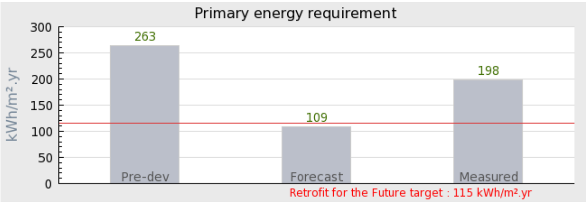
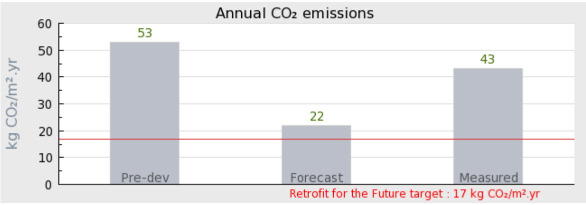
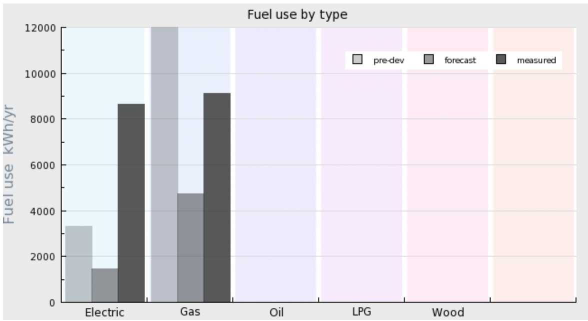
http://lowenergybuildings.org.uk

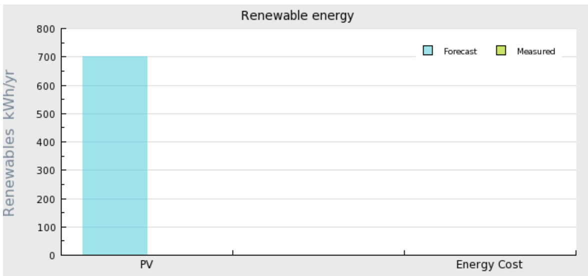
Project name Addressing Energy Consumption and Climate Change Adaptation in non-South facing, post-Decent Homes properties.

Project summary The project property is an east-west facing, brick cavity construction, mid terrace house built in 1992. This type and era of dwelling correspond to approximately 100,000 similar social properties in England alone. We have developed a holistic strategy that will reduce the CO2 emissions of our proposed property by 80% whilst addressing how existing homes can adapt to climate change in the future. Our proposal is a combination of existing technologies used along side new innovative solutions to form a comprehensive strategy to reduce heating, hot water and electricity use. The underlying strategy is replicable across all terraced housing.









Project Description

Projected build start date	01 Mar 2010
Projected date of occupation	01 Jan 2010
Project stage	Under construction
Project location	London, London, England
Energy target	Retrofit for the Future
Build type	Refurbishment
Building sector	Public Residential

Property type	Mid Terrace
Existing external wall construction	Masonry Cavity
Existing external wall additional information	Likely a partial fill of cavity with Uvalue of 0.55 W/m2K
Existing party wall construction	Uninsulated masonry wall which rises beyond the roofline
Floor area	83.7 m²
Floor area calculation method	PHPP

Project team

Organisation	East Thames Housing Association
Project lead	East Thames Housing Association
Client	East Thames Housing Association
Architect	Penoyre and Prasad
Mechanical & electrical consultant(s)	XCO2 Energy
Energy consultant(s)	XCO2 Energy and Rajat Gupta Oxford Brookes University
Structural engineer	
Quantity surveyor	
Other consultant	Rajat Gupta Oxford Brookes University
Contractor	Lakehouse

Design strategies

Planned occupancy	The current tenants have lived at the property for nearly 17 years. The presence of a long term, sitting tenant will help the team to collect valuable operating energy use data and demonstrate the impact of our behavioural change measures. It is proposed that the tenants will remain throughout phase 2. Close communication and considerate construction practices will help to avoid decanting the residents. We believe this is important to enhance the scalability of our proposals.
Space heating strategy	Current secondary space heating will be removed. Primary heating will be provided via a condensing combi gas boiler that is capable of accepting preheated water. Distribution of heat will be via the existing wet radiator system with the only additions being insulation for all pipework and a bespoke feedback control and display system as discussed in 'Other relevant retrofit strategies' below.

Water heating strategy	Waste water heat recovery (WWHRS) will be installed beneath the shower with a vertical heat exchanger where the heat in the waste water is transferred to the incoming cold water. A gas saver (FGHRS) will be installed which recovers heat from the exhaust gases by transferring the energy to incoming cold water. The solar thermal system has been designed to reduce the losses including; energy used to heat water that is unused before it cools down, heat loss from the store and pipework and energy used to sterilise stored water. Design features include evacuated tube collectors, insulated open vented thermal store and pipework, solar divert valve, combi boiler accepting pre-heated water, mains pressure feed and thermal store heat exchanger.
Fuel strategy	Mains gas and mains electricity as currently installed.
Renewable energy generation strategy	A small photovoltaic array will be installed to create the final reductions in CO2 required to meet the Retrofit target. Our current modelling estimates that a 0.99kW array will be required although this may change as the project develops. PV array will be grid connected. The design team energy strategy was to carry out as many efficiency improvements as possible before addressing any of the target with microgeneration via renewables.
Passive solar strategy	Due to the property being east-west facing the potential for passive solar design is limited. Movable shutters or shades will be available on all glazing to allow the tenant to limit or allow solar radiation into the home as they like.
Space cooling strategy	Dynamic overheating modelling has been carried out on the property to determine whether overheating is a problem and whether artificial cooling would be required. It was found that with adequate sizing of secure insulated louvers/vents and a rooflight as well as internal thermal mass provided by a heavyweight finish that artificial cooling would not be required. The CIBSE Design Summer Year weather file for London was used for the modelling.

Daylighting strategy	Daylight levels will be improved through the installation of the 'solar ventilation chimney' (see project images illustration). This will involve the installation of a skylight in the roof which after alterations to the loft space will project daylight to the first floor landing area which currently achieves poor daylight levels in the centre of the house. Daylight will be borrowed from the landing by all the bedrooms and bathroom. Daylighting analysis will be carried out during phase 2 to maximise the benefit of the skylight without excessive solar gain. The daylighting will allow the landing to become a useable space where a study/home office area will be placed.
Ventilation strategy	Secure operable louvers/vents to be installed for use during winter and when unoccupied in summer. Actuator controlled skylight to be installed in roof which will connect to the landing below by boxing out and extending into the loft. This will provide a route for a natural stack ventilation path created by the pressure difference between the high skylight opening and low level louver/vent openings. A control and real time monitoring system will provide information to the tenants on whether vents or windows should be opened to improve internal comfort. The monitoring system will be linked to CO_2, internal and external temperature sensors to ensure that comfort is optimised without excessive heat loss.
Airtightness strategy	Initial air tightness test has been carried out and the results show the dwelling already achieves 5.6 m3/m2/hr@ 50 Pa. Smoke stick testing (see project images) shows the majority of the air leakage is through electrical sockets, service penetrations to the internal soil stack and damaged plasterwork around openings. During the retrofit we intend to improve the air tightness to a level of 3 m3/m2/hr@ 50 Pa, which is generally accepted as the highest recommended air tightness without the use of whole house mechanical ventilation. The higher level of air tightness will be achieved through a high standard of work during the installation of other measures, including window and door replacement and the replace and enlargement of the soil duct.

