

# Borough Grove Low Carbon Refurbishment

## Interim Case Study

### Background to Project

In 2009 Drum Housing Association, part of Radian, began work on an exemplar low carbon refurbishment demonstration scheme at Borough Grove in Petersfield, Hampshire. The thirteen 3-bed semi detached properties, of concrete REEMA construction, were in need of substantial upgrade, having reached the end of their envisaged useful life.

As part of the 'Retrofit South East' project, part funded by the European Regional Development Fund secured via SEEDA, Radian enhanced the specification of this upgrade to encompass a package of low energy and sustainability measures sufficient to reduce carbon emissions by 77% in seven properties and 86% in the remaining six. In addition, further features were incorporated into one showhome property for which funding was secured to keep it open for demonstration purposes until June 2011.

The Borough Grove refurbishment forms the centre piece of the 'Retrofit South East' project, whose aim is to develop a model for low carbon retrofit of social housing that will help to transform businesses and reduce carbon emissions from existing housing stock across the South East region. Further information is available on the Retrofit South East website:

[www.radian.co.uk/201004072131/retrofit.html](http://www.radian.co.uk/201004072131/retrofit.html)



# The Existing Properties

The properties on Borough Grove form part of a former council estate in Petersfield built in the early 1950s. The precast reinforced concrete (REEMA) homes were built in the wake of the Second World War, to provide a speedy solution to the housing shortage at the time. Their original useful life was envisaged to be 30 years. Having considerably outperformed this, they had a number of defects which made them unmortgageable and in need of considerable investment to bring them nearer to modern standards.

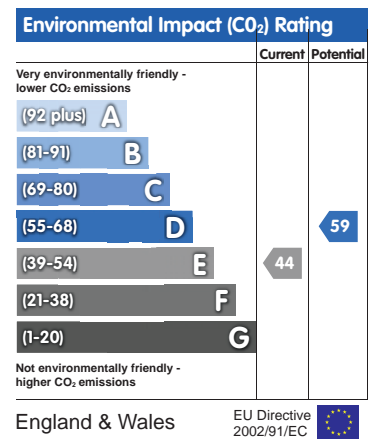
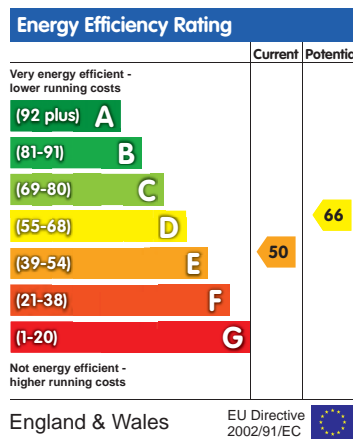
The properties were all 'E' rated, with residents' energy bills typically ranging between £1000-£1500 per year, and many failing to achieve thermal comfort. Carbon emissions for space heating, hot water & lighting were typically 6tCO<sub>2</sub>/yr or 7.2tCO<sub>2</sub>/yr in total, including appliance based electricity use<sup>1</sup>. A typical Energy Efficiency and Environmental Impact Rating can be seen here.

In practice, some characteristics of homes varied slightly in terms of boiler age and some built form characteristics (for instance some properties had conservatories attached while others did not).

In keeping with REEMA type construction all homes have hollow precast concrete walls, solid concrete floors and concrete ceilings, with pitched roofs clad in concrete tiles. Prior to refurbishment the properties had approximately 100mm loft insulation, no floor or wall insulation, double glazing installed in the mid-90s, and gas boilers in need of replacement (some still with back boilers and very low efficiency). One property on the estate had been sold previously under 'right to buy', and while an opportunity to participate in efficiency measures, such as external wall insulation was offered, funding could unfortunately not be provided by Radian or the private owners, meaning they were unable to participate at this time.

Radian's objective with the refurbishment was to demonstrate low carbon refurbishment techniques in practice and show how, with advanced measures, the performance of these homes can be improved towards the standard of modern new build.

<sup>1</sup> Based on Standard Assessment Procedure and Code for Sustainable Homes methodology for electricity.



Right: Energy Efficiency and Environmental Impact Ratings for No 8 Borough Grove, prior to refurbishment. Note the 'potential' Energy Efficiency Rating and Environmental Impact Rating is to improve the property to a band 'D' – the final result goes considerably beyond this!

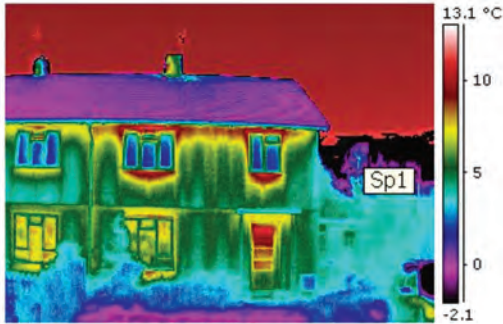
## New Build or Refurbish?

