Report

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EFS ‘Fireplace Heatsaver’

This report supersedes Report 50631/1 dated July 2007.

Report 50631/1 Edition 2
August 2007

Carried out for: **Environmental Fireplace Solution Limited**
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PREFACE

This report supersedes Report 50631/1 dated July 2007.

At the request of Environmental Fireplace Solutions Ltd the name of the product has been changed from Carbon Shield to Fireplace Heatsaver.

These changes do not affect the overall results or conclusions of the report as originally issued.

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1 INTRODUCTION

This report gives the results of the energy and CO_2 savings in dwellings with working fireplaces resulting from the use of a "'Fireplace Heatsaver'" manufactured by Environmental Fireplace Solution Limited. The ''Fireplace Heatsaver'' is designed to prevent the heat generated within a dwelling from the primary heat source (boiler) going up the chimney. This is achieved by fitting it over a fireplace opening in a freestanding position against the fireplace opening or installed in a sealed position. The appliance within the fireplace then becomes redundant once the ''Fireplace Heatsaver'' is in place. The manufacturer claims for the ''Fireplace Heatsaver'' are:

- Primary heat is reflected back into the room after the ''Fireplace Heatsaver'' is installed resulting in reduced use of fossils fuels from primary heat source. The primary heat source could either be a gas or oil fired boiler.
- Reduced carbon emissions from primary heat source
- Eliminates usage of fossil fuels from secondary heat source and carbon emissions. The secondary heat source would normally be a decorative fuel effect fire (DFE) or a live inset fuel effect fire. These would normally fit into a fireplace opening.
- The use of the ''Fireplace Heatsaver'' which is transparent provides an aesthetic view of the fireplace with the appliance remaining in place rather than simply bricking in the fire place opening to prevent the heat going up the chimney

The main objectives of these tests were:

- To demonstrate the potential energy and carbon savings for a typical dwelling when the 'Fireplace Heatsaver' is installed with a decorative fuel effect fire (DFE) and inset live fuel effect fire (ILFE) with the 'Fireplace Heatsaver' in free standing and sealed positions

- To compare the ventilation rates for the various installations with the 'Fireplace Heatsaver' to that of a trickle vent

This work has been carried out by a series of laboratory tests and by calculation and is reported below.

Any marketing information, which is produced using the results contained within this report, must be submitted to a Director at BSRIA for approval prior to release.

Figure 1 'Fireplace Heatsaver' fitted to open fireplace

2 TEST METHODOLOGY

The tests were designed to measure the reduction of the air flow rate resulting from the installation of the 'Fireplace Heatsaver' when it was installed in two positions, i.e when it was freestanding and in a sealed position. The measured reduction in the airflow rates is used in the calculations to determine the energy and costs savings. Tests were performed on two types of gas appliances. These were:

A decorative fuel effect (DFE) fire
An inset live fuel effect fire (ILFE) fire

Both fires were installed in a fireplace typical of those in a dwelling. Before the fires were installed, the chimney and flow measuring system were tested for gas tightness and were found to satisfy the gas tightness requirement within BSEN 14471: 2005 of 2.0 litres/sec m^{-2} at a test pressure of 40 Pa.

DFE TESTS

A suction fan was installed within the airflow measuring system to provide an airflow over the range 0-80 m^3/hr for the DFE fire on a 200 mm diameter chimney and the static pressure recorded without the 'Fireplace Heatsaver' and with the 'Fireplace Heatsaver'. The reduction of the airflow rate was then determined from the graphs at the reference pressure corresponding to 40 m^3/hr. This figure was then used to determine the energy and carbon savings.

ILFE TESTS

The same procedure was applied as in the case of the DFE fire with the airflow within a range of 0-80 m^3/hr. The reduction of the airflow rate was then determined from the graphs at the reference pressure corresponding to 20 m^3/hr.

The ventilation rates of 40 m^3/hr. and 20 m^3/hr were obtained from the Government's SAP 2005 document (table 2.1) for a chimney and open flue conditions. Tests were carried out in accordance with the test matrix below.

Table 1 Test Matrix

Test no	Description of Test	Reference air flow rate for calculation purposes m^3/hr	Diameter and height of chimney
1	Tests with and without 'Fireplace Heatsaver' with DFE open gas fire in situ. In this test the 'Fireplace Heatsaver' was installed in the freestanding position	40	200 diameter, 5 m high
2	Tests with 'Fireplace Heatsaver' with DFE open gas fire in situ. In this test, the 'Fireplace Heatsaver' was sealed to the front of the fireplace	40	200 diameter, 5 m high
3	Tests with and without 'Fireplace Heatsaver' with ILFE gas fire in situ. In this test the 'Fireplace Heatsaver' was installed in the freestanding position	20	200 diameter 5 m high
4	Tests with 'Fireplace Heatsaver' with ILFE gas fire in situ. In this test the 'Fireplace Heatsaver' was sealed to the front of the fireplace	20	200 diameter 5 m high

An addition test was carried out to compare the ventilation rates of the 'Fireplace Heatsaver' with the DFE and ILFE to that of a trickle ventilator. The trickle ventilator used in the test was supplied by EFS and has a free area of 4000 mm^2.

3 INSTRUMENTATION

The following instruments were used during the tests.

Instrument	Serial number and BSRIA ID number
FC0510 Furness controls Ltd micro-manometers	Serial no:990471 BSRIA ID number 502 Serial no.961159 BSRIA ID number 374
FCO91 MK2 selection boxes	Serial number 961160 BSRIA ID number 369
PT 570 CV Micro-manometer	Serial number 5502 BSRIA ID number 200786
Pitot tube	Serial number 200408

4 CALCULATION OF THE COSTS SAVINGS

The total costs savings due to the 'Fireplace Heatsaver' is given by the following relation.

Total costs savings = Savings from primary heating + Savings from secondary heating.

The savings from the primary heating is a result of the reduced airflow rate up the chimney by the use of the 'Fireplace Heatsaver'. The reduced airflow is referenced to the ventilation rates of 40 m^3/hr and 20 m^3/hr for a chimney and open flue as given in SAP 2005

The savings from the secondary heating is obtained by not using the fire, but the boiler instead. This is to make up for the deficit in the secondary heating which is no longer available due to the installation of the 'Fireplace Heatsaver'. These savings would result because boilers are generally far more efficient than gas fires. A non-condensing gas boiler would have an efficiency of between 80-85%. A DFE fire in comparison would have an efficiency of around 20%.

4.1 CALCULATION OF THE PRIMARY COST SAVINGS:

The primary costs savings per annum due to installation of the 'Fireplace Heatsaver' is calculated from the relation.

Primary Costs savings ('Fireplace Heatsaver') =(reduced mass flow rate of air through chimney with 'Fireplace Heatsaver' × specific heat capacity of air × ΔT × (P- S)× pence/kWh)/appliance Sedbuk efficiency.

(1)

Where ΔT is the temperature difference between the inside and outside air of the dwelling. In accordance with SAP 2005, the average external temperature corresponding to a base temperature of 15.5°C and 2130 degree days was taken as 6.5 °C . Hence ΔT =9.0°C

The term P-S represents the time in the heating season the secondary heating is not operating.

Where P = heating season length × 24 hrs.
S = hours of operation of the secondary heating

The number of hrs/annum the secondary heating operates is obtained by determining the total kWh over the heating season and dividing by the output of the appliance. SAP 2005 assumes that 10% of the total annual heating requirements is provided by a secondary heating appliance.

4.2 CALCULATION OF THE SECONDARY COST SAVINGS

The secondary costs savings = kWh of secondary heating (1/efficiency of secondary heating - 1/efficiency of primary heating)"× pence/kWh…(2)

The total costs savings per annum = (1) + (2)

4.3 CALCULATION OF THE CO_2 SAVINGS

CO_2 emissions (tonnes) per annum = Total energy savings per annum (KWh) × Fuel emissions factor (kg CO_2/KWh) × 0.001……(4)

The fuel emissions factor for the combustion of natural gas is 0.19 (source Carbon Trust web site).

4.4 ASSUMPTIONS

The following assumptions are made in the calculations:

1. The open DFE fire (secondary heat source) and ILFE fire are each rated around 3.0 kW and their efficiencies are respectively 20% and 55%. (efficiency figures provided by EFS)
2. The Sedbulk efficiency of a conventional non-condensing gas fired boiler is 85%
3. The total heating season length is 238 days (SAP 2005)
4. The total annual heating requirements based on a 3 bedroom gas heated dwelling of 120 m^2 is 6162 KWh. Ref BSRIA report 50478 "SAP calculations for Dunbrik". The secondary heating contribution is therefore 616.2 KWh.
5. The calculations assume a range of gas prices from 2.0- 5.0 pence per KWh (based on British gas tariff)

5 RESULTS

The results of the tests on the DFE and ILFE fire are included in Appendix D.