Strategy for minimising thermal bridges	We have already conducted some thermal imaging (see project images) which identified some thermal bridges including; window frames, front door and location where the party walls extend above the roof. These areas will be addressed via replacement of windows and external doors with high performance units with thermal break frames. The party walls will be insulated externally, as with the external walls but with additional insulation to the un insulated loft space side of the wall to address the bridge through the roof. Further thermal imaging analysis will be carried out to identify and rectify other areas of concern. All junctions will be assessed and when insulation fitting is carried out a continuous layer will be maintained throughout.
Modelling strategy	SAP 2005 modelling with whole house energy v6 spreadsheet and specialised appendix Q for WWHRS and FGHRS. Overheating modelling was carried out using Appendix P of SAP and dynamic simulation via IES Virtual Environment software. Insolation analysis was carried out using Ecotect to determine the impact of mounting solar generation on an east facing pitched roof. Monitoring was carried out on the occupied dwelling on the main incoming electrical supply, all main use plug sockets, supply and use domestic hot water and main gas meter readings for a 25 day period. The data collected can be deemed representative for the whole years electricity and hot water use but can not be relied on for space heating due to the short monitoring period.

Insulation strategy	External walls will be improved by the addition of 150mm external rigid insulation with a new render finish U-value improved to 0.15W/m K. Ground floor will incorporate vacuum insulated panels over the current beam and block floor, U-value improved to 0.15W/m K. In the roof 125mm mineral fibre between joists and 350mm above, U-value improved to 0.1 W/m K. The party walls will also be insulated to avoid heat loss shown up during the thermal imaging. Existing glazing to be replaced with high performance triple glazing, U-value of 0.7 W/m K. Front door will be replaced with a composite insulated version, U-value of 1.0 W/m K. These U-values are significantly beyond the levels expected of Part L compliant new dwellings.
Other relevant retrofit strategies	As discussed in 'Contextual information' high electrical use is a concern and will therefore be addressed as follows. The following appliances will be replaced with current best energy performing models; tumble dryer, fridge freezer, oven, and ceramic hobs. Automatic standby power savers and a bespoke real time electricity meter will be installed to attempt to reduce the baseload by 100w. The bespoke package of feedback meters will relate real time heat and electricity usage to cost. The displays will also feature information on internal and external temperature; windows left open, extract fans on and hot water use. Internal ventilated drying space (see section in project images) will be incorporated to avoid use of the tumble dryer.
Other information (constraints or opportunities influencing project design or outcomes)	The modelled and monitored data was compared with the major difference being a monitored electrical use 2.6 times higher than that predicted by SAP. The high occupancy density (4 adults in an 84m2 home) and fact that the property is occupied almost 24 hours a day is likely to be the reason for the high electrical demand (see project images for a typical days monitored electricity profile). We therefore intend to incorporate a number of electrical efficiency measures that cannot be modelled in SAP.

Energy use

Fuel use by type (kWh/yr)

Fuel	previous	forecast	measured
Electric	3303	1455	4319
Gas	11983	4756	5016
Oil			
LPG			
Wood			

Primary energy requirement & CO_2 emissions

	previous	forecast	measured
Annual CO_2 emissions (kg CO_2/m^2.yr)	53	22	43
Primary energy requirement (kWh/m^2.yr)	263	109	198

Renewable energy (kWh/yr)

Renewables technology	forecast	measured
PV	702	
-		
Energy consumed by generation		

Airtightness (m^3/m^2.hr @ 50 Pascals)

	Date of test	**Test result**
Pre-development airtightness	21 Apr 2010	5.62
Final airtightness	13 Sep 2011	6.76

Annual space heat demand (kWh/m^2.yr)

	Pre-development	forecast	measured
Space heat demand	-	40	-

Whole house energy calculation method	SAP Extension for Whole House
Other energy calculation method	
Predicted annual heating load	-
Other energy target(s)	Reduce primary energy use to below 115 kWh/m2/yr

Building services

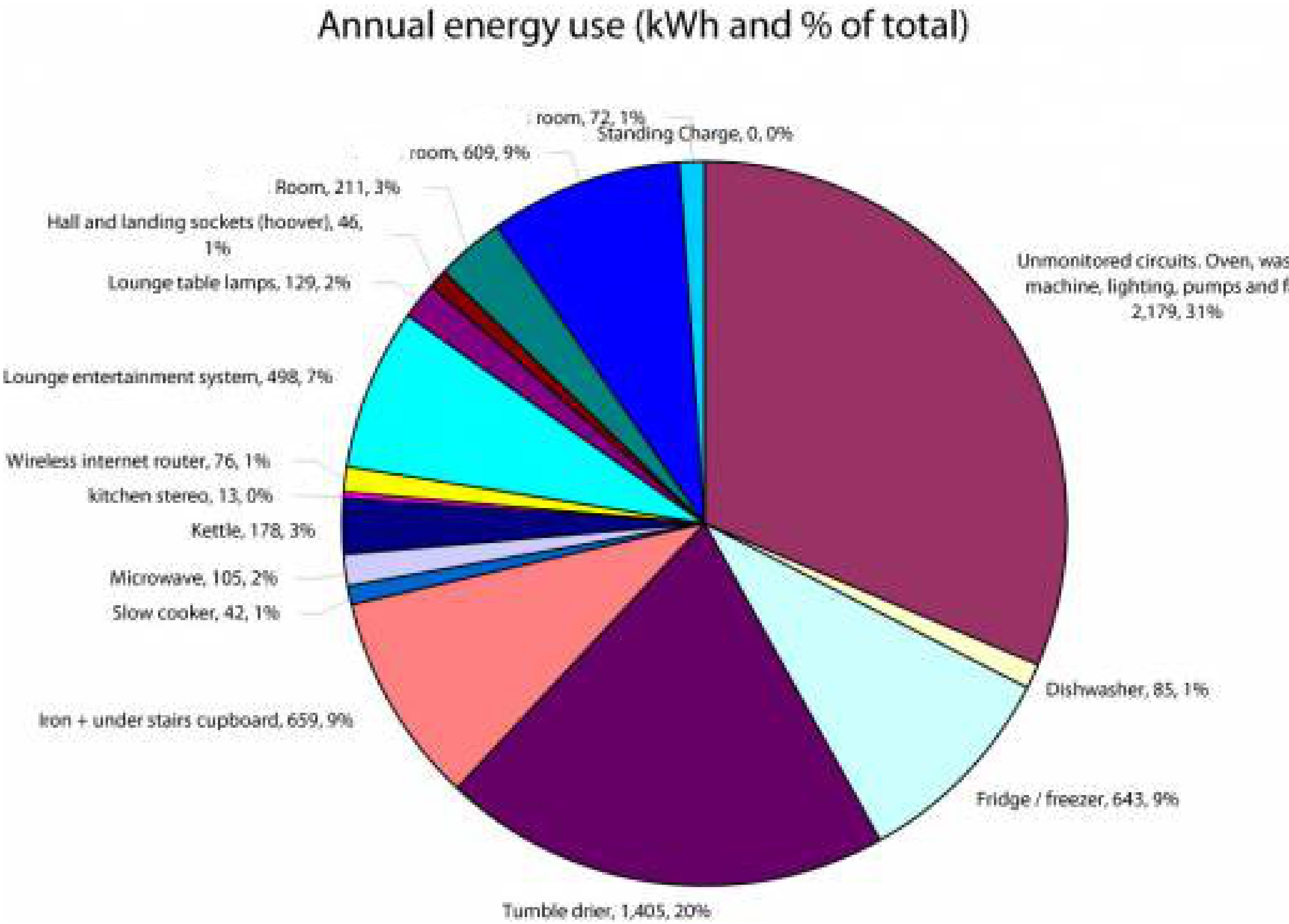
Occupancy	NULL
Space heating	NULL
Hot water	NULL
Ventilation	NULL
Controls	NULL
Cooking	NULL