In 2006 Drum Housing completed an award winning redevelopment of 148 new eco-homes, constructed to replace 58 precast concrete REEMA homes on the site adjacent to Borough Grove in Petersfield. The 'Privett Green' development followed a period of extensive consultation with residents, with the majority expressing a preference for redevelopment. It has achieved an overall site rating of BREEAM EcoHomes 'Very Good' (although if individual units were to be assessed, 10% of the homes would achieve and 'Excellent' rating, or Code for Sustainable Homes level 3 or 4, by virtue of micro-renewables installed).

At neighbouring Borough Grove, residents preferred not to have their homes developed, leading Radian to develop a programme for refurbishment instead. Building on success with award winning experience at Kingsley (Woodfields Generation Homes Low Energy Refurbishment), and nearby Highfield Road (a low carbon refurbishment of 20 REEMA dwellings in 2008), funding was secured for an advanced refurbishment programme which would substantially reduce carbon emissions and enhance sustainability, driving the properties towards the standards achieved by the new build properties at Privett Green.

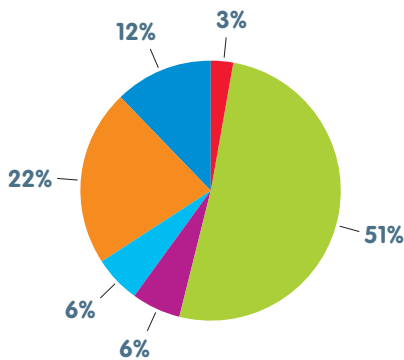
# Sustainability Features

The refurbishment programme at Borough Grove involved a complete upgrade of internal and external finishings to make the homes Decent Homes compliant, including new kitchens and bathrooms, re-wiring, re-plastering and re-roofing. While work was being carried out, residents were temporarily decanted into nearby properties at Highfield Road, which were recently refurbished to a high energy performance standard in 2008-9. Building on the experience at Highfield Road and elsewhere, a substantial package of low energy and sustainability features was included. The key features of this package are described below.

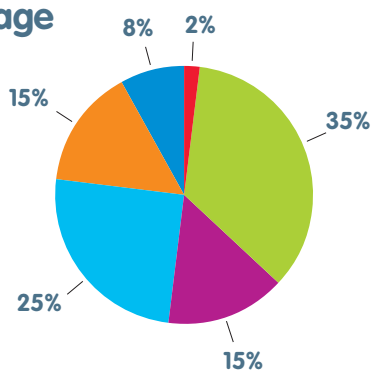


Thermal Infrared image of the front East-facing elevation of No 14 Borough Grove, prior to refurbishment, showing substantial heat loss through uninsulated concrete walls, ground floor window and single glazed wooden door. © Horton Levi Ltd.

## Where was heat being lost prior to refurbishment?



## UK average



- Windows
- Doors
- External walls
- Ground floors
- Roof
- Draughts

Extract from Parity Projects' Home Energy Masterplan for number 14 Borough Grove, before refurbishment, showing substantial heat loss through the uninsulated concrete walls. © Parity Projects

## Walls

The chart (left) shows that over 50% of the heat loss from these properties was through the uninsulated concrete walls. Insulating walls externally is generally preferable to internal wall insulation, where possible, as it helps reduce heat loss through thermal bridging as well as maximizing thermal mass within the dwelling, which helps maintain a more even indoor temperature.

External wall insulation was applied to all properties, comprising of 100mm Kingspan Kooltherm phenolic insulation with a Wetherby K-silicon wet render finish. This has reduced the wall U value from 2.34W/m<sup>2</sup>K to below 0.3W/m<sup>2</sup>K, cutting heat loss by a factor of nearly ten. Insulation was returned around corners to meet door and window frames to a thickness of 25mm to minimize cold bridging in these areas.

## Floors

Around the concrete floor slab 'edge' insulation, in the form of 50mm extruded polystyrene board, has been applied to a depth of 300mm below the first floor level, covered with weatherproof Trespa cladding panels. In the showhome an additional 20mm Aerogel insulation bonded to 18mm chipboard has been applied above the ground floor to further reduce heat loss from the concrete floor, requiring repositioning of all doors and stairways. This has reduced the floor U value from its original level of 0.68 W/m<sup>2</sup>K to 0.58 and 0.30 W/m<sup>2</sup>K respectively.