Table 2 DFE Results based on gas price of 2 pence/kWh

Installation	Air flow rate m^3/hr	Primary energy savings kWh/annum	Secondary Energy savings kWh/annum	Total energy savings kWh/annum	Primary cost savings £/annum	Secondary cost savings/annum £	Total cost savings/annum £
'Fireplace Heatsaver' in free standing position	13.58	539.64	2356.06	2895.69	10.79	47.12	57.91
'Fireplace Heatsaver' in sealed position	5.23	710.33	2356.06	3066.39	14.21	47.12	61.33

Table 3 ILFE Results based on gas price of 2 pence/kWh

Installation	Air flow rate m^3/hr	Primary energy savings kWh/annum	Secondary Energy savings kWh/annum	Total energy savings kWh/annum	Primary cost savings £/annum	Secondary cost savings/annum £	Total cost savings/annum £
'Fireplace Heatsaver' in free standing position	8.64	232.12	395.42	627.55	4.64	7.91	12.55
'Fireplace Heatsaver' in sealed position	4.56	315.32	395.42	710.74	6.31	7.91	14.21

Table 4 DFE Results based on gas price of 5 pence/kWh

Installation	Air flow rate m^3/hr	Primary energy savings kWh/annum	Secondary Energy savings kWh/annum	Total energy savings kWh/annum	Primary cost savings £/annum	Secondary cost savings/annum £	Total cost savings/annum £
'Fireplace Heatsaver' in free standing position	13.58	539.64	2356.06	2895.69	26.98	117.80	144.78
'Fireplace Heatsaver' in sealed position	5.23	710.33	2356.06	3066.39	35.52	117.80	153.32

Table 5 ILFE Results based on gas price of 5 pence/kWh

Installation	Air flow rate m^3/hr	Primary energy savings kWh/annum	Secondary Energy savings kWh/annum	Total energy savings kWh/annum	Primary cost savings £/annum	Secondary cost savings/annum £	Total cost savings/annum £
'Fireplace Heatsaver' in free standing position	8.64	232.12	395.42	627.55	11.61	19.77	31.38
'Fireplace Heatsaver' in sealed position	4.56	315.32	395.42	710.74	15.77	19.77	35.54

Table 6 CO_2 savings- DFE/Tonnes per annum

Description	Primary	Secondary	Total CO_2 – tonnes per annum
'Fireplace Heatsaver' in free standing position	0.103	0.448	0.550
'Fireplace Heatsaver' in sealed position	0.135	0.448	0.583

Table 7 CO_2 savings- ILFE/Tonnes per annum

Description	Primary	Secondary	Total CO_2 – tonnes per annum
'Fireplace Heatsaver' in free standing position	0.044	0.075	0.119
'Fireplace Heatsaver' in sealed position	0.060	0.075	0.135

Table 8 Comparison of ventilation rates for trickle vent of 4000 mm^2 free area against DFE and ILFE installation

Installation	Ventilation rate m^3/hr (DFE installation)	Ventilation rate m^3/hr (ILFE installation)
Open fire place- no 'Fireplace Heatsaver'	40.0	20.0
Trickle Vent	16.74	10.50
'Fireplace Heatsaver' in free standing position	13.58	8.64
'Fireplace Heatsaver' in sealed position	5.23	4.56

The comparison is made at the reference pressure of -3.05 Pa corresponding to a ventilation rate of 40 m^3/hr for the DFE fire and -1.60 Pa corresponding to a ventilation rate of 20 m^3/hr for the ILFE fire.

6 CONCLUSIONS

Laboratory tests were carried out to determine the potential energy and CO_2 savings that would result from the use of the EFS 'Fireplace Heatsaver'. These were performed for two types of fires; a DFE and ILFE fire using a 200 mm diameter twinned wall chimney. The assumptions on the heating season length for the primary heating (Boiler) and secondary heating (Fire) are based on data taken from the Government's Standard Assessment Procedure for Energy rating of Dwellings SAP 2005. The main findings are given below.

1. The use of the 'Fireplace Heatsaver' on the DFE fire resulted in a total cost savings of £57.91 and £61.33/annum in the freestanding and sealed position when gas is charged at 2.0P/kWh. At 5.0 p/kWh, the corresponding savings are £144.78 and £153.32

2. The use of the 'Fireplace Heatsaver' on the ILFE fire resulted in total cost savings of £12.55 and £14.21/annum in the freestanding and sealed position when gas is charged at 2.0P/kWh. At 5p/kWh, the corresponding savings are £31.38 and £35.54

3. The total CO_2 savings obtained using the 'Fireplace Heatsaver' for the DFE in the freestanding and sealed positions were 0.550 tonnes and 0.583 tonnes respectively. For the ILFE the corresponding savings were 0.119 and 0.135 tonnes.

4. Flow rate measurements conducted with a trickle vent with a free area of 4000 m^2 show that the ventilation rates through the 'Fireplace Heatsaver' were lower compared to the trickle vent.

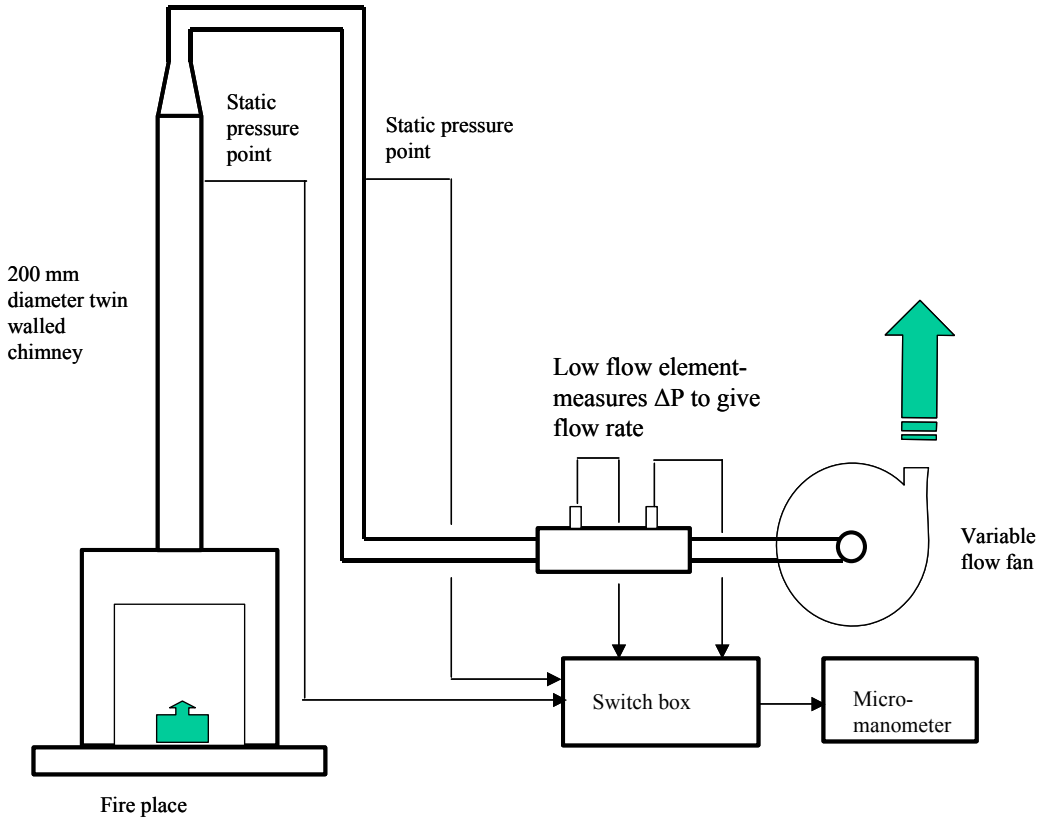
5. The savings are evaluated on ventilation rates of 40 m^3/hr and 20 m^3/hr for the DFE and ILFE. In practice, the actual ventilation rates through a chimneystack for the majority of the existing housing stock, particularly those pre 1965 may exceed these values which would result in increased savings. The actual ventilation rates are dependent on a number of factors e.g. gaps and openings in the building structure, permeability of materials, pressure differential across the chimney pots caused by the wind speed, density differences caused by temperature difference between the inside and outside of the building, cross sectional area of the chimney etc. Unlined chimneys also have a typical cross sectional area of (9 inches × 9 inches) that is 60% greater than a 200 mm internal diameter twinned wall chimney.