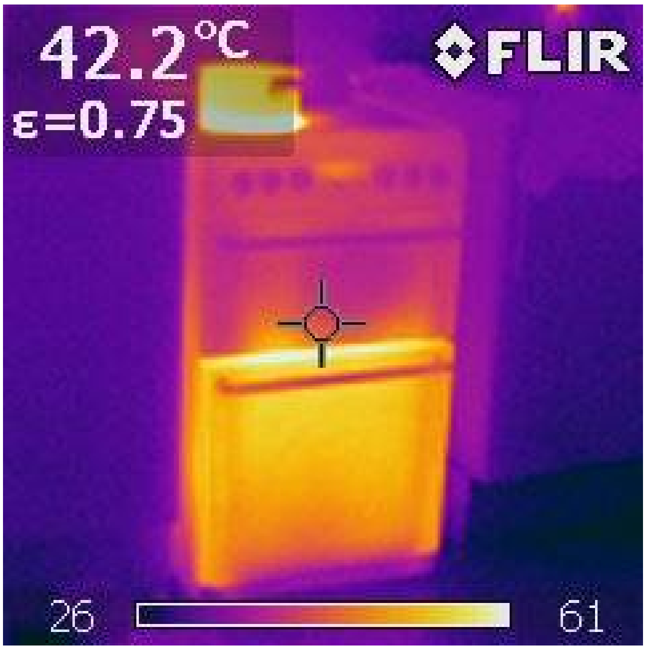
Lighting	NULL
Appliances	NULL
Renewables	NULL
Strategy for minimising thermal bridges	NULL

Building construction

Storeys	
Volume	
Thermal fabric area	
Roof description	NULL
Roof U-value	0.00W/m² K
Walls description	NULL
Walls U-value	0.00W/m² K
Party walls description	NULL
Party walls U-value	0.00W/m² K
Floor description	NULL
Floor U-value	0.00W/m² K
Glazed doors description	NULL
Glazed doors U-value	0.00W/m² K
Opaque doors description	NULL
Opaque doors U-value	0.00W/m² K
Windows description	NULL
Windows U-value	0.00W/m² K
Windows energy transmittance (G-value)	
Windows light transmittance	
Rooflights description	NULL
Rooflights light transmittance	
Rooflights U-value	0.00W/m² K

Project images

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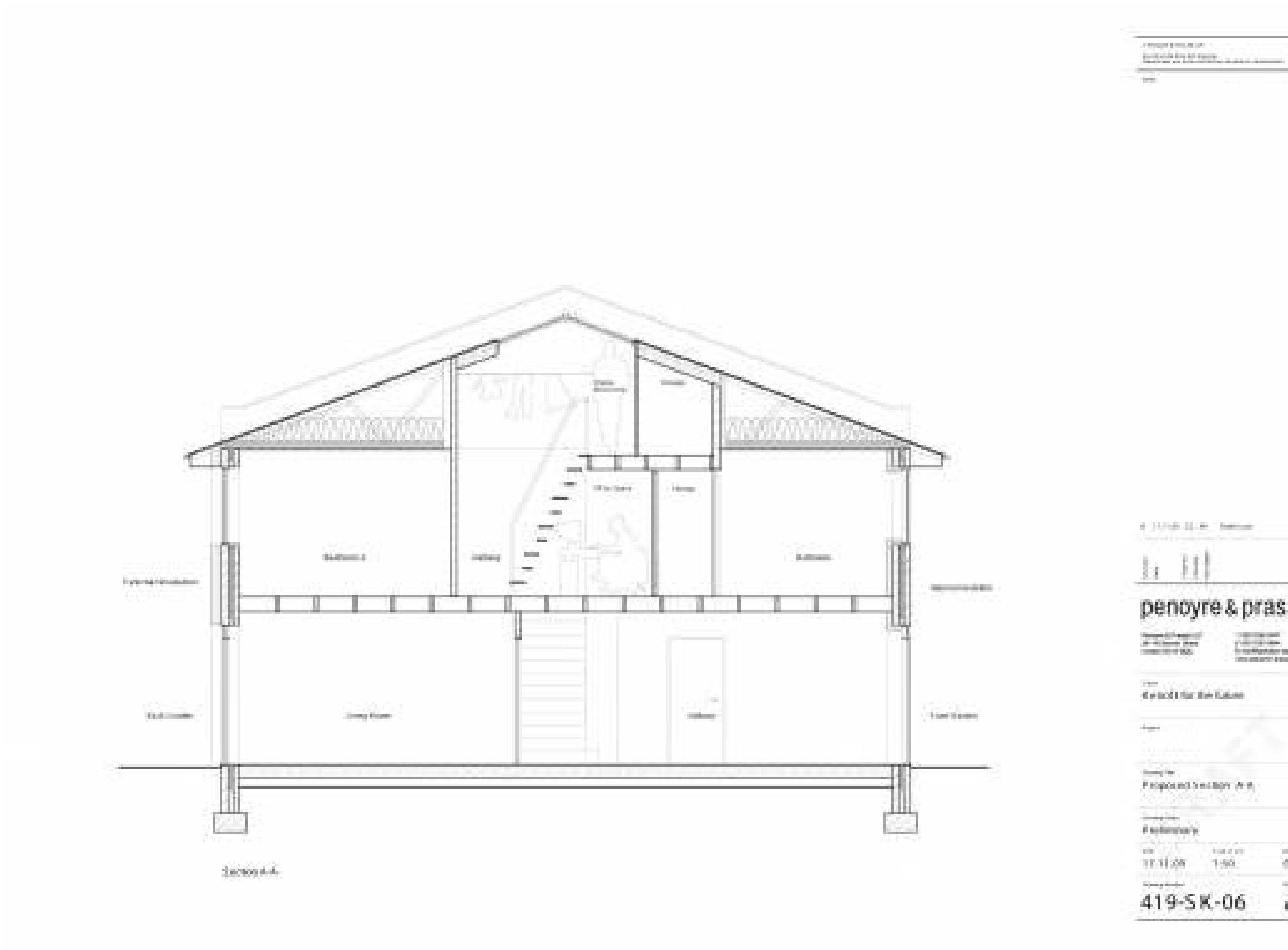
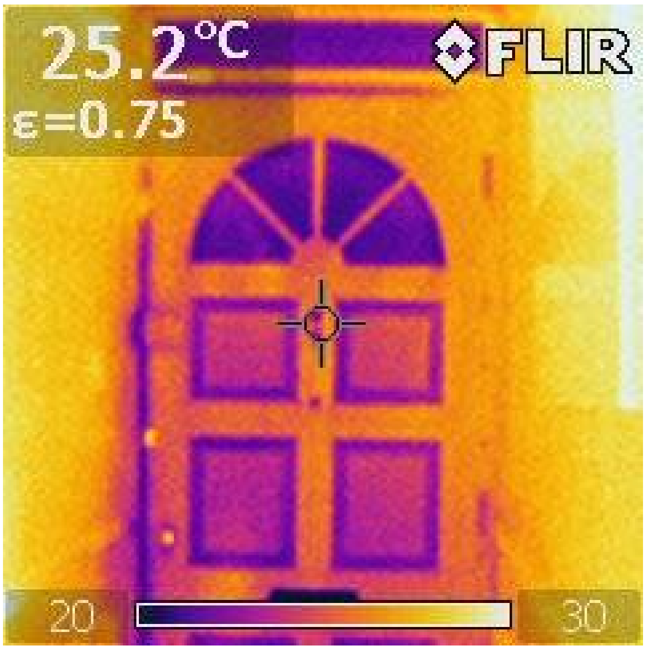
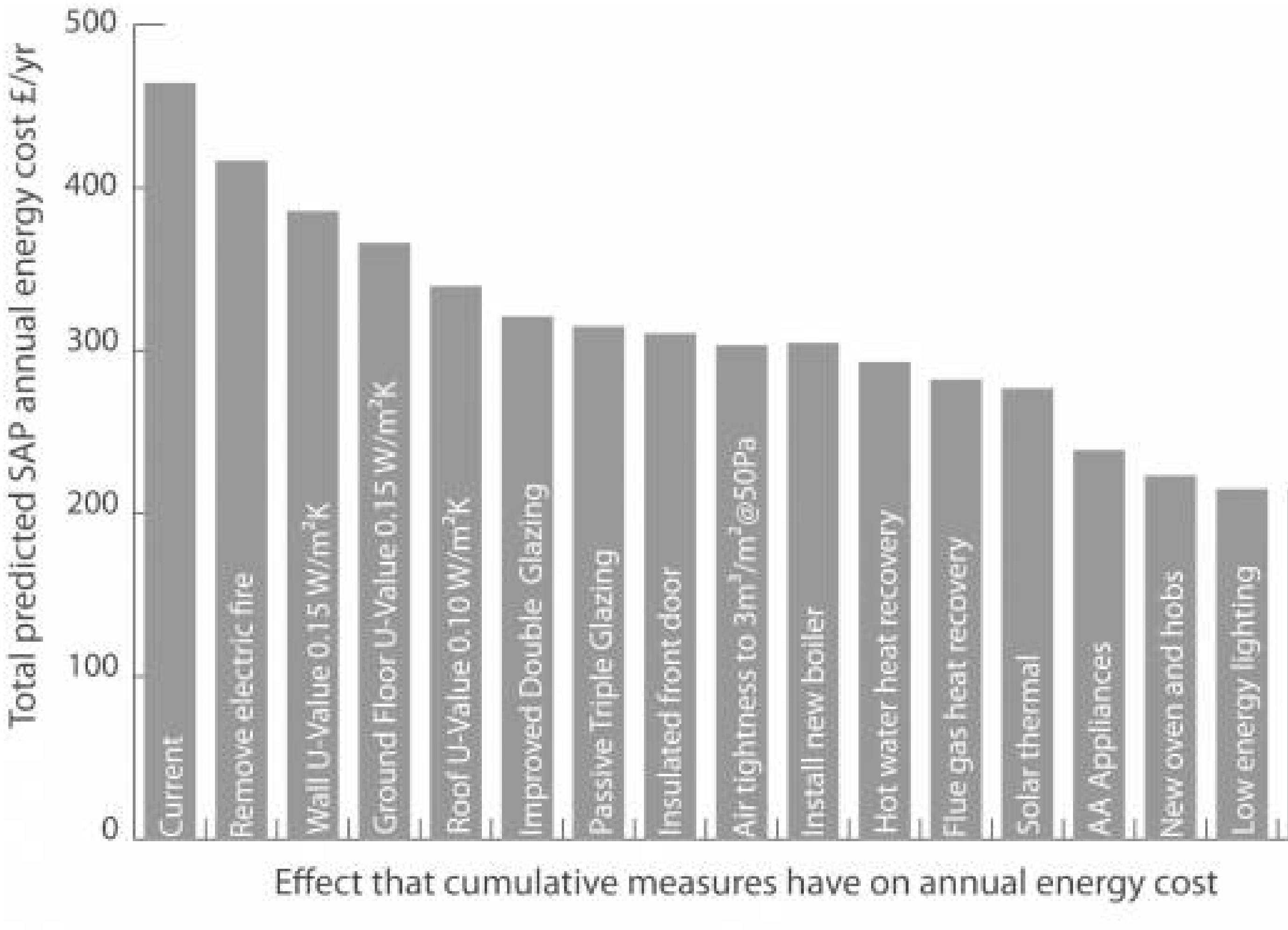
ε=0.75
FLIR
26
61