## Roof

Original loft insulation was removed due to age, as well as to enable re-wiring, and replaced with a depth of 300mm mineral wool laid between and across joists. A small 3x4m decked area was provided to allow storage of residents' belongings without compromising the insulation, and a new insulated and draughtproofed loft hatch installed.

## Windows & doors

The application of external wall insulation required the repositioning of windows and, since they were 15 years old, the decision was taken to replace them with new higher performance alternatives. This also enabled

slight resizing to enable a better fit with the insulation thickness at window reveals. All windows were replaced with BFRC rated 'A' or 'B' windows, with U-values 1.3 and 1.4 W/m<sup>2</sup>K respectively. The previous single glazed wooden doors were replaced with 'A' rated GRP doors supplied by Steelwood Doors.

## Air tightness & ventilation

An air tightness target of 5m<sup>3</sup>/m<sup>2</sup>hr was specified as part of the refurbishment programme and a range of measures employed to achieve this level. Precast concrete properties like these REEMA homes are typically more air tight than traditional masonry construction and pressure tests indicated leakage rates below 8m<sup>3</sup>/m<sup>2</sup>hr prior to refurbishment. Measures were employed to reduce this, including sealing all service entry points to the dwellings; ensuring areas around windows and doors were properly sealed; and sealing the area where floor joists met precast concrete wall panels, which was shown by a smoke test to be an air leakage weak point.

Improvements to air tightness need to be combined with means of controlled ventilation in order to maintain indoor air quality and prevent excess humidity accumulating. To support this, through-the-wall mechanical ventilation with heat recovery fans (Vent-Axia HR25 and HR200WK) were installed in all kitchens and bathrooms.

## Solar photovoltaics

All properties were re-roofed as part of the refurbishment and the opportunity taken to install solar photovoltaics on all properties. Dulas Engineering supplied and installed the Kyocera polycrystalline panels, with a generation capacity of 2.1kWp on the six South East facing properties and 1.48kWp on remaining seven properties (East-West facing). The expected output from the systems is 1680kWh/yr for the 2.1kWp systems and 1180kWh/yr for the 1.48kWp systems. Residents will not receive the Feed In Tariff since systems were installed with grants from the Low Carbon Buildings Programme. However, they should still benefit from electricity bill savings of up to £80-120/yr (depending on system size), assuming they are able to time demand to coincide with periods of maximum output<sup>2</sup>.

## Solar water heating

In addition to solar PV, 3m<sup>2</sup> Solartwin solar water heating panels were installed on the six South-East facing properties with a new mains pressure Gledhill thermal store with integral insulation. Electric showers were replaced with new mains hot water low flow shower fittings to help make maximum use of available solar heated water. The systems should provide around 50% of residents' annual hot water demand, which, combined with the low flow shower heads and taps, should realise a substantial reduction in residents' hot water bills.

<sup>2</sup> This assumes an average of half the total annual output can be consumed internally over a year.

## Heating systems and controls

All gas heated dwellings were fitted with Ideal icos HE18 condensing gas boilers, with seasonal efficiency 90.3%. They were also provided with new controls including room thermostat, boiler interlock and TRVs on all radiators.

## Lights & appliances

All internal and external lights were fitted with low energy CFL light bulbs. Rotary dryers were fitted in gardens to enable open air clothes drying. The showhome is additionally being fitted with A-rated appliances including cooker, fridge freezer and washing machine. All homes will be provided with a Wattson display electricity meter, which glows different colours to alert residents of different levels of electricity use. The meters are fully PV compatible and allow residents to download full history of electrical consumption and generation to enable data to be viewed graphically, via their 'Holmes data sleuth' software.

## Behaviour & lifestyle change

A resident liaison officer was employed throughout the early stages of the project to support residents through the process, and has worked closely with them to communicate the implications of energy and sustainability improvements on the houses. An important feature of the resident support was to provide a permanent site office in one of the void properties, providing the opportunity for residents to easily drop in with questions or concerns. Following the completion of all properties, residents will be invited to a day long event in the showhome organised by the successful and locally based 'Greening Campaign', which will include training and guidance on living in their new low energy homes.

## Water efficiency

All homes have been fitted with low flow taps, low flow showers, dual flush WCs, and a 200 litre water butt for rainwater storage in the garden. Water meters have been installed in all properties by South East Water, enabling accurate remote meter reading, and offering residents the option of being billed on a metered basis, if they so choose.