6.1 RECOMMENDATIONS

It is recommended that the actual ventilation rates on at least 10 typical dwellings be measured where DFE and ILFE fires are installed and the energy and CO_2 savings recalculated.

APPENDICES

Appendix: A Schematic of test facility



Appendix: B Installation

Figure 2 Installation of 200 mm twin wall chimney and air flow measuring system

Figure 3 Air Flow measuring system and instrumentation

Figure 4 Installation of DFE fire

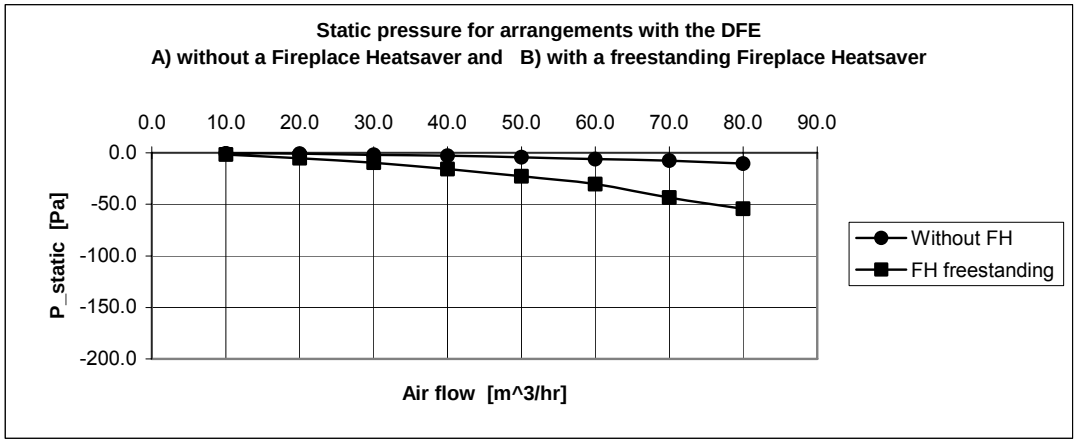
Figure 5 Installation of ILFE Fire

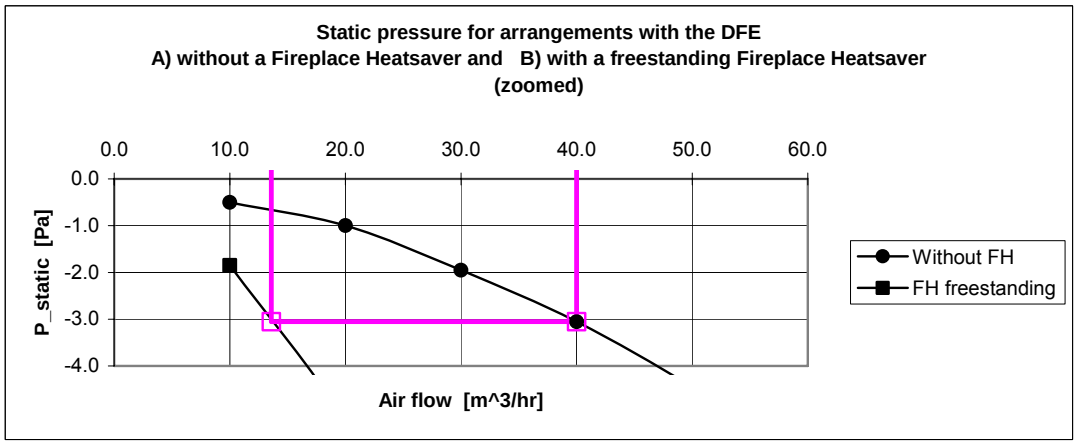
Figure 6 Smoke test

Appendix: C Test results

DFE results with a freestanding 'Fireplace Heatsaver'

			Without FH	With FH freestanding
Air flow [m^3/hr]	**Air flow [L/min]**	**DP [Pa]**	**P_static [Pa]**	**P_static [Pa]**
10.00	166.7	5.8	-0.50	-1.85
20.00	333.3	11.6	-1.00	-5.20
30.00	500.0	17.4	-1.95	-9.75
40.00	666.7	23.2	-3.05	-15.75
50.00	833.3	29	-4.45	-22.75
60.00	1000.0	34.8	-6.05	-30.50
70.00	1166.7	40.6	-7.65	-43.60
80.00	1333.3	46.4	-10.45	-54.35



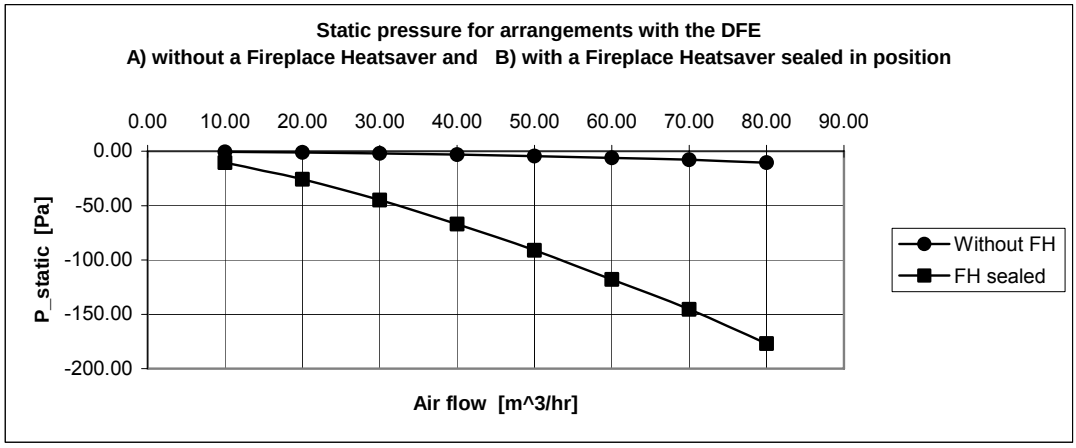


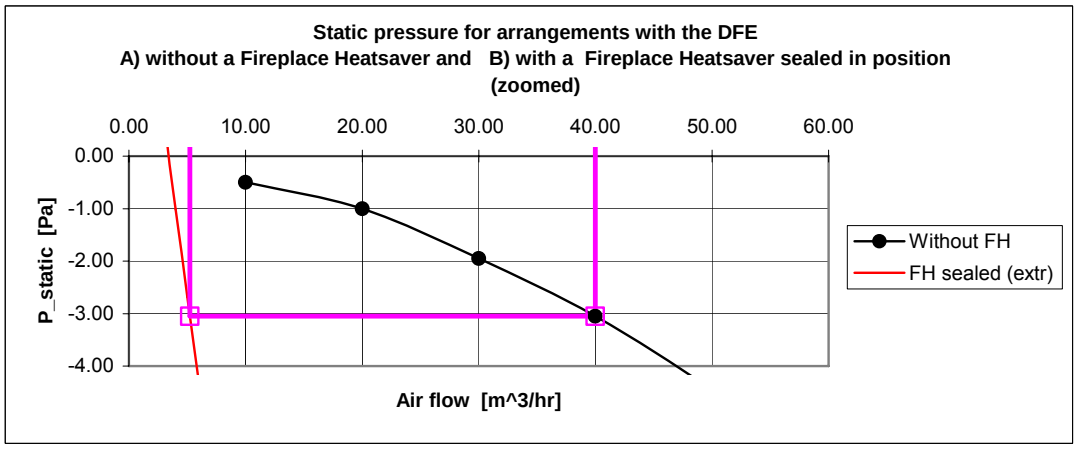
DFE results with a freestanding 'Fireplace Heatsaver'

Value	Unit	Symbol	Description
5.23	m^3/hr	Φ	Value of the air flow at which the static pressure for the system with a 'Fireplace Heatsaver' is -3.05 Pa
34.77	m^3/hr	$\Delta\Phi$	Flow reduction in the system with a 'Fireplace Heatsaver' with respect to the system without a shield for st_p = -3.05 Pa
1.23	kg/m^3	ρ	Density of the air at 14˚ C
1.026	kJ/kg K	C	Specific heat capacity of air
9	°C	ΔT	Temperature difference based on 2130 degree days, a heating season length of 238 days and base temperature of 15.5°C
3	kW	H_{out}	Output rating of the appliance (DFE)
20	%	μ_{dfe}	Efficiency of the appliance (DFE)
85	%	μ_B	Efficiency of the boiler
6162	kWh	E_{req}	SAP calculated annual heating requirements of a 3 bedroom gas heated dwelling of 120 m^2
5712	hr	P	Length of the heating season = 238 days · 24 hr
205.4	hr	S	Number of hours when the secondary source is operating = (10% of E_{req}) / H_{out}
710.331	kWh	ΔE_1	Primary energy savings = $\Delta\Phi/3600\cdot\rho\cdot C\cdot \Delta T\cdot(P-S)/ \mu_B$
2356.059	kWh	ΔE_2	Secondary energy savings = (10% of H_{req})·$(1/\mu_{dfe}-1/\mu_B)$
3066.389	kWh	ΔE	Total energy savings per annum = $\Delta E_1 + \Delta E_2$
0.19	kg CO_2 /kWh	ef	Fuel emissions factor (natural gas)
0.583	t	CO_2	CO_2 emissions savings per annum = $\Delta E\cdot ef\cdot 0.001$

DFE results with a sealed 'Fireplace Heatsaver'

			Without FH	With FH sealed
Air flow [m^3/hr]	**Air flow [L/min]**	**DP [Pa]**	**P_static [Pa]**	**P_static [Pa]**
10.00	166.7	5.8	-0.50	-10.50
20.00	333.3	11.6	-1.00	-25.85
30.00	500.0	17.4	-1.95	-45.00
40.00	666.7	23.2	-3.05	-67.00
50.00	833.3	29	-4.45	-91.00
60.00	1000.0	34.8	-6.05	-118.00
70.00	1166.7	40.6	-7.65	-145.50
80.00	1333.3	46.4	-10.45	-177.00





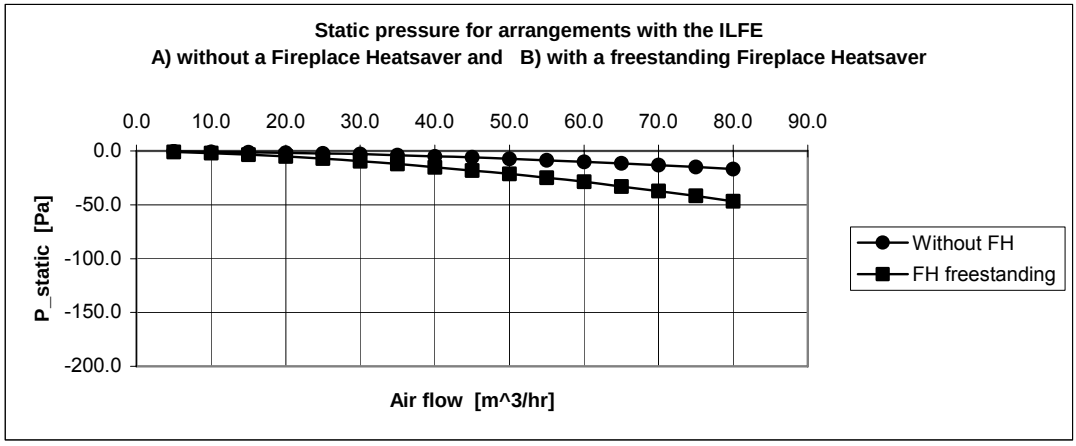
DFE results with a sealed 'Fireplace Heatsaver'

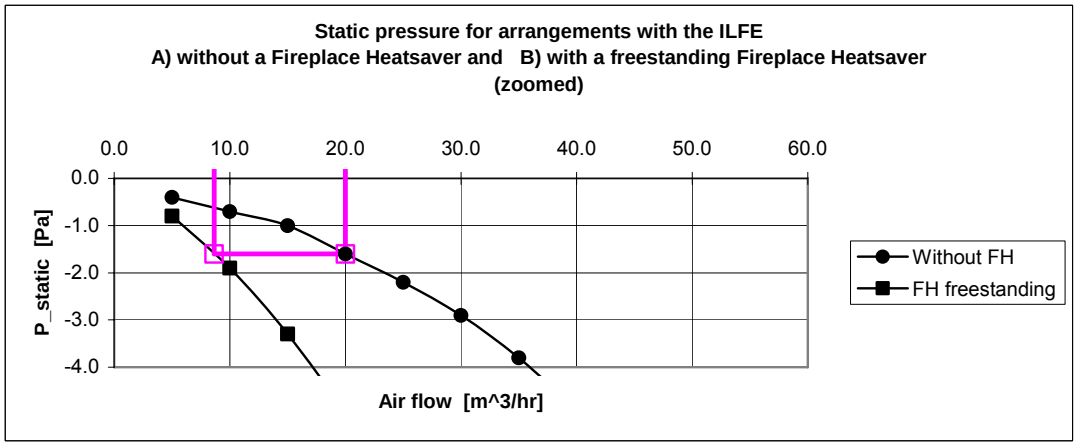
Value	Unit	Symbol	Description
13.58	m^3/hr	Φ	Value of the air flow at which the static pressure for the system with a 'Fireplace Heatsaver' is -3.05 Pa
26.42	m^3/hr	$\Delta\Phi$	Flow reduction in the system with a 'Fireplace Heatsaver' with respect to the system without a shield for st_p = -3.05 Pa
1.23	kg/m^3	ρ	Density of the air at 14˚ C
1.026	kJ/kg K	C	Specific heat capacity of air
9	°C	ΔT	Temperature difference based on 2130 degree days, a heating season length of 238 days and base temperature of 15.5°C
3	kW	H_{out}	Output rating of the appliance (DFE)
20	%	μ_{dfe}	Efficiency of the appliance (DFE)
85	%	μ_B	Efficiency of the boiler
6162	kWh	E_{req}	SAP calculated annual heating requirements of a 3 bedroom gas heated dwelling of 120 m^2
5712	hr	P	Length of the heating season = 238 days · 24 hr
205.4	hr	S	Number of hours when the secondary source is operating = (10% of E_{req}) / H_{out}
739.689	kWh	ΔE_1	Primary energy savings = $\Delta\Phi/3600\cdot\rho\cdot C\cdot \Delta T\cdot(P-S)/ \mu_B$
2356.059	kWh	ΔE_2	Secondary energy savings = (10% of H_{req})·$(1/\mu_{dfe}-1/\mu_B)$
2895.695	kWh	ΔE	Total energy savings per annum = $\Delta E_1 + \Delta E_2$
0.19	kg CO_2 /kWh	ef	Fuel emissions factor (natural gas)
0.550	t	CO_2	CO_2 emissions savings per annum = $\Delta E\cdot ef\cdot 0.001$

ILFE results with a freestanding 'Fireplace Heatsaver'

			Without FH	With FH freestanding
Air flow [m^3/hr]	Air flow [L/min]	DP [Pa]	P_static [Pa]	P_static [Pa]
5.00	83.3	2.9	-0.40	-0.80
10.00	166.7	5.8	-0.70	-1.90
15.00	250.0	8.7	-1.00	-3.30
20.00	333.3	11.6	-1.60	-5.00
25.00	416.7	14.5	-2.20	-7.10
30.00	500.0	17.4	-2.90	-9.40
35.00	583.3	20.3	-3.80	-12.00
40.00	666.7	23.2	-4.90	-15.00

			Without FH	With FH freestanding
Air flow [m^3/hr]	Air flow [L/min]	DP [Pa]	P_static [Pa]	P_static [Pa]
45.00	750.0	26.1	-5.90	-18.10
50.00	833.3	29	-7.20	-21.20
55.00	916.7	31.9	-8.60	-25.00
60.00	1000.0	34.8	-10.10	-28.60
65.00	1083.3	37.7	-11.60	-32.90
70.00	1166.7	40.6	-13.10	-37.20
75.00	1250.0	43.5	-14.90	-41.60
80.00	1333.3	46.4	-16.80	-46.70


Static pressure for arrangements with the ILFE
A) without a Fireplace Heatsaver and B) with a freestanding Fireplace Heatsaver
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
0.0
-50.0
-100.0
-150.0
-200.0
P_static [Pa]
Air flow [m^3/hr]
Without FH
FH freestanding


Static pressure for arrangements with the ILFE
A) without a Fireplace Heatsaver and B) with a freestanding Fireplace Heatsaver
(zoomed)
0.0
10.0
20.0
30.0
40.0
50.0
60.0
0.0
-1.0
-2.0
-3.0
-4.0
P_static [Pa]
Air flow [m^3/hr]
Without FH
FH freestanding

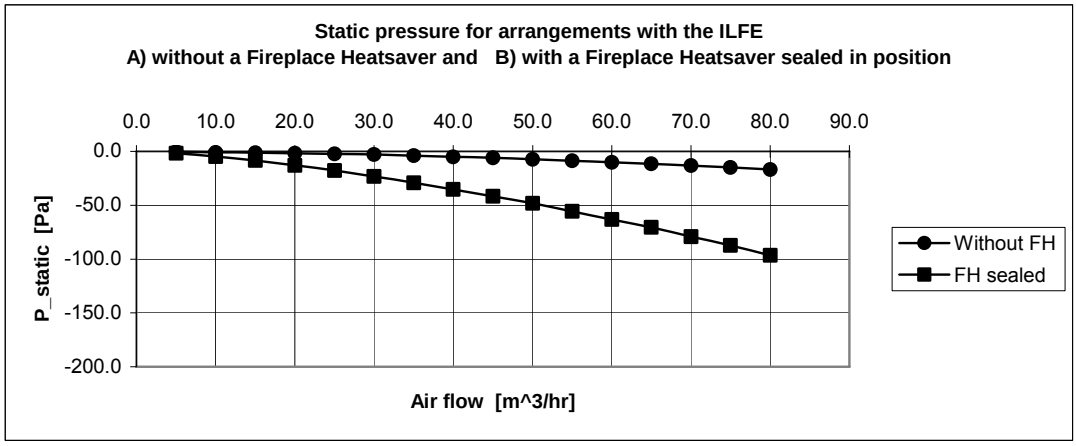
ILFE results with a freestanding 'Fireplace Heatsaver'

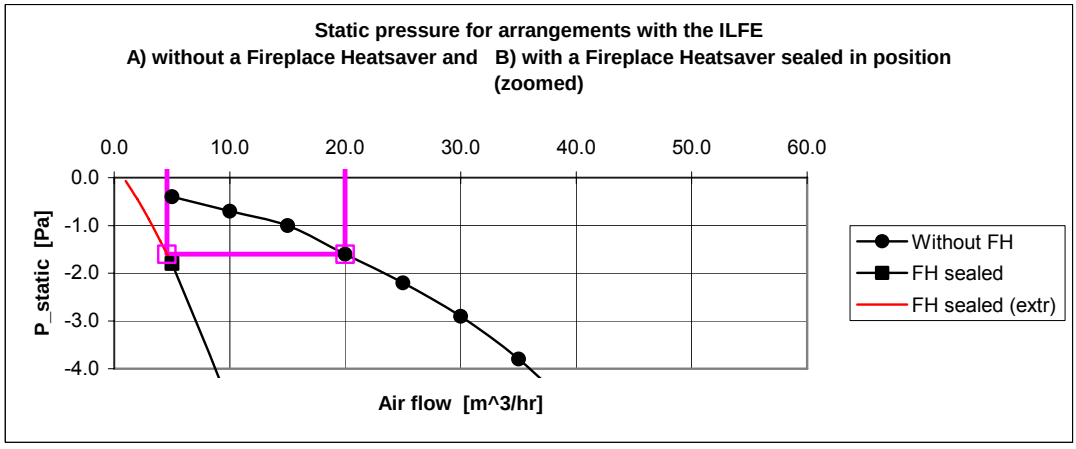
Value	Unit	Symbol	Description
8.64	m^3/hr	Φ	Value of the air flow at which the static pressure for the system with a 'Fireplace Heatsaver' is –1.60Pa
11.36	m^3/hr	$\Delta\Phi$	Flow reduction in the system with a 'Fireplace Heatsaver' with respect to the system without a shield for st_p = -1.60 Pa
1.23	kg/m^3	ρ	Density of the air at 14˚ C
1.026	kJ/kg K	C	Specific heat capacity of air
9	°C	ΔT	Temperature difference based on 2130 degree days, a heating season length of 238 days and base temperature of 15.5°C
3	kW	H_{out}	Output rating of the appliance (ILFE)
55	%	μ_{ilfe}	Efficiency of the appliance (ILFE)
85	%	μ_B	Efficiency of the boiler
6162	kWh	E_{req}	SAP calculated annual heating requirements of a 3 bedroom gas heated dwelling of 120 m^2
5712	hr	P	Length of the heating season = 238 days · 24 hr
205.4	hr	S	Number of hours when the secondary source is operating = (10% of E_{req}) / H_{out}
232.124	kWh	ΔE_1	Primary energy savings = $\Delta\Phi/3600\cdot\rho\cdot C\cdot \Delta T\cdot(P-S)/ \mu_B$
395.422	kWh	ΔE_2	Secondary energy savings = (10% of H_{req})·$(1/\mu_{ilfe}-1/\mu_B)$
627.546	kWh	ΔE	Total energy savings per annum = $\Delta E_1 + \Delta E_2$
0.19	kg CO_2 /kWh	ef	Fuel emissions factor (natural gas)
0.119	t	CO_2	CO_2 emissions savings per annum = $\Delta E\cdot ef\cdot 0.001$

ILFE results with a sealed 'Fireplace Heatsaver'

			Without FH	With FH freestanding
Air flow [m^3/hr]	Air flow [L/min]	DP [Pa]	P_static [Pa]	P_static [Pa]
5.00	83.3	2.9	-0.40	-1.80
10.00	166.7	5.8	-0.70	-4.80
15.00	250.0	8.7	-1.00	-8.50
20.00	333.3	11.6	-1.60	-12.90
25.00	416.7	14.5	-2.20	-17.70
30.00	500.0	17.4	-2.90	-23.10
35.00	583.3	20.3	-3.80	-29.10
40.00	666.7	23.2	-4.90	-35.20

			Without FH	With FH freestanding
Air flow [m^3/hr]	Air flow [L/min]	DP [Pa]	P_static [Pa]	P_static [Pa]
45.00	750.0	26.1	-5.90	-41.80
50.00	833.3	29	-7.20	-48.20
55.00	916.7	31.9	-8.60	-55.60
60.00	1000.0	34.8	-10.10	-63.10
65.00	1083.3	37.7	-11.60	-70.60
70.00	1166.7	40.6	-13.10	-79.20
75.00	1250.0	43.5	-14.90	-87.20
80.00	1333.3	46.4	-16.80	-96.60



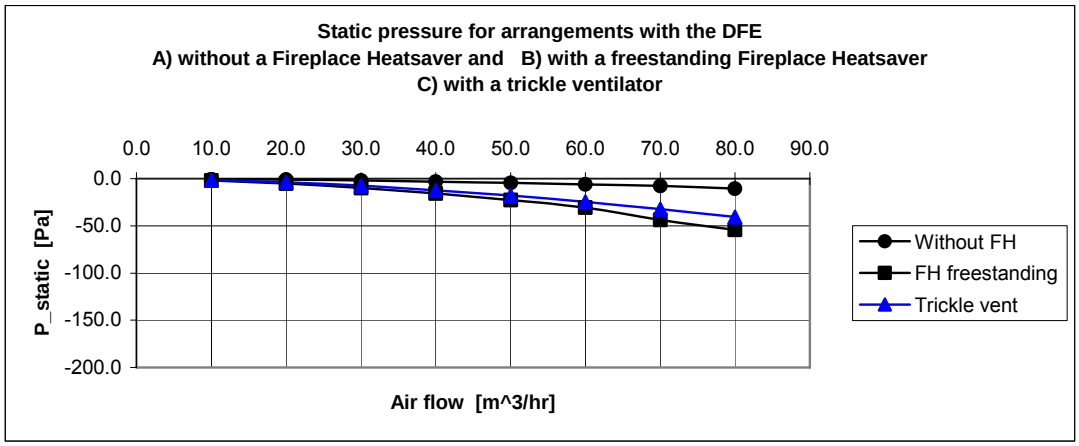


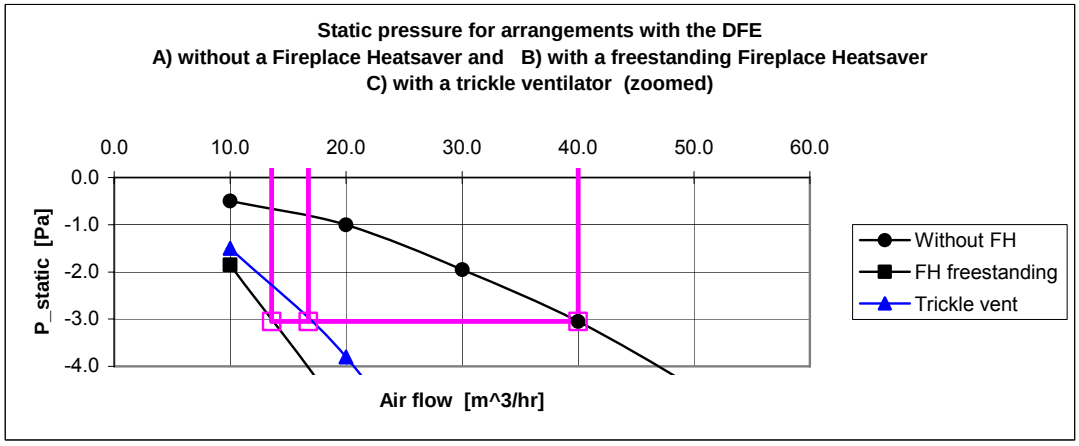
ILFE results with a sealed 'Fireplace Heatsaver'

Value	Unit	Symbol	Description
4.56	m^3/hr	Φ	Value of the air flow at which the static pressure for the system with a 'Fireplace Heatsaver' is –1.60Pa
15.44	m^3/hr	$\Delta\Phi$	Flow reduction in the system with a 'Fireplace Heatsaver' with respect to the system without a shield for st_p = -1.60 Pa
1.23	kg/m^3	ρ	Density of the air at 14° C
1.026	kJ/kg K	C	Specific heat capacity of air
9	°C	ΔT	Temperature difference based on 2130 degree days, a heating season length of 238 days and base temperature of 15.5°C
3	kW	H_{out}	Output rating of the appliance (ILFE)
55	%	μ_{ilfe}	Efficiency of the appliance (ILFE)
85	%	μ_B	Efficiency of the boiler
6162	kWh	E_{req}	SAP calculated annual heating requirements of a 3 bedroom gas heated dwelling of 120 m^2
5712	hr	P	Length of the heating season = 238 days · 24 hr
205.4	hr	S	Number of hours when the secondary source is operating = (10% of E_{req}) / H_{out}
315.322	kWh	ΔE_1	Primary energy savings = $\Delta\Phi/3600\cdot\rho\cdot C\cdot \Delta T\cdot(P-S)/ \mu_B$
395.422	kWh	ΔE_2	Secondary energy savings = (10% of H_{req})·$(1/\mu_{ilfe}-1/\mu_B)$
710.744	kWh	ΔE	Total energy savings per annum = $\Delta E_1 + \Delta E_2$
0.19	kg CO_2 /kWh	ef	Fuel emissions factor (natural gas)
0.135	t	CO_2	CO_2 emissions savings per annum = $\Delta E\cdot ef\cdot 0.001$

DFE results with a freestanding 'Fireplace Heatsaver' and a trickle ventilator

			Without FH	With FH freestanding	Trickle ventilator
Air flow [m^3/hr]	**Air flow [L/min]**	**dP [Pa]**	**P_static [Pa]**	**P_static [Pa]**	**P_static [Pa]**
10.00	166.7	5.8	-0.50	-1.85	-1.50
20.00	333.3	11.6	-1.00	-5.20	-3.80
30.00	500.0	17.4	-1.95	-9.75	-7.30
40.00	666.7	23.2	-3.05	-15.75	-12.30
50.00	833.3	29.0	-4.45	-22.75	-18.00
60.00	1000.0	34.8	-6.05	-30.50	-24.70
70.00	1166.7	40.6	-7.65	-43.60	-32.10
80.00	1333.3	46.4	-10.45	-54.35	-40.60

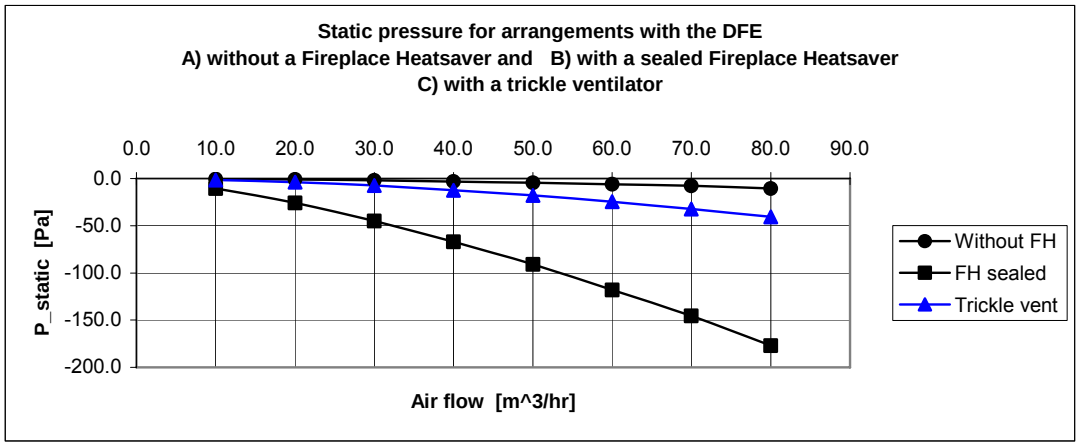


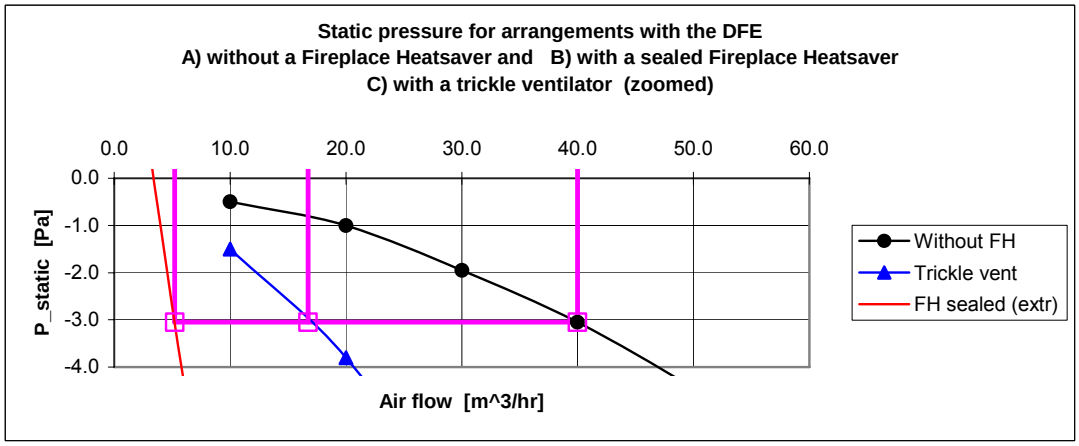


Installation	Ventilation rate [m^3/h]
DFE without a 'Fireplace Heatsaver'	40.00
Trickle ventilator	16.74
DFE with a freestanding 'Fireplace Heatsaver'	13.58

DFE results with a sealed 'Fireplace Heatsaver' and a trickle ventilator

			Without FH	With FH sealed	Trickle ventilator
Air flow [m^3/hr]	Air flow [L/min]	dP [Pa]	P_static [Pa]	P_static [Pa]	P_static [Pa]
10.00	166.7	5.8	-0.50	-10.50	-1.50
20.00	333.3	11.6	-1.00	-25.85	-3.80
30.00	500.0	17.4	-1.95	-45.00	-7.30
40.00	666.7	23.2	-3.05	-67.00	-12.30
50.00	833.3	29.0	-4.45	-91.00	-18.00
60.00	1000.0	34.8	-6.05	-118.00	-24.70
70.00	1166.7	40.6	-7.65	-145.50	-32.10
80.00	1333.3	46.4	-10.45	-177.00	-40.60



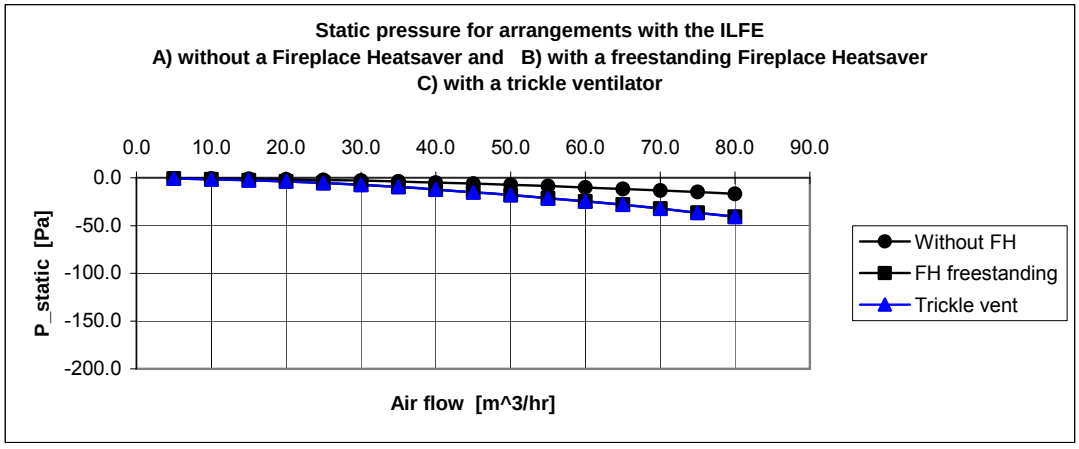


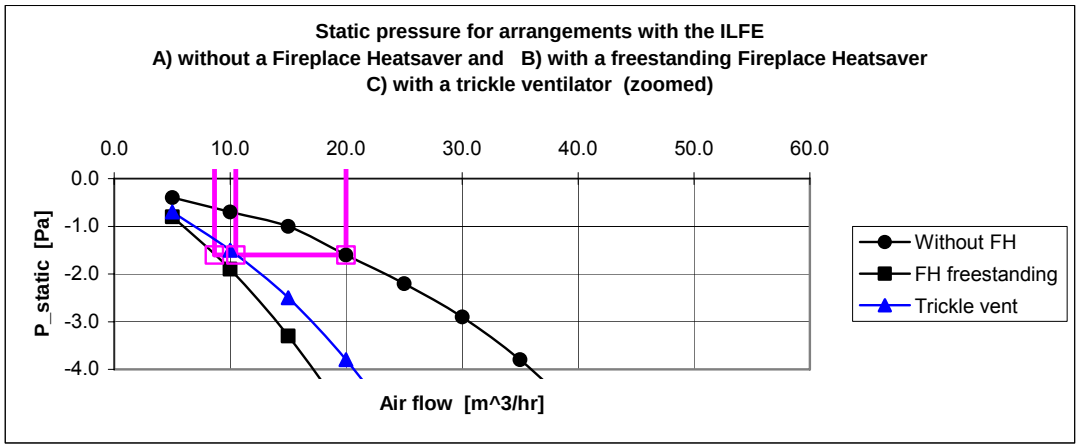
Installation	Ventilation rate [m^3/h]
DFE without a 'Fireplace Heatsaver'	40.00
Trickle ventilator	16.74
DFE with a sealed 'Fireplace Heatsaver'	5.23

ILFE results with a freestanding 'Fireplace Heatsaver' and a trickle ventilator

			Without FH	With FH freestanding	Trickle ventilator
Air flow [m^3/hr]	Air flow [L/min]	dP [Pa]	P_static [Pa]	P_ static [Pa]	P_static [Pa]
5.00	83.3	2.9	-0.40	-0.80	-0.70
10.00	166.7	5.8	-0.70	-1.90	-1.50
15.00	250.0	8.7	-1.00	-3.30	-2.50
20.00	333.3	11.6	-1.60	-5.00	-3.80
25.00	416.7	14.5	-2.20	-7.10	-5.40
30.00	500.0	17.4	-2.90	-9.40	-7.30
35.00	583.3	20.3	-3.80	-12.00	-9.60
40.00	666.7	23.2	-4.90	-15.00	-12.30

			Without FH	With FH freestanding	Trickle ventilator
Air flow [m^3/hr]	Air flow [L/min]	DP [Pa]	P_static [Pa]	P_static [Pa]	P_static [Pa]
45.00	750.0	26.1	-5.90	-18.10	-15.10
50.00	833.3	29	-7.20	-21.20	-18.00
55.00	916.7	31.9	-8.60	-25.00	-21.30
60.00	1000.0	34.8	-10.10	-28.60	-24.70
65.00	1083.3	37.7	-11.60	-32.90	-28.10
70.00	1166.7	40.6	-13.10	-37.20	-32.10
75.00	1250.0	43.5	-14.90	-41.60	-36.70
80.00	1333.3	46.4	-16.80	-46.70	-40.60



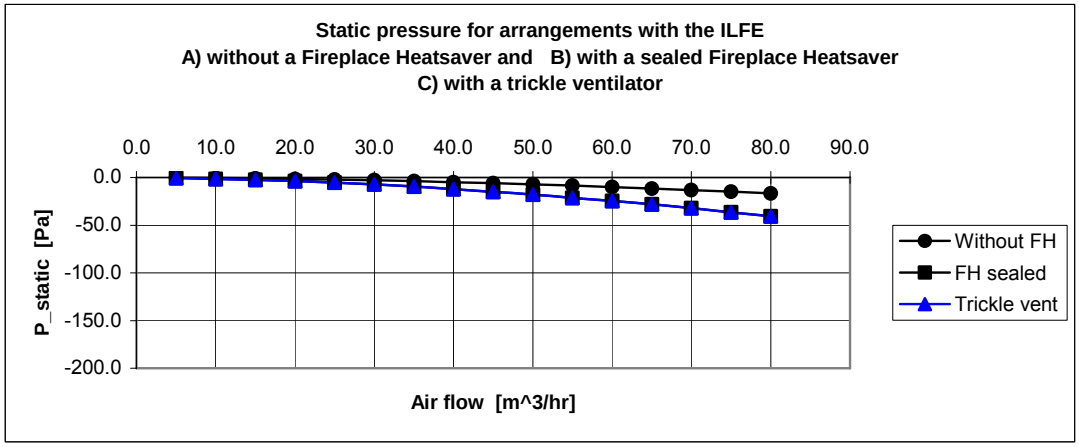


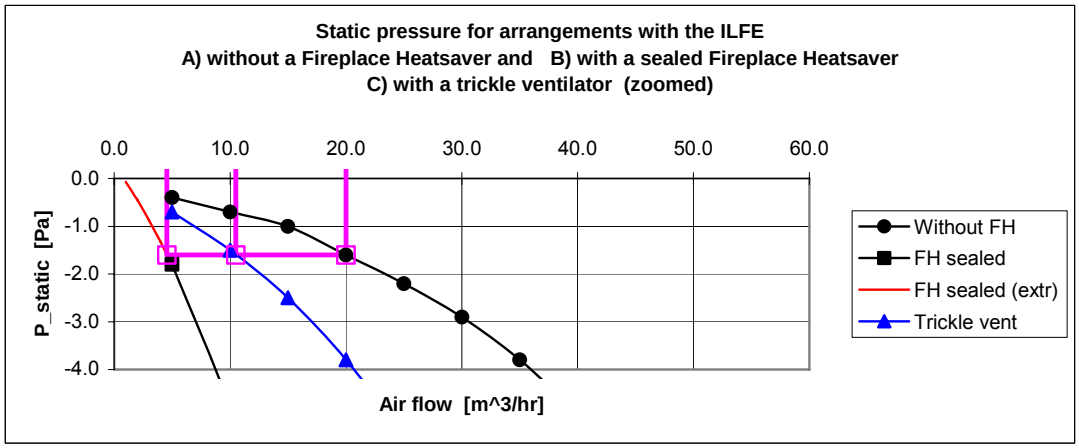
Installation	Ventilation rate [m^3/h]
ILFE without a 'Fireplace Heatsaver'	20.00
Trickle ventilator	10.50
ILFE with a freestanding 'Fireplace Heatsaver'	8.64

ILFE results with a sealed 'Fireplace Heatsaver' and a trickle ventilator

			Without FH	With FH sealed	Trickle ventilator
Air flow [m^3/hr]	Air flow [L/min]	DP [Pa]	P_static [Pa]	P_static [Pa]	P_static [Pa]
5.00	83.3	2.9	-0.40	-1.80	-0.70
10.00	166.7	5.8	-0.70	-4.80	-1.50
15.00	250.0	8.7	-1.00	-8.50	-2.50
20.00	333.3	11.6	-1.60	-12.90	-3.80
25.00	416.7	14.5	-2.20	-17.70	-5.40
30.00	500.0	17.4	-2.90	-23.10	-7.30
35.00	583.3	20.3	-3.80	-29.10	-9.60
40.00	666.7	23.2	-4.90	-35.20	-12.30

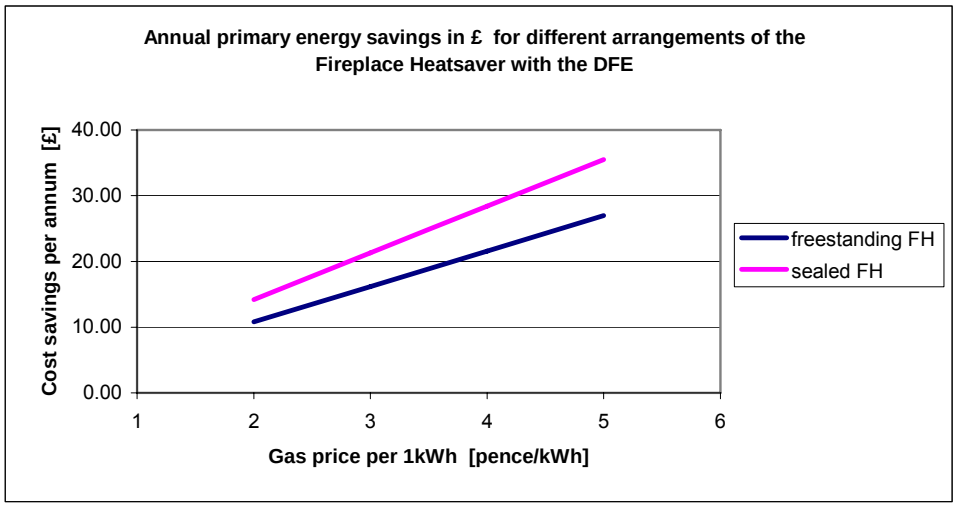
			Without FH	With FH sealed	Trickle ventilator
Air flow [m^3/hr]	Air flow [L/min]	dP [Pa]	P_static [Pa]	P_static [Pa]	P_static [Pa]
45.00	750.0	26.1	-5.90	-41.80	-15.10
50.00	833.3	29	-7.20	-48.20	-18.00
55.00	916.7	31.9	-8.60	-55.60	-21.30
60.00	1000.0	34.8	-10.10	-63.10	-24.70
65.00	1083.3	37.7	-11.60	-70.60	-28.10
70.00	1166.7	40.6	-13.10	-79.20	-32.10
75.00	1250.0	43.5	-14.90	-87.20	-36.70
80.00	1333.3	46.4	-16.80	-96.60	-40.60

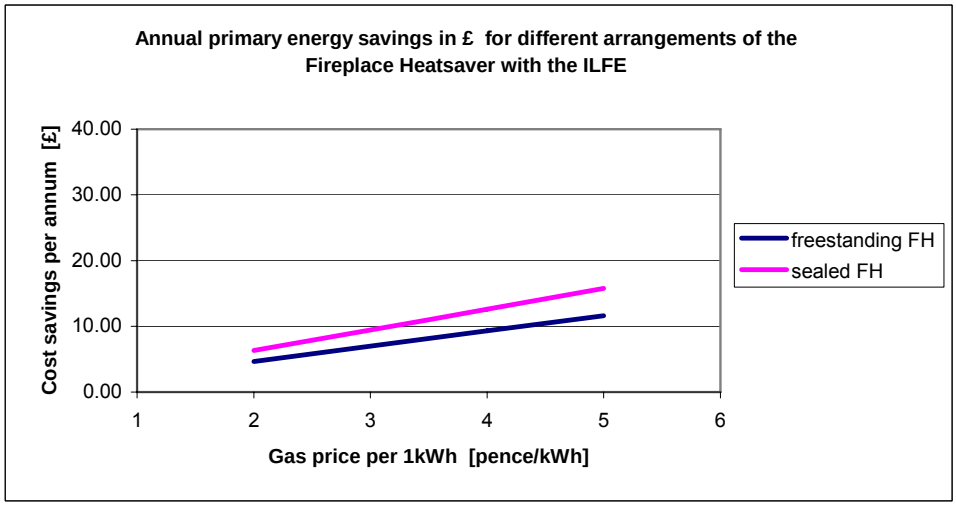




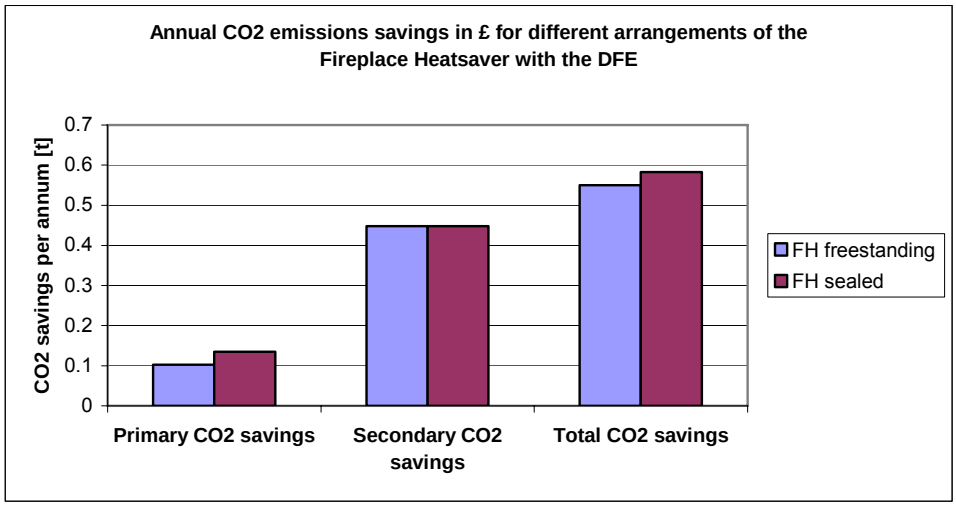
Installation	Ventilation rate [m^3/h]
ILFE without a 'Fireplace Heatsaver'	20.00
Trickle ventilator	10.50
ILFE with a sealed 'Fireplace Heatsaver'	4.56

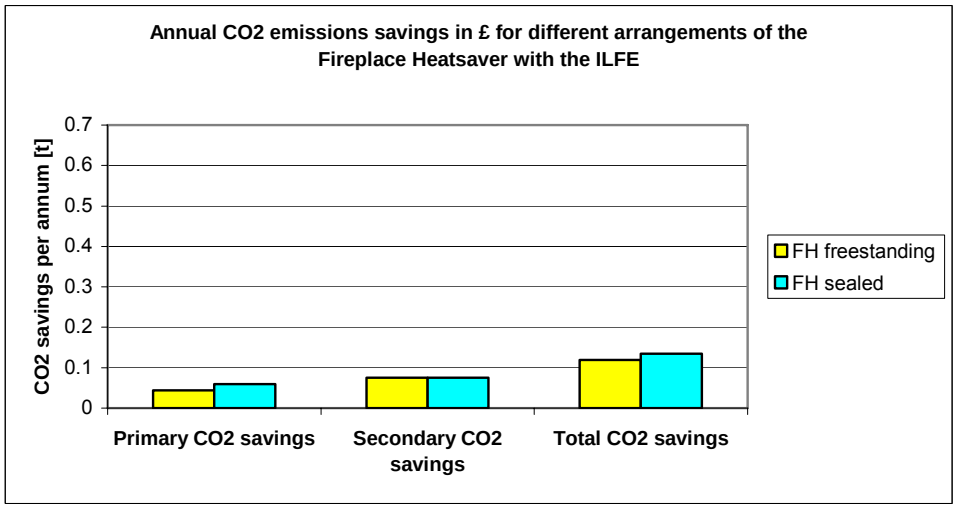
Annual energy savings for two arrangements of the 'Fireplace Heatsaver' with the DFE and ILFE





Annual CO2 emissions savings for two arrangements of the 'Fireplace Heatsaver' with the DFE and ILFE





Summary of energy and CO_2 emissions savings per annum for different gas prices

				Gas price				
		Energy savings source	Energy savings per annum [kWh]	2.0 [p/kWh]	3.0 [p/kWh]	4.0 [p/kWh]	5.0 [p/kWh]	CO_2 savings [tonnes]
DFE	Freestanding	Primary	539.636	10.79	16.19	21.59	26.98	0.103
		Secondary	2356.059	47.12	70.68	94.24	117.80	0.448
		Total	2895.695	57.91	86.87	115.83	144.78	0.550
	Sealed	Primary	710.331	14.21	21.31	28.41	35.52	0.135
		Secondary	2356.059	47.12	70.68	94.24	117.80	0.448
		Total	3066.389	61.33	91.99	122.66	153.32	0.583
ILFE	Freestanding	Primary	232.124	4.64	6.96	9.28	11.61	0.044
		Secondary	395.422	7.91	11.86	15.82	19.77	0.075
		Total	627.546	12.55	18.83	25.10	31.38	0.119
	Sealed	Primary	315.322	6.31	9.46	12.61	15.77	0.060
		Secondary	395.422	7.91	11.86	15.82	19.77	0.075
		Total	710.744	14.21	21.32	28.43	35.54	0.135