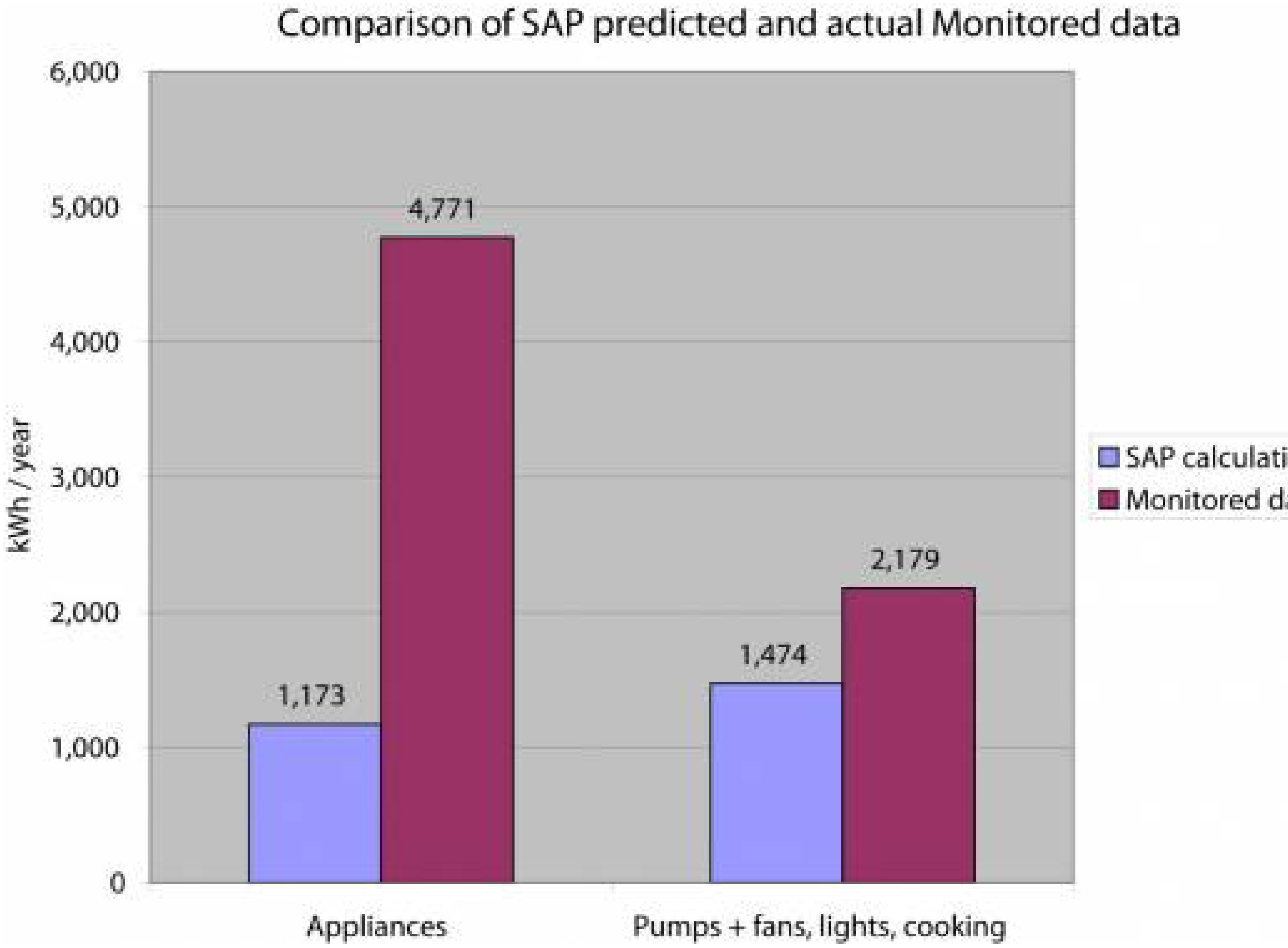
Section A-A
penoyre & pras
Proposed Section A-A
Preliminary
17.11.09
1:50
419-SK-06