Two homes will have full rainwater harvesting systems. The showhome (number 16) incorporates a new system called FlushRain which has not been used before. This system collects water from the gutter downpipes into a tank in the loft that supplies the toilets by gravity. A pump in the roof is alerted by water sensors in the collectors and draws the rainwater into the roof tank, filtering it on the way. A back-up mains supply is provided for when there is insufficient rain. Another property (number 8) will feature a rain water harvesting system with a tank located in the ground and will also incorporate additional water flow meters to transform it into a 'water exemplar' property.



## Waste

The refurbishment programme has been subject to a site wide waste management plan, and throughout the refurbishment accurate quantities of materials have been ordered wherever possible. An off-site recycling facility means that on average 85% of waste materials are being recycled. For individual homes, recycling facilities are being provided by the local authority.

## Monitoring

In addition to the water metering and display energy devices mentioned above, monthly electricity, gas and water meter readings have been taken for each individual property since autumn 2009, and will be continued until after residents have all moved back in, to allow evaluation of the effectiveness of the refurbishment works. Tiny tag temperature data loggers have also been installed in all properties since before the work began and will be used to help evaluate improvements in terms of thermal comfort.

# Results

The chart below shows the effect of the low carbon measures described on the homes at Borough Grove, in terms of SAP rating and annual carbon emissions. The seven East facing homes achieve a high 'B' rating, while the six remaining South East facing homes, with extra PV and solar water heating,

achieve an 'A' rating, including the showhome (whose extra floor insulation earns it an extra SAP point taking the overall rating to 93). This reduces carbon emissions for 'regulated' energy sources (heating, hot water, lighting and ventilation) by 77%, 86% and 88% respectively.

Energy Performance Specification For Show Home Showing Incremental Improvements	EPC band	SAP rating	EI Rating	CO <sub>2</sub> emissions (kg/vr)*	% CO <sub>2</sub> reduction
Baseline Home	E	49	43	5868	0%
+100mm phenolic wall external insulation	C	69	64	3461	41%
+300mm mineral wool loft insulation (top up)	C	70	66	3284	44%
+50mm XPS vertical edge floor insulation	C	71	67	3219	45%
+A-rated windows and doors	C	74	71	2792	52%
+Improved air tightness & MVHR	C	74	73	2650	55%
+high efficiency gas boiler & cylinder insulation	C	80	80	1965	67%
+low energy lights throughout	B	81	80	1923	67%
+1.48kWp solar PV	B	87	86	1328	77%
+extra (2.1kWp) solar PV	B	91	90	972	83%
+extra (2.1kWp) solar PV and 3m <sup>2</sup> SWH	A	92	92	816	86%
+20mm aerogel floor insulation	A	93	93	692	88%

\* for space heating, hot water, lights & ventilation, using SAP 2005 Summary of effect of low carbon measures incorporated at Borough Grove on SAP rating and carbon emissions.

Absolute CO<sub>2</sub> emissions are reduced to below 1 tonne per household for the South East facing properties. Adding in appliance based electricity takes total CO<sub>2</sub> emissions to around 2.5tCO<sub>2</sub> per household for East-facing homes and 2.0tCO<sub>2</sub> for the South East facing homes.

Following completion of the refurbishment on all properties, the monitoring strategy above will enable analysis of actual performance in use, in terms of both energy and water efficiency, to see if these predictions are being realised in practice.



# Costs

The total budget for all refurbishment work undertaken at Borough Grove was £1.2million, or an average of £92k per dwelling. Of this, the sustainability features described above accounted for an average of £36k per property (£32k for the East facing properties, with no solar water heating and a smaller area of PV, £39k for the South East facing properties with solar water heating and more PV, and £46k for the showhome). The cost of decanting residents to nearby properties during refurbishment work accounted for an average of £13k per property.

Investment for the scheme was provided by a combination of Radian's planned maintenance budget, support from the European Regional Development Fund (as part of the 'Retrofit

South East' project), grants received from the Low Carbon Buildings Programme for solar water heating and PV, and some funding for basic measures provided through the Carbon Emissions Reduction Target (CERT).

## Next Steps

Completion of the refurbishment works at Borough Grove is expected in February 2011. Following this, Radian will publish a follow up Case Study which provides further detail on costs, lessons learned, and evidence of energy and water consumption in practice, based on feedback from the team, contractors and residents.

# RETROFIT South East

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## Project Partners

Radian (lead partner) – [www.radian.co.uk](http://www.radian.co.uk)

Camco – [www.camcoglobal.com](http://www.camcoglobal.com)

Parity Projects – [www.parityprojects.com](http://www.parityprojects.com)

GESB – [www.gesb.eu](http://www.gesb.eu)

## Project website

[www.radian.co.uk/201004072131/retrofit.html](http://www.radian.co.uk/201004072131/retrofit.html)



Project partners are:

