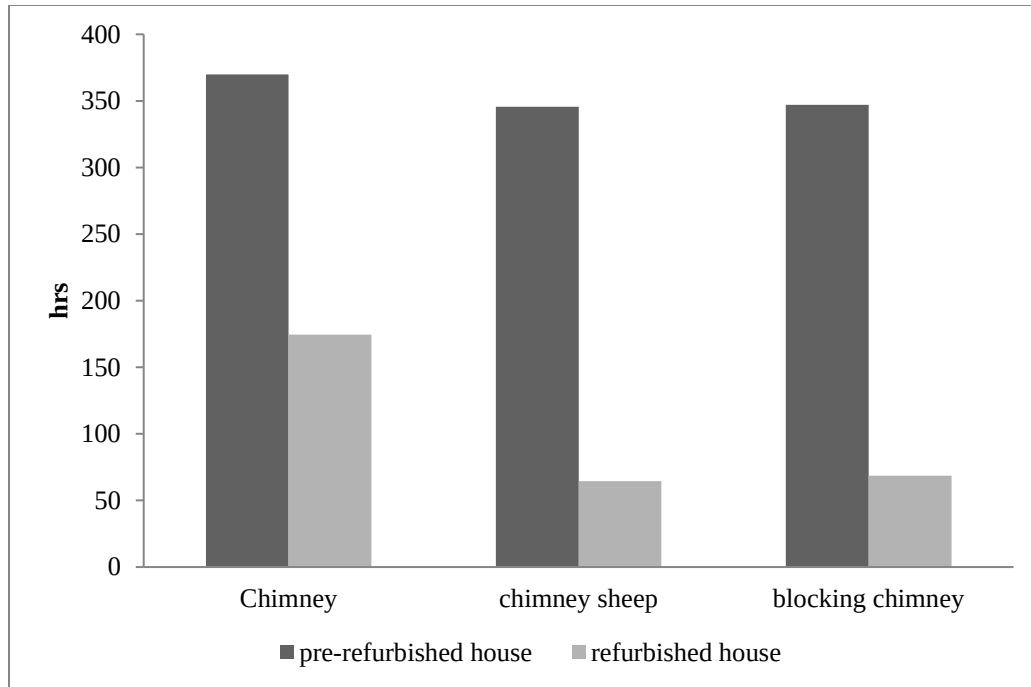


Figure 3. Discomfort hours of pre and post refurbished terraced house in London during summer

4. CONCLUSIONS

Computer simulations were carried out to determine the potential energy, cost and CO₂ savings that would result from applying a ‘Chimney Sheep’.

Computer simulations were performed for three types of houses in three cities across the UK in various weather conditions. Furthermore, results from applying ‘Chimney Sheep’ were compared to blocking or removing the chimney. The main findings are given below:

1. The use of the ‘Chimney Sheep’ in a typical three bedroom terraced house results in a total cost saving of £178.38 for the house in Aberdeen, £154.45 for the house in Liverpool and £137.67 for the house in London per annum when gas is charged at 12 p/kWh.
2. The use of the ‘Chimney Sheep’ in in a typical three bedroom detached house results in a total cost saving of £108.44 for the house in Aberdeen, £92.55 for the house in Liverpool and £81.80 for the house in London per annum when gas is charged at 12 p/kWh.
3. A comparison of savings from using a ‘Chimney Sheep’ and from blocking a chimney for all houses and under all three weather conditions shows very small differences between the results. Considering the required time and costs for removing and blocking the chimney to reach these savings compared to applying ‘Chimney Sheep’, sealing the chimney with a ‘Chimney Sheep’ is more beneficial.
4. Comparison of discomfort hours during summer before and after using ‘Chimney Sheep’ suggests that sealing the chimney during summer is as important as closing it during winter.

5. From this study the average reduction in CO₂ emissions resulting from applying a ‘Chimney Sheep’ in a house with a chimney built before 1965 is around 0.19 tonnes CO₂/yr. Multiplying this number by the estimated 11,068,800 houses with chimneys in England gives an approximate reduction in CO₂ emissions of over 2 million tonnes per year if Chimney Sheep were to be used in every dwelling with a chimney in England.

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