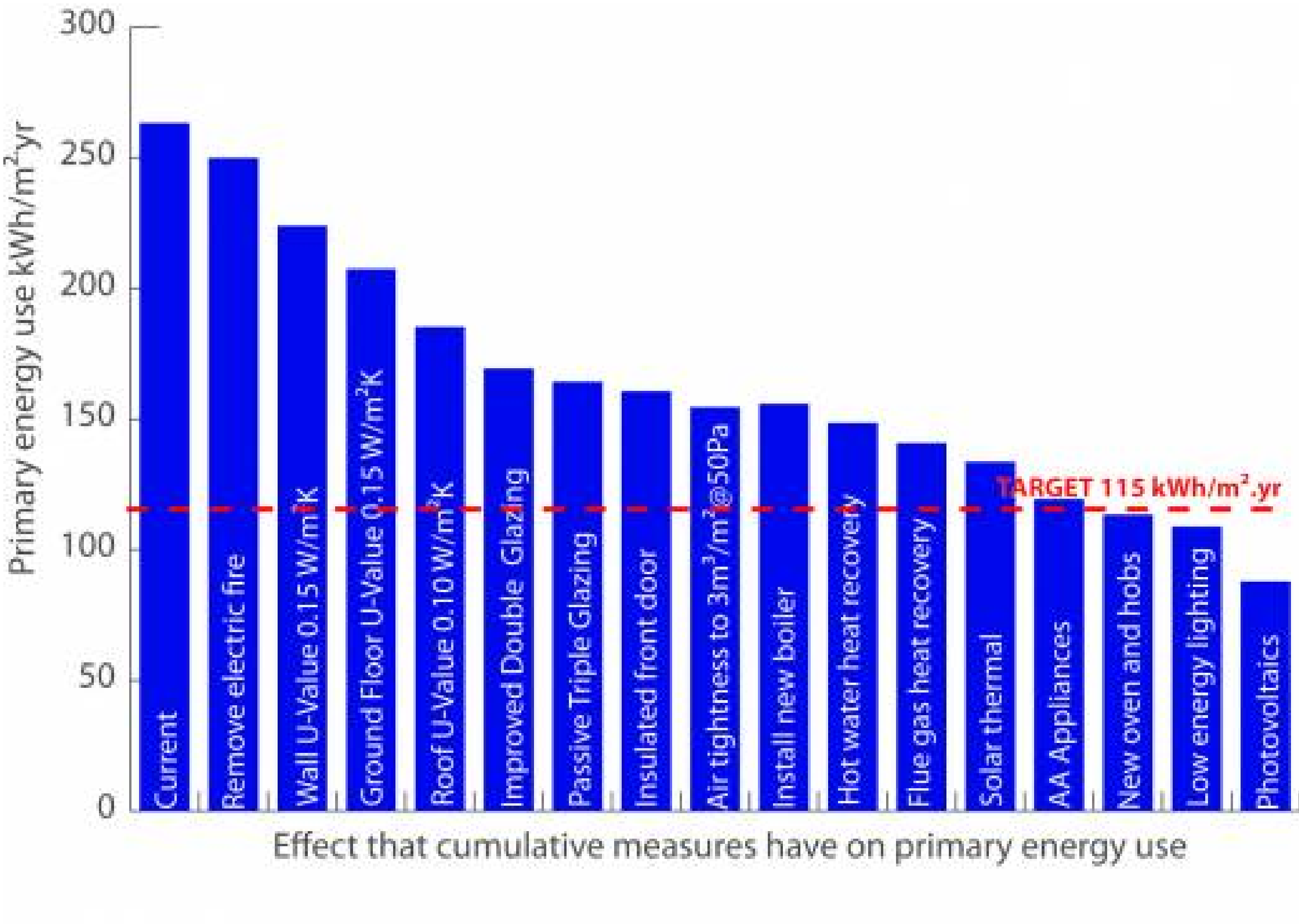

25.2°C
ε=0.75
FLIR
20
30

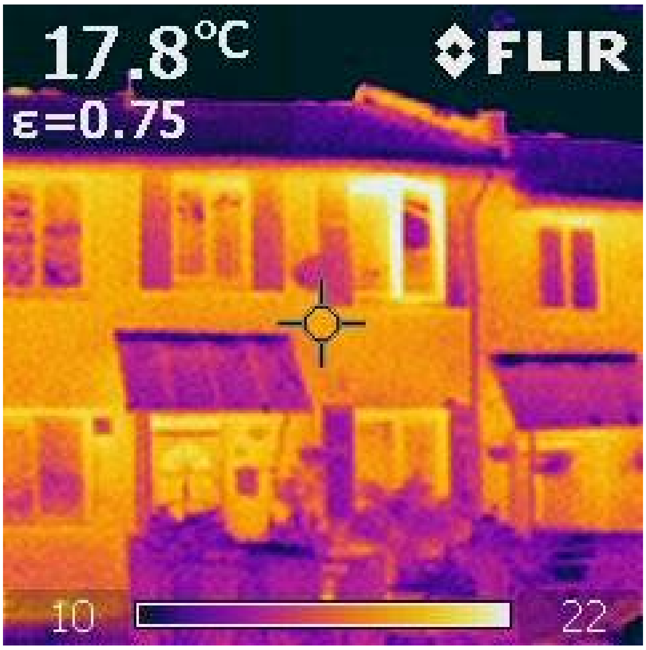

penoyre & pras
419-SK-04



Total predicted SAP annual energy cost £/yr
500
400
300
200
100
0
Current
Remove electric fire
Wall U-Value 0.15 W/m²K
Ground Floor U-Value 0.15 W/m²K
Roof U-Value 0.10 W/m²K
Improved Double Glazing
Passive Triple Glazing
Insulated front door
Air tightness to 3m³/m²@50Pa
Install new boiler
Hot water heat recovery
Flue gas heat recovery
Solar thermal
AA Appliances
New oven and hobs
Low energy lighting
Effect that cumulative measures have on annual energy cost


Comparison of SAP predicted and actual Monitored data
6,000
5,000
4,000
3,000
2,000
1,000
0
kWh / year
4,771
1,173
2,179
1,474
Appliances
Pumps + fans, lights, cooking
SAP calculati
Monitored d


300
250
200
150
100
50
0
Primary energy use kWh/m²yr
TARGET 115 kWh/m².yr
Current
Remove electric fire
Wall U-Value 0.15 W/m²K
Ground Floor U-Value 0.15 W/m²K
Roof U-Value 0.10 W/m²K
Improved Double Glazing
Passive Triple Glazing
Insulated front door
Air tightness to 3m³/m²@50Pa
Install new boiler
Hot water heat recovery
Flue gas heat recovery
Solar thermal
AA Appliances
New oven and hobs
Low energy lighting
Photovoltaics
Effect that cumulative measures have on primary energy use


17.8°C
FLIR
ε=0.75
10
22

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East & West Elevations
Preliminary
419-SK-02

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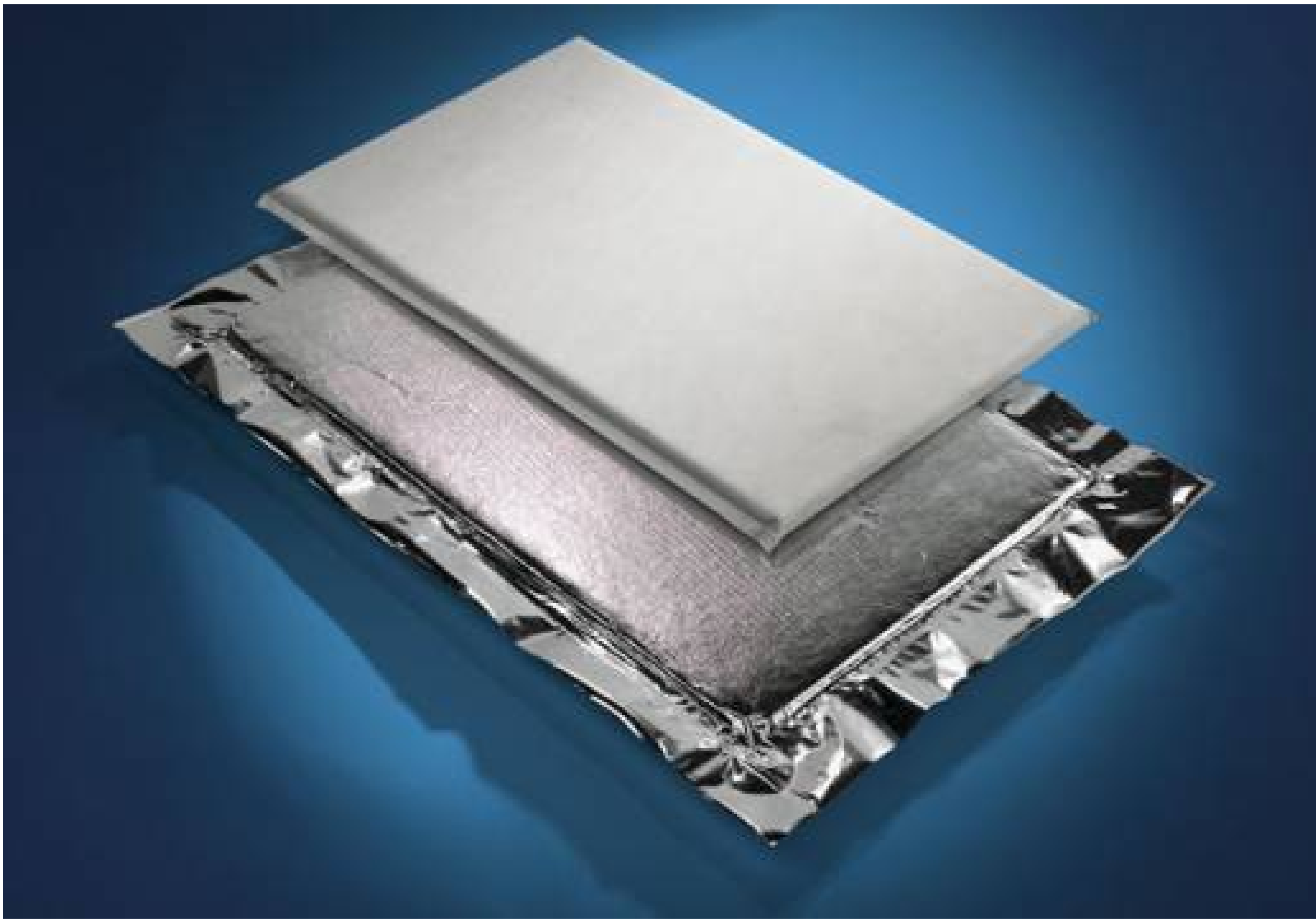
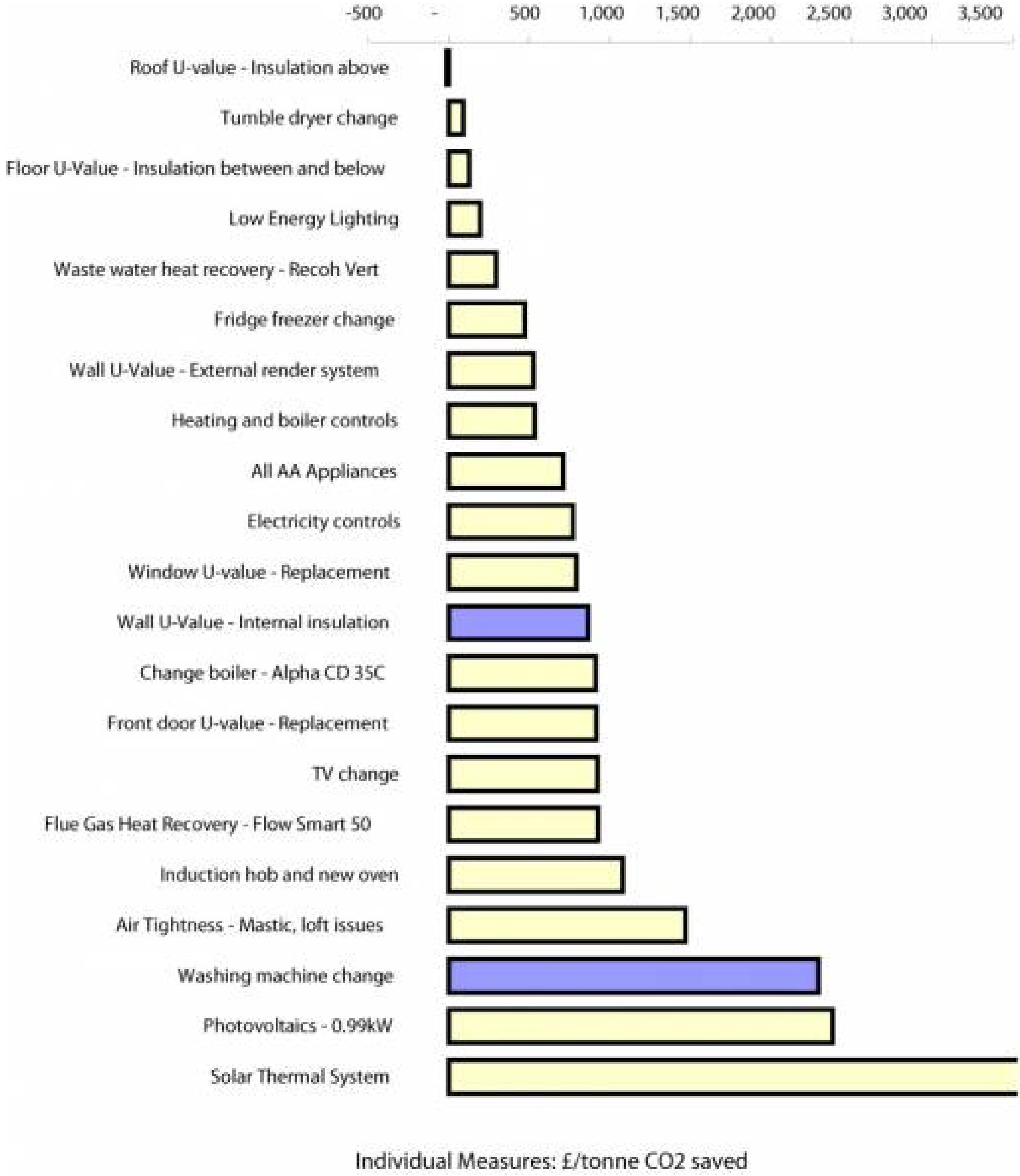
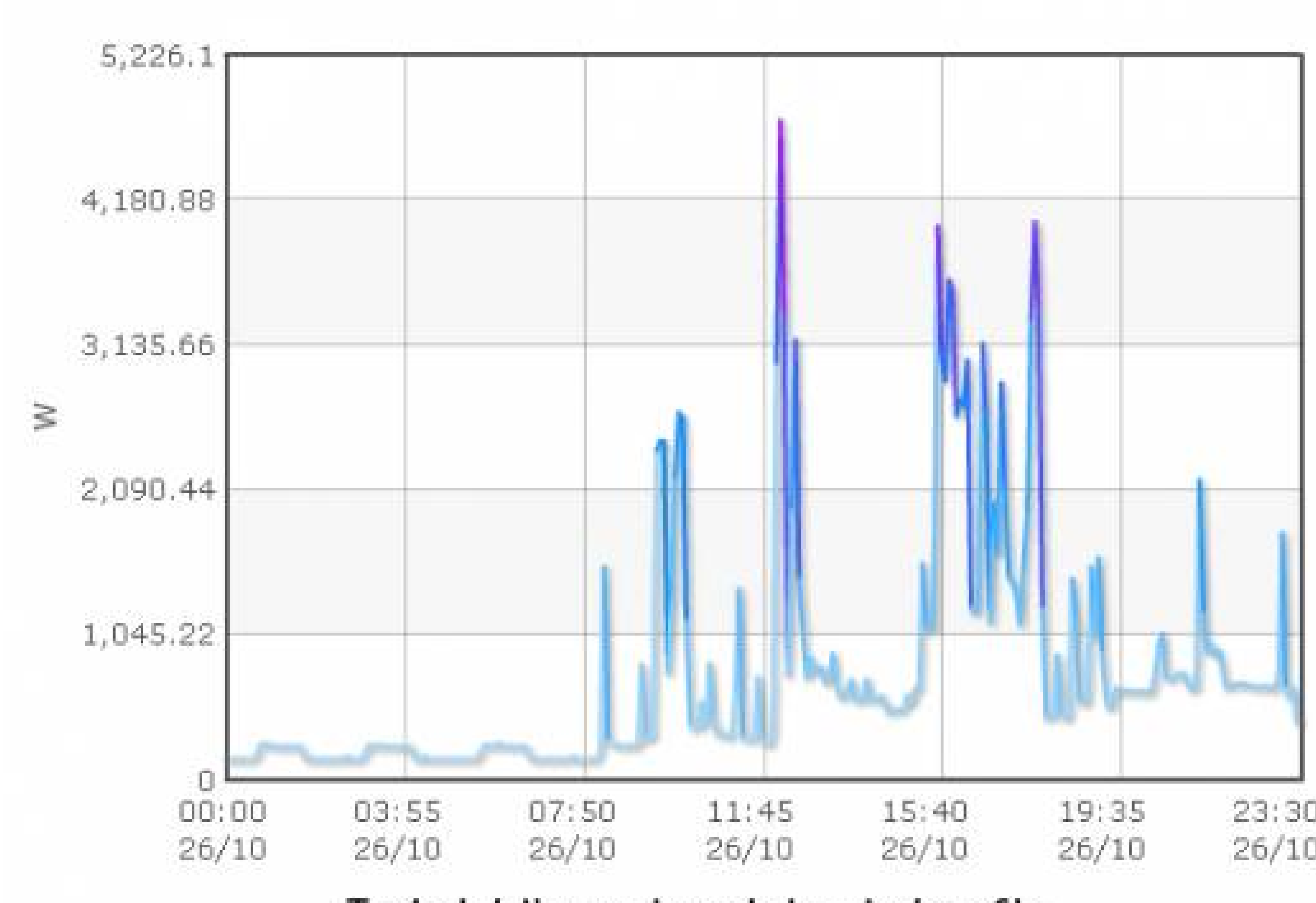
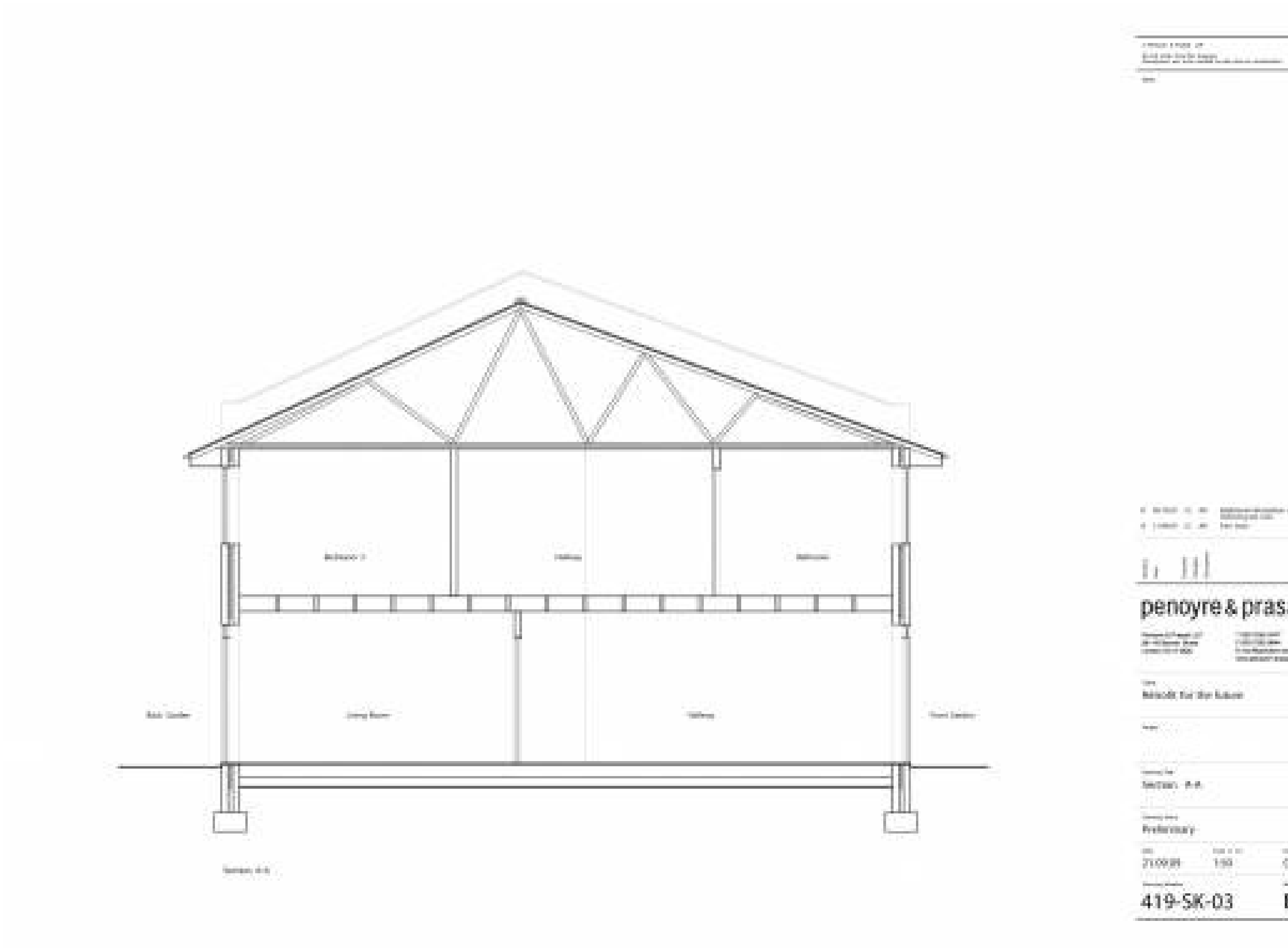
Ground & First Floor Plan
Preliminary
1:50
419-SK-01




-500
-
500
1,000
1,500
2,000
2,500
3,000
3,500
Roof U-value - Insulation above
Tumble dryer change
Floor U-Value - Insulation between and below
Low Energy Lighting
Waste water heat recovery - Recoh Vert
Fridge freezer change
Wall U-Value - External render system
Heating and boiler controls
All AA Appliances
Electricity controls
Window U-value - Replacement
Wall U-Value - Internal insulation
Change boiler - Alpha CD 35C
Front door U-value - Replacement
TV change
Flue Gas Heat Recovery - Flow Smart 50
Induction hob and new oven
Air Tightness - Mastic, loft issues
Washing machine change
Photovoltaics - 0.99kW
Solar Thermal System
Individual Measures: £/tonne CO2 saved



Typical daily monitored electrical profile


penoyre & pras
Preliminary
419-SK-03

Dwelling Airtightness Testing Report

BSRIA Airtightness
Old Bracknell Lane West
Bracknell, Berkshire RG12 7AH
Phone: 0800 5871000
Fax: 01344 465691

BSRIA Airtightness & Acoustics

Report N°: DAT-XC001- -1-PL1-T1

Date:	08/10/2009	**Airtightness Engineer:**	C Knights
Accreditation Body:	ATTMA	**Registration Number:**	0005

Client: XC02 Energy Ltd **Region:** N/A **Address:** 50-52 Wharf Road London N1 7EU **Telephone:** 0207 7001000 **Facsimile:** 0207 1836620	**Plot N°:** 1 **Developers Type:** N/A **Development Name:** **Development Address:**

Test Results at 50 Pascals

		Q_{50}: Airflow (m³/h):	1351
Measured Air Permeability (m³/(h.m²)):	5.82	**Design Air Permeability (m³/(h.m²)):**	

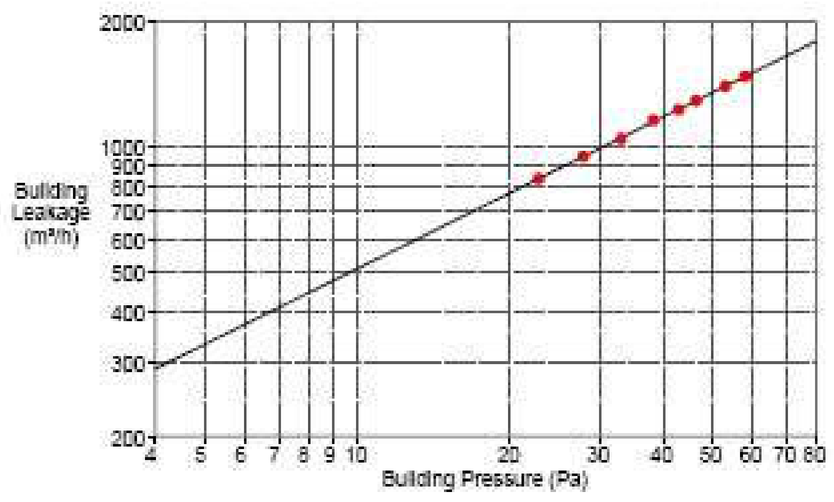
Did the dwelling achieve the required air permeability as specified in the SAP calculations?	

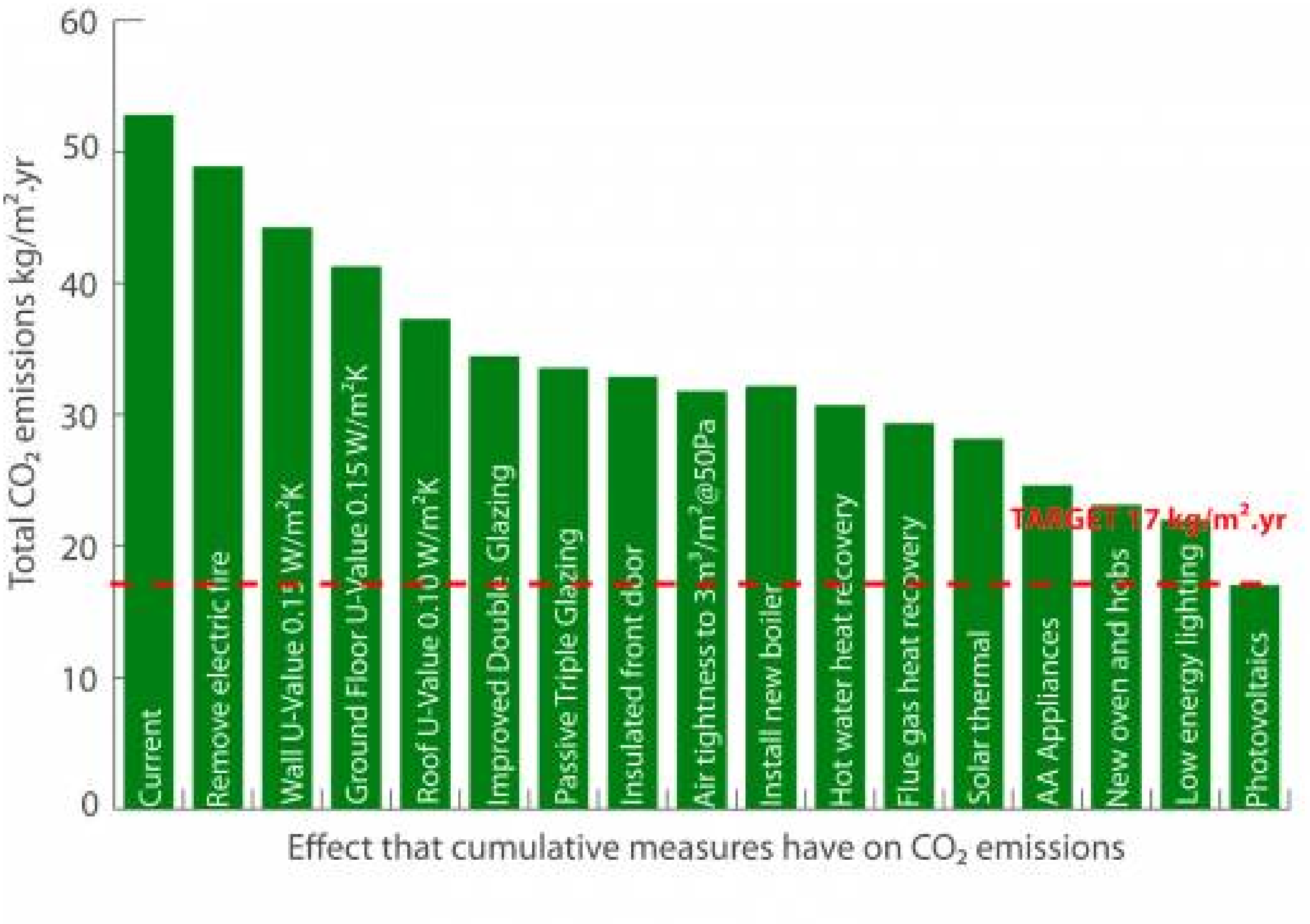
Building Leakage Curve

Air Flow Coefficient (C_{env}):	124.8	**Air Leakage Coefficient (C_L):**	125.4
Exponent (n):	0.61	**Correlation Coefficient (r²):**	0.9998

Test Information

		TS1 Leakage Area (m²):	0.067
Type of Test:	Depressurisation	**Test Method:**	B
Test Standard:	TS1	**Regulation Complied With:**	N/A





60
50
40
30
20
10
0
Total CO_2 emissions kg/m².yr
TARGET 17 kg/m².yr
Current
Remove electric fire
Wall U-Value 0.13 W/m²K
Ground Floor U-Value 0.15 W/m²K
Roof U-Value 0.10 W/m²K
Improved Double Glazing
Passive Triple Glazing
Insulated front door
Air tightness to 3m³/m²@50Pa
Install new boiler